Title: Encyclopaedia Britannica, 11th Edition, "Lightfoot, Joseph" to "Liquidation"

Author: Various

Release date: November 24, 2012 [EBook #41472]

Language: English

Credits: Produced by Marius Masi, Don Kretz and the Online
Distributed Proofreading Team at http://www.pgdp.net

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THE ENCYCLOPÆDIA BRITANNICA

A DICTIONARY OF ARTS, SCIENCES, LITERATURE AND GENERAL INFORMATION

ELEVENTH EDITION

VOLUME XVI SLICE VI

Lightfoot, Joseph to Liquidation

Articles in This Slice

LIGHTFOOT, JOSEPH BARBER

LIGHTFOOT, JOSEPH BARBER (1828-1889), English theologian and bishop of Durham, was born at Liverpool on the 13th of April 626
1828. His father was a Liverpool accountant. He was educated at King Edward's school, Birmingham, under James Prince Lee, afterwards bishop of Manchester, and had as contemporaries B. F. Westcott and E. W. Benson. In 1847 Lightfoot went up to Trinity College, Cambridge, and there read for his degree with Westcott. He graduated senior classic and 30th wrangler, and was elected a fellow of his college. From 1854 to 1859 he edited the *Journal of Classical and Sacred Philology*. In 1857 he became tutor and his fame as a scholar grew rapidly. He was made Hulsean professor in 1861, and shortly afterwards chaplain to the Prince Consort and honorary chaplain in ordinary to the queen. In 1866 he was Whitehall preacher, 627
and in 1871 he became canon of St Paul's. His sermons were not remarkable for eloquence, but a certain solidity and balance of judgment, an absence of partisanship, a sobriety of expression combined with clearness and force of diction, attracted hearers and inspired them with confidence. As was written of him in *The Times* after his death, "his personal character carried immense weight, but his great position depended still more on the universally recognized fact that his belief in Christian truth and his defence of it were supported by learning as solid and comprehensive as could be found anywhere in Europe, and by a temper not only of the utmost candour but of the highest scientific capacity. The days in which his university influence was asserted were a time of much shaking of old beliefs. The disintegrating speculations of an influential school of criticism in Germany were making their way among English men of culture just about the time, as is usually the case, when the tide was turning against them in their own country. The peculiar service which was rendered at this juncture by the 'Cambridge School' was that, instead of opposing a mere dogmatic opposition to the Tübingen critics, they met them frankly on their own ground; and instead of arguing that their conclusions ought not to be and could not be true, they simply proved that their facts and their premisses were wrong. It was a characteristic of equal importance that Dr Lightfoot, like Dr Westcott, never discussed these subjects in the mere spirit of controversy. It was always patent that what he was chiefly concerned with was the substance and the life of Christian truth, and that his whole energies were employed in this inquiry because his whole heart was engaged in the truths and facts which were at stake. He was not diverted by controversy to side-issues; and his labour was devoted to the positive elucidation of the sacred documents in which the Christian truth is enshrined."

In 1872 the anonymous publication of *Supernatural Religion* created considerable sensation. In a series of masterly papers in the *Contemporary Review*, between December 1874 and May 1877, Lightfoot successfully undertook the defence of the New Testament canon. The articles were published in collected form in 1889. About the same time he was engaged in contributions to W. Smith's *Dictionary of Christian Biography* and *Dictionary of the Bible*, and he also joined the committee for revising the translation of the New Testament. In 1875 he became Lady Margaret professor of divinity in succession to William Selwyn. He had previously written his commentaries on the epistles to the Galatians (1865), Philippians (1868) and Colossians (1875), the notes to which were distinguished by sound judgment and enriched from his large store of patristic and classical learning. These commentaries may be described as to a certain extent a new departure in New Testament exegesis. Before Lightfoot's time commentaries, especially on the epistles, had not infrequently consisted either of short homilies on particular portions of the text, or of endeavours to enforce foregone conclusions, or of attempts to decide with infinite industry and ingenuity between the interpretations of former commentators. Lightfoot, on the contrary, endeavoured to make his author interpret himself, and by considering the general drift of his argument to discover his meaning where it appeared doubtful. Thus he was able often to recover the meaning of a passage which had long been buried under a heap of contradictory glosses, and he founded a school in which sobriety and common sense were added to the industry and ingenuity of former commentators. In 1879 Lightfoot was consecrated bishop of Durham in succession to C. Baring. His moderation, good sense, wisdom, temper, firmness and erudition made him as successful in this position as he had been when professor of theology, and he speedily surrounded himself with a band of scholarly young men. He endeavoured to combine his habits of theological study with the practical work of administration. He exercised a large liberality and did much to further the work of temperance and purity organizations. He continued to work at his editions of the *Apostolic Fathers*, and in 1885 published an edition of the Epistles of Ignatius and Polycarp, collecting also a large store of valuable materials for a second edition of Clement of Rome, which was published after his death (1st ed., 1869). His defence of the authenticity of the Epistles of Ignatius is one of the most important contributions to that very difficult controversy. His unremitting labours impaired his health and shortened his splendid career at Durham. He was never married. He died at Bournemouth on the 21st of December 1889, and was succeeded in the episcopate by Westcott, his schoolfellow and lifelong friend.

Four volumes of his *Sermons* were published in 1890.

LIGHTHOUSE

LIGHTHOUSE, a form of building erected to carry a light for the purpose of warning or guidance, especially at sea.

1. Early History.—The earliest lighthouses, of which records exist, were the towers built by the Libyans and Cushites in Lower Egypt, beacon fires being maintained in some of them by the priests. Lesches, a Greek poet (*c.* 660 B.C.) mentions a lighthouse at Sigeum (now Cape Incihisari) in the Troad. This appears to have been the first light regularly maintained for the guidance of mariners. The famous Pharos[1] of Alexandria, built by Sostratus of Cnidus in the reign of Ptolemy II. (283-247 B.C.) was regarded as one of the wonders of the world. The tower, which took its name from that of the small island on which it was built, is said to have been 600 ft. in height, but the evidence in support of this statement is doubtful. It was destroyed by an earthquake in the 13th century, but remains are said to have been visible as late as 1350. The name Pharos became the general

term for all lighthouses, and the term “pharology” has been used for the science of lighthouse construction.

The tower at Ostia was built by the emperor Claudius (A.D. 50). Other famous Roman lighthouses were those at Ravenna, Pozzuoli and Messina. The ancient Pharos at Dover and that at Boulogne, later known as *la Tour d’Ordre*, were built by the Romans and were probably the earliest lighthouses erected in western Europe. Both are now demolished.

The light of Cordouan, on a rock in the sea at the mouth of the Gironde, is the earliest example now existing of a wave-swept tower. Earlier towers on the same rock are attributed the first to Louis le Debonnaire (*c.* A.D. 805) and the second to Edward the Black Prince. The existing structure was begun in 1584 during the reign of Henri II. of France and completed in 1611. The upper part of the beautiful Renaissance building was removed towards the end of the 18th century and replaced by a loftier cylindrical structure rising to a height of 207 ft. above the rock and with the focal plane of the light 196 ft. above high water (fig. 1). Until the 18th century the light exhibited from the tower was from an oak log fire, and subsequently a coal fire was in use for many years. The ancient tower at Corunna, known as the Pillar of Hercules, is supposed to have been a Roman Pharos. The Torre del Capo at Genoa originally stood on the promontory of San Berrique. It was built in 1139 and first used as a lighthouse in 1326. It was rebuilt on its present site in 1643. This beautiful tower rises 236 ft. above the cliff, the light being elevated 384 ft. above sea-level. A lens light was first installed in 1841. The Pharos of Meloria was constructed by the Pisans in 1154 and was several times rebuilt until finally destroyed in 1290. On the abandonment of Meloria by the Pisans, they erected the still existing tower at Leghorn in 1304.

In the 17th and 18th centuries numerous towers, on which were erected braziers or grates containing wood or coal fires, were established in various positions on the coasts of Europe. Among such stations in the United Kingdom were Tynemouth (*c.* 1608), the Isle of May (1636), St Agnes (1680), St Bees (1718) and the Lizard (1751). The oldest lighthouse in the United States is believed to be the Boston light situated on Little Brewster Island on the south side of the main entrance to Boston Harbour, Mass. It was established in 1716, the present structure dating from 1859. During the American War of Independence the lighthouse suffered many vicissitudes and was successively destroyed and rebuilt three times by the American or British forces. At the third rebuilding in 1783 a stone tower 68 ft. in height was erected, the illuminant consisting of four oil 628
lamps. Other early lighthouse structures on the New England coast were those at Beaver Tail, near the entrance to Newport Harbour (1740), and the Brant at the entrance to Nantucket Harbour (1754). A watch-house and beacon appear to have been erected on Beacon or Lighthouse Island as well as on Point Allerton Hill near Boston, prior to 1673, but these structures would seem to have been in the nature of look-out stations in time of war rather than lighthouses for the guidance of mariners.

2. Lighthouse Structures.—The structures of lighthouses may be divided into two classes, (*a*) those on rocks, shoals or in other situations exposed to the force of the sea, and (*b*) the more numerous class of land structures.

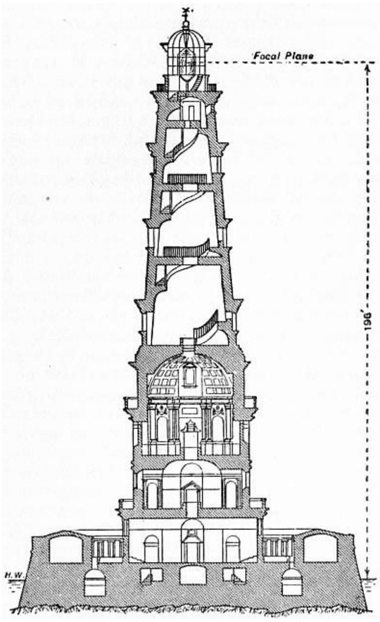

Fig. 1.—Cordouan Lighthouse.

Wave-swept Towers.—In determining the design of a lighthouse tower to be erected in a wave-swept position consideration must be given to the physical features of the site and its surroundings. Towers of this description are classified as follows: (1) Masonry and concrete structures; (2) Openwork steel and iron-framed erections on pile or other foundations; (3) Cast iron plated towers; (4) Structures erected on cylinder foundations.

(1) *Masonry Towers.*—Masonry or concrete towers are generally preferred for erection on wave-swept rocks affording good foundation, and have also been constructed in other situations where adequate foundations have been made by sinking caissons into a soft sea bed. Smeaton’s tower on the Eddystone Rock is the model upon which most later designs of masonry towers have been based, although many improvements in detail have since been made. In situations of great exposure the following requirements in design should be observed: (*a*) The centre of gravity of the tower structure should be as low as possible. (*b*) The mass of the structure superimposed at any horizontal section must be sufficient to prevent its displacement by the combined forces of wind and waves without dependence on the adhesion at horizontal joint faces or on the dovetailing of stones introduced as an additional safeguard. (*c*) The structure should be circular in plan throughout, this form affording the least resistance to wave stroke and wind pressure in any direction. (*d*) The lower portion of the tower exposed to the direct horizontal stroke of the waves should, for preference, be constructed with vertical face. The upper portion to be either straight with uniform batter or continuously curved in the vertical plane. External projections from the face of the tower, except in the case of a gallery under the lantern, should be avoided, the surface throughout being smooth. (*e*) The height from sea-level to the top of the tower should be sufficient to avoid the obscuration of the light by broken water or dense spray driving over the lantern. (*f*) The foundation of the tower should be carried well into the solid rock. (*g*) The materials of which the tower is built should be of high density and of resistant nature. (*h*) The stones used in the construction of the tower, at any rate those on the outer face, should be dovetailed or joggled one to the other in order to prevent their being dislodged by the sea during the process of construction and as an additional safeguard of stability. Of late years, cement concrete has been used to a considerable extent for maritime structures, including lighthouses, either alone or faced with masonry.

(2) *Openwork Structures.*—Many examples of openwork steel and iron lighthouses exist. Some typical examples are described hereafter. This form of design is suitable for situations where the tower has to be carried on a foundation of iron or steel piles driven or screwed into an insecure or sandy bottom, such as on shoals, coral reefs and sand banks or in places where other materials of construction are exceptionally costly and where facility of erection is a desideratum.

(3) *Cast iron Towers.*—Cast iron plated towers have been erected in many situations where the cost of stone or scarcity of labour would have made the erection of a masonry tower excessively expensive.

(4) *Caisson Foundations.*—Cylinder or caisson foundations have been used for lighthouse towers in numerous cases where such structures have been erected on sand banks or shoals. A remarkable instance is the Rothersand Tower. Two attempts have been made to sink a caisson in the outer Diamond Shoal off Cape Hatteras on the Atlantic coast of the United States, but these have proved futile.

The following are brief descriptions of the more important wave-swept towers in various parts of the world.

Eddystone (*Winstanley’s Tower*).—The Eddystone rocks, which lie about 14 m. off Plymouth, are fully exposed to south-west seas. The reef is submerged at high water of spring tides. Four towers have been constructed on the reef. The first lighthouse (fig. 2) was polygonal in plan and highly ornamented with galleries and projections which offered considerable resistance to the sea stroke. The work was begun by Henry Winstanley, a gentleman of Essex, in 1695. In 1698 it was finished to a height of 80 ft. to the wind vane and the light exhibited, but in the following year, in consequence of damage by storms, the tower was increased in diameter from 16 ft. to 24 ft. by the addition of an outer ring of masonry and made solid to a height of 20 ft. above the rock, the tower being raised to nearly 120 ft. The work was completed in the year 1700. The lower part of the structure appears to have been of stone, the upper part and lantern of timber. During the great storm of the 20th of November 1703 the tower was swept away, those in it at the time, including the builder, being drowned.

Eddystone (*Rudyerd’s Tower*, fig. 3).—This structure was begun in 1706 and completed in 1709. It was a frustum of a cone 22 ft. 8 in. in diameter at the base and 14 ft. 3 in. at the top. The tower was 92 ft. in height to the top of the lantern. The work consisted principally of oak timbers securely bolted and cramped together, the lower part being filled in solid with stone to add weight to the structure. The simplicity of the design and the absence of projections from the outer face rendered the tower very suitable to withstand the onslaught of the waves. The lighthouse was destroyed by fire in 1755.

Eddystone (*Smeaton’s Tower*, fig. 4).—This famous work, which consisted entirely of stone, was begun in 1756, the light being first exhibited in 1759. John Smeaton was the first engineer to use dovetailed joints for the stones in a lighthouse structure. The stones, which averaged 1 ton in weight, were fastened to each other by means of dovetailed vertical joint faces, oak key wedges, and by oak tree-nails wedged top and bottom, extending vertically from every course into the stones beneath it. During the 19th century the tower was strengthened on two occasions by the addition of heavy wrought iron ties, and the overhanging cornice was reduced in diameter to prevent the waves from lifting the stones from their beds. In 1877, owing partly to the undermining of the rock on which the tower was built and the insufficient height of the structure, the Corporation 629
of Trinity House determined on the erection of a new lighthouse in place of Smeaton’s tower.

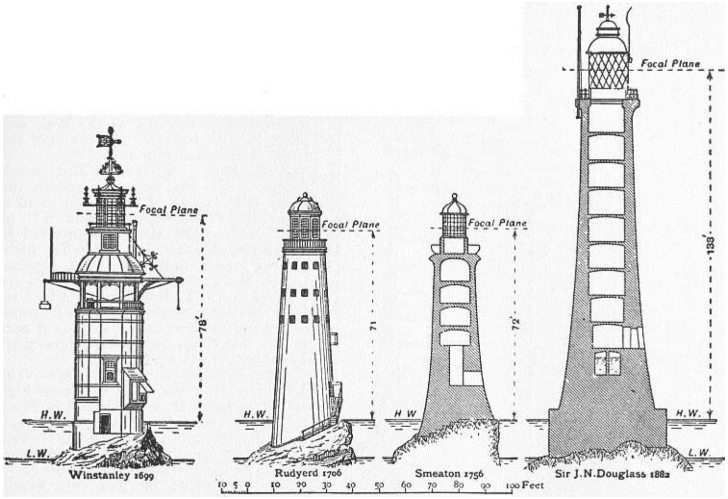

Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Lighthouses on the Eddystone.

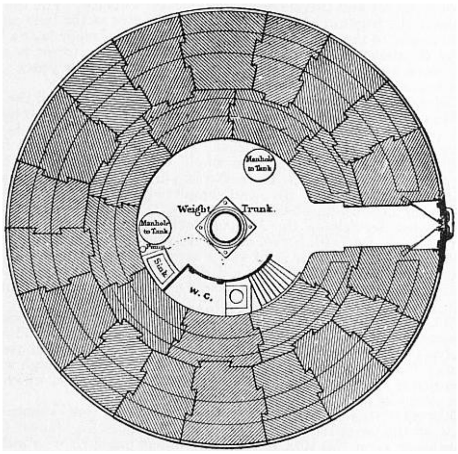

Fig. 6.—Plan of Entrance Floor, Eddystone Lighthouse.

Eddystone, New Lighthouse (*J. N. Douglass*).—The site selected for the new tower is 120 ft. S.S.E. from Smeaton’s lighthouse, where a suitable foundation was found, although a considerable section of the lower courses had to be laid below the level of low water. The vertical base is 44 ft. in diameter and 22 ft. in height. The tower (figs. 5 and 6) is a concave elliptic frustum, and is solid, with the exception of a fresh-water tank, to a height of 25 ft. 6 in. above high-water level. The walls above this level vary in thickness from 8 ft. 6 in. to 2 ft. 3 in. under the gallery. All the stones are dovetailed, both horizontally and vertically, on all joint faces, the stones of the foundation course being secured to the rock by Muntz metal bolts. The tower contains 62,133 cub. ft. of granite, weighing 4668 tons. The height of the structure from low water ordinary spring tides to the mean focal plane is 149 ft. and it stands 133 ft. above high water. The lantern is a cylindrical helically framed structure with domed roof. The astragals are of gun-metal and the pedestal of cast iron. The optical apparatus consists of two superposed tiers of refracting lens panels, 12 in each tier of 920 mm. focal distance. The lenses subtend an angle of 92° vertically. The 12 lens panels are arranged in groups of two, thus producing a group flashing light showing 2 flashes of 1½ seconds’ duration every half minute, the apparatus revolving once in 3 minutes. The burners originally fitted in the apparatus were of 6-wick pattern, but these were replaced in 1904 by incandescent oil vapour burners. The intensity of the combined beam of light from the two apparatus is 292,000 candles. At the time of the completion of the lighthouse two bells, weighing 2 tons each and struck by mechanical power, were installed for fog-signalling purposes. Since that date an explosive gun-cotton fog signal has been erected, the bells being removed. At a lower level in the tower are installed 2 21-in. parabolic silvered reflectors with 2-wick burners, throwing a fixed light of 8000 candle-power over a danger known as the Hand Deeps. The work of preparing the foundation was begun on the 17th of July 1878, the foundation stone being laid by the late duke of Edinburgh on the 19th of August 1879. The last stone was laid on the 1st of June 1881, and the light was exhibited for the first time on the 18th of May 1882. The upper portion of Smeaton’s tower, which was removed on completion of the new lighthouse, was re-erected on Plymouth Hoe, where it replaced the old Trinity House sea mark. One of the principal features in the design of the new Eddystone lighthouse tower is the solid vertical base. This construction was much criticized at the time, but experience has proved that heavy seas striking the massive cylindrical structure are immediately broken up and rush round to the opposite side, spray alone ascending to the height of the lantern gallery. On the other hand, the waves striking the old tower at its foundation ran up the surface, which presented a curved face to the waves, and, unimpeded by any projection until arriving at the lantern gallery, were partially broken up by the cornice and then spent themselves in heavy spray over the lantern. The shock to which the cornice of the gallery was exposed was so great that stones were sometimes lifted from their beds. The new Eddystone tower presents another point of dissimilarity from Smeaton’s structure, in that the stones forming the floors consist of single corbels built into the wall and constituting solid portions thereof. In Smeaton’s tower the floors consisted of stone arches, the thrust being taken by the walls of the tower itself, which were strengthened for the purpose by building in chains in the form of hoops (fig. 7). The system of constructing corbelled stone floors was first adopted by R. Stevenson in the Bell Rock lighthouse (fig. 8).

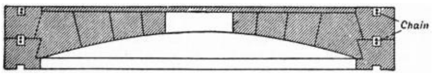

Fig. 7.—Floor, Smeaton’s Eddystone Lighthouse.

Bell Rock Lighthouse (fig. 9).—The Bell Rock, which lies 12 m. off the coast of Forfarshire, is exposed to a considerable extent at low water. The tower is submerged to a depth of about 16 ft. at high water of spring tides. The rock is of hard sandstone. The lighthouse was constructed by Robert Stevenson and is 100 ft. in height, the solid portion being carried to a height of 21 ft. above high water. The work of construction was begun in 1807, and finished in 1810, the light being first exhibited in 1811. The total weight of the tower is 2076 tons. A new lantern and dioptric apparatus were erected on the tower in 1902. The focal plane of the light is elevated 93 ft. above high water.

Skerryvore Lighthouse (fig. 10).—The Skerryvore Rocks, 12 m. off the island of Tyree in Argyllshire, are wholly open to the Atlantic. The work, designed by Alan Stevenson, was begun in 1838 and finished in 1844. The tower, the profile of which is a hyperbolic curve, is 138 ft. high to the lantern base, 42 ft. diameter at the base, and 16 ft. at the top. Its weight is 4308 tons. The structure contains 9 rooms in addition to the lantern chamber. It is solid to a height of 26 ft. above the base.

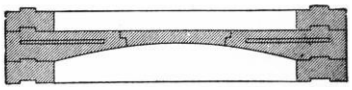

Fig. 8.—Floor, Stevenson's Bell Rock Lighthouse.

Heaux de Brehat Lighthouse.—The reef on which this tower is constructed lies off the coast of Brittany, and is submerged at high tide. The work was carried out in 1836-1839. The tower is circular in plan with a gallery at a height of about 70 ft. above the base. The tower is 156 ft. in height from base to lantern floor.

Haut Banc du Nord Lighthouse.—This tower is placed on a reef at the north-west extremity of the Île de Ré, and was constructed in 1849-1853. It is 86 ft. in height to the lantern floor.

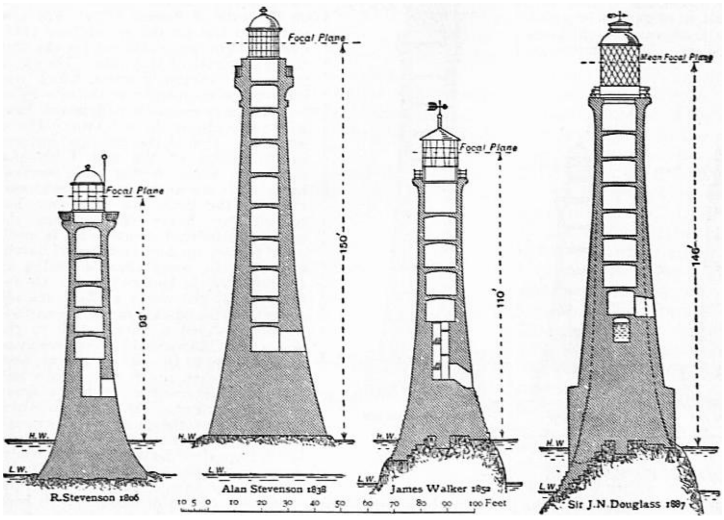

Fig. 9.—Bell Rock. Fig. 10.—Skerryvore. Fig. 11.—Bishop Rock. Fig. 12.—Bishop Rock.

Bishop Rock Lighthouse.—The lighthouse on the Bishop Rock, which is the westernmost landfall rock of the Scilly Islands, occupies perhaps a more exposed situation than any other in the world. The first lighthouse erected there was begun in 1847 under the direction of N. Douglass. The 630
tower consisted of a cast and wrought iron openwork structure having the columns deeply sunk into the rock. On the 5th of February 1850, when the tower was ready for the erection of the lantern and illuminating apparatus, a heavy storm swept away the whole of the structure. This tower was designed for an elevation of 94 ft. to the focal plane. In 1851 the erection of a granite tower, from the designs of James Walker, was begun; the light was first exhibited in 1858. The tower (fig. 11) had an elevation to the focal plane of 110 ft., the lower 14 courses being arranged in steps, or offsets, to break up the force of the waves. This structure also proved insufficient to withstand the very heavy seas to which it was exposed. Soon after its completion the 5-cwt. fog bell, fixed to the lantern gallery 100 ft. above high-water mark, was washed away, together with the flagstaff and ladder. The tower vibrated considerably during storms, and it was found that some of the external blocks of granite had been split by the excessive stress to which they had been exposed. In 1874 the tower was strengthened by bolting continuous iron ties to the internal surfaces of the walls. In 1881, when further signs of damage appeared, it was determined to remove the upper storey or service room of the lighthouse, and to case the structure from its base upwards with granite blocks securely dovetailed to each other and to the existing work. At the same time it was considered advisable to increase the elevation of the light, and place the mean focal plane of the new apparatus at an elevation of 146 ft. above high-water mark. The work was begun in 1883, and the new apparatus was first illuminated on the 25th of October 1887. During the operation of heightening the tower it was necessary to install a temporary light, consisting of a cylindrical lightship lantern with catoptric apparatus; this was raised from time to time in advance of the structure as the work proceeded. The additional masonry built into the tower amounts approximately to 3220 tons. Profiting by the experience gained after the construction of the new Eddystone tower, Sir J. N. Douglass decided to build the lower portion of the improved Bishop Rock tower in the form of a cylinder, but with considerably increased elevation (figs. 12 and 13). The cylindrical base is 40 ft. in diameter, and rises to 25 ft. above high-water mark. The lantern is cylindrical and helically framed, 14 ft. in diameter, the glazing being 15 ft. in height. The optical apparatus consists of two superposed tiers of lenses of 1330 mm. focal distance, the lenses subtending a horizontal angle of 36° and a vertical angle of 80°. The apparatus consists of 5 groups of lenses each group producing a double flashing light of one minute period, the whole apparatus revolving once in five minutes. The maximum aggregate candle-power of the flash is 622,000 candles. A gun-cotton explosive fog signal is attached to the lantern. The cost of the various lighthouses on the Bishop Rock has been as follows:

1. Cast iron lighthouse	£12,500	0	0
2. Granite lighthouse	34,559	18	9
3. Improved granite lighthouse	64,889	0	0

The Smalls Lighthouse.—A lighthouse has existed on the Smalls rock, 18½ m. off Milford Haven, since 1776, when an oak pile structure was erected by Henry Whiteside. The existing structure, after the model of the second lighthouse on the Bishop Rock, was erected in 1856-1861 by the Trinity House and is 114 ft. in height from the foundation to the lantern floor. A new optical apparatus was installed in 1907.

Minot's Ledge Lighthouse.—The tower, which is 89 ft. in height, is built of granite upon a reef off Boston Harbor, Mass., and occupied five years in construction, being completed in 1860 at a cost of £62,500. The rock just bares at low water. The stones are dovetailed vertically but not on their horizontal beds in the case of the lower 40 ft. or solid portion of the tower, bonding bolts being substituted for the horizontal dovetailed joints used in the case of the Wolf and other English towers. The shape of the tower is a conical frustum.

Wolf Rock Lighthouse.—This much exposed rock lies midway between the Scilly Isles and the Lizard Point, and is submerged to the depth of about 6 ft. at high water. The tower was erected in 1862-1869 (fig. 14). It is 116 ft. 6 in. high, 41 ft. 8 in. diameter at the base, decreasing to 17 ft. at the top. The walls are 7 ft. 9½ in. thick, decreasing to 2 ft. 3 in. The shaft is a concave elliptic frustum, and contains 3296 tons. The lower part of the tower has projecting scarcements in order to break up the sea.

Dhu Heartach Rock Lighthouse.—The Dhu Heartach Rock, 35 ft. above high water, is 14 m. from the island of Mull, which is the nearest shore. The maximum diameter of the tower (fig. 15), which is of parabolic outline, is 36 ft., decreasing to 16 ft.; the shaft is solid for 32 ft. above the rock; the masonry weighs 3115 tons, of which 1810 are contained in the solid part. This tower occupied six years in erection, and was completed in 1872.

Great Basses Lighthouse, Ceylon.—The Great Basses lighthouse lies 6 m. from the nearest land. The cylindrical base is 32 ft. in diameter, above which is a tower 67 ft. 5 in. high and 23 ft. in diameter. The walls vary in thickness from 5 ft. to 2 ft. The tower, including the base, contains about 2768 tons. The work was finished in three years, 1870-1873.

Spectacle Reef Lighthouse, Lake Huron.—This is a structure similar to that on Minot's ledge, standing on a limestone reef at the northern end of the lake. The tower (fig. 16) was constructed with a view to withstanding the effects of ice massing in solid fields thousands of acres in extent and travelling at considerable velocity. The tower is in shape the frustum of a cone, 32 ft. in diameter at the base and 93 ft. in height to the coping of the gallery. The focal plane is at a level of 97 ft. above the base. The lower 34 ft. of the tower is solid. The work was completed in 1874, having occupied four years. The cost amounted to approximately £78,000.

Chicken Rock Lighthouse.—The Chicken Rock lies 1 m. off the Calf of Man. The curve of the tower, which is 123 ft. 4 in. high, is hyperbolic, the diameter varying from 42 ft. to 16 ft. The tower is submerged 5 ft. at high-water springs. The solid part is 32 ft. 6 in. in height, weighing 2050 tons, the whole weight of the tower being 3557 tons. The walls decrease from 9 ft. 3 in. to 2 ft. 3 in. in thickness. The work was begun in 1869 and completed in 1874.

Ar'men Lighthouse.—The masonry tower, erected by the French Lighthouse Service, on the Ar'men Rock off the western extremity of the Île de Sein, Finistère, occupied fifteen years in construction (1867-1881). The rock is of small area, barely uncovered at low water, and it was therefore found impossible to construct a tower having a base diameter greater than 24 ft. The focal plane of the light is 94 ft. above high water (fig. 17).

St George's Reef Lighthouse, California.—This structure consists of a square pyramidal stone tower rising from the easterly end of an oval masonry pier, built on a rock to a height of 60 ft. above the water. The focal plane is at an elevation of 146 ft. above high water. The site is an exceedingly dangerous one, and the work, which was completed in 1891, cost approximately £144,000.

Rattray Head Lighthouse.—This lighthouse was constructed between the years 1892 and 1895 by the Northern Lighthouse Commissioners upon the Ron Rock, lying about one-fifth of a mile off Rattray Head, Aberdeenshire. The focal plane is 91 ft. above high water, the building being approximately 113 ft. in height. In the tower there is a fog-horn worked by compressed air.

Fastnet Lighthouse.—In the year 1895 it was reported to the Irish Lights Commissioners that the then existing lighthouse on the Fastnet Rock off the south-west coast of Ireland, which was completed in 1854 and consisted of a circular cast iron tower 86 ft. in height on the summit of the rock, was considerably undermined. It was subsequently determined to proceed with the erection of a granite structure of increased height and founded upon a sound ledge of rock on one side of the higher, but now considerably undermined. portion of the reef. This lighthouse tower has its foundation laid near high-water level. The focal plane is at a level of 158 ft. above high-water mark. The cost of the structure, which was commenced in 1899 and completed in 1904, was £79,000.

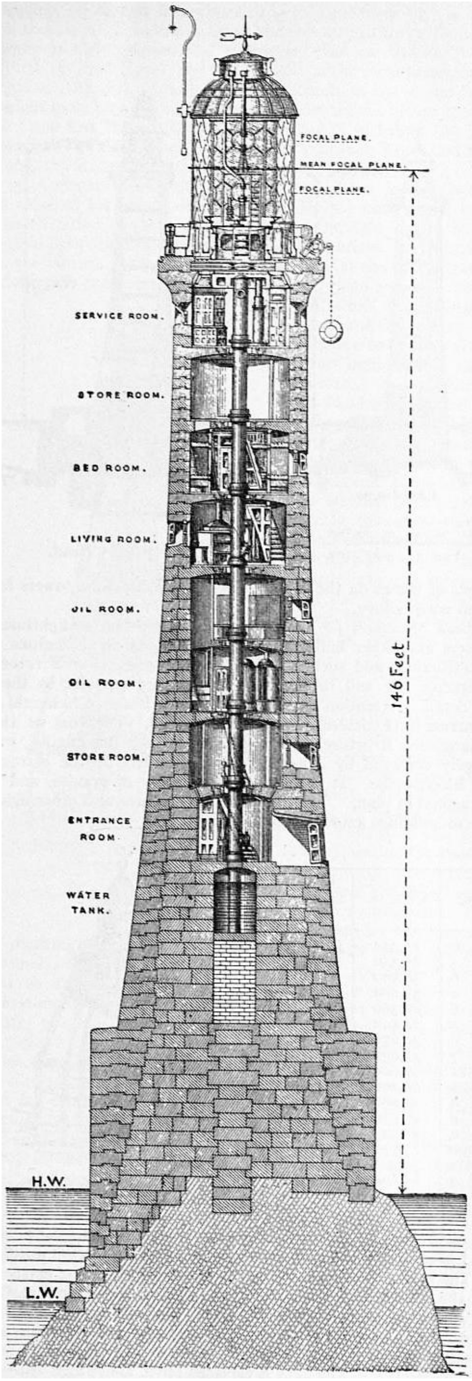

Fig. 13.—Bishop Rock Lighthouse.

Beachy Head Lighthouse.—A lighthouse has been erected upon the foreshore at the foot of Beachy Head, near Eastbourne, to replace the old structure on the cliff having an elevation of 284 ft. above high-water mark. Experience proved that the light of the latter was frequently obscured by banks of mist or fog, while at the lower level the transparency of the atmosphere was considerably less impaired. The Trinity House therefore decided in the year 1899 to proceed with the construction of a granite tower upon the foreshore at a distance of some 570 ft. from the base of the cliff (fig. 18). The foreshore at this point consists of chalk, and the selected site just bares at low water ordinary spring tides. The foundation course was laid at a depth of 10 ft. below the surface, the area being excavated within a coffer-dam. The tower, which is 47 ft. in diameter at the base, has an elevation to the focal plane above high water of 103 ft., or a total height from foundation course to gallery coping of 123 ft. 6 in. The lower or solid portion of the tower has its face stones constructed in vertical offsets or steps in a similar manner to that adopted at the Wolf Rock and elsewhere. The tower is constructed with a facing of granite, all the stones being dovetailed in the usual manner. The hearting of the base is largely composed of concrete. The work was completed in 1902 and cost £56,000.

Maplin Lighthouse.—The screw pile lighthouse erected on the Maplin Sand in the estuary of the river Thames in 1838 is the earliest of its kind and served as a model for numerous similar structures in various parts of the world. The piles are nine in number, 5 in. diameter of solid wrought iron with screws 4 ft. diameter (fig. 19).

Fowey Rocks Lighthouse, Florida.—This iron structure, which was begun in 1875 and completed in 1878, stands on the extreme northern point of the Florida reefs. The height of the tower, which is founded on wrought iron piles driven 10 ft. into the coral rock, is 110 ft. from high water to focal plane. The iron openwork pyramidal structure encloses a plated iron dwelling for the accommodation of the keepers. The cost of construction amounted to £32,600.

Alligator Reef Lighthouse, Florida.—This tower is one of the finest iron sea-swept lighthouse structures in the world. It consists of a pyramidal iron framework 135 ft. 6 in. in height, standing on the Florida Reef in 5 ft. of water. The cost of the structure, which is similar to the Fowey Rocks tower, was £37,000.

American Shoal Lighthouse, Florida.—This tower (fig. 20) is typical of the openwork pile structures on the Florida reefs, and was completed in 1880. The focal plane of the light is at an elevation of 109 ft. above high water.

Wolf Trap Lighthouse.—This building was erected during the years 1893 and 1894 on Wolf Trap Spit in Chesapeake Bay, near the site of the old openwork structure which was swept away by ice early in 1893. The new tower is formed upon a cast iron caisson 30 ft. in diameter sunk 18 ft. into the sandy bottom. The depth of water on the shoal is 16 ft. at low water. The caisson was filled with concrete, and is surmounted by a brick superstructure 52 ft. in height from low water to the focal plane of the light. A somewhat similar structure was erected in 1885-1887 on the Fourteen Foot Bank in Delaware Bay, at a cost of £24,700. The foundation in this case was, however, shifting sand, and the caisson was carried to a greater depth.

Rothersand Lighthouse.—This lighthouse, off the entrance to the river Weser (Germany), is a structure of great interest on account of the difficulties met with in its construction. The tower had to be founded on a bottom of shifting sand 20 ft. below low water and in a very exposed situation. Work was begun in May 1881, when attempts were made to sink an iron caisson under pneumatic pressure. Owing to the enormous scour removing the sand from one side of the caisson it tilted to an alarming angle, but eventually it was sunk to a level of 70 ft. below low-water mark. In October of the same year the whole structure collapsed. Another attempt, made in May 1883, to sink a caisson of bi-convex shape in plan 47 ft. long, 37 ft. wide and 62 ft. in height, met with success, and after many difficulties the structure was sunk to a depth of 73 ft. below low water, the sides being raised by the addition of iron plating as the caisson sank. The sand was removed from the interior by suction. Around the caisson foundation were placed 74,000 cub. yds. of mattress work and stones, the interior being filled with concrete. Towards the end of 1885 the lighthouse was completed, at a total cost, including the first attempt, of over £65,000. The tower is an iron structure in the shape of a concave elliptic frustum, its base being founded upon the caisson foundation at about half-tide level (fig. 21). The light is electric, the current being supplied by cable from the shore. The focal plane is 78 ft. above high water or 109 ft. from the sand level. The total height from the foundation of the caisson to the top of the vane is 185 ft.

Other famous wave-swept towers are those at Haulbowline Rock (Carlingford Lough, Ireland, 1823); Horsburgh (Singapore, 1851); Bayes d'Olonne (Bay of Biscay, 1861); Hanois (Alderney, 1862); Daedalus Reef, iron tower (Red Sea, 1863); Alguada Reef (Bay of Bengal, 1865); Longships (Land's End, 1872); the Prongs (Bombay, 1874); Little Basses (Ceylon, 1878); the Graves (Boston, U.S.A., 1905); Jument d'Ouessant (France, 1907); and Roche Bonne (France, building 1910).

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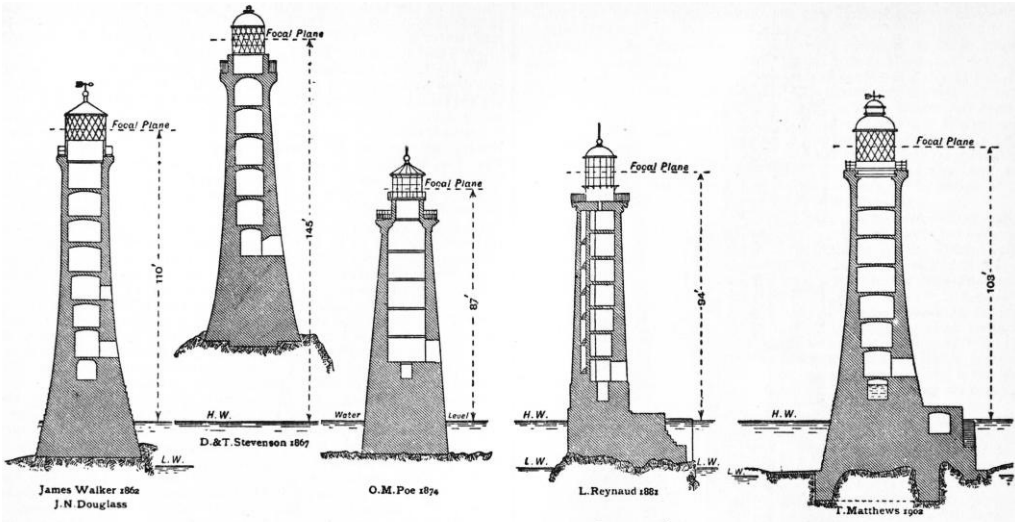


FIG. 14.—Wolf Rock. FIG. 15.—Dhu Heartach. FIG. 16.—Spectacle Reef. FIG. 17.—Ar'men. FIG. 18.—Beachy Head.

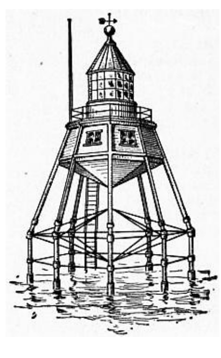
Jointing of Stones in Rock Towers.—Various methods of jointing the stones in rock towers are shown in figs. 6 and 22. The great distinction between the towers built by successive engineers to the Trinity House and other rock lighthouses is that, in the former the stones of each course are dovetailed together both laterally and vertically and are not connected by metal or wooden pins and wedges and dowled as in most other cases. This dovetail method was first adopted at the Hanois Rock at the suggestion of Nicholas Douglass. On the upper face, one side and at one end of each block is a dovetailed projection. On the under face and the other side and end, corresponding dovetailed recesses are formed with just sufficient clearance for the raised bands to enter in setting (fig. 23). The cement mortar in the joint formed between the faces so locks the dovetails that the stones cannot be separated without breaking (fig. 24).

TABLE I.—*Comparative Cost of Exposed Rock Towers.*

Name of Structure.	Total Cost.			Cub. ft.	Cost per cub. ft. of Masonry.		
Eddystone, Smeaton (1759)	£40,000	0	0	13,343	£2	9	11½
Bell Rock, Firth of Forth (1811)	55,619	12	1	28,530	1	19	0
Skerryvore, west coast of Scotland (1844)	72,200	11	6	58,580	1	4	7¾
Bishop Rock, first granite tower (1858)	34,559	18	9	35,209	0	19	7½
Smalls, Bristol Channel (1861)	50,124	11	8	46,386	1	1	7¼
Hanois, Alderney (1862)	25,296	0	0	24,542	1	0	7¼
Wolf Rock, Land's End (1869)	62,726	0	0	59,070	1	1	3
Dhu Heartach, west coast of Scotland (1872)	72,584	9	7	42,050	1	14	6
Longships, Land's End (1872)	43,869	8	11	47,610	0	18	5
Eddystone, Douglass (1882)	59,255	0	0	65,198	0	18	2
Bishop Rock, strengthening and part reconstruction (1887)	64,889	0	0	45,080	1	8	9
Great Basses, Ceylon (1873)	63,560	0	0	47,819	1	6	7
Minot's Ledge, Boston, Mass. (1860)	62,500	0	0	36,322	1	17	2
Spectacle Reef, Lake Huron (1874)	78,125	0	0	42,742	1	16	2
Ar'men, France (1881)	37,692	0	0	32,400	1	3	3
Fastnet, Ireland (1904)	79,000	0	0	62,600	1	5	5½

Effect of Waves.—The wave stroke to which rock lighthouse towers are exposed is often considerable. At the Dhu Heartach, during the erection of the tower, 14 joggled stones, each of 2 tons weight, were washed away after having been set in cement at a height of 37 ft. above high water, and similar damage was done during the construction of the Bell Rock tower. The effect of waves on the Bishop Rock and Eddystone towers has been noted above.

Land Structures for Lighthouses.—The erection of lighthouse towers and other buildings on land presents no difficulties of construction, and such buildings are of ordinary architectural character. It will therefore be unnecessary to refer to them in detail. Attention is directed to the Phare d'Eckmühl at Penmarc'h (Finistère), completed in 1897. The cost of this magnificent structure, 207 ft. in height from the ground, was largely defrayed by a bequest of £12,000 left by the marquis de Blocqueville. It is constructed entirely of granite, and is octagonal in plan. The total cost of the tower and other lighthouse buildings amounted to £16,000.



The tower at Île Vierge (Finistère), completed in 1902, has an elevation of 247 ft. from the ground level to the focal plane, and is probably the highest structure of its kind in the world.

The brick tower, constructed at Spurn Point, at the entrance to the Humber and completed in 1895, replaced an earlier structure erected by Smeaton at the end of the 18th century. The existing tower is constructed on a foundation consisting of concrete cylinders sunk in the shingle beach. The focal plane of the light is elevated 120 ft. above high water.

Besides being built of stone or brick, land towers are frequently constructed of cast iron plates or open steel- 633
work with a view to economy. Fine examples of the former are to be found in many British colonies and elsewhere, that on Dassen Island (Cape of Good Hope), 105 ft. in height to the focal plane, being typical (fig. 25). Many openwork structures up to 200 ft. in height have been built. Recent examples are the towers erected at Cape San Thomé (Brazil) in 1882, 148 ft. in height (fig. 26), Mocha (Red Sea) in 1903, 180 ft. and Sanganeb Reef (Red Sea) 1906, 165 ft. in height to the focal plane.

3. OPTICAL APPARATUS.—Optical apparatus in lighthouses is required for one or other of three distinct purposes: (1) the concentration of the rays derived from the light source into a belt of light distributed

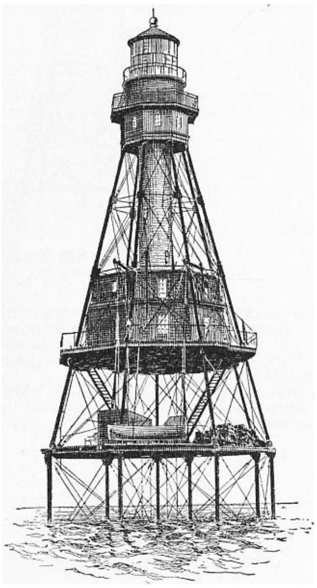


Fig. 20.—American Shoal Lighthouse, Florida.

Fig. 19.—Maplin Pile Lighthouse.

evenly around the horizon, condensation in the vertical plane only being employed; (2) the concentration of the rays both vertically and horizontally into a pencil or cone of small angle directed towards the horizon and caused to revolve about the light source as a centre, thus producing a flashing light; and (3) the condensation of the light in the vertical plane and also in the horizontal plane in such a manner as to concentrate the rays over a limited azimuth only.

Apparatus falling under the first category produce a fixed light, and further distinction can be provided in this class by mechanical means of occultation, resulting in the production of an occulting or intermittent light. Apparatus included in the second class are usually employed to produce flashing lights, but sometimes the dual condensation is taken advantage of to produce a fixed pencil of rays thrown towards the horizon for the purpose of marking an isolated danger or the limits of a narrow channel. Such lights are best described by the French term *feux de direction*. Catoptric apparatus, by which dual condensation is produced, are moreover sometimes used for fixed lights, the light pencils overlapping each other in azimuth. Apparatus of the third class are employed for sector lights or those throwing a beam of light over a wider azimuth than can be conveniently covered by an apparatus of the second class, and for reinforcing the beam of light emergent from a fixed apparatus in any required direction.

The above classification of apparatus depends on the resultant effect of the optical elements. Another classification divides the instruments themselves into three classes: (*a*) catoptric, (*b*) dioptric and (*c*) catadioptric.

Catoptric apparatus are those by which the light rays are reflected only from the faces of incidence, such as silvered mirrors of plane, spherical, parabolic or other profile. *Dioptric* elements are those in which the light rays pass through the optical glass, suffering refraction at the incident and emergent faces (fig. 27). *Catadioptric* elements are combined of the two foregoing and consist of optical prisms in which the light rays suffer refraction at the incident face, total internal reflexion at a second face and again refraction on emergence at the third face (fig. 28).

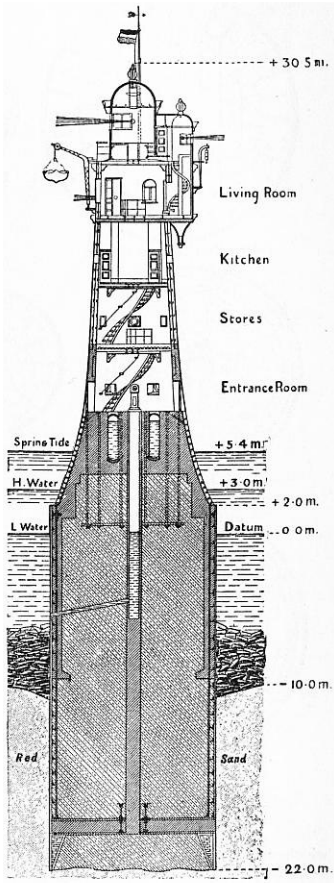


Fig. 21.—Rothersand Lighthouse.

The object of these several forms of optical apparatus is not only to produce characteristics or distinctions in lights to enable them to be readily recognized by mariners, but to utilize the light rays in directions above and below the horizontal plane, and also, in the case of revolving or flashing lights, in azimuths not requiring to be illuminated for strengthening the beam in the direction of the mariner. It will be seen that the effective condensation in flashing lights is very much greater than in fixed belts, thus enabling higher intensities to be obtained by the use of flashing lights than with fixed apparatus.

Catoptric System.—Parabolic reflectors, consisting of small facets of silvered glass set in plaster of Paris, were first used about the year 1763 in some of the Mersey lights by Mr Hutchinson, then dock master at Liverpool (fig. 29). Spherical metallic reflectors were introduced in France in 1781, followed by parabolic reflectors on silvered copper in 1790 in England and France, and in Scotland in 1803. The earlier lights were of fixed type, a number of reflectors being arranged on a frame or stand in such a manner that the pencils of emergent rays overlapped and thus illuminated the whole horizon continuously. In 1783 the first revolving light was erected at Marstrand in Sweden. Similar apparatus were installed at Cordouan (1790), Flamborough Head (1806) and at the Bell Rock (1811). To produce a revolving or flashing light the reflectors were fixed on a revolving carriage having several faces. Three or more reflectors in a face were set with their axes parallel.

A type of parabolic reflector now in use is shown in fig. 30. The sizes in general use vary from 21 in. to 24 in. diameter. These instruments are still largely used for light-vessel illumination, and a few important land lights are at the present time of catoptric type, including those at St Agnes (Scilly Islands), Cromer and St Anthony (Falmouth).

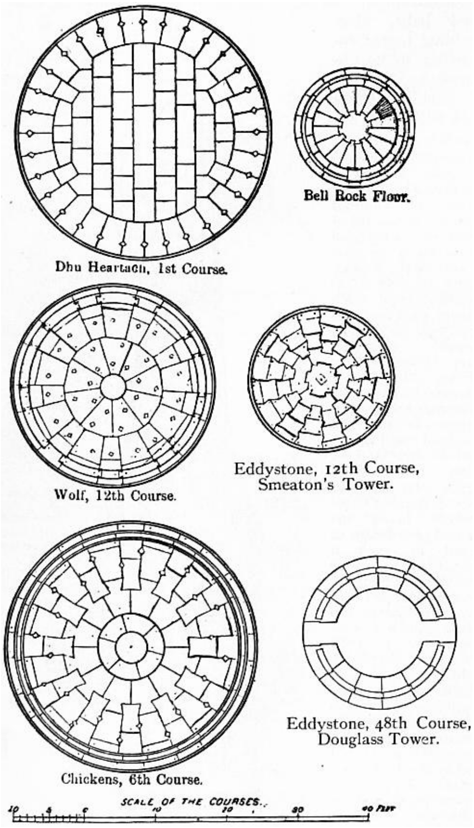


Fig. 22.—Courses of various Lighthouse Towers.

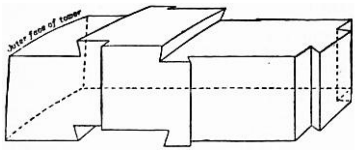


Fig. 23.—Perspective drawing of Dovetailed Stone (Wolf Rock).

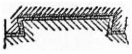


Fig. 24.—Section of Dovetail.

Dioptric System.—The first adaptation of dioptric lenses to lighthouses is probably due to T. Rogers, who used lenses at one of the Portland lighthouses between 1786 and 1790. Subsequently lenses by the same maker were used at Howth, Waterford and the North Foreland. Count Buffon had in 1748 proposed to grind out of a solid piece of glass a lens in steps or concentric zones in order to reduce the thickness to a minimum (fig. 31). Condorcet in 1773 and Sir D. Brewster in 1811 designed built-up lenses consisting of stepped annular rings. Neither of these proposals, however, was intended to apply to lighthouse purposes. In 1822 Augustin Fresnel constructed a built-up annular lens in which the centres of curvature of the different rings receded from the axis according to their distances from the centre, so as practically to eliminate spherical aberration; the only spherical surface being the small central part or "bull's eye" (fig. 32). These lenses were intended for revolving lights only. Fresnel next produced his cylindric refractor or lens belt, consisting of a zone of glass generated by the revolution round a vertical axis of a medial section of the annular 634
lens (fig. 33). The lens belt condensed and parallelized the light rays in the vertical plane only, while the annular lens does so in every plane. The first revolving light constructed from Fresnel's designs was erected at the Cordouan lighthouse in 1823. It consisted of 8 panels of annular lenses placed round the lamp at a focal distance of 920 mm. To utilize the light, which would otherwise escape above the lenses, Fresnel introduced a series of 8 plain silvered mirrors, on which the light was thrown by a system of lenses. At a subsequent period mirrors were also placed in the lower part of the optic. The apparatus was revolved by clockwork. This optic embodied the first combination of dioptric and catoptric elements in one design (fig. 34). In the following year Fresnel designed a dioptric lens with catoptric mirrors for fixed light, which was the first of its kind installed in a lighthouse. It was erected at the Chassiron lighthouse in 1827 (fig. 35). This combination is geometrically perfect, but not so practically on account of the great loss of light entailed by metallic reflection which is at least 25% greater than the system described under. Before his death in 1827 Fresnel devised his totally reflecting or catadioptric prisms to take the place of the silvered reflectors previously used above and below the lens elements (fig. 28). The ray Fi falling on the prismoidal ring ABC is refracted in the direction *i r* and meeting the face AB at an angle of incidence greater than the critical, is totally reflected in the direction *r e* emerging after second refraction in a horizontal direction. Fresnel devised these prisms for use in fixed light apparatus, but the principle was, at a later date, also applied to flashing lights, in the first instance by T. Stevenson. Both the dioptric lens and catadioptric prism invented by Fresnel are still in general use, the mathematical calculations of the great French designer still forming the basis upon which lighthouse opticians work.

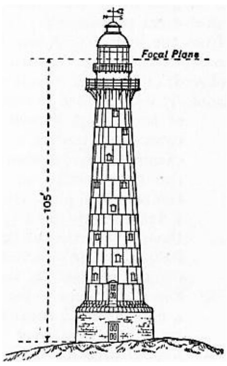


Fig. 25.—Dassen Island Lighthouse (cast iron).

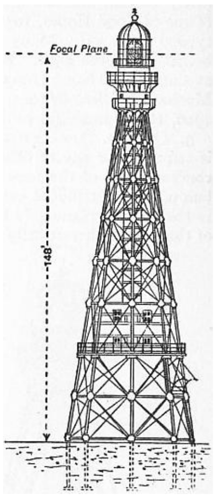


Fig. 26.—Cape San Thomé Lighthouse.

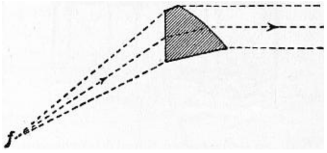


Fig. 27.—Dioptric Prism.

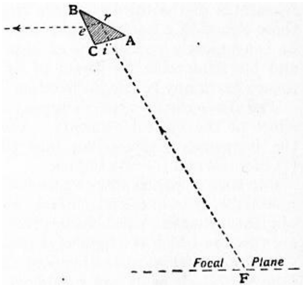


Fig. 28.—Catadioptric or Reflecting Prism.

Fresnel also designed a form of fixed and flashing light in which the distinction of a fixed light, varied by flashes, was produced by placing panels of straight refracting prisms in a vertical position on a revolving carriage outside the fixed light apparatus. The revolution of the upright prisms periodically increased the power of the beam, by condensation of the rays emergent from the fixed apparatus, in the horizontal plane.

The lens segments in Fresnel's early apparatus were of polygonal form instead of cylindrical, but subsequently manufacturers succeeded in grinding glass in cylindrical rings of the form now used. The first apparatus of this description was made by Messrs Cookson of Newcastle in 1836 at the suggestion of Alan Stevenson and erected at Inchkeith.

In 1825 the French Commission des Phares decided upon the exclusive use of lenticular apparatus in its service. The Scottish Lighthouse Board followed with the Inchkeith revolving apparatus in 1835 and the Isle of May fixed optic in 1836. In the latter instrument Alan Stevenson introduced helical frames for holding the glass prisms in place, thus avoiding complete obstruction of the light rays in any azimuth. The first dioptric light erected by the Trinity House was that formerly at Start Point in Devonshire, constructed in 1836. Catadioptric or reflecting prisms for revolving lights were not used until 1850, when Alan Stevenson designed them for the North Ronaldshay lighthouse.

Dioptric Mirror.—The next important improvement in lighthouse optical work was the invention of the dioptric spherical mirror by Mr (afterwards Sir) J. T. Chance in 1862. The zones or prisms are generated round a vertical axis and divided into segments. This form of mirror is still in general use (figs. 36 and 37).

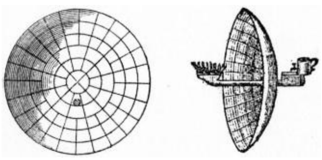


Fig. 29.—Early Reflector and Lamp (1763).

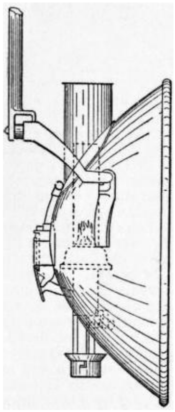


Fig. 30.—Modern Parabolic Reflector.

Azimuthal Condensing Prisms.—Previous to 1850 all apparatus were designed to emit light of equal power in every azimuth either constantly or periodically. The only exception was where a light was situated on a stretch of coast where a mirror could be placed behind the flame to utilize the rays, which would otherwise pass landward, and reflect them back, passing through the flame and lens in a seaward direction. In order to increase the intensity of lights in certain azimuths T. Stevenson devised his azimuthal condensing prisms which, in various forms and methods of application, have been largely used for the purpose of strengthening the light rays in required directions as, for instance, where coloured sectors are provided. Applications of this system will be referred to subsequently.

Optical Glass for Lighthouses.—In the early days of lens lights the only glass used for the prisms was made in France at the St Gobain and Premontré works, which have long been celebrated for the high quality of optical glass produced. The early dioptric lights erected in the United Kingdom, some 13 in all, were made by Messrs Cookson of South Shields, who were instructed by Léonor Fresnel, the brother of Augustin. At first they tried to mould the lens and then to grind it out of one thick sheet of glass. The successors of the Cookson firm abandoned the manufacture of lenses in 1845, and the firm of Letourneau & Lepaute of Paris again became the monopolists. In 1850 Messrs Chance Bros. & Co. of Birmingham began the manufacture of optical glass, assisted by M. Tabouret, a French expert who had been a colleague of Augustin Fresnel himself. The first light made by the firm was shown at the Great Exhibition of 1851, since when numerous dioptric apparatus have been constructed by Messrs Chance, who are, at this time, the only manufacturers of lighthouse glass in the United Kingdom. Most of the glass used for apparatus constructed in France is manufactured at St Gobain. Some of the glass used by German constructors is made at Rathenow in Prussia and Goslar in the Harz.

The glass generally employed for lighthouse optics has for its refractive index a mean value of $\mu = 1.51$, the corresponding critical angle being 41° 30′. Messrs Chance have used dense flint glass for the upper and lower refracting rings of high angle lenses and for dioptric mirrors in certain cases. This glass has a value of $\mu = 1.62$ with critical angle 38° 5′.

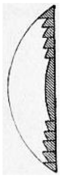


Fig. 31. Buffon's Lens.

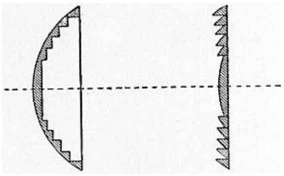


Fig. 32. Fresnel's Annular Lens.

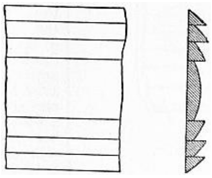


Fig. 33. Fresnel's Lens Belt.

Occulting Lights.—During the last 25 years of the 19th century the disadvantages of fixed lights became more and more apparent. At the present day the practice of installing such, except occasionally in the case of the smaller and less important of harbour or river lights, has practically ceased. The necessity for providing a distinctive characteristic for every light when possible has led to the conversion of many of the fixed-light apparatus of earlier years into occulting lights, and often to their supersession by more modern and powerful flashing apparatus. An occulting apparatus in general use consists of a cylindrical screen, fitting over the burner, rapidly lowered and raised by means of a cam-wheel at stated intervals. The cam-wheel is actuated by means of a weight or spring clock. Varying characteristics may be procured by means of such a contrivance—single, double, triple or other systems of occultation. The eclipses or periods of darkness bear much the same relation to the times of illumination as do the flashes to the eclipses in a revolving or flashing light. In the case of a first-order fixed light the cost of conversion to an occulting characteristic does not exceed £250 to £300. With apparatus illuminated by gas the occultations may be produced by successively raising and lowering the gas at stated intervals. Another form of occulting mechanism employed consists of a series of vertical screens mounted on a carriage and revolving round the burner. The carriage is rotated on rollers or ball bearings or carried upon a small mercury float. The usual driving mechanism employed is a spring clock. "Otter" screens are used in cases when it is desired to produce different periods of occultations in two or more positions in azimuth in order to differentiate sectors marking shoals, &c. The screens are of sheet metal blacked and arranged vertically, some what in the manner of the laths of a venetian blind, and operated by mechanical means.

Leading Lights.—In the case of lights designed to act as a lead through a narrow channel or as direction lights, it is undesirable to employ a flashing apparatus. Fixed-light optics are employed to meet such cases, and are generally fitted with occulting mechanism. A typical apparatus of this description is that at Gage Roads, Fremantle, West Australia (fig. 38). The occulting bright light covers the fairway, and is flanked by sectors of occulting red and green light marking dangers and intensified by vertical condensing prisms. A good example of a holophotal direction light was exhibited at the 1900 Paris Exhibition, and afterwards erected at Suzac lighthouse (France). The light consists of an annular lens 500 mm. focal distance, of 180° horizontal angle and 157° vertical, with a mirror of 180° at the back. The lens throws a red beam of about 4½° amplitude in azimuth, and 50,000 candle-power over a narrow channel. The illuminant is an incandescent petroleum vapour burner. Holophotal direction lenses of this type can only be applied where the sector to be marked is of comparatively small angle. Silvered metallic mirrors of parabolic form are also used for the purpose. The use of single direction lights frequently renders the construction of separate towers for leading lights unnecessary.

If two distinct lights are employed to indicate the line of navigation through a channel or between dangers they must be sufficiently far apart to afford a good lead, the front or seaward light being situated at a lower elevation than the rear or landward one.

Coloured Lights.—Colour is used as seldom as possible as a distinction, entailing as it does a considerable reduction in the power of the light. It is necessary in some instances for differentiating sectors over dangers and for harbour lighting purposes. The use of coloured lights as alternating flashes for lighthouse lights is not to be commended, on account of the unequal absorption of the coloured and bright rays by the atmosphere. When such distinction has been employed, as in the Wolf Rock apparatus, the red and white beams can be approximately equalized in initial intensity by constructing the lens and prism panels for the red light of larger angle than those for the white beams. Owing to the absorption by the red colouring, the power of a red beam is only 40% of the intensity of the corresponding white light. The corresponding intensity of green light is 25%. When red or green sectors are employed they should invariably be reinforced by mirrors, azimuthal condensing prisms, or other means to raise the coloured beam to approximately the same intensity as the white light. With the introduction of group-flashing characteristics the necessity for using colour as a means of distinction disappeared.

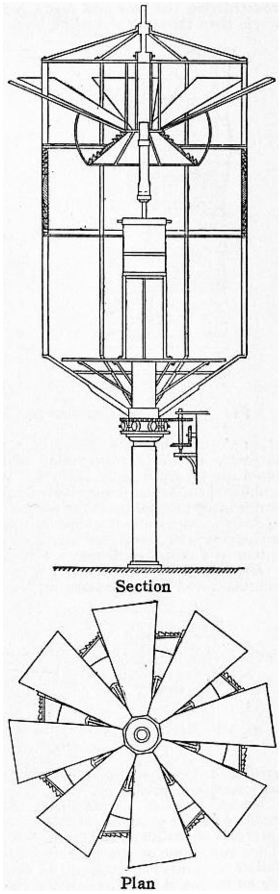


Fig. 34.—Fresnel’s Revolving Apparatus at Cordouan Lighthouse.

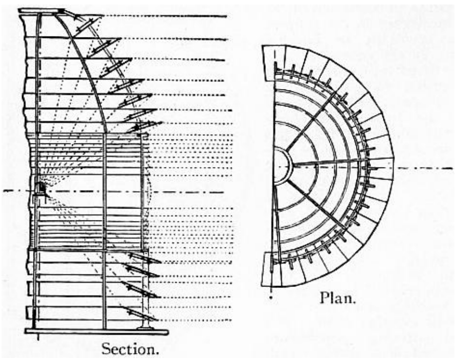


Fig. 35.—Fixed Apparatus at Chassiron Lighthouse (1827).

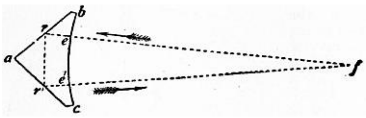


Fig. 36.—Vertical Section. Prism of Dioptric Spherical Mirror.

High-Angle Vertical Lenses.—Messrs Chance of Birmingham have manufactured lenses having 97° of vertical amplitude, but this result was only attained by using dense flint glass of high refractive index for the upper and lower elements. It is doubtful, however, whether the use of refracting elements for a greater angle than 80° vertically is attended by any material corresponding advantage.

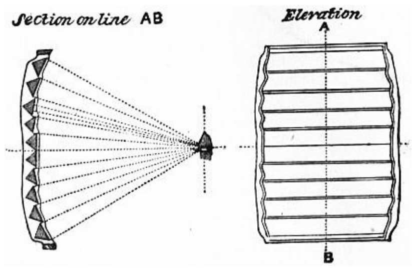


Fig. 37.—Chance’s Dioptric Spherical Mirror.

Group Flashing Lights.—One of the most useful distinctions consists in the grouping of two or more flashes separated by short intervals of darkness, the group being succeeded by a longer eclipse. Thus two, three or more flashes of, say, half second duration or less follow each other at intervals of about 2 seconds and are succeeded by an eclipse of, say, 10 seconds, the sequence being completed in a period of, say, 15 seconds. In 1874 Dr John Hopkinson introduced the very valuable improvement of dividing the lenses of a dioptric revolving light with the panels of reflecting prisms above and below them, setting them at an angle to produce the group-flashing characteristic. The first apparatus of this type constructed were those now in use at Tampico, Mexico and the Little Basses lighthouse, Ceylon (double flashing). The Casquets apparatus (triple flashing) was installed in 1877. A group-flashing catoptric light had, however, been exhibited from the “Royal Sovereign” light-vessel in 1875. A sectional plan of the quadruple-flashing first order apparatus at Pendeen in Cornwall is shown in fig. 39; and fig. 55 (Plate 1.) illustrates a double flashing first order light at Pachena Point in British Columbia. Hopkinson’s system has been very extensively used, most of the group-flashing lights shown in the accompanying tables, being designed upon the general lines he introduced. A modification of the system consists in grouping two or more lenses together separated by equal angles, and filling the remaining angle in azimuth by a reinforcing mirror or screen. A group-flashing distinction was proposed for gas lights by J. R. Wigham of Dublin, who obtained it in the case of a revolving apparatus by alternately raising and lowering the flame. The first apparatus in which this method was employed was erected at Galley Head, Co. Cork (1878). At this lighthouse 4 of Wigham's large gas burners with four tiers of first-order revolving lenses, eight in each tier, were adopted. By successive lowering and raising of the gas flame at the focus of each tier of lenses he produced the group-flashing distinction. The light showed, instead of one prolonged flash at intervals of one minute, as would be produced by the apparatus in the absence of a gas occulter, a group of short flashes varying in number between six and seven. The uncertainty, however, in the number of flashes contained in each group is found to be an objection to the arrangement. This device was adopted at other gas-illuminated stations in Ireland at subsequent dates. The quadriform apparatus and gas installation at Galley Head were superseded in 1907 by a first order bi-form apparatus with incandescent oil vapour burner showing five flashes every 20 seconds.

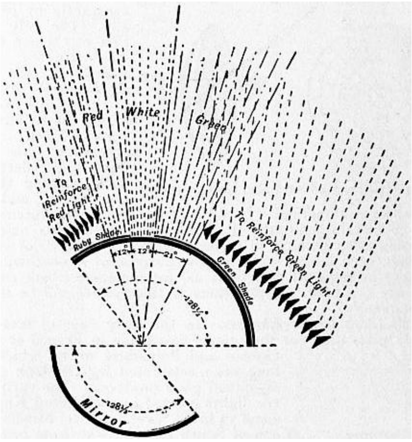


Fig. 38.—Gage Roads Direction Light.

Flashing Lights indicating Numbers.—Captain F. A. Mahan, late engineer secretary to the United States Lighthouse Board, devised for that service a system of flashing lights to indicate certain numbers. The apparatus installed at Minot's Ledge lighthouse near Boston Harbour, Massachusetts, has a flash indicating the number 143, thus: - ---- ---, the dashes indicating short flashes. Each group is separated by a longer period of darkness than that between successive members of a group. The flashes in a group indicating a figure are about 1½ seconds apart, the groups being 3 seconds apart, an interval of 16 seconds' darkness occurring between each repetition. Thus the number is repeated every half minute. Two examples of this system were exhibited by the United States Lighthouse Board at the Chicago Exhibition in 1893, viz. the second-order apparatus just mentioned and a similar light of the first order for Cape Charles on the Virginian coast. The lenses are arranged in a somewhat similar manner to an ordinary group-flashing light, the groups of lenses being placed on one side of the optic, while the other is provided with a catadioptric mirror. This system of numerical flashing for lighthouses has been frequently proposed in various forms, notably by Lord Kelvin. The installation of the lights described is, however, the first practical application of the system to large and important coast lights. The great cost involved in the alteration of the lights of any country to comply with the requirements of a numerical system is one of the objections to its general adoption.

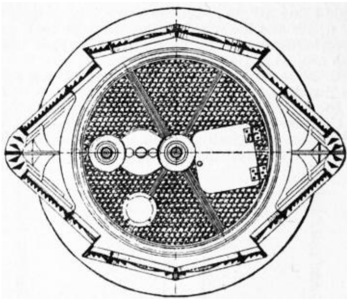


Fig. 39.—Pendeen Apparatus. Plan at Focal Plane.

Plate I.

Fig. 54.—FASTNET LIGHTHOUSE—FIRST ORDER SINGLE-FLASHING

Fig. 55.—PACHENA POINT LIGHTHOUSE, b.c.—FIRST ORDER DOUBLE-

PLATE II.

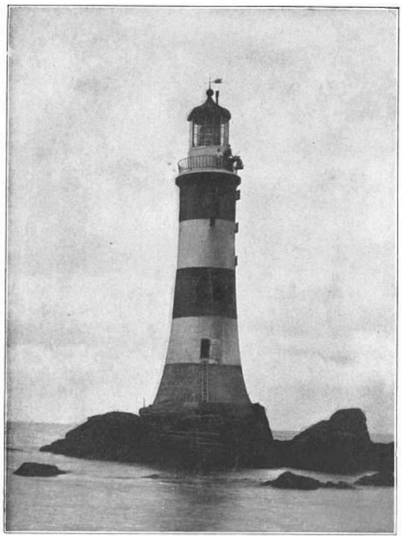


FIG. 56.—OLD EDDYSTONE LIGHTHOUSE.

FIG. 57.—EDDYSTONE LIGHTHOUSE.

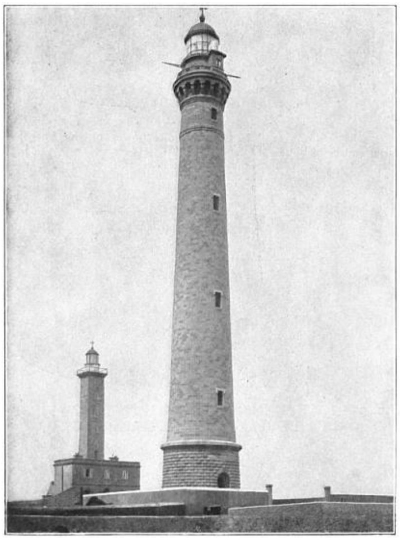


FIG. 58.—ILE VIERGE LIGHTHOUSE.

FIG. 59.—MINOT’S LEDGE LIGHTHOUSE.

Hyper-radial Apparatus.—In 1885 Messrs Barbier of Paris constructed the first hyper-radial apparatus (1330 mm. focal distance) to the design of Messrs D. and C. Stevenson. This had a height of 1812 mm. It was tested during the South Foreland experiments in comparison with other lenses, and found to give excellent results with burners of large focal diameter. Apparatus of similar focal distance (1330 mm.) were subsequently established at Round Island, Bishop Rock, and Spurn Point in England, Fair Isle and Sule Skerry (fig. 40) in Scotland, Bull Rock and Tory Island in Ireland, Cape d’Antifer in France, Pei Yu-shan in China and a lighthouse in Brazil.

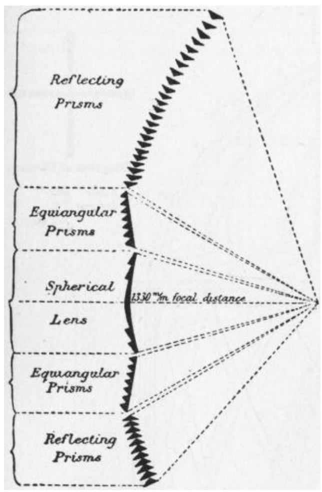


FIG. 40.—Sule Skerry Apparatus.

The light erected in 1907 at Cape Race, Newfoundland, is a fine example of a four-sided hyper-radial apparatus mounted on a mercury float. The total weight of the revolving part of the light amounts to 7 tons, while the motive clock weight required to rotate this large mass at a speed of two complete revolutions a minute is only 8 cwt. and the weight of mercury required for flotation 950 ℔. A similar apparatus was placed at Manora Point, Karachi, India, in 1908 (fig. 41).

The introduction of incandescent and other burners of focal compactness and high intensity has rendered the use of optics of such large dimensions as the above, intended for burners of great focal diameter, unnecessary. It is now possible to obtain with a second-order optic (or one of 700 mm. focal distance), having a powerful incandescent petroleum burner in focus, a beam of equal intensity to that which would be obtained from the apparatus having a 10-wick oil burner or 108-jet gas burner at its focus.

Stephenson’s Spherical Lenses and Equiangular Prisms.—Mr C. A. Stephenson in 1888 designed a form of lens spherical in the horizontal and vertical sections. This admitted of the construction of lenses of long focal distance without the otherwise corresponding necessity of increased diameter of lantern. A lens of this type and of 1330 mm. focal distance was constructed in 1890 for Fair Isle lighthouse. The spherical form loses in efficiency if carried beyond an angle subtending 20° at the focus, and to obviate this loss Mr Stephenson designed his equiangular prisms, which have an inclination outwards. It is claimed by the designer that the use of equiangular prisms results in less loss of light and less divergence than is the case when either the spherical or Fresnel form is adopted. An example of this design is seen (fig. 40) in the Sule Skerry apparatus (1895).

Fixed and Flashing Lights.—The use of these lights, which show a fixed beam varied at intervals by more powerful flashes, is not to be recommended, though a large number were constructed in the earlier years of dioptric illumination and many are still in existence. The distinction can be produced in one or other of three ways: (*a*) by the revolution of detached panels of straight condensing lens prisms placed vertically around a fixed light optic, (*b*) by utilizing revolving lens panels in the middle portion of the optic to produce the flashing light, the upper and lower sections of the apparatus being fixed zones of catadioptric or reflecting elements emitting a fixed belt of light, and (*c*) by interposing panels of fixed light section between the flashing light panels of a revolving apparatus. In certain conditions of the atmosphere it is possible for the fixed light of low power to be entirely obscured while the flashes are visible, thus vitiating the true characteristic of the light. Cases have frequently occurred of such lights being mistaken for, and even described in lists of light as, revolving or flashing lights.

”Cute” and Screens.—Screens of coloured glass, intended to distinguish the light in particular azimuths, and of sheet iron, when it is desired to “cut off” the light sharply on any angle, should be fixed as far from the centre of the light as possible in order to reduce the escape of light rays due to divergence. These screens are usually attached to the lantern framing.

Divergence.—A dioptric apparatus designed to bend all incident rays of light from the light source in a horizontal direction would, if the flame could be a point, have the effect of projecting a horizontal band or zone of light, in the case of a fixed apparatus, and a cylinder of light rays, in the case of a flashing light, towards the horizon. Thus the mariner in the near distance would receive no light, the rays, visible only at or near the horizon, passing above the level of his eye. In practice this does not occur, sufficient natural divergence being produced ordinarily owing to the magnitude of the flame. Where the electric arc is employed it is often necessary to design the prisms so as to produce artificial divergence. The measure of the natural divergence for any point of the lens is the angle whose sine is the ratio of the diameter of the flame to the distance of the point from centre of flame.

In the case of vertical divergence the mean height of the flame must be substituted for the diameter. The angle thus obtained is the total divergence, that is, the sum of the angles above and below the horizontal plane or to right and left of the medial section. In fixed dioptric lights there is, of course, no divergence in the horizontal plane. In flashing lights the horizontal divergence is a matter of considerable importance, determining as it does the duration or length of time the flash is visible to the mariner.

Feux-Éclairs or Quick Flashing Lights.—One of the most important developments in the character of lighthouse illuminating apparatus that has occurred in recent years has been in the direction of reducing the length of flash. The initiative in this matter was taken by the French lighthouse authorities, and in France alone forty lights of this type were established between 1892 and 1901. The use of short flash lights rapidly spread to other parts of the world. In England the lighthouse at Pendeen (1900) exhibits a quadruple flash every 15 seconds, the flashes being about ¼ second duration (fig. 39), while the bivalve apparatus erected on Lundy Island (1897) shows 2 flashes of $^{1}/_{3}$ second duration in quick succession every 20 seconds. Since 1900 many quick flashing lights have been erected on the coasts of the United Kingdom and in other countries. The early *feux-éclairs*, designed by the French engineers and others, had usually a flash of $^{1}/_{10}$th to $^{1}/_{3}$rd of a second duration. As a result of experiments carried out in France in 1903-1904, $^{3}/_{10}$ second has been adopted by the French authorities as the minimum duration for white flashing lights. If shorter flashes are used it is found that the reduction in duration is attended by a corresponding, but not proportionate, diminution in effective intensity. In the case of many electric flashing lights the duration is of necessity reduced, but the greater initial intensity of the flash permits this loss without serious detriment to efficiency. Red or green requires a considerably greater duration than do white flashes. The intervals between the flashes in lights of this character are also small, 2½ seconds to 7 seconds. In group-flashing lights the intervals between the flashes are about 2 seconds or even less, with periods of 7 to 10 or 15 seconds between the groups. The flashes are arranged in single, double, triple or even quadruple groups, as in the older forms of apparatus. The *feu-éclair* type of apparatus enables a far higher intensity of flash to be obtained than was previously possible without any corresponding increase in the luminous power of the burner or other source of light. This result depends entirely upon the greater ratio of condensation of light employed, panels of greater angular breadth than was customary in the older forms of apparatus being used with a higher rotatory velocity. It has been urged that short flashes are insufficient for taking bearings, but the utility of a light in this respect does not seem to depend so much upon the actual length of the flash as upon its frequent recurrence at short intervals. At the Paris Exhibition of 1900 was exhibited a fifth-order flashing light giving short flashes at 1 second intervals; this represents the extreme to which the movement towards the reduction of the period of flashing lights has yet been carried.

Mercury Floats.—It has naturally been found impracticable to revolve the optical apparatus of a light with its mountings, sometimes weighing over 7 tons, at the high rate of speed required for *feux-éclairs* by means of the old system of roller carriages, though for some small quick-revolving lights ball bearings have been successfully adopted. It has therefore become almost the universal practice to carry the rotating portions of the apparatus upon a mercury float. This beautiful application of mercury rotation was the invention of Bourdelles, and is now utilized not only for the high-speed apparatus, but also generally for the few examples of the older type still being constructed. The arrangement consists of an annular cast iron bath or trough of such dimensions that a similar but slightly smaller annular float immersed in the bath and surrounded by mercury displaces a volume of the liquid metal whose weight is equal to that of the apparatus supported. Thus a comparatively insignificant quantity of mercury, say 2 cwt., serves to ensure the flotation of a mass of over 3 tons. Certain differences exist between the type of float usually constructed in France and those generally designed by English engineers. In all cases provision is made for lowering the mercury bath or raising the float and apparatus for examination. Examples of mercury floats are shown in figs. 41, 42, 43 and Plate I., figs. 54 and 55.

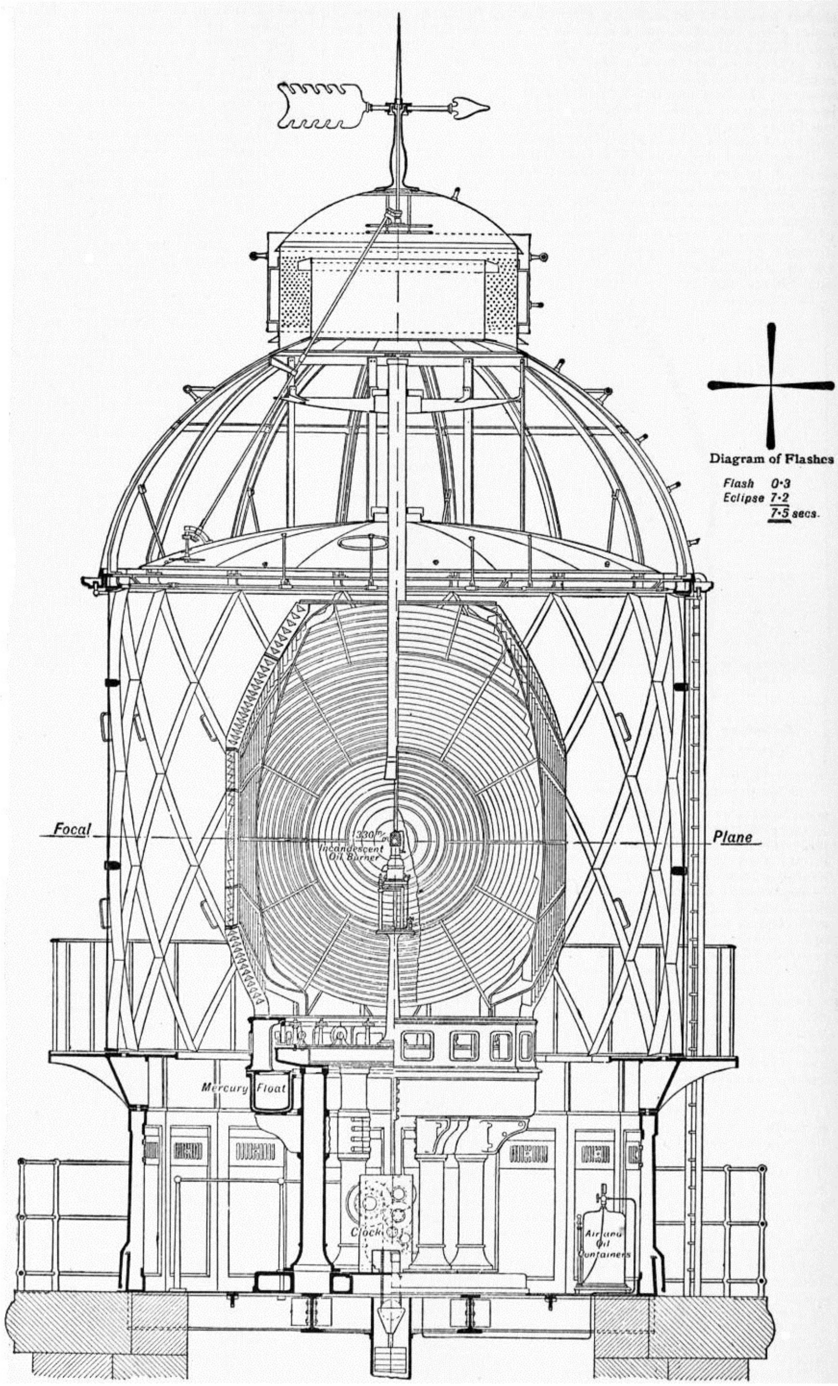


Fig. 41.—Manora Point Apparatus and Lantern.

Multiform Apparatus.—In order to double the power to be obtained from a single apparatus at stations where lights of exceptionally high intensity are desired, the expedient of placing one complete lens apparatus above another has sometimes been adopted, as at the Bishop Rock (fig. 13), and at the Fastnet lighthouse in Ireland (Plate I., fig. 54). Triform and quadriform apparatus have also been erected in Ireland; particulars of the Tory Island triform apparatus will be found in table VII. The adoption of the multiform system involves the use of lanterns of increased height.

Twin Apparatus.—Another method of doubling the power of a light is by mounting two complete and distinct optics side by side on the same revolving table, as I shown in fig. 43 of the Île Vierge apparatus. Several such lights have been installed by the French Lighthouse Service.

Port Lights.—Small self-contained lanterns and lights are in common use for marking the entrances to harbours and in other similar positions where neither high power nor long range is requisite. Many such lights are unattended in the sense that they do not require the attention of a keeper for days and even weeks together. These are described in more detail in section 6 of this article. A typical port light consists of a copper or brass lantern containing a lens of the fourth order (250 mm. focal distance) or smaller, and a single wick or 2-wick Argand capillary burner. Duplex burners are also used. The apparatus may exhibit a fixed light or, more usually, an occulting characteristic is produced by the revolution of screens actuated by spring clockwork around the burner. The lantern may be placed at the top of a column, or suspended from the head of a mast. Coal gas and electricity are also used as illuminants for port lights when local supplies are available. The optical apparatus used in connexion with electric light is described below.

"Orders" of Apparatus.—Augustin Fresnel divided the dioptric lenses, designed by him, into "orders" or sizes depending on their local distance. This division is still used, although two additional "orders," known as "small third order" and "hyper-radial" respectively are in ordinary use. The following table gives the principal dimensions of the several sizes in use:— 639

Table II.

Order.	Focal Distance, mm.	Vertical Angles of Optics. (Ordinary Dimensions.)			
		Dioptric Belt only.	Holophotal Optics.		
			Lower Prisms.	Lens.	Upper Prisms.
Hyper-Radial	1330	80°	21°	57°	48°
1st order	920	92°, 80°, 58°	21°	57°	48°
2nd order	700	80°	21°	57°	48°
3rd order	500	80°	21°	57°	48°
Small 3rd order	375	80°	21°	57°	48°
4th order	250	80°	21°	57°	48°
5th order	187.5	80°	21°	57°	48°
6th order	150	80°	21°	57°	48°

Lenses of small focal distance are also made for buoy and beacon lights.

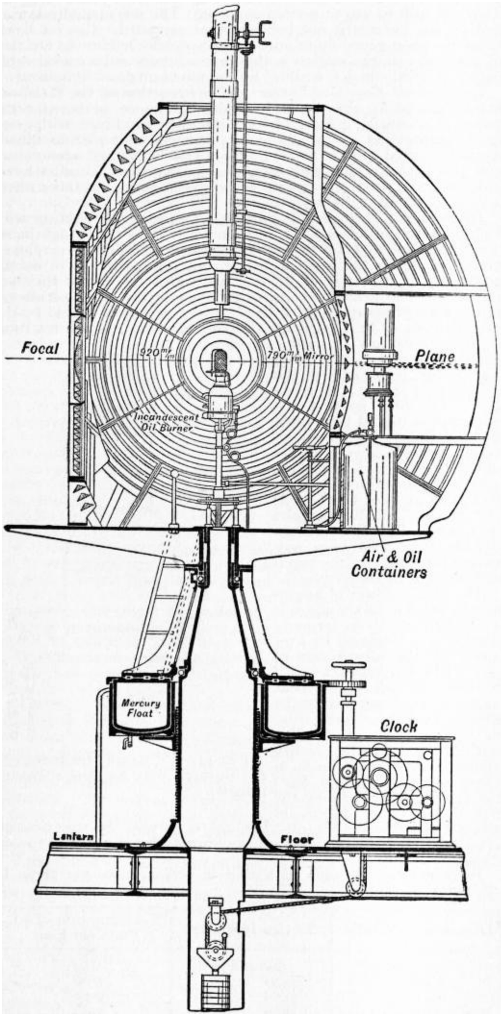


Fig. 42.—Cape Naturaliste Apparatus.

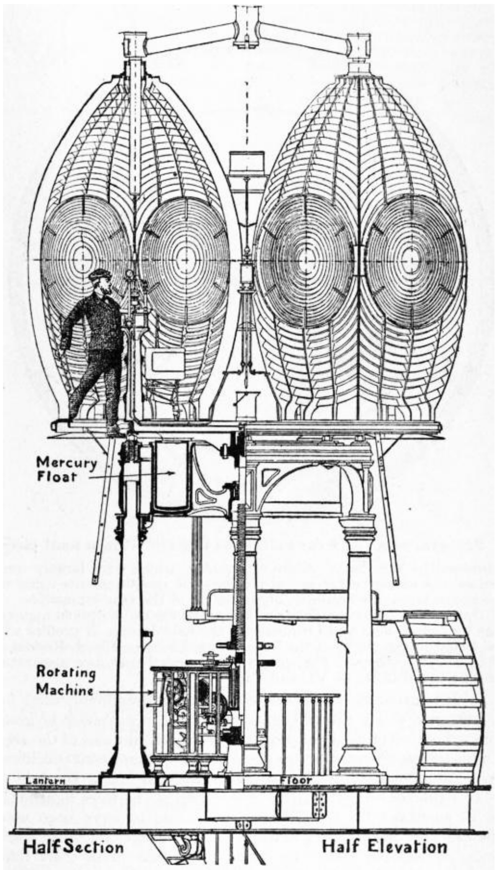


Fig. 43.—Île Vierge Apparatus.

Light Intensities.—The powers of lighthouse lights in the British Empire are expressed in terms of standard candles or in "lighthouse units" (one lighthouse unit = 1000 standard candles). In France the unit is the "Carcel" = .952 standard candle. The powers of burners and optical apparatus, then in use in the United Kingdom, were carefully determined by actual photometric measurement in 1892 by a committee consisting of the engineers of the three general lighthouse boards, and the values so obtained are used as the basis for calculating the intensities of all British lights. It was found that the intensities determined by photometric measurement were considerably less than the values given by the theoretical calculations formerly employed. A deduction of 20% was made from the mean experimental results obtained to compensate for loss by absorption in the lantern glass, variations in effects obtained by different men in working the burners and in the illuminating quality of oils, &c. The resulting reduced values are termed “service” intensities.

As has been explained above, the effect of a dioptric apparatus is to condense the light rays, and the measure of this condensation is the ratio between the vertical divergence and the vertical angle of the optic in the case of fixed lights. In flashing lights the ratio of vertical condensation must be multiplied by the ratio between the horizontal divergence and the horizontal angle of the panel. The loss of light by absorption in passing through the glass and by refraction varies from 10% to 15%. For apparatus containing catadioptric elements a larger deduction must be made.

The intensity of the flash emitted from a dioptric apparatus, showing a white light, may be found approximately by the empirical formula I = PCVH/*vh*, where I = intensity of resultant beam, P = service intensity of flame, V = vertical angle of optic, *v* = angle of mean vertical divergence, H = horizontal angle of panel, *h* = angle of mean horizontal divergence, and C = constant varying between .9 and .75 according to the description of 640
apparatus. The factor H/*h* must be eliminated in the case of fixed lights. Deduction must also be made in the case of coloured lights. It should, however, be pointed out that photometric measurements alone can be relied upon to give accurate values for lighthouse intensities. The values obtained by the use of Allard’s formulae, which were largely used before the necessity for actual photometric measurements came to be appreciated, are considerably in excess of the true intensities.

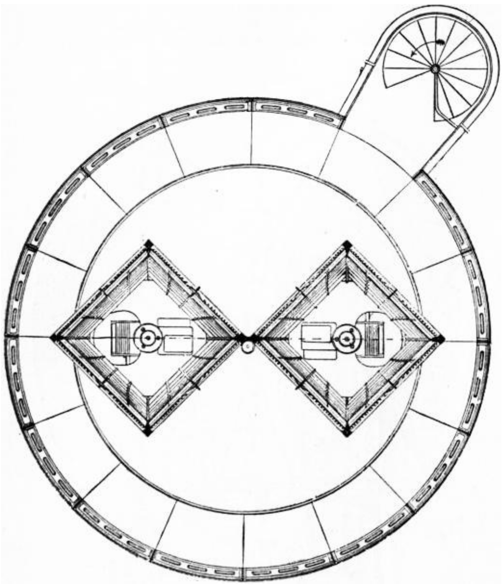


Fig. 43a.—Île Vierge Apparatus and Lantern. Plan at focal plane.

Optical Calculations.—The mathematical theory of optical apparatus for lighthouses and formulae for the calculations of profiles will be found in the works of the Stevensons, Chance, Allard, Reynaud, Ribière and others. Particulars of typical lighthouse apparatus will be found in tables VI. and VII.

4. Illuminants.—The earliest form of illuminant used for lighthouses was a fire of coal or wood set in a brazier or grate erected on top of the lighthouse tower. Until the end of the 18th and even into the 19th century this primitive illuminant continued to be almost the only one in use. The coal fire at the Isle of May light continued until 1810 and that at St Bees lighthouse in Cumberland till 1823. Fires are stated to have been used on the two towers of Nidingen, in the Kattegat, until 1846. Smeaton was the first to use any form of illuminant other than coal fires; he placed within the lantern of his Eddystone lighthouse a chandelier holding 24 tallow candles each of which weighed $\frac{2}{5}$ of a ℔ and emitted a light of 2.8 candle power. The aggregate illuminating power was 67.2 candles and the consumption at the rate of 3.4 ℔ per hour.

Oil.—Oil lamps with flat wicks were used in the Liverpool lighthouses as early as 1763. Argand, between 1780 and 1783, perfected his cylindrical wick lamp which provides a central current of air through the burner, thus allowing the more perfect combustion of the gas issuing from the wick. The contraction in the diameter of the glass chimney used with wick lamps is due to Lange, and the principle of the multiple wick burner was devised by Count Rumford. Fresnel produced burners having two, three and four concentric wicks. Sperm oil, costing 5s. to 8s. per gallon, was used in English lighthouses until 1846, but about that year colza oil was employed generally at a cost of 2s. 9d. per gallon. Olive oil, lard oil and coconut oil have also been used for lighthouse purposes in various parts of the world.

Mineral Oil Burners.—The introduction of mineral oil, costing a mere fraction of the expensive animal and vegetable oils, revolutionized the illumination of lighthouses. It was not until 1868 that a burner was devised which successfully consumed hydrocarbon oils. This was a multiple wick burner invented by Captain Doty. The invention was quickly taken advantage of by lighthouse authorities, and the “Doty” burner, and other patterns involving the same principle, remained practically the only oil burners in lighthouse use until the last few years of the 19th century.

The lamps used for supplying oil to the burner are of two general types, viz. those in which the oil is maintained under pressure by mechanical action and constant level lamps. In the case of single wick, and some 2-wick burners, oil is supplied to the burner by the capillary action of the wick alone.

The mineral oils ordinarily in use are petroleum, which for lighthouse purposes should have a specific gravity of from .820 to .830 at 60° F. and flashing point of not less than 230° F. (Abel close test), and Scottish shale oil or paraffin with a specific gravity of about .810 at 60° F. and flash point of 140° to 165° F. Both these varieties may be obtained in England at a cost of about $6\frac{1}{2}$d. per gallon in bulk.

Coal Gas had been introduced in 1837 at the inner pier light of Troon (Ayrshire) and in 1847 it was in use at the Heugh lighthouse (West Hartlepool). In 1878 cannel coal gas was adopted for the Galley Head lighthouse, with 108-jet Wigham burners. Sir James Douglass introduced gas burners consisting of concentric rings, two to ten in number, perforated on the upper edges. These give excellent results and high intensity, 2600 candles in the case of the 10-ring burner with a flame diameter at the focal plane of $5\frac{5}{8}$ in. They are still in use at certain stations. The use of multiple ring and jet gas burners is not being further extended. Gas for lighthouse purposes generally requires to be specially made; the erection of gas works at the station is thus necessitated and a considerable outlay entailed which is avoided by the use of oil as an illuminant.

Incandescent Coal Gas Burners.—The invention of the Welsbach mantle placed at the disposal of the lighthouse authorities the means of producing a light of high intensity combined with great focal compactness. For lighthouse purposes other gaseous illuminants than coal gas are as a rule more convenient and economical, and give better results with incandescent mantles. Mantles have, however, been used with ordinary coal gas in many instances where a local supply is available.

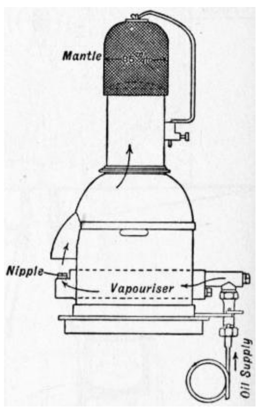


Fig. 44.—“Chance” Incandescent Oil Burner, with 85 mm. diameter mantle.

Incandescent Mineral Oil Burners.—Incandescent lighting with high-flash mineral oil was first introduced by the French Lighthouse Service in 1898 at L’Île Penfret lighthouse. The burners employed are all made on the same principle, but differ slightly in details according to the type of lighting apparatus for which they are intended. The principle consists in injecting the liquid petroleum in the form of spray mixed with air into a vaporizer heated by the mantle flame or by a subsidiary heating burner. A small reservoir of compressed air is used—charged by means of a hand pump—for providing the necessary pressure for injection. On first ignition the vaporizer is heated by a spirit flame to the required temperature. A reservoir air pressure of 125 ℔ per sq. in. is employed, a reducing valve supplying air to the oil at from 60 to 65 ℔ per sq. in. Small reservoirs containing liquefied carbon dioxide have also been employed for supplying the requisite pressure to the oil vessel.

The candle-power of apparatus in which ordinary multiple wick burners were formerly employed is increased by over 300% by the substitution of suitable incandescent oil burners. In 1902 incandescent oil burners were adopted by the general lighthouse authorities in the United Kingdom. The burners used in the Trinity House Service and some of those made in France have the vaporizers placed over the flame. In other forms, of which the “Chance” burner (fig. 44) is a type, the vaporization is effected by means of a subsidiary burner placed under the main flame.

Particulars of the sizes of burner in ordinary use are given in the following table.

Diameter of Mantle.	Service Intensity.	Consumption of oil.

		Pints per hour.
35 mm.	600 candles.	.50
55 mm.	1200 ”	1.00
85 mm.	2150 ”	2.25
Triple mantle 50 mm.	3300 ”	3.00

The intrinsic brightness of incandescent burners generally may be taken as being equivalent to from 30 candles to 40 candles per sq. cm. of the vertical section of the incandescent mantle.

In the case of wick burners, the intrinsic brightness varies, according to the number of wicks and the type of burner from about 3.5 candles to about 12 candles per sq. cm., the value being at its maximum with the larger type of burner. The luminous intensity of a beam from a dioptric apparatus is, *ceteris paribus*, proportional to the intrinsic brightness of the luminous source of flame, and not of the total luminous intensity. The intrinsic brightness of the flame of oil burners increases only slightly with their focal diameter, consequently while the consumption of oil increases the efficiency of the burner for a given apparatus decreases. The illuminating power of the condensed beam can only be improved to a slight extent, and, in fact, is occasionally decreased, by increasing the number of wicks in the burner. The same argument applies to the case of multiple ring and multiple jet gas burners which, notwithstanding their large total intensity, have comparatively small intrinsic brightness. The economy of the new system is instanced by the case of the Eddystone bi-form apparatus, which with the concentric 6-wick burner consuming 2500 gals. of oil per annum, gave a total intensity of 79,250 candles. Under the new régime the intensity is 292,000 candles, the oil consumption being practically halved.

Incandescent Oil Gas Burners.—It has been mentioned that incandescence with low-pressure coal gas produces flames of comparatively small intrinsic brightness. Coal gas cannot be compressed beyond a small extent without considerable injurious condensation and other accompanying evils. Recourse has therefore been had to compressed oil gas, which is capable of undergoing compression to 10 or 12 atmospheres with little detriment, and can conveniently be stored in portable reservoirs. The burner employed resembles the ordinary Bunsen burner with incandescent mantle, and the rate of consumption of gas is 27.5 cub. in. per hour per candle. A reducing valve is used for supplying the gas to the burner at constant pressure. The burners can be left unattended for considerable periods. The system was first adopted in France, where it is installed at eight lighthouses, among others the Ar’men Rock light, and has been extended to other parts of the world including several stations in Scotland and England. The mantles used in France are of 35 mm. diameter. The 35 mm. mantle gives a candle-power of 400, with an intrinsic brightness of 20 candles per sq. cm.

The use of oil gas necessitates the erection of gas works at the lighthouse or its periodical supply in portable reservoirs from a neighbouring station. A complete gas works plant costs about £800. The annual expenditure for gas lighting in France does not exceed £72 per light where works are installed, or £32 where gas is supplied from elsewhere. In the case of petroleum vapour lighting the annual cost of oil amounts to about £26 per station.

Acetylene.—The high illuminating power and intrinsic brightness of the flame of acetylene makes it a very suitable illuminant for lighthouses and beacons, providing certain difficulties attending its use can be overcome. At Grangemouth an unattended 21-day beacon has been illuminated by an acetylene flame for some years with considerable success, and a beacon light designed to run unattended for six months was established on Bedout Island in Western Australia in 1910. Acetylene has also been used in the United States, Germany, the Argentine, China, Canada, &c., for lighthouse and beacon illumination. Many buoys and beacons on the German and Dutch coasts have been supplied with oil gas mixed with 20% of acetylene, thereby obtaining an increase of over 100% in illuminating intensity. In France an incandescent burner consuming acetylene gas mixed with air has been installed at the Chassiron lighthouse (1902). The French Lighthouse Service has perfected an incandescent acetylene burner with a 55 mm. mantle having an intensity of over 2000 candle-power, with intrinsic brightness of 60 candles per sq. cm.

Electricity.—The first installation of electric light for lighthouse purposes in England took place in 1858 at the South Foreland, where the Trinity House established a temporary plant for experimental purposes. This installation was followed in 1862 by the adoption of the illuminant at the Dungeness lighthouse, where it remained in service until the year 1874 when oil was substituted for electricity. The earliest of the permanent installations now existing in England is that at Souter Point which was illuminated in 1871. There are in England four important coast lights illuminated by electricity, and one, viz. Isle of May, in Scotland. Of the former St Catherine’s, in the Isle of Wight, and the Lizard are the most powerful. Electricity was substituted as an illuminant for the then existing oil light at St Catherine’s in 1888. The optical apparatus consisted of a second-order 16-sided revolving lens, which was transferred to the South Foreland station in 1904, and a new second order (700 mm.) four-sided optic with a vertical angle of 139°, exhibiting a flash of .21 second duration every 5 seconds substituted for it. A fixed holophote is placed inside the optic in the dark or landward arc, and at the focal plane of the lamp. This holophote condenses the rays from the arc falling upon it into a pencil of small angle, which is directed horizontally upon a series of reflecting prisms which again bend the light and throw it downwards through an aperture in the lantern floor on to another series of prisms, which latter direct the rays seaward in the form of a sector of fixed red light at a lower level in the tower. A somewhat similar arrangement exists at Souter Point lighthouse.

The apparatus installed at the Lizard in 1903 is similar to that at St Catherine’s, but has no arrangement for producing a subsidiary sector light. The flash is of .13 seconds duration every 3 seconds. The apparatus replaced the two fixed electric lights erected in 1878.

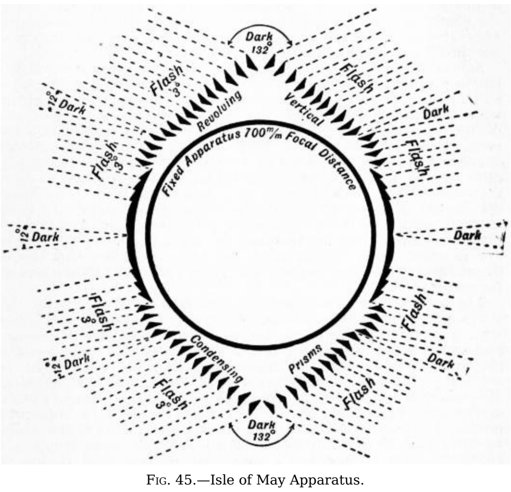


Fig. 45.—Isle of May Apparatus.

The Isle of May lighthouse, at the mouth of the Firth of Forth, was first illuminated by electricity in 1886. The optical apparatus consists of a second-order fixed-light lens with reflecting prisms, and is surrounded by a revolving system of vertical condensing prisms which split up the vertically condensed beam of light into 8 separate beams of 3° in azimuth. The prisms are so arranged that the apparatus, making one complete revolution in the minute, produces a group characteristic of 4 flashes in quick succession every 30 seconds (fig. 45). The fixed light is not of the ordinary Fresnel section, the refracting portion being confined to an angle of 10°, and the remainder of the vertical section consisting of reflecting prisms.

In France the old south lighthouse at La Hève was lit by electricity in 1863. This installation was followed in 1865 by a similar one at the north lighthouse. In 1910 there were thirteen important coast lights in France illuminated by electricity. In other parts of the world, Macquarie lighthouse, Sydney, was lit by electricity in 1883; Tino, in the gulf of Spezia, in 1885; and Navesink lighthouse, near the entrance to New York Bay, in 1898. Electric apparatus were also installed at the lighthouse at Port Said in 1869, on the opening of the canal; Odessa in 1871; and at the Rothersand, North Sea, in 1885. There are several other lights in various parts of the world illuminated by this agency.

Incandescent electric lighting has been adopted for the illumination of certain light-vessels in the United States, and a few small harbour and port lights, beacons and buoys.

Table VI. gives particulars of some of the more important electric lighthouses of the world.

Electric Lighthouse Installations in France.—A list of the thirteen lighthouses on the French coast equipped with electric light installations will be found in table VI. It has been already mentioned that the two lighthouses at La Hève were lit by electric light in 1863 and 1865. These installations were followed within a few years by the establishment of electricity as illuminant at Gris-Nez. In 1882 M. Allard, the then director-general of the French Lighthouse Service, prepared a scheme for the electric lighting of the French littoral by means of 46 lights distributed more or less uniformly along the coast-line. All the apparatus were to be of the same general type, the optics consisting of a fixed belt of 300 mm. focal distance, around the outside of which revolved a system of 24 faces of vertical lenses. These vertical panels condensed the belt of fixed light into beams of 3° amplitude in azimuth, producing flashes of about ¾ sec. duration. To illuminate the near sea the vertical divergence of the lower prisms of the fixed belt was artificially increased. These optics are very similar to that in use at the Souter Point lighthouse, Sunderland. The intensities obtained were 120,000 candles in the case of fixed lights and 900,000 candles with flashing lights. As a result of a nautical inquiry held in 1886, at which date the lights of

Dunkerque, Calais, Gris-Nez, La Canche, Baleines and Planier had been lighted, in addition to the old apparatus at La Hève, it was decided to limit the installation of electrical apparatus to important landfall lights—a decision which the Trinity House had already arrived at in the case of the English coast—and to establish new apparatus at six stations only. These were Créac’h d’Ouessant (Ushant), Belle-Île, La Coubre at the mouth of the river Gironde, Barfleur, Île d’Yeu and Penmarc’h. At the same time it was determined to increase the powers of the existing electric lights. The scheme as amended in 1886 was completed in 1902.[2] 642

All the electrically lit apparatus, in common with other optics established in France since 1893, have been provided with mercury rotation. The most recent electric lights have been constructed in the form of twin apparatus, two complete and distinct optics being mounted side by side upon the same revolving table and with corresponding faces parallel. It is found that a far larger aggregate candle-power is obtained from two lamps with 16 mm. to 23 mm. diameter carbons and currents of 60 to 120 amperes than with carbons and currents of larger dimensions in conjunction with single optics of greater focal distance. A somewhat similar circumstance led to the choice of the twin form for the two very powerful non-electric apparatus at Île Vierge (figs. 43 and 43A) and Ailly, particulars of which will be seen in table VII.

Several of the de Meritens magneto-electric machines of 5.5 K.W., laid down many years ago at French electric lighthouse stations, are still in use. All these machines have five induction coils, which, upon the installation of the twin optics, were separated into two distinct circuits, each consisting of 2½ coils. This modification has enabled the old plants to be used with success under the altered conditions of lighting entailed by the use of two lamps. The generators adopted in the French service for use at the later stations differ materially from the old type of de Meritens machine. The Phare d’Eckmühl (Penmarc’h) installation serves as a type of the more modern machinery. The dynamos are alternating current two-phase machines, and are installed in duplicate. The two lamps are supplied with current from the same machine, the second dynamo being held in reserve. The speed is 810 to 820 revolutions per minute.

The lamp generally adopted is a combination of the Serrin and Berjot principles, with certain modifications. Clockwork mechanism with a regulating electromagnet moves the rods simultaneously and controls the movements of the carbons so that they are displaced at the same rate as they are consumed. It is usual to employ currents of varying power with carbons of corresponding dimensions according to the atmospheric conditions. In the French service two variations are used in the case of twin apparatus produced by currents of 60 and 120 amperes at 45 volts with carbons 14 mm. and 18 mm. diameter, while in single optic apparatus currents of 25, 50 and 100 amperes are utilized with carbon of 11 mm., 16 mm. and 23 mm. diameter. In England fluted carbons of larger diameter are employed with correspondingly increased current. Alternating currents have given the most successful results in all respects. Attempts to utilize continuous current for lighthouse arc lights have, up to the present, met with little success.

The cost of a first-class electric lighthouse installation of the most recent type in France, including optical apparatus, lantern, dynamos, engines, air compressor, siren, &c., but not buildings, amounts approximately to £5900.

Efficiency of the Electric Light.—In 1883 the lighthouse authorities of Great Britain determined that an exhaustive series of experiments should be carried out at the South Foreland with a view to ascertaining the relative suitability of electricity, gas and oil as lighthouse illuminants. The experiments extended over a period of more than twelve months, and were attended by representatives of the chief lighthouse authorities of the world. The results of the trials tended to show that the rays of oil and gas lights suffered to about equal extent by atmospheric absorption, but that oil had the advantage over gas by reason of its greater economy in cost of maintenance and in initial outlay on installation. The electric light was found to suffer to a much larger extent than either oil or gas light per unit of power by atmospheric absorption, but the infinitely greater total intensity of the beam obtainable by its use, both by reason of the high luminous intensity of the electric arc and its focal compactness, more than outweighed the higher percentage of loss in fog. The final conclusion of the committee on the relative merits of electricity, gas or oil as lighthouse illuminants is given in the following words: “That for ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required electricity offers the greater advantages.”

5. Miscellaneous Lighthouse Equipment. *Lanterns.*—Modern lighthouse lanterns usually consist of a cast iron or steel pedestal, cylindrical in plan, on which is erected the lantern glazing, surmounted by a domed roof and ventilator (fig. 41). Adequate ventilation is of great importance, and is provided by means of ventilators in the pedestal and a large ventilating dome or cowl in the roof. The astragals carrying the glazing are of wrought steel or gun-metal. The astragals are frequently arranged helically or diagonally, thus causing a minimum of obstruction to the light rays in any vertical section and affording greater rigidity to the structure. The glazing is usually ¼-in. thick plate-glass curved to the radius of the lantern. In situations of great exposure the thickness is increased. Lantern roofs are of sheet steel or copper secured to steel or cast-iron rafter frames. In certain instances it is found necessary to erect a grille or network outside the lantern to prevent the numerous sea birds, attracted by the light, from breaking the glazing by impact. Lanterns vary in diameter from 5 ft. to 16 ft. or more, according to the size of the optical apparatus. For first order apparatus a diameter of 12 ft. or 14 ft. is usual.

Lightning Conductors.—The lantern and principal metallic structures in a lighthouse are usually connected to a lightning conductor carried either to a point below low water or terminating in an earth plate embedded in wet ground. Conductors may be of copper tape or copper-wire rope.

Rotating Machinery.—Flashing-light apparatus are rotated by clockwork mechanism actuated by weights. The clocks are fitted with speed governors and electric warning apparatus to indicate variation in speed and when rewinding is required. For occulting apparatus either weight clocks or spring clocks are employed.

Accommodation for Keepers, &c.—At rock and other isolated stations, accommodation for the keepers is usually provided in the towers. In the case of land lighthouses, dwellings are provided in close proximity to the tower. The service or watch room should be situated immediately under the lantern floor. Oil is usually stored in galvanized steel tanks. A force pump is sometimes used for pumping oil from the storage tanks to a service tank in the watch-room or lantern.

6. Unattended Lights and Beacons.—Until recent years no unattended lights were in existence. The introduction of Pintsch’s gas system in the early ’seventies provided a means of illumination for beacons and buoys of which large use has been made. Other illuminants are also in use to a considerable extent.

Unattended Electric Lights.—In 1884 an iron beacon lighted by an incandescent lamp supplied with current from a secondary battery was erected on a tidal rock near Cadiz. A 28-day clock was arranged for eclipsing the light between sunrise and sunset and automatically cutting off the current at intervals to produce an occulting characteristic. Several small dioptric apparatus illuminated with incandescent electric lamps have been made by the firm of Barbier Bénard et Turenne of Paris, and supplied with current from batteries of Daniell cells, with electric clockwork mechanism for occulting the light. These apparatus have been fitted to beacons and buoys, and are generally arranged to automatically switch off the current during the day-time. They run unattended for periods up to two months. Two separate lenses and lamps are usually provided, with lamp changer, only one lamp being in circuit at a time. In the event of failure in the upper lamp of the two the current automatically passes to the lower lamp.

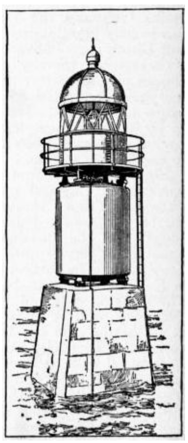


Fig. 46.—Garvel Beacon.

Oil-gas Beacons.—In 1881 a beacon automatically lighted by Pintsch’s compressed oil gas was erected on the river Clyde, and large numbers of these structures have since been installed in all parts of the world. The gas is contained in an iron or steel reservoir placed within the beacon structure, refilled by means of a flexible hose on the occasions of the periodical visits of the tender. The beacons, which remain illuminated for periods up to three months are charged to 7 atmospheres. Many lights are provided with occulting apparatus actuated by the gas passing from the reservoir to the burner automatically cutting off and turning on the supply. The Garvel beacon (1899) on the Clyde is shown in fig. 46. The burner has 7 jets, and the light is occulting. Since 1907 incandescent mantle burners for oil gas have been largely used for beacon illumination, both for fixed and occulting lights.

Acetylene has also been used for the illumination of beacons and other unattended lights.

Lindberg Lights.—In 1881-1882 several beacons lighted automatically by volatile petroleum spirit on the Lindberg-Lyth and Lindberg-Trotter systems were established in Sweden. Many lights of this type have subsequently been placed in different parts of the world. The volatile spirit lamp burns day and night. Occultations are produced by a screen or series of screens rotated round the light by the ascending current of heated air and gases from the lamp 643 acting upon a horizontal fan. The speed of rotation of the fan cannot be accurately adjusted, and the times of occultation therefore are liable to slight variation. The lights run unattended for periods up to twenty-one days.

Benson-Lee Lamps.—An improvement upon the foregoing is the Benson-Lee lamp, in which a similar occulting arrangement is often used, but the illuminant is paraffin consumed in a special burner having carbon-tipped wicks which require no trimming. The flame intensity of the light is greater than that of the burner consuming light spirit. The introduction of paraffin also avoids the danger attending the use of the more volatile spirit. Many of these lights are in use on the Scottish coast. They are also used in other parts of the United Kingdom, and in the United States, Canada and other countries.

Permanent Wick Lights.—About 1891 the French Lighthouse Service introduced petroleum lamps consuming ordinary high-flash lighthouse oil, and burning without attention for periods of several months. The burners are of special construction, provided with a very thick wick which is in the first instance treated in such a manner as to cause the formation of a deposit of carbonized tar on its exposed upper surface. This crust prevents further charring of the wick after ignition, the oil becoming vaporized from the under side of the crust. Many fixed, occulting and flashing lights fitted with these burners are established in France and other countries. In the case of the occulting types a revolving screen is placed around the burner and carried upon a miniature mercury float. The rotation is effected by means of a small Gramme motor on a vertical axis, fitted with a speed governor, and supplied with current from a battery of primary cells. The oil reservoir is placed in the upper part of the lantern and connected with the burner by a tube, to which is fitted a constant level regulator for maintaining the burning level of the oil at a fixed height. In the flashing or revolving light types the arrangement is generally similar, the lenses being revolved upon a mercury float which is rotated by the electric motor. The flashing apparatus established at St Marcouf in 1901 has a beam intensity of 1000 candle-power, and is capable of running unattended for three months. The electric current employed for rotating the apparatus is supplied by four

Lalande and Chaperon primary cells, coupled in series, each giving about 0.15 ampere at a voltage of 0.65. The power required to work the apparatus is at the maximum about 0.165 ampere at 0.75 volt, the large surplus of power which is provided for the sake of safety being absorbed by a brake or governor connected with the motor.

Wigham Beacon Lights.—Wigham introduced an oil lamp for beacon and buoy purposes consisting of a vertical container filled with ordinary mineral oil or paraffin, and carrying a roller immediately under the burner case over which a long flat wick passes. One end of the wick is attached to a float which falls in the container as the oil is consumed, automatically drawing a fresh portion of the wick over the roller. The other end of the wick is attached to a free counterweight which serves to keep it stretched. The oil burns from the convex surface of the wick as it passes over the roller, a fresh portion being constantly passed under the action of the flame. The light is capable of burning without attention for thirty days. These lights are also fitted with occulting screens on the Lindberg system. The candle-power of the flame is small.

7. Light-Vessels.—The earliest light-vessel placed in English waters was that at the Nore in 1732. The early light-ships were of small size and carried lanterns of primitive construction and small size suspended from the yard-arms. Modern light-vessels are of steel, wood or composite construction. Steel is now generally employed in new ships. The wood and composite ships are sheathed with Muntz metal. The dimensions of English light-vessels vary. The following may be taken as the usual limits:

Length	80 ft. to 114 ft.
Beam	20 ft. to 24 ft.
Depth moulded	13 ft. to 15 ft. 6 in.
Tonnage	155 to 280.

The larger vessels are employed at outside and exposed stations, the smaller ships being stationed in sheltered positions and in estuaries. The moorings usually consist of 3-ton mushroom anchors and 1⅝ open link cables. The lanterns in common use are 8 ft. in diameter, circular in form, with glazing 4 ft. in height. They are annular in plan, surrounding the mast of the vessel upon which they are hoisted for illumination, and are lowered to the deck level during the day. Fixed lanterns mounted on hollow steel masts are now being used in many services, and are gradually displacing the older type. The first English light-vessel so equipped was constructed in 1904. Of the 87 light-vessels in British waters, including unattended light-vessels, eleven are in Ireland and six in Scotland. At the present time there are over 750 light-vessels in service throughout the world.

Until about 1895 the illuminating apparatus used in light-vessels was exclusively of catoptric form, usually consisting of 21 in. or 24 in. silvered parabolic reflectors, having 1, 2 or 3-wick mineral oil burners in focus. The reflectors and lamps are hung in gimbals to preserve the horizontal direction of the beams.

The following table gives the intensity of beam obtained by means of a type of reflector in general use:

21-in. Trinity House Parabolic Reflector

				Service Intensity of Beam.
Burners	1	wick “Douglass”		2715 candles
”	2	”	(Catoptric)	4004 ”
”	2	”	(Dioptric)	6722 ”
”	3	”		7528 ”

In revolving flashing lights two or more reflectors are arranged in parallel in each face. Three, four or more faces or groups of reflectors are arranged around the lantern in which they revolve, and are carried upon a turn-table rotated by clockwork. The intensity of the flashing beam is therefore equivalent to the combined intensities of the beams emitted by the several reflectors in each face. The first light-vessel with revolving light was placed at the Swin Middle at the entrance to the Thames in 1837. Group-flashing characteristics can be produced by special arrangements of the reflectors. Dioptric apparatus is now being introduced in many new vessels, the first to be so fitted in England being that stationed at the Swin Middle in 1905, the apparatus of which is gas illuminated and gives a flash of 25,000 candle-power.

Fog signals, when provided on board light-vessels are generally in the form of reed-horns or sirens, worked by compressed air. The compressors are driven from steam or oil engines. The cost of a modern type of English light-vessel, with power-driven compressed air siren, is approximately £16,000.

In the United States service, the more recently constructed vessels have a displacement of 600 tons, each costing £18,000. They are provided with self-propelling power and steam whistle fog signals. The illuminating apparatus is usually in the form of small dioptric lens lanterns suspended at the mast-head—3 or more to each mast, but a few of the ships, built since 1907, are provided with fourth-order revolving dioptric lights in fixed lanterns. There are 53 light-vessels in service on the coasts of the United States with 13 reserve ships.

Electrical Illumination.—An experimental installation of the electric light placed on board a Mersey light-vessel in 1886 by the Mersey Docks and Harbour Board proved unsuccessful. The United States Lighthouse Board in 1892 constructed a light-vessel provided with a powerful electric light, and moored her on the Cornfield Point station in Long Island Sound. This vessel was subsequently placed off Sandy Hook (1894) and transferred to the Ambrose Channel Station in 1907. Five other light-vessels in the United States have since been provided with incandescent electric lights—either with fixed or occulting characteristics—including Nantucket Shoals (1896), Fire Island (1897), Diamond Shoals (1898), Overfalls Shoal (1901) and San Francisco (1902).

Gas Illumination.—In 1896 the French Lighthouse Service completed the construction of a steel light-vessel (Talais), which was ultimately placed at the mouth of the Gironde. The construction of this vessel was the outcome of experiments carried out with a view to produce an efficient light-vessel at moderate cost, lit by a dioptric flashing light with incandescent oil-gas burner. The construction of the Talais was followed by that of a second and larger vessel, the Snouw, on similar lines, having a length of 65 ft. 6 in., beam 20 ft. and a draught of 12 ft., with a displacement of 130 tons. The cost of this vessel complete with optical apparatus and gasholders, with accommodation for three men, was approximately £5000. The vessel was built in 1898-1899.[3] A third vessel was constructed in 1901-1902 for the Sandettié Bank on the general lines adopted for the preceding examples of her class, but of the following increased dimensions: length 115 ft.; width at water-line 20 ft. 6 in.; and draught 15 ft., with a displacement of 342 tons (fig. 47). Accommodation is provided for a crew of eight men. The optical apparatus (fig. 48) is dioptric, consisting of 4 panels of 250 mm. focal distance, carried upon a “Cardan” joint below the lens table, and counter-balanced by a heavy pendulum weight. The apparatus is revolved by clockwork and illuminated by compressed oil gas with incandescent mantle. The candle-power of the beam is 35,000. The gas is contained in three reservoirs placed in the hold. The apparatus is contained in a 6-ft. lantern constructed at the head of a tubular mast 2 ft. 6 in. diameter. A powerful siren is provided with steam engine and boiler for working the air compressors. The total cost of the vessel, including fog signal and optical apparatus, was £13,600. A vessel of similar construction to the Talais was placed by the Trinity House in 1905 on the Swin Middle station. The illuminant is oil gas. Gas illuminated light-vessels have also been constructed for the German and Chinese Lighthouse Service.

Unattended Light-vessels.—In 1881 an unattended light-vessel, illuminated with Pintsch’s oil gas, was constructed for the Clyde, and is still in use at the Garvel Point. The light is occulting, and is shown from a dioptric lens fitted at the head of a braced iron lattice tower 30 ft. above water-level. The vessel is of iron, 40 ft. long, 12 ft. beam and 8 ft. deep, and has a storeholder on board containing oil gas under a pressure of six atmospheres capable of maintaining a light for three months. A similar vessel is placed off Calshot Spit in Southampton Water, and several have been constructed for the French and other Lighthouse Services. The French boats are provided with deep main and bilge keels similar to those adopted in the larger gas illuminated vessels. In 1901 a light-vessel 60 ft. in length was placed off the Otter Rock on the west coast of Scotland; it is constructed of steel, 24 ft. beam, 12 ft. deep and draws 9 ft. of water (fig. 49). The focal plane is elevated 25 ft. above the water-line, and the lantern is 6 ft. in diameter. The optical apparatus is of 500 mm. focal distance and hung in gimbals with a pendulum balance and “Cardan” joint as in the Sandettié light-vessel. The illuminant is oil gas, with an occulting characteristic. The storeholder contains 10,500 cub. ft. of gas at eight atmospheres, sufficient to supply the light for ninety days and nights. A bell is provided, struck by clappers moved by the roll of the vessel. The cost of the vessel complete was £2979. The Northern Lighthouse Commissioners have four similar vessels in service, and others have been stationed in the Hugli estuary, at Bombay, off the Chinese coasts and elsewhere. In 1909 an unattended gas illuminated light-vessel provided with a dioptric flashing apparatus was placed at the Lune Deep in Morecambe Bay. It is also fitted with a fog bell struck automatically by a gas operated mechanism. 644

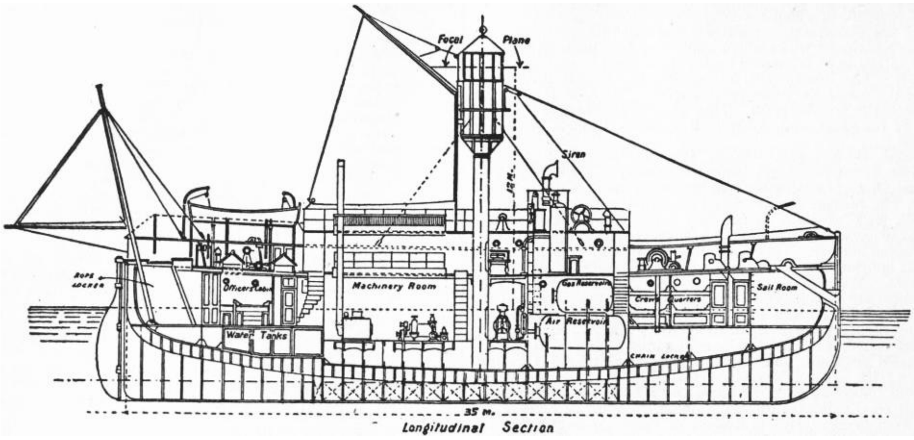


Fig. 47.—Sandettié Lightship.

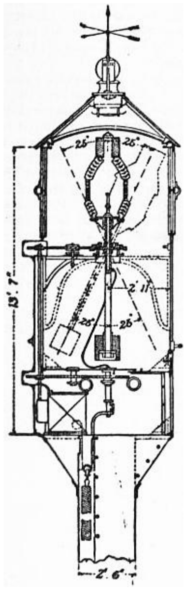


Fig. 48.—Lantern of Sandettié Lightship.

Electrical Communication of Light-vessels with the Shore.—Experiments were instituted in 1886 at the Sunk light-vessel off the Essex coast with the view to maintaining telephonic communication with the shore by means of a submarine cable 9 m. in length. Great difficulties were experienced in maintaining communication during stormy weather, breakages in the cable being frequent. These difficulties were subsequently partially overcome by the employment of larger vessels and special moorings. Wireless telegraphic installations have now (1910) superseded the cable communications with light-vessels in English waters except in four cases. Seven light-vessels, including the four off the Goodwin Sands, are now fitted for wireless electrical communication with the shore.

In addition many pile lighthouses and isolated rock and island stations have been placed in electrical communication with the shore by means of cables or wireless telegraphy. The Fastnet lighthouse was, in 1894, electrically connected with the shore by means of a non-continuous cable, it being found impossible to maintain a continuous cable in shallow water near the rock owing to the heavy wash of the sea. A copper conductor, carried down from the tower to below low-water mark, was separated from the cable proper, laid on the bed of the sea in a depth of 13 fathoms, by a distance of about 100 ft. The lighthouse was similarly connected to earth on the opposite side of the rock. The conductor terminated in a large copper plate, and to the cable end was attached a copper mushroom. Weak currents were induced in the lighthouse conductor by the main current in the cable, and messages received in the tower by the help of electrical relays. On the completion of the new tower on the Fastnet Rock in 1906 this installation was superseded by a wireless telegraphic installation.

8. Distribution and Distinction of Lights, &c.—*Methods of Distinction.*—The following are the various light characteristics which may be exhibited to the mariner:—

Fixed.—Showing a continuous or steady light. Seldom used in modern lighthouses and generally restricted to small port or harbour lights. A fixed light is liable to be confused with lights of shipping or other shore lights.

Flashing.[4]—Showing a single flash, the duration of darkness always being greater than that of light. This characteristic or that immediately following is generally adopted for important lights. The French authorities have given the name *Feux-Eclair* to flashing lights of short duration.

Group-Flashing.—Showing groups of two or more flashes in quick succession (not necessarily of the same colour) separated by eclipses with a larger interval of darkness between the groups.

Fixed and Flashing.—Fixed light varied by a single white or coloured flash, which may be preceded and followed by a short eclipse. This type of light, in consequence of the unequal intensities of the beams, is unreliable, and examples are now seldom installed although many are still in service.

Fixed and Group-Flashing.—Similar to the preceding and open to the same objections.

Revolving.—This term is still retained in the "Lists of Lights" issued by the Admiralty and some other authorities to denote a light gradually increasing to full effect, then decreasing to eclipse. At short distances and in clear weather a faint continuous light may be observed. There is no essential difference between revolving and flashing lights, the distinction being merely due to the speed of rotation, and the term might well be abandoned as in the United States lighthouse list.

Occulting.—A continuous light with, at regular intervals, one sudden and total eclipse, the duration of light always being equal to or greater than that of darkness. This characteristic is usually exhibited by fixed dioptric apparatus fitted with some form of occulting mechanism. Many lights formerly of fixed characteristic have been converted to occulting.

Group Occulting.—A continuous light with, at regular intervals, groups of two or more sudden and total eclipses. 645

Alternating.—Lights of different colours (generally red and white) alternately without any intervening eclipse. This characteristic is not to be recommended for reasons which have already been referred to. Many of the permanent and unwatched lights on the coasts of Norway and Sweden are of this description.

Colour.—The colours usually adopted for lights are white, red and green. White is to be preferred whenever possible, owing to the great absorption of light by the use of red or green glass screens.

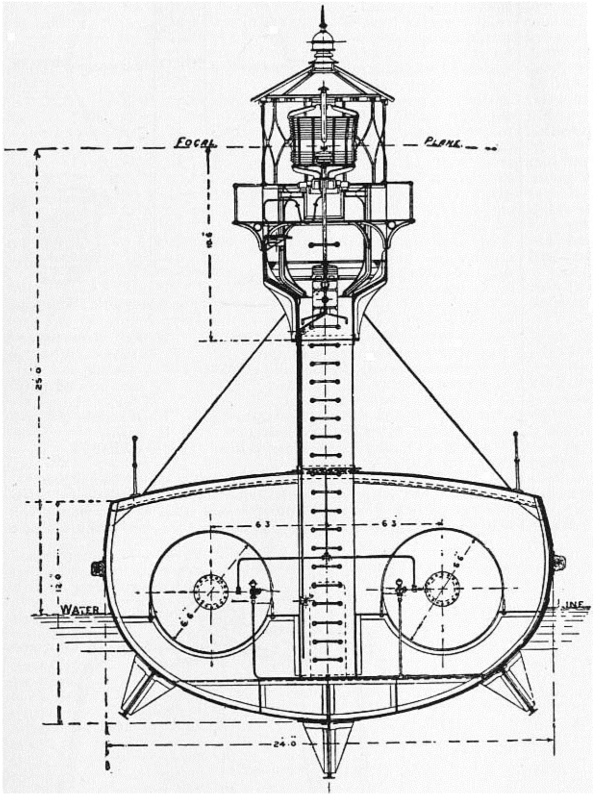


FIG. 49.—Otter Rock Light-vessel.

Sectors.—Coloured lights are often requisite to distinguish cuts or sectors, and should be shown from fixed or occulting light apparatus and not from flashing apparatus. In marking the passage through a channel, or between sandbanks or other dangers, coloured light sectors are arranged to cover the dangers, white light being shown over the fairway with sufficient margin of safety between the edges of the coloured sectors next the fairway and the dangers.

Choice of Characteristic and Description of Apparatus.—In determining the choice of characteristic for a light due regard must be paid to existing lights in the vicinity. No light should be placed on a coast line having a characteristic the same as, or similar to, another in its neighbourhood unless one or more lights of dissimilar characteristic, and at least as high power and range, intervene. In the case of “landfall lights” the characteristic should differ from any other within a range of 100 m. In narrow seas the distance between lights of similar characteristic may be less. Landfall lights are, in a sense, the most important of all and the most powerful apparatus available should be installed at such stations. The distinctive characteristic of a light should be such that it may be readily determined by a mariner without the necessity of accurately timing the period or duration of flashes. For landfall and other important coast stations flashing dioptric apparatus of the first order (920 mm. focal distance) with powerful burners are required. In countries where the atmosphere is generally clear and fogs are less prevalent than on the coasts of the United Kingdom, second or third order lights suffice for landfalls having regard to the high intensities available by the use of improved illuminants. Secondary coast lights may be of second, third or fourth order of flashing character, and important harbour lights of third or fourth order. Less important harbours and places where considerable range is not required, as in estuaries and narrow seas, may be lighted by flashing lights of fourth order or smaller size. Where sectors are requisite, occulting apparatus should be adopted for the main light; or subsidiary lights, fixed or occulting, may be exhibited from the same tower as the main light but at a lower level. In such cases the vertical distance between the high and the low light must be sufficient to avoid commingling of the two beams at any range at which both lights are visible. Such commingling or blending is due to atmospheric aberration.

Range of Lights.—The range of a light depends first on its elevation above sea-level and secondly on its intensity. Most important lights are of sufficient power to render them visible at the full geographical range in clear weather. On the other hand there are many harbour and other lights which do not meet this condition.

The distances given in lists of lights from which lights are visible—except in the cases of lights of low power for the reason given above—are usually calculated in nautical miles as seen from a height of 15 ft. above sea-level, the elevation of the lights being taken as above high water. Under certain atmospheric conditions, and especially with the more powerful lights, the glare of the light may be visible considerably beyond the calculated range.

TABLE III.—*Distances at which Objects can be seen at Sea, according to their Respective Elevations and the Elevation of the Eye of the Observer.* (A. Stevenson.)

Heights in Feet.	Distances in Geographical or Nautical Miles.	Heights in Feet.	Distances in Geographical or Nautical Miles.
5	2.565	110	12.03
10	3.628	120	12.56
15	4.443	130	13.08
20	5.130	140	13.57
25	5.736	150	14.02
30	6.283	200	16.22
35	6.787	250	18.14
40	7.255	300	19.87
45	7.696	350	21.46
50	8.112	400	22.94
55	8.509	450	24.33
60	8.886	500	25.65
65	9.249	550	26.90
70	9.598	600	28.10
75	9.935	650	29.25
80	10.26	700	30.28
85	10.57	800	32.45
90	10.88	900	34.54
95	11.18	1000	36.28
100	11.47		

EXAMPLE: A tower 200 ft. high will be visible 20.66 nautical miles to an observer, whose eye is elevated 15 ft. above the water; thus, from the table:

15	ft. elevation,	distance visible	4.44	nautical miles
200	”	”	16.22	”
			——	
			20.66	”

Elevation of Lights.—The elevation of the light above sea-level need not, in the case of landfall lights, exceed 200 ft., which is sufficient to give a range of over 20 nautical miles. One hundred and fifty feet is usually sufficient for coast lights. Lights placed on high headlands are liable to be enveloped in banks of fog at times when at a lower level the atmosphere is comparatively clear (*e.g.* Beachy Head). No definite rule can, however, be laid down, and local circumstances, such as configuration of the coast line, must be taken into consideration in every case.

Choice of Site.—"Landfall" stations should receive first consideration and the choice of location for such a light ought never to be made subservient to the lighting of the approaches to a port. Subsidiary lights are available for the latter purpose. Lights installed to guard shoals, reefs or other dangers should, when practicable, be placed seaward of the danger itself, as it is desirable that seamen should be able to "make" the light with confidence. Sectors marking dangers seaward of the light should not be employed except when the danger is in the near vicinity of the light. Outlying dangers require marking by a light placed on the danger or by a floating light in its vicinity.

9. Illuminated Buoys.—*Gas Buoys.* Pintsch's oil gas has been in use for the illumination of buoys since 1878. In 1883 an automatic occulter was perfected, worked by the gas passing from the reservoir to the burner. The lights placed on these buoys burn continuously for three or more months. The buoys and lanterns are made in various forms and sizes. The spar buoy (fig. 50) may be adopted for situations where strong tides or currents prevail. Oil gas lights are frequently fitted to Courtenay whistling (fig. 51) and bell buoys.

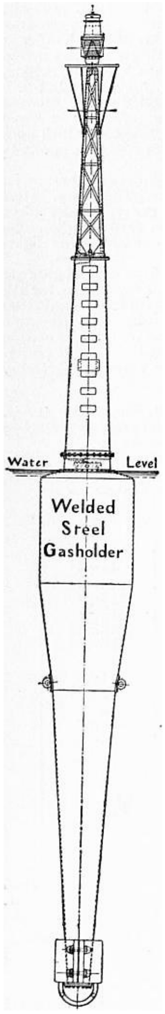


Fig. 50.—Spar Gas Buoy.

In the ordinary type of gas buoy lantern the burner employed is of the multiple-jet, Argand ring, or incandescent type. Incandescent mantles have been applied to buoy lights in France with successful results. Since 1906, and more recently the same system of illumination has been adopted in England and other countries. The lenses employed are of cylindrical dioptric fixed-light form, usually 100 mm. to 300 mm. diameter. Some of the largest types of gas-buoy in use on the French coast have an elevation from water level to the focal plane of over 26 ft. with a beam intensity of more than 1000 candles. A large gas-buoy with an elevation of 34 ft. to the focal plane was placed at the entrance to the Gironde in 1907. It has an incandescent burner and exhibits a light of over 1500 candles. Oil gas forms the most trustworthy and efficient illuminant for buoy purposes yet introduced, and the system has been largely adopted by lighthouse and harbour authorities.

There are now over 2000 buoys fitted with oil gas apparatus, in addition to 600 beacons, light-vessels and boats.

Electric Lit Buoys.—Buoys have been fitted with electric light, both fixed and occulting. Six electrically lit spar-buoys were laid down in the Gedney channel, New York lower bay, in 1888. These were illuminated by 100 candle-power Swan lamps with continuous current supplied by cable from a power station on shore. The wear and tear of the cables caused considerable trouble and expense. In 1895 alternating current was introduced. The installation was superseded by gas lit buoys in 1904.

Acetylene and Oil Lighted Buoys.—Acetylene has been extensively employed for the lighting of buoys in Canada and in the United States; to a less extent it has also been adopted in other countries. Both the low pressure system, by which the acetylene gas is produced by an automatic generator, and the so-called high pressure system in which purified acetylene is held in solution in a high pressure gasholder filled with asbestos composition saturated with acetone, have been employed for illuminating buoys and beacons. Wigham oil lamps are also used to a limited extent for buoy lighting.

Bell Buoys.—One form of clapper actuated by the roll of the buoy (shown in fig. 52) consists of a hardened steel ball placed in a horizontal phosphor-bronze cylinder provided with rubber buffers. Three of these cylinders are arranged around the mouth of the fixed bell, which is struck by the balls rolling backwards and forwards as the buoy moves. Another form of bell mechanism consists of a fixed bell with three or more suspended clappers placed externally which strike the bell when the buoy rolls.

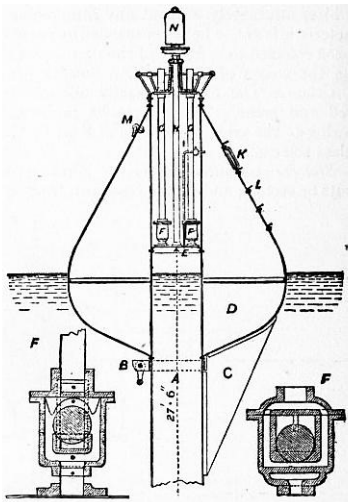


Fig. 51.—Courtenay's Automatic Whistling Buoy.

A, Cylinder, 27 ft. 6 in. long.
B, Mooring shackle.
C, Rudder.
D, Buoy.
E, Diaphragm.
F, Ball valves.
G, Air inlet tubes.
H, Air (compressed outlet tube to whistle).
I, Compressed air inlet to buoy.
K, Manhole.
L, Steps.
N, Whistle.

10. Fog Signals.—The introduction of coast fog signals is of comparatively recent date. They were, until the middle of the 19th century, practically unknown except so far as a few isolated bells and guns were concerned. The increasing demands of navigation, and the application of steam power to the propulsion of ships resulting in an increase of their speed, drew attention to the necessity of providing suitable signals as aids to navigation during fog and mist. In times of fog the mariner can expect no certain assistance from even the most efficient system of coast lighting, since the beams of light from the most powerful electric lighthouse are frequently entirely dispersed and absorbed by the particles of moisture, forming a sea fog of even moderate density, at a distance of less than a ¼ m. from the shore. The careful experiments and scientific research which have been devoted to the subject of coast fog-signalling have produced much that is useful and valuable to the mariner, but unfortunately the practical results so far have not been so satisfactory as might be desired, owing to (1) the very short range of the most powerful signals yet produced under certain unfavourable acoustic conditions of the atmosphere, (2) the difficulty experienced by the mariner in judging at any time how far the atmospheric conditions are against him in listening for the expected signal, and (3) the difficulty in locating the position of a sound signal by phonic observations.

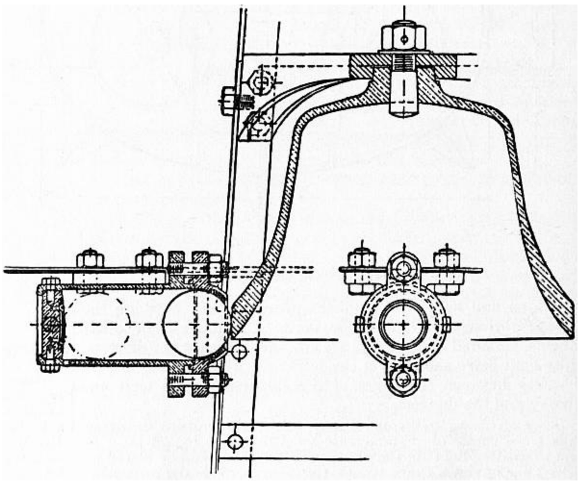


Fig. 52.—Buoy Bell.

Bells and Gongs are the oldest and, generally speaking, the least efficient forms of fog signals. Under very favourable acoustic conditions the sounds are audible at considerable ranges. On the other hand, 2-ton bells have been inaudible at distances of a few hundred yards. The 1893 United States trials showed that a bell weighing 4000 ℔ struck by a 450 ℔ hammer was heard at a distance of 14 m. across a gentle breeze and at over 9 m. against a 10-knot breeze. Bells are frequently used for beacon and buoy signals, and in some cases at isolated rock and other stations where there is insufficient accommodation for sirens and horns, but their use is being gradually discontinued in this country for situations where a powerful signal 647 is required. Gongs, usually of Chinese manufacture, were formerly in use on board English light-ships and are still used to some extent abroad. These are being superseded by more powerful sound instruments.

Explosive Signals.—Guns were long used at many lighthouse and light-vessel stations in England, and are still in use in Ireland and at some foreign stations. These are being gradually displaced by other explosive or compressed air signals. No explosive signals are in use on the coasts of the United States. In 1878 sound rockets charged with gun-cotton were first used at Flamborough Head and were afterwards supplied to many other stations.[5] The nitrated gun-cotton or tonite signals now in general use are made up in 4 oz. charges. These are hung at the end of an iron jib or pole attached to the lighthouse lantern or other structure, and fired by means of a detonator and electric battery. The discharge may take place within 12 ft. of a structure without danger. The cartridges are stored for a considerable period without deterioration and with safety. This form of signal is now very generally adopted for rock and other stations in Great Britain, Canada, Newfoundland, northern Europe and other parts of the world. An example will be noticed in the illustration of the Bishop Rock lighthouse, attached to the lantern (fig. 13). Automatic hoisting and firing appliances are also in use.

Whistles.—Whistles, whether sounded by air or steam, are not used in Great Britain, except in two instances of harbour signals under local control. It has been objected that their sound has too great a resemblance to steamers' whistles, and they are wasteful of power. In the United States and Canada they are largely used. The whistle usually employed consists of a metallic dome or bell against which the high-pressure steam impinges. Rapid vibrations are set up both in the metal of the bell and in the internal air, producing a shrill note. The Courtenay buoy whistle, already referred to, is an American invention and finds favour in the United States, France, Germany and elsewhere.

Reed-Horns.—These instruments in their original form were the invention of C. L. Daboll, an experimental horn of his manufacture being tried in 1851 by the United States Lighthouse Board. In 1862 the Trinity House adopted the instrument for seven land and light-vessel stations. For compressing air for the reed-horns as well as sirens, caloric, steam, gas and oil engines have been variously used, according to local circumstances. The reed-horn was improved by Professor Holmes, and many examples from his designs are now in use in England and America. At the Trinity House experiments with fog signals at St Catherine's (1901) several types of reed-horn were experimented with. The Trinity House service horn uses air at 15 ℔ pressure with a consumption of .67 cub. ft. per second and 397 vibrations. A small manual horn of the Trinity House type consumes .67 cub. ft. of air at 5 ℔ pressure. The trumpets of the latter are of brass.

Sirens.—The most powerful and efficient of all compressed air fog signals is the siren. The principle of this instrument may be briefly explained as follows:—It is well known that if the tympanic membrane is struck periodically and with sufficient rapidity by air impulses or waves a musical sound is produced. Robinson was the first to construct an instrument by which successive puffs of air under pressure were ejected from the mouth of a pipe. He obtained this effect by using a stop-cock revolving at high speed in such a manner that 720 pulsations per second were produced by the intermittent escape of air through the valves or ports, a smooth musical note being given. Cagniard de la Tour first gave such an instrument the name of siren, and constructed it in the form of an air chamber with perforated lid or cover, the perforations being successively closed and opened by means of a similarly perforated disk fitted to the cover and revolving at high speed. The perforations being cut at an angle, the disk was self-rotated by the oblique pressure of the air in escaping through the slots. H. W. Dove and Helmholtz introduced many improvements, and Brown of New York patented, about 1870, a steam siren with two disks having radial perforations or slots. The cylindrical form of the siren now generally adopted is due to Slight, who used two concentric cylinders, one revolving within the other, the sides being perforated with vertical slots. To him is also due the centrifugal governor largely used to regulate the speed of rotation of the siren. Over the siren mouth is placed a conical trumpet to collect and direct the sound in the desired direction. In the English service these trumpets are generally of considerable length and placed vertically, with bent top and bell mouth. Those at St Catherine's are of cast-iron with copper bell mouth, and have a total axial length of 22 ft. They are 5 in. in diameter at the siren mouth, the bell mouth being 6 ft. in diameter. At St Catherine's the sirens are two in number, 5 in. in diameter, being sounded simultaneously and in unison (fig. 53). Each siren is provided with ports for producing a high note as well as a low note, the two notes being sounded in quick succession once every minute. The trumpet mouths are separated by an angle of 120° between their axes. This double form has been adopted in certain instances where the angle desired to be covered by the sound is comparatively wide. In Scotland the cylindrical form is used generally, either automatically or motor driven. By the latter means the admission of air to the siren can be delayed until the cylinder is rotating at full speed, and a much sharper sound is produced than in the case of the automatic type. The Scottish trumpets are frequently constructed so that the greater portion of the length is horizontal. The Girdleness trumpet has an axial length of 16 ft., 11 ft. 6 in. being horizontal. The trumpet is capable of being rotated through an angle as well as dipped below the horizon. It is of cast-iron, no bell mouth is used, and the conical mouth is 4 ft. in diameter. In France the sirens are cylindrical and very similar to the English self-driven type. The trumpets have a short axial length, 4 ft. 6 in., and are of brass, with bent bell mouth. The Trinity House has in recent years reintroduced the use of disk sirens, with which experiments are still being carried out both in the United Kingdom and abroad. For light-vessels and rock stations where it is desired to distribute the sound equally in all directions the mushroom-head trumpet is occasionally used. The Casquets trumpet of this type is 22 ft. in length, of cast-iron, with a mushroom top 6 ft. in diameter. In cases where neither the mushroom trumpet nor the twin siren is used the single bent trumpet is arranged to rotate through a considerable angle. Table IV. gives particulars of a few typical sirens of the most recent form.

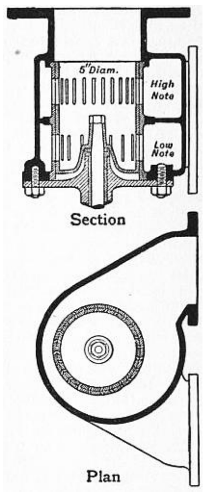


Fig. 53.—St Catherine's Double-noted Siren.

Table IV.

Station.	Description.	Vibrations per sec.		Sounding Pressure in lb per sq. in.	Cub. ft. of air used per sec. of blast reduced to atmospheric pressure.		Remarks.
		High.	Low.		High.	Low.	
St Catherine's (Trinity House)	Two 5-in. cylindrical, automatically driven sirens	295	182	25	32	16	The air consumption is for 2 sirens.
Girdleness (N.L.C)	7-in. cylindrical siren, motor driven	234	100	30	130	26	
Casquets (Trinity House)	7-in. disk siren, motor driven	..	98	25	..	36	
French pattern siren	6-in. cylindrical siren,	326	..	28	14	..	A uniform note of 326

	automatically driven						vibrations per sec. has now been adopted generally in France.

Since the first trial of the siren at the South Foreland in 1873 a very large number of these instruments have been established both at lighthouse stations and on board light-vessels. In all cases in Great Britain and France they are now supplied with air compressed by steam or other mechanical power. In the United States and some other countries steam, as well as compressed air, sirens are in use.

Diaphones.—The diaphone is a modification of the siren, which has been largely used in Canada since 1903 in place of the siren. It is claimed that the instrument emits a note of more constant pitch than does the siren. The distinction between the two instruments is that in the siren a revolving drum or disk alternately opens and closes elongated air apertures, while in the diaphone a piston pulsating at high velocity serves to alternately cover and uncover air slots in a cylinder.

The St Catherine’s Experiments.—Extensive trials were carried out during 1901 by the Trinity House at St Catherine’s lighthouse, Isle of Wight, with several types of sirens and reed-horns. Experiments were also made with different pattern of trumpets, including forms having elliptical sections, the long axis being placed vertically. The conclusions of the committee may be briefly summarized as follows: (1) When a large arc requires to be guarded two fixed trumpets suitably placed are more effective than one large trumpet capable of being rotated. (2) When the arc to be guarded is larger than that effectively covered by two trumpets, the mushroom-head trumpet is a satisfactory instrument for the purpose. (3) A siren rotated by a separate motor yields better results than when self-driven. (4) No advantage commensurate with the additional power required is obtained by the use of air at a higher pressure than 25 ℔ per sq. in. (5) The number of vibrations per second produced by the siren or reed should be in unison with the proper note of the associated trumpet. (6) When two notes of different pitch are employed the difference between these should, if possible, be an octave. (7) For calm weather a low note is more suitable than a high note, but when sounding against the wind and with a rough and noisy sea a high note has the greater range. (8) From causes which cannot be determined at the time or predicted beforehand, areas sometimes exist in which the sounds of fog signals may be greatly enfeebled or even lost altogether. This effect was more frequently observed during comparatively calm weather and at no great distance from the signal station. (It has often been observed that the sound of a signal may be entirely lost within a short distance of the source, while heard distinctly at a greater distance and at the same time.) (9) The siren was the most effective signal experimented with; the reed-horn, although inferior in power, is suitable for situations of secondary importance. (No explosive signals were under trial during the experiments.) (10) A fog signal, owing to the uncertainty attending its audibility, must be regarded only as an auxiliary aid to navigation which cannot at all times be relied upon.

Submarine Bell Signals.—As early as 1841 J. D. Colladon conducted experiments on the lake of Geneva to test the suitability of water as a medium for transmission of sound signals and was able to convey distinctly audible sounds through water for a distance of over 21 m., but it was not until 1904 that any successful practical application of this means of signalling was made in connexion with light-vessels. There are at present (1910) over 120 submarine bells in service, principally in connexion with light-vessels, off the coasts of the United Kingdom, United States, Canada, Germany, France and other countries. These bells are struck by clappers actuated by pneumatic or electrical mechanism. Other submerged bells have been fitted to buoys and beacon structures, or placed on the sea bed; in the former case the bell is actuated by the motion of the buoy and in others by electric current, transmitted by cable from the shore. In some cases, when submarine bells are associated with gas buoys or beacons, the compressed gas is employed to actuate the bell striking mechanism. To take full advantage of the signals thus provided it is necessary for ships approaching them to be fitted with special receiving mechanism of telephonic character installed below the water line and in contact with the hull plating. The signals are audible by the aid of ear pieces similar to ordinary telephone receivers. Not only can the bell signals be heard at considerable distances—frequently over 10 m.—and in all conditions of weather, but the direction of the bell in reference to the moving ship can be determined within narrow limits. The system is likely to be widely extended and many merchant vessels and war ships have been fitted with signal receiving mechanism.

The following table (V.) gives the total numbers of fog signals of each class in use on the 1st of January 1910 in certain countries.

Table V.

	Sirens.	Diaphone.	Horns, Trumpets, &c.		Whistles.	Explosive Signals (tonite, &c.).	Guns.	Bells.	Gongs.	Submarine Bells.	Totals.
			Power.	Manual.							
England and Channel Islands	44	..	27	31	2	15	..	48	10	16	193
Scotland and Isle of Man	35	..	6	2	..	5	..	16	3	..	67
Ireland	12	..	2	6	..	11	3	11	..	3	48
France	12	..	7	1	..	1	..	25	..	2	48
United States (excluding inland lakes and rivers)	43	..	35	15	59	..	..	218	1	36	407
British North America (excluding inland lakes and rivers)	6	66	5	79	16	8	..	24	..	11	215

When two kinds of signal are employed at any one station, one being subsidiary, the latter is omitted from the enumeration. Buoy and unattended beacon bells and whistles are also omitted, but local port and harbour signals not under the immediate jurisdiction of the various lighthouse boards are included, more especially in Great Britain.

11. Lighthouse Administration. The principal countries of the world possess organized and central authorities responsible for the installation and maintenance of coast lights and fog signals, buoys and beacons.

United Kingdom.—In England the corporation of Trinity House, or according to its original charter, “The Master Wardens, and Assistants of the Guild Fraternity or Brotherhood of the most glorious and undivided Trinity and of St Clement, in the Parish of Deptford Strond, in the county of Kent,” existed in the reign of Henry VII. as a religious house with certain duties connected with pilotage, and was incorporated during the reign of Henry VIII. In 1565 it was given certain rights to maintain beacons, &c., but not until 1680 did it own any lighthouses. Since that date it has gradually purchased most of the ancient privately owned lighthouses and has erected many new ones. The act of 1836 gave the corporation control of English coast lights with certain supervisory powers over the numerous local lighting authorities, including the Irish and Scottish Boards. The corporation now consists of a Master, Deputy-master, and 22 Elder Brethren (10 of whom are honorary), together with an unlimited number of Younger Brethren, who, however, perform no executive duties. In Scotland and the Isle of Man the lights are under the control of the Commissioners of Northern Lighthouses constituted in 1786 and incorporated in 1798. The lighting of the Irish coast is in the hands of the Commissioners of Irish Lights formed in 1867 in succession to the old Dublin Ballast Board. The principal local light boards in the United Kingdom are the Mersey Docks and Harbour Board, and the Clyde Lighthouse Trustees. The three general lighthouse boards of the United Kingdom, by the provision of the Mercantile Marine Act of 1854, are subordinate to the Board of Trade, which controls all finances.

On the 1st of January 1910 the lights, fog signals and submarine bells in service under the control of the several authorities in the United Kingdom were as follows:

	Light-houses.	Light-vessels.	Fog Signals.	Submarine Bells.
Trinity House	116	51	97	12
Northern Lighthouse Commissioners	138	5	44	..
Irish Lights Commissioners	93	11	35	3
Mersey Docks and Harbour Board	16	6	13	2
Admiralty	31	2	6	..
Clyde Lighthouse Trustees	14	1	5	..
Other local lighting authorities	809	11	89	2
Totals	1217	87	289	19

Some small harbour and river lights of subsidiary character are not included in the above total.

United States.—The United States Lighthouse Board was constituted by act of Congress in 1852. The Secretary of Commerce and Labor is the ex-officio president. The board consists of two officers of the navy, two engineer officers of the army, and two civilian scientific members, with two secretaries, one a naval officer, the other an officer of engineers in the army. The members are appointed by the president of the United States. The coast-line of the states, with the lakes and rivers and Porto Rico, is divided into 16 executive districts for purposes of administration.

The following table shows the distribution of lighthouses, light-vessels, &c., maintained by the lighthouse board in the United States in June 1909. In addition there are a few small lights and buoys privately maintained.

Lighthouses and beacon lights	1333
Light-vessels in position	53
Light-vessels for relief	13

Gas lighted buoys in position	94
Fog signals operated by steam or oil engines	228
Fog signals operated by clockwork, &c.	205
Submarine signals	43
Post lights	2333
Day or unlighted beacons	1157
Bell buoys in position	169
Whistling buoys in position	94
Other buoys	5760
Steam tenders	51
Constructional Staff	318
Light keepers; and light attendants	3137
Officers and crews of light-vessels and tenders	1693

France.—The lighthouse board of France is known as the Commission des Phares, dating from 1792 and remodelled in 1811, and is under the direction of the minister of public works. It consists of four engineers, two naval officers and one member of the Institute, one inspector-general of marine engineers, and one hydrographic engineer. The chief executive officers are an Inspecteur Général des Ponts et Chaussées, who is director of the board, and another engineer of the same corps, who is engineer-in-chief and secretary. The board has control of about 750 lights, including those of Corsica, Algeria, &c. A similar system has been established in Spain.

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Table VI.—*Electric Lighthouse Apparatus.*

Name.	Characteristic.	Period.	Duration of Flash.	Candle-power (Service Intensity).	Focal Distance of Lens.	Ratio of Angular Breadth of Panel to Whole Circle.	Current.	Voltage.	Carbons.	Electric Generato
		Secs.	Secs.	Standard Candles.	mm.		Amps.		mm.	
United Kingdom—										
Souter Point (Durham)	Single flash	30	5	Candle-power not officially determined.	500	1 : 8	..	40	17	Holmes machine alternating revs.)
South Foreland (Kent)	Single flash	2.5	.35		700	1 : 16	..	40	26	do.
Lizard (Cornwall)	Single flash	3	.13		700	1 : 4	145 for 50 mm. carbons	40	50 and 60 fluted	De Merite alternators revs.)
St Catherine’s (Isle of Wight)	Single flash	5	.21		700	1 : 4	145 for 50 mm. carbons	40	50 and 60 fluted	do.
Isle of May (Firth of Forth)	4 flash	30	.4		700 (Fixed apparatus)	1 : 8	220	40	40	do.
France—										
Dunkerque (Strait of Dover)	2 flash	10	.2 to .4	3,500,000 to 6,500,000	300	1 : 12	30 and 60	45	14 and 18	2 De Merit alternators, of 5.5 k.w. revs.)
Calais (Strait of Dover) [Les Baleines (1882) similar]	4 flash	15	.75	900,000	300	1 : 24	60	45	18	do.
Cap Gris-nez (Strait of Dover)	Single flash	5	.10 to .14	15,000,000 to 30,000,000	300	1 : 4	60 to 120	45	18 and 28	do.
La Canche (Strait of Dover)	2 flash	10	.10 to .14	15,000,000 to 30,000,000	300	1 : 4	30 to 60	45	14 and 18	do.
Cap de la Hève (Havre, English Channel) [Île d’Yeu in the Bay of Biscay (1895) similar]	Single flash	5	.10 to .14	10,000,000 to 20,000,000	300	1 : 4	60 to 120	45	18 and 28	De Merite alternators revs.)
Créac’h d’Ouessant (Ushant) [Barfleur (English Channel) 1903, La Coubre (Bay of Biscay) 1905, and Belle Île (Bay of Biscay) 1903, similar]	2 flash	10	.10 to .14	15,000,000 to 30,000,000	300	1 : 4	60 to 120	45	18 and 28	2 De Merit alternators, of 5.5 k.w. revs.)
Penmarc’h (Phare d’Eckmühl) (Finistère)	Single flash	5	.10 to .14	15,000,000 to 30,000,000	300	1 : 4	30 and 60	45	14 and 18	Two-pha Labour alternators to 820 rev
Planier (near Marseilles)	Single flash	5	.10 to .14	15,000,000 to 30,000,000	300	1 : 4	30 to 60	45	14 to 18	De Merite alternators revs.)
Italy—										
Tino (Gulf of Spezia)	3 flash	30	1.25	Undetermined.	700	1 : 24	50 110 200	50	15 25 35	do. (830 revs
America—										
Navesink (Entrance to New York Bay)	Single flash	5	.08	About 60,000,000	700	Nearly 1 : 2	Max. 100	50	23	Alternati dynamos (revs.)
Australia—										
Macquarie (Sydney, N.S.W.)	Single flash	60	8	5,000,000	920	1 : 16	55 110	50	15 25	De Merite alternators revs.)

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Table VII.—*Typical Non-Electric Lighthouse Apparatus.*

Name.	Locality.	Characteristic.	Period.	Duration of Flashes.	Candle-Power in Standard Candles (Service Intensity).	Focal Distance of Lens.	Ratio of Angular Breadth of Panel to Whole Circle.	Illuminant.	Burner.
			Secs.	Secs.		mm.			
Casquets	Channel Islands	3 flash	30	1.5	185,000	920	1 : 9	Incandescent petroleum vapour	“Matthews” 3 50 mm. dia. mantles
Eddystone	South Devon	2 flash	30	1.5	292,000	920	1 : 12	do.	do.
Bishop Rock	Scilly Isles	2 flash	60	4.0	622,000	1330	1 : 10	do.	do.
Spurn Point	Yorkshire	Single flash	20	1.5	519,000	1330	1 : 6	do.	do.
Lundy Island	Bristol Channel	2 flash	20	.33	374,000	920	Nearly 1 : 4	do.	do.
Pendeen	Cornwall	4 flash	15	.25	190,000	920	1 : 8	do.	do.

Roker Pier	Sunderland	Single flash	5	.10	175,000	500	Nearly 1 : 2	do.	“Chance” 55 mm. dia. mantle
Bell Rock	Near Firth of Tay	Red and white flashes alternately every 30 secs.	60	.50	392,000	920 and 1330	White about 1 : 9 red about 1 : 2.2	do.	“Chance” 55 mm. dia. mantle
Kinnaird’s Head	Aberdeenshire	Single flash	15	.50	881,000	920 and 1330	1 : 2.2	do.	do.
Tarbet Ness	Dornoch Firth	6 flash	30	.50	89,000	700	1 : 12	do.	“Chance” 55 mm. dia. mantle
Sule Skerry	West of Orkneys	3 flash	30	1.0	378,000	1330	1 : 9	do.	“Chance” 85 mm. dia. mantle
Pladda	South end of Arran Island	3 flash	30	.50	597,000	1330	1 : 6	do.	do.
Tory Island	Co. Donegal	3 flash	60	3.0	17,000 to 326,000	1330	1 : 6	Coal Gas	Wigham, 108 jets (maximum)
Fastnet	Co. Cork	Single flash	5	.17	750,000	920	1 : 4	Incandescent petroleum vapour	Irish pattern 50 mm. mantle
Kinsale	do.	2 flash	10	.25	460,000	920	1 : 6	do.	do.
Howth Bailey	Dublin Bay	Single flash	30	1.0	950,000	920	13 : 32	do.	Irish pattern 3-50 mm. dia. mantles
Chassiron	Bay of Biscay	Single flash	10	1.0	70,000	920	1 : 8	Oil	6 wick
				.50	180,000	920	1 : 8	Incandescent oil gas	30 mm. dia. mantle
				.70	360,000	920	1 : 8	Incandescent acetylene	55 mm. dia. mantle
Cap d’Antifer	English Channel	Single flash	20	1.0	400,000	1330	1 : 6	Incandescent petroleum vapour	French pattern 85 mm. mantle
Île de Batz	Finistère	4 flash	25	.37	200,000	920	1 : 8	do.	do.
Ar’men	do.	3 flash	20	.38	200,000	700	1 : 5	do.	do.
Villefranche	Mediterranean	Single flash	5	.38	250,000	700	1 : 4	do.	do.
Île Vierge	Finistère	Single flash	5	.38	500,000	700	1 : 4	do.	do.
Kennery Island	Bombay	2 flash	10	.25	250,000	920	Nearly 1:4	do.	70 mm. dia. mantle
Cape Race	Newfoundland	Single flash	7.5	.30	1,100,000	1330	1 : 4	do.	“Chance” 85 mm. dia. mantle
Pachena Point	British Columbia	2 flash	7.5	.44	220,000	920	1 : 8	do.	do.
Cape Hermes	Cape Colony	Single flash	3	.31	30,000	250	1 : 3	do.	“Chance” 55 mm. dia. mantle
Hood Point	do.	4 flash	40	.58	200,000	920	1 : 8	do.	“Chance” 85 mm. dia. mantle
Cape Naturaliste	West Australia	2 flash	10	.15	450,000	920	About 1 : 3	do.	do.
Point Cloates	do.	Single flash	5	.30	300,000	700	1 : 3	do.	do.
Pecks Ledge	Connecticut, U.S.A.	2 flash	30	.50	10,000	250	1 : 4	do.	34 mm. dia. mantle
Fire Island	New York, U.S.A.	Single flash	60	4.0	250,000	920	1 : 8	do.	55 mm. dia. mantle
Gray’s Harbor	Washington, Pacific Coast, U.S.A.	Alternating red and white flashes	5	.20	White 10,000 red 8,000	500	..	Oil	3 wick

* The dates given are of the establishment of the optical apparatus. In many cases incandescent bu

English Colonies.—In Canada the coast lighting is in the hands of the minister of marine, and in most other colonies the public works departments have control of lighthouse matters. 651

Other Countries.—In Denmark, Austria, Holland, Russia, Sweden, Norway and many other countries the minister of marine has charge of the lighting and buoying of coasts; in Belgium the public works department controls the service.

In the Trinity House Service at shore lighthouse stations there are usually two keepers, at rock stations three or four, one being ashore on leave. When there is a fog signal at a station there is usually an additional keeper, and at electric light stations a mechanical engineer is also employed as principal keeper. The crews of light-vessels as a rule consist of 11 men, three of them and the master or mate going on shore in rotation.

The average annual cost of maintenance of an English shore lighthouse, with two keepers, is £275. For shore lighthouses with three keepers and a siren fog signal the average cost is £444. The maintenance of a rock lighthouse with four keepers and an explosive fog signal is about £760, and an electric light station costs about £1100 annually to maintain.

A light-vessel of the ordinary type in use in the United Kingdom entails an annual expenditure on maintenance of approximately £1320, excluding the cost of periodical overhaul.

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(W. T. D.; N. G. G.)

1 A full account is given in Hermann Thiersch, *Pharos Antike, Islam und Occident* (1909). See also Minaret.

2 In 1901 one of the lights decided upon in 1886 and installed in 1888—Créac’h d’Ouessant—was replaced by a still more powerful twin apparatus exhibited at the 1900 Paris Exhibition. Subsequently similar apparatus to that at Créac’h were installed at Gris-Nez, La Canche, Planier, Barfleur, Belle-Île and La Coubre, and the old Dunkerque optic has been replaced by that removed from Belle-Île.

3 Both the Talais and Snouw light-vessels have since been converted into unattended light-vessels.

4 For the purposes of the mariner a light is classed as flashing or occulting solely according to the duration of light and darkness and without any reference to the apparatus employed. Thus, an occulting apparatus, in which the period of darkness is greater than that of light, is classed in the Admiralty “List of Lights” as a “flashing” light.

5 The Flamborough Head rocket was superseded by a siren fog signal in 1908.

LIGHTING.

LIGHTING. Artificial light is generally produced by raising some body to a high temperature. If the temperature of a solid body be greater than that of surrounding bodies it parts with some of its energy in the form of radiation. Whilst the temperature is low these radiations are not of a kind to which the eye is sensitive; they are exclusively radiations less refrangible and of greater wave-length than red light, and may be called infra-red. As the temperature is increased the infra-red radiations increase, but presently there are added radiations which the eye perceives as red light. As the temperature is further increased, the red light increases, and yellow, green and blue rays are successively thrown off. On raising the temperature to a still higher point, radiations of a wave-length shorter even than violet light are produced, to which the eye is insensitive, but which act strongly on certain chemical substances; these may be called ultra-violet rays. Thus a very hot body in general throws out rays of various wave-length; the hotter the body the more of every kind of radiation will it throw out, but the proportion of short waves to long waves becomes vastly greater as the temperature is increased. Our eyes are only sensitive to certain of these waves, viz. those not very long and not very short. The problem of the artificial production of light with economy of energy is the same as that of raising some body to such a temperature that it shall give as large a proportion as possible of those rays which the eye is capable of feeling. For practical purposes this temperature is the highest temperature we can produce. As an illustration of the luminous effect of the high temperature produced by converting other forms of energy into heat within a small space, consider the following statements. If burned in ordinary gas burners, 120 cub. ft. of 15 candle gas will give a light of 360 standard candles for one hour. The heat produced by the combustion is equivalent to about 60 million foot-pounds. If this gas be burned in a modern gas-engine, about 8 million foot-pounds of useful work will be done outside the engine, or about 4 horse-power for one hour. If this be used to drive a dynamo for one hour, even if the machine has an efficiency of only 80%, the energy of the current will be about 6,400,000 foot-pounds per hour, about half of which, or only 3,200,000 foot-pounds, is converted into radiant energy in the electric arc. But this electric arc will radiate a light of 2000 candles when viewed horizontally, and two or three times as much when viewed from below. Hence 3 million foot-pounds changed to heat in the electric arc may be said roughly to affect our eyes six times as much as 60 million foot-pounds changed to heat in an ordinary gas burner.

Owing to the high temperature at which it remains solid, and to its great emissive power, the radiant body used for artificial illumination is usually some form of carbon. In an oil or ordinary coal-gas flame this carbon is present in minute particles derived from the organic substances with which the flame is supplied and heated to incandescence by the heat liberated in their decomposition, while in the electric light the incandescence is the effect of the heat developed by the electric current passed through a resisting rod or filament of carbon. In some cases, however, other substances replace carbon as the radiating body; in the incandescent gas light certain earthy oxides are utilized, and in metallic filament electric lamps such metals as tungsten or tantalum.

1. Oil Lighting

Vegetable and animal oils.

From the earliest times the burning of oil has been a source of light, but until the middle of the 19th century only oils of vegetable and animal origin were employed in indoor lamps for this purpose. Although many kinds were used locally, only colza and sperm oils had any very extended use, and they have been practically supplanted by mineral oil, which was introduced as an illuminant in 1853. Up to the latter half of the 18th century the lamps were shallow vessels into which a short length of wick dipped; the flame was smoky and discharged acrid vapours, giving the minimum of light with the maximum of smell. The first notable improvement was made by Ami Argand in 1784. His burner consisted of two concentric tubes between which the tubular wick was placed; the open inner tube led a current of air to play upon the inner surface of the circular flame, whilst the combustion was materially improved by placing around the flame a chimney which rested on a perforated gallery a short distance below the burner. Argand’s original burner is the parent form of innumerable modifications, all more or less complex, such as the Carcel and the moderator.

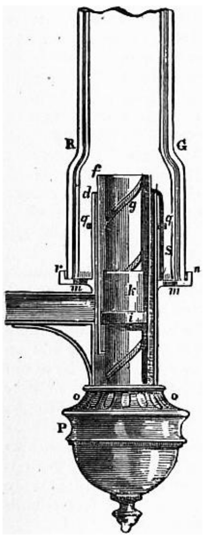

Fig. 1.

A typical example of the Argand burner and chimney is represented in fig. 1, in which the burner is composed of three tubes, *d*, *f*, *g*. The tube *g* is soldered to the bottom of the tube *d*, just above *o*, and the interval between the outer surface of the tube *g* and the inner surface of the tube *d* is an annular cylindrical cavity closed at the bottom, containing the cylindrical cotton wick immersed in oil. The wick is fixed to the wick tube *ki*, which is capable of being moved spirally; within the annular cavity is also the tube *f*, which can be moved round, and serves to elevate and depress the wick. P is a cup that screws on the bottom of the tube *d*, and receives the superfluous oil that drops down from the wick along the inner surface of the tube *g*. The air enters through the holes *o*, *o*, and passes up through the tube *g* to maintain the combustion in the interior of the circular flame. The air which maintains the combustion on the exterior part of the wick enters through the holes *m*, with which rn is perforated. When the air in the chimney is rarefied by the heat of the flame, the surrounding heavier air, entering the lower part of the chimney, passes upward with a rapid current, to restore the equilibrium. RG is the cylindrical glass chimney with a shoulder or constriction at R, G. The oil flows from a side reservoir, and occupies the cavity between the tubes *g* and *d*. The part *ki* is a short tube, which receives the circular wick, and slides spirally on the tube *g*, by means of a pin working in the hollow spiral groove on the exterior surface of *g*. The wick-tube has also a catch, which works in a perpendicular slit in the tube *f*; and, by turning the tube *f*, the wick-tube will be raised or lowered, for which purpose a ring, or gallery, *rn*, fits on the tube *d*, and receives the glass chimney RG; a wire S is attached to the tube *f*, and, bending over, descends along the outside of *d*. The part *rn*, that supports the glass chimney, is connected by four other wires with the ring *q*, which surrounds the tube *d*, and can be moved round. When *rn* is turned round, it carries with it the ring *q*, the wire S, and the tube *f*, thus raising or depressing the wick. 652

A device in the form of a small metallic disk or button, known as the Liverpool button from having been first adopted in the so-called Liverpool lamp, effects for the current of air passing up the interior of the Argand burner the same object as the constriction of the chimney RG secures in the case of the external tube. The button fixed on the end of a wire is placed right above the burner tube *g*, and throws out equally all round against the flame the current of air which passes up through *g*. The result of these expedients, when properly applied, is the production of an exceedingly solid brilliant white light, absolutely smokeless, this showing that the combustion of the oil is perfectly accomplished.

The means by which a uniformly regulated supply of oil is brought to the burner varies with the position of the oil reservoir. In some lamps, not now in use, by ring-formed reservoirs and other expedients, the whole of the oil was kept as nearly as possible at the level of the burner. In what are termed fountain reading, or study lamps, the principal reservoir is above the burner level, and various means are adopted for maintaining a supply from them at the level of the burner. But the most convenient position for the oil reservoir in lamps for general use is directly under the burner, and in this case the stand of the lamp itself is utilized as the oil vessel. In the case of fixed oils, as the oils of animal and vegetable origin used to be called, it is necessary with such lamps to introduce some appliance for forcing a supply of oil to the burner, and many methods of effecting this were devised, most of which were ultimately superseded by the moderator lamp. The Carcel or pump lamp, invented by B. G. Carcel in 1800, is still to some extent used in France. It consists of a double piston or pump, forcing the oil through a tube to the burner, worked by clockwork.

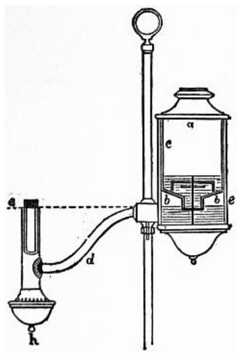

Fig. 2.—Section of Reading Lamp.

A form of reading lamp still in use is seen in section in fig. 2. The lamp is mounted on a standard on which it can be raised or lowered at will, and fixed by a thumb screw. The oil reservoir is in two parts, the upper *ac* being an inverted flask which fits into *bb*, from which the burner is directly fed through the tube *d*; *h* is an overflow cup for any oil that escapes at the burner, and it is pierced with air-holes for admitting the current of air to the centre tube of the Argand burner. The lamp is filled with oil by withdrawing the flask *ac*, filling it, and inverting it into its place. The under reservoir *bb* fills from it to the burner level *ee*, on a line with the mouth of *ac*. So soon as that level falls below the mouth of *ac*, a bubble of air gets access to the upper reservoir, and oil again fills up *bb* to the level *ee*.

The moderator lamp (fig. 3), invented by Franchot about 1836, from the simplicity and efficiency of its arrangements rapidly superseded almost all other forms of mechanical lamp for use with animal and vegetable oils. The two essential features of the moderator lamp are (1) the strong spiral spring which, acting on a piston within the cylindrical reservoir of the lamp, serves to propel the oil to the burner, and (2) the ascending tube C through which the oil passes upwards to the burner. The latter consist of two sections, the lower fixed to and passing through the piston A into the oil reservoir, and the upper attached to the burner. The lower or piston section moves within the

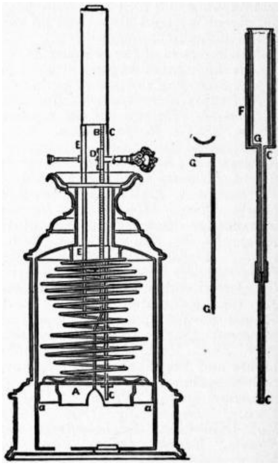

Fig. 3.—Section of Moderator Lamp.

upper, which forms a sheath enclosing nearly its whole length when the spring is fully wound up. Down the centre of the upper tube passes a wire, "the moderator," G, and it is by this wire that the supply of oil to the burner is regulated. The spring exerts its greatest force on the oil in the reservoir when it is fully wound up, and in proportion as it expands and descends its power decreases. But when the apparatus is wound up the wire passing down the upper tube extends throughout the whole length of the lower and narrower piston tube, obstructing to a certain extent the free flow of the oil. In proportion as the spring uncoils, the length of the wire within the lower tube is decreased; the upward flow of oil is facilitated in the same ratio as the force urging it upwards is weakened. In all mechanical lamps the flow is in excess of the consuming capacity of the burner, and in the moderator the surplus oil, flowing over the wick, falls back into the reservoir above the piston, whence along with new supply oil it descends into the lower side by means of leather valves *a*, *a*. B represents the rack which, with the pinion D, winds up the spiral spring hard against E when the lamp is prepared for use. The moderator wire is seen separately in GG; and FGC illustrates the arrangement of the sheathing tubes, in the upper section of which the moderator is fixed.

As early as 1781 the idea was mooted of burning naphtha, obtained by the distillation of coal at low temperatures, for illuminating purposes, and in 1820, when coal gas was struggling into prominence, light oils obtained by the distillation of coal tar were employed in the Holliday lamp, which is still the chief factor in illuminating the street barrow of the costermonger. In this lamp the coal naphtha is in a conical reservoir, from the apex of which it flows slowly down through a long metal capillary to a rose burner, which, heated up by the flame, vaporizes the naphtha, and thus feeds the ring of small jets of flame escaping from its circumference.

Mineral oils.

It was in 1847 that James Young had his attention drawn to an exudation of petroleum in the Riddings Colliery at Alfreton, in Derbyshire, and found that he could by distillation obtain from it a lubricant of considerable value. The commercial success of this material was accompanied by a failure of the supply, and, rightly imagining that as the oil had apparently come from the Coal Measures, it might be obtained by distillation from material of the same character, Young began investigations in this direction, and in 1850 started distilling oils from a shale known as the "Bathgate mineral," in this way founding the Scotch oil industry. At first little attention was paid to the fitness of the oil for burning purposes, although in the early days at Alfreton Young attempted to burn some of the lighter distillates in an Argand lamp, and later in a lamp made many years before for the consumption of turpentine. About 1853, however, it was noticed that the lighter distillates were being shipped to Germany, where lamps fitted for the consumption of the grades of oil now known as lamp oil were being made by Stohwasser of Berlin; some of these lamps were imported, and similar lamps were afterwards manufactured by Laidlaw in Edinburgh. 653

In Pennsylvania in 1859 Colonel E. L. Drake's successful boring for petroleum resulted in the flooding of the market with oil at prices never before deemed possible, and led to the introduction of lamps from Germany for its consumption. Although the first American patent for a petroleum lamp is dated 1859, that year saw forty other applications, and for the next twenty years they averaged about eighty a year.

English lamp-makers were not behind in their attempts to improve on the methods in use for producing the highest results from the various grades of oil, and in 1865 Hinks introduced the duplex burner, while later improvements made in various directions, by Hinks, Silber, and Defries led to the high degree of perfection to be found in the lamps of to-day. Mineral oil for lamps as used in England at the present time may be defined as consisting of those portions of the distillate from shale oil or crude petroleum which have their flash-point above 73° F., and which are mobile enough to be fed by capillarity in sufficient quantity to the flame. The oil placed in the lamp reservoir is drawn up by the capillarity of the wick to the flame, and being there volatilized, is converted by the heat of the burning flame into a gaseous mixture of hydrogen and hydrocarbons, which is ultimately consumed by the oxygen of the air and converted into carbon dioxide and water vapour, the products of complete combustion.

To secure high illuminating power, together with a smokeless flame and only products of complete combustion, strict attention must be paid to several important factors. In the first place, the wick must be so arranged as to supply the right quantity of oil for gasification at the burner-head—the flame must be neither starved nor overfed: if the former is the case great loss of light is occasioned, while an excess of oil, by providing more hydrocarbons than the air-supply to the flame can completely burn, gives rise to smoke and products of incomplete combustion. The action of the wick depending on the capillary action of the microscopic tubes forming the cotton fibre, nothing but long-staple cotton of good quality should be employed; this should be spun into a coarse loose thread with as little twist in it as possible, and from this the wick is built up. Having obtained a wick of soft texture and loose plait, it should be well dried before the fire, and when put in position in the lamp must fill the wick-holder without being compressed. It should be of sufficient length to reach to the bottom of the oil reservoir and leave an inch or two on the bottom. Such a wick will suck up the oil in a regular and uniform way, provided that the level of the oil is not allowed to fall too low in the lamp, but it must be remembered that the wick acts as a filter for the oil, and that if any sediment be present it will be retained by and choke the capillaries upon which the action of the wick depends, so that a wick should not be used for too long a time. A good rule is that the wick should, when new, trail for 2 in. on the bottom of the oil vessel, and should be discarded when these 2 in. have been burnt off.

When the lamp is lighted the oil burns with a heavy, smoky flame, because it is not able to obtain sufficient oxygen to complete the combustion, and not only are soot flakes produced, but products of incomplete combustion, such as carbon monoxide and even petroleum vapour, escape—the first named highly injurious to health, and the second of an offensive odour. To supply the *necessary amount of air* to the flame, an artificial draught has to be created which shall impinge upon the bottom of the flame and sweep upwards over its surface, giving it rigidity, and by completing the combustion in a shorter period of time than could be done otherwise, increasing the calorific intensity and thus raising the carbon particles in the flame to a far higher incandescence so as to secure a greater illuminating power. This in practice has been done in two ways, first by drawing in the air by the up-suck of the heated and expanded products of combustion in a chimney fitted over the flame, and secondly by creating a draught from a small clockwork fan in the base of the lamp. It is necessary to break the initial rush of the draught: this is mostly effected by disks of perforated metal in the base of the burner, called *diffusers*, while the metal dome which surrounds and rises slightly above the wick-holder serves to deflect the air on to the flame, as in the Wanzer lamp. These arrangements also act to a certain extent as regenerators, the air passing over the heated metal surfaces being warmed before reaching the flame, whilst disks, cones, buttons, perforated tubes, inner air-tubes, &c., have been introduced to increase the illuminating power and complete the combustion.

Table I.

Type.	Name.	Grains of Oil per candle-power per hour.		Total Candle-power.	
		American.	Russian.	American.	Russian.
Circular wick	Veritas, 60-line	64.5	112.5	122.5	78
	Veritas, 30-line	42.5	50.	60	60
	Veritas, 20-line	43.75	58.5	40	35
	Ariel, 12-line center draught	52.8	70.9	18	18
	Reading, 14-line	97.9	85.4	12	12
	Kosmos, 10-line	63.9	97.2	9	9
	Wizard, 15-line	56.9	51.3	18	19
Flat wick, single	Wanzer, no glass	42.6	48.3	17	17
	Solid slip, gauze and cone	84.4	84.4	8	8
	Old slip, fixed gauze	60.9	89.3	7	7
Flat wick, duplex	Feeder wick	56.2	55.7	20	22
	Ordinary	51.2	46.6	20	22

American oil—Sp. gr. 0.7904; flash-point, 110°F. Russian oil—Sp. gr. 0.823; flash-point, 83° F.

According to Sir Boverton Redwood, duplex burners which give a flame of 28 candle-power have an average oil consumption of 50 grains per candle per hour, while Argand flames of 38 candle-power consume about 45 grains of oil per candle per hour. These figures were obtained from lamps of the best types, and to obtain information as to the efficiency of the lamps used in daily practice, a number of the most popular types were examined, using both American and Russian oil. The results obtained are embodied in Table 1. The first noteworthy point in this table is the apparent superiority of the American over Russian oil in the majority of the lamps employed, and there is no doubt that the bulk of the lamps on the market are constructed to burn American or shale oil. A second interesting point is that with the flat-flame lamps the Russian oil is as good as the American. We have Redwood's authority, moreover, for the fact that after prolonged burning the Russian oil, even in lamps least suited to it, gives highly improved results. Although the average consumption with these lamps is close upon 60 grains per candle with American oil, yet some of the burners are so manifestly wasteful that 50 grains per candle-power per hour is the fairest basis to take for any calculation as to cost.

The dangers of the mineral oil lamp, which were a grave drawback in the past, have been very much reduced by improvements in construction and quality, and if it were possible to abolish the cheap and dangerous rubbish sold in poor neighbourhoods, and to prevent the use of side-fillers and glass reservoirs in lamps of better quality, a still larger reduction in the number of accidents would take place. In the use of the lamp for domestic purposes only soft well-fitting wicks should be employed, and the lamp should be filled with oil each day so as never to allow it to burn too low and so leave a large space above the surface of the oil in the reservoir. The lamp should never be moved whilst alight, and it should only be put out by means of a proper extinguisher or by blowing across the top instead of down the chimney. By these means the risk of accident would be so reduced as to compare favourably with other illuminants.

Candles, oil and coal gas all emit the same products of complete combustion, viz. carbon dioxide and water vapour. The quantities of these compounds emitted from different illuminants for every candle of light per hour will be seen from the following table:

	Cubic Feet per Candle.	
Illuminant.	Carbon Dioxide.	Water Vapour.
Sperm candle	0.41	0.41
Oil lamp	0.24	0.18
Gas—Flat flame	0.26	0.67
Argand	0.17	0.45
Regenerative	0.07	0.19
Incandescent	0.03	0.08

From these data it appears that if the sanitary condition of the air of a dwelling-room be measured by the amount of carbon dioxide present, as is usually done, candles are the most prejudicial to health and comfort, oil lamps less so, and gas least, an assumption which practical experience does not bear out. The explanation of this is to be found in these facts: First, where we illuminate a room with candles or oil we are contented with a less intense and more local light than when we are using gas, and in a room of ordinary size would be more likely to use a lamp or two candles than the far higher illumination we should demand if gas were employed. Secondly, the amount of water vapour given off during the combustion of gas is greater than in the case of the other illuminants, and water vapour absorbing radiant heat from the burning gas becomes heated, and, diffusing itself about the room, causes great oppression. Also the air, being highly charged with moisture, is unable to take up so rapidly the water vapour which is always evaporating from the surface of our skin, and in this way the functions of the body receive a slight check, resulting in a feeling of depression. 654

Oil-spray lamps.

A very successful type of oil lamp for use in engineering is represented by the Lucigen, Doty, and Wells lights, in which the oil is forced from a reservoir by air-pressure through a spiral heated by the flame of the lamp, and the heated oil, being then ejected partly as vapour and partly as spray, burns with a large and highly luminous flame. The great drawback to these devices is that a certain proportion of the oil spray escapes combustion and is deposited in the vicinity of the light. This form of lamp is often used for heating as well as lighting; the rivets needed for the Forth Bridge were heated in trays by lamps of this type at the spot where they were required. The great advantage of these lamps was that oils of little value could be employed, and the light obtained approximated to 750 candles per gallon of oil consumed. They may to a certain extent be looked upon as the forerunners of perhaps the most successful form of incandescent oil-burner.

Oil applied to incandescent lighting.

As early as 1885 Arthur Kitson attempted to make a burner for heating purposes on the foregoing principle, *i.e.* by injecting oil under pressure from a fine tube into a chamber where it would be heated by the waste heat escaping from the flame below, the vapour so produced being made to issue from a small jet under the pressure caused by the initial air-pressure and the expansion in the gasifying tube. This jet of gas was then led into what was practically an atmospheric burner, and drew in with it sufficient air to cause its combustion with a non-luminous blue flame of great heating power. At the time when this was first done the Welsbach mantle had not yet reached the period of commercial utility, and attempts were made to use this flame for the generation of light by consuming it in a mantle of fine platinum gauze, which, although giving a very fine illuminating effect during the first few hours, very soon shared the fate of all platinum mantles—that is, carbonization of the platinum surface took place, and destroyed its power of light emissivity. It was not until 1893 that the perfecting of the Welsbach mantle enabled this method of consuming the oil to be employed. The Kitson lamp, and also the Empire lamp on a similar principle, have given results which ought to ensure their future success, the only drawback being that they need a certain amount of intelligent care to keep them in good working order.

Incandescent table-lamps.

Oil gas and oil vapours differ from coal gas merely in the larger proportion and greater complexity of the hydrocarbon molecules present, and to render the oil flame available for incandescent lighting it is only necessary to cause the oil gas or vapour to become mixed with a sufficient proportion of air before it arrives at the point of combustion. But with gases so rich in hydrocarbons as those developed from oil it is excessively difficult to get the necessary air intimately and evenly mixed with the gas in sufficient proportion to bring about the desired result. If even coal gas be taken and mixed with 2.27 volumes of air, its luminosity is destroyed, but such a flame would be useless with the incandescent mantle, as if the non-luminous flame be superheated a certain proportion of its luminosity will reappear. When such a flame is used with a mantle the superheating effect of the mantle itself very quickly leads to the decomposition of the hydrocarbons and blackening of the mantle, which not only robs it of its light-giving powers, but also rapidly ends its life. If, however, the proportion of air be increased, the appearance of the flame becomes considerably altered, and the hydrocarbon molecules being burnt up before impact with the heated surface of the mantle, all chance of blackening is avoided.

On the first attempts to construct a satisfactory oil lamp which could be used with the incandescent mantle, this trouble showed itself to be a most serious one, as although it was comparatively easy so to regulate a circular-wicked flame fed by an excess of air as to make it non-luminous, the moment the mantle was put upon this, blackening quickly appeared, while when methods for obtaining a further air supply were devised, the difficulty of producing a flame which would burn for a considerable time without constant necessity for regulation proved a serious drawback. This trouble has militated against most of the incandescent oil lamps placed upon the market.

It soon became evident that if a wick were employed the difficulty of getting it perfectly symmetrical was a serious matter, and that it could only be utilized in drawing the oil up to a heating chamber where it could be volatilized to produce the oil gas, which on then being mixed with air would give the non-luminous flame. In the earlier forms of incandescent oil lamps the general idea was to suck the oil up by the capillarity of a circular wick to a point a short distance below the opening of the burner at which the flame was formed, and here the oil was vaporized or gasified by the heat of the head of the burner. An air supply was then drawn up through a tube passing through the centre of the wick-tube, while a second air current was so arranged as to discharge itself almost horizontally upon the burning gas below the cap, in this way giving a non-luminous and very hot flame, which if kept very carefully adjusted afforded excellent results with an incandescent mantle. It was an arrangement somewhat of this character that was introduced by the Welsbach Company. The lamps, however, required such careful attention, and were moreover so irregular in their performance, that they never proved very successful. Many other forms have reached a certain degree of perfection, but have not so far attained sufficient regularity of action to make them commercial successes. One of the most successful was devised by F. Altmann, in which an ingenious arrangement caused the vaporization of oil and water by the heat of a little oil lamp in a lower and separate chamber, and the mixture of oil gas and steam was then burnt in a burner-head with a special arrangement of air supply, heating a mantle suspended above the burner-head.

The perfect petroleum incandescent lamp has not yet been made, but the results thus obtained show that when the right system has been found a very great increase in the amount of light developed from the petroleum may be expected. In one lamp experimented with for some time it was easy to obtain 3500 candle hours per gallon of oil, or three times the amount of light obtainable from the oil when burnt under ordinary conditions.

Air-gas.

Before the manufacture of coal-gas had become so universal as it is at present, a favourite illuminant for country mansions and even villages where no coal-gas was available was a mixture of air with the vapour of very volatile hydrocarbons, which is generally known as "air-gas." This was produced by passing a current of dry air through or over petroleum spirit or the light hydrocarbons distilled from tar, when sufficient of the hydrocarbon was taken up to give a luminous flame in flat flame and Argand burners in the same way as coal-gas, the trouble being that it was difficult to regulate the amount of hydrocarbon held in suspension by the air, as this varied very widely with the temperature. As coal-gas spread to the smaller villages and electric lighting became utilized in large houses, the use of air-gas died out, but with the general introduction of the incandescent mantle it again came to the front. In the earlier days of this revival, air-gas rich in hydrocarbon vapour was made and was further aerated to give a non-luminous flame by burning it in an atmospheric burner.

One of the best illustrations of this system was the Aerogene gas introduced by A. I. van Vriesland, which was utilized for lighting a number of villages and railway stations on the continent of Europe. In this arrangement a revolving coil of pipes continually dips into petroleum spirit contained in a cylinder, and the air passed into the cylinder through the coil of pipes becomes highly carburetted by the time it reaches the outlet at the far end of the cylinder. The resulting gas when burnt in an ordinary burner gives a luminous flame; it can be used in atmospheric burners differing little from those of the ordinary type. With an ordinary Welsbach "C" burner it gives a duty of about 30 candles per foot of gas consumed, the high illuminating power being due to the fact that the gas is under a pressure of from 6 to 8 in. With such a gas, containing a considerable percentage of hydrocarbon vapour, any leakage into the air of a room would give rise to an explosive mixture, in the same way that coal-gas would do, but inasmuch as mixtures of the vapour of petroleum spirit and air are only explosive for a very short range, that is, from 1.25 to 5.3%, some systems have been introduced in which by keeping the amount of petroleum vapour at 2% and burning the gas under pressure in a specially constructed non-aerating mantle burner, not only has it been found possible to produce a very large volume of gas per gallon of spirit employed, but the gas is itself non-explosive, increase in the amount of air taking it farther away from the explosive limit. The Hooker, De Laitte and several other systems have been based upon this principle. 655

2. Gas Lighting

In all measurements of illuminating value the standard of comparison used in England is the light yielded by a sperm candle of the size known as "sixes," *i.e.* six to the pound, consuming 120 grains of sperm per hour, and although in photometric work slight inequalities in burning have led to the candle being discarded in practice, the standard lamps burning pentane vapour which have replaced them are arranged to yield a light of ten candles, and the photometric results are expressed as before in terms of candles.

When William Murdoch first used coal-gas at his Redruth home in 1779, he burnt the gas as it escaped from the open end of a small iron tube, but soon realizing that this plan entailed very large consumption of gas and gave a very small amount of light, he welded up the end of his tube and bored three small holes in it, so arranged that they formed three divergent jets of flame. From the shape of the flame so produced this burner received the name of the “cockspur” burner, and it was the one used by Murdoch when in 1807 he fitted up an installation of gas lighting at Phillips & Lee’s works in Manchester. This—the earliest form of gas burner—gave an illuminating value of a little under one candle per cubic foot of gas consumed, and this duty was slightly increased when the burner was improved by flattening up the welded end of the tube and making a series of small holes in line and close together, the jets of flame from which gave the burner the name of the “cockscomb.” It did not need much inventive faculty to replace the line of holes by a saw-cut, the gas issuing from which burnt in a sheet, the shape of which led to the burner being called the “batswing.” This was followed in 1820 by the discovery of J. B. Neilson, of Glasgow, whose name is remembered in connexion with the use of the hot-air blast in iron-smelting, that, by allowing two flames to impinge upon one another so as to form a flat flame, a slight increase in luminosity was obtained, and after several preliminary stages the union jet or “fishtail” burner was produced. In this form of burner two holes, bored at the necessary angle in the same nipple, caused two streams of gas to impinge upon each other so that they flattened themselves out into a sheet of flame. The flames given by the batswing and fishtail burners differed in shape, the former being wide and of but little height, whilst the latter was much higher and more narrow. This factor ensured for the fishtail a greater amount of popularity than the batswing burner had obtained, as the flame was less affected by draughts and could be used with a globe, although the illuminating efficiency of the two burners differed little.

Regenerative burner.

In a lecture at the Royal Institution on the 20th of May 1853, Sir Edward Frankland showed a burner he had devised for utilizing the heat of the flame to raise the temperature of the air supply necessary for the combustion of the gas. The burner was an Argand of the type then in use, consisting of a metal ring pierced with holes so as to give a circle of small jets, the ring of flame being surrounded by a chimney. But in addition to this chimney, Frankland added a second external one, extending some distance below the first and closed at the bottom by a glass plate fitted air-tight to the pillar carrying the burner. In this way the air needed for the combustion of the gas had to pass down the space between the two chimneys, and in so doing became highly heated, partly by contact with the hot glass, and partly by radiation. Sir Edward Frankland estimated that the temperature of the air reaching the flame was about 500°F. In 1854 a very similar arrangement was brought forward by the Rev. W. R. Bowditch, and, as a large amount of publicity was given to it, the inception of the regenerative burner was generally ascribed to Bowditch, although undoubtedly due to Frankland.

The principle of regeneration was adopted in a number of lamps, the best of which was brought out by Friedrich Siemens in 1879. Although originally made for heating purposes, the light given by the burner was so effective and superior to anything obtained up to that time that it was with some slight alterations adapted for illuminating purposes.

Improvements followed in the construction and design of the regenerative lamp, and when used as an overhead burner it was found that not only was an excellent duty obtained per cubic foot of gas consumed, but that the lamp could be made a most efficient engine of ventilation, as an enormous amount of vitiated air could be withdrawn from the upper part of a room through a flue in the ceiling space. So marked was the increase in light due to the regeneration that a considerable number of burners working on this principle were introduced, some of them like the Wenham and Cromartie coming into extensive use. They were, however, costly to install, so that the flat flame burner retained its popularity in spite of the fact that its duty was comparatively low, owing to the flame being drawn out into a thin sheet and so exposed to the cooling influence of the atmosphere. Almost at the same time that Murdoch was introducing the cockscomb and cockspur burners, he also made rough forms of Argand burner, consisting of two concentric pipes between which the gas was led and burnt with a circular flame. This form was soon improved by filling in the space between the tubes with a ring of metal, bored with fine holes so close together that the jets coalesced in burning and gave a more satisfactory flame, the air necessary to keep the flame steady and ensure complete combustion being obtained by the draught created by a chimney placed around it. When it began to be recognized that the temperature of the flame had a great effect upon the amount of light emitted, the iron tips, which had been universally employed, both in flat flame and Argand burners, were replaced by steatite or other non-conducting material of similar character, to prevent as far as possible heat from being withdrawn from the flame by conduction.

In 1880 the burners in use for coal-gas therefore consisted of flat flame, Argand, and regenerative burners, and the duty given by them with a 16-candle gas was as follows:—

Burner.	Candle units per cub. ft. of gas.
Union jet flat flame, No. 0	0.59
″ ″ 1	0.85
″ ″ 2	1.22
″ ″ 3	1.63
″ ″ 4	1.74
″ ″ 5	1.87
″ ″ 6	2.15
″ ″ 7	2.44
Ordinary Argand	2.90
Standard Argand	3.20
Regenerative	7 to 10

The luminosity of a coal-gas flame depends upon the number of carbon particles liberated within it, and the temperature to which they can be heated. Hence the light given by a flame of coal-gas can be augmented by (1) increasing the number of the carbon particles, and (2) raising the temperature to which they are exposed. The first process is carried out by enrichment (see Gas: *Manufacture*), the second is best obtained by regeneration, the action of which is limited by the power possessed by the material of which burners are composed to withstand the superheating. Although with a perfectly made regenerative burner it might be possible for a short time to get a duty as high as 16 candles per cubic foot from ordinary coal-gas, such a burner constructed of the ordinary materials would last only a few hours, so that for practical use and a reasonable life for the burner 10 candles per cubic foot was about the highest commercial duty that could be reckoned on. This limitation naturally caused inventors to search for methods by which the emission of light could be obtained from coal-gas otherwise than by the incandescence of the carbon particles contained within the flame itself. A coal-gas flame consumed in an atmospheric burner under the conditions necessary to develop its maximum 656
heating power could be utilized to raise to incandescence particles having a higher emissivity for light than carbon. This led to the gradual evolution of incandescent gas lighting.

Incandescent gas light.

Long before the birth of the Welsbach mantle it had been known that when certain unburnable refractory substances were heated to a high temperature they emitted light, and Goldsworthy Gurney in 1826 showed that a cylinder of lime could be brought to a state of dazzling brilliancy by the flame of the oxy-hydrogen blowpipe, a fact which was utilized by Thomas Drummond shortly afterwards in connexion with the Ordnance Survey of Ireland. The mass of a lime cylinder is, however, relatively very considerable, and consequently an excessive amount of heat has to be brought to bear upon it, owing to radiation and conduction tending to dissipate the heat. This is seen by holding in the flame of an atmospheric burner a coil of thick platinum wire, the result being that the wire is heated to a dull red only. With wire of medium thickness a bright red heat is soon attained, and a thin wire glows with a vivid incandescence, and will even melt in certain parts of the flame. Attempts were accordingly made to reduce the mass of the material heated, and this form of lighting was tried in the streets of Paris, buttons of zirconia and magnesia being heated by an oxy-coal-gas flame, but the attempt was soon abandoned owing to the high cost and constant renewals needed. In 1835 W. H. Fox Talbot discovered that even the feeble flame of a spirit lamp is sufficient to heat lime to incandescence, provided the lime be in a sufficiently fine state of division. This condition he fulfilled by soaking blotting-paper in a solution of a calcium salt and then incinerating it. Up to 1848, when J. P. Gillard introduced the intermittent process of making water-gas, the spirit flame and oxy-hydrogen flame were alone free from carbon particles. Desiring to use the water-gas for lighting as well as heating purposes Gillard made a mantle of fine platinum gauze to fit over the flame, and for a time obtained excellent results, but after a few days the lighting value of the mantle fell away gradually until it became useless, owing to the wire becoming eroded on the surface by the flame gases. This idea has been revived at intervals, but the trouble of erosion has always led to failure.

The next important stage in the history of gas lighting was the discovery by R. W. von Bunsen about 1855 of the atmospheric burner, in which a non-luminous coal-gas flame is obtained by causing the coal-gas before its combustion to mix with a certain amount of air. This simple appliance has opened up for coal-gas a sphere of usefulness for heating purposes as important as its use for lighting. After the introduction of the atmospheric burner the idea of the incandescent mantle was revived early in the eighties by the Clamond basket and a resuscitation of the platinum mantle. The Clamond basket or mantle, as shown at the Crystal Palace exhibition of 1882-1883, consisted of a cone of threads of calcined magnesia. A mixture of magnesium hydrate and acetate, converted into a paste or cream by means of water, was pressed through holes in a plate so as to form threads, and these, after being moulded to the required shape, were ignited. The heat decomposed the acetate to form a luting material which glued the particles of magnesium oxide produced into a solid mass, whilst the hydrate gave off water and became oxide. The basket was supported with its apex downwards in a little platinum wire cage, and a mixture of coal-gas and air was driven into it under pressure from an inverted blowpipe burner above it.

The Welsbach mantle was suggested by the fact that Auer von Welsbach had been carrying out researches on the rare earths, with constant use of the spectroscope. Desiring to obtain a better effect than that produced by heating his material on a platinum wire, he immersed cotton in a solution of the metallic salt, and after burning off the organic matter found that a replica of the original thread, composed of the oxide of the metal, was left, and that it glowed brightly in the flame. From this he evolved the idea of utilizing a fabric of cotton soaked in a solution of a metallic salt for lighting purposes, and in 1885 he patented his first commercial mantle. The oxides used in these mantles were zirconia, lanthania, and yttria, but these were so fragile as to be practically useless, whilst the light they emitted was very poor. Later he found that the oxide of thorium—thoria—in conjunction with other rare earth oxides, not only increased the light-giving powers of the mantle, but added considerably to its strength, and the use of this oxide was protected by his 1886 patent. Even these mantles were very unsatisfactory until it was found that the purity of the oxides had a wonderful effect upon the amount of light, and finally came the great discovery that it was a trace of ceria in admixture with the thoria that gave the mantle the marvellous power of emitting light.

Certain factors limit the number of oxides that can be used in the manufacture of an incandescent mantle. Atmospheric influences must not have any action upon them, and they must be sufficiently refractory not to melt or even soften to any extent at the temperature of the flame; they must also be non-volatile, whilst the shrinkage during the process of “burning off” must not be excessive. The following table gives the light-emissivity from pure and commercial samples of the oxides which most nearly conform to the above requirements; the effect of impurity upon the lighting power will be seen to be most marked.

	Pure.	Commercial.
Metals—		
Zirconia	1.5	3.1
Thoria	0.5	6.0
Earth metals—		
Cerite earths—Ceria	0.4	0.9
Lanthania		6.0
Yttrite earths—Yttria		3.2
Erbia	0.6	1.7
Common earths—Chromium oxide	0.4	0.4
Alumina	0.6	0.6
Alkaline earth metals—		
Baryta	3.3	3.3
Strontia	5.2	5.5
Magnesia	5.0	5.0

Of these oxides thoria, when tested for shrinkage, duration and strength, stands pre-eminent. It is also possible to employ zirconia and alumina. Zirconia has the drawback that in the hottest part of the flame it is liable not only to shrinkage and semi-fusion, but also to slow volatilization, and the same objections hold good with respect to alumina. With thoria the shrinkage is smaller than with any other known substance, and it possesses very high refractory powers.

The factor which gives thoria its pre-eminence as the basis of the mantle is that in the conversion of thorium nitrate into thorium oxide by heat, an enormous expansion takes place, the oxide occupying more than ten times the volume of the nitrate. This means that the mass is highly spongy, and contains an enormous number of little air-cells which must render it an excellent non-conductor. A mantle made with thoria alone gives practically no light. But the power of light-emissivity is awakened by the addition of a small trace of ceria; and careful experiment shows that as ceria is added to it little by little, the light which the mantle emits grows greater and greater, until the ratio of 99% of thoria and 1% of ceria is reached, when the maximum illuminating effect is obtained. The further addition of ceria causes gradual diminution of light, until, when with some 10% of ceria has been added, the light given by the mantle is again almost inappreciable. When cerium nitrate is converted by heat into cerium oxide, the expansion which takes place is practically nil, the ceria obtained from a gramme of the nitrate occupying about the same space as the original nitrate. Thus, although by weight the ratio of ceria to thoria is as 1:99, by volume it is only as 1:999.

Manufacture of mantles.

The most successful form of mantle is made by taking a cylinder of cotton net about 8 in. long, and soaking it in a solution of nitrates of the requisite metals until the microscopic fibres of the cotton are entirely filled with liquid. A longer soaking is not advantageous, as the acid nature of the liquid employed tends to weaken the fabric and render it more delicate to handle. The cotton is then wrung out to free it from the excess of liquid, and one end is sewn together with an asbestos thread, a loop of the same material or of thin platinum wire being fixed across the constricted portion to provide a support by which the mantle may be held by the carrying rod, which is either external to the mantle, or (as is most often the case) fixed centrally in the burner head. It is then ready for “burning off,” a process in which the organic matter is removed and the nitrates are converted into oxides. The flame of an atmospheric burner is first applied to the 657
constricted portion at the top of the mantle, whereupon the cotton gradually burns downwards, the shape of the mantle to a great extent depending on the regularity with which the combustion takes place. A certain amount of carbon is left behind after the flame has died out, and this is burnt off by the judicious application of a flame from an atmospheric blast burner to the interior. The action which takes place during the burning off is as follows: The cellulose tubes of the fibre are filled with the crystallized nitrates of the metals used, and as the cellulose burns the nitrates decompose, giving up oxygen and forming fusible nitrites, which in their semi-liquid condition are rendered coherent by the rapid expansion as the oxide forms. As the action continues the nitrites become oxides, losing their fusibility, so that by the time the organic matter has disappeared a coherent thread of oxide is left in place of the nitrate-laden thread of cotton. In the early days of incandescent lighting the mantles had to be sent out unburnt, as no process was known by which the burnt mantle could be rendered sufficiently strong to bear carriage. As the success of a mantle depends upon its fitting the flame, and as the burning off requires considerable skill, this was a great difficulty. Moreover the acid nature of the nitrates in the fibres rapidly rotted them, unless they had been subjected to the action of ammonia gas, which neutralized any excess of acid. It was discovered, however, that the burnt-off mantle could be temporarily strengthened by dipping it in collodion, a solution of soluble gun-cotton in ether and alcohol together with a little castor-oil or similar material to prevent excessive shrinkage when drying. When the mantle was removed from the solution a thin film of solid collodion was left on it, and this could be burned away when required.

After the Welsbach mantle had proved itself a commercial success many attempts were made to evade the monopoly created under the patents, and, although it was found impossible to get the same illuminating power with anything but the mixture of 99% thoria and 1% ceria, many ingenious processes were devised which resulted in at least one improvement in mantle manufacture. One of the earliest attempts in this direction was the “Sunlight” mantle, in which cotton was saturated with the oxides of aluminium, chromium and zirconium, the composition of the burnt-off mantle being:—

Alumina	86.88
Chromium oxide	8.68
Zirconia	4.44
	———
	100.00

The light given by these mantles was entirely dependent upon the proportion of chromium oxides present, the alumina playing the part of base in the same way that the thoria does in the Welsbach mantle, the zirconia being added merely to strengthen the structure. These mantles enjoyed considerable popularity owing to the yellowish pink light they emitted, but, although they could give an initial illumination of 12 to 15 candles per foot of gas consumed, they rapidly lost their light-giving power owing to the slow volatilization of the oxides of chromium and aluminium.

Another method of making the mantle was first to produce a basis of thoria, and, having got the fabric in thorium oxide, to coat it with a mixture of 99% thoria and 1% ceria. This modification seems to give an improvement in the initial amount of light given by the mantle. In the Voelker mantle a basis of thoria was produced, and was then coated by dipping in a substance termed by the patentee “Voelkerite,” a body made by fusing together a number of oxides in the electric furnace. The fused mass was then dissolved in the strongest nitric acid, and diluted with absolute alcohol to the necessary degree. A very good mantle having great lasting power was thus produced. It was claimed that the process of fusing the materials together in the electric furnace altered the composition in some unexplained way, but the true explanation is probably that all water of hydration was eliminated.

The “Daylight” mantle consisted of a basis of thoria or thoria mixed with zirconia, dipped in collodion containing a salt of cerium in solution; on burning off the collodion the ceria was left in a finely divided condition on the surface of the thoria. In this way a very high initial illuminating power was obtained, which, however, rapidly fell as the ceria slowly volatilized.

Perhaps the most interesting development of the Welsbach process was dependent upon the manufacture of filaments of soluble guncotton or collodion as in the production of artificial silk. In general the process consisted in forcing a thick solution of the nitrated cellulose through capillary glass tubes, the bore of which was less than the one-hundredth of a millimetre. Ten or twelve of the expressed fibres were then twisted together and wound on a bobbin, the air of the room being kept sufficiently heated to cause the drying of the filaments a few inches from the orifice of the tube. The compound thread was next denitrated to remove its extreme inflammability, and for this purpose the skeins were dipped in a solution of (for instance) ammonium sulphide, which converted them into ordinary cellulose. After washing and drying the skeins were ready for the weaving machines. In 1894 F. de Mare utilized collodion for the manufacture of a mantle, adding the necessary salts to the collodion before squeezing it into threads. O. Knöfler in 1895, and later on A. Plaissetty, took out patents for the manufacture of mantles by a similar process to De Mare’s, the difference between the two being that Knöfler used ammonium sulphide for the denitration of his fabric, whilst Plaissetty employed calcium sulphide, the objection to which is the trace of lime left in the material. Another method for making artificial silk which has a considerable reputation is that known as the Lehner process, which in its broad outlines somewhat resembles the Chardonnet, but differs from it in that the excessively high pressures used in the earlier method are done away with by using a solution of a more liquid character, the thread being hardened by passing through certain organic solutions. This form of silk lends itself perhaps better to the carrying of the salts forming the incandescent oxides than the previous solutions, and mantles made by this process, known as Lehner mantles, showed promise of being a most important development of De Mare’s original idea. Mantles made by these processes show that it is possible to obtain a very considerable increase in life and light-emissivity, but mantles made on this principle could not now be sold at a price which would enable them to compete with mantles of the Welsbach type.

The cause of the superiority of these mantles having been realized, developments in the required direction were made. The structure of the cotton mantle differed widely from that obtained by the various collodion processes, and this alteration in structure was mainly responsible for the increase in life. Whereas the average of a large number of Welsbach mantles tested only showed a useful life of 700 to 1000 hours, the collodion type would average about 1500 hours, some mantles being burnt for an even longer period and still giving an effective illumination. This being so, it was clear that one line of advance would be found in obtaining some material which, whilst giving a structure more nearly approaching that of the collodion mantle, would be sufficiently cheap to compete with the Welsbach mantle, and this was successfully done.

By the aid of the microscope the structure of the mantle can be clearly defined, and in examining the Welsbach mantle before and after burning, it will be noticed that the cotton thread is a closely twisted and plaited rope of myriads of minute fibres, whilst the collodion mantle is a bundle of separate filaments without plait or heavy twisting, the number of such filaments varying with the process by which it was made. This latter factor experiment showed to have a certain influence on the useful light-giving life of the mantle, as whereas the Knöfler and Plaissetty mantles had an average life of about 1500 hours, the Lehner fabric, which contained a larger number of finer threads, could often be burnt continuously for over 3000 hours, and at the end of that period gave a better light than most of the Welsbach after as many hundred.

It is well known that plaiting gave the cotton candle-wick that power of bending over, when freed from the binding effect of the candle material and influenced by heat, which brought the tip out from the side of the flame. This, by enabling the air to get at it and burn it away, removed the nuisance of having to snuff the candle, which for many centuries has rendered it a tiresome method of lighting. In the cotton mantle, the tight twisting of the fibre brings this torsion into play. When the cotton fibres saturated with the nitrates of the rare metals are burnt off, and the conversion into oxides takes place, as the cotton begins to burn, not only does the shrinkage of the mass throw a strain on the oxide skeleton, but the last struggle of torsion in the burning of the fibre tends towards disintegration of the fragile mass, and this all plays a part in making the cotton mantle inferior to the collodion type.

If ramie fibre be prepared in such a way as to remove from it all traces of the glutinous coating, a silk-like fabric can be obtained from it, and if still further prepared so as to improve its absorbent powers, it can be formed into mantles having a life considerably greater than is possessed by those of the cotton fabric. Ramie thus seemed likely to yield a cheap competitor in length of endurance to the collodion mantle, and results have justified this expectation. By treating the fibre so as to remove the objections against its use for mantle-making, and then making it into threads with the least possible amount of twist, a mantle fabric can be made in every way superior to that given by cotton.

The Plaissetty mantles, which as now manufactured also show a considerable advance in life and light over the original Welsbach mantles, are made by impregnating stockings of either cotton or ramie with the nitrates of thorium and cerium in the usual way, and, before burning off, mercerizing the mantle by steeping in ammonia solution, which converts the nitrates into hydrates, and gives greater density and strength to the finished mantle. The manufacturers of the Plaissetty mantle have also made a modification in the process by which the saturated fabric can be so 658
prepared as to be easily burnt off by the consumer on the burner on which it is to be used, in this way doing away with the initial cost of burning off, shaping, hardening and collodionizing.

Intensifying systems.

Since 1897 inventions have been patented for methods of intensifying the light produced by burning gas under a mantle and increasing the light generated per unit volume of gas. The systems have either been self-intensifying or have depended on supplying the gas (or gas and air) under an increased pressure. Of the self-intensifying systems those of Lucas and Scott-Snell have been the most successful. A careful study has been made by the inventor of the Lucas light of the influence of various sizes and shapes of chimneys in the production of draught. The specially formed chimney used exerts a suction on the gas flame and air, and the burner and mantle are so constructed as to take full advantage of the increased air supply, with the result that the candle power given by the mantle is considerably augmented. With the Scott-Snell system the results obtained are about the same as those given by the Lucas light, but in this case the waste heat from the burner is caused to operate a plunger working in the crown of the lamp which sucks and delivers gas to the burner. Both these systems are widely used for public lighting in many large towns of the United Kingdom and the continent of Europe.

The other method of obtaining high light-power from incandescent gas burners necessitates the use of some form of motive power in order to place the gas, or both gas and air, under an increased pressure. The gas compressor is worked by a water motor, hot air or gas engine; a low pressure water motor may be efficiently driven by water from the main, but with large installations it is more economical to drive the compressor by a gas engine. To overcome the intermittent flow of gas caused by the stroke of the engine, a regulator on the floating bell principle is placed after the compressor; the pressure of gas in the apparatus governs automatically the flow of gas to the engine. With the Sugg apparatus for high power lighting the gas is brought from the district pressure, which is equal to about 2½ in. of water, to an average of 12 in. water pressure. The light obtained by this system when the gas pressure is 9½ in. is 300 candle power with an hourly consumption of 10 cub. ft. of gas, equivalent to 30 candles per cubic foot, and with a gas pressure equal to 14 in. of water 400 candles are obtained with an hourly consumption of 12½ cub. ft., which represents a duty of 32 candles per cubic foot of gas consumed. High pressure incandescent lighting makes it possible to burn a far larger volume of gas in a given time under a mantle than is the case with low pressure lighting, so as to create centres of high total illuminating value to compete with arc lighting in the illumination of large spaces, and the Lucas, Keith, Scott-Snell, Millennium, Selas, and many other pressure systems answer most admirably for this purpose.

Inverted burners.

The light given by the ordinary incandescent mantle burning in an upright position tends rather to the upward direction, because owing to the slightly conical shape of the mantle the maximum light is emitted at an angle a little above the horizontal. Inasmuch as for working purposes the surface that a mantle illuminates is at angles below 45° from the horizontal, it is evident that a considerable loss of efficient lighting is brought about, whilst directly under the light the burner and fittings throw a strong shadow. To avoid this trouble attempts have from time to time been made to produce inverted burners which should heat a mantle suspended below the mouth of the burner. As early as 1882 Clamond made what was practically an inverted gas and air blowpipe to use with his incandescent basket, but it was not until 1900-1901 that the inverted mantle became a possibility. Although there was a strong prejudice against it at first, as soon as a really satisfactory burner was introduced, its success was quickly placed beyond doubt. The inverted mantle has now proved itself one of the chief factors in the enormous success achieved by incandescent mantle lighting, as the illumination given by it is far more efficient than with the upright mantle, and it also lends itself well to ornamental treatment.

Burners.

When the incandescent mantle was first introduced in 1886 an ordinary laboratory Bunsen burner was experimentally employed, but unless a very narrow mantle just fitting the top of the tube was used the flame could not be got to fit the mantle, and it was only the extreme outer edge of the flame which endowed the mantle fabric with the high incandescent. A wide burner top was then placed on the Bunsen tube so as to spread the flame, and a larger mantle became possible, but it was then found that the slowing down of the rate of flow at the mouth of the burner owing to its enlargement caused flashing or firing back, and to prevent this a wire gauze covering was fitted to the burner head; and in this way the 1886-1887 commercial Welsbach burner was produced. The length of the Bunsen tube, however, made an unsightly fitting, so it was shortened, and the burner head made to slip over it, whilst an external lighting back plate was added. The form of the “C” burner thus arrived at has undergone no important further change. When later on it was desired to make incandescent mantle burners that should not need the aid of a chimney to increase the air supply, the long Bunsen tube was reverted to, and the Kern, Bandsept, and other burners of this class all have a greater total length than the ordinary burners. To secure proper mixing of the air and gas, and to prevent flashing back, they all have heads fitted with baffles, perforations, gauze, and other devices which oppose considerable resistance to the flow of the stream of air and gas.

In 1900, therefore, two classes of burner were in commercial existence for incandescent lighting—(1) the short burner with chimney, and (2) the long burner without chimney. Both classes had the burner mouth closed with gauze or similar device, and both needed as an essential that the mantle should fit closely to the burner head.

Prior to 1900 attempts had been made to construct a burner in which an incandescent mantle should be suspended head downwards. Inventors all turned to the overhead regenerative gas lamps of the Wenham type, or the inverted blowpipe used by Clamond, and in attempting to make an inverted Bunsen employed either artificial pressure to the gas or the air, or to both, or else enclosed the burner and mantle in a globe, and by means of a long chimney created a strong draught. These burners also were all regenerative and aimed at heating the air or gas or mixture of the two, and they had the further drawback of being complicated and costly. Regeneration is a valuable adjunct in ordinary gas lighting as it increases the actions that liberate the carbon particles upon which the luminosity of a flame is dependent, and also increases the temperature; but with the mixture of air and gas in a Bunsen regeneration is not a great gain when low and is a drawback when intense, because incipient combination is induced between the oxygen of the air and the coal-gas before the burner head is reached, the proportions of air and gas are disturbed, and the flame instead of being non-luminous shows slight luminosity and tends to blacken the mantle. The only early attempt to burn a mantle in an inverted position without regeneration or artificial pressure or draught was made by H. A. Kent in 1897, and he used, not an inverted Bunsen, but one with the top elongated and turned over to form a siphon, so that the point of admixture of air and gas was below the level of the burner head, and was therefore kept cool and away from the products of combustion.

In 1900 J. Bernt and E. Cérvenka set themselves to solve the problem of making a Bunsen burner which should consume gas under ordinary gas pressure in an inverted mantle. They took the short Bunsen burner, as found in the most commonly used upright incandescent burners, and fitted to it a long tube, preferably of non-conducting material, which they called an isolator, and which is designed to keep the flame at a distance from the Bunsen. They found that it burnt fairly well, and that the tendency of the flame to burn or lap back was lessened, but that the hot up-current of heated air and products of combustion streamed up to the air holes of the Bunsen, and by contaminating the air supply caused the flame to pulsate. They then fixed an inverted cone on the isolator to throw the products of combustion outwards and away from the air holes, and found that the addition of this “deflecting cone” steadied the flame. Having obtained a satisfactory flame, they attacked the problem of the burner head. 659
Experiments showed that the burner head must be not only open but also of the same size or smaller than the burner tube, and that by projecting it downwards into the mantle and leaving a space between the mantle and the burner head the maximum mantle surface heated to incandescence was obtained. It was also found that the distance which the burner head projects into the mantle is equivalent to the same amount of extra water pressure on the gas, and with a long mantle it was found useful under certain conditions to add a cylinder or sleeve with perforated sides to carry the gas still lower into the mantle. The principles thus set forth by Kent, Bernt and Cérvenka form the basis of construction of all the types of inverted mantle burners which so greatly increased the popularity of incandescent gas lighting at the beginning of the 20th century, whilst improvements in the shape of the mantle for inverted lighting and the methods of attachment to the burner have added to the success achieved.

The wonderful increase in the amount of light that can be obtained from gas by the aid of the incandescent gas mantle is realized when one compares the 1 to 3.2 candles per cubic foot given by the burners used in the middle of the 19th century with the duty of incandescent burners, as shown in the following table:—

Light yielded per cubic foot of Gas.

Burner.	Candle power.
Low pressure upright incandescent burners	15 to 20 candles
Inverted burners	14 to 21 ”
Kern burners	20 to 24 ”
High pressure burners	22 to 36 ”

(V. B. L.)

3. Electric Lighting.

Electric lamps are of two varieties: (1) *Arc Lamps* and (2) *Incandescent* or *Glow Lamps*. Under these headings we may briefly consider the history, physical principles, and present practice of the art of electric lighting.

1. *Arc Lamps.*—If a voltaic battery of a large number of cells has its terminal wires provided with rods of electrically-conducting carbon, and these are brought in contact and then slightly separated, a form of electric discharge takes place between them called the *electric arc*. It is not quite certain who first observed this effect of the electric current. The statement that Sir Humphry Davy, in 1801, first produced and studied the phenomenon is probably correct. In 1808 Davy had provided for him at the Royal Institution a battery of 2000 cells, with which he exhibited the electric arc on a large scale.

The electric arc may be produced between any conducting materials maintained at different potentials, provided that the source of electric supply is able to furnish a sufficiently large current; but for illuminating purposes pieces of hard graphitic carbon are most convenient. If some source of continuous electric current is connected to rods of such carbon, first brought into contact and then slightly separated, the following facts may be noticed: With a low electromotive force of about 50 or 60 volts no discharge takes place until the carbons are in actual contact, unless the insulation of the air is broken down by the passage of a small electric spark. When this occurs, the space between the carbons is filled at once with a flame or luminous vapour, and the carbons themselves become highly incandescent at their extremities. If they are horizontal the flame takes the form of an arch springing between their tips; hence the name *arc*. This varies somewhat in appearance according to the nature of the current, whether continuous or alternating, and according as it is formed in the open air or in an enclosed space to which free access of oxygen is prevented. Electric arcs between metal surfaces differ greatly in colour according to the nature of the metal. When formed by an alternating current of high electromotive force they resemble a lambent flame, flickering and producing a somewhat shrill humming sound.

Electric arcs may be classified into continuous or alternating current arcs, and open or enclosed arcs, carbon arcs with pure or chemically impregnated carbons, or so-called flame arcs, and arcs formed with metallic or oxide electrodes, such as magnetite. A continuous current arc is formed with an electric current flowing always in the same direction; an alternating current arc is formed with a periodically reversed current. An open arc is one in which the carbons or other material forming the arc are freely exposed to the air; an enclosed arc is one in which they are included in a glass vessel. If carbons impregnated with various salts are used to colour or increase the light, the arc is called a chemical or flame arc. The carbons or electrodes may be arranged in line one above the other, or they may be inclined so as to project the light downwards or more in one direction. In a carbon arc if the current is continuous the positive carbon becomes much hotter at the end than the negative, and in the open air it is worn away, partly by combustion, becoming hollowed out at the extremity into a *crater*. At the same time the negative carbon gradually becomes pointed, and also wears away, though much less quickly than the positive. In the continuous-current open arc the greater part of the light proceeds from the highly incandescent positive crater. When the arc is examined through dark glasses, or by the optical projection of its image upon a screen, a violet band or stream of vapour is seen to extend between the two carbons, surrounded by a nebulous golden flame or aureole. If the carbons are maintained at the right distance apart the arc remains steady and silent, but if the carbons are impure, or the distance between them too great, the true electric arc rapidly changes its place, flickering about and frequently becoming extinguished; when this happens it can only be restored by bringing the carbons once more into contact. If the current is alternating, then the arc is symmetrical, and both carbons possess nearly the same appearance. If it is enclosed in a vessel nearly air-tight, the rate at which the carbons are burnt away is greatly reduced, and if the current is continuous the positive carbon is no longer cratered out and the negative no longer so much pointed as in the case of the open arc.

Carbons.

Davy used for his first experiments rods of wood charcoal which had been heated and plunged into mercury to make them better conductors. Not until 1843 was it proposed by J. B. L. Foucault to employ pencils cut from the hard graphitic carbon deposited in the interior of gas retorts. In 1846 W. Greener and W. E. Staite patented a process for manufacturing carbons for this purpose, but only after the invention of the Gramme dynamo in 1870 any great demand arose for them. F. P. É. Carré in France in 1876 began to manufacture arc lamp carbons of high quality from coke, lampblack and syrup. Now they are made by taking some specially refined form of finely divided carbon, such as the soot or lampblack formed by cooling the smoke of burning paraffin or tar, or by the carbonization of organic matter, and making it into a paste with gum or syrup. This carbon paste is forced through dies by means of a hydraulic press, the rods thus formed being subsequently baked with such precautions as to preserve them perfectly straight. In some cases they are *cored*, that is to say, have a longitudinal hole down them, filled in with a softer carbon. Sometimes they are covered with a thin layer of copper by electro-deposition. They are supplied for the market in sizes varying from 4 or 5 to 30 or 40 millimetres in diameter, and from 8 to 16 in. in length. The value of carbons for arc lighting greatly depends on their purity and freedom from ash in burning, and on perfect uniformity of structure. For ordinary purposes they are generally round in section, but for certain special uses, such as lighthouse work, they are made fluted or with a star-shaped section. The positive carbon is usually of larger section than the negative. For continuous-current arcs a cored carbon is generally used as a positive, and a smaller solid carbon as a negative. For flame arc lamps the carbons are specially prepared by impregnating them with salts of calcium, magnesium and sodium. The calcium gives the best results. The rod is usually of a composite type. The outer zone is pure carbon to give strength, the next zone contains carbon mixed with the metallic salts, and the inner core is the same but less compressed. In addition to the metallic salts a flux has to be introduced to prevent the formation of a 660
non-conducting ash, and this renders it desirable to place the carbons in a downward pointing direction to get rid of the slag so formed. Bremer first suggested in 1898 for this purpose the fluorides of calcium, strontium or barium. When such carbons are used to form an electric arc the metallic salts deflagrate and produce a flame round the arc which is strongly coloured, the object being to produce a warm yellow glow, instead of the somewhat violet and cold light of the pure carbon arc, as well as a greater emission of light. As noxious vapours are however given off, flame arcs can only be used out of doors. Countless researches have been made on the subject of carbon manufacture, and the art has been brought to great perfection.

Special manuals must be consulted for further information (see especially a treatise on *Carbon making for all electrical purposes*, by F. Jehl, London, 1906).

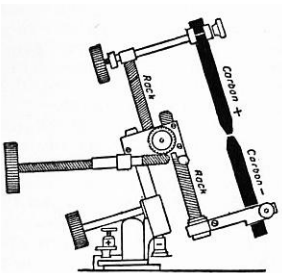

Fig. 4.

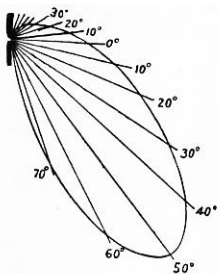

Fig. 5.

Physical phenomena.

The physical phenomena of the electric arc are best examined by forming a carbon arc between two carbon rods of the above description, held in line in a special apparatus, and arranged so as to be capable of being moved to or from each other with a slow and easily regulated motion. An arrangement of this kind is called a *hand-regulated arc lamp* (fig. 4). If such an arc lamp is connected to a source of electric supply having an electromotive force preferably of 100 volts, and if some resistance is included in the circuit, say about 5 ohms, a steady and continuous arc is formed when the carbons are brought together and then slightly separated. Its appearance may be most conveniently examined by projecting its image upon a screen of white paper by means of an achromatic lens. A very little examination of the distribution of light from the arc shows that the illuminating or candle-power is not the same in different directions. If the carbons are vertical and the positive carbon is the upper of the two, the illuminating power is greatest in a direction at an angle inclined about 40 or 50 degrees below the horizon, and at other directions has different values, which may be represented by the lengths of radial lines drawn from a centre, the extremities of which define a curve called the *illuminating curve* of the arc lamp (fig. 5). Considerable differences exist between the forms of the illuminating-power curves of the continuous and alternating current and the open or enclosed arcs. The chief portion of the emitted light proceeds from the incandescent crater; hence the form of the illuminating-power curve, as shown by A. P. Trotter in 1892, is due to the apparent area of the crater surface which is visible to an eye regarding the arc in that direction. The form of the illuminating-power curve varies with the length of the arc and relative size of the carbons. Leaving out of account for the moment the properties of the arc as an illuminating agent, the variable factors with which we are concerned are (i.) the current through the arc; (ii.) the potential difference of the carbons; (iii.) the length of the arc; and (iv.) the size of the carbons. Taking in the first place the typical direct-current arc between solid carbons, and forming arcs of different lengths and with carbons of different sizes, it will be found that, beginning at the lowest current capable of forming a true arc, the potential difference of the carbons (the arc P.D.) decreases as the current increases. Up to a certain current strength the arc is silent, but at a particular critical value P.D. suddenly drops about 10 volts, the current at the same time rising 2 or 3 amperes. At that moment the arc begins to *hiss*, and in this hissing condition, if the current is still further increased, P.D. remains constant over wide limits. This drop in voltage on hissing was first noticed by A. Niaudet (*La Lumière électrique*, 1881, 3, p. 287). It has been shown by Mrs Ayrton (*Journ. Inst. Elec. Eng.* 28, 1899, p. 400) that the hissing is mainly due to the oxygen which gains access from the air to the crater, when the latter becomes so large by reason of the increase of the current as to overspread the end of the positive carbon. According to A. E. Blondel and Hans Luggin, hissing takes place whenever the current density becomes greater than about 0.3 or 0.5 ampere per square millimetre of crater area.

The relation between the current, the carbon P.D., and the length of arc in the case of the direct-current arc has been investigated by many observers with the object of giving it mathematical expression.

Let V stand for the potential difference of the carbons in volts, A for the current through the arc in amperes, L for the length of the arc in millimetres, R for the resistance of the arc; and let *a*, *b*, *c*, *d*, &c., be constants. Erik Edlund in 1867, and other workers after him, considered that their experiments showed that the relation between V and L could be expressed by a simple linear equation,

$$V = a + bL.$$

Later researches by Mrs Ayrton (Electrician, 1898, 41, p. 720), however, showed that for a direct-current arc of given size with solid carbons, the observed values of V can be better represented as a function both of A and of L of the form

$$V = a + bL + \frac{c + dL}{A}.$$

In the case of direct-current arcs formed with solid carbons, Edlund and other observers agree that the arc resistance R may be expressed by a simple straight line law, $R = e + fL$. If the arc is formed with cored carbons, Mrs Ayrton demonstrated that the lines expressing resistance as a function of arc length are no longer straight, but that there is a rather sudden dip down when the length of the arc is less than 3 mm.

The constants in the above equation for the potential difference of the carbons were determined by Mrs Ayrton in the case of solid carbons to be—

$$V = 38.9 + 2.07L + \frac{11.7 + 10.5L}{A}.$$

There has been much debate as to the meaning to be given to the constant *a* in the above equation, which has a value apparently not far from forty volts for a direct-current arc with solid carbons. The suggestion made in 1867 by Edlund (*Phil. Mag.*, 1868, 36, p. 358), that it implied the existence of a counter-electromotive force in the arc, was opposed by Luggin in 1889 (*Wien. Ber.* 98, p. 1198), Ernst Lecher in 1888 (*Wied. Ann.*, 1888, 33, p. 609), and by Franz Stenger in 1892 (*Id.* 45, p. 33); whereas Victor von Lang and L. M. Arons in 1896 (*Id.* 30, p. 95), concluded that experiment indicated the presence of a counter-electromotive force of 20 volts. A. E. Blondel concludes, from experiments made by him in 1897 (*The Electrician*, 1897, 39, p. 615), that there is no counter-electromotive force in the arc greater than a fraction of a volt. Subsequently W. Duddëll (*Proc. Roy. Soc.*, 1901, 68, p. 512) described experiments tending to prove the real existence of a counter-electromotive force in the arc, probably having a thermo-electric origin, residing near the positive electrode, and of an associated lesser adjuvant *e.m.f.* near the negative carbon.

This fall in voltage between the carbons and the arc is not uniformly distributed. In 1898 Mrs Ayrton described the results of experiments showing that if V_1 is the potential difference between the positive carbon and the arc, then

$$V_1 = 31.28 + \frac{9 + 3.1L}{A};$$

and if V_2 is the potential difference between the arc and the negative carbon, then

$$V_2 = 7.6 + \frac{13.6}{A},$$

where A is the current through the arc in amperes and L is the length of the arc in millimetres.

The total potential difference between the carbons, minus the fall in potential down the arc, is therefore equal to the sum of $V_1 + V_2 = V_3$.

$$\text{Hence } V_3 = 38.88 + \frac{22.6 + 3.1L}{A}.$$

The difference between this value and the value of V, the total potential difference between the carbons, gives the loss in potential due to the true 661
arc. These laws are simple consequences of straight-line laws connecting the work spent in the arc at the two electrodes with the other quantities. If W be the work spent in the arc on either carbon, measured by the product of the current and the potential drop in passing from the carbon to the arc, or vice versa, then for the positive carbon $W = a + bA$, if the length of arc is constant, $W = c + dL$, if the current through the arc is constant, and for the negative carbon $W = e + fA$.

In the above experiments the potential difference between the carbons and the arc was measured by using a third exploring carbon as an electrode immersed in the arc. This method, adopted by Lecher, F. Uppenborn, S. P. Thompson, and J. A. Fleming, is open to the objection that the introduction of the third carbon may to a considerable extent disturb the distribution of potential.

The total work spent in the continuous-current arc with solid carbons may, according to Mrs Ayrton, be expressed by the equation

$$W = 11.7 + 10.5L + (38.9 + 2.07L) A.$$

It will thus be seen that the arc, considered as a conductor, has the property that if the current through it is increased, the difference of potential between the carbons is decreased, and in one sense, therefore, the arc may be said to act as if it were a *negative resistance*. Frith and Rodgers (*Electrician*, 1896, 38, p. 75) have suggested that the resistance of the arc should be measured by the ratio between a small increment of carbon potential difference and the resulting small increment of current; in other words, by the equation dV/dA, and not by the ratio simply of V:A. Considerable discussion has taken place whether an electrical resistance can have a negative value, belonging as it does to the class of scalar mathematical quantities. Simply considered as an electrical conductor, the arc resembles an intensely heated rod of magnesia or other refractory oxide, the true resistance of which is decreased by rise of temperature. Hence an increase of current through such a rod of refractory oxide is accompanied by a decrease in the potential difference of the ends. This, however, does not imply a negative resistance, but merely the presence of a resistance with a negative temperature coefficient. If we plot a curve such that the ordinates are the difference of potential of the carbons and the abscissae the current through the arc for constant length of arc, this curve is now called a *characteristic curve* of the arc and its slope at any point the instantaneous resistance of the arc.

Other physical investigations have been concerned with the intrinsic brightness of the crater. It has been asserted by many observers, such as Blondel, Sir W. de W. Abney, S. P. Thompson, Trotter, L. J. G. Violle and others, that this is practically independent of the current passing, but great differences of opinion exist as to its value. Abney's values lie between 39 and 116, Trotter's between 80 and 170 candles per square millimetre. Blondel in 1893 made careful determinations of the brightness of the arc crater, and came to the conclusion that it was 160 candles per square millimetre. Subsequently J. E. Petavel found a value of 147 candles per square millimetre for current densities varying from .06 to .26 amperes per square millimetre (*Proc. Roy. Soc.*, 1899, 65, p. 469). Violle also, in 1893, supported the opinion that the brightness of the crater per square millimetre was independent of the current density, and from certain experiments and assumptions as to the specific heat of carbon, he asserted the temperature of the crater was about 3500° C. It has been concluded that this constancy of temperature, and therefore of brightness, is due to the fact that the crater is at the temperature of the boiling-point of carbon, and in that case its temperature should be raised by increasing the pressure under which the arc works. W. E. Wilson in 1895 attempted to measure the brightness of the crater under various pressures, and found that under five atmospheres the resistance of the arc appeared to increase and the temperature of the crater to fall, until at a pressure of 20 atmospheres the brightness of the crater had fallen to a dull red. In a later paper Wilson and G. F. Fitzgerald stated that these preliminary experiments were not confirmed, and their later researches throw considerable doubt on the suggestion that it is the boiling-point of carbon which determines the temperature of the crater. (See *Electrician*, 1895, 35, p. 260, and 1897, 38, p. 343.)

Alternating current arc.

The study of the alternating-current arc has suggested a number of new experimental problems for investigators. In this case all the factors, namely, current, carbon P.D., resistance, and illuminating power, are periodically varying; and as the electromotive force reverses itself periodically, at certain instants the current through the arc is zero. As the current can be interrupted for a moment without extinguishing the arc, it is possible to work the electric arc from an alternating current generator without apparent intermission in the light, provided that the frequency is not much below 50. During the moment that the current is zero the carbon continues to glow. Each carbon in turn becomes, so to speak, the crater carbon, and the illuminating power is therefore symmetrically distributed. The curve of illumination is as shown in fig. 3. The nature of the variation of the current and arc P.D. can be examined by one of two methods, or their modifications, originally due to Jules Joubert and A. E. Blondel. Joubert's method, which has been perfected by many observers, consists in attaching to the shaft of the alternator a contact which closes a circuit at an assigned instant during the phase. This contact is made to complete connexion either with a voltmeter or with a galvanometer placed as a shunt across the carbons or in series with the arc. By this arrangement these instruments do

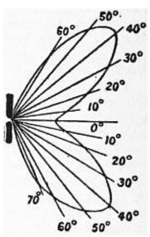

Fig. 6.

not read, as usual, the root-mean-square value of the arc P.D. or current, but give a constant indication determined by, and indicating, the instantaneous values of these quantities at some assigned instant. By progressive variation of the phase-instant at which the contact is made, the successive instantaneous values of the electric quantities can be measured and plotted out in the form of curves. This method has been much employed by Blondel, Fleming, C. P. Steinmetz, Tobey and Walbridge, Frith, H. Görges and many others. The second method, due to Blondel, depends on the use of the *Oscillograph*, which is a galvanometer having a needle or coil of very small periodic time of vibration, say $1/2000$th part of a second or less, so that its deflections can follow the variations of current passing through the galvanometer. An improved form of oscillograph, devised by Duddell, consists of two fine wires, which are strained transversely to the lines of flux of a strong magnetic field (see Oscillograph). The current to be examined is made to pass up one wire and down the other, and these wires are then slightly displaced in opposite directions. A small mirror attached to the wires is thus deflected rapidly to and fro in synchronism with the variations of the current. From the mirror a ray of light is reflected which falls upon a photographic plate made to move across the field with a uniform motion. In this manner a photographic trace can be obtained of the wave form. By this method the variations of electric quantities in an alternating-current arc can be watched. The variation of illuminating power can be followed by examining and measuring the light of the arc through slits in a revolving stroboscopic disk, which is driven by a motor synchronously with the variation of current through the arc.

The general phenomena of the alternating-current arc are as follow:—

If the arc is supplied by an alternator of low inductance, and soft or cored carbons are employed to produce a steady and silent arc, the potential difference of the carbons periodically varies in a manner not very different from that of the alternator on open circuit. If, however, hard carbons are used, the alternating-current arc deforms the shape of the alternator electromotive force curve; the carbon P.D. curve may then have a very different form, and becomes, in general, more rectangular in shape, usually having a high peak at the front. The arc also impresses the deformation on the current curve. Blondel in 1893 (*Electrician*, 32, p. 161) gave a number of potential and current curves for alternating-current arcs, obtained by the Joubert contact method, using two movable coil galvanometers of high resistance to measure respectively potential difference and current. Blondel's deductions were that the shape of the current and volt curves is greatly affected by the nature of the carbons, and also by the amount of inductance and resistance in the circuit of the alternator. Blondel, W. E. Ayrton, W. E. Sumpner and Steinmetz have all observed that the alternating-current arc, when hissing or when formed with uncored carbons, acts like an inductive resistance, and that there is a lag between the current curves and the potential difference curves. Hence the *power-factor*, or ratio between the true power and the product of the root-mean-square values of arc current and carbon potential difference, in this case is less than unity. For silent arcs Blondel found power-factors lying 662
between 0.88 and 0.95, and for hissing ones, values such as 0.70. Ayrton and Sumpner stated that the power-factor may be as low as 0.5. Joubert, as far back as 1881, noticed the deformation which the alternating-current arc impresses upon the electromotive force curve of an alternator, giving an open circuit a simple harmonic variation of electromotive force. Tobey and Walbridge in 1890 gave the results of a number of observations taken with commercial forms of alternating-current arc lamps, in which the same deformation was apparent. Blondel in 1896 came to the conclusion that with the same alternator we can produce carbon P.D. curves of very varied character, according to the material of the core, the length of the arc, and the inductance of the circuit. Hard carbons gave a P.D. curve with a flat top even when worked on a low inductance alternator.

The periodic variation of light in the alternating-current arc has also been the subject of inquiry. H. Görges in 1895 at Berlin applied a stroboscopic method to steady the variations of illuminating power. Fleming and Petavel employed a similar arrangement, driving the stroboscopic disk by a synchronous motor (*Phil. Mag.*, 1896, 41). The light passing through slits of the disk was selected in one particular period of the phase, and by means of a lens could be taken from any desired portion of the arc or the incandescent carbons. The light so selected was measured relatively to the mean value of the horizontal light emitted by the arc, and accidental variations were thus eliminated. They found that the light from any part is periodic, but owing to the slow cooling of the carbons never quite zero, the minimum value happening a little later than the zero value of the current. The light emitted by a particular carbon when it is the negative, does not reach such a large maximum value as when it is the positive. The same observers made experiments which seemed to show that for a given expenditure of power in the arc the alternating current arc in general gives less mean spherical candle-power than the continuous current one.

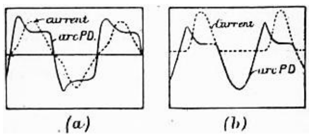

Fig. 7.

The effect of the wave form on the efficiency of the alternating-current arc has engaged the attention of many workers. Rössler and Wedding in 1894 gave an account of experiments with alternating-current arcs produced by alternators having electromotive force curves of very different wave forms, and they stated that the efficiency or mean spherical candle-power per watt expended in the arc was greatest for the flattest of the three wave forms by nearly 50%. Burnie in 1897 gave the results of experiments of the same kind. His conclusion was, that since the light of the arc is a function of the temperature, that wave form of current is most efficient which maintains the temperature most uniformly throughout the half period. Hence, generally, if the current rises to a high value soon after its commencement, and is preserved at that value, or nearly at that value, during the phase, the efficiency of the arc will be greater when the current curve is more pointed or peaked. An important contribution to our knowledge concerning alternating-current arc phenomena was made in 1899 by W. Duddell and E. W. Marchant, in a paper containing valuable results obtained with their improved oscillograph.[1] They studied the behaviour of the alternating-current arc when formed both with solid carbons, with cored carbons, and with carbon and metal rods. They found that with solid carbons the arc P.D. curve is always square-shouldered and begins with a peak, as shown in fig. 7 (*a*), but with cored carbons it is more sinusoidal. Its shape depends on the total resistance in the circuit, but is almost independent of the type of alternator, whereas the current wave form is largely dependent on the machine used, and on the nature and amount of the impedance in the circuit; hence the importance of selecting a suitable alternator for operating alternating-current arcs. The same observers drew attention to the remarkable fact that if the arc is formed between a carbon and metal rod, say a zinc rod, there is a complete interruption of the current over half a period corresponding to that time during which the carbon is positive; this suggests that the rapid cooling of the metal facilitates the flow of the current from it, and resists the flow of current to it. The dotted curve in fig. 7 (*b*) shows the current curve form in the case of a copper rod. By the use of the oscillograph Duddell and Marchant showed that the hissing continuous-current arc is intermittent, and that the current is oscillatory and may have a frequency of 1000 per second. They also showed that enclosing the arc increases the arc reaction, the front peak of the potential curve becoming more marked and the power-factor of the arc reduced.

Enclosed arc lamps.

If a continuous-current electric arc is formed in the open air with a positive carbon having a diameter of about 15 millimetres, and a negative carbon having a diameter of about 9 millimetres, and if a current of 10 amperes is employed, the potential difference between the carbons is generally from 40 to 50 volts. Such a lamp is therefore called a 500-watt arc. Under these conditions the carbons each burn away at the rate of about 1 in. per hour, actual combustion taking place in the air which gains access to the highly-heated crater and negative tip; hence the most obvious means of preventing this disappearance is to enclose the arc in an air-tight glass vessel. Such a device was tried very early in the history of arc lighting. The result of using a completely air-tight globe, however, is that the contained oxygen is removed by combustion with the carbon, and carbon vapour or hydrocarbon compounds diffuse through the enclosed space and deposit themselves on the cool sides of the glass, which is thereby obscured. It was, however, shown by L. B. Marks (*Electrician* 31, p. 502, and 38, p. 646) in 1893, that if the arc is an arc formed with a small current and relatively high voltage, namely, 80 to 85 volts, it is possible to admit air in such small amount that though the rate of combustion of the carbons is reduced, yet the air destroys by oxidation the carbon vapour escaping from the arc. An arc lamp operated in this way is called an enclosed arc lamp (fig. 8). The top of the enclosing bulb is closed by a gas check plug which admits through a small hole a limited supply of air. The peculiarity of an enclosed arc lamp operated with a continuous current is that the carbons do not burn to a crater on the positive, and a sharp tip or mushroom on the negative, but preserve nearly flat surfaces. This feature affects the distribution of the light. The illuminating curve of the enclosed arc, therefore, has not such a strongly marked maximum value as that of the open arc, but on the other hand the true arc or column of incandescent carbon vapour is less steady in position, wandering round from place to place on the surface of the carbons. As a compensation for this defect, the combustion of the carbons per hour in commercial forms of enclosed arc lamps is about one-twentieth part of that of an open arc lamp taking the same current.

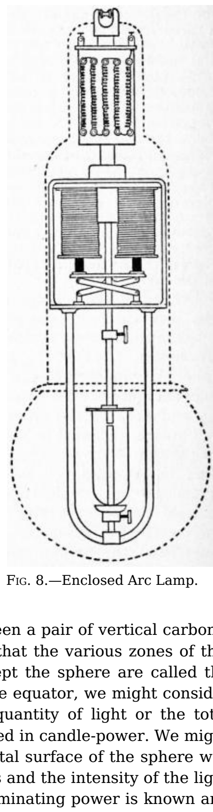
Fig. 8.—Enclosed Arc Lamp.

It was shown by Fleming in 1890 that the column of incandescent carbon vapour constituting the true arc possesses a unilateral conductivity (*Proc. Roy. Inst.* 13, p. 47). If a third carbon is dipped into the arc so as to constitute a third pole, and if a small voltaic battery of a few cells, with a galvanometer in circuit, is connected in between the middle pole and the negative carbon, it is found that when the negative pole of the battery is in connexion with the negative carbon the galvanometer indicates a current, but does not when the positive pole of the battery is in connexion with the negative carbon of the arc.

The arc as an illuminant.

Turning next to the consideration of the electric arc as a source of light, we have already noticed that the illuminating power in different directions is not the same. If we imagine an electric arc, formed between a pair of vertical carbons, to be placed in the centre of a hollow sphere painted white on the interior, then it would be found that the various zones of this sphere are unequally illuminated. If the points in which the carbons when prolonged would intercept the sphere are called the poles, and the line where the horizontal plane through the arc would intercept the sphere is called the equator, we might consider 663
the sphere divided up by lines of latitude into zones, each of which would be differently illuminated. The total quantity of light or the total illumination of each zone is the product of the area of the zone and the intensity of the light falling on the zone measured in candle-power. We might regard the sphere as uniformly illuminated with an intensity of light such that the product of this intensity and the total surface of the sphere was numerically equal to the surface integral obtained by summing up the products of the areas of all the elementary zones and the intensity of the light falling on each. This mean intensity is called the *mean spherical candle-power* of the arc. If the distribution of the illuminating power is known and given by an illumination curve, the mean spherical candle-power can be at once deduced (*La Lumière électrique*, 1890, 37, p. 415).

Let BMC (fig. 9) be a semicircle which by revolution round the diameter BC sweeps out a sphere. Let an arc be situated at A, and let the element of the circumference PQ = ds sweep out a zone of the sphere. Let the intensity of light falling on this zone be I. Then if θ ≈ the angle MAP and $d\theta$ the incremental angle PAQ, and if R is the radius of the sphere, we have

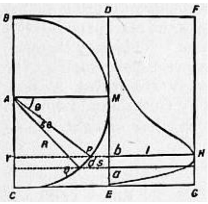

Fig. 9.

$$ds = \mathrm{R}d\theta;$$

also, if we project the element PQ on the line DE we have

$$ab = ds \cos\theta,$$
$$\therefore\ ab = \mathrm{R}\cos\theta d\theta$$
$$\text{and } \mathrm{I}ab = \mathrm{IR}\cos\theta d\theta.$$

Let r denote the radius PT of the zone of the sphere, then

$$r = \mathrm{R}\cos\theta.$$

Hence the area of the zone swept out by PQ is equal to

$$2\pi\mathrm{R}\cos\theta\ ds = 2\pi\mathrm{R}^2\cos\theta d\theta$$

in the limit, and the total quantity of light falling on the zone is equal to the product of the mean intensity or candle-power I in the direction AP and the area of the zone, and therefore to

$$2\pi\mathrm{IR}^2\cos\theta d\theta.$$

Let I_0 stand for the mean spherical candle-power, that is, let I_0 be defined by the equation

$$4\pi\mathrm{R}^2\mathrm{I}_0 = 2\pi\mathrm{R}\Sigma(\mathrm{I}ab)$$

where $\Sigma(\mathrm{I}ab)$ is the sum of all the light actually falling on the sphere surface, then

$$\mathrm{I}_0 = \frac{1}{2\mathrm{R}}\Sigma(\mathrm{I}ab) = \frac{\Sigma(\mathrm{I}ab)}{2\mathrm{RI}_{max}}\mathrm{I}_{max}$$

where I_{max} stands for the maximum candle-power of the arc. If, then, we set off at b a line bH perpendicular to DE and in length proportional to the candle-power of the arc in the direction AP, and carry out the same construction for a number of different observed candle-power readings at known angles above and below the horizon, the summits of all ordinates such as bH will define a curve DHE. The mean spherical candle-power of the arc is equal to the product of the maximum candle-power (I_{max}), and a fraction equal to the ratio of the area included by the curve DHE to its circumscribing rectangle DFGE. The area of the curve DHE multiplied by 2π/R gives us the *total flux of light* from the arc.

Owing to the inequality in the distribution of light from an electric arc, it is impossible to define the illuminating power by a single number in any other way than by stating the mean spherical candle-power. All such commonly used expressions as "an arc lamp of 2000 candle-power" are, therefore, perfectly meaningless.

Photometry of arc.

The photometry of arc lamps presents particular difficulties, owing to the great difference in quality between the light radiated by the arc and that given by any of the ordinarily used light standards. (For standards of light and photometers, see Photometer.) All photometry depends on the principle that if we illuminate two white surfaces respectively and exclusively by two separate sources of light, we can by moving the lights bring the two surfaces into such a condition that their *illumination* or *brightness* is the same without regard to any small colour difference. The quantitative measurement depends on the fact that the illumination produced upon a surface by a source of light is inversely as the square of the distance of the source. The trained eye is capable of making a comparison between two surfaces illuminated by different sources of light, and pronouncing upon their equality or otherwise in respect of brightness, apart from a certain colour difference; but for this to be done with accuracy the two illuminated surfaces, the brightness of which is to be compared, must be absolutely contiguous and not separated by any harsh line. The process of comparing the light from the arc directly with that of a candle or other similar flame standard is exceedingly difficult, owing to the much greater proportion and intensity of the violet rays in the arc. The most convenient practical working standard is an incandescent lamp run at a high temperature, that is, at an efficiency of about 2½ watts per candle. If it has a sufficiently large bulb, and has been *aged* by being worked for some time previously, it will at a constant voltage preserve a constancy in illuminating power sufficiently long to make the necessary photometric comparisons, and it can itself be compared at intervals with another standard incandescent lamp, or with a flame standard such as a Harcourt pentane lamp.

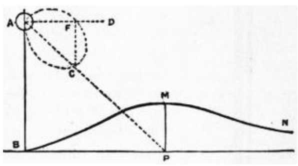

Fig. 10.

In measuring the candle-power of arc lamps it is necessary to have some arrangement by which the brightness of the rays proceeding from the arc in different directions can be measured. For this purpose the lamp may be suspended from a support, and a radial arm arranged to carry three mirrors, so that in whatever position the arm may be placed, it gathers light proceeding at one particular angle above or below the horizon from the arc, and this light is reflected out finally in a constant horizontal direction. An easily-arranged experiment enables us to determine the constant loss of light by reflection at all the mirrors, since that reflection always takes place at 45°. The ray thrown out horizontally can then be compared with that from any standard source of light by means of a fixed photometer, and by sweeping round the radial arm the photometric or illuminating curve of the arc lamp can be obtained. From this we can at once determine the nature of the illumination which would be produced on a horizontal surface if the arc lamp were suspended at a given distance above it. Let A (fig. 10) be an arc lamp placed at a height h(= AB) above a horizontal plane. Let ACD be the illuminating power curve of the arc, and hence AC the candle-power in a direction AP. The illumination (I) or brightness on the horizontal plane at P is equal to

$$\mathrm{AC}\cos\mathrm{APM}/(\mathrm{AP})^2 = \mathrm{FC}/(h^2 + x^2),\ \text{where } x = \mathrm{BP}.$$

Hence if the candle-power curve of the arc and its height above the surface are known, we can describe a curve BMN, whose ordinate PM will denote the brightness on the horizontal surface at any point P. It is easily seen that this ordinate must have a maximum value at some point. This brightness is best expressed in *candle-feet*, taking the unit of illumination to be that given by a standard candle on a white surface at a distance of 1 ft. If any number of arc lamps are placed above a horizontal plane, the brightness at any point can be calculated by adding together the illuminations due to each respectively.

The process of delineating the photometric or polar curve of intensity for an arc lamp is somewhat tedious, but the curve has the advantage of showing exactly the distribution of light in different directions. When only the mean spherical or mean hemispherical candle-power is required the process can be shortened by employing an integrating photometer such as that of C. P. Matthews (*Trans. Amer. Inst. Elec. Eng.*, 1903, 19, p. 1465), or the lumen-meter of A. E. Blondel which enables us to determine at one observation the total flux of light from the arc and therefore the mean spherical candle-power per watt.

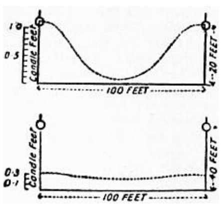

Fig. 12.

Street arc lighting.

In the use of arc lamps for street and public lighting, the question of the distribution of light on the horizontal surface is all-important. In order that street surfaces may be well lighted, the minimum illumination should not fall below 0.1 candle-foot, and in general, in well-lighted streets, the maximum illumination will be 1 candle-foot and upwards. By means of an illumination photometer, such as that of W. H. Preece and A. P. Trotter, it is easy to measure the illumination in candle-feet at any point in a street surface, and to plot out a number of contour lines of equal illumination. Experience has shown that to obtain satisfactory results the lamps must be placed on a high mast 20 or 25 ft. above the roadway surface. These posts are now generally made of cast iron in various ornamental forms (fig. 11), the necessary conductors for conveying the current up to the lamp being taken inside the iron mast. (The pair of incandescent lamps halfway down the standard are for use in the middle of the night, when the arc lamp would give more light than is required; they are lighted by an automatic switch whenever the arc is extinguished.) The lamp itself is generally enclosed in an opalescent spherical globe, which is woven over with wire-netting so that in case of fracture the pieces may not cause damage. The necessary trimming, that is, the replacement of carbons, is effected either by lowering the lamp or, preferably, by carrying round a portable ladder enabling the trimmer to reach it. For the purpose of public illumination it is very usual to employ a lamp taking 10 amperes, and therefore absorbing about 500 watts. Such a lamp is called a 500-watt arc lamp, and it is found that a satisfactory illumination is given for most street purposes by placing 500-watt arc lamps at distances varying from 40 to 100 yds., and at a height of 20 to 25 ft. above the roadway. The maximum candle-power of a 500-watt arc enclosed in a roughened or ground-glass globe will not exceed 1500 candles, and that of a 6.8-ampere arc (continuous) about 900 candles. If, however, the arc is an enclosed arc with double globes, the absorption of light would reduce the effective maximum to about 200 c.p. and 120 c.p. respectively. When arc lamps are placed in public thoroughfares not less than 40 yds. apart, the illumination anywhere on the street surface is practically determined by the two nearest ones. Hence the total illumination at any point may be obtained by adding 664 together the illuminations due to each arc separately. Given the photometric polar curves or illuminating-power curves of each arc taken outside the shade or globe, we can therefore draw a curve representing the resultant illumination on the horizontal surface. It is obvious that the higher the lamps are placed, the more uniform is the street surface illumination, but the less its average value; thus two 10-ampere arcs placed on masts 20 ft. above the road surface and 100 ft. apart will give a maximum illumination of about 1.1 and a minimum of about 0.15 candle-feet in the interspace (fig 12). If the lamps are raised on 40-ft. posts the maximum illumination will fall to 0.3, and the minimum will rise to 0.2. For this reason masts have been employed as high as 90 ft. In docks and railway yards high masts (50 ft.) are an advantage, because the strong contrasts due to shadows of trucks, carts, &c., then become less marked, but for street illumination they should not exceed 30 to 35 ft. in height. Taking the case of 10-ampere and 6.8-ampere arc lamps in ordinary opal shades, the following figures have been given by Trotter as indicating the nature of the resultant horizontal illumination:—

FIG. 11.

Arc Current in Amperes.	Height above Road in Feet.	Distance apart in Feet.	Horizontal Illumination in Candle-Feet.	
			Maximum.	Minimum.
10	20	120	1.85	0.12
10	25	120	1.17	0.15
10	40	120	0.5	0.28
6.8	20	90	1.1	0.21
6.8	40	120	0.3	0.17

As regards distance apart, a very usual practice is to place the lamps at spaces equal to six to ten times their height above the road surface. Blondel (*Electrician*, 35, p. 846) gives the following rule for the height (*h*) of the arc to afford the maximum illumination at a distance (*d*) from the foot of the lamp-post, the continuous current arc being employed:—

For naked arc	$h = 0.95\ d.$
” arc in rough glass globe	$h = 0.85\ d.$
” ” opaline glob	$h =$ ”
” ” opal globe	$h = 0.5\ d.$
” ” holophane globe	$h = 0.5\ d.$

These figures show that the distribution of light on the horizontal surface is greatly affected by the nature of the enclosing globe. For street illumination naked arcs, although sometimes employed in works and factory yards, are entirely unsuitable, since the result produced on the eye by the bright point of light is to paralyse a part of the retina and contract the pupil, hence rendering the eye less sensitive when directed on feebly illuminated surfaces. Accordingly, diffusing globes have to be employed. It is usual to place the arc in the interior of a globe of from 12 to 18 in. in diameter. This may be made of ground glass, opal glass, or be a dioptric globe such as the holophane. The former two are strongly absorptive, as may be seen from the results of experiments by Guthrie and Redhead. The following table shows the astonishing loss of light due to the use of opal globes:—

	Naked Arc.	Arc in Clear Globe.	Arc in Rough Glass Globe.	Arc in Opal Globe.
Mean spherical c.p.	319	235	160	144
Mean hemispherical c.p.	450	326	215	138
Percentage value of transmitted light	100	53	23	19
Percentage absorption	0	47	77	81

By using Trotter’s, Fredureau’s or the holophane globe, the light may be so diffused that the whole globe appears uniformly luminous, and yet not more than 20% of the light is absorbed. Taking the absorption of an ordinary opal globe into account, a 500-watt arc does not usually give more than 500 c.p. as a maximum candle-power. Even with a naked 500-watt arc the mean spherical candle-power is not generally more than 500 c.p., or at the rate of 1 c.p. per watt. The maximum candle-power for a given electrical power is, however, greatly dependent on the current density in the carbon, and to obtain the highest current density the carbons must be as thin as possible. (See T. Hesketh, “Notes on the Electric Arc,” *Electrician*, 39, p. 707.)

For the efficiency of arcs of various kinds, expressed by the mean hemispherical candle power per ampere and per watt expended in the arc, the following figures were given by L. Andrews (“Long-flame Arc Lamps,” *Journal Inst. Elec. Eng.*, 1906, 37, p. 4).

	Candle-power per ampere.	Candle-power per watt.
Ordinary open carbon arc	82	1.54
Enclosed carbon arc	55	0.77
Chemical carbon or flame arc	259	5.80
High voltage inclined carbon arc	200	2.24

It will be seen that the flame arc lamp has an enormous advantage over other types in the light yielded for a given electric power consumption.

Arc lamp

The practical employment of the electric arc as a means of illumination is dependent upon mechanism for automatically keeping two suitable carbon rods in the proper position, and moving them so as to enable a steady arc to be maintained. Means must be provided for holding the carbons in line, and when the lamp is not in operation they must fall together, or come together when the current is

mechanism. switched on, so as to start the arc. As soon as the current passes, they must be moved slightly apart, and gripped in position immediately the current reaches its right value, being moved farther apart if the current increases in strength, and brought together if it decreases. Moreover, it must be possible for a considerable length of carbon to be fed through the lamp as required. 665

One early devised form of arc-lamp mechanism was a system of clockwork driven by a spring or weight, which was started and stopped by the action of an electromagnet; in modern lighthouse lamps a similar mechanism is still employed. W. E. Staite (1847), J. B. L. Foucault (1849), V. L. M. Serrin (1857), J. Duboscq (1858), and a host of later inventors, devised numerous forms of mechanical and clockwork lamps. The modern self-regulating type may be said to have been initiated in 1878 by the differential lamp of F. von Hefner-Alteneck, and the clutch lamp of C. F. Brush. The general principle of the former may be explained as follows: There are two solenoids, placed one above the other. The lower one, of thick wire, is in series with the two carbon rods forming the arc, and is hence called the *series coil*. Above this there is placed another solenoid of fine wire, which is called the *shunt coil*. Suppose an iron rod to be placed so as to be partly in one coil and partly in another; then when the coils are traversed by currents, the iron core will be acted upon by forces tending to pull it into these solenoids. If the iron core be attached to one end of a lever, the other end of which carries the upper carbon, it will be seen that if the carbons are in contact and the current is switched on, the series coil alone will be traversed by the current, and its magnetic action will draw down the iron core, and therefore pull the carbons apart and strike the arc. The moment the carbons separate, there will be a difference of potential between them, and the shunt coil will then come into action, and will act on the core so as to draw the carbons together. Hence the two solenoids act in opposition to each other, one increasing and the other diminishing the length of the arc, and maintaining the carbons in the proper position. In the lamp of this type the upper carbon is in reality attached to a rod having a side-rack gearing, with a train of wheels governed by a pendulum. The action of the series coil on the mechanism is to first lock or stop the train, and then lift it as a whole slightly. This strikes the arc. When the arc is too long, the series coil lowers the gear and finally releases the upper carbon, so that it can run down by its own weight. The principle of a shunt and series coil operating on an iron core in opposition is the basis of the mechanism of a number of arc lamps. Thus the lamp invented by F. Krizik and L. Piette, called from its place of origin the Pilsen lamp, comprises an iron core made in the shape of a double cone or spindle (fig. 13), which is so arranged in a brass tube that it can move into or out of a shunt and series coil, wound the one with fine and the other with thick insulated wire, and hence regulate the position of the carbon attached to it. The movement of this core is made to feed the carbons directly without the intervention of any clockwork, as in the case of the Hefner-Alteneck lamp. In the clutch-lamp mechanism the lower carbon is fixed, and the upper carbon rests upon it by its own weight and that of its holder. The latter consists of a long rod passing through guides, and is embraced somewhere by a ring capable of being tilted or lifted by a finger attached to the armature of an electromagnet the coils of which are in series with the arc. When the current passes through the magnet it attracts the armature, and by tilting the ring lifts the upper carbon-holder and hence strikes the arc. If the current diminishes in value, the upper carbon drops a little by its own weight, and the feed of the lamp is thus effected by a series of small lifts and drops of the upper carbon (fig. 14). Another element sometimes employed in arc-lamp mechanism is the brake-wheel regulator. This is a feature of one form of the Brockie and of the Crompton-Pochin lamps. In these the movement of the carbons is effected by a cord or chain which passes over a wheel, or by a rack geared with the brake wheel. When no current is passing through the lamp, the wheel is free to move, and the carbons fall together; but when the current is switched on, the chain or cord passing over the brake wheel, or the brake wheel itself is gripped in some way, and at the same time the brake wheel is lifted so that the arc is struck.

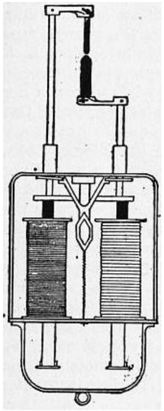

FIG. 13

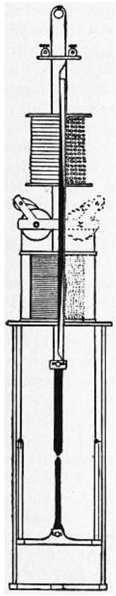

FIG. 14

Although countless forms of self-regulating device have been invented for arc lamps, nothing has survived the test of time so well as the typical mechanisms which work with carbon rods in one line, one or both rods being moved by a controlling apparatus as required. The early forms of semi-incandescent arc lamp, such as those of R. Werdermann and others, have dropped out of existence. These were not really true arc lamps, the light being produced by the incandescence of the extremity of a thin carbon rod pressed against a larger rod or block. The once famous Jablochkoff candle, invented in 1876, consisted of two carbon rods about 4 mm. in diameter, placed parallel to each other and separated by a partition of kaolin, steatite or other refractory non-conductor. Alternating currents were employed, and the candle was set in operation by a match or starter of high-resistance carbon paste which connected the tips of the rods. When this burned off, a true arc was formed between the parallel carbons, the separator volatilizing as the carbons burned away. Although much ingenuity was expended on this system of lighting between 1877 and 1881, it no longer exists. One cause of its disappearance was its relative inefficiency in light-giving power compared with other forms of carbon arc taking the same amount of power, and a second equally important reason was the waste in carbons. If the arc of the electric candle was accidentally blown out, no means of relighting existed; hence the great waste in half-burnt candles. H. Wilde, J. C. Jamin, J. Rapieff and others endeavoured to provide a remedy, but without success.

It is impossible to give here detailed descriptions of a fraction of the arc-lamp mechanisms devised, and it must suffice to indicate the broad distinctions between various types. (1) Arc lamps may be either *continuous-current* or *alternating-current* lamps. For outdoor public illumination the former are greatly preferable, as owing to the form of the illuminating power-curve they send the light down on the road surface, provided the upper carbon is the positive one. For indoor, public room or factory lighting, *inverted arc* lamps are sometimes employed. In this case the positive carbon is the lower one, and the lamp is carried in an inverted metallic reflector shield, so that the light is chiefly thrown up on the ceiling, whence it is diffused all round. The alternating-current arc is not only less efficient in mean spherical candle-power per watt of electric power absorbed, but its distribution of light is disadvantageous for street purposes. Hence when arc lamps have to be worked off an alternating-current circuit for public lighting it is now usual to make use of a *rectifier*, which rectifies the alternating current into an unidirectional though pulsating current. (2.) Arc lamps may be also classified, as above described, into *open* or *enclosed arcs*. The enclosed arc can be made to burn for 200 hours with one pair of carbons, whereas open-arc lamps are usually only able to work, 8, 16 or 32 hours without recarboning, even when fitted with double carbons. (3) Arc lamps are further divided into *focussing* and *non-focussing* lamps. In the former the lower carbon is made to move up as the upper carbon moves down, and the arc is therefore maintained at the same level. This is advisable for arcs included in a globe, and essential in the case of lighthouse lamps and lamps for optical purposes. (4) Another subdivision is into *hand-regulated* and *self-regulating* lamps. In the hand-regulated arcs the carbons are moved by a screw attachment as required, as in some forms of search-light lamp and lamps for optical lanterns. The carbons in large search-light lamps are usually placed horizontally. The self-regulating lamps may be classified into groups depending upon the nature of the regulating appliances. In some cases the regulation is controlled only by a *series coil*, and in others only by a *shunt coil*. Examples of the former are the original Gülcher and Brush clutch lamp, and some modern enclosed arc lamps; and of the latter, the Siemens "band" lamp, and the Jackson-Mensing lamp. In series coil lamps the variation of the current in the coil throws into or out of action the carbon-moving mechanism; in shunt coil lamps the variation in voltage between the carbons is caused to effect the same changes. Other types of lamp involve the use both of shunt and series coils acting against each other. A further classification of the self-regulating lamps may be found in the nature of the carbon-moving mechanism. This may be some modification of the Brush ring clutch, hence called *clutch* lamps; or some variety of *brake wheel*, as employed in Brockie and Crompton lamps; or else some form of *electric motor* is thrown into or out of action and effects the necessary changes. In many cases the arc-lamp mechanism is provided with a *dash-pot*, or contrivance in which a piston moving nearly air-tight in a cylinder prevents sudden jerks in the motion of the mechanism, and thus does away with the "hunting" or rapid up-and-down movements to which some varieties of clutch mechanism are liable. One very efficient form is illustrated in the Thomson lamp and Brush-Vienna lamp. In this mechanism a shunt and series coil are placed side by side, and 666
have iron cores suspended to the ends of a rocking arm held partly within them. Hence, according as the magnetic action of the shunt or series coil prevails, the rocking arm is tilted backwards or forwards. When the series coil is not in action the *motion* is free, and the upper carbon-holder slides down, or the lower one slides up, and starts the arc. The series coil comes into action to withdraw the carbons, and at the same time locks the mechanism. The shunt coil then operates against the series coil, and between them the carbon is fed forwards as required. The control to be obtained is such that the arc shall never become so long as to flicker and become extinguished, when the carbons would come together again with a rush, but the feed should be smooth and steady, the position of the carbons responding quickly to each change in the current.

The introduction of enclosed arc lamps was a great improvement, in consequence of the economy effected in the consumption of carbon and in the cost of labour for trimming. A well-known and widely used form of enclosed arc lamp is the Jandus lamp, which in large current form can be made to burn for two hundred hours without recarboning, and in small or midget form to burn for forty hours, taking a current of two amperes at 100 volts. Such lamps in many cases conveniently replace large sizes of incandescent lamps, especially for shop lighting, as they give a whiter light. Great improvements have also been made in inclined carbon arc lamps. One reason for the relatively low efficiency of the usual vertical rod arrangement is that the crater can only radiate laterally, since owing to the position of the negative carbon no crater light is thrown directly downwards. If, however, the carbons are placed in a downwards slanting position at a small angle like the letter V and the arc formed at the bottom tips, then the crater can emit downwards all the light it produces. It is found, however, that the arc is unsteady unless a suitable magnetic field is employed to keep the arc in position at the carbon tips. This method has been adopted in the Carbone arc, which, by the employment of inclined carbons, and a suitable electromagnet to keep the true arc steady at the ends of the carbons, has achieved considerable success. One feature of the Carbone arc is the use of a relatively high voltage between the carbons, their potential difference being as much as 85 volts.

Arrangement. Arc lamps may be arranged either (i.) in series, (ii.) in parallel or (iii.) in series parallel. In the first case a number, say 20, may be traversed by the same current, in that case supplied at a pressure of 1000 volts. Each must have a magnetic cut-out, so that if the carbons stick together or remain apart the current to the other lamps is not interrupted, the function of such a cut-out being to close the main circuit immediately any one lamp ceases to pass current. Arc lamps worked in series are generally supplied with a current from a constant current dynamo, which maintains an invariable current of, say 10 amperes, independently of the number of lamps on the external circuit. If the lamps, however, are worked in series off a constant potential circuit, such as one supplying at the same time incandescent lamps, provision must be made by which a resistance coil can be substituted for any one lamp removed or short-circuited. When lamps are worked in parallel, each lamp is independent, but it is then necessary to add a resistance in series with the lamp. By special devices three lamps can be worked in series of 100 volt circuits. Alternating-current arc lamps can be worked off a high-tension circuit in parallel by providing each lamp with a small transformer. In some cases the alternating high-tension current is *rectified* and supplied as a unidirectional current to lamps in series. If single alternating-current lamps have to be worked off a 100 volt alternating-circuit, each lamp must have in series with it a choking coil or economy coil, to reduce the circuit pressure to that required for one lamp. Alternating-current lamps take a larger *effective* current, and work with a less effective or virtual carbon P.D., than continuous current arcs of the same wattage.

Cost.

The cost of working public arc lamps is made up of several items. There is first the cost of supplying the necessary electric energy, then the cost of carbons and the labour of recarboning, and, lastly, an item due to depreciation and repairs of the lamps. An ordinary type of open 10 ampere arc lamp, burning carbons 15 and 9 mm. in diameter for the positive and negative, and working every night of the year from dusk to dawn, uses about 600 ft. of carbons per annum. If the positive carbon is 18 mm. and the negative 12 mm., the consumption of each size of carbon is about 70 ft. per 1000 hours of burning. It may be roughly stated that at the present prices of plain open arc-lamp carbons the cost is about 15s. per 1000 hours of burning; hence if such a lamp is burnt every night from dusk to midnight the annual cost in that respect is about £1, 10s. The annual cost of labour per lamp for trimming is in Great Britain from £2 to £3; hence, approximately speaking, the cost per annum of maintenance of a public arc lamp burning every night from dusk to midnight is about £4 to £5, or perhaps £6, per annum, depreciation and repairs included. Since such a 10 ampere lamp uses half a Board of Trade unit of electric energy every hour, it will take 1000 Board of Trade units per annum, burning every night from dusk to midnight; and if this energy is supplied, say at 1½d. per unit, the annual cost of energy will be about £6, and the upkeep of the lamp, including carbons, labour for trimming and repairs, will be about £10 to £11 per annum. The cost for labour and carbons is considerably reduced by the employment of the enclosed arc lamp, but owing to the absorption of light produced by the inner enclosing globe, and the necessity for generally employing a second outer globe, there is a lower resultant candle-power per watt expended in the arc. Enclosed arc lamps are made to burn without attention for 200 hours, singly on 100 volt circuits, or two in series on 200 volt circuits, and in addition to the cost of carbons per hour being only about one-twentieth of that of the open arc, they have another advantage in the fact that there is a more uniform distribution of light on the road surface, because a greater proportion of light is thrown out horizontally.

It has been found by experience that the ordinary type of open arc lamp with vertical carbons included in an opalescent globe cannot compete in point of cost with modern improvements in gas lighting as a means of street illumination. The violet colour of the light and the sharp shadows, and particularly the non-illuminated area just beneath the lamp, are grave disadvantages. The high-pressure flame arc lamp with inclined chemically treated carbons has, however, put a different complexion on matters. Although the treated carbons cost more than the plain carbons, yet there is a great increase of emitted light, and a 9-ampere flame arc lamp supplied with electric energy at 1½d. per unit can be used for 1000 hours at an inclusive cost of about £s to £6, the mean emitted illumination being at the rate of 4 c.p. per watt absorbed. In the Carbone arc lamp, the carbons are worked at an angle of 15° or 20° to each other and the arc is formed at the lower ends. If the potential difference of the carbons is low, say only 50-60 volts, the crater forms between the tips of the carbons and is therefore more or less hidden. If, however, the voltage is increased to 90-100 then the true flame of the arc is longer and is curved, and the crater forms at the exteme tip of the carbons and throws all its light downwards. Hence results a far greater mean hemispherical candle power (M.H.S.C.P.), so that whereas a 10-ampere 60 volt open arc gives at most 1200 M.H.S.C.P., a Carbone 10-ampere 85 volt arc will give 2700 M.H.S.C.P. Better results still can be obtained with impregnated carbons. But the flame arcs with impregnated carbons cannot be enclosed, so the consumption of carbon is greater, and the carbons themselves are more costly, and leave a greater ash on burning; hence more trimming is required. They give a more pleasing effect for street lighting, and their golden yellow globe of light is more useful than an equally costly plain arc of the open type. This improvement in efficiency is, however, accompanied by some disadvantages. The flame arc is very sensitive to currents of air and therefore has to be shielded from draughts by putting it under an "economizer" or chamber of highly refractory material which surrounds the upper carbon, or both carbon tips, if the arc is formed with inclined carbons. (For additional information on flame arc lamps see a paper by L. B. Marks and H. E. Clifford, *Electrician*, 1906, 57, p. 975.)

2. *Incandescent Lamps*.—Incandescent electric lighting, although not the first, is yet in one sense the most obvious method of utilizing electric energy for illumination. It was evolved from the early observed fact that a conductor is heated when traversed by an electric current, and that if it 667 has a high resistance and a high melting-point it may be rendered incandescent, and therefore become a source of light. Naturally every inventor turned his attention to the employment of wires of refractory metals, such as platinum or alloys of platinum-iridium, &c., for the purpose of making an incandescent lamp. F. de Moleyns experimented in 1841, E. A. King and J. W. Starr in 1845, J. J. W. Watson in 1853, and W. E. Staite in 1848, but these inventors achieved no satisfactory result. Part of their want of success is attributable to the fact that the problem of the economical production of electric current by the dynamo machine had not then been solved. In 1878 T. A. Edison devised lamps in which a platinum wire was employed as the light-giving agent, carbon being made to adhere round it by pressure. Abandoning this, he next directed his attention to the construction of an "electric candle," consisting of a thin cylinder or rod formed of finely-divided metals, platinum, iridium, &c., mixed with refractory oxides, such as magnesia, or zirconia, lime, &c. This refractory body was placed in a closed vessel and heated by being traversed by an electric current. In a further improvement he proposed to use a block of refractory oxide, round which a bobbin of fine platinum or platinum-iridium wire was coiled. Every other inventor who worked at the problem of incandescent lighting seems to have followed nearly the same path of invention. Long before this date, however, the notion of employing carbon as a substance to be heated by the current had entered the minds of inventors; even in 1845 King had employed a small rod of plumbago as the substance to be heated. It was obvious, however, that carbon could only be so heated when in a space destitute of oxygen, and accordingly King placed his plumbago rod in a barometric vacuum. S. W. Konn in 1872, and S. A. Kosloff in 1875, followed in the same direction.

Carbon filament lamp.

No real success attended the efforts of inventors until it was finally recognized, as the outcome of the work by J. W. Swan, T. A. Edison, and, in a lesser degree, St. G. Lane Fox and W. E. Sawyer and A. Man, that the conditions of success were as follow: First, the substance to be heated must be carbon in the form of a thin wire rod or thread, technically termed a *filament*; second, this must be supported and enclosed in a vessel formed entirely of glass; third, the vessel must be exhausted as perfectly as possible; and fourth, the current must be conveyed into and out of the carbon filament by means of platinum wires hermetically sealed through the glass.

One great difficulty was the production of the carbon filament. King, Sawyer, Man and others had attempted to cut out a suitably shaped piece of carbon from a solid block; but Edison and Swan were the first to show that the proper solution of the difficulty was to carbonize an organic substance to which the necessary form had been previously given. For this purpose cardboard, paper and ordinary thread were originally employed, and even, according to Edison, a mixture of lampblack and tar rolled out into a fine wire and bent into a spiral. At one time Edison employed a filament of bamboo, carbonized after being bent into a horse-shoe shape. Swan used a material formed by treating ordinary crochet cotton-thread with dilute sulphuric acid, the "parchmentized thread" thus produced being afterwards carbonized. In the modern incandescent lamp the filament is generally constructed by preparing first of all a form of soluble cellulose. Carefully purified cotton-wool is dissolved in some solvent, such as a solution of zinc chloride, and the viscous material so formed is forced by hydraulic pressure through a die. The long thread thus obtained, when hardened, is a semi-transparent substance resembling cat-gut, and when carefully carbonized at a high temperature gives a very dense and elastic form of carbon filament. It is cut into appropriate lengths, which after being bent into horse-shoes, double-loops, or any other shape desired, are tied or folded round carbon formers and immersed in plumbago crucibles, packed in with finely divided plumbago. The crucibles are then heated to a high temperature in an ordinary combustion or electric furnace, whereby the organic matter is destroyed, and a skeleton of carbon remains. The higher the temperature at which this carbonization is conducted, the denser is the resulting product. The filaments so prepared are sorted and measured, and short leading-in wires of platinum are attached to their ends by a carbon cement or by a carbon depositing process, carried out by heating electrically the junction of the carbon and platinum under the surface of a hydrocarbon liquid. They are then mounted in bulbs of lead glass having the same coefficient of expansion as platinum, through the walls of which, therefore, the platinum wires can be hermetically sealed. The bulbs pass into the exhausting-room, where they are exhausted by some form of mechanical or mercury pump. During this process an electric current is sent through the filament to heat it, in order to disengage the gases occluded in the carbon, and exhaustion must be so perfect that no luminous glow appears within the bulb when held in the hand and touched against one terminal of an induction coil in operation.

In the course of manufacture a process is generally applied to the carbon which is technically termed "treating." The carbon filament is placed in a vessel surrounded by an atmosphere of hydrocarbon, such as coal gas or vapour of benzol. If current is then passed through the filament the hydrocarbon vapour is decomposed, and carbon is thrown down upon the filament in the form of a lustrous and dense deposit having an appearance like steel when seen under the microscope. This deposited carbon is not only much more dense than ordinary carbonized organic material, but it has a much lower specific electric resistance. An untreated carbon filament is generally termed the primary carbon, and a deposited carbon the secondary carbon. In the process of treating, the greatest amount of deposit is at any places of high resistance in the primary carbon, and hence it tends to cover up or remedy the defects which may exist. The bright steely surface of a well-treated filament is a worse radiator than the rougher black surface of an untreated one; hence it does not require the expenditure of so much electric power to bring it to the same temperature, and probably on account of its greater density it ages much less rapidly.

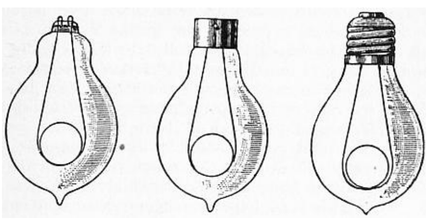

Fig. 15.

Finally, the lamp is provided with a collar having two sole plates on it, to which the terminal wires are attached, or else the terminal wires are simply bent into two loops; in a third form, the Edison screw terminal, it is provided with a central metal plate, to which one end of the filament is connected, the other end being joined to a screw collar. The collars and screws are formed of thin brass embedded in plaster of Paris, or in some material like vitrite or black glass (fig. 15). To put the lamp into connexion with the circuit supplying the current, it has to be fitted into a socket or holder. Three of the principal types of holder in use are the bottom contact (B.C.) or Dornfeld socket, the Edison screw-collar socket and the Swan or loop socket. In the socket of C. Dornfeld (fig. 16, *a* and *a′*) two spring pistons, in contact with the two sides of the circuit, are fitted into the bottom of a short metallic tube having bayonet joint slots cut in the top. The brass collar on the lamp has two pins, by means of which a bayonet connexion is made between it and the socket; and when this is done, the spring pins are pressed against the sole plates on the lamp. In the Edison socket (fig. 16, *b*) a short metal tube with an insulating lining has on its interior a screw sleeve, which is in connexion with one wire of the circuit; at the bottom of the tube, and insulated from the screw sleeve, is a central metal button, which is in connexion with the other side of the circuit. On screwing the lamp into the socket, the screw collar of the lamp and the boss or plate at the base of the lamp make contact with the corresponding parts of the socket, and complete the connexion. In some cases a form of switch is included in the socket, which is then termed the key-holder. For loop lamps the socket consists of an insulated block, having on it two little hooks, which engage with the eyes of the lamp. This insulating block also carries some form of spiral spring or pair of spring loops, by means of which the lamp is pressed away from the socket, and the eyes kept tight by the hooks. This spring or Swan socket (fig. 16, *c*) is found useful in places where the lamps are subject to vibration, for in such cases the Edison screw collar cannot well be used, because the vibration loosens the contact of the lamp in the socket. The sockets may be fitted with appliances for holding ornamental shades or conical reflectors.

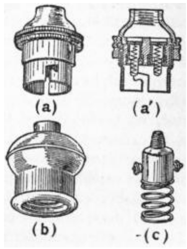

Fig. 16.—Incandescent Lamp Sockets.

The incandescent filament being a very brilliant line of light, various devices are adopted for moderating its brilliancy and distributing the light. A 668
simple method is to sand-blast the exterior of the bulb, whereby it acquires an appearance similar to that of ground glass, or the bare lamp may be enclosed in a suitable glass shade. Such shades, however, if made of opalescent or semi-opaque glass, absorb 40 to 60% of the light; hence various forms of dioptric shade have been invented, consisting of clear glass ruled with prismatic grooves in such a manner as to diffuse the light without any very great absorption. Invention has been fertile in devising etched, coloured, opalescent, frosted and ornamental shades for decorative purposes, and in constructing special forms for use in situations, such as mines and factories for explosives, where the globe containing the lamp must be air-tight. High candle-power lamps, 500, 1000 and upwards, are made by placing in one large glass bulb a number of carbon filaments arranged in parallel between two rings, which are connected with the main leading-in wires. When incandescent lamps are used for optical purposes it is necessary to compress the filament into a small space, so as to bring it into the focus of a lens or mirror. The filament is then coiled or crumpled up into a spiral or zigzag form. Such lamps are called *focus lamps*.

Classification of lamps.

Incandescent lamps are technically divided into high and low voltage lamps, high and low efficiency lamps, standard and fancy lamps. The difference between high and low efficiency lamps is based upon the relation of the power absorbed by the lamp to the candle-power emitted. Every lamp when manufactured is marked with a certain figure, called the *marked volts*. This is understood to be the electromotive force in volts which must be applied to the lamp terminals to produce through the filament a current of such magnitude that the lamp will have a practically satisfactory life, and give in a horizontal direction a certain candle-power, which is also marked upon the glass. The numerical product of the current in amperes passing through the lamp, and the difference in potential of the terminals measured in volts, gives the total power taken up by the lamp in watts; and this number divided by the candle-power of the lamp (taking generally a horizontal direction) gives the *watts per candle-power*. This is an important figure, because it is determined by the temperature; it therefore determines the quality of the light emitted by the lamp, and also fixes the average duration of the filament when rendered incandescent by a current. Even in a good vacuum the filament is not permanent. Apart altogether from accidental defects, the carbon is slowly volatilized, and carbon molecules are also projected in straight lines from different portions of the filament. This process not only causes a change in the nature of the surface of the filament, but also a deposit of carbon on the interior of the bulb, whereby the glass is blackened and the candle-power of the lamp reduced. The volatilization increases very rapidly as the temperature rises. Hence at points of high resistance in the filament, more heat being generated, a higher temperature is attained, and the scattering of the carbon becomes very rapid; in such cases the filament is sooner or later cut through at the point of high resistance. In order that incandescent lighting may be practically possible, it is essential that the lamps shall have a certain *average life*, that is, duration; and this useful duration is fixed not merely by the possibility of passing a current through the lamp at all, but by the rate at which the candle-power diminishes. The decay of candle-power is called the *ageing* of the lamp, and the useful life of the lamp may be said to be that period of its existence before it has deteriorated to a point when it gives only 75% of its original candle-power. It is found that in practice carbon filament lamps, as at present made, if worked at a higher efficiency than 2½ watts per candle-power, exhibit a rapid deterioration in candle-power and an abbreviated life. Hence lamp manufacturers classify lamps into various classes, marked for use say at 2½, 3, 3½ and 4 watts per candle. A 2½ watt per candle lamp would be called a *high-efficiency lamp*, and a 4 watt per candle lamp would be called a *low-efficiency* lamp. In ordinary circumstances the low-efficiency lamp would probably have a longer life, but its light would be less suitable for many purposes of illumination in which colour discrimination is required.

The possibility of employing high-efficiency lamps depends greatly on the uniformity of the electric pressure of the supply. If the voltage is exceedingly uniform, then high-efficiency lamps can be satisfactorily employed; but they are not adapted for standing the variations in pressure which are liable to occur with public supply-stations, since, other things being equal, their filaments are less substantial. The classification into high and low voltage lamps is based upon the watts per candle-power corresponding to the marked volts. When incandescent lamps were first introduced, the ordinary working voltage was 50 or 100, but now a large number of public supply-stations furnish current to consumers at a pressure of 200 or 250 volts. This increase was necessitated by the enlarging area of supply in towns, and therefore the necessity for conveying through the same subterranean copper cables a large supply of electric energy without increasing the maximum current value and the size of the cables. This can only be done by employing a higher working electromotive force; hence arose a demand for incandescent lamps having marked volts of 200 and upwards, technically termed high-voltage lamps. The employment of higher pressures in public supply-stations has necessitated greater care in the selection of the lamp fittings, and in the manner of carrying out the wiring work. The advantages, however, of higher supply pressures, from the point of view of supply-stations, are undoubted. At the same time the consumer desired a lamp of a higher efficiency than the ordinary carbon filament lamp. The demand for this stimulated efforts to produce improved carbon lamps, and it was found that if the filament were exposed to a very high temperature, 3000° C. in an electric furnace, it became more refractory and was capable of burning in a lamp at an efficiency of 2½ watts per c.p. Inventors also turned their attention to substances other than carbon which can be rendered incandescent by the electric current.

Oxide filaments.

The luminous efficiency of any source of light, that is to say, the percentage of rays emitted which affect the eye as light compared with the total radiation, is dependent upon its temperature. In an ordinary oil lamp the luminous rays do not form much more than 3% of the total radiation. In the carbon-filament incandescent lamp, when worked at about 3 watts per candle, the luminous efficiency is about 5%; and in the arc lamp the radiation from the crater contains about 10 to 15% of eye-affecting radiation. The temperature of a carbon filament working at about 3 watts per candle is not far from the melting-point of platinum, that is to say, is nearly 1775° C. If it is worked at a higher efficiency, say 2.5 watts per candle-power, the temperature rises rapidly, and at the same time the volatilization and molecular scattering of the carbon is rapidly increased, so that the average duration of the lamp is very much shortened. An improvement, therefore, in the efficiency of the incandescent lamp can only be obtained by finding some substance which will endure heating to a higher temperature than the carbon filament. Inventors turned their attention many years ago, with this aim, to the refractory oxides and similar substances. Paul Jablochkoff in 1877 described and made a lamp consisting of a piece of kaolin, which was brought to a state of incandescence first by passing over it an electric spark, and afterwards maintained in a state of incandescence by a current of lower electromotive force. Lane Fox and Edison, in 1878, proposed to employ platinum wires covered with films of lime, magnesia, steatite, or with the rarer oxides, zirconia, thoria, &c.; and Lane Fox, in 1879, suggested as an incandescent substance a mixture of particles of carbon with the earthy oxides. These earthy oxides—magnesia, lime and the oxides of the rare earths, such as thoria, zirconia, erbia, yttria, &c.—possess the peculiarity that at ordinary temperatures they are practically non-conductors, but at very high temperatures their resistance at a certain point rapidly falls, and they become fairly good conductors. Hence if they can once be brought into a state of incandescence a current can pass through them and maintain them in that state. But at this temperature they give
up oxygen to carbon; hence no mixtures of earthy oxides with carbon are permanent when heated, and failure has attended all attempts to use a 669
carbon filament covered with such substances as thoria, zirconia or other of the rare oxides.

Nernst lamp.

H. W. Nernst in 1897, however, patented an incandescent lamp in which the incandescent body consists entirely of a slender rod or filament of magnesia. If such a rod is heated by the oxy-hydrogen blowpipe to a high temperature it becomes conductive, and can then be maintained in an intensely luminous condition by passing a current through it after the flame is withdrawn. Nernst found that by mixing together, in suitable proportions, oxides of the rare earths, he was able to prepare a material which can be formed into slender rods and threads, and which is rendered sufficiently conductive to pass a current with an electromotive force as low as 100 volts, merely by being heated for a few moments with a spirit lamp, or even by the radiation from a neighbouring platinum spiral brought to a state of incandescence.

The Nernst lamp, therefore (fig. 17), consists of a slender rod of the mixed oxides attached to platinum wires by an oxide paste. Oxide filaments of this description are not enclosed in an exhausted glass vessel, and they can be brought, without risk of destruction, to a temperature considerably higher than a carbon filament; hence the lamp has a higher luminous efficiency. The material now used for the oxide rod or “glower” of Nernst lamps is a mixture of zirconia and yttria, made into a paste and squirted or pressed into slender rods. This material is non-conductive when cold, but when slightly heated it becomes conductive and then falls considerably in resistance. The glower, which is straight in some types of the lamp but curved in others, is generally about 3 or 4 cm. long and 1 or 2 mm. in diameter. It is held in suitable terminals, and close to it, or round it, but not touching it, is a loose coil of platinum wire, also covered with oxide and called the “heater” (fig. 18). In series with it is a spiral of iron wire, enclosed in a bulb full of hydrogen, which is called the "ballast resistance." The socket also contains a switch controlled by an electromagnet. When the current is first switched on it passes through the heater coil which, becoming incandescent, by radiation heats the glower until it becomes conductive. The glower then takes current, becoming itself brilliantly incandescent, and the electromagnet becoming energized switches the heater coil out of circuit. The iron ballast wire increases in resistance with increase of current, and so operates to keep the total current through the glower constant in spite of small variations of circuit voltage. The disadvantages of the lamp are (1) that it does not light immediately after the current is switched on and is therefore not convenient for domestic use; (2) that it cannot be made in small light units such as 5 c.p.; (3) that the socket and fixture are large and more complicated than for the carbon filament lamp. But owing to the higher temperature, the light is whiter than that of the carbon glow lamp, and the efficiency or candle power per watt is greater. Since, however, the lamp must be included in an opal globe, some considerable part of this last advantage is lost. On the whole the lamp has found its field of operation rather in external than in domestic lighting.

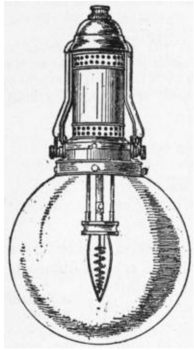

FIG. 17.—Nernst Lamp A Type.

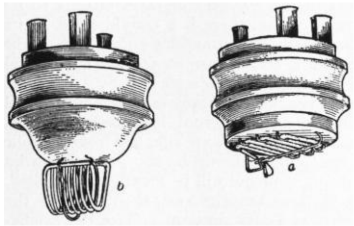

FIG. 18.—Nernst Lamp, Burners for B Type. *a*, low voltage; *b*, high voltage.

Metallic filament lamps.

Great efforts were made in the latter part of the 19th century and the first decade of the 20th to find a material for the filament of an incandescent lamp which could replace carbon and yet not require a preliminary heating like the oxide glowers. This resulted in the production of refractory metallic filament lamps made of osmium, tantalum, tungsten and other rare metals. Auer von Welsbach suggested the use of osmium. This metal cannot be drawn into wire on account of its brittleness, but it can be made into a filament by mixing the finely divided metal with an organic binding material which is carbonized in the usual way at a high temperature, the osmium particles then cohering. The difficulty has hitherto been to construct in this way metallic filament lamps of low candle power (16 c.p.) for 220 volt circuits, but this is being overcome. When used on modern supply circuits of 220 volts a number of lamps may be run in series, or a step-down transformer employed.

FIG. 19.—Tantalum Lamp.

The next great improvement came when W. von Bolton produced the tantalum lamp in 1904. There are certain metals known to have a melting point about 2000° C. or upwards, and of these tantalum is one. It can be produced from the potassium tantalo-fluoride in a pulverulent form. By carefully melting it *in vacuo* it can then be converted into the reguline form and drawn into wire. In this condition it has a density of 16.6 (water = 1), is harder than platinum and has greater tensile strength than steel, viz. 95 kilograms per sq. mm., the value for good steel being 70 to 80 kilograms per sq. mm. The electrical resistance at 15° C. is 0.146 ohms per metre with section of 1 sq. mm. after annealing at 1900° C. *in vacuo* and therefore about 6 times that of mercury; the temperature coefficient is 0.3 per degree C. At the temperature assumed in an incandescent lamp when working at 1.5 watts per c.p. the resistance is 0.830 ohms per metre with a section of 1 sq. mm. The specific heat is 0.0365. Bolton invented methods of producing tantalum in the form of a long fine wire 0.05 mm. in diameter. To make a 25 c.p. lamp 650 mm., or about 2 ft., of this wire are wound backwards and forwards zigzag on metallic supports carried on a glass frame, which is sealed into an exhausted glass bulb. The tantalum lamp so made (fig. 19), working on a 110 volt circuit takes 0.36 amperes or 39 watts, and hence has an efficiency of about 1.6 watts per c.p. The useful life, that is the time in which it loses 20% of its initial candle power, is about 400-500 hours, but in general a life of 800-1000 hours can be obtained. The bulb blackens little in use, but the life is said to be shorter with alternating than with direct current. When worked on alternating current circuits the filament after a time breaks up into sections which become curiously sheared with respect to each other but still maintain electrical contact. The resistance of tantalum increases with the temperature; hence the temperature coefficient is positive, and sudden rises in working voltage do not cause such variations in candle-power as in the case of the carbon lamp.

Patents have also been taken out for lamps made with filaments of such infusible metals as tungsten and molybdenum, and Siemens and Halske, Sanders and others, have protected methods for employing zirconium and other rare metals. According to the patents of Sanders (German patents Nos. 133701, 137568, 137569) zirconium filaments are manufactured from the hydrogen or nitrogen compounds of the rare earths by the aid of some organic binding material. H. Kuzel of Vienna (British Patent No. 28154 of 1904) described methods of making metallic filaments from any metal. He employs the metals in a colloidal condition, either as hydrosol, organosol, gel, or colloidal suspension. The metals are thus obtained in a gelatinous form, and can be squirted into filaments which are dried and reduced to the metallic form by passing an electric current through them (*Electrician*, 57, 894). This process has a wide field of application, and enables the most refractory and infusible metals to be obtained in a metallic wire form. The zirconium and tungsten wire lamps are equal to or surpass the tantalum lamp in efficiency and are capable of giving light, with a 670
useful commercial life, at an efficiency of about one watt per candle. Lamps called osram lamps, with filaments composed of an alloy of osmium and tungsten (wolfram), can be used with a life of 1000 hours when run at an efficiency of about 1.5 watts per candle.

Tungsten lamps are made by the processes of Just and Hanaman (German patent No. 154262 of 1903) and of Kuzel, and at a useful life of 1000 hours, with a falling off in light-giving power of only 10-15%, they have been found to work at an efficiency of one to 1.25 watts per c.p. Further collected information on modern metallic wire lamps and the patent literature thereof will be found in an article in the *Engineer* for December 7, 1906.

Mention should also be made of the Helion filament glow lamp in which the glower is composed largely of silicon, a carbon filament being used as a base. This filament is said to have a number of interesting qualities and an efficiency of about 1 watt per candle (see the *Electrician*, 1907, 58, p. 567).

Mercury vapour lamps.

The mercury vapour lamps of P. Cooper-Hewitt, C. O. Bastian and others have a certain field of usefulness. If a glass tube, highly exhausted, contains mercury vapour and a mercury cathode and iron anode, a current can be passed through it under high electromotive force and will then be maintained when the voltage is reduced. The mercury vapour is rendered incandescent and glows with a brilliant greenish light which is highly actinic, but practically monochromatic, and is therefore not suitable for general illumination because it does not reveal objects in their daylight colours. It is, however, an exceedingly economical source of light. A 3-ampere Cooper-Hewitt mercury lamp has an efficiency of 0.15 to 0.33 watts per candle, or practically the same as an arc lamp, and will burn for several thousand hours. A similar lamp with mercury vapour included in a tube of *uviol* glass specially transparent to ultra-violet light (prepared by Schott & Co. of Jena) seems likely to replace the Finsen arc lamp in the treatment of lupus. Many attempts have been made to render the mercury vapour lamp polychromatic by the use of amalgams of zinc, sodium and bismuth in place of pure mercury for the negative electrode.

Photometry of glow lamps.

An important matter in connexion with glow lamps is their photometry. The arrangement most suitable for the photometry and testing of incandescent lamps is a gallery or room large enough to be occupied by several workers, the walls being painted dead black. The photometer, preferably one of the Lummer-Brodhun form, is set up on a gallery or bench. On one side of it must be fixed a working standard, which as first suggested by Fleming is preferably a large bulb incandescent lamp with a specially "aged" filament. Its candle-power can be compared, at regular intervals and known voltages, with that of some accepted flame standard, such as the 10 candle pentane lamp of Vernon Harcourt. In a lamp factory or electrical laboratory it is convenient to have a number of such large bulb standard lamps. This working standard should be maintained at a fixed distance on one side of the photometer, such that when worked at a standard voltage it creates an illumination of one candle-foot on one side of the photometer disk. The incandescent lamp to be examined is then placed on the other side of the photometer disk on a travelling carriage, so that it can be moved to and fro. Arrangements must be made to measure the current and the voltage of this lamp under test, and this is most accurately accomplished by employing a potentiometer (*q.v.*). The holder which carries the lamp should allow the lamp to be held with its axis in any required position; in making normal measurements the lamp should have its axis vertical, the filament being so situated that none of the turns or loops overlies another as seen from the photometer disk. Observations can then be made of the candle-power corresponding to different currents and voltages.

The candle-power of the lamp varies with the other variables in accordance with exponential laws of the following kind:—

If A is the current in amperes through the lamp, V the voltage or terminal potential difference, W the power absorbed in watts, *c.p.* the maximum candle-power, and *a*, *b*, *c*, &c., constants, it has been found that A and *c.p.* are connected by an exponential law such that

$$c.p. = a\mathrm{A}^x$$

For carbon filament lamps x is a number lying between 5 and 6, generally equal to 5.5 or 5.6. Also it has been found that $c.p. = b\mathrm{W}^3$ very nearly, and that

$$c.p. = c\mathrm{V}^y \text{ nearly}$$

where c is some other constant, and for carbon filaments y is a number nearly equal to 6. It is obvious that if the candle-power of the lamp varies very nearly as the 6th power of the current and of the voltage, the candle-power must vary as the cube of the wattage.

Sir W. de W. Abney and E. R. Festing have also given a formula connecting candle-power and watts equivalent to $c.p. = (W - d)^2$ where d is a constant.

In the case of the tantalum lamp the exponent x has a value near to 6, but the exponent y is a number near to 4, and the same for the osmium filament. Hence for these metallic glowers a certain percentage variation of voltage does not create so great a variation in candle-power as in the case of the carbon lamp.

Curves delineating the relation of these variables for any incandescent lamp are called its *characteristic-curves*. The life or average duration is a function of W/*c.p.*, or of the *watts per candle-power*, and therefore of the voltage at which the lamp is worked. It follows from the above relation that the watts per candle-power vary inversely as the fourth power of the voltage.

From limited observations it seems that the average life of a carbon-filament lamp varies as the fifth or sixth power of the watts per candle-power. If V is the voltage at which the lamp is worked and L is its average life, then L varies roughly as the twenty-fifth power of the reciprocal of the voltage, or

$$L = aV^{-25}.$$

A closer approximation to experience is given by the formula

$$\log_{10}L = 13.5 - \frac{V}{10} - \frac{V^2}{20{,}000}.$$

(See J. A. Fleming, "Characteristic Curves of Incandescent Lamps," *Phil. Mag.* May 1885).

Ageing of lamps. All forms of incandescent or glow lamps are found to deteriorate in light-giving power with use. In the case of carbon filaments this is due to two causes. As already explained, carbon is scattered from the filament and deposited upon the glass, and changes also take place in the filament which cause it to become reduced in temperature, even when subjected to the same terminal voltage. In many lamps it is found that the first effect of running the lamp is slightly to increase its candle-power, even although the voltage be kept constant; this is the result of a small decrease in the resistance of the filament. The heating to which it is subjected slightly increases the density of the carbon at the outset; this has the effect of making the filament lower in resistance, and therefore it takes more current at a constant voltage. The greater part, however, of the subsequent decay in candle-power is due to the deposit of carbon upon the bulb, as shown by the fact that if the filament is taken out of the bulb and put into a new clean bulb the candle-power in the majority of cases returns to its original value. For every lamp there is a certain point in its career which may be called the "smashing-point," when the candle-power falls below a certain percentage of the original value, and when it is advantageous to replace it by a new one. Variations of pressure in the electric supply exercise a prejudicial effect upon the light-giving qualities of incandescent lamps. If glow lamps, nominally of 100 volts, are supplied from a public lighting-station, in the mains of which the pressure varies between 90 and 110 volts, their life will be greatly abbreviated, and they will become blackened much sooner than would be the case if the pressure were perfectly constant. Since the candle-power of the lamp varies very nearly as the fifth or sixth power of the voltage, it follows that a variation of 10% in the electromotive force creates a variation of nearly 50% in the candle-power. Thus a 16 candle-power glow lamp, marked for use at 100 volts, was found on test to give the following candle-powers at voltages varying between 90 and 105: At 105 volts it gave 22.8 c.p.; at 100 volts, 16.7 c.p.; at 95 volts, 12.2 c.p.; and at 90 volts, 8.7 c.p. Thus a variation of 25% in the candle-power was caused by a variation in voltage of only 5%. The same kind of variation in working voltage exercises also a marked effect upon the average duration of the lamp. The following figures show the results of some tests on typical 3.1 watt lamps run at voltages above the normal, taking the average life when worked at the marked volts (namely, 100) as 1000 hours: 671

At	101	volts the	life was	818	hours.
"	102	"	"	681	"
"	103	"	"	662	"
"	104	"	"	452	"
"	105	"	"	374	"
"	106	"	"	310	"

Voltage regulators. Self-acting regulators have been devised by which the voltage at the points of consumption is kept constant, even although it varies at the point of generation. If, however, such a device is to be effective, it must operate very quickly, as even the momentary effect of increased pressure is felt by the lamp. It is only therefore where the working pressure can be kept exceedingly constant that high-efficiency lamps can be advantageously employed, otherwise the cost of lamp renewals more than counterbalances the economy in the cost of power. The slow changes that occur in the resistance of the filament make themselves evident by an increase in the watts per candle-power. The following table shows some typical figures indicating the results of ageing in a 16 candle-power carbon-filament glow lamp:—

Hours run.	Candle-Power.	Watts per Candle-Power.
0	16.0	3.16
100	15.8	3.26
200	15.86	3.13
300	15.68	3.37
400	15.41	3.53
500	15.17	3.51
600	14.96	3.54
700	14.74	3.74

The gradual increase in watts per candle-power shown by this table does not imply necessarily an increase in the total power taken by the lamp, but is the consequence of the decay in candle-power produced by the blackening of the lamp. Therefore, to estimate the value of an incandescent lamp the user must take into account not merely the price of the lamp and the initial watts per candle-power, but the rate of decay of the lamp.

Edison effect. The scattering of carbon from the filament to the glass bulb produces interesting physical effects, which have been studied by T. A. Edison, W. H. Preece and J. A. Fleming. If into an ordinary carbon-filament glow lamp a platinum plate is sealed, not connected to the filament but attached to a third terminal, then it is found that when the lamp is worked with continuous current a galvanometer connected in between the middle plate and the positive terminal of the lamp indicates a current, but not when connected in between the negative terminal of the lamp and the middle plate. If the middle plate is placed between the legs of a horse-shoe-shaped filament, it becomes blackened most quickly on the side facing the negative leg. This effect, commonly called the *Edison effect*, is connected with an electric discharge and convection of carbon which takes place between the two extreme ends of the filament, and, as experiment seems to show, consists in the conveyance of an electric charge, either by carbon molecules or by bodies smaller than molecules. There is, however, an electric discharge between the ends of the filament, which rapidly increases with the temperature of the filament and the terminal voltage; hence one of the difficulties of manufacturing high-voltage glow lamps, that is to say, glow lamps for use on circuits having an electromotive force of 200 volts and upwards, is the discharge from one leg of the filament to the other.

Domestic use. A brief allusion may be made to the mode of use of incandescent lamps for interior and private lighting. At the present time hardly any other method of distribution is adopted than that of an arrangement *in parallel*; that is to say, each lamp on the circuit has one terminal connected to a wire which finally terminates at one pole of the generator, and its other terminal connected to a wire leading to the other pole. The lamp filaments are thus arranged between the conductors like the rungs of a ladder. In series with each lamp is placed a switch and a fuse or cut-out. The lamps themselves are attached to some variety of ornamental fitting, or in many cases suspended by a simple pendant, consisting of an insulated double flexible wire attached at its upper end to a ceiling rose, and carrying at the lower end a shade and socket in which the lamp is placed. Lamps thus hung head downwards are disadvantageously used because their *end-on candle-power* is not generally more than 60% of their maximum candle-power. In interior lighting one of the great objects to be attained is uniformity of illumination with avoidance of harsh shadows. This can only be achieved by a proper distribution of the lamps. It is impossible to give any hard and fast rules as to what number must be employed in the illumination of any room, as a great deal depends upon the nature of the reflecting surfaces, such as the walls, ceilings, &c. As a rough guide, it may be stated that for every 100 sq. ft. of floor surface one 16 candle-power lamp placed about 8 ft. above the floor will give a dull illumination, two will give a good illumination and four will give a brilliant illumination. We generally judge of the nature of the illumination in a room by our ability to read comfortably in any position. That this may be done, the horizontal illumination on the book should not be less than one candle-foot. The following table shows approximately the illuminations in candle-feet, in various situations, derived from actual experiments:—

In a well-lighted room on the floor or tables	1.0 to 3.0 c.f.
On a theatre stage	3.0 to 4.0 c.f.
On a railway platform	.05 to .5 c.f.
In a picture gallery	.65 to 3.5 c.f.

The mean daylight in May in the interior of a room	30.0 to 40.0 c.f.
In full sunlight	7000 to 10,000 c.f.
In full moonlight	1/60th to 1/100th c.f.

From an artistic point of view, one of the worst methods of lighting a room is by pendant lamps, collected in single centres in large numbers. The lights ought to be distributed in different portions of the room, and so shaded that the light is received only by reflection from surrounding objects. Ornamental effects are frequently produced by means of candle lamps in which a small incandescent lamp, imitating the flame of a candle, is placed upon a white porcelain tube as a holder, and these small units are distributed and arranged in electroliers and brackets. For details as to the various modes of placing conducting wires in houses, and the various precautions for safe usage, the reader is referred to the article Electricity Supply. In the case of low voltage metallic filament lamps when the supply is by alternating current there is no difficulty in reducing the service voltage to any lower value by means of a transformer. In the case of direct current the only method available for working such low voltage lamps off higher supply voltages is to arrange the lamps in series.

Additional information on the subjects treated above may be found in the following books and original papers:—

Mrs Ayrton, *The Electric Arc* (London, 1900); Houston and Kennelly, *Electric Arc Lighting and Electric Incandescent Lighting*; S. P. Thompson, *The Arc Light*, Cantor Lectures, Society of Arts (1895); H. Nakano, “The Efficiency of the Arc Lamp,” *Proc. American Inst. Elec. Eng.* (1889); A. Blondel, “Public and Street Lighting by Arc Lamps,” *Electrician*, vols. xxxv. and xxxvi. (1895); T. Heskett, “Notes on the Electric Arc,” *Electrician*, vol. xxxix. (1897); G. S. Ram, *The Incandescent Lamp and its Manufacture* (London, 1895); J. A. Fleming, *Electric Lamps and Electric Lighting* (London, 1899); J. A. Fleming, “The Photometry of Electric Lamps,” *Jour. Inst. Elec. Eng.* (1903), 32, p. 1 (in this paper a copious bibliography of the subject of photometry is given); J. Dredge, *Electric Illumination* (2 vols., London, 1882, 1885); A. P. Trotter, “The Distribution and Measurement of Illumination,” *Proc. Inst. C.E.* vol. cx. (1892); E. L. Nichols, “The Efficiency of Methods of Artificial Illumination,” *Trans. American Inst. Elec. Eng.* vol. vi. (1889); Sir W. de W. Abney, *Photometry*, Cantor Lectures, Society of Arts (1894); A. Blondel, “Photometric Magnitudes and Units,” *Electrician* (1894); J. E. Petavel, “An Experimental Research on some Standards of Light,” *Proc. Roy. Soc.* lxv. 469 (1899); F. Jehl, *Carbon-Making for all Electrical Purposes* (London, 1906); G. B. Dyke, “On the Practical Determination of the Mean Spherical Candle Power of Incandescent and Arc Lamps,” *Phil. Mag.* (1905); the *Preliminary Report of the Sub-Committee of the American Institute of Electrical Engineers* on “Standards of Light”; Clifford C. Paterson, “Investigations on Light Standards and the Present Condition of the High Voltage Glow Lamp,” *Jour. Inst. Elec. Eng.* (January 24, 1907); J. Swinburne, “New Incandescent Lamps,” *Jour. Inst. Elec. Eng.* (1907); L. Andrews, “Long Flame Arc Lamps,” Jour. Inst. Elec. Eng. (1906); W. von Bolton and O. Feuerlein, “The Tantalum Lamp,” *The Electrician* (Jan. 27, 1905). Also the current issues of *The Illuminating Engineer*. 672

(J. A. F.)

Methods of charging.

Commercial Aspects.—The cost of supplying electricity depends more upon the rate of supply than upon the quantity supplied; or, as John Hopkinson put it, “the cost of supplying electricity for 1000 lamps for ten hours is very much less than ten times the cost of supplying the same number of lamps for one hour.” Efforts have therefore been made to devise a system of charge which shall in each case bear some relation to the cost of the service. Consumers vary largely both in respect to the quantity and to the period of their demands, but the cost of supplying any one of them with a given amount of electricity is chiefly governed by the amount of his maximum demand at any one time. The reason for this is that it is not generally found expedient to store electricity in large quantities. Electricity supply works generate the electricity for the most part at the moment it is used by the consumer. Electric lamps are normally in use on an average for only about four hours per day, and therefore the plant and organization, if employed for a lighting load only, are idle and unremunerative for about 20 hours out of the 24. It is necessary to have in readiness machinery capable of supplying the maximum possible requirements of all the consumers at any hour, and this accounts for a very large proportion of the total cost. The cost of raw material, viz. coal, water and stores consumed in the generation of electricity sold, forms relatively only a small part of the total cost, the major part of which is made up of the fixed charges attributable to the time during which the works are unproductive. This makes it very desirable to secure demands possessing high “load” and “diversity” factors. The correct way to charge for electricity is to give liberal rebates to those consumers who make prolonged and regular use of the plant, that is to say, the lower the “peak” demand and the more continuous the consumption, the better should be the discount. The consumer must be discouraged from making sudden large demands on the plant, and must be encouraged, while not reducing his total consumption, to spread his use of the plant over a large number of hours during the year. Mr Arthur Wright has devised a tariff which gives effect to this principle. The system necessitates the use of a special indicator—not to measure the quantity of electricity consumed, which is done by the ordinary meter—but to show the maximum amount of current taken by the consumer at any one time during the period for which he is to be charged. In effect it shows the proportion of plant which has had to be kept on hand for his use. If the indicator shows that say twenty lamps is the greatest number which the consumer has turned on simultaneously, then he gets a large discount on all the current which his ordinary meter shows that he has taken beyond the equivalent of one hour’s daily use of those twenty lamps. Generally the rate charged under this system is 7d. per unit for the equivalent of one hour’s daily use of the maximum demand and 1d. per unit for all surplus. It is on this principle that it pays to supply current for tramway and other purposes at a price which primâ facie is below the cost of production; it is only apparently so in comparison with the cost of producing electricity for lighting purposes. In the case of tramways the electricity is required for 15 or 16 hours per day. Electricity for a single lamp would cost on the basis of this “maximum-demand-indicator” system for 15 hours per day only 1.86d. per unit. In some cases a system of further discounts to very large consumers is combined with the Wright system. Some undertakers have abandoned the Wright system in favour of average flat rates, but this does not imply any failure of the Wright system; on the contrary, the system, having served to establish the most economical consumption of electricity, has demonstrated the average rate at which the undertakers are able to give the supply at a fair profit, and the proportion of possible new customers being small the undertakers find it a simplification to dispense with the maximum demand indicator. But in some cases a mistake has been made by offering the unprofitable early-closing consumers the option of obtaining electricity at a flat rate much lower than their load-factor would warrant and below cost price. The effect of this is to nullify the Wright system of charging, for a consumer will not elect to pay for his electricity on the Wright system if he can obtain a lower rate by means of a flat rate system. Thus the long-hour profitable consumer is made to pay a much higher price than he need be charged, in order that the unprofitable short-hour consumer may be retained and be made actually still more unprofitable. It is not improbable that ultimately the supply will be charged for on the basis of a rate determined by the size and character of the consumer’s premises, or the number and dimensions of the electrical points, much in the same way as water is charged for by a water rate determined by the rent of the consumer’s house and the number of water taps.

Wiring of houses.

Most new houses within an electricity supply area are wired for electricity during construction, but in several towns means have to be taken to encourage small shopkeepers and tenants of small houses to use electricity by removing the obstacle of the first outlay on wiring. The cost of wiring may be taken at 15s. to £2 per lamp installed including all necessary wire, switches, fuses, lamps, holders, casing, but not electroliers or shades. Many undertakers carry out wiring on the easy payment or hire-purchase system. Parliament has sanctioned the adoption of these systems by some local authorities and even authorized them to do the work by direct employment of labour. The usual arrangement is to make an additional charge of ½d. per unit on all current used, with a minimum payment of 1s. per 8 c.p. lamp, consumers having the option of purchasing the installation at any time on specified conditions. The consumer has to enter into an agreement, and if he is only a tenant the landlord has to sign a memorandum to the effect that the wiring and fittings belong to the supply undertakers. Several undertakers have adopted a system of maintenance and renewal of lamps, and at least one local authority undertakes to supply consumers with lamps free of charge.

Consumption.

There is still considerable scope for increasing the business of electricity supply by judicious advertising and other methods. Comparisons of the kilowatt hour consumption per capita in various towns show that where an energetic policy has been pursued the profits have improved by reason of additional output combined with increased load factor. The average number of equivalent 8 c.p. lamps connected per capita in the average of English towns is about 1.2. The average number of units consumed per capita per annum is about 23, and the average income per capita per annum is about 5s. In a number of American cities 20s. per capita per annum is obtained. In the United States a co-operative electrical development association canvasses both the general public and the electricity supply undertakers. Funds are provided by the manufacturing companies acting in concert with the supply authorities and contractors, and the spirit underlying the work is to advertise the merits of electricity—not any particular company or interest. Their efforts are directed to securing new consumers and stimulating the increased and more varied use of electricity among actual consumers.

All supply undertakers are anxious to develop the consumption of electricity for power purposes even more than for lighting, but the first cost of installing electric motors is a deterrent to the adoption of electricity in small factories and shops, and most undertakers are therefore prepared to let out motors, &c., on hire or purchase on varying terms according to circumstances.

A board of trade unit will supply one 8 c.p. carbon lamp of 30 hours or 30 such lamps for one hour. In average use an incandescent lamp will last about 800 hours, which is equal to about 12 months normal use; a good lamp will frequently last more than double this time before it breaks down.

A large number of towns have adopted electricity for street lighting. Frank Bailey has furnished particulars of photometric tests which he has made on new and old street lamps in the city of London. From these tests the following comparative figures are deduced:— 673

	Average total Cost per c.p. per annum.
Gas—	
Double burner ordinary low pressure incandescent (mean of six tests)	11.1d.
Single burner high-pressure gas	9.0
Double burner high-pressure gas	11.7
Arc lamp—	
Old type of lantern	8
Flame arc	5

From these tests of candle-power the illumination at a distance of 100 ft. from the source is estimated as follows:—

	Candle Ft.		Ratio.
Double ordinary incandescent gas lamp illumination	0.013	=	1.0
Single high pressure ordinary incandescent gas lamp illumination	0.016	=	1.24
Double high pressure ordinary incandescent gas lamp illumination	0.027	=	2.10
Ordinary arc lamp	0.060	=	4.50
Flame arc lamp	0.120	=	9.00

The cost of electricity, light for light, is very much less than that of gas. The following comparative figures relating to street lighting at Croydon have been issued by the lighting committee of that corporation:—

Type of Lamp.	Number of Lamps.	Distance apart (yds.)	Total Cost.	Average c.p. per Mile.	Cost per c.p. per annum.
Incandescent gas	2,137	80	£7,062	839	15.86d.
Incandescent electric	90	66	288	1,373	13.71
Electric arcs	428	65	7,212	10,537	11.32

Apart from cheaper methods of generation there are two main sources of economy in electric lighting. One is the improved arrangement and use of electrical installations, and the other is the employment of lamps of higher efficiency. As regards the first, increased attention has been given to the position, candle-power and shading of electric lamps so as to give the most effective illumination in varying circumstances and to avoid excess of light. The ease with which electric lamps may be switched on and off from a distance has lent itself to arrangements whereby current may be saved by switching off lights not in use and by controlling the number of lamps required to be alight at one time on an electrolier. Appreciable economies are brought about by the scientific disposition of lights and the avoidance of waste in use. As regards the other source of economy, the Nernst, the tantalum, the osram, and the metallized carbon filament lamp, although costing more in the first instance than carbon lamps, have become popular owing to their economy in current consumption. Where adopted largely they have had a distinct effect in reducing the rate of increase of output from supply undertakings, but their use has been generally encouraged as tending towards the greater popularity of electric light and an ultimately wider demand. Mercury vapour lamps for indoor and outdoor lighting have also proved their high efficiency, and the use of flame arc lamps has greatly increased the cheapness of outdoor electric lighting.

The existence of a “daylight load” tends to reduce the all-round cost of generating and distributing electricity. This daylight load is partly supplied by power for industrial purposes and partly by the demand for electricity in many domestic operations. The use of electric heating and cooking apparatus (including radiators, ovens, grills, chafing dishes, hot plates, kettles, flat-irons, curling irons, &c.) has greatly developed, and provides a load which extends intermittently throughout the greater part of the twenty-four hours. Electric fans for home ventilation are also used, and in the domestic operations where a small amount of power is required (as in driving sewing machines, boot cleaners, washing machines, mangles, knife cleaners, “vacuum” cleaners, &c.) the electric motor is being largely adopted. The trend of affairs points to a time when the total demand from such domestic sources will greatly exceed the demand for lighting only. The usual charges for current to be used in domestic heating or power operations vary from 1d. to 2d. per unit. As the demand increases the charges will undergo reduction, and there will also be a reflex action in bringing down the cost of electricity for lighting owing to the improved load factor resulting from an increase in the day demand. In the cooking and heating and motor departments also there has been improvement in the efficiency of the apparatus, and its economy is enhanced by the fact that current may be switched on and off as required.

Testing meters.

The Board of Trade are now prepared to receive electric measuring instruments for examination or testing at their electrical standardizing laboratory, where they have a battery power admitting of a maximum current of 7000 amperes to be dealt with. The London county council and some other corporations are prepared upon requisition to appoint inspectors to test meters on consumers’ premises.

Wiring rules.

All supply undertakers now issue rules and regulations for the efficient wiring of electric installations. The rules and regulations issued by the institution of electrical engineers have been accepted by many local authorities and companies, and also by many of the fire insurance companies. The Phoenix fire office rules were the first to be drawn up, and are adopted by many of the fire offices, but some other leading insurance offices have their own rules under which risks are accepted without extra premium. In the opinion of the insurance companies “the electric light is the safest of all illuminants and is preferable to any others when the installation has been thoroughly well put up.” Regulations have also been issued by the London county council in regard to theatres, &c., by the national board of fire underwriters of America (known as the “National Electrical Code”), by the fire underwriters association of Victoria (Commonwealth of Australia), by the Calcutta fire insurance agents association and under the Canadian Electric Light Inspection Act. In Germany rules have been issued by the Verband Deutscher Elektrotechniker and by the union of private fire insurance companies of Germany, in Switzerland by the Association Suisse des électriciens, in Austria by the Elektrotechnischer Verein of Vienna, in France by ministerial decree and by the syndicat professionel des industries électriques. (For reprints of these regulations see *Electrical Trades Directory.*)

(E. Ga.)

1 *Journ. Inst. Elec. Eng.* 28, p. 1. The authors of this paper give numerous instructive curves taken with the oscillograph, showing the form of the arc P.D. and current curves for a great variety of alternating-current arcs.

LIGHTNING, the visible flash that accompanies an electric discharge in the sky. In certain electrical conditions of the atmosphere a cloud becomes highly charged by the coalescence of drops of vapour. A large drop formed by the fusion of many smaller ones contains the same amount of electricity upon a smaller superficial area, and the electric potential of each drop, and of the whole cloud, rises. When the cloud passes near another cloud stratum or near a hilltop, tower or tree, a discharge takes place from the cloud in the form of lightning. The discharge sometimes takes place from the earth to the cloud, or from a lower to a higher stratum, and sometimes from conductors silently. Rain discharges the electricity quietly to earth, and lightning frequently ceases with rain (see Atmospheric Electricity).

LIGHTNING CONDUCTOR, or Lightning Rod (Franklin), the name usually given to apparatus designed to protect buildings or ships from the destructive effects of lightning (Fr. *paratonnerre*, Ger. *Blitzableiter*). The upper regions of the atmosphere being at a different electrical potential from the earth, the thick dense clouds which are the usual prelude to a thunder storm serve to conduct the electricity of the upper air down towards the earth, and an electrical discharge takes place across the air space when the pressure is sufficient. Lightning discharges were distinguished by Sir Oliver Lodge into two distinct types—the *A* and the *B* flashes. The *A* flash is of the simple type which arises when an electrically charged cloud approaches the earth without an intermediate cloud intervening. In the second type *B*, where another cloud intervenes between the cloud carrying the primary charge and the earth, the two clouds practically form a condenser; and when a discharge from the first takes place into the second the free charge on the earth side of the lower cloud is suddenly relieved, and the disruptive discharge from the latter to earth takes such an erratic course that according to the Lightning Research Committee “no series of lightning conductors of the hitherto recognized type suffice to protect the building.” In Germany two kinds of lightning stroke have been recognized, one as “zündenden” (causing fire), analogous to the *B* flash, the other as “kalten” (not causing fire), the ordinary *A* discharge. The destructive effect of the former was noticed in 1884 by A. Parnell, who quoted instances of damage due to mechanical force, which he stated in many cases took place in a more or less upward direction. 674

The object of erecting a number of pointed rods to form a lightning conductor is to produce a glow or brush discharge and thus neutralize or relieve the tension of the thunder-cloud. This, if the latter is of the *A* type, can be successfully accomplished, but sometimes the lightning flash takes place so suddenly that it cannot be prevented, however great the number of points provided, there being such a store of energy in the descending cloud that they are unable to ward off the shock. A *B* flash may ignore the points and strike some metal work in the vicinity; to avoid damage to the structure this must also be connected to the conductors. A single air terminal is of no more use than an inscribed sign-board; besides multiplying the number of points, numerous paths, as well as interconnexions between the conductors, must be arranged to lead the discharge to the earth. The system of pipes and gutters on a roof must be imitated; although a single rain-water pipe would be sufficient to deal with a summer shower, in practice pipes are used in sufficient number to carry off the greatest storm.

Protected Area.—According to Lodge “there is no space near a rod which can be definitely styled an area of protection, for it is possible to receive violent sparks and shocks from the conductor itself, not to speak of the innumerable secondary discharges that are liable to occur in the wake of the main flash.” The report of the Lightning Research Committee contains many examples of buildings struck in the so-called “protected area.”

Material for Conductors.—Franklin’s original rods (1752) were made of iron, and this metal is still employed throughout the continent of Europe and in the United States. British architects, who objected to the unsightliness of the rods, eventually specified copper tape, which is generally run round the sharp angles of a building in such a manner as to increase the chances of the lightning being diverted from the conductor. The popular idea is that to secure the greatest protection a rod of the largest area should be erected, whereas a single large conductor is far inferior to a number of smaller ones and copper as a material is not so suitable for the purpose as iron. A copper rod allows the discharge to pass too quickly and produces a violent shock, whereas iron offers more impedance and allows the flash to leak away by damping down the oscillations. Thus there is less chance of a side flash from an iron than from a copper conductor.

Causes of Failure.—A number of failures of conductors were noticed in the 1905 report of the Lightning Research Committee. One cause was the insufficient number of conductors and earth connexions; another was the absence of any system for connecting the metallic portion of the buildings to the conductors. In some cases the main stroke was received, but damage occurred by side-flash to isolated parts of the roof. There were several examples of large metallic surfaces being charged with electricity, the greater part of which was safely discharged, but enough followed unauthorized paths, such as a speaking-tube or electric bell wires, to cause damage. In one instance a flash struck the building at two points simultaneously; one portion followed the conductor, but the other went to earth jumping from a small finial to a greenhouse 30 ft. below.

Construction of Conductors.—The general conclusions of the Lightning Research Committee agree with the independent reports of similar investigators in Germany, Hungary and Holland. The following is a summary of the suggestions made:—

The conductors may be of copper, or of soft iron protected by galvanizing or coated with lead. A number of paths to earth must be provided; well-jointed rain-water pipes may be utilized.

Fig. 1.—Holdfast.

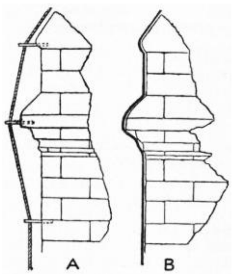

Fig. 2.

Fig. 3.—Aigrette.

Every chimney stack or other prominence should have an air terminal. Conductors should run in the most direct manner from air to earth, and be kept away from the walls by holdfasts (fig. 1), in the manner shown by A (fig. 2); the usual method is seen in B (fig. 2), where the tape follows the contour of the building and causes side flash. A building with a long roof should also be fitted with a horizontal conductor along the ridge, and to this aigrettes (fig. 3) should be attached; a simpler method is to support the cable by holdfasts armed with a spike (fig. 4). Joints must be held together mechanically as well as electrically, and should be protected from the action of the air. At Westminster Abbey the cables are spliced and inserted in a box which is filled with lead run in when molten.

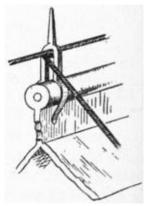

Fig. 4.—Holdfast on Roof.

Earth Connexion.—A copper plate not less than 3 sq. ft. in area may be used as an earth connexion if buried in permanently damp ground. Instead of a plate there are advantages in using the tubular earth shown in fig. 5. The cable packed in carbon descends to the bottom of the perforated tube which is driven into the ground, a connexion being made to the nearest rain-water pipe to secure the necessary moisture. No further attention is required. Plate earths should be tested every year. The number of earths depends on the area of the building, but at least two should be provided. Insulators on the conductor are of no advantage, and it is useless to gild or otherwise protect the points of the air-terminals. As heated air offers a good path for lightning (which is the reason why the kitchen-chimney is often selected by the discharge), a number of points should be fixed to high chimneys and there should be at least two conductors to earth. All roof metals, such as finials, flashings, rain-water gutters, ventilating pipes, cowls and stove pipes, should be connected to the system of conductors. The efficiency of the installation depends on the interconnexion of all metallic parts, also on the quality of the earth connexions. In the case of magazines used for explosives, it is questionable whether the usual plan of erecting rods at the sides of the buildings is efficient. The only way to ensure safety is to enclose the magazine in iron; the next best is to arrange the conductors so that they surround it like a bird cage.

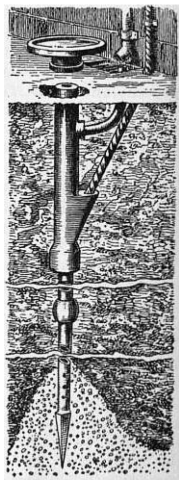

Fig. 5.—Tubular Earth.

Bibliography.—The literature, although extensive, contains so many descriptions of ludicrous devices, that the student, after reading Benjamin Franklin’s *Experiments and Observations on Electricity made at Philadelphia* (1769), may turn to the *Report* of the Lightning Rod Conference of December 1881. In the latter work there are abstracts of many valuable papers, especially the reports made to the French Academy, among others by Coulomb, Laplace, Gay-Lussac, Fresnel, Regnault, &c. In 1876 J. Clerk Maxwell read a paper before the British Association in which he brought forward the idea (based on Faraday’s experiments) of protecting a building from the effects of lightning by surrounding it with a sort of cage of rods or stout wire. It was not, however, until the Bath meeting of the British Association in 1888 that the subject was fully discussed by the physical and engineering sections. Sir Oliver Lodge showed the futility of single conductors, and advised the interconnexion of all the metal work on a building to a number of conductors buried in the earth. The action of lightning flashes was also demonstrated by him in lectures delivered before the Society of Arts (1888). The Clerk Maxwell system was adopted to a large extent in Germany, and in July 1901 a sub-committee of the Berlin Electro-technical Association was formed, which published rules. In 1900 a paper entitled “The Protection of Public Buildings from Lightning,” by Killingworth Hedges, led to the formation, by the Royal Institute of British Architects and the Surveyors’ Institution, of the Lightning Research Committee, on which the Royal Society and the Meteorological Society were represented. The *Report*, edited by Sir Oliver Lodge, Sir John Gavey and Killingworth Hedges (Hon. Sec.), was published in April 1905. An illustrated supplement, compiled by K. Hedges and entitled *Modern Lightning Conductors* (1905), contains particulars of the independent reports of the German committee, the Dutch Academy of Science, and the Royal Joseph university, Budapest. A description is also given of the author’s modified Clerk Maxwell system, in which the metal work of the roofs of a building form the upper part, the rain-water pipes taking the place of the usual lightning-rods. See also Sir Oliver Lodge, *Lightning Conductors* (London, 1902).

(K. H.)

LIGHTS, CEREMONIAL USE OF.

The ceremonial use of lights in the Christian Church, with which this article is mainly concerned, probably has a double origin: in a very natural symbolism, and in the adaptation of certain pagan and Jewish rites and customs of which the symbolic meaning was Christianized. Light is everywhere the symbol of joy and of life-giving power, as darkness is of death and destruction. Fire, the most mysterious and impressive of the elements, the giver of light and of all the good things of life, is a thing sacred and adorable in primitive religions, and fire-worship still has its place in two at least of the great religions of the world. The Parsis adore fire as the visible expression of Ahura-Mazda, the eternal principle of light and righteousness; the Brahmans worship it as divine and omniscient.[1] The Hindu festival of Dewāli (Diyawālī, from *diya*, light), when temples and houses are illuminated with countless lamps, is held every November to celebrate Lakhshmi, the goddess of prosperity. In the ritual of the Jewish temple fire and light played a conspicuous part. In the Holy of Holies was a “cloud of light” (*shekinah*), symbolical of the presence of Yahweh, and before it stood the candlestick with six branches, on each of which and on the central stem was a lamp eternally burning; while in the forecourt was an altar on which the sacred fire was never allowed to go out. Similarly the Jewish synagogues have each their eternal lamp; while in the religion of Islam lighted lamps mark things and places specially holy; thus the Ka’ba at Mecca is illuminated by thousands of lamps hanging from the gold and silver rods

Non-Christian religions.

that connect the columns of the surrounding colonnade.

Greece and Rome.

The Greeks and Romans, too, had their sacred fire and their ceremonial lights. In Greece the *Lampadedromia* or *Lampadephoria* (torch-race) had its origin in ceremonies connected with the relighting of the sacred fire. Pausanias (i. 26, § 6) mentions the golden lamp made by Callimachus which burned night and day in the sanctuary of Athena Polias on the Acropolis, and (vii. 22, §§ 2 and 3) tells of a statue of Hermes Agoraios, in the market-place of Pharae in Achaea, before which lamps were lighted. Among the Romans lighted candles and lamps formed part of the cult of the domestic tutelary deities; on all festivals doors were garlanded and lamps lighted (Juvenal, *Sat.* xii. 92; Tertullian, *Apol.* xxxv.). In the cult of Isis lamps were lighted by day. In the ordinary temples were candelabra, *e.g.* that in the temple of Apollo Palatinus at Rome, originally taken by Alexander from Thebes, which was in the form of a tree from the branches of which lights hung like fruit. In comparing pagan with Christian usage it is important to remember that the lamps in the pagan temples were not symbolical, but votive offerings to the gods. Torches and lamps were also carried in religious processions.

Funeral lamps.

The pagan custom of burying lamps with the dead conveyed no such symbolical meaning as was implied in the late Christian custom of placing lights on and about the tombs of martyrs and saints. Its object was to provide the dead with the means of obtaining light in the next world, a wholly material conception; and the lamps were for the most part unlighted. It was of Asiatic origin, traces of it having been observed in Phoenicia and in the Punic colonies, but not in Egypt or Greece. In Europe it was confined to the countries under the domination of Rome.[2]

Christian symbolism of light.

In Christianity, from the very first, fire and light are conceived as symbols, if not as visible manifestations, of the divine nature and the divine presence. Christ is "the true Light" (John i. 9), and at his transfiguration "the fashion of his countenance was altered, and his raiment was white and glistering" (Luke ix. 29); when the Holy Ghost descended upon the apostles, "there appeared unto them cloven tongues of fire, and it sat upon each of them" (Acts ii. 3); at the conversion of St Paul "there shined round him a great light from heaven" (Acts ix. 3); while the glorified Christ is represented as standing "in the midst of seven candlesticks ... his head and hairs white like wool, as white as snow; and his eyes as a flame of fire" (Rev. i. 14, 15). Christians are "children of Light" at perpetual war with "the powers of darkness."

The early Church.

All this might very early, without the incentive of Jewish and pagan example, have affected the symbolic ritual of the primitive Church. There is, however, no evidence of any ceremonial use of lights in Christian worship during the first two centuries. It is recorded, indeed (Acts xx. 7, 8), that on the occasion of St Paul's preaching at Alexandria in Troas "there were many lights in the upper chamber"; but this was at night, and the most that can be hazarded is that a specially large number were lighted as a festive illumination, as in modern Church festivals (Martigny, *Dict. des antiqu. Chrét.*). As to a purely ceremonial use, such early evidence as exists is all the other way. A single sentence of Tertullian (*Apol.* xxxv.) sufficiently illuminates Christian practice during the 2nd century. "On days of rejoicing," he says, "we do not shade our door-posts with laurels nor encroach upon the day-light with lamps" (*die laeto non laureis postes obumbramus nec lucernis diem infringimus*). Lactantius, writing early in the 4th century, is even more sarcastic in his references to the heathen practice. "They kindle lights," he says, "as though to one who is in darkness. Can he be thought sane who offers the light of lamps and candles to the Author and Giver of all light?" (*Div. Inst. vi. de vero cultu*, cap. 2, in Migne, *Patr. lat.* vi. 637).[3] This is primarily an attack on votive lights, and does not necessarily exclude their ceremonial use in other ways. There is, indeed, evidence that they were so used before Lactantius wrote. The 34th canon of the synod of Elvira (305), which was contemporary with him, forbade candles to be lighted in cemeteries during the day-time, which points to an established custom as well as to an objection to it; and in the Roman catacombs lamps have been found of the 2nd and 3rd centuries which seem to have been ceremonial or symbolical.[4] Again, according to the *Acta* of 676 St Cyprian (d. 258), his body was borne to the grave *praelucentibus cereis*, and Prudentius, in his hymn on the martyrdom of St Lawrence (*Peristeph.* ii. 71, in Migne, *Patr. lat.* lx. 300), says that in the time of St Laurentius, *i.e.* the middle of the 3rd century, candles stood in the churches of Rome on golden candelabra. The gift, mentioned by Anastasius (*in Sylv.*), made by Constantine to the Vatican basilica, of a *pharum* of gold, garnished with 500 dolphins each holding a lamp, to burn before St Peter's tomb, points also to a custom well established before Christianity became the state religion.

Tertullian and Lactantius.

2nd and 3rd centuries.

Jerome and Vigilantius.

Whatever previous custom may have been—and for the earliest ages it is difficult to determine absolutely owing to the fact that the Christians held their services at night—by the close of the 4th century the ceremonial use of lights had become firmly and universally established in the Church. This is clear, to pass by much other evidence, from the controversy of St Jerome with Vigilantius.

Vigilantius, a presbyter of Barcelona, still occupied the position of Tertullian and Lactantius in this matter. "We see," he wrote, "a rite peculiar to the pagans introduced into the churches on pretext of religion, and, while the sun is still shining, a mass of wax tapers lighted.... A great honour to the blessed martyrs, whom they think to illustrate with contemptible little candles (*de vilissimis cereolis*)!" Jerome, the most influential theologian of the day, took up the cudgels against Vigilantius (he "ought to be called Dormitantius"), who, in spite of his fatherly admonition, had dared again "to open his foul mouth and send forth a filthy stink against the relics of the holy martyrs" (*Hier. Ep.* cix. al. 53—*ad Ripuarium Presbyt.*, in Migne, *Patr. lat.* p. 906). If candles are lit before their tombs, are these the ensigns of idolatry? In his treatise *contra Vigilantium* (*Patr. lat.* t. xxiii.) he answers the question with much common sense. There can be no harm if ignorant and simple people, or religious women, light candles in honour of the martyrs. "We are not born, but reborn, Christians," and that which when done for idols was detestable is acceptable when done for the martyrs. As in the case of the woman with the precious box of ointment, it is not the gift that merits reward, but the faith that inspires it. As for lights in the churches, he adds that "in all the churches of the East, whenever the gospel is to be read, lights are lit, though the sun be rising (*jam sole rutilante*), not in order to disperse the darkness, but as a visible sign of gladness (*ad signum laetitiae demonstrandum*)." Taken in connexion with a statement which almost immediately precedes this—"Cereos autem non clara luce accendimus, sicut frustra calumniaris: sed ut noctis tenebras hoc solatio temperemus" (§ 7)—this seems to point to the fact that the ritual use of lights in the church services, so far as already established, arose from the same conservative habit as determined the development of liturgical vestments, *i.e.* the lights which had been necessary at the nocturnal meetings were retained, after the hours of service had been altered, and invested with a symbolical meaning.

Practice in the 4th century.

Already they were used at most of the conspicuous functions of the Church. Paulinus, bishop of Nola (d. 431), describes the altar at the eucharist as "crowned with crowded lights,"[5] and even mentions the "eternal lamp."[6] For their use at baptisms we have, among much other evidence, that of Zeno of Verona for the West,[7] and that of Gregory of Nazianzus for the East.[8] Their use at funerals is illustrated by Eusebius's description of the burial of Constantine,[9] and Jerome's account of that of St Paula.[10] At ordinations they were used, as is shown by the 6th canon of the council of Carthage (398), which decrees that the acolyte is to hand to the newly ordained deacon *ceroferarium cum cereo*. As to the blessing of candles, according to the *Liber pontificalis* Pope Zosimus in 417 ordered these to be blessed,[11] and the Gallican and Mozarabic rituals also provided for this ceremony.[12] The Feast of the Purification of the Virgin, known as Candlemas (*q.v.*), because on this day the candles for the whole year are blessed, was established—according to some authorities—by Pope Gelasius I. about 492. As to the question of "altar lights," however, it must be borne in mind that these were not placed upon the altar, or on a retable behind it, until the 12th century. These were originally the candles carried by the deacons, according to the *Ordo Romanus* (i. 8; ii. 5; iii. 7) seven in number, which were set down either on the steps of the altar, or, later, behind it. In the Eastern Church, to this day, there are no lights on the high altar; the lighted candles stand on a small altar beside it, and at various parts of the service are carried by the lectors or acolytes before the officiating priest or deacon. The "crowd of lights" described by Paulinus as crowning the altar were either grouped round it or suspended in front of it; they are represented by the sanctuary lamps of the Latin Church and by the crown of lights suspended in front of the altar in the Greek.

Eastern Church.

Development of the use.

To trace the gradual elaboration of the symbolism and use of ceremonial lights in the Church, until its full development and systematization in the middle ages, would be impossible here. It must suffice to note a few stages in the process. The burning of lights before the tombs of martyrs led naturally to their being burned also before relics and lastly before images and pictures. This latter practice, hotly denounced as idolatry during the iconoclastic controversy (see Iconoclasm), was finally established as orthodox by the second general council of Nicaea (787), which restored the worship of images. A later development, however, by which certain lights themselves came to be regarded as objects of worship and to have other lights burned before *them*, was condemned as idolatrous by the synod of Noyon in 1344.[13] The passion for symbolism extracted ever new meanings out of the candles and their use. Early in the 6th century Ennodius, bishop of Pavia, pointed out the three-fold elements of a wax-candle (*Opusc.* ix. and x.), each of which would make it an offering acceptable to God; the rush-wick is the product of pure water, the wax is the offspring of virgin bees,[14] the flame is sent from heaven.[15] Clearly, wax was a symbol of the Blessed Virgin and the holy humanity of Christ. The later middle ages developed the idea. Durandus, in his *Rationale*, interprets the wax as the body of Christ, the wick as his soul, the flame as his divine nature; and the consuming candle as symbolizing his passion and death.

In the Roman Catholic Church.

In the completed ritual system of the medieval Church, as still preserved in the Roman Catholic communion, the use of ceremonial lights falls 677 under three heads. (1) They may be symbolical of the light of God's presence, of Christ as "Light of Light," or of "the children of Light" in conflict with the powers of darkness; they may even be no more than expressions of joy on the occasion of great festivals. (2) They may be votive, *i.e.* offered as an act of worship (*latria*) to God. (3) They are, in virtue of their benediction by the Church, *sacramentalia*, *i.e.* efficacious for the good of men's souls and bodies, and for the confusion of the powers of darkness.[16] With one or more of these implications, they are employed in all the public functions of the Church. At the consecration of a church twelve lights are placed round the walls at the twelve spots where these are anointed by the bishop with holy oil, and on every anniversary these are relighted; at the dedication of an altar tapers are lighted and censed at each place where the table is anointed (*Pontificale Rom.* p. ii. *De eccl. dedicat. seu consecrat.*). At every liturgical service, and especially at Mass and at choir services, there must be at least two lighted tapers on the altar,[17] as symbols of the presence of God and tributes of adoration. For the Mass the rule is that there are six lights at High Mass, four at a *missa cantata*, and two at private masses. At a Pontifical High Mass (*i.e.* when the bishop celebrates) the lights are seven, because seven golden candlesticks surround the risen Saviour, the chief bishop of the Church (see Rev. i. 12). At most pontifical functions, moreover, the bishop—as the representative of Christ—is

Dedication of a church.

At Mass and choir services.

preceded by an acolyte with a burning candle (*bugia*) on a candlestick. The *Ceremoniale Episcoporum* (i. 12) further orders that a burning lamp is to hang at all times before each altar, three in front of the high altar, and five before the reserved Sacrament, as symbols of the eternal Presence. In practice, however, it is usual to have only one lamp lighted before the tabernacle in which the Host is reserved. The special symbol of the real presence of Christ is the *Sanctus* candle, which is lighted at the moment of consecration and kept burning until the communion. The same symbolism is intended by the lighted tapers which must accompany the Host whenever it is carried in procession, or to the sick and dying.

Sanctuary lamps.

Symbol of the Real Presence.

As symbols of light and joy a candle is held on each side of the deacon when reading the Gospel at Mass; and the same symbolism underlies the multiplication of lights on festivals, their number varying with the importance of the occasion. As to the number of these latter no rule is laid down. They differ from liturgical lights in that, whereas these must be tapers of pure beeswax or lamps fed with pure olive oil (except by special dispensation under certain circumstances), those used merely to add splendour to the celebration may be of any material; the only exception being, that in the decoration of the altar gas-lights are forbidden.

Tenebrae.

In general the ceremonial use of lights in the Roman Catholic Church is conceived as a dramatic representation in fire of the life of Christ and of the whole scheme of salvation. On Easter Eve the new fire, symbol of the light of the newly risen Christ, is produced, and from this are kindled all the lights used throughout the Christian year until, in the gathering darkness (*tenebrae*) of the Passion, they are gradually extinguished. This quenching of the light of the world is symbolized at the service of *Tenebrae* in Holy Week by the placing on a stand before the altar of thirteen lighted tapers arranged pyramidally, the rest of the church being in darkness. The penitential psalms are sung, and at the end of each a candle is extinguished. When only the central one is left it is taken down and carried behind the altar, thus symbolizing the betrayal and the death and burial of Christ. This ceremony can be traced to the 8th century at Rome.

The Paschal Candle.

On Easter Eve new fire is made[18] with a flint and steel, and blessed; from this three candles are lighted, the *lumen Christi*, and from these again the Paschal Candle.[19] This is the symbol of the risen and victorious Christ, and burns at every solemn service until Ascension Day, when it is extinguished and removed after the reading of the Gospel at High Mass. This, of course, symbolizes the Ascension; but meanwhile the other lamps in the church have received their light from the Paschal Candle, and so symbolize throughout the year the continued presence of the light of Christ.

Baptism. Ordination, etc.

Funeral lights.

At the consecration of the baptismal water the burning Paschal Candle is dipped into the font "so that the power of the Holy Ghost may descend into it and make it an effective instrument of regeneration." This is the symbol of baptism as rebirth as children of Light. Lighted tapers are also placed in the hands of the newly-baptized, or of their god-parents, with the admonition "to preserve their baptism inviolate, so that they may go to meet the Lord when he comes to the wedding." Thus, too, as "children of Light," candidates for ordination and novices about to take the vows carry lights when they come before the bishop; and the same idea underlies the custom of carrying lights at weddings, at the first communion, and by priests going to their first mass, though none of these are liturgically prescribed. Finally, lights are placed round the bodies of the dead and carried beside them to the grave, partly as symbols that they still live in the light of Christ, partly to frighten away the powers of darkness.

Excommunication.

Conversely, the extinction of lights is part of the ceremony of excommunication (*Pontificale Rom.* pars iii.). Regino, abbot of Prum, describes the ceremony as it was carried out in his day, when its terrors were yet unabated (*De eccles. disciplina*, ii. 409). "Twelve priests should stand about the bishop, holding in their hands lighted torches, which at the conclusion of the anathema or excommunication they should cast down and trample under foot." When the excommunication is removed, the symbol of reconciliation is the handing to the penitent of a burning taper.

Protestant Churches.

As a result of the Reformation the use of ceremonial lights was either greatly modified, or totally abolished in the Protestant Churches. In the Reformed (Calvinistic) Churches altar lights were, with the rest, done away with entirely as popish and superstitious. In the Lutheran Churches they were retained, and in Evangelical Germany have even survived most of the other medieval rites and ceremonies (*e.g.* the use of vestments) which were not abolished at the Reformation itself.

Church of England.

In the Church of England the practice has been less consistent. The first Prayer-book of Edward VI. directed two lights to be placed on the altar. This direction was omitted in the second Prayer-book; but the "Ornaments Rubric" of Queen Elizabeth's Prayer-book seemed again to make them obligatory. The question of how far this did so is a much-disputed one and is connected with the whole problem of the meaning and scope of the rubric (see Vestments). An equal uncertainty reigns with regard to the actual usage of the Church of England from the Reformation onwards. Lighted candles certainly continued to decorate the holy table in Queen Elizabeth's chapel, to the scandal of Protestant zealots. They also seem to have been retained, at least for a while, in certain cathedral and collegiate churches. There is, however, no mention of ceremonial candles in the detailed account of the services of the Church of England given by William Harrison (*Description of England*, 1570); and the attitude of the Church towards their use, until the ritualistic movement of the 17th century, would seem to be authoritatively expressed in the *Third Part of the Sermon against Peril of Idolatry*, which quotes with approval the views of Lactantius and compares "our Candle Religion" with the "Gentiles Idolators." This pronouncement, indeed, though it certainly condemns the use of ceremonial 678 lights in most of its later developments, and especially the conception of them as votive offerings whether to God or to the saints, does not necessarily exclude, though it undoubtedly discourages, their purely symbolical use.[20] In this connexion it is worth pointing out that the homily against idolatry was reprinted, without alteration and by the king's authority, long after altar lights had been restored under the influence of the high church party supreme at court. Illegal under the Act of Uniformity they seem never to have been. The use of "wax lights and tapers" formed one of the indictments brought by P. Smart, a Puritan prebendary of Durham, against Dr Burgoyne, Cosin and others for setting up "superstitious ceremonies" in the cathedral "contrary to the Act of Uniformity." The indictments were dismissed in 1628 by Sir James Whitelocke, chief justice of Chester and a judge of the King's Bench, and in 1629 by Sir Henry Yelverton, a judge of Common Pleas and himself a strong Puritan (see *Hierurgia Anglicana*, ii pp. 230 seq.). The use of ceremonial lights was among the indictments in the impeachment of Laud and other bishops by the House of Commons, but these were not based on the Act of Uniformity. From the Restoration onwards the use of ceremonial lights, though far from universal, was not unusual in cathedrals and collegiate churches.[21] It was not, however, till the ritual revival of the 19th century that their use was at all widely extended in parish churches. The growing custom met with fierce opposition; the law was appealed to, and in 1872 the Privy Council declared altar lights to be illegal (*Martin* v. *Mackonochie*). This judgment, founded as was afterwards admitted on insufficient knowledge, produced no effect; and, in the absence of any authoritative pronouncement, advantage was taken of the ambiguous language of the Ornaments Rubric to introduce into many churches practically the whole ceremonial use of lights as practised in the pre-Reformation Church. The matter was again raised in the case of *Read and others* v. *the Bishop of Lincoln* (see Lincoln Judgment), one of the counts of the indictment being that the bishop had, during the celebration of Holy Communion, allowed two candles to be alight on a shelf or retable behind the communion table when they were not necessary for giving light. The archbishop of Canterbury, in whose court the case was heard (1889), decided that the mere presence of two candles on the table, burning during the service but lit before it began, was lawful under the first Prayer-Book of Edward VI. and had never been made unlawful. On the case being appealed to the Privy Council, this particular indictment was dismissed on the ground that the vicar, not the bishop, was responsible for the presence of the lights, the general question of the legality of altar lights being discreetly left open.

The "Lincoln Judgment."

The custom of placing lighted candles round the bodies of the dead, especially when "lying in state," has never wholly died out in Protestant countries, though their significance has long been lost sight of.[22] In the 18th century, moreover, it was still customary in England to accompany a funeral with lighted tapers. Picart (*op. cit.* 1737) gives a plate representing a funeral cortège preceded and accompanied by boys, each carrying four lighted candles in a branched candlestick. There seems to be no record of candles having been carried in other processions in England since the Reformation. The usage in this respect in some "ritualistic" churches is a revival of pre-Reformation ceremonial.

See the article "Lucerna," by J. Toutain in Daremberg and Saglio's *Dict. des antiquités grecques et romaines* (Paris, 1904); J. Marquardt, "Römische Privataltherthümer" (vol. v. of Becker's *Röm. Alterthümer*), ii. 238-301; article "Cièrges et lampes," in the Abbé J. A. Martigny's *Dict. des Antiquités Chrétiennes* (Paris, 1865); the articles "Lichter" and "Koimetarien" (pp. 834 seq.) in Herzog-Hauck's *Realencyklopädie* (3rd ed., Leipzig. 1901); the article "Licht" in Wetzer and Welte's *Kirchenlexikon* (Freiburg-i.-B., 1882-1901), an excellent exposition of the symbolism from the Catholic point of view, also "Kerze" and "Lichter"; W. Smith and S. Cheetham, *Dict. of Chr. Antiquities* (London, 1875-1880), i. 939 seq.; in all these numerous further references will be found. See also Mühlbauer, *Gesch. u. Bedeutung der Wachslichter bei den kirchlichen Funktionen* (Augsburg, 1874); V. Thalhofer, *Handbuch der Katholischen Liturgik* (Freiburg-i.-B., 1887), i. 666 seq.; and, for the post-Reformation use in the Church of England, *Hierurgia Anglicana*, new ed. by Vernon Staley (London, 1903).

(W. A. P.)

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1 "O Fire, thou knowest all things!" See A. Bourquin, "Brahma-karma, ou rites sacrés des Brahmans," in the *Annales du Musée Guimet* (Paris, 1884, t. vii.).

2 J. Toutain, in Daremberg and Saglio, *Dictionnaire, s.v.* "Lucerna."

3 This is quoted with approval by Bishop Jewel in the homily *Against Peril of Idolatry* (see below).

4 This symbolism—whatever it was—was not pagan, *i.e.* the lamps were not placed in the graves as part of the furniture of the dead—in the Catacombs they are found only in the niches of the galleries and the arcosolia—nor can they have been votive in the sense popularized later.

5 "Clara coronantur densis altaria lychnis" (*Poem. De S. Felice natalitium*, xiv. 99, in Migne, *Patr. lat.* lxi. 467).

6 "Continuum scyphus est argenteus aptus ad usum."

7 "Sal, ignis et oleum" (Lib. i. Tract. xiv. 4, in Migne, xi. 358).

8 *In sanct. Pasch.* c. 2; Migne, *Patr. graeca*, xxxvi. 624.

9 φῶτα τ᾽ ἐφάψαντες κύκλῳ ἐπὶ σκευῶν χρυσῶν, θαυμαστὸν θέαα τοῖς ὁρῶσι παρεῖχον (*Vita Constantini*, iv. 66).

10 "Cum alii Pontifices lampadàs cereosque proferrent, alii choras psallentium ducerent" (Ep. cviii. *ad Eustochium virginem*, in Migne).

11 This may be the paschal candle only. In some codices the text runs: “Per parochias concessit licentiam benedicendi Cereum Paschalem” (Du Cange, *Glossarium, s.v.* “Cereum Paschale”). In the three variants of the notice of Zosimus given in Duchesne’s edition of the *Lib. pontif.* (1886-1892) the word *cera* is, however, alone used. Nor does the text imply that he gave to the suburbican churches a privilege hitherto exercised by the metropolitan church. The passage runs: “Hic constituit ut diaconi leva tecta haberent de palleis linostimis per parrochias et ut cera benedicatur,” &c. *Per parrochias* here obviously refers to the head-gear of the deacons, not to the candles.

12 See also the *Peregrinatio Sylviae* (386), 86, &c., for the use of lights at Jerusalem, and Isidore of Seville (*Etym.* vii. 12; xx. 10) for the usage in the West. That even in the 7th century the blessing of candles was by no means universal is proved by the 9th canon of the council of Toledo (671), “De benedicendo cereo et lucerna in privilegiis Paschae.” This canon states that candles and lamps are not blessed in some churches, and that inquiries have been made why *we* do it. In reply, the council decides that it should be done to celebrate the mystery of Christ’s resurrection. See Isidore of Seville, *Conc.*, in Migne, *Pat. lat.* lxxxiv. 369.

13 Du Cange, *Glossarium, s.v.* “Candela.”

14 Bees were believed, like fish, to be sexless.

15 “Venerandis compactam elementis facem tibi, Domine, mancipamus: in qua trium copula munerum primum de impari numero complacebit: quae quod gratis Deo veniat auctoribus, non habetur incertum: unum quod de fetibus fluminum accedunt nutrimenta flammarum: aliud quod apum tribuit intemerata fecunditas, in quarum partibus nulla partitur damna virginitas: ignis etiam coelo infusus adhibetur” (*Opusc.* x. in Migne, *Patr. lat.* t. lxiii.).

16 All three conceptions are brought out in the prayers for the blessing of candles on the Feast of the Purification of the B.V.M. (Candlemas, *q.v.*). (1) “O holy Lord, ... who ... by the command didst cause this liquid to come by the labour of bees to the perfection of wax, ... we beseech thee ... to bless and sanctify these candles for the use of men, and the health of bodies and souls....” (2) “... these candles, which we thy servants desire to carry lighted to magnify thy name; that by offering them to thee, being worthily inflamed with the holy fire of thy most sweet charity, we may deserve,” &c. (3) “O Lord Jesus Christ, the true light, ... mercifully grant, that as these lights enkindled with visible fire dispel nocturnal darkness, so our hearts illumined by invisible fire,” &c. (*Missale Rom.*). In the form for the blessing of candles *extra diem Purificationis B. Mariae Virg.* the virtue of the consecrated candles in discomfiting demons is specially brought out: “that in whatever places they may be lighted, or placed, the princes of darkness may depart, and tremble, and may fly terror-stricken with all their ministers from those habitations, nor presume further to disquiet and molest those who serve thee, Almighty God” (*Rituale Rom.*).

17 Altar candlesticks consist of five parts: the foot, stem, knob in the centre, bowl to catch the drippings, and pricket (a sharp point on which the candle is fixed). It is permissible to use a long tube, pointed to imitate a candle, in which is a small taper forced to the top by a spring (*Cong. Rit.*, 11th May 1878).

18 This is common to the Eastern Church also. Pilgrims from all parts of the East flock to Jerusalem to obtain the “new fire” on Easter Eve at the Church of the Holy Sepulchre. Here the fire is supposed to be miraculously sent from heaven. The rush of the pilgrims to kindle their lights at it is so great, that order is maintained with difficulty by Mahommedan soldiers.

19 The origin of the Paschal Candle is lost in the mists of antiquity. According to the abbé Châtelain (quoted in Diderot’s *Encyclopédie, s.v.* “Cièrge”) the Paschal Candle was not originally a candle at all, but a wax column on which the dates of the movable feasts were inscribed. These were later written on paper and fixed to the Paschal Candle, a custom which in his day survived in the Cluniac churches.

20 This homily, written by Bishop Jewel, is largely founded on Bullinger’s *De origine erroris in Divinorum et sacrorum cultu* (1528, 1539).

21 A copper-plate in Bernard Picart’s *Ceremonies and Religious Customs of the Various Nations* (Eng. trans., London, 1737), vi. pt. 1, p. 78, illustrating an Anglican Communion service at St Paul’s, shows two lighted candles on the holy table.

22 In some parts of Scotland it is still customary to place two lighted candles on a table beside a corpse on the day of burial.

LIGNE, CHARLES JOSEPH, Prince de (1735-1814), soldier and writer, came of a princely family of Hainaut, and was born at Brussels in 1735. As an Austrian subject he entered the imperial army at an early age. He distinguished himself by his valour in the Seven Years’ War, notably at Breslau, Leuthen, Hochkirch and Maxen, and after the war rose rapidly to the rank of lieutenant field marshal. He became the intimate friend and counsellor of the emperor Joseph II., and, inheriting his father’s vast estates, lived in the greatest splendour and luxury till the War of the Bavarian Succession brought him again into active service. This war was short and uneventful, and the prince then travelled in England, Germany, Italy, Switzerland and France, devoting himself impartially to the courts, the camps, the salons and the learned assemblies of philosophers and scientists in each country. In 1784 he was again employed in military work, and was promoted to Feldzeugmeister. In 1787 he was with Catherine II. in Russia, accompanied her in her journey to the Crimea, and was made a Russian field marshal by the empress. In 1788 he was present at the siege of Belgrade. Shortly after this he was invited to place himself at the head of the Belgian revolutionary movement, in which one of his sons and many of his relatives were prominent, but declined with great courtesy, saying that “he never revolted in the winter.” Though suspected by Joseph of collusion with the rebels, the two friends were not long estranged, and after the death of the emperor the prince remained in Vienna. His Brabant estates were overrun by the French in 1792-1793, and his eldest son killed in action at La Croix-du-Bois in the Argonne (September 14, 1792). He was given the rank of field marshal (1809) and an honorary command at court, living in spite of the loss of his estates in comparative luxury and devoting himself to literary work. He lived long enough to characterize the proceedings of the congress of Vienna with the famous *mot*: “Le Congrès danse mais ne marche pas.” He died at Vienna on the 13th of December 1814. His grandson, Eugene Lamoral de Ligne (1804-1880), was a distinguished Belgian statesman.

His collected works appeared in thirty-four volumes at Vienna during the last years of his life (*Mélanges militaires*, *littéraires*, *sentimentaires*), and he bequeathed his manuscripts to the emperor’s Trabant Guard, of which he was captain (*Œuvres posthumes*, Dresden and Vienna, 1817). Selections were published in French and German (*Œuvres choisies de M. le prince de Ligne* (Paris, 1809); *Lettres et pensées du Maréchal Prince de Ligne*, ed. by Madame de Staël (1809); *Œuvres historiques, littéraires ... correspondance et poésies diverses* (Brussels, 1859); *Des Prinzen Karl von Ligne militärische Werke*, ed. Count Pappenheim (Sulzbach, 1814). The most important of his numerous works on all military subjects is the *Fantaisies et préjugés militaires*, which originally appeared in 1780. A modern edition is that published by J. Dumaine (Paris, 1879). A German version (*Militärische Vorurtheile und Phantasien*, &c.) appeared as early as 1783. This work, though it deals lightly and cavalierly with the most important subjects (the prince even proposes to found an international academy of the art of war, wherein the reputation of generals could be impartially weighed), is a military classic, and indispensable to the students of the post-Frederician period. On the whole, it may be said that the prince adhered to the school of Guibert (*q.v.*), and a full discussion will be found in Max Jähns’ *Gesch. d. Kriegswissenschaften*, iii. 2091 et seq. Another very celebrated work by the prince is the mock autobiography of Prince Eugene (1809).

See *Revue de Bruxelles* (October 1839); Reiffenberg, “Le Feldmaréchal Prince Charles Joseph de Ligne,” *Mémoires de l’académie de Bruxelles*, vol. xix.; Peetermans, *Le Prince de Ligne, ou un écrivain grand seigneur* (Liége, 1857), *Études et notices historiques concernant l’histoire des Pays Bas*, vol. iii. (Brussels, 1890); *Mémoires et publications de la Société des Sciences, &c. du Hainault*, vol. iii., 5th series; Dublet *Le Prince de Ligne et ses contemporains* (Paris, 1889), Wurzbach, *Biogr. Lexikon d. Kaiserth. Österr.* (Vienna, 1858); Hirtenfeld, *Der Militär-Maria-Theresien-Orden*, vol. i. (Vienna, 1857), Ritter von Rettersberg, *Biogr. d. ausgezeichnetsten Feldherren* (Prague, 1829); Schweigerd, *Österr. Helden*, vol. iii. (Vienna, 1854); Thürheim, *F. M. Karl Joseph Fürst de Ligne* (Vienna, 1877). 679

LIGNITE (Lat. *lignum*, wood), an imperfectly formed coal, usually brownish in colour, and always showing the structure of the wood from which it was derived (see Coal).

LIGONIER, JOHN (Jean Louis) **LIGONIER,** Earl (1680-1770), British Field Marshal, came of a Huguenot family of Castres in the south of France, members of which emigrated to England at the close of the 17th century. He entered the army as a volunteer under Marlborough. From 1702 to 1710 he was engaged, with distinction, in nearly every important battle and siege of the war. He was one of the first to mount the breach at the siege of Liége, commanded a company at the Schellenberg and at Blenheim, and was present at Menin (where he led the storming of the covered way), Ramillies, Oudenarde and Malplaquet (where he received twenty-three bullets through his clothing and remained unhurt). In 1712 he became governor of Fort St Philip, Minorca, and in 1718 was adjutant-general of the troops employed in the Vigo expedition, where he led the stormers of Fort Marin. Two years later he became colonel of the “Black Horse” (now 7th Dragoon Guards), a command which he retained for 29 years. His regiment soon attained an extraordinary degree of efficiency. He was made brigadier-general in 1735, major-general in 1739, and accompanied Lord Stair in the Rhine Campaign of 1742-1743. George II. made him a Knight of the Bath on the field of Dettingen. At Fontenoy Ligonier commanded the British foot, and acted throughout the battle as adviser to the duke of Cumberland. During the "Forty-Five" he was called home to command the British army in the Midlands, but in January 1746 was placed at the head of the British and British-paid contingents of the Allied army in the Low Countries. He was present at Roucoux (11th Oct. 1746), and, as general of horse, at Val (1st July 1747), where he led the last charge of the British cavalry. In this encounter his horse was killed, and he was taken prisoner, but was exchanged in a few days. With the close of the campaign ended Ligonier's active career, but (with a brief interval in 1756-1757) he occupied various high civil and military posts to the close of his life. In 1757 he was made, in rapid succession, commander-in-chief, colonel of the 1st Foot Guards (now Grenadier Guards), and a peer of Ireland under the title of Viscount Ligonier of Enniskillen, a title changed in 1762 for that of Clonmell. From 1759 to 1762 he was master-general of the Ordnance, and in 1763 he became Baron, and in 1766 Earl, in the English peerage. In the latter year he became field marshal. He died in 1770. His younger brother, Francis, was also a distinguished soldier; and his son succeeded to the Irish peerage of Lord Ligonier.

See Combes, *J. L. Ligonier, une étude* (Castres, 1866), and the histories of the 7th Dragoon Guards and Grenadier Guards.

LIGUORI, ALFONSO MARIA DEI (1696-1787), saint and doctor of the Church of Rome, was born at Marianella, near Naples, on the 27th of September 1696, being the son of Giuseppe dei Liguori, a Neapolitan noble. He began life at the bar, where he obtained considerable practice; but the loss of an important suit, in which he was counsel for a Neapolitan noble against the grand duke of Tuscany, and in which he had entirely mistaken the force of a leading document, so mortified him that he withdrew from the legal world. In 1726 he entered the Congregation of Missions as a novice, and became a priest in 1726. In 1732 he founded the "Congregation of the Most Holy Redeemer" at Scala, near Salerno; the headquarters of the Order were afterwards transferred to Nocera dei Pagani. Its members, popularly called Liguorians or Redemptorists, devote themselves to the religious instruction of the poor, more especially in country districts; Liguori specially forbade them to undertake secular educational work. In 1750 appeared his celebrated devotional book on the *Glories of Mary*; three years later came his still more celebrated treatise on moral theology. In 1755 this was much enlarged and translated into Latin under the title of *Homo Apostolicus*. In 1762, at the express desire of the pope, he accepted the bishopric of Sant' Agata dei Goti, a small town in the province of Benevent; though he had previously refused the archbishopric of Palermo. Here he worked diligently at practical reforms, being specially anxious to raise the standard of clerical life and work. In 1775 he resigned his bishopric on the plea of enfeebled health; he retired to his Redemptorists at Nocera, and died there in 1787. In 1796 Pius VI. declared him "venerable"; he was beatified by Pius VII. in 1816, canonized by Gregory XVI. in 1839, and finally declared one of the nineteen "Doctors of the Church" by Pius IX. in 1871.

Liguori is the chief representative of a school of casuistry and devotional theology still abundantly represented within the Roman Church. Not that he was in any sense its founder. He was simply a fair representative of the Italian piety of his day—amiable, ascetic in his personal habits, indefatigable in many forms of activity, and of more than respectable abilities; though the emotional side of his character had the predominance over his intellect. He was learned, as learning was understood among the Italian clergy of the 18th century; but he was destitute of critical faculty, and the inaccuracy of his quotations is proverbial. In his casuistical works he was a diligent compiler, whose avowed design was to take a middle course between the two current extremes of severity and laxity. In practice, he leant constantly towards laxity. Eighteenth-century Italy looked on religion with apathetic indifference, and Liguori convinced himself that only the gentlest and most lenient treatment could win back the alienated laity; hence he was always willing to excuse errors on the side of laxity as due to an excess of zeal in winning over penitents. Severity, on the other hand, seemed to him not only inexpedient, but positively wrong. By making religion hard it made it odious, and thus prepared the way for unbelief. Like all casuists, he took for granted that morality was a recondite science, beyond the reach of all but the learned. When a layman found himself in doubt, his duty was not to consult his conscience, but to take the advice of his confessor; while the confessor himself was bound to follow the rules laid down by the casuistical experts, who delivered themselves of a kind of "counsel's opinion" on all knotty points of practical morality. But experts proverbially differ: what was to be done when they disagreed? Suppose, for instance, that some casuists held it wrong to dance on Sunday, while others held it perfectly lawful. In Liguori's time there were four ways of answering the question. Strict moralists—called rigorists, or "tutiorists"—maintained that the austerer opinion ought always to be followed; dancing on Sundays was certainly wrong, if any good authorities had declared it to be so. Probabiliorists maintained that the more general opinion ought to prevail, irrespectively of whether it was the stricter or the laxer; dancing on Sunday was perfectly lawful, if the majority of casuists approved it. Probabilists argued that any opinion might be followed, if it could show good authority on its side, even if there was still better authority against it; dancing on Sunday must be innocent, if it could show a fair sprinkling of eminent names in its favour. The fourth and last school—the "laxists"—carried this principle a step farther, and held that a practice must be unobjectionable, if it could prove that any one "grave Doctor" had defended it; even if dancing on Sunday had hitherto lain under the ban of the church, a single casuist could legitimate it by one stroke of his pen. Liguori's great achievement lay in steering a middle course between these various extremes. The gist of his system, which is known as "equi-probabilism," is that the more indulgent opinion may always be followed, whenever the authorities in its favour are as good, or nearly as good, as those on the other side. In this way he claimed that he had secured liberty in its rights without allowing it to degenerate into licence. However much they might personally disapprove, zealous priests could not forbid their 680
parishioners to dance on Sunday, if the practice had won widespread toleration; on the other hand, they could not relax the usual discipline of the church on the strength of a few unguarded opinions of too indulgent casuists. Thus the Liguorian system surpassed all its predecessors in securing uniformity in the confessional on a basis of established usage, two advantages amply sufficient to ensure its speedy general adoption within the Church of Rome.

Lives by A. M. Tannoja, a pupil of Liguori's (3 vols., Naples, 1798-1802); new ed., Turin, 1857; French trans., Paris, 1842; P. v. A. Giattini (Rome, 1815: Ger. trans., Vienna, 1835); F. W. Faber (4 vols., London, 1848-1849); M. A. Hugues (Münster, 1857); O. Gisler (Einsiedeln, 1887); K. Dilgskron (2 vols., Regensburg, 1887), perhaps the best; A. Capecelatro (2 vols., Rome, 1893); A. des Retours (Paris, 1903); A. C. Berthe (St Louis, 1906).

Works (*a*) Collected editions. Italian: (Monza, 1819, 1828; Venice, 1830; Naples, 1840 ff.; Turin, 1887, ff.). French: (Tournai, 1855 ff., new ed., 1895 ff.) German: (Regensburg, 1842-1847). English: (22 vols., New York, 1887-1895). Editions of the *Theologia Moralis* and other separate works are very numerous. (*b*) *Letters*: (2 vols., Monza, 1831; 3 vols., Rome, 1887 ff.). See also Meyrick, *Moral and Devotional Theology of the Church of Rome, according to the Teaching of S. Alfonso de Liguori* (London, 1857), and art. Casuistry.

(St. C.)

LIGURES BAEBIANI, in ancient geography, a settlement of Ligurians in Samnium, Italy. The towns of Taurasia and Cisauna in Samnium had been captured in 298 B.C. by the consul L. Cornelius Scipio Barbatus, and the territory of the former remained Roman state domain. In 180 B.C. 47,000 Ligurians from the neighbourhood of Luna (Ligures Apuani), with women and children, were transferred to this district, and two settlements were formed taking their names from the consuls of 181 B.C., the Ligures Baebiani and the Ligures Corneliani. The site of the former town lies 15 m. N. of Beneventum, on the road to Saepinum and Aesernia. In its ruins several inscriptions have been found, notably a large bronze tablet discovered in a public building in the Forum bearing the date A.D. 101, and relating to the alimentary institution founded by Trajan here (see Veleia). A sum of money was lent to landed proprietors of the district (whose names and estates are specified in the inscription), and the interest which it produced formed the income of the institution, which, on the model of that of Veleia, would have served to support a little over one hundred children. The capital was 401,800 sesterces, and the annual interest probably at 5%, *i.e.* 20,090 sesterces (£4018 and £201 respectively). The site of the other settlement—that of the Ligures Corneliani—is unknown.

See T. Mommsen in *Corp. Inscr. Lat.* ix. (Berlin, 1883), 125 sqq.

(T. As.)

LIGURIA, a modern territorial division of Italy, lying between the Ligurian Alps and the Apennines on the N., and the Mediterranean on the S. and extending from the frontier of France on the W. to the Gulf of Spezia on the E. Its northern limits touch Piedmont and Lombardy, while Emilia and Tuscany fringe its eastern borders, the dividing line following as a rule the summits of the mountains. Its area is 2037 sq. m. The railway from Pisa skirts the entire coast of the territory, throwing off lines to Parma from Sarzana and Spezia, to Milan and Turin from Genoa, and to Turin from Savona, and there is a line from Ventimiglia to Cuneo and Turin by the Col di Tenda. Liguria embraces the two provinces of Genoa and Porto Maurizio (Imperia), which once formed the republic of Genoa. Its sparsely-peopled mountains slope gently northward towards the Po, descending, however, abruptly into the sea at several points; the narrow coast district, famous under the name of the Riviera (*q.v.*), is divided at Genoa into the Riviera di Ponente towards France, and the Riviera di Levante towards the east. Its principal products are wheat, maize, wine, oranges, lemons, fruits, olives and potatoes, though the olive groves are being rapidly supplanted by flower-gardens, which grow flowers for export. Copper and iron pyrites are mined. The principal industries are iron-works, foundries, iron shipbuilding, engineering, and boiler works (Genoa, Spezia, Sampierdarena, Sestri Ponente, &c.), the production of cocoons, and the manufacture of cottons and woollens. Owing to the sheltered situation and the mildness of their climate, many of the coast towns are chosen by thousands of foreigners for winter residence, while the Italians frequent them in summer for sea-bathing. The inhabitants have always been adventurous seamen—Columbus and Amerigo Vespucci were Genoese,—and the coast has several good harbours, Genoa, Spezia and Savona being the best. In educational and general development, Liguria stands high among the regions of Italy. The populations of the respective provinces and their chief towns are, according to the census of 1901 (*popolazione residente* or *legale*)—province of Genoa, pop. 931,156; number of communes 197; chief towns—Genoa (219,507), Spezia (66,263), Savona (38,648), Sampierdarena (34,084), Sestri Ponente (17,225). Province of Porto Maurizio, pop. 144,604, number of communes 106; chief towns—Porto Maurizio (7207), S. Remo (20,027), Ventimiglia (11,468), Oneglia (8252). Total for Liguria, 1,075,760.

The Ligurian coast became gradually subject to the Romans, and the road along it must have been correspondingly prolonged: up to the end of the Hannibalic war the regular starting-point for Spain by sea was Pisae, in 195 B.C. it was the harbour of Luna (Gulf of Spezia),[1] though Genua must have become Roman a little before this time, while, in 137 B.C., C. Hostilius Mancinus marched as far as Portus Herculis (Villafranca), and in 121 B.C. the province of Gallia Narbonensis was formed and the coast-road prolonged to the Pyrenees. In 14 B.C. Augustus restored the whole road from Placentia to Dertona (Via Postumia), and thence to Vada Sabatia (Via Aemilia[2]) and the River Varus (Var), so that it thenceforth took the name of Via Julia Augusta (see Aemilia, Via[2]). The other chief roads of Liguria were the portion of the Via Postumia from Dertona to Genua, a road from above Vada through Augusta Bagiennorum and Pollentia to Augusta Taurinorum, and another from Augusta Taurinorum to Hasta and Valentia. The names of the villages—Quarto, Quinto, &c.—on the south-east side and Pontedecimo on the north of Genoa allude to their distance along the Roman roads. The Roman Liguria, forming the ninth region of Augustus, was thus far more extensive than the modern, including the country on the north slopes of the Apennines and Maritime Alps between the Trebia and the Po, and extending a little beyond Albintimilium. On the west Augustus formed the provinces of the Alpes Maritimae and the Alpes Cottiae. Towns of importance were few, owing to the nature of the country. Dertona was the only colony, and Alba Pompeia, Augusta Bagiennorum, Pollentia, Hasta, Aquae Statiellae, and Genua may also be mentioned; but the Ligurians dwelt entirely in villages, and were organized as tribes. The mountainous character of Liguria made the spread of culture difficult; it remained a forest district, producing timber, cattle, ponies, mules, sheep, &c. Oil and wine had to be imported, and when the cultivation of the olive began is not known.

The arrangement made by Augustus lasted until the time of Diocletian, when the two Alpine provinces were abolished, and the watershed became the boundary between Italy and Gaul. At this time we find the name Liguria extended as far as Milan, while in the 6th century the old Liguria was separated from it, and under the Lombards formed the fifth Italian province under the name of Alpes Cottiae. In the middle ages the ancient Liguria north of the Apennines fell to Piedmont and Lombardy, while that to the south, with the coast strip, belonged to the republic of Genoa.

(T. As.)

Archaeology and Philology.—It is clear that in earlier times the Ligurians occupied a much more extensive area than the Augustan region; for instance Strabo (i. 2, 92; iv. 1, 7) gives earlier authorities for their possession of the land on which the Greek colony of Massalia (Marseilles) was founded; and Thucydides (vi. 2) speaks of a settlement of Ligurians in Spain who expelled the Sicani thence. Southward their domain extended as far as Pisa on the coast of Etruria and Arretium inland in the time of Polybius (ii. 6), and a somewhat vague reference in Lycophron (line 1351) to 681
the Ligurians as enemies of the founders of Agylla (*i.e.* Caere) suggests that they once occupied even a larger tract to the south. Seneca (*Cons. ad Helv.* vii. 9), states that the population of Corsica was partly Ligurian. By combining traditions recorded by Dionysius (i. 22; xiv. 37) and others (*e.g.* Serv. *ad. Aen.* xi. 317) as having been held by Cato the Censor and by Philistus of Syracuse (385 B.C.) respectively, Professor Ridgeway (*Who were the Romans?* London, 1908, p. 3) decides in favour of identifying the Ligurians with a tribe called the Aborigines who occupy a large place in the early traditions of Italy (see Dionysius i. cc. 10 ff.); and who may at all events be regarded with reasonable certainty as constituting an early pre-Roman and pre-Tuscan stratum in the population of Central Italy (see Latium). For a discussion of this question see Volsci. Ridgeway holds that the language of the Ligurians, as well as their antiquities, was identical with that of the early Latins, and with that of the Plebeians of Rome (as contrasted with that of the Patrician or Sabine element), see Rome: *History* (*ad. init.*). The archaeological side of this important question is difficult. Although great progress has been made with the study of the different strata of remains in prehistoric Italy and of those of Liguria itself (see for instance the excellent *Introduction à l'histoire romaine* by Basile Modestov (Paris, 1907, p. 122 ff.) and W. Ridgeway's *Early Age of Greece*, p. 240 ff.) no general agreement has been reached among archaeologists as to the particular races who are to be identified as the authors of the early strata, earlier, that is, than that stratum which represents the Etruscans.

On the linguistic side some fairly certain conclusions have been reached. D'Arbois de Jubainville (*Les Premiers habitants de l'Europe*, ed. 2, Paris, 1880-1894) pointed out the great frequency of the suffix -*asco*- (and -*usco*-) both in ancient and in modern Ligurian districts, and as far north as *Caranusca* near Metz, and also in the eastern Alps and in Spain. He pointed out also, what can scarcely be doubted, that the great mass of the Ligurian proper names (*e.g.* the streams *Vinelasca*, *Porcobera*, *Comberanea*; *mons Tuledo*; *Venascum*), have a definite Indo-European character. Farther Karl Müllenhof in vol. iii. of his *Deutsche Alterthumskunde* (Berlin, 1898) made a careful collection of the proper names reserved in Latin inscriptions of the Ligurian districts, such as the *Tabula Genuatium* (*C.I.L.* i. 99) of 117 B.C. A complete collection of all Ligurian place and personal names known has been made by S. Elizabeth Jackson, B.A., and the collection is to be combined with the inscriptional remains of the district in *The Pre-Italic Dialects*, edited by R. S. Conway (see *The Proceedings of the British Academy*). Following Kretschmer *Kuhn's Zeitschrift* (xxxviii. 97), who discussed several inscriptions found near Ornavasso (Lago Maggiore) and concluded that they showed an Indo-European language, Conway, though holding that the inscriptions are more Celtic than Ligurian, pointed out strong evidence in the ancient place names of Liguria that the language spoken there in the period which preceded the Roman conquest was Indo-European, and belonged to a definite group, namely, languages which preserved the original *q* as Latin did, and did not convert it into *p* as did the Umbro-Safine tribes. The same is probably true of Venetia (see Veneti), and of an Indo-European language preserved on inscriptions found at Coligny and commonly referred to the Sequani (see *Comptes Rendus de l'Ac. d'Insc.*, Paris, 1897, 703; E. B. Nicholson, *Sequanian*, London, 1898; Thurneysen, *Zeitschr. f. Kelt. Phil.*, 1899, 523). Typically Ligurian names are *Quiamelius*, which contains the characteristic Ligurian word *melo*- "stone" as in *mons Blustiemelus* (*C.I.L.* v. 7749), *Intimelium* and the modern *Vintimiglia*. The tribal names *Soliceli*, *Stoniceli*, clearly contain the same element as Lat. *aequi-coli* (dwellers on the plain), *sati-cola*, &c., namely *quel-*, cf. Lat. *in-quil-inus*, *colo*, Gr. πολεῖν, τέλλεσθαι. And it should be added that the Ligurian ethnica show the prevailing use of the two suffixes -*co*- and -*ati*-, which there is reason to refer to the pre-Roman stratum of population in Italy (see Volsci).

Besides the authorities already cited the student may be referred to C. Pauli, *Altitalische Studien*, vol. i., especially for the alphabet of the insc.; W. Ridgeway, *Who were the Romans?* (followed by the abstract of a paper by the present writer) in *The Proceedings of the British Academy*, vol. iii. p. 42; and to W. H. Hall's, *The Romans on the Riviera and the Rhône* (London, 1898); Issel's *La Liguria geologica e preistorica* (Genoa, 1892). A further batch of Celto-Ligurian inscriptions from Giubiasco near Bellinzona (Canton Ticino) is published by G. Herbig, in the *Anzeiger f. Schweizer. Altertumskunde*, vii. (1905-1906), p. 187; and one of the same class by Elia Lattes, *Di un' Iscriz. ante-Romana trovata a Carcegna sul Lago d' Orta* (*Atti d. r. Accad. d. Scienze di Torino*, xxxix., Feb. 1904).

(R. S. C.)

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1 The dividing line between Liguria and Etruria was the lower course of the river Macra (Magra), so that, while the harbour of Luna was in the former, Luna itself was in the latter.

LI HUNG CHANG (1823-1901), Chinese statesman, was born on the 16th of February 1823 at Hofei, in Ngan-hui. From his earliest youth he showed marked ability, and when quite young he took his bachelor degree. In 1847 he became a Tsin-shi, or graduate of the highest order, and two years later was admitted into the imperial Hanlin college. Shortly after this the central provinces of the empire were invaded by the Taiping rebels, and in defence of his native district he raised a regiment of militia, with which he did such good service to the imperial cause that he attracted the attention of Tsêng Kuo-fan, the generalissimo in command. In 1859 he was transferred to the province of Fu-kien, where he was given the rank of taotai, or intendant of circuit. But Tsêng had not forgotten him, and at his request Li was recalled to take part against the rebels. He found his cause supported by the "Ever Victorious Army," which, after having been raised by an American named Ward, was finally placed under the command of Charles George Gordon. With this support Li gained numerous victories leading to the surrender of Suchow and the capture of Nanking. For these exploits he was made governor of Kiangsu, was decorated with a yellow jacket, and was created an earl. An incident connected with the surrender of Suchow, however, left a lasting stain upon his character. By an arrangement with Gordon the rebel wangs, or princes, yielded Nanking on condition that their lives should be spared. In spite of the assurance given them by Gordon, Li ordered their instant execution. This breach of faith so aroused Gordon's indignation that he seized a rifle, intending to shoot the falsifier of his word, and would have done so had not Li saved himself by flight. On the suppression of the rebellion (1864) Li took up his duties as governor, but was not long allowed to remain in civil life. On the outbreak of the rebellion of the Nienfei, a remnant of the Taipings, in Ho-nan and Shan-tung (1866) he was ordered again to take the field, and after some misadventures he succeeded in suppressing the movement. A year later he was appointed viceroy of Hukwang, where he remained until 1870, when the Tientsin massacre necessitated his transfer to the scene of the outrage. He was, as a natural consequence, appointed to the viceroyalty of the metropolitan province of Chihli, and justified his appointment by the energy with which he suppressed all attempts to keep alive the anti-foreign sentiment among the people. For his services he was made imperial tutor and member of the grand council of the empire, and was decorated with many-eyed peacocks' feathers.

To his duties as viceroy were added those of the superintendent of trade, and from that time until his death, with a few intervals of retirement, he practically conducted the foreign policy of China. He concluded the Chifu convention with Sir Thomas Wade (1876), and thus ended the difficulty caused by the murder of Mr Margary in Yunnan; he arranged treaties with Peru and Japan, and he actively directed the Chinese policy in Korea. On the death of the emperor T'ungchi in 1875 he, by suddenly introducing a large armed force into the capital, effected a *coup d'état* by which the emperor Kwang Sü was put on the throne under the tutelage of the two dowager empresses; and in 1886, on the conclusion of the Franco-Chinese war, he arranged a treaty with France. Li was always strongly impressed with the necessity of strengthening the empire, and when viceroy of Chihli he raised a large well-drilled and well-armed force, and spent vast sums both in fortifying Port Arthur and the Taku forts and in increasing the navy. For years he had watched the successful reforms effected in Japan and had a well-founded dread of coming into conflict with that empire. But in 682
1894 events forced his hand, and in consequence of a dispute as to the relative influence of China and Japan in Korea, war broke out. The result proved the wisdom of Li's fears. Both on land and at sea the Chinese forces were ignominiously routed, and in 1895, on the fall of Wei-hai-wei, the emperor sued for peace. With characteristic subterfuge his advisers suggested as peace envoys persons whom the mikado very properly and promptly refused to accept, and finally Li was sent to represent his imperial master at the council assembled at Shimonoseki. With great diplomatic skill Li pleaded the cause of his country, but finally had to agree to the cession of Formosa, the Pescadores, and the Liaotung peninsula to the conquerors, and to the payment of an indemnity of 200,000,000 taels. By a subsequent arrangement the Liaotung peninsula was restored to China, in exchange for an increased indemnity. During the peace discussions at Shimonoseki, as Li was being borne through the narrow streets of the town, a would-be assassin fired a pistol point-blank in his face. The wound inflicted was not serious, and after a few days' rest Li was able to take up again the suspended negotiations. In 1896 he represented the emperor at the coronation of the tsar, and visited Germany, Belgium, France, England, and the United States of America. For some time after his return to China his services were demanded at Peking, where he was virtually constituted minister for foreign affairs; but in 1900 he was transferred to Canton as viceroy of the two Kwangs. The Boxer movement, however, induced the emperor to recall him to the capital, and it was mainly owing to his exertions that, at the conclusion of the outbreak, a protocol of peace was signed in September 1901. For many months his health had been failing, and he died on the 7th of November 1901. He left three sons and one daughter.

(R. K. D.)

LILAC,[1] or Pipe Tree (*Syringa vulgaris*), a tree of the olive family, Oleaceae. The genus contains about ten species of ornamental hardy deciduous shrubs native in eastern Europe and temperate Asia. They have opposite, generally entire leaves and large panicles of small regular flowers, with a bell-shaped calyx and a 4-lobed tubular corolla, with the two stamens characteristic of the order attached at the mouth of the tube. The common lilac is said to have come from Persia in the 16th century, but is doubtfully indigenous in Hungary, the borders of Moldavia, &c. Two kinds of *Syringa*, viz. *alba* and *caerulea*, are figured and described by Gerard (*Herball*, 1597), which he calls the white and the blue pipe privets. The former is the common privet, *Ligustrum vulgare*, which, and the ash tree, *Fraxinus excelsior*, are the only members of the family native in Great Britain. The latter is the lilac, as both figure and description agree accurately with it. It was carried by the European colonists to north-east America, and is still grown in gardens of the northern and middle states.

There are many fine varieties of lilac, both with single and double flowers; they are among the commonest and most beautiful of spring-flowering shrubs. The so-called Persian lilac of gardens (*S. dubia*, *S. chinensis* var. *Rothomagensis*), also known as the Chinese or Rouen lilac, a small shrub 4 to 6 ft. high with intense violet flowers appearing in May and June, is considered to be a hybrid between *S. vulgaris* and *S. persica*—the true Persian lilac, a native of Persia and Afghanistan, a shrub 4 to 7 ft. high with bluish-purple or white flowers. Of other species, *S. Josikaea*, from Transylvania, has scentless bluish-purple flowers; *S. Emodi*, a native of the Himalayas, is a handsome shrub with large ovate leaves and dense panicles of purple or white strongly scented flowers. Lilacs grow freely and flower profusely in almost any soil and situation, but when neglected are apt to become choked with suckers which shoot up in great numbers from the base. They are readily propagated by means of these suckers.

Syringa is also a common name for the mock-orange *Philadelphus coronarius* (nat. ord. *Saxifragaceae*), a handsome shrub 2 to 10 ft. high, with smooth ovate leaves and clusters of white flowers which have a strong orange-like scent. It is a native of western Asia, and perhaps some parts of southern Europe.

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1 The Span. *lilac*, Fr. *lilac*, mod. lilas, are adapted from Arab. *lilak*, Pers. *līlak*, variant of *nilak*, of a blue color, *nil*, blue, the indigo-plant.

LILBURNE, JOHN (*c.* 1614-1657), English political agitator, was the younger son of a gentleman of good family in the county of Durham. At the age of twelve he was apprenticed to a clothier in London, but he appears to have early addicted himself to the "contention, novelties, opposition of government, and violent and bitter expressions" for which he afterwards became so conspicuous as to provoke the saying of Harry Marten (the regicide) that, "if the world was emptied of all but John Lilburn, Lilburn would quarrel with John, and John with Lilburn." He appears at one time to have been law-clerk to William Prynne. In February 1638, for the part he had taken in importing and circulating *The Litany* and other publications of John Bastwick and Prynne, offensive to the bishops, he was sentenced by the Star Chamber to be publicly whipped from the Fleet prison to Palace Yard, Westminster, there to stand for two hours in the pillory, and afterwards to be kept in gaol until a fine of £500 had been paid. He devoted his enforced leisure to his favourite form of literary activity, and did not regain his liberty until November 1640, one of the earliest recorded speeches of Oliver Cromwell being made in support of his petition to the House of Commons (Nov. 9, 1640). In 1641 he received an indemnity of £3000. He now entered the army, and in 1642 was taken prisoner at Brentford and tried for his life; sentence would no doubt have been executed had not the parliament by threatening reprisals forced his exchange. He soon rose to the rank of lieutenant-colonel, but in April 1645, having become dissatisfied with the predominance of Presbyterianism, and refusing to take the covenant, he resigned his commission, presenting at the same time to the Commons a petition for considerable arrears of pay. His violent language in Westminster Hall about the speaker and other public men led in the following July to his arrest and committal to Newgate, whence he was discharged, however, without trial, by order of the House, in October. In January 1647 he was committed to the Tower for accusations against Cromwell, but was again set at liberty in time to become a disappointed spectator of the failure of the "Levellers" or ultrademocratic party in the army at the Ware rendezvous in the following November. The scene produced a deep impression on his mind, and in February 1649 he along with other petitioners presented to the House of Commons a paper entitled *The Serious Apprehensions of a part of the People on behalf of the Commonwealth*, which he followed up with a pamphlet, *England's New Chains Discovered*, criticizing Ireton, and another exposing the conduct of Cromwell, Ireton and other leaders of the army since June 1647 (*The Hunting of the Foxes from Newmarket and Triploe Heath to Whitehall by Five Small Beagles*, the "beagles" being Lilburne, Richard Overton, William Walwyn, Prince and another). Finally, the *Second Part of England's New Chains Discovered*, a violent outburst against "the dominion of a council of state, and a constitution of a new and unexperienced nature," became the subject of discussion in the House, and led anew to the imprisonment of its author in the Tower on the 11th of April. His trial in the following October, on a charge of seditious and scandalous practices against the state, resulted in his unanimous acquittal, followed by his release in November. In 1650 he was advocating the release of trade from the restrictions of chartered companies and monopolists.

In January 1652, for printing and publishing a petition against Sir Arthur Hesilrige and the Haberdashers' Hall for what he conceived to have been an injury done to his uncle George Lilburne in 1649, he was sentenced to pay fines amounting to £7000, and to be banished the Commonwealth, with prohibition of return under the pain of death. In June 1653 he nevertheless came back from the Low Countries, where he had busied himself in pamphleteering and such other agitation as was possible, and was immediately arrested; the trial, which was protracted from the 13th of July to the 20th of August, issued in his acquittal, to the great joy of London, but it was nevertheless thought proper to keep him in captivity for "the peace of the nation." He was detained successively in the Tower, in Jersey, in Guernsey and in Dover Castle. At Dover he came under Quaker influence, and signified his readiness at last to be done with "carnal sword fightings and fleshly bustlings and contests"; and in 1655, on giving security for his good behaviour, he was set free. He now settled at Eltham in Kent, frequently preaching at Quaker meetings in the neighbourhood during the brief remainder of his troubled life. He died on the 29th of August 1657.

His brother, Colonel Robert Lilburne, was among those who signed the death-warrant of Charles I. In 1656 he was M.P. for the East Riding of 683
Yorkshire, and at the restoration was sentenced to lifelong imprisonment.

See D. Masson, *Life of Milton* (iv. 120); Clement Walker (*History of Independency*, ii. 247); W. Godwin (*Commonwealth*, iii. 163-177), and Robert Bisset (*Omitted Chapters of the History of England*, 191-251).

LILIACEAE, in botany, a natural order of Monocotyledons belonging to the series Liliiflorae, and generally regarded as representing the typical order of Monocotyledons. The plants are generally perennial herbs growing from a bulb or rhizome, sometimes shrubby as in butcher’s broom (*Ruscus*) or tree-like as in species of *Dracaena, Yucca* or *Aloe*. The flowers are with few exceptions hermaphrodite, and regular with parts in threes (fig. 5), the perianth which is generally petaloid occupying the two outer whorls, followed by two whorls of stamens, with a superior ovary of three carpels in the centre of the flower; the ovary is generally three-chambered and contains an indefinite number of anatropous ovules on axile placentas (see fig. 2). The fruit is a capsule splitting along the septa (septicidal) (fig. 1), or between them (loculicidal), or a berry (fig. 6, *3*); the seeds contain a small embryo in a copious fleshy or cartilaginous endosperm. Liliaceae is one of the larger orders of flowering plants containing about 2500 species in 200 genera; it is of world-wide distribution. The plants show great diversity in vegetative structure, which together with the character and mode of dehiscence of the fruit afford a basis for the subdivision of the order into tribes, eleven of which are recognized. The following are the most important tribes.

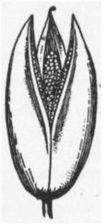


FIG. 1.—Fruit or Capsule of Meadow Saffron (*Colchicum autumnale*) dehiscing along the septa.

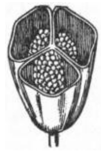


FIG. 2.—Same cut across showing the three chambers with the seeds attached along the middle line—axile placentation.

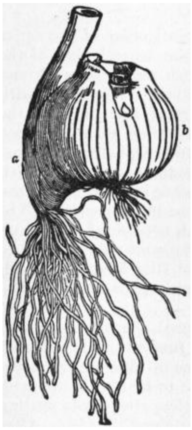


FIG. 3.—Corm of Meadow Saffron (*Colchicum autumnale*). *a*, Old corm shrivelling; *b*, young corm produced laterally from the old one.

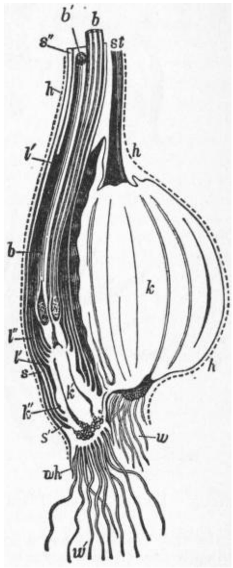


FIG. 4.—Corm of *Colchicum autumnale* in autumn when the plant is in flower.

k, Present corm.
h, *h*, Brown scales covering it.
w, Its roots.
st, Its withered flowering stem.
k′, Younger corm produced from *k*.
wh, Roots from *k*′, which grows at expense of *k*.
s, *s*′, *s*″, Sheathing leaves.
l′, *l*″, Foliage leaves.
b, *b*′, Flowers.
k″, Young corm produced from
k′, in autumn, which in succeeding autumn will produce flowers.

Melanthoideae.—The plants have a rhizome or corm, and the fruit is a capsule. It contains 36 genera, many of which are north temperate and three are represented in Britain, viz. *Tofieldia*, an arctic and alpine genus of small herbs with a slender scape springing from a tuft of narrow ensiform leaves and bearing a raceme of small green flowers; *Narthecium* (bog-asphodel), herbs with a habit similar to *Tofieldia*, but with larger golden-yellow flowers; and *Colchicum*, a genus with about 30 species including the meadow saffron or autumn crocus (*C. autumnale*). *Colchicum* illustrates the corm-development which is rare in Liliaceae though common in the allied order Iridaceae; a corm is formed by swelling at the base of the axis (figs. 3, 4) and persists after the flowers and leaves, bearing next season’s plant as a lateral shoot in the axil of a scale-leaf at its base. *Gloriosa*, well known in cultivation, climbs by means of its tendril-like leaf-tips; it has handsome flowers with decurved orange-red or yellow petals; it is a native of tropical Asia and Africa. *Veratrum* is an alpine genus of the north temperate zone.

Asphodeloideae.—The plants generally have a rhizome bearing radical leaves, as in asphodel, rarely a stem with a tuft of leaves as in *Aloe*, very rarely a tuber (*Eriospermum*) or bulb (*Bowiea*). The flowers are borne in a terminal raceme, the anthers open introrsely and the fruit is a capsule, very rarely, as in *Dianella*, a berry. It contains 64 genera. *Asphodelus* (asphodel) is a Mediterranean genus; *Simethis*, a slender herb with grassy radical leaves, is a native of west and southern Europe extending into south Ireland. *Anthericum* and *Chlorophytum*, herbs with radical often grass-like leaves and scapes bearing a more or less branched inflorescence of small generally white flowers, are widely spread in the tropics. Other genera are *Funkia*, native of China and Japan, cultivated in the open air in Britain; *Hemerocallis*, a small genus of central Europe and temperate Asia—*H. flava* is known in gardens as the day lily; *Phormium*, a New Zealand genus to which belongs New Zealand flax, *P. tenax*, a useful fibre-plant; *Kniphofia*, South and East Africa, several species of which are cultivated; and *Aloe*. A small group of Australian genera closely approach the order Juncaceae in having small crowded flowers with a scarious or membranous perianth; they include *Xanthorrhoea* (grass-tree or black-boy) and *Kingia*, arborescent plants with an erect woody stem crowned with a tuft of long stiff narrow leaves, from the centre of which rises a tall dense flower-spike or a number of stalked flower-heads; this group has been included in Juncaceae, from which it is doubtfully distinguished only by the absence of the long twisted stigmas which characterize the true rushes.

Allioideae.—The plants grow from a bulb or short rhizome; the inflorescence is an apparent umbel formed of several shortened monochasial cymes and subtended by a pair of large bracts. It contains 22 genera, the largest of which *Allium* has about 250 species—7 are British; *Agapanthus* or African lily is a well-known garden plant; in *Gagea*, a genus of small bulbous herbs found in most parts of Europe, the inflorescence is reduced to a few flowers or a single flower; *G. lutea* is a local and rare British plant.

Lilioideae.—Bulbous plants with a terminal racemose inflorescence; the anthers open introrsely and the capsule is loculicidal. It contains 28 genera, several being represented in Britain. The typical genus *Lilium* and *Fritillaria* are widely distributed in the temperate regions of the northern hemisphere; *F. meleagris*, snake’s head, is found in moist meadows in some of the southern and central English counties; *Tulipa* contains more than 50 species in Europe and temperate Asia, and is specially abundant in the dry districts of central Asia; *Lloydia*, a small slender alpine plant, widely distributed in the northern hemisphere, occurs on Snowdon in Wales; *Scilla* (squill) is a large genus, chiefly in Europe and Asia—*S. nutans* is the bluebell or wild hyacinth; *Ornithogalum* (Europe, Africa and west Asia) is closely allied to *Scilla—O. umbellatum*, star of Bethlehem, is naturalized in Britain; *Hyacinthus* and *Muscari* are chiefly Mediterranean; *M. racemosum*, grape hyacinth, occurs in sandy pastures in the eastern counties of England. To this group belong a number of tropical and especially South African genera such as *Albuca*, *Urginea*, *Drimia*, *Lachenalia* and others.

Dracaenoideae.—The plants generally have an erect stem with a crown of leaves which are often leathery; the anthers open introrsely and the fruit is a berry or capsule. It contains 9 genera, several of which, such as *Yucca* (fig. 5), *Dracaena* and *Cordyline* include arborescent species in which the stem increases in thickness continually by a centrifugal formation of new tissue; an extreme case is afforded by *Dracaena Draco*, the dragon-tree of Teneriffe. *Yucca* and several allied genera are natives of the dry country of the southern and western United States and of Central America. *Dracaena* and the allied genus *Cordyline* occur in the warmer regions of the Old World. There is a close relation between the pollination of many yuccas and the life of a moth (*Pronuba yuccasella*); the flowers are open and scented at night when the female moth becomes active, first collecting a load of pollen and then depositing her eggs, generally in a different flower from that which has supplied the pollen. The eggs are deposited in the ovary-wall, usually just below an ovule; after each deposition the moth runs to the top of the pistil and thrusts some pollen into the opening of the stigma. Development of larva and seed go on together, a few of the seeds serving as food for the insect, which when mature eats through the 684
pericarp and drops to the ground, remaining dormant in its cocoon until the next season of flowering when it emerges as a moth.

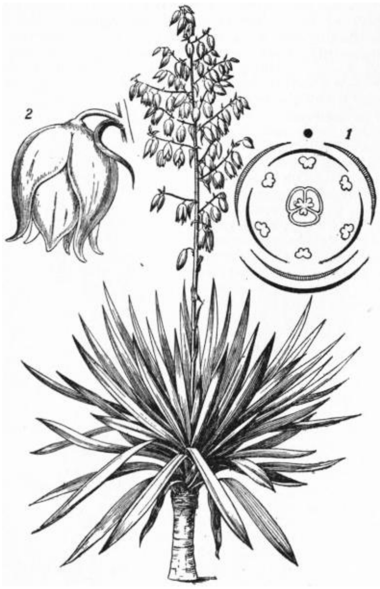


Fig. 5.—*Yucca gloriosa*. Plant much reduced. 1, Floral diagram. 2, Flower.

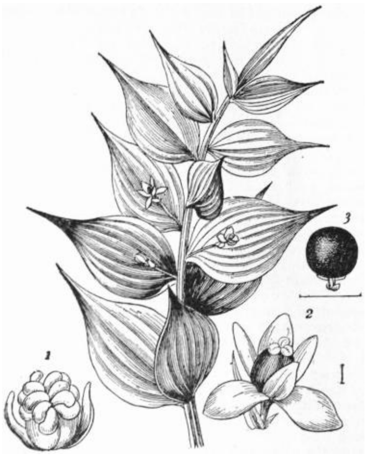
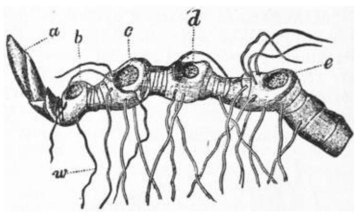


Fig. 6.—Twig of Butcher’s Broom, *Ruscus aculeatus*, slightly enlarged. 1, Male flower, 2, female flower, both enlarged; 3, berry, slightly reduced.

Asparagoideae.—Plants growing from a rhizome; fruit a berry. *Asparagus* contains about 100 species in the dryer warmer parts of the Old World; it has a short creeping rhizome, from which springs a slender, herbaceous or woody, often very much branched, erect or climbing stem, the ultimate branches of which are flattened or needle-like leaf-like structures (*cladodes*), the true leaves being reduced to scales or, in the climbers, forming short, hard more or less recurved spines. *Ruscus aculeatus* (fig. 6) is butcher’s broom, an evergreen shrub with flattened leaf-like cladodes, native in the southerly portion of England and Wales; the small flowers are unisexual and borne on the face of the cladode; the male contains three stamens, the filaments of which are united to form a short stout column on which are seated the diverging cells of the anthers; in the female the ovary is enveloped by a fleshy staminal tube on which are borne three barren anthers. *Polygonatum* and *Maianthemum* are allied genera with a herbaceous leafy stem and, in the former axillary flowers, in the latter flowers in a terminal raceme; both occur rarely in woods in Britain; *P. multiflorum* is the well-known Solomon’s seal of gardens (fig. 7), so called from the seal-like scars on the rhizome of stems of previous seasons, the hanging flowers of which contain no honey, but are visited by bees for the pollen. *Convallaria* is lily of the valley; *Aspidistra*, native of the Himalayas, China and Japan, is a well-known pot plant; its flowers depart from the normal arrangement of the order in having the parts in fours (tetramerous). Paris, including the British Herb *Paris* (*P. quadrifolia*), has solitary tetra- to poly-merous flowers terminating the short annual shoot which bears a whorl of four or more leaves below the flower; in this and in some species of the nearly allied genus *Trillium* (chiefly temperate North America) the flowers have a fetid smell, which together with the dark purple of the ovary and stigmas and frequently also of the stamens and petals, attracts carrion-loving flies, which alight on the stigma and then climb the anthers and become dusted with pollen; the pollen is then carried to the stigmas of another flower.



From Strasburger’s *Lehrbuch der Botanik*, by permission of Gustav Fischer.

Fig. 7.—Rhizome of *Polygonatum multiflorum*.

a, Bud of next year’s aerial shoot.
b, Scar of this year’s, and *c, d, e*, scars of three preceding years’ aerial shoots.
w, Roots.

Luzuriagoideae are shrubs or undershrubs with erect or climbing branches and fruit a berry. *Lapageria*, a native of Chile, is a favourite greenhouse climber with fine bell-shaped flowers.

Smilacoideae are climbing shrubs with broad net-veined leaves and small dioecious flowers in umbels springing from the leaf-axils; the fruit is a berry. They climb by means of tendrils, which are stipular structures arising from the leaf-sheath. *Smilax* is a characteristic tropical genus containing about 200 species; the dried roots of some species are the drug sarsaparilla.

The two tribes *Ophiopogonoideae* and *Aletroideae* are often included in a distinct order, Haemodoraceae. The plants have a short rhizome and narrow or lanceolate basal leaves; and they are characterized by the ovary being often half-inferior. They contain a few genera chiefly old world tropical and subtropical. The leaves of species of *Sansevieria* yield a valuable fibre.

Liliaceae may be regarded as the typical order of the series Liliiflorae. It resembles Juncaceae in the general plan of the flower, which, however, has become much more elaborate and varied in the form and colour of its perianth in association with transmission of pollen by insect agency; a link between the two orders is found in the group of Australian genera referred to above under Asphodeloideae. The tribe Ophiopogonoideae, with its tendency to an inferior ovary, suggests an affinity with the Amaryllidaceae which resemble Liliaceae in habit and in the horizontal plan of the flower, but have an inferior ovary. The tribe Smilacoideae, shrubby climbers with net-veined leaves and small unisexual flowers, bears much the same relationship to the order as a whole as does the order Dioscoreaceae, which have a similar habit, but flowers with an inferior ovary, to the Amaryllidaceae.

LILIENCRON, DETLEV VON (1844-1909), German poet and novelist, was born at Kiel on the 3rd of June 1844. He entered the army and took part in the campaigns of 1866 and 1870-71, in both of which he was wounded. He retired with the rank of captain and spent some time in America, afterwards settling at Kellinghusen in Holstein, where he remained till 1887. After some time at Munich, he settled in Altona and then at Altrahistedt, near Hamburg. He died in July 1909. He first attracted attention by the volume of poems, *Adjutantenritte und andere Gedichte* (1883), which was followed by several unsuccessful dramas, a volume of short stories, *Eine Sommerschlacht* (1886), and a novel *Breide Hummelsbüttel* (1887). Other collections of short stories appeared under the titles *Unter flatternden Fahnen* (1888). *Der Mäcen* (1889), *Krieg und Frieden* (1891); of lyric poetry in 1889, 1890 (*Der Heidegänger und andere Gedichte*), 1893, and 1903 (*Bunte Beute*). Interesting, too, is the humorous epic 685 *Poggfred* (1896; 2nd ed. 1904). Liliencron is one of the most eminent of recent German lyric poets; his *Adjutantenritte*, with its fresh original note, broke with the well-worn literary conventions which had been handed down from the middle of the century. Liliencron's work is, however, somewhat unequal, and he lacks the sustained power which makes the successful prose writer.

Liliencron's *Sämtliche Werke* have been published in 14 vols. (1904-1905); his *Gedichte* having been previously collected in four volumes under the titles *Kampf und Spiele, Kämpfe und Ziele, Nebel und Sonne* and *Bunte Beute* (1897-1903). See O. J. Bierbaum, *D. von Liliencron* (1892); H. Greinz, *Liliencron, eine literarhistorische Würdigung* (1896); F. Oppenheimer, *D. von Liliencron* (1898).

LILITH (Heb. *lilâtu*, "night"; hence "night-monster"), a female demon of Jewish folk-lore, equivalent to the English vampire. The personality and name are derived from a Babylonian-Assyrian demon Lilit or Lilu. Lilith was believed to have a special power for evil over children. The superstition was extended to a cult surviving among some Jews even as late as the 7th century A.D. In the Rabbinical literature Lilith becomes the first wife of Adam, but flies away from him and becomes a demon.

LILLE, a city of northern France, capital of the department of Nord, 154 m. N. by E. of Paris on the Northern railway. Pop. (1906) 196,624. Lille is situated in a low fertile plain on the right bank of the Deûle in a rich agricultural and industrial region of which it is the centre. It is a first-class fortress and headquarters of the I. army corps, and has an enceinte and a pentagonal citadel, one of Vauban's finest works, situated to the west of the town, from which it is divided by the Deûle. The modern fortifications comprise over twenty detached forts and batteries, the perimeter of the defences being about 20 m. Before 1858 the town, fortified by Vauban about 1668, occupied an elliptical area of about 2500 yds. by 1300, with the church of Notre-Dame de la Treille in the centre, but the ramparts on the south side have been demolished and the ditches filled up, their place being now occupied by the great Boulevard de la Liberté, which extends in a straight line from the goods station of the railway to the citadel. At the S.E. end of this boulevard are grouped the majority of the numerous educational establishments of the city. The new enceinte encloses the old communes of Esquermes, Wazemmes and Moulins-Lille, the area of the town being thus more than doubled. In the new quarters fine boulevards and handsome squares, such as the Place de la République, have been laid out in pleasant contrast with the sombre aspect of the old town. The district of St André to the north, the only elegant part of the old town, is the residence of the aristocracy. Outside the enceinte populous suburbs surround the city on every side. The demolition of the fortifications on the north and east of the city, which is continued in those directions by the great suburbs of La Madeleine, St Maurice and Fives, must accelerate its expansion towards Roubaix and Tourcoing. At the demolition of the southern fortifications, the Paris gate, a triumphal arch erected in 1682 in honour of Louis XIV., after the conquest of Flanders, was preserved. On the east the Ghent and Roubaix gates, built in the Renaissance style, with bricks of different colours, date from 1617 and 1622, the time of the Spanish domination. On the same side the Noble-Tour is a relic of the medieval ramparts. The present enceinte is pierced by numerous gates, including water gates for the canal of the Deûle and for the Arbonnoise, which extends into a marsh in the south-west corner of the town. The citadel, which contains the barracks and arsenal, is surrounded by public gardens. The more interesting buildings are in the old town, where, in the Grande Place and Rue Faidherbe, its animation is concentrated. St Maurice, a church in the late Gothic style, dates in its oldest portions from the 15th century, and was restored in 1872; Ste Cathérine belongs to the 15th, 16th and 18th centuries, St André to the first years of the 18th century, and Ste Madeleine to the last half of the 17th century; all possess valuable pictures, but St Maurice alone, with nave and double aisles, and elegant modern spire, is architecturally notable. Notre-Dame de la Treille, begun in 1855, in the style of the 15th century, possesses an ancient statue of the Virgin which is the object of a well-known pilgrimage. Of the civil buildings the Bourse (17th century) built round a courtyard in which stands a bronze statue of Napoleon I., the Hôtel d'Aigremont, the Hôtel Gentil and other houses are in the Flemish style; the Hôtel de Ville, dating in the main from the middle of the 19th century, preserves a portion of a palace built by Philip the Good, duke of Burgundy, in the 15th century. The prefecture, the Palais des Beaux-Arts, the law-courts, the school of arts and crafts, and the Lycée Faidherbe are imposing modern buildings. In the middle of the Grande Place stands a column, erected in 1848, commemorating the defence of the town in 1792 (see below), and there are also statues to Generals L. L. C. Faidherbe and F. O. de Négrier, and busts of Louis Pasteur and the popular poet and singer A. Desrousseaux. The Palais des Beaux-Arts contains a museum and picture galleries, among the richest in France, as well as a unique collection of original designs of the great masters bequeathed to Lille by J. B. Wicar, and including a celebrated wax model of a girl's head usually attributed to some Italian artist of the 16th century. The city also possesses a commercial and colonial museum, an industrial museum, a fine collection of departmental and municipal archives, the museum of the Institute of Natural Sciences and a library containing many valuable manuscripts, housed at the Hôtel de Ville. The large military hospital, once a Jesuit college, is one of several similar institutions.

Lille is the seat of a prefect and has tribunals of first instance and of commerce, a board of trade arbitrators, a chamber of commerce and a branch of the Bank of France. It is the centre of an académie (educational division) and has a university with faculties of laws, letters, science and medicine and pharmacy, together with a Catholic institute comprising faculties of theology, law, medicine and pharmacy, letters, science, a technical school, and a department of social and political science. Secondary education is given at the Lycée Faidherbe, and the Lycée Fénelon (for girls), a higher school of commerce, a national technical school and other establishments; to these must be added schools of music and fine arts, and the Industrial and Pasteur Institutes.

The industries, which are carried on in the new quarters of the town and in the suburbs, are of great variety and importance. In the first rank comes the spinning of flax and the weaving of cloth, table-linen, damask, ticking and flax velvet. The spinning of flax thread for sewing and lace-making is specially connected with Lille. The manufacture of woollen fabrics and cotton-spinning and the making of cotton-twist of fine quality are also carried on. There are important printing establishments, state factories for the manufacture of tobacco and the refining of saltpetre and very numerous breweries, while chemical, oil, white lead and sugar-works, distilleries, bleaching-grounds, dye-works, machinery and boiler works and cabinet-making occupy many thousands of workmen. Plant for sugar-works and distilleries, military stores, steam-engines, locomotives, and bridges of all kinds are produced by the company of Fives-Lille. Lille is one of the most important junctions of the Northern railway, and the Deûle canal affords communication with neighbouring ports and with Belgium. Trade is chiefly in the raw material and machinery for its industries, in the products thereof, and in the wheat and other agricultural products of the surrounding district.

Lille (l'Île) is said to date its origin from the time of Count Baldwin IV. of Flanders, who in 1030 surrounded with walls a little town which had arisen around the castle of Buc. In the first half of the 13th century, the town, which had developed rapidly, obtained communal privileges. Destroyed by Philip Augustus in 1213, it was rebuilt by Joanna of Constantinople, countess of Flanders, but besieged and retaken by Philip the Fair in 1297. After having taken part with the Flemings against the king of France, it was ceded to the latter in 1312. In 1369 Charles V., king of France, gave it to Louis de Male, who transmitted his rights to his daughter Margaret, wife of Philip the Bold, duke of Burgundy. Under the Burgundian rule 686 Lille enjoyed great prosperity; its merchants were at the head of the London Hansa. Philip the Good made it his residence, and within its walls held the first chapters of the order of the Golden Fleece. With the rest of Flanders it passed from the dukes of Burgundy to Austria and then to Spain. After the death of Philip IV. of Spain, Louis XIV. reclaimed the territory and besieged Lille in 1667. He forced it to capitulate, but preserved all its laws, customs, privileges and liberties. In 1708, after an heroic resistance, it surrendered to Prince Eugène and the duke of Marlborough. The treaty of Utrecht restored it to France. In 1792 the Austrians bombarded it for nine days and nights without intermission, but had ultimately to raise the siege.

See É. Vanhende, *Lille et ses institutions communales de 620 à 1804* (Lille, 1888).

LILLEBONNE, a town of France in the department of Seine-Inférieure, 3½ m. N. of the Seine and 24 m. E. of Havre by the Western railway. Pop. (1906) 5370. It lies in the valley of the Bolbec at the foot of wooded hills. The church of Notre-Dame, partly modern, preserves a Gothic portal of the 16th century and a graceful tower of the same period. The park contains a fine cylindrical donjon and other remains of a castle founded by William the Conqueror and rebuilt in the 13th century. The principal industries are cotton-spinning and the manufacture of calico and candles.

Lillebonne under the Romans, *Juliobona*, was the capital of the Caletes, or inhabitants of the Pays de Caux, in the time of Caesar, by whom it was destroyed. It was afterwards rebuilt by Augustus, and before it was again ruined by the barbarian invasions it had become an important centre whence Roman roads branched out in all directions. The remains of ancient baths and of a theatre capable of holding 3000 persons have been brought to light. Many Roman and Gallic relics, notably a bronze statue of a woman and two fine mosaics, have been found and transported to the museum at Rouen. In the middle ages the fortifications of the town were constructed out of materials supplied by the theatre. The town recovered some of its old importance under William the Conqueror.

LILLIBULLERO, or Lilliburlero, the name of a song popular at the end of the 17th century, especially among the army and supporters of William III. in the war in Ireland during the revolution of 1688. The tune appears to have been much older, and was sung to an Irish nursery song at the beginning of the 17th century, and the attribution of Henry Purcell is based on the very slight ground that it was published in *Music's Handmaid*, 1689, as "A new Irish Tune" by Henry Purcell. It was also a marching tune familiar to soldiers. The doggerel verses have generally been assigned to Thomas Wharton, and deal with the administration of Talbot, earl of Tyrconnel, appointed by James as his lieutenant in Ireland in 1687. The refrain of the song *lilliburllero bullen a la* gave the title of the song. Macaulay says of the song "The verses and the tune caught the fancy of the nation. From one end of England to the other all classes were singing this idle rhyme." Though Wharton claimed he had "sung a king out of three kingdoms" and Burnet says "perhaps never had so slight a thing so great an effect" the success of the song was "the effect, and not the cause of that excited state of public feeling which produced the revolution" (Macaulay, *Hist. of Eng.* chap. ix.).

LILLO, GEORGE (1693-1739), English dramatist, son of a Dutch jeweller, was born in London on the 4th of February 1693. He was brought up to his father's trade and was for many years a partner in the business. His first piece, *Silvia, or the Country Burial*, was a ballad opera produced at Lincoln's Inn Fields in November 1730. On the 22nd of June 1731 his domestic tragedy, *The Merchant*, renamed later *The London Merchant, or the History of George Barnwell*, was produced by Theophilus Cibber and his company at Drury Lane. The piece is written in prose, which is not free from passages which are really blank verse, and is founded on "An excellent ballad of George Barnwell, an apprentice of London who ... thrice robbed his master, and murdered his uncle in Ludlow." In breaking through the tradition that the characters of every tragedy must necessarily be drawn from people of high rank and fortune he went back to the Elizabethan domestic drama of passion of which the *Yorkshire Tragedy* is a type. The obtrusively moral purpose of this play places it in the same literary category as the novels of Richardson. Scoffing critics called it, with reason, a "Newgate tragedy," but it proved extremely popular on the stage. It was regularly acted for many years at holiday seasons for the moral benefit of the apprentices. The last act contained a scene, generally omitted on the London stage, in which the gallows actually figured. In 1734 Lillo celebrated the marriage of the Princess Anne with William IV. of Orange in *Britannia and Batavia*, a masque. A second tragedy, *The Christian Hero*, was produced at Drury Lane on the 13th of January 1735. It is based on the story of Scanderbeg, the Albanian chieftain, a life of whom is printed with the play. Thomas Whincop (d. 1730) wrote a piece on the same subject, printed posthumously in 1747. Both Lillo and William Havard, who also wrote a dramatic version of the story, were accused of plagiarizing Whincop's *Scanderbeg*. Another murder-drama, *Fatal Curiosity*, in which an old couple murder an unknown guest, who proves to be their own son, was based on a tragedy at Bohelland Farm near Penryn in 1618. It was produced by Henry Fielding at the Little Theatre in the Haymarket in 1736, but with small success. In the next year Fielding tacked it on to his own *Historical Register for 1736*, and it was received more kindly. It was revised by George Colman the elder in 1782, by Henry Mackenzie in 1784, &c. Lillo also wrote an adaptation of the Shakespearean play of *Pericles, Prince of Tyre*, with the title *Marina* (Covent Garden, August 1st, 1738); and a tragedy, *Elmerick, or Justice Triumphant* (produced posthumously, Drury Lane, February 23rd, 1740). The statement made in the prologue to this play that Lillo died in poverty seems unfounded. His death took place on the 3rd of September 1739. He left an unfinished version of *Arden of Feversham*, which was completed by Dr John Hoadly and produced in 1759. Lillo's reputation proved short-lived. He has nevertheless a certain cosmopolitan importance, for the influence of *George Barnwell* can be traced in the sentimental drama of both France and Germany.

See *Lillo's Dramatic Works with Memoirs of the Author by Thomas Davies* (reprint by Lowndes, 1810); Cibber's *Lives of the Poets*, v.; Genest, *Some Account of the English Stage*; Alois Brandl, "Zu Lillo's Kaufmann in London," in *Vierteljahrschrift für Literaturgeschichte* (Weimar, 1890, vol. iii.); Leopold Hoffmann, *George Lillo* (Marburg, 1888); Paul von Hofmann-Wellenhof, *Shakspere's Pericles und George Lillo's Marina* (Vienna, 1885). There is a novel founded on Lillo's play, *Barnwell* (1807), by T. S. Surr, and in "George de Barnwell" (*Novels by Eminent Hands*) Thackeray parodies Bulwer-Lytton's *Eugene Aram*.

LILLY, WILLIAM (1602-1681), English astrologer, was born in 1602 at Diseworth in Leicestershire, his family having been settled as yeomen in the place for "many ages." He received a tolerably good classical education at the school of Ashby-de-la-Zouche, but he naïvely tells us what may perhaps have some significance in reference to his after career, that his master "never taught logic." In his eighteenth year, his father having fallen into great poverty, he went to London and was employed in attendance on an old citizen and his wife. His master, at his death in 1627, left him an annuity of £20; and, Lilly having soon afterwards married the widow, she, dying in 1633, left him property to the value of about £1000. He now began to dabble in astrology, reading all the books on the subject he could fall in with, and occasionally trying his hand at unravelling mysteries by means of his art. The years 1642 and 1643 were devoted to a careful revision of all his previous reading, and in particular having lighted on Valentine Naibod's *Commentary on Alchabitius*, he "seriously studied him and found him to be the profoundest author he ever met with." About the same time he tells us that he "did carefully take notice of every grand action betwixt king and parliament, and did first then incline to believe that as all sublunary affairs depend on superior causes, so there was a possibility of discovering them by the configurations of the superior bodies." And, having thereupon "made some essays," he "found encouragement to proceed further, and ultimately framed to himself that method which he ever afterwards followed." He then began to issue his prophetical almanacs and other works, which met with serious attention from some of the most prominent members of the Long Parliament. If we may believe himself, Lilly lived on friendly and almost intimate terms with Bulstrode Whitlock, Lenthall the speaker, Sir Philip Stapleton, Elias Ashmole and others. Even Selden seems to have given him some countenance, and probably the chief difference between him and the mass of the community at the time was that, while others believed in the general truth of astrology, he ventured to specify the future events to which its calculations pointed. Even from his own account of himself, however, it is evident that he did not trust implicitly to the indications given by the aspects of the heavens, but like more vulgar fortune-tellers kept his eyes and ears open for any information which might make his predictions safe. It appears that he had correspondents both at home and in foreign parts to keep him conversant with the probable current of affairs. Not a few of his exploits indicate rather the quality of a clever police detective than of a profound astrologer. After the Restoration he very quickly fell into disrepute. His sympathy with the parliament, which his predictions had generally shown, was not calculated to bring him into royal favour. He came under the lash of Butler, who, making allowance for some satiric exaggeration, has given in the character of Sidrophel a probably not very incorrect picture of the man; and, having by this time amassed a tolerable fortune, he bought a small estate at Hersham in Surrey, to which he retired, and where he diverted the exercise of his peculiar talents to the practice of medicine. He died in 1681.

Lilly's life of himself, published after his death, is still worth looking into as a remarkable record of credulity. So lately as 1852 a prominent London publisher put forth a new edition of Lilly's *Introduction to Astrology*, "with numerous emendations adapted to the improved state of the science."

LILOAN, a town of the province of Cebú, Philippine Islands, on the E. coast, 10 m. N.E. of Cebú, the capital of the province. Pop. (1903), after the annexation of Compostela, 15,626. There are seventeen villages or *barrios* in the town, and eight of them had in 1903 a population exceeding 1000. The language is Visayan. Fishing is the principal industry. Liloan has one of the principal coal beds on the island; and rice, Indian corn, sugar-cane and coffee are cultivated. Coconuts and other tropical fruits are important products.

LILY, *Lilium*, the typical genus of the botanical order Liliaceae, embracing nearly eighty species, all confined to the northern hemisphere, and widely distributed throughout the north temperate zone. The earliest in cultivation were described in 1597 by Gerard (*Herball*, p. 146), who figures eight kinds of true lilies, which include *L. album* (*L. candidum*) and a variety, *bizantinum*, two umbellate forms of the type *L. bulbiferum*, named *L. aureum* and *L. cruentum latifolium*, and three with pendulous flowers, apparently forms of the martagon lily. Parkinson, in his *Paradisus* (1629), described five varieties of martagon, six of umbellate kinds—two white ones, and *L. pomponium*, *L. chalcedonicum*, *L. carniolicum* and *L. pyrenaicum*—together with one American, *L. canadense*, which had been introduced in 1629. For the ancient and medieval history of the lily, see M. de Cannart d'Hamale's *Monographie historique et littéraire des lis* (Malines, 1870). Since that period many new species have been added. The latest authorities for description and classification of the genus are J. G. Baker ("Revision of the Genera and Species of Tulipeae," *Journ. of Linn. Soc.* xiv. p. 211, 1874), and J. H. Elwes (*Monograph of the Genus* Lilium, 1880), who first tested all the species under cultivation, and has published every one beautifully figured by W. H. Fitch, and some hybrids. With respect to the production of hybrids, the genus is remarkable for its power of resisting the influence of foreign pollen, for the seedlings of any species, when crossed, generally resemble that which bears them. A good account of the new species and principal varieties discovered since 1880, with much information on the cultivation of lilies and the diseases to which they are subject, will be found in the report of the Conference on Lilies, in the *Journal of the Royal Horticultural Society*, 1901. The new species include a number discovered in central and western China by Dr Augustine Henry and other collectors; also several from Japan and California.

The structure of the flower represents the simple type of monocotyledons, consisting of two whorls of petals, of three free parts each, six free stamens, and a consolidated pistil of three carpels, ripening into a three-valved capsule containing many winged seeds. In form, the flower assumes three types: trumpet-shaped, with a more or less elongated tube, *e.g. L. longiflorum* and *L. candidum*; an open form with spreading perianth leaves, *e.g. L. auratum*; or assuming a pendulous habit, with the tips strongly reflexed, *e.g.* the martagon type. All have scaly bulbs, which in three west American species, as *L. Humboldti*, are remarkable for being somewhat intermediate between a bulb and a creeping rhizome. *L. bulbiferum* and its allies produce aerial reproductive bulbils in the axils of the leaves. The bulbs of several species are eaten, such as of *L. avenaceum* in Kamchatka, of *L. Martagon* by the Cossacks, and of *L. tigrinum*, the "tiger lily," in China and Japan. Medicinal uses were ascribed to the species, but none appear to have any marked properties in this respect.

The white lily, *L. candidum*, the λείριον of the Greeks, was one of the commonest garden flowers of antiquity, appearing in the poets from Homer downwards side by side with the rose and the violet. According to Hehn, roses and lilies entered Greece from the east by way of Phrygia, Thrace and Macedonia (*Kulturpflanzen und Hausthiere*, 3rd ed., p. 217). The word λείριον itself, from which *lilium* is derived by assimilation of consonants, appears to be Eranian (*Ibid.* p. 527), and according to ancient etymologists (Lagarde, *Ges. Abh.* p. 227) the town of Susa was connected with the Persian name of the lily *sûsan* (Gr. σοῦσον, Heb. *shôshan*). Mythologically the white lily, *Rosa Junonis*, was fabled to have sprung from the milk of Hera. As the plant of purity it was contrasted with the rose of Aphrodite. The word κρίνον, on the other hand, included red and purple lilies, Plin. *H.N.* xxi. 5 (11, 12), the red lily being best known in Syria and Judaea (Phaselis). This perhaps is the "red lily of Constantinople" of Gerard, *L. chalcedonicum*. The lily of the Old Testament (shôshan) may be conjectured to be a red lily from the simile in Cant. v. 13, unless the allusion is to the fragrance rather than the colour of the lips, in which case the white lily must be thought of. The "lilies of the field," Matt. vi. 28, are κρίνα, and the comparison of their beauty with royal robes suggests their identification with the red Syrian lily of Pliny. Lilies, however, are not a conspicuous feature in the flora of Palestine, and the red anemone (*Anemone coronaria*), with which all the hill-sides of Galilee are dotted in the spring, is perhaps more likely to have suggested the figure. For the lily in the pharmacopoeia of the ancients see Adams's *Paul. Aegineta*, iii. 196. It was used in unguents and against the bites of snakes, &c. In the middle ages the flower continued to be common and was taken as the symbol of heavenly purity. The three golden lilies of France are said to have been originally three lance-heads.

Madonna or White Lily (*Lilium candidum*). About ¼ nat. size.

Lily of the valley, *Convallaria majalis*, belongs to a different tribe (*Asparagoideae*) of the same order. It grows wild in woods in some parts of England, and in Europe, northern Asia and the Alleghany Mountains of North America. The leaves and flower-scapes spring from an underground creeping stem. The small pendulous bell-shaped flowers contain no honey but are visited by bees for the pollen.

The word "lily" is loosely used in connexion with many plants which are not really liliums at all, but belong to genera which are quite distinct botanically. Thus, the Lent lily is *Narcissus Pseudo-narcissus*; the African lily is *Agapanthus umbellatus*; the Belladonna lily is *Amaryllis Belladonna* (*q.v.*); the Jacobaea lily is *Sprekelia formosissima*; the Mariposa lily is *Calochortus*; the lily of the Incas is *Alstroemeria pelegrina*; St Bernard's lily is *Anthericum Liliago*; St Bruno's lily is *Anthericum* (or *Paradisia*) *Liliastrum*; the water lily is *Nymphaea alba*; the Arum lily is *Richardia africana*; and there are many others.

Lily of the Valley (*Convallaria majalis*). About ¼ nat. size.

The true lilies are so numerous and varied that no general cultural instructions will be alike suitable to all. Some species, as *L. Martagon*, *candidum*, *chalcedonicum*, *Szovitzianum* (or *colchicum*), *bulbiferum*, *croceum*, *Henryi*, *pomponium*—the "Turk's cap lily," and others, will grow in almost any good garden soil, and succeed admirably in loam of a rather heavy character, and dislike too much peat. But a compost of peat, loam and leaf-soil suits *L. auratum*, *Brownii*, *concolor*, *elegans*, *giganteum*, *japonicum*, *longiflorum*, *monadelphum*, *pardalinum*, *speciosum*, and the tiger lily (*L. tigrinum*) well, and a larger proportion of peat is indispensable for the beautiful American *L. superbum* and *canadense*. The margin of rhododendron beds, where there are sheltered recesses amongst the plants, suits many of the more delicate species well, partial shade and shelter of some kind being essential. The bulbs should be planted from 6 to 10 in. (according to size) below the surface, which should at once be mulched over with half-decayed leaves or coconut fibre to keep out frost.

The noble *L. auratum*, with its large white flowers, having a yellow band and numerous red or purple spots, is a magnificent plant when grown to perfection; and so are the varieties called *rubro-vittatum* and *cruentum*, which have the central band crimson instead of yellow; and the broad-petalled *platyphyllum*, and its almost pure white sub-variety called *virginale*. Of *L. speciosum* (well known to most gardeners as *lancifolium*), the true typical form and the red-spotted and white varieties are grand plants for late summer blooming in the conservatory. The tiger lily, *L. tigrinum*, and its varieties *Fortunei*, *splendidum* and *flore-pleno*, are amongst the best species for the flower garden; *L. Thunbergianum* and its many varieties being also good border flowers. The pretty *L. Leichtlinii* and *L. colchicum* (or *Szovitsianum*) with drooping yellow flowers and the scarlet drooping-flowered *L. tenuifolium* make up, with those already mentioned, a series of the finest hardy flowers of the summer garden. The Indian *L. giganteum* is perfectly distinct in character, having broad heart-shaped leaves, and a noble stem 10 to 14 ft. high, bearing a dozen or more large deflexed, funnel-shaped, white, purple-stained flowers; *L. cordifolium* (China and Japan) is similar in character, but dwarfer in habit.

For pot culture, the soil should consist of three parts turfy loam to one of leaf-mould and thoroughly rotted manure, adding enough pure grit to keep the compost porous. If leaf-mould is not at hand, turfy peat may be substituted for it. The plants should be potted in October. The pots should be plunged in a cold frame and protected from frost, and about May may be removed to a sheltered and moderately shady place out-doors to remain till they flower, when they may be removed to the greenhouse. This treatment suits the gorgeous *L. auratum*, the splendid varieties of *L. speciosum* (*lancifolium*) and also the chaste-flowering trumpet-tubed *L. longiflorum* and its varieties. Thousands of bulbs of such lilies as *longiflorum* and *speciosum* are now retarded in refrigerators and taken out in batches for greenhouse work as required.

Diseases.—Lilies are, under certain conditions favourable to the development of the disease, liable to the attacks of three parasitic fungi. The most destructive is *Botrytis cinerea* which forms orange-brown or buff specks on the stems, pedicels, leaves and flower-buds, which increase in size and become covered with a delicate grey mould, completely destroying or disfiguring the parts attacked. The spores formed on the delicate grey mould are carried during the summer from one plant to another, thus spreading the disease, and also germinate in the soil where the fungus may remain passive during the winter producing a new crop of spores next spring, or sometimes attacking the scales of the bulbs forming small black hard bodies embedded in the flesh. For prevention, the surface soil covering bulbs should be removed every autumn and replaced by soil mixed with kainit; manure for mulching should also be mixed with kainit, which acts as a steriliser. If the fungus appears on the foliage spray with potassium sulphide solution (2 oz. in 3 gallons of water). *Uromyces Erythronii*, a rust, sometimes causes considerable injury to the foliage of species of *Lilium* and other bulbous plants, forming large discoloured blotches on the leaves. The diseased stems should be removed and burned before the leaves fall; as the bulb is not attacked the plant will start growth next season free from disease. *Rhizopus necans* is sometimes the cause of extensive destruction of bulbs. The fungus attacks injured roots and afterwards passes into the bulb which becomes brown and finally rots. The fungus hibernates in the soil and enters through broken or injured roots, hence care should be taken when removing the bulbs that the roots are injured as little as possible. An excellent packing material for dormant buds is coarsely crushed wood-charcoal to which has been added a sprinkling of flowers of sulphur. This prevents infection from outside and also destroys any spores or fungus mycelium that may have been packed away along with the bulbs.

When cultivated in greenhouses liliums are subject to attack from aphides (green fly) in the early stages of growth. These pests can be kept in check by syringing with nicotine, soft-soap and quassia solutions, or by "vaporising" two or three evenings in succession, afterwards syringing the plants with clear tepid water.

LILYE, or Lily, **WILLIAM** (*c.* 1468-1522), English scholar, was born at Odiham in Hampshire. He entered the university of Oxford in 1486, and after graduating in arts went on a pilgrimage to Jerusalem. On his return he put in at Rhodes, which was still occupied by the knights of St John, under whose protection many Greeks had taken refuge after the capture of Constantinople by the Turks. He then went on to Italy, where he attended the lectures of Sulpitius Verulanus and Pomponius Laetus at Rome, and of Egnatius at Venice. After his return he settled in London (where he became intimate with Thomas More) as a private teacher of grammar, and is believed to have been the first who taught Greek in that city. In 1510 Colet, dean of St Paul's, who was then founding the school which afterwards became famous, appointed Lilye the first high master. He died of the plague on the 25th of February 1522.

Lilye is famous not only as one of the pioneers of Greek learning, but as one of the joint-authors of a book, familiar to many generations of students during the 19th century, the old Eton Latin grammar. The *Brevissima Institutio*, a sketch by Colet, corrected by Erasmus and worked upon by Lilye, contains two portions, the author of which is indisputably Lilye. These are the lines on the genders of nouns, beginning *Propria quae maribus*, and those on the conjugation of verbs beginning *As in praesenti*. The *Carmen de Moribus* bears Lilye's name in the early editions; but Hearne asserts that it was written by Leland, who was one of his scholars, and that Lilye only adapted it. Besides the *Brevissima Institutio*, Lilye wrote a variety of Latin pieces both in prose and Verse. Some of the latter are printed along with the Latin verses of Sir Thomas More in *Progymnasmata Thomae Mori et Gulielmi Lylii Sodalium* (1518). Another volume of Latin verse (*Antibossicon ad Gulielmum Hormannum*, 1521) is directed against a rival schoolmaster and grammarian, Robert Whittington, who had "under the feigned name of Bossus, much provoked Lilye with scoffs and biting verses."

See the sketch of Lilye's life by his son George, canon of St Paul's, written for Paulus Jovius, who was collecting for his history the lives of the learned men of Great Britain; and the article by J. H. Lupton, formerly sur-master of St Paul's School, in the *Dictionary of National Biography*.

LIMA, a city and the county-seat of Allen county, Ohio, U.S.A., on the Ottawa river, about 70 m. S.S.W. of Toledo, Pop. (1890) 15,981; (1900)

21,723, of whom 1457 were foreign-born and 731 were negroes; (1910 census) 30,508. It is served by the Pennsylvania (Pittsburgh, Ft. Wayne & Chicago division), the Erie, the Cincinnati, Hamilton & Dayton, the Lake Erie & Western, the Detroit, Toledo & Ironton railways, and by six interurban electric lines. Immediately N. of the city is a state asylum for the insane. Lima has a Carnegie library, a city hospital and a public park of 100 acres. Among the principal buildings are the county court house, a masonic temple, an Elks' home and a soldiers' and sailors' memorial building. Lima College was conducted here from 1893 to 1908. Lima is situated in the centre of the great north-western oil-field (Trenton limestone of the Ordovician system) of Ohio, which was first developed in 1885; the product of the Lima district was 20,575,138 barrels in 1896, 15,877,730 barrels in 1902 and 6,748,676 barrels in 1908. The city is a headquarters of the Standard Oil Company, and the refining of petroleum is one of the principal industries. The total value of the factory product in 1905 was $8,155,586, an increase of 31.1% over that in 1900. Lima contains railway shops of the Cincinnati, Hamilton & Dayton and the Lake Erie & Western railways. The city has a large wholesale and jobbing trade. The municipality owns and operates the water-works. Lima was laid out in 1831, and was first organized as a city under a general state law in 1842. 689

LIMA, a coast department of central Peru, bounded N. by Ancachs, E. by Junin and Huancavelica, S. by Ica and W. by the Pacific Ocean. Pop. (1906 estimate) 250,000; area 13,314 sq. m. The eastern boundary follows the crests of the Western Cordillera, which gives to the department the western slopes of this chain with the drainage basins of the rivers Huaura, Chancay, Chillon, Rimac, Lurin, Mala and Cañete. Although the department forms part of the rainless region, these rivers, fed from the snows of the high Andes, provide water for the irrigation of large areas devoted to the raising of cotton, sugar, sorghum, Indian corn, alfalfa, potatoes, grapes and olives. The sugar estates of the Cañete are among the best in Peru and are served by a narrow gauge railway terminating at the small port of Cerro Azul. Indian corn is grown in Chancay and other northern valleys, and is chiefly used, together with alfalfa and barley, in fattening swine for lard. The mineral resources are not important, though gold washings in the Cañete valley have been worked since early colonial times. One of the most important industrial establishments in the republic is the smelting works at Casapalca, on the Oroya railway, in the Rimac valley, which receives ores from neighbouring mines of the district of Huarochiri. The department is crossed from S.W. to N.E. by the Oroya railway, and several short lines run from the city of Lima to neighbouring towns. Besides Lima (*q.v.*) the principal towns are Huacho, Cañete (port), Canta, Yauyos, Chorrillos, Miraflores and Barranco—the last three being summer resorts for the people of the capital, with variable populations of 15,000, 6000 and 5000 respectively. About 15 m. S. of Lima, near the mouth of the Lurin, are the celebrated ruins of Pachacamac, which are believed to antedate the occupation of this region by the Incas.

LIMA, the principal city and the capital of Peru and of the department and province of Lima, on the left bank of the river Rimac, 7½ m. above its mouth and the same distance E. by N. of its seaport Callao, in 12° 2′ 34″ S., 77° 7′ 36″ W. Pop. (1906 estimate) 140,000, of whom a large proportion is of negro descent, and a considerable number of foreign birth. The city is about 480 ft. above sea-level, and stands on an arid plain, which rises gently toward the S., and occupies an angle between the Cerros de San Jeronimo (2493 ft.) and San Cristobal (1411 ft.) on the N. and a short range of low hills, called the Cerros de San Bartolomé, on the E. The surrounding region is arid, like all this part of the Pacific coast, but through irrigation large areas have been brought under cultivation, especially along the watercourses. The Rimac has its source about 105 m. N.E. of Lima and is fed by the melting snows of the higher Andes. It is an insignificant stream in winter and a raging torrent in summer. Its tributaries are all of the same character, except the Rio Surco, which rises near Chorrillos and flowing northward joins the Rimac a few miles above the city. These, with the Rio Lurin, which enters the Pacific a short distance S. of Chorrillos, provide water for irrigating the districts near Lima. The climate varies somewhat from that of the arid coast in general, in having a winter of four months characterized by cloudy skies, dense fogs and sometimes a drizzling rain. The air in this season is raw and chilly. For the rest of the year the sky is clear and the air dry. The mean temperature for the year is 66° F., the winter minimum being 59° and the summer maximum 78°.

The older part of Lima was laid out and built with mathematical regularity, the streets crossing each other at right angles and enclosing square areas, called *manzanas*, of nearly uniform size. Later extensions, however, did not follow this plan strictly, and there is some variation from the straight line in the streets and also in the size and shape of the manzanas. The streets are roughly paved with cobble stones and lighted with gas or electricity. A broad boulevard of modern construction partly encircles the city, occupying the site of the old brick walls (18 to 20 ft. high, 10 to 12 ft. thick at the base and 9 ft. at the top) which were constructed in 1585 by a Fleming named Pedro Ramon, and were razed by Henry Meiggs during the administration of President Balta. The water-supply is derived from the Rimac and filtered, and the drainage, once carried on the surface, now passes into a system of subterranean sewers. The streets and suburbs of Lima are served by tramways, mostly worked by electric traction. The suburban lines include two to Callao, one to Magdalena, and one to Miraflores and Chorrillos. On the north side of the river is the suburb or district of San Lazaro, shut in by the encircling hills and occupied in great part by the poorer classes. The principal squares are the Plaza Mayor, Plaza Bolívar (formerly P. de la Inquisicion and P. de la Independencia), Plaza de la Exposicion, and Plaza del Acho, on the north side of the river, the site of the bull-ring. The public gardens, connected with the Exposition palace on the S. side of the city, and the Paseo Colon are popular among the Limeños as pleasure resorts. The long Paseo Colon, with its parallel drives and paths, is ornamented with trees, shrubbery and statues, notably the Columbus statue, a group in marble designed by the sculptor Salvatore Revelli. It is the favourite fashionable resort. A part of the old wagon road from Lima to Callao, which was paved and improved with walks and trees by viceroy O'Higgins, is also much frequented. The avenue (3 m. long) leading from the city to Magdalena was beautified by the planting of four rows of palms during the Pierola administration. Among other public resorts are the Botanical garden, the Grau and Bolognesi avenues (parts of the Boulevard), the Acho avenue on the right bank of the Rimac, and the celebrated avenue of the Descalzos, on the N. side of the river, bordered with statuary. The noteworthy monuments of the city are the bronze equestrian statue of Bolívar in the plaza of that name, the Columbus statue already mentioned, the Bolognesi statue in the small square of that name, and the San Martin statue in the Plaza de la Exposicion. The 22nd of May monument, a marble shaft crowned by a golden bronze figure of Victory, stands where the Callao road crosses the Boulevard. Most conspicuous among the public buildings of Lima is the cathedral, whose twin towers and broad façade look down upon the Plaza Mayor. Its foundation stone was laid in 1535 but the cathedral was not consecrated until 1625. The great earthquake of 1746 reduced it to a mass of ruins, but it was reconstructed by 1758, practically, as it now stands. It has double aisles and ten richly-decorated chapels, in one of which rest the remains of Francisco Pizarro, the conqueror of Peru. Also facing the same square are the archiepiscopal and government palaces; the latter formerly the palace of the viceroys. The interesting *casa* of the Inquisition, whose tribunals rivalled those of Madrid in cruelty, faces upon Plaza Bolívar, as also the old University of San Marcos, which dates from 1551 and has faculties of theology, law, medicine, philosophy and literature, mathematics, and administrative and political economy. The churches and convents of Lima are richly endowed as a rule, and some of the churches represent a very large expenditure of money. The convent of San Francisco, near the Plaza 690
Mayor, is the largest monastic establishment in Lima and contains some very fine carvings. Its church is the finest in the city after the cathedral. Other noteworthy churches are those of the convents of Santo Domingo, La Merced and San Augustine. There are a number of conventual establishments (for both sexes), which, with their chapels, and with the smaller churches, retreats, sanctuaries, &c., make up a total of 66 institutions devoted to religious observances. An attractive, and perhaps the most popular public building in Lima is the Exposition palace on the plaza and in the public gardens of the same name, on the south side of the city. It dates from 1872; its halls are used for important public assemblies, and its upper floor is occupied by the National Historical Institute, its museum and the gallery of historical paintings. Other noteworthy edifices and institutions are the National Library, the Lima Geographical Society, founded in 1888; the Mint, which dates from 1565 and is considered to be one of the best in South America; the great bull-ring of the Plaza del Acho, which dates from 1768 and can seat 8000 spectators; the Concepcion market; a modern penitentiary; and various charitable institutions. In addition to the old university on the Plaza Bolívar, which has been modernized and greatly improved, Lima has a school of engineers and mines (founded 1876), the old college of San Carlos, a normal school (founded 1905), a school of agriculture (situated outside the city limits and founded in 1902), two schools for girls under the direction of religious sisters, an episcopal seminary called the Seminario Conciliar de Santo Toribio, and a school of arts and trades in which elementary technical instruction is given. Under the old régime, primary instruction was almost wholly neglected, but the 20th century brought about important changes in this respect. In addition to the primary schools, the government maintains free night schools for workmen.

The residences of the city are for the most part of one storey and have mud walls supported by a wooden framework which enclose open spaces, called *patios*, around which the living rooms are ranged. The better class of dwellings have two floors and are sometimes built of brick. A projecting, lattice-enclosed window for the use of women is a prominent feature of the larger houses and gives a picturesque effect to the streets.

Manufacturing has had some considerable development since the closing years of the 19th century; the most important manufactories are established outside the city limits; they produce cotton and woollen textiles, the products of the sugar estates, chocolate, cocaine, cigars and cigarettes, beer, artificial liquors, cotton-seed oil, hats, macaroni, matches, paper, soap and candles. The commercial interests of the city are important, a large part of the interior being supplied from this point. With its port Callao the city is connected by two steam railways, one of which was built as early as 1848; one railway runs northward to Ancon, and another, the famous Oroya line, runs inland 130 m., crossing the Western Cordillera at an elevation of 15,645 ft. above sea-level, with branches to Cerro de Pasco and Huari. The export trade properly belongs to Callao, though often credited to Lima. The Limeños are an intelligent, hospitable, pleasure-loving people, and the many attractive features of their city make it a favourite place of residence for foreigners.

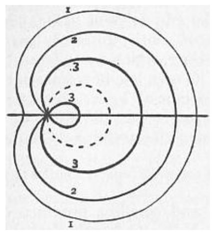
Lima was founded on the 18th of January 1535 by Francisco Pizarro, who named it Ciudad de los Reyes (City of the Kings) in honour of the emperor Charles V. and Doña Juana his mother, or, according to some authorities, in commemoration of the Feast of the Epiphany (6th January) when its site is said to have been selected. The name soon after gave place to that of Lima, a Spanish corruption of the Quichua word Rimac. In 1541 Lima was made an episcopal see, which in 1545 was raised to a metropolitan see. Under Spanish rule, Lima was the principal city of South America, and for a time was the entrepôt for all the Pacific coast colonies south of Panama. It became very prosperous during this period, though often visited by destructive earthquakes, the most disastrous of which was that of the 28th of October 1746, when the cathedral and the greater part of the city were reduced to ruins, many lives were lost, and the port of Callao was destroyed. Lima was not materially affected by the military operations of the war of independence until 1821, when a small army of Argentines and Chileans under General San Martin invested the city, and took possession of it on the 12th of July upon the withdrawal of the Spanish forces. San Martin was proclaimed the protector of Peru as a free state on the 28th of July, but resigned that office on the 20th of September 1822 to avoid a fratricidal struggle with Bolívar. In March 1828 Lima was again visited by a destructive earthquake, and in 1854-1855 an epidemic of yellow fever carried off a great number of its inhabitants. In November 1864, when a hostile Spanish fleet was on the coast, a congress of South American plenipotentiaries was held here to concert measures of mutual defence. Lima has been the principal sufferer in the many revolutions and disorders which have convulsed Peru under the republic, and many of them originated in the city itself. During the earlier part of this period the capital twice fell into the hands of foreigners, once in 1836 when the Bolivian general Santa Cruz made himself the chief of a Bolivian-Peruvian confederation, and again in 1837 when an invading force of Chileans and Peruvian refugees landed at Ancon and defeated the Peruvian forces under President Orbegoso. The city prospered greatly under the two administrations of President Ramon Castilla, who gave Peru its first taste of peace and good government, and under those of Presidents Balta and Pardo, during which many important public improvements were made. The greatest calamity in the history of Lima was its occupation by a Chilean army under the command of General Baquedano after the bloody defeat of the Peruvians at Miraflores on the 15th of January 1881. Chorrillos and Miraflores with their handsome country residences had already been sacked and burned and their helpless residents murdered. Lima escaped this fate, thanks to the intervention of foreign powers, but during the two years and nine months of this occupation the Chileans systematically pillaged the public edifices, turned the old university of San Marcos into barracks, destroyed the public library, and carried away the valuable contents of the Exposition palace, the models and apparatus of the medical school and other educational institutions, and many of the monuments and art treasures with which the city had been enriched. A forced contribution of $1,000,000 a month was imposed upon the population in addition to the revenues of the custom house. When the Chilean garrison under Captain Lynch was withdrawn on the 22nd of October 1883, it took 3000 wagons to carry away the plunder which had not already been shipped. Of the government palace and other public buildings nothing remained but the bare walls. The buoyant character of the people, and the sympathy and assistance generously offered by many civilized nations, contributed to a remarkably speedy recovery from so great a misfortune. Under the direction of its keeper, Don Ricardo Palma, 8315 volumes of the public library were recovered, to which were added valuable contributions from other countries. The portraits of the Spanish viceroys were also recovered, except five, and are now in the portrait gallery of the Exposition palace. The poverty of the country after the war made recovery difficult, but years of peace have assisted it.

See Mariano F. Paz Soldan, *Diccionario geográfico-estadistico del Perú* (Lima, 1877); Mateo Paz Soldan and M. F. Paz Soldan, *Geografia del Perú* (Paris, 1862); Manuel A. Fuentes, *Lima, or Sketches of the Capital of Peru* (London, 1866); C. R. Markham, *Cuzo and Lima* (London, 1856), and *History of Peru* (Chicago, 1892); Alexandre Garland, *Peru in 1906* (Lima, 1907); and C. R. Enock, *Peru* (London, 1908). For earlier descriptions see works referred to under Peru.

(A. J. L.)

LIMAÇON

LIMAÇON (from the Lat. *limax*, a slug), a curve invented by Blaise Pascal and further investigated and named by Gilles Personne de Roberval. It is generated by the extremities of a rod which is constrained to move so that its middle point traces out a circle, the rod always passing through a fixed point on the circumference. The polar equation is $r = a + b \cos \theta$, where $2a$ = length of the rod, and b = diameter of the circle. The curve may be regarded as an epitrochoid (see Epicycloid) in which the rolling and fixed circles have equal radii. It is the inverse of a central conic for the focus, and the first positive pedal of a circle for any point. The form of the limaçon depends on the ratio of the two constants; if a be greater than b, the curve lies entirely outside the circle; if a equals b, it is known as a cardioid (*q.v.*); if a is less than b, the curve has a node within the circle; the particular case when $b = 2a$ is known as the trisectrix (*q.v.*). In the figure (1) is a limaçon, (2) the cardioid, (3) the trisectrix.



Properties of the limaçon may be deduced from its mechanical construction; thus the length of a focal chord is constant and the normals at the extremities of a focal chord intersect on a fixed circle. The area is $(b^2 + a^2/2)\pi$, and the length is expressible as an elliptic integral.

LIMASOL

LIMASOL, a seaport of Cyprus, on Akrotiri Bay of the south coast. Pop. (1901) 8298. Excepting a fort attributed to the close of the 12th century the town is without antiquities of interest, but in the neighbourhood are the ancient sites of Amathus and Curium. Limasol has a considerable trade in wine and carobs. The town was the scene of the marriage of Richard I., king of England, with Berengaria, in 1191.

LIMB

LIMB. (1) (In O. Eng. *lim*, cognate with the O. Nor. and Icel. *limr*, Swed. and Dan. *lem*; probably the word is to be referred to a root *li-* seen in an obsolete English word "lith," a limb, and in the Ger. *Glied*), originally any portion or member of the body, but now restricted in meaning to the external members of the body of an animal apart from the head and trunk, the legs and arms, or, in a bird, the wings. It is sometimes used of the lower limbs only, and is synonymous with "leg." The word is also used of the main branches of a tree, of the projecting spurs of a range of mountains, of the arms of a cross, &c. As a translation of the Lat. *membrum*, and with special reference to the church as the "body of Christ," "limb" was frequently used by ecclesiastical writers of the 16th and 17th centuries of a person as being a component part of the church; cf. such expressions as "limb of Satan," "limb of the law," &c. From the use of *membrum* in medieval Latin for an estate dependent on another, the name "limb" is given to an outlying portion of another, or to the subordinate members of the Cinque Ports, attached to one of the principal towns; Pevensey was thus a "limb" of Hastings. (2) An edge or border, frequently used in scientific language for the boundary of a surface. It is thus used of the edge of the disk of the sun or moon, of the expanded part of a petal or sepal in botany, &c. This word is a shortened form of "limbo" or "limbus," Lat. for an edge, for the theological use of which see Limbus.

LIMBACH

LIMBACH, a town in the kingdom of Saxony, in the manufacturing district of Chemnitz, 6 m. N.W. of that city. Pop. (1905) 13,723. It has a public park and a monument to the composer Pache. Its industries include the making of worsteds, cloth, silk and sewing-machines, and dyeing and bleaching.

LIMBER, an homonymous word, having three meanings. (1) A two-wheeled carriage forming a detachable part of the equipment of all guns on travelling carriages and having on it a framework to contain ammunition boxes, and, in most cases, seats for two or three gunners. The French equivalent is *avant-train*, the Ger. *Protz* (see Artillery and Ordnance). (2) An adjective meaning pliant or flexible and so used with reference to a person's mental or bodily qualities, quick, nimble, adroit. (3) A nautical term for the holes cut in the flooring in a ship above the keelson, to allow water to drain to the pumps.

The etymology of these words is obscure. According to the *New English Dictionary* the origin of (1) is to be found in the Fr. *limonière*, a derivative of *limon*, the shaft of a vehicle, a meaning which appears in English from the 15th century but is now obsolete, except apparently among the miners of the north of England. The earlier English forms of the word are *lymor* or *limmer*. Skeat suggests that (2) is connected with "limp," which he refers to a Teutonic base *lap-*, meaning to hang down. The *New English Dictionary* points out that while "limp" does not occur till the beginning of the 18th century, "limber" in this sense is found as early as the 16th. In Thomas Cooper's (1517?-1594) *Thesaurus Linguae Romanae et Britannicae* (1565), it appears as the English equivalent of the Latin *lentus*. A possible derivation connects it with "limb."

LIMBORCH, PHILIPP VAN (1633-1712), Dutch Remonstrant theologian, was born on the 19th of June 1633, at Amsterdam, where his father was a lawyer. He received his education at Utrecht, at Leiden, in his native city, and finally at Utrecht University, which he entered in 1652. In 1657 he became a Remonstrant pastor at Gouda, and in 1667 he was transferred to Amsterdam, where, in the following year, the office of professor of theology in the Remonstrant seminary was added to his pastoral charge. He was a friend of John Locke. He died at Amsterdam on the 30th of April 1712.

His most important work, *Institutiones theologiae christianae, ad praxin pietatis et promotionem pacis christianae unice directae* (Amsterdam, 1686, 5th ed., 1735), is a full and clear exposition of the system of Simon Episcopius and Stephan Curcellaeus. The fourth edition (1715) included a posthumous "Relatio historica de origine et progressu controversiarum in foederato Belgio de praedestinatione." Limborch also wrote *De veritate religionis Christianae amica collatio cum erudito Judaeo* (Gouda, 1687); *Historia Inquisitionis* (1692), in four books prefixed to the "Liber Sententiarum Inquisitionis Tolosanae" (1307-1323); and *Commentarius in Acta Apostolorum et in Epistolas ad Romanos et ad Hebraeos* (Rotterdam, 1711). His editorial labours included the publication of various works of his predecessors, and of *Epistolae ecclesiasticae praestantium ac eruditorum virorum* (Amsterdam, 1684), chiefly by Jakobus Arminius, Joannes Uytenbogardus, Konrad Vorstius (1569-1622), Gerhard Vossius (1577-1649), Hugo Grotius, Simon Episcopius (his grand-uncle) and Gaspar Barlaeus; they are of great value for the history of Arminianism. An English translation of the Theologia was published in 1702 by William Jones (*A Complete System or Body of Divinity, both Speculative and Practical, founded on Scripture and Reason*, London, 1702); and a translation of the *Historia Inquisitionis*, by Samuel Chandler, with "a large introduction concerning the rise and progress of persecution and the real and pretended causes of it" prefixed, appeared in 1731. See Herzog-Hauck, *Realencyklopädie*.

LIMBURG, one of the many small feudal states into which the duchy of Lower Lorraine was split up in the second half of the 11th century. The first count, Walram of Arlon, married Judith the daughter of Frederick of Luxemburg, duke of Lower Lorraine (d. 1065), who bestowed upon him a portion of his possessions lying upon both sides of the river Meuse. It received its name from the strong castle built by Count Walram on the river Vesdre, where the town of Limburg now stands. Henry, Walram's son (d. 1119), was turbulent and ambitious. On the death of Godfrey of Bouillon (1089) he forced the emperor Henry IV. to recognize him as duke of Lower Lorraine. He was afterwards deposed and imprisoned by Count Godfrey of Louvain on whom the ducal title had been bestowed by the emperor Henry V. (1106). For three generations the possession of the ducal title was disputed between the rival houses of Limburg and Louvain. At length a reconciliation took place (1155); the name of duke of Lower Lorraine henceforth disappears, the rulers of the territory on the Meuse become dukes of Limburg, those of the larger territory to the west dukes of Brabant. With the death of Duke Walram IV. (1280) the succession passed to his daughter, Irmingardis, who was married to Reinald I., count of Guelders. Irmingardis died without issue (1282), and her cousin, Count Adolph of Berg, laid claim to the duchy. His rights were disputed by Reinald, who was in possession and was recognized by the emperor. Too weak to assert his claim by force of arms Adolph sold his rights (1283) to John, duke of Brabant (*q.v.*). This led to a long and desolating war for five years, at the end of which (1288), finding the power of Brabant superior to his own Reinald in his turn sold his rights to count Henry III. of Luxemburg. Henry and Reinald, supported by the archbishop of Cologne and other allies, now raised a great army. The rival forces met at Woeringen (5th of June 1288) and John of Brabant (*q.v.*) gained a complete victory. It proved decisive, the duchies of Limburg and Brabant passing under the rule of a common sovereign. The duchy comprised during this period the bailiwicks of Hervé, Montzen, Baelen, Sprimont and Wallhorn, and the counties of Rolduc, Daelhem and Falkenberg, to which was added in 1530 the town of 692
Maastricht. The provisions and privileges of the famous Charter of Brabant, the *Joyeuse Entrée* (*q.v.*), were from the 15th century extended to Limburg and remained in force until the French Revolution. By the treaty of Westphalia (1648) the duchy was divided into two portions, the counties of Daelhem and Falkenberg with the town of Maastricht being ceded by Spain to the United Provinces, where they formed what was known as a "Generality-Land." At the peace of Rastatt (1714) the southern portion passed under the dominion of the Austrian Habsburgs and formed part of the Austrian Netherlands until the French conquest in 1794. During the period of French rule (1794-1814) Limburg was included in the two French departments of Ourthe and Meuse Inférieure. In 1814 the old name of Limburg was restored to one of the provinces of the newly created kingdom of the Netherlands, but the new Limburg comprised besides the ancient duchy, a piece of Gelderland and the county of Looz. At the revolution of 1830 Limburg, with the exception of Maastricht, threw in its lot with the Belgians, and during the nine years that King William refused to recognize the existence of the kingdom of Belgium the Limburgers sent representatives to the legislature at Brussels and were treated as Belgians. When in 1839 the Dutch king suddenly announced his intention of accepting the terms of the settlement proposed by the treaty of London, as drawn up by representatives of the great powers in 1831, Belgium found herself compelled to relinquish portions of Limburg and Luxemburg. The part of Limburg that lay on the right bank of the Meuse, together with the town of Maastricht and a number of communes—Weert, Haelen, Kepel, Horst, &c.—on the left bank of the river, became a sovereign duchy under the rule of the king of Holland. In exchange for the cession of the rights of the Germanic confederation over the portion of Luxemburg, which was annexed by the treaty to Belgium, the duchy of Limburg (excepting the communes of Maastricht and Venloo) was declared to belong to the Germanic confederation. This somewhat unsatisfactory condition of affairs continued until 1866, when at a conference of the great powers, held in London to consider the Luxemburg question (see Luxemburg), it was agreed that Limburg should be freed from every political tie with Germany. Limburg became henceforth an integral part of Dutch territory.

See P. S. Ernst, *Histoire du Limbourg* (7 vols., Liége, 1837-1852); C. J. Luzac, *De Landen van Overmuze in Zonderheid 1662* (Leiden, 1888); M. J. de Poully, *Histoire de Maastricht et de ses environs* (1850); *Diplomaticke bescheiden betreffends de Limburg-Luxemburgsche aangelegenheden 1866-1867* (The Hague, 1868); and R. Fruin, *Geschied. der Staats-Instellingen in Nederland* (The Hague, 1901).

(G. E.)

LIMBURG, or Limbourg, the smallest of the nine provinces of Belgium, occupying the north-east corner of the kingdom. It represents only a portion of the ancient duchy of Limburg (see above). The part east of the Meuse was transferred to Holland by the London conference, and a further portion was attached to the province of Liége including the old capital now called Dolhain. Much of the province is represented by the wild heath district called the Campine, recently discovered to form an extensive coal-field. The operations for working it were only begun in 1906. North-west of Hasselt is Beverloo, where all the Belgian troops go through a course of instruction annually. Among the towns are Hasselt, the capital, St Trond and Looz. From the last named is derived the title of the family known as the dukes of Looz, whose antiquity equals that of the extinct reigning family of Limburg itself. The title of duc de Looz is one of the four existing ducal titles in the Netherlands, the other three being d'Arenberg, Croy and d'Ursel. Limburg contains 603,085 acres or 942 sq. m. In 1904 the population was 255,359, giving an average of 271 per sq. m.

LIMBURG, a town of Germany, in the Prussian province of Hesse-Nassau, on the Lahn, here crossed by a bridge dating from 1315, and on the main line of railway from Coblenz to Lollar and Cassel, with a branch to Frankfort-on-Main. Pop. (1905) 9917. It is the seat of a Roman Catholic bishop. The small seven-towered cathedral, dedicated to St George the martyr, is picturesquely situated on a rocky site overhanging the river. This was founded by Conrad Kurzbold, count of Niederlahngau, early in the 10th century, and was consecrated in 1235. It was restored in 1872-1878. Limburg has a castle, a new town hall and a seminary for the education of priests; its industries include the manufacture of cloth, tobacco, soap, machinery, pottery and leather. Limburg, which was a flourishing place during the middle ages, had its own line of counts until 1414, when it was purchased by the elector of Trier. It passed to Nassau in 1803. In September 1796 it was the scene of a victory gained by the Austrians under the archduke Charles over the French.

See Hillebrand, *Limburg an der Lahn unter Pfandherrschaft 1344-1624* (Wiesbaden, 1899).

LIMBURG, the south-easternmost and smallest province of Holland, bounded N. by Gelderland, N.W. by North Brabant, S.W. by the Belgian province of Limburg, and S. by that of Liége, and E. by Germany. Its area is 850 sq. m., and its population in 1900 was 281,934. It is watered by the Meuse (Maas) which forms part of its south-western boundary (with Belgium) and then flows through its northern portion, and by such tributaries as the Geul and Roer (Ruhr). Its capital is Maastricht, which gives name to one of the two administrative districts into which it is divided, the other being Roermond.

LIMBURG CHRONICLE, or Festi Limpurgenses, the name of a German chronicle written most probably by Tileman Elhen von Wolfhagen after 1402. It is a source for the history of the Rhineland between 1336 and 1398, but is perhaps more valuable for the information about German manners and customs, and the old German folk-songs and stories which it contains. It has also a certain philological interest.

The chronicle was first published by J. F. Faust in 1617, and has been edited by A. Wyss for the *Monumenta Germaniae historica. Deutsche Chroniken*, Band iv. (Hanover, 1883). See A. Wyss, *Die Limburger Chronik untersucht* (Marburg, 1875).

LIMBURGITE, in petrology, a dark-coloured volcanic rock resembling basalt in appearance, but containing normally no felspar. The name is taken from Limburg (Germany), where they occur in the well-known rock of the Kaiserstuhl. They consist essentially of olivine and augite with a brownish glassy ground mass. The augite may be green, but more commonly is brown or violet; the olivine is usually pale green or colourless, but is sometimes yellow (hyalosiderite). In the ground mass a second generation of small eumorphic augites frequently occurs; more rarely olivine is present also as an ingredient of the matrix. The principal accessory minerals are titaniferous iron oxides and apatite. Felspar though sometimes present is never abundant, and nepheline also is unusual. In some limburgites large phenocysts of dark brown hornblende and biotite are found, mostly with irregular borders blackened by resorption; in others there are large crystals of soda orthoclase or anorthoclase. Hauyne is an ingredient of some of the limburgites of the Cape Verde Islands. Rocks of this group occur in considerable numbers in Germany (Rhine district) and in Bohemia, also in Scotland, Auvergne, Spain, Africa (Kilimanjaro), Brazil, &c. They are associated principally with basalts, nepheline and leucite basalts and monchiquites. From the last-named rocks the limburgites are not easily separated as the two classes bear a very close resemblance in structure and in mineral composition, though many authorities believe that the ground mass of the monchiquites is not a glass but crystalline analcite. Limburgites may occur as flows, as sills or dykes, and are sometimes highly vesicular. Closely allied to them are the *augitites*, which are distinguished only by the absence of olivine; examples are known from Bohemia, Auvergne, the Canary Islands, Ireland, &c.

LIMBUS (Lat. for "edge," "fringe," *e.g.* of a garment), a theological term denoting the border of hell, where dwell those who, while not condemned to torture, yet are deprived of the joy of heaven. The more common form in English is "limbo," which is used both in the technical theological sense and derivatively in the sense of "prison," or for the condition of being lost, deserted, obsolete. In theology there are (1) the *Limbus Infantum*, and (2) the *Limbus Patrum*.

1. The *Limbus Infantum* or *Puerorum* is the abode to which human beings dying without actual sin, but with their original sin unwashed away by baptism, were held to be consigned; the category included, not unbaptized infants merely, but also idiots, cretins and the like. The word "limbus," in the theological application, occurs first in the *Summa* of Thomas Aquinas; for its extensive currency it is perhaps most indebted to the *Commedia* of Dante (*Inf.* c. 4). The question as to the destiny of infants dying unbaptized presented itself to theologians at a comparatively early period. Generally speaking it may be said that the Greek fathers inclined to a cheerful and the Latin fathers to a gloomy view. Thus Gregory of Nazianzus (*Orat.* 40) says "that such children as die unbaptized without their own fault shall neither be glorified nor punished by the righteous Judge, as having done no wickedness, though they die unbaptized, and as rather suffering loss than being the authors of it." Similar opinions were expressed by Gregory of Nyssa, Severus of Antioch and others—opinions which it is almost impossible to distinguish from the Pelagian view that children dying unbaptized might be admitted to eternal life, though not to the kingdom of God. In his recoil from Pelagian heresy, Augustine was compelled to sharpen the antithesis between the state of the saved and that of the lost, and taught that there are only two alternatives—to be with Christ or with the devil, to be with Him or against Him. Following up, as he thought, his master's teaching, Fulgentius declared that it is to be believed as an indubitable truth that, "not only men who have come to the use of reason, but infants dying, whether in their mother's womb or after birth, without baptism in the name of the Father, Son and Holy Ghost, are punished with everlasting punishment in eternal fire." Later theologians and schoolmen followed Augustine in rejecting the notion of any final position intermediate between heaven and hell, but otherwise inclined to take the mildest possible view of the destiny of the irresponsible and unbaptized. Thus the proposition of Innocent III. that "the punishment of original sin is deprivation of the vision of God" is practically repeated by Aquinas, Scotus, and all the other great theologians of the scholastic period, the only outstanding exception being that of Gregory of Rimini, who on this account was afterwards called "tortor infantum." The first authoritative declaration of the Latin Church upon this subject was that made by the second council of Lyons (1274), and confirmed by the council of Florence (1439), with the concurrence of the representatives of the Greek Church, to the effect that "the souls of those who die in mortal sin or in original sin only forthwith descend into hell, but to be punished with unequal punishments." Perrone remarks (*Prael. Theol.* pt. iii. chap. 6, art. 4) that the damnation of infants and also the comparative lightness of the punishment involved in this are thus *de fide*; but nothing is determined as to the place which they occupy in hell, as to what constitutes the disparity of their punishment, or as to their condition after the day of judgment. In the council of Trent there was considerable difference of opinion as to what was implied in deprivation of the vision of God, and no definition was attempted, the Dominicans maintaining the severer view that the "limbus infantum" was a dark subterranean fireless chamber, while the Franciscans placed it in a region of light above the earth. Some theologians continue to maintain with Bellarmine that the infants "in limbo" are affected with some degree of sadness on account of a felt privation; others, following the *Nodus praedestinationis* of Celestine Sfrondati (1649-1696), hold that they enjoy every kind of natural felicity, as regards their souls now, and as regards their bodies after the resurrection, just as if Adam had not sinned. In the condemnation (1794) of the synod of Pistoia (1786), the twenty-sixth article declares it to be false, rash and injurious to treat as Pelagian the doctrine that those dying in original sin are not punished with fire, as if that meant that there is an intermediate place, free from fault and punishment, between the kingdom of God and everlasting damnation. 693

2. The *Limbus Patrum*, *Limbus Inferni* or *Sinus Abrahae* ("Abraham's Bosom"), is defined in Roman Catholic theology as the place in the underworld where the saints of the Old Testament were confined until liberated by Christ on his "descent into hell." Regarding the locality and its

pleasantness or painfulness nothing has been taught as *de fide*. It is sometimes regarded as having been closed and empty since Christ's descent, but other authors do not think of it as separate in place from the *limbus infantum*. The whole idea, in the Latin Church, has been justly described as the mere *caput mortuum* of the old catholic doctrine of Hades, which was gradually superseded in the West by that of purgatory.

LIME (O. Eng. *lim*, Lat. *limus*, mud, from *linere*, to smear), the name given to a viscous exudation of the holly-tree, used for snaring birds and known as "bird-lime." In chemistry, it is the popular name of calcium oxide, CaO, a substance employed in very early times as a component of mortars and cementing materials. It is prepared by the burning of limestone (a process described by Dioscorides and Pliny) in kilns similar to those described under Cement. The value and subsequent treatment of the product depend on the purity of the limestone; a pure stone yields a "fat" lime which readily slakes; an impure stone, especially if magnesia be present, yields an almost unslakable "poor" lime. See Cement, Concrete and Mortar, for details.

Pure calcium oxide "quick-lime," obtained by heating the pure carbonate, is a white amorphous substance, which can be readily melted and boiled in the electric furnace, cubic and acicular crystals being deposited on cooling the vapour. It combines with water, evolving much heat and crumbling to pieces; this operation is termed "slaking" and the resulting product "slaked lime"; it is chemically equivalent to the conversion of the oxide into hydrate. A solution of the hydrate in water, known as lime-water, has a weakly alkaline reaction; it is employed in the detection of carbonic acid. "Milk of lime" consists of a cream of the hydrate and water. Dry lime has no action upon chlorine, carbon dioxide and sulphur dioxide, although in the presence of water combination ensues.

In medicine lime-water, applied externally, is an astringent and desiccative, and it enters into the preparation of linamentum calcis and carron oil which are employed to heal burns, eczema, &c. Applied internally, lime-water is an antacid; it prevents the curdling of milk in large lumps (hence its prescription for infants); it also acts as a gastric sedative. Calcium phosphate is much employed in treating rickets, and calcium chloride in haemoptysis and haemophylia. It is an antidote for mineral and oxalic acid poisoning.

LIME,[1] or Linden. The lime trees, species of *Tilia*, are familiar timber trees with sweet-scented, honeyed flowers, which are borne on a common peduncle proceeding from the middle of a long bract. The genus, which gives the name to the natural order Tiliaceae, contains about ten species of trees, natives of the north temperate zone. The general name *Tilia europaea*, the name given by Linnaeus to the European lime, includes several well-marked sub-species, often regarded as distinct species. These are: (1) the small-leaved lime, *T. parvifolia* (or *T. cordata*), probably wild in woods in England and also wild throughout Europe, except in the extreme south-east, and Russian Asia. (2) *T. intermedia*, the common lime, which is widely planted in Britain but not wild there, has a less northerly distribution than *T. cordata*, from which it differs in its somewhat larger leaves and downy fruit. (3) The large-leaved lime, *T. platyphyllos* (or *T. grandifolia*), occurs only as an introduction in Britain, and is wild in Europe south of Denmark. It differs from the other two limes in its larger leaves, often 4 in. across, which are downy beneath, its downy twigs and its prominently ribbed fruit. The lime sometimes acquires a great size; one is recorded in Norfolk as being 16 yds. in circumference, and Ray mentions one of the same girth. The famous linden tree which gave the town of Neuenstadt in Württemberg the name of "*Neuenstadt an der grossen Linden*" was 9 ft. in diameter.

The lime is a very favourite tree. It is an object of beauty in the spring when the delicately transparent green leaves are bursting from the protection of the pink and white stipules, which have formed the bud-scales, and retains its fresh green during early summer. Later, the fragrance of its flowers, rich in honey, attracts innumerable bees; in the autumn the foliage becomes a clear yellow but soon falls. Among the many famous avenues of limes may be mentioned that which gave the name to one of the best-known ways in Berlin, "Unter den Linden," and the avenue at Trinity College, Cambridge. 694

The economic value of the tree chiefly lies in the inner bark or liber (Lat. for bark), called bast, and the wood. The former was used for paper and mats and for tying garlands by the ancients (*Od.* i. 38; Pliny xvi. 14. 25, xxiv. 8. 33). Bast mats are now made chiefly in Russia, the bark being cut in long strips, when the liber is easily separable from the corky superficial layer. It is then plaited into mats about 2 yds. square; 14,000,000 come to Britain annually, chiefly from Archangel. The wood is used by carvers, being soft and light, and by architects in framing the models of buildings. Turners use it for light bowls, &c. *T. americana* (bass-wood) is one of the most common trees in the forests of Canada and extends into the eastern and southern United States. It is sawn into lumber and under the name of white-wood used in the manufacture of wooden ware, cheap furniture, &c., and also for paper pulp (C. S. Sargent, *Silva of North America*). It was cultivated by Philip Miller at Chelsea in 1752.

The common lime was well known to the ancients. Theophrastus says the leaves are sweet and used for fodder for most kinds of cattle. Pliny alludes to the use of the liber and wood, and describes the tree as growing in the mountain-valleys of Italy (xvi. 30). See also Virg. *Geo.* i. 173, &c.; Ov. *Met.* viii. 621, x. 92. Allusion to the lightness of the wood is made in Aristoph. *Birds*, 1378.

For the sweet lime (*Citrus Limetta* or *Citrus acida*) and lime-juice, see Lemon.

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1 This is an altered form of O. Eng. and M. Eng. *lind*; cf. Ger. *Linde*, cognate with Gr. ἐλάτη, the silver fir. "Linden" in English means properly "made of lime—or lind—wood," and the transference to the tree is due to the Ger. *Lindenbaum*.

LIMERICK, a western county of Ireland, in the province of Munster, bounded N. by the estuary of the Shannon and the counties of Clare and Tipperary, E. by Tipperary, S. by Cork and W. by Kerry. The area is 680,842 acres, or about 1064 sq. m. The greater part of the county is comparatively level, but in the south-east the picturesque Galtees, which extend into Tipperary, attain in Galtymore a height of 3015 ft., and on the west, stretching into Kerry, there is a circular amphitheatre of less elevated mountains. The Shannon is navigable for large vessels to Limerick, above which are the rapids of Doonas and Castleroy, and a canal. The Shannon is widely famous as a sporting river, and Castleconnell is a well-known centre. The Maigne, which rises in the Galtees and flows into the Shannon, is navigable as far as the town of Adare.

This is mainly a Carboniferous Limestone county, with fairly level land, broken by ridges of Old Red Sandstone. On the north-east, the latter rock rises on Slievefelim, round a Silurian core, to 1523 ft. In the south, Old Red Sandstone rises above an enclosed area of Silurian shales at Ballylanders, the opposite scarp of Old Red Sandstone forming the Ballyhoura Hills on the Cork border. Volcanic ashes, andesites, basalts and intrusive sheets of basic rock, mark an eruptive episode in the Carboniferous Limestone. These are well seen under Carrigogunnell Castle, and in a ring of hills round Ballybrood. At Ballybrood, Upper Carboniferous beds occur, as an outlier of a large area that links the west of the county with the north of Kerry. The coals in the west are not of commercial value. Lead-ore has been worked in places in the limestone.

Limerick includes the greater part of the Golden Vale, the most fertile district of Ireland, which stretches from Cashel in Tipperary nearly to the town of Limerick. Along the banks of the Shannon there are large tracts of flat meadow land formed of deposits of calcareous and peaty matter, exceedingly fertile. The soil in the mountainous districts is for the most part thin and poor, and incapable of improvement. The large farms occupy the low grounds, and are almost wholly devoted to grazing. The acreage under tillage decreases, the proportion to pasturage being as one to nearly three. All the crops (of which oats and potatoes are the principal) show a decrease, but there is a growing acreage of meadow land. The numbers of live stock, on the other hand, are on the whole well maintained, and cattle, sheep, pigs, goats and poultry are all extensively reared. The inhabitants are employed chiefly in agriculture, but coarse woollens are manufactured, and also paper, and there are many meal and flour mills. Formerly there were flax-spinning and weaving mills, but the industry is now practically extinct. Limerick is the headquarters of an important salmon-fishery on the Shannon. The railway communications are entirely included in the Great Southern and Western system, whose main line crosses the south-eastern corner of the county, with two branches to the city of Limerick from Limerick Junction and from Charleville, and lines from Limerick south-westward to Tralee in county Kerry, and to Foynes on the Shannon estuary. Limerick is also served by a line from the north through county Tipperary. The port of Limerick, at the head of the estuary, is the most important on the west coast.

The county includes 14 baronies. The number of members returned to the Irish parliament was eight, two being returned for each of the boroughs of Askeaton and Kilmallock, in addition to two returned for the county, and two for the county of the city of Limerick. The present county parliamentary divisions are the east and west, each returning one member. The population (158,912 in 1891, 146,098 in 1901) shows a decrease somewhat under the average of the Irish counties generally, emigration being, however, extensive; of the total about 94% are Roman Catholics, and about 73% are rural. The chief towns are Limerick (pop. 38,151), Rathkeale (1749) and Newcastle or Newcastle West (2599). The city of Limerick constitutes a county in itself. Assizes are held at Limerick, and quarter-sessions at Bruff, Limerick, Newcastle and Rathkeale. The county is divided between the Protestant dioceses of Cashel, Killaloe and Limerick; and between the Roman Catholic dioceses of the same names.

Limerick was included in the kingdom of Thomond. Afterwards it had a separate existence under the name of Aine-Cliach. From the 8th to the 11th century it was partly occupied by the Danes (see Limerick, City). As a county, Limerick is one of the twelve generally considered to owe their formation to King John. By Henry II. it was granted to Henry Fitzherbert, but his claim was afterwards resigned, and subsequently various Anglo-Norman settlements were made. About 100,000 acres of the estates of the earl of Desmond, which were forfeited in 1586, were situated in the county, and other extensive confiscations took place after the Cromwellian wars. In 1709 a German colony from the Palatinate was settled by Lord Southwell near Bruff, Rathkeale and Adare.

There are only slight remains of the round tower at Ardpatrick, but that at Dysert is much better preserved; another at Kilmallock is in great part a reconstruction. There are important remains of stone circles, pillar stones and altars at Loch Gur. In several places there are remains of old moats and tumuli. Besides the monasteries in the city of Limerick, the most important monastic ruins are those of Adare abbey, Askeaton abbey, Galbally friary, Kilflin monastery, Kilmallock and Monaster-Nenagh abbey.

LIMERICK, a city, county of a city, parliamentary borough, port and the chief town of Co. Limerick, Ireland, occupying both banks and an island (King’s Island) of the river Shannon, at the head of its estuary, 129 m. W.S.W. of Dublin by the Great Southern and Western railway. Pop. (1901) 38,151. The situation is striking, for the Shannon is here a broad and noble stream, and the immediately surrounding country consists of the rich lowlands of its valley, while beyond rise the hills of the counties Clare and Tipperary. The city is divided into English Town (on King’s Island), Irish Town and Newtown Pery, the first including the ancient nucleus of the city, and the last the principal modern streets. The main stream of the Shannon is crossed by Thomond Bridge and Sarsfield or Wellesley Bridge. The first is commanded by King John’s Castle, on King’s Island, a fine Norman fortress fronting the river, and used as barracks. At the west end of the bridge is preserved the Treaty Stone, on which the Treaty of Limerick was signed in 1691. The cathedral of St Mary, also on King’s Island, was originally built in 1142-1180, and exhibits some Early English work, though largely altered at dates subsequent to that period. The Roman Catholic cathedral of St John is a modern building (1860) in early pointed style. The churches of St Munchin (to whom is attributed the foundation of the see in the 6th century) and St John, Whitamore’s Castle and a Dominican priory, are other remains of antiquarian interest; while the principal city and county buildings are a chamber of commerce, a custom house commanding the river, and court house, town hall and barracks. A picturesque public park adjoins the railway station in Newtown Pery.

The port is the most important on the west coast, and accommodates vessels of 3000 tons in a floating dock; there is also a graving dock. Communication with the Atlantic is open and secure, while a vast network of inland navigation is opened up by a canal avoiding the rapids above the city. Quays extend for about 1600 yds. on each side of the river, and vessels of 600 tons can moor alongside at spring tides. The principal imports are grain, sugar, timber and coal. The exports consist mainly of agricultural produce. The principal industrial establishments include flour-mills (Limerick supplying most of the west of Ireland with flour), factories for bacon-curing and for condensed milk and creameries. Some brewing, distilling and tanning are carried on, and the manufacture of very beautiful lace is maintained at the Convent of the Good Shepherd; but a formerly important textile industry has lapsed. The salmon fisheries of the Shannon, for which Limerick is the headquarters of a district, are the most valuable in Ireland. The city is governed by a corporation, and the parliamentary borough returns one member. 695

Limerick is said to have been the *Regia* of Ptolemy and the *Rosse-de-Nailleagh* of the Annals of Multifernan. There is a tradition that it was visited by St Patrick in the 5th century, but it is first authentically known as a settlement of the Danes, who sacked it in 812 and afterwards made it the principal town of their kingdom of Limerick, but were expelled from it towards the close of the 10th century by Brian Boroimhe. From 1106 till its conquest by the English in 1174 it was the seat of the kings of Thomond or North Munster, and, although in 1179 the kingdom of Limerick was given by Henry II. to Herbert Fitzherbert, the city was frequently in the possession of the Irish chieftains till 1195. Richard I. granted it a charter in 1197. By King John it was committed to the care of William de Burgo, who founded English Town, and for its defence erected a strong castle. The city was frequently besieged in the 13th and 14th centuries. In the 15th century its fortifications were extended to include Irish Town, and until their demolition in 1760 it was one of the strongest fortresses of the kingdom. In 1651 it was taken by General Ireton, and after an unsuccessful siege by William III. in 1690 its resistance was terminated on the 3rd of October of the following year by the treaty of Limerick. The dismantling of its fortifications began in 1760, but fragments of the old walls remain. The original municipal rights of the city had been confirmed and extended by a succession of sovereigns, and in 1609 it received a charter constituting it a county of a city, and also incorporating a society of merchants of the staple, with the same privileges as the merchants of the staple of Dublin and Waterford. The powers of the corporation were remodelled by the Limerick Regulation Act of 1823. The prosperity of the city dates chiefly from the foundation of Newtown Pery in 1769 by Edmund Sexton Pery (d. 1806), speaker of the Irish House of Commons, whose family subsequently received the title of the earldom of Limerick. Under the Local Government Act of 1898 Limerick became one of the six county boroughs having a separate county council.

LIMERICK, a name which has been adopted to distinguish a certain form of verse which began to be cultivated in the middle of the 19th century. A limerick is a kind of burlesque epigram, written in five lines. In its earlier form it had two rhymes, the word which closed the first or second line being usually employed at the end of the fifth, but in later varieties different rhyming words are employed. There is much uncertainty as to the meaning of the name, and as to the time when it became attached to a particular species of nonsense verses. According to the *New Eng. Dict.* “a song has existed in Ireland for a very considerable time, the construction of the verse of which is identical with that of Lear’s” (see below), and in which the invitation is repeated, “Will you come up to Limerick?” Unfortunately, the specimen quoted in the *New Eng. Dict.* is not only not identical with, but does not resemble Lear’s. Whatever be the derivation of the name, however, it is now universally used to describe a set of verses formed on this model, with the variations in rhyme noted above:—

“There was an old man who said ‘Hush!
I perceive a young bird in that bush!’
When they said, ‘Is it small?’
He replied, ‘Not at all!
It is five times the size of the bush.’”

The invention, or at least the earliest general use of this form, is attributed to Edward Lear, who, when a tutor in the family of the earl of Derby at Knowsley, composed, about 1834, a large number of nonsense-limericks to amuse the little grandchildren of the house. Many of these he published, with illustrations, in 1846, and they enjoyed and still enjoy an extreme popularity. Lear preferred to give a geographical colour to his absurdities, as in:—

“There was an old person of Tartary
Who cut through his jugular artery,
When up came his wife,
And exclaimed, ‘O my Life,
How your loss will be felt through all Tartary!’”

but this is by no means essential. The neatness of the form has led to a very extensive use of the limerick for all sorts of mock-serious purposes, political, social and sarcastic, and a good many specimens have achieved a popularity which has been all the wider because they have, perforce, been confined to verbal transmission. In recent years competitions of the “missing word” type have had considerable vogue, the competitor, for instance, having to supply the last line of the limerick.

LIMES GERMANICUS. The Latin noun *limes* denoted generally a path, sometimes a boundary path (possibly its original sense) or boundary, and hence it was utilized by Latin writers occasionally to denote frontiers definitely delimited and marked in some distinct fashion. This latter sense has been adapted and extended by modern historians concerned with the frontiers of the Roman Empire. Thus the Wall of Hadrian in north England (see Britain: *Roman*) is now sometimes styled the *Limes Britannicus*, the frontier of the Roman province of Arabia facing the desert the *Limes Arabicus* and so forth. In particular the remarkable frontier lines which bounded the Roman provinces of Upper (southern) Germany and Raetia, and which at their greatest development stretched from near Bonn on the Rhine to near Regensburg on the Danube, are often called the *Limes Germanicus*. The history of these lines is the subject of the following paragraphs. They have in the last fifteen years become much better known through systematic excavations financed by the German empire and through other researches connected therewith, and though many important details are still doubtful, their general development can be traced.

From the death of Augustus (A.D. 14) till after A.D. 70 Rome accepted as her German frontier the water-boundary of the Rhine and upper Danube. Beyond these rivers she held only the fertile plain of Frankfort, opposite the Roman border fortress of Moguntiacum (Mainz), the southernmost slopes of the Black Forest and a few scattered têtes-du-pont. The northern section of this frontier, where the Rhine is deep and broad, remained the Roman boundary till the empire fell. The southern part was different. The upper Rhine and upper Danube are easily crossed. The frontier which they form is inconveniently long, enclosing an acute-angled wedge of foreign territory—the modern Baden and Württemberg. The German populations of these lands seem in Roman times to have been scanty, and Roman subjects from the modern Alsace and Lorraine had drifted across the river eastwards. The motives alike of geographical convenience and of the advantages to be gained by recognizing these movements of Roman subjects combined to urge a forward policy at Rome, and when the vigorous Vespasian had succeeded the fool-criminal Nero, a series of advances began which gradually closed up the acute angle, or at least rendered it obtuse.

The first advance came about 74, when what is now Baden was invaded and in part annexed and a road carried from the Roman base on the upper Rhine, Strassburg, to the Danube just above Ulm. The point of the angle was broken off. The second advance was made by Domitian about A.D. 83. He pushed out from Moguntiacum, extended the Roman territory east of it and enclosed the whole within a systematically delimited and defended frontier with numerous blockhouses along it and larger forts in the rear. Among the blockhouses was one which by various enlargements and refoundations grew into the well-known Saalburg fort on the Taunus near Homburg. This advance necessitated a third movement, the construction 696 of a frontier connecting the annexations of A.D. 74 and 83. We know the line of this frontier which ran from the Main across the upland Odenwald to the upper waters of the Neckar and was defended by a chain of forts. We do not, however, know its date, save that, if not Domitian’s work, it was carried out soon after his death, and the whole frontier thus constituted was reorganized, probably by Hadrian, with a continuous wooden palisade reaching from Rhine to Danube. The angle between the rivers was now almost full. But there remained further advance and further fortification. Either Hadrian or, more probably, his successor Pius pushed out from the Odenwald and the Danube, and marked out a new frontier roughly parallel to but in advance of these two lines, though sometimes, as on the Taunus, coinciding with the older line. This is the frontier which is now visible and visited by the curious. It consists, as we see it to-day, of two distinct frontier works, one, known as the Pfahlgraben, is an earthen mound and ditch, best seen in the neighbourhood of the Saalburg but once extending from the Rhine southwards into southern Germany. The other, which begins where the earthwork stops, is a wall, though not a very formidable wall, of stone, the Teufelsmauer; it runs roughly east and west parallel to the Danube, which it finally joins at Heinheim near Regensburg. The Pfahlgraben is remarkable for the extraordinary directness of its southern part, which for over 50 m. runs mathematically straight and points almost absolutely true for the Polar star. It is a clear case of an ancient frontier laid out in American fashion. This frontier remained for about 100 years, and no doubt in that long period much was done to it to which we cannot affix precise dates. We cannot even be absolutely certain when the frontier laid out by Pius was equipped with the Pfahlgraben and Teufelsmauer. But we know that the pressure of the barbarians began to be felt seriously in the later part of the 2nd century, and after long struggles the whole or almost the whole district east of Rhine and north of Danube was lost—seemingly all within one short period—about A.D. 250.

The best English account will be found in H. F. Pelham’s essay in *Trans. of the Royal Hist. Soc.* vol. 20, reprinted in his *Collected Papers*, pp. 178-211 (Oxford, 1910), where the German authorities are fully cited.

(F. J. H.)

LIMESTONE, in petrography, a rock consisting essentially of carbonate of lime. The group includes many varieties, some of which are very distinct; but the whole group has certain properties in common, arising from the chemical composition and mineral character of its members. All limestones dissolve readily in cold dilute acids, giving off bubbles of carbonic acid. Citric or acetic acid will effect this change, though the mineral acids are more commonly employed. Limestones, when pure, are soft rocks readily scratched with a knife-blade or the edge of a coin, their hardness being 3; but unless they are earthy or incoherent, like chalk or sinter, they do not disintegrate by pressure with the fingers and cannot be scratched with the finger nail. When free from impurities limestones are white, but they generally contain small quantities of other minerals than calcite which affect their colour. Many limestones are yellowish or creamy, especially those which contain a little iron oxide, iron carbonate or clay. Others are bluish from the presence of iron sulphide, or pyrites or marcasite; or grey and black from admixture with carbonaceous or bituminous substances. Red limestones usually contain haematite; in green limestones there may be glauconite or chlorite. In crystalline limestones or marbles many silicates may occur producing varied colours, *e.g.* epidote, chlorite, augite (green); vesuvianite and garnet (brown and red); graphite, spinels (black and grey); epidote, chondrodite (yellow). The specific gravity of limestones ranges from 2.6 to 2.8 in typical examples.

When seen in the field, limestones are often recognizable by their method of weathering. If very pure, they may have smooth rounded surfaces, or may be covered with narrow runnels cut out by the rain. In such cases there is very little soil, and plants are found growing only in fissures or crevices where the insoluble impurities of the limestone have been deposited by the rain. The less pure rocks have often eroded or pitted surfaces, showing bands or patches rendered more resistant to the action of the weather by the presence of insoluble materials such as sand, clay or chert. These surfaces are often known from the crust of hydrous oxides of iron produced by the action of the atmosphere on any ferriferous ingredients of the rock; they are sometimes black when the limestone is carbonaceous; a thin layer of gritty sand grains may be left on the surface of limestones which are slightly arenaceous. Most limestones which contain fossils show these most clearly on weathered surfaces, and the appearance of fragments of corals, crinoids and shells on the exposed parts of a rock indicate a strong probability that that rock is a limestone. The interior usually shows the organic structures very imperfectly or not at all.

Another characteristic of pure limestones, where they occur in large masses occupying considerable areas, is the frequency with which they produce bare rocky ground, especially at high elevations, or yield only a thin scanty soil covered with short grass. In mountainous districts limestones are often recognizable by these peculiarities. The chalk downs are celebrated for the close green sward which they furnish. More impure limestones, like those of the Lias and Oolites, contain enough insoluble mineral matter to yield soils of great thickness and value, *e.g.* the Cornbrash. In limestone regions all waters tend to be hard, on account of the abundant carbonate of lime dissolved by percolating waters, and caves, swallow holes, sinks, pot-holes and underground rivers may occur in abundance. Some elevated tracts of limestone are very barren (*e.g.* the Causses), because the rain which falls in them sinks at once into the earth and passes underground. To a large extent this is true of the chalk downs, where surface waters are notably scarce, though at considerable depths the rocks hold large supplies of water.

The great majority of limestones are of organic formation, consisting of the debris of the skeletons of animals. Some are foraminiferal, others are crinoidal, shelly or coral limestones according to the nature of the creatures whose remains they contain. Of foraminiferal limestones chalk is probably the best known; it is fine, white and rather soft, and is very largely made up of the shells of globigerina and other foraminifera (see Chalk). Almost equally important are the nummulitic limestones so well developed in Mediterranean countries (Spain, France, the Alps, Greece, Algeria, Egypt, Asia Minor, &c.). The pyramids of Egypt are built mainly of nummulitic limestone. Nummulites are large cone-shaped foraminifera with many chambers arranged in spiral order. In Britain the small globular shells of *Saccamina* are important constituents of some Carboniferous limestones; but the upper portion of that formation in Russia, eastern Asia and North America is characterized by the occurrence of limestones filled with the spindle-shaped shells of *Fusulina*, a genus of foraminifera now extinct.

Coral limestones are being formed at the present day over a large extent of the tropical seas; many existing coral reefs must be of great thickness. The same process has been going on actively since a very early period of the earth’s history, for similar rocks are found in great abundance in many geological formations. Some Silurian limestones are rich in corals; in the Devonian there are deposits which have been described as coral reefs (Devonshire, Germany). The Carboniferous limestone, or mountain limestones of England and North America, is sometimes nearly entirely coralline, and the great dolomite masses of the Trias in the eastern Alps are believed by many to be merely altered coral reefs. A special feature of coral limestones is that, although they may be to a considerable extent dolomitized, they are generally very free from silt and mechanical impurities.

Crinoidal limestones, though abundant among the older rocks, are not in course of formation on any great scale at the present time, as crinoids, formerly abundant, are now rare. Many Carboniferous and Silurian limestones consist mainly of the little cylindrical joints of these animals. They are easily recognized by their shape, and by the fact that many of them show a tube along their axes, which is often filled up by carbonate of lime; under the microscope they have a punctate or fenestrate structure and each joint behaves as a simple crystalline plate with uniform optical properties in polarized light. Remains of other echinoderms (starfishes and sea urchins) are often found in plenty in Secondary and Tertiary limestones, but very seldom make up the greater part of the rock. Shelly limestones may consist of mollusca or of brachiopoda, the former being common in limestones of all ages while the latter attained their principal development in the Palaeozoic epoch. The shells are often broken and may have been reduced to shell sand before the rock consolidated. Many rocks of this class are impure and pass into marls and shelly sandstones which were deposited in 697 shallow waters, where land-derived sediment mingled with remains of the creatures which inhabited the water. Fresh-water limestones are mostly of this class and contain shells of those varieties of mollusca which inhabit lakes. Brackish water limestones also are usually shelly. Corallines (bryozoa, polyzoa, &c.), cephalopods (*e.g.* ammonites, belemnites), crustaceans and sponges occur frequently in limestones. It should be understood that it is not usual for a rock to be built up entirely of one kind of organism though it is classified according to its most abundant or most conspicuous ingredients.

In the organic limestones there usually occurs much finely granular calcareous matter which has been described as limestone mud or limestone paste. It is the finely ground substance which results from the breaking down of shells, &c., by the waves and currents, and by the decay which takes place in the sea bottom before the fragments are compacted into hard rock. The skeletal parts of marine animals are not always converted into limestone in the place where they were formed. In shallow waters, such as are the favourite haunts of mollusca, corals, &c., the tides and storms are frequently sufficiently powerful to shift the loose material on the sea bottom. A large part of a coral reef consists of broken coral rock dislodged from the growing mass and carried upwards to the beach or into the lagoon. Large fragments also fall over the steep outward slopes of the reef and build up a talus at their base. Coral muds and coral sands produced by the waves acting in these detached blocks, are believed to cover two and a half millions of square miles of the ocean floor. Owing to the fragile nature of the shells of foraminifera they readily become disintegrated, especially at considerable depths, largely by the solvent action of carbonic acid in sea water as they sink to the bottom. The chalk in very great part consists not of entire shells but of debris of foraminifera, and mollusca (such as *Inoceramus*, &c.). The Globigerina ooze is the most widespread of modern calcareous formations. It occupies nearly fifty millions of square miles of the sea bottom, at an average depth of two thousand fathoms. Pteropod ooze, consisting mainly of the shells of pteropods (mollusca) also has a wide distribution, especially in northern latitudes.

Consolidation may to a considerable extent be produced by pressure, but more commonly cementation and crystallization play a large part in the process. Recent shell sands on beaches and in dunes are not unfrequently converted into a soft, semi-coherent rock by rain water filtering downwards, dissolving and redepositing carbonate of lime between the sand grains. In coral reefs also the mass soon has its cavities more or less obliterated by a deposit of calcite from solution. The fine interstitial mud or paste presents a large surface to the solvents, and is more readily attacked than the larger and more compact shell fragments. In fresh-water marls considerable masses of crystalline calcite may be produced in this way, enclosing well-preserved molluscan shells. Many calcareous fragments consist of aragonite, wholly or principally, and this mineral tends to be replaced by calcite. The aragonite, as seen in sections under the microscope, is usually fibrous or prismatic, the calcite is more commonly granular with a well-marked network of rhombohedral cleavage cracks. The replacement of aragonite by calcite goes on even in shells lying on modern sea shores, and is often very complete in rocks belonging to the older geological periods. By the recrystallization of the finer paste and the introduction of calcite in solution the interior of shells, corals, foraminifera, &c., becomes occupied by crystalline calcite, sometimes in comparatively large grains, while the original organic structures may be very well-preserved.

Some limestones are exceedingly pure, *e.g.* the chalk and some varieties of mountain limestone, and these are especially suited for making lime. The majority, however, contain admixture of other substances, of which the commonest are clay and sand. Clayey or argillaceous limestones frequently occur in thin or thick beds alternating with shales, as in the Lias of England (the marlstone series). Friable argillaceous fresh-water limestones are called “marls,” and are used in many districts for top dressing soils, but the name “marl” is loosely applied and is often given to beds which are not of this nature (*e.g.* the red marls of the Trias). The “cement stones” of the Lothians in Scotland are argillaceous limestones of Lower Carboniferous age, which when burnt yield cement. The gault (Upper Cretaceous) is a calcareous clay, often containing well-preserved fossils, which lies below the chalk and attains considerable importance in the south-east of England. Arenaceous limestones pass by gradual transitions into shelly sandstones; in the latter the shells are often dissolved leaving cavities, which may be occupied by casts. Some of the Old Red Sandstone is calcareous. In other cases the calcareous matter has recrystallized in large plates which have shining cleavage surfaces dotted over with grains of sand (Lincolnshire limestone). The Fontainebleau sandstone has large calcite rhombohedra filled with sand grains. Limestones sometimes contain much plant matter which has been converted into a dark coaly substance, in which the original woody structures may be preserved or may not. The calcareous petrified plants of Fifeshire occur in such a limestone, and much has been learned from a microscopic study of them regarding the anatomy of the plants of the Carboniferous period. Volcanic ashes occur in some limestones, a good example being the calcareous schalsteins or tuffs of Devonshire, which are usually much crushed by earth movements. In the Globigerina ooze of the present day there is always a slight admixture of volcanic materials derived either from wind-blown dust, from submarine eruptions or from floating pieces of pumice. Other limestones contain organic matter in the shape of asphalt, bitumen or petroleum, presumably derived from plant remains. The well-known *Val de Travers* is a bituminous limestone of lower Neocomian age found in the valley of that name near Neuchâtel. Some of the oil beds of North America are porous limestones, in the cavities of which the oil is stored up. Siliceous limestones, where their silica is original and of organic origin, have contained skeletons of sponges or radiolaria. In the chalk the silica has usually been dissolved and redeposited as flint nodules, and in the Carboniferous limestone as chert bands. It may also be deposited in the corals and other organic remains, silicifying them, with preservation of the original structures (*e.g.* some Jurassic and Carboniferous limestones).

The oolitic limestones form a special group distinguished by their consisting of small rounded or elliptical grains resembling fish roe; when coarse they are called pisolites. Many of them are very pure and highly fossiliferous. The oolitic grains in section may have a nucleus, *e.g.* a fragment of a shell, quartz grain, &c., around which concentric layers have been deposited. In many cases there is also a radiating structure. They consist of calcite or aragonite, and between the grains there is usually a cementing material of limestone mud or granular calcite crystals. Deposits of silica, carbonate of iron or small rhombohedra of dolomite are often found in the interior of the spheroids, and oolites may be entirely silicified (Pennsylvania, Cambrian rocks of Scotland). Oolitic ironstones are very abundant in the Cleveland district of Yorkshire and form an important iron ore. They are often impure, and their iron may be present as haematite or as chalybite. Oolitic limestones are known from many geological formations, *e.g.* the Cambrian and Silurian of Scotland and Wales, Carboniferous limestone (Bristol), Jurassic, Tertiary and Recent limestones. They are forming at the present day in some coral reefs and in certain petrifying springs like those of Carlsbad. Their chief development in England is in the Jurassic rocks where they occur in large masses excellently adapted for building purposes, and yield the well-known freestones of Portland and Bath. Some hold that they are chemical precipitates and that the concentric oolitic structure is produced by successive layers of calcareous deposit laid down on fragments of shells, &c., in highly calcareous waters. An alternative hypothesis is that minute cellular plants (*Girvanella*, &c.), have extracted the carbonate of lime from the water, and have been the principal agents in producing the successive calcareous crusts. Such plants can live even in hot waters, and there seems much reason for regarding them as of importance in this connexion.

Another group of limestones is of inorganic or chemical origin, having been deposited from solution in water without the intervention of living organisms. A good example of these is the “stalactite” which forms pendent masses on the roofs of caves in limestone districts, the calcareous waters exposed to evaporation in the air of the cave laying down successive layers of stalactite in the places from which they drip. At the same time and in the same way “stalagmite” gathers on the floor below, and often accumulates in thick masses which contain bones of animals and the weapons of primitive cave-dwelling man. Calc sinters are porous limestones deposited by the evaporation of calcareous springs; travertine is a well-known Italian rock of this kind. At Carlsbad oolitic limestones are forming, but it seems probable that minute algae assist in this process. Chemical deposits of carbonate of lime may be produced by the evaporation of sea water in some upraised coral lagoons and similar situations, but it is unlikely that this takes place to any extent in the open sea, as sea water contains very little carbonate of lime, apparently because marine organisms so readily abstract it; still some writers believe that a considerable part of the chalk is really a chemical precipitate. Onyx marbles are banded limestones of chemical origin with variegated colours such as white, yellow, green and red. They are used for ornamental work and are obtained in Persia, France, the United States, Mexico, &c.

Limestones are exceedingly susceptible to chemical changes of a metasomatic kind. They are readily dissolved by carbonated waters and acid solutions, and their place may then be occupied by deposits of a different kind. The silification of oolites and coral rocks and their replacement by iron ores above mentioned are examples of this process. Many extensive hematite deposits are in this way formed in limestone districts. Phosphatization sometimes takes place, amorphous phosphate of lime being substituted for carbonate of lime, and these replacement products often have great value as sources of natural fertilizers. On ocean rocks in dry climates the droppings of birds (guano) which contain much phosphate, percolating into the underlying limestones change them into a hard white or yellow phosphate rock (*e.g.* Sombrero, Christmas Island, &c.), sometimes known as rock-guano or mineral guano. In the north of France beds of phosphate are found in the chalk; they occur also in England on a smaller scale. All limestones, especially those laid down in deep waters contain some lime phosphate, derived from shells of certain brachiopods, fish bones, teeth, whale bones, &c. and this may pass into solution and be redeposited in certain horizons, a process resembling the formation of flints. 698
On the sea bottom at the present day phosphatic nodules are found which have gathered round the dead bodies of fishes and other animals. As in flint the organic structures of the original limestone may be well preserved though the whole mass is phosphatized.

Where uprising heated waters carrying mineral solutions are proceeding from deep seated masses of igneous rocks they often deposit a portion of their contents in limestone beds. At Leadville, in Colorado, for example, great quantities of rich silver lead ore, which have yielded not a little gold, have been obtained from the limestones, while other rocks, though apparently equally favourably situated, are barren. The lead and fluorspar deposits of the north of England (Alston Moor, Derbyshire) occur in limestone. In the Malay States the limestones have been impregnated with tin oxide. Zinc ores are very frequently associated with beds of limestone, as at Vieille Montagne in Belgium, and copper ores are found in great quantity in Arizona in rocks of this kind. Apart from ore deposits of economic value a great number of different minerals, often well crystallized, have been observed in limestones.

When limestones occur among metamorphic schists or in the vicinity of intrusive plutonic masses (such as granite), they are usually recrystallized and have lost their organic structures. They are then known as crystalline limestones or marbles (*q.v.*).

(J. S. F.)

LIMINA APOSTOLORUM, an ecclesiastical term used to denote Rome, and especially the church of St Peter and St Paul. A *Visitatio Liminum* might be undertaken *ex voto* or *ex lege*. The former, visits paid in accordance with a vow, were very frequent in the middle ages, and were under the special protection of the pope, who put the ban upon any who should molest pilgrims “who go to Rome for God’s sake.” The question of granting dispensations from such a vow gave rise to much canonical legislation, in which the papacy had finally to give in to the bishops. The visits demanded by law were of more importance. In 743 a Roman synod decreed that all bishops subject to the metropolitan see of Rome should meet personally every year in that city to give an account of the state of their dioceses. Gregory VII. included in the order all metropolitans of the Western Church, and Sixtus V. (by the bull *Romanus Pontifex*, Dec. 20, 1584) ordered the bishops of Italy, Dalmatia and Greece to visit Rome every three years; those of France, Germany, Spain and Portugal, Belgium, Hungary, Bohemia and the British Isles every four years; those from the rest of Europe every five years; and bishops from other continents every ten years. Benedict XIV. in 1740 extended the summons to all abbots, provosts and others who held territorial jurisdiction.

LIMITATION, STATUTES OF, the name given to acts of parliament by which rights of action are limited in the United Kingdom to a fixed period after the occurrence of the events giving rise to the cause of action. This is one of the devices by which lapse of time is employed to settle disputed claims. There are mainly two modes by which this may be effected. We may say that the active enjoyment of a right—or possession—for a determined period shall be a good title against all the world. That is the method known generally as Prescription (*q.v.*). It looks to the length of time during which the defendant in a disputed claim has been in possession or enjoyment of the matter in dispute. But the principle of the statutes of limitation is to look to the length of time during which the plaintiff has been out of possession. The point of time at which he might first have brought his action having been ascertained, the lapse of the limited period after that time bars him for ever from bringing his action. In both cases the policy of the law is expressed by the maxim *Interest reipublicae ut sit finis litium*.

The principle of limitation was first adopted in English law in connexion with real actions, *i.e.* actions for the recovery of real property. At first a fixed date was taken, and no action could be brought of which the cause had arisen before that date. By the Statute of Westminster the First (3 Edward I. c. 39), the beginning of the reign of Richard I. was fixed as the date of limitation for such actions. This is the well-known “period of legal memory” recognized by the judges in a different class of cases to which a rule of prescription was applied. Possession of rights in *alieno solo* from time immemorial was held to be an indefeasible title, and the courts held time immemorial to begin with the first year of Richard I.

A period absolutely fixed became in time useless for the purposes of limitation, and the method of counting back a certain number of years from the date of the writs was adopted in the Statute 32 Henry VIII. c. 2, which fixed periods of thirty, fifty and sixty years for various classes of actions named therein. A large number of statutes since that time have established periods of limitation for different kinds of actions. Of those now in force the most important are the Limitation Act 1623 for personal actions in general, and the Real Property Limitation Act 1833 relating to actions for the recovery of land. The latter statute has been repealed and virtually re-enacted by the Real Property Limitation Act 1874, which reduced the period of limitation from twenty years to twelve, for all actions brought after the 1st January 1879. The principal section of the act of 1833 will show the *modus operandi*: “After the 31st December 1833, no person shall make an entry or distress, or bring an action to recover any land or rent *but within twenty years next after the time* at which the right to make such entry or distress or to bring such action shall have first accrued to some person through whom he claims, or shall have first accrued to the person making or bringing the same.” Another section defines the times at which the right of action or entry shall be deemed to have accrued in particular cases; *e.g.* when the estate claimed shall have been an estate or interest in reversion, such right shall be deemed to have first accrued at the time at which such estate or interest became an estate or interest in possession. Thus suppose lands to be let by A to B from 1830 for a period of fifty years, and that a portion of such lands is occupied by C from 1831 without any colour of title from B or A—C’s long possession would be of no avail against an action brought by A for the recovery of the land after the determination of B’s lease. A would have twelve years after the determination of the lease within which to bring his action, and might thus, by an action brought in 1891, disestablish a person who had been in quiet possession since 1831. What the law looks to is not the length of time during which C has enjoyed the property, but the length of time which A has suffered to elapse since he might first have brought his action. It is to be observed, however, that the Real Property Limitation Act does more than bar the remedy. It extinguishes the right, differing in this respect from the other Limitation Acts, which, while barring the remedy, preserve the right, so that it may possibly become available in some other way than by action.

By section 14 of the act of 1833, when any acknowledgment of the title of the person entitled shall have been given to him or his agent in writing signed by the person in possession, or in receipt of the profits or rent, then the right of the person (to whom such acknowledgment shall have been given) to make an entry or distress or bring an action shall be deemed to have first accrued at the time at which such acknowledgment, or the last of such acknowledgments, was given. By section 15, persons under the disability of infancy, lunacy or coverture, or beyond seas, and their representatives, are to be allowed ten years from the termination of this disability, or death (which shall have first happened), notwithstanding that the ordinary period of limitation shall have expired.

By the act of 1623 actions of trespass, detinue, trover, replevin or account, actions on the case (except for slander), actions of debt arising out of a simple contract and actions for arrears of rent not due upon specialty shall be limited to six years from the date of the cause of action. Actions for assault, menace, battery, wounds and imprisonment are limited to four years, and actions for slander to two years. Persons labouring under the disabilities of infancy, lunacy or unsoundness of mind are allowed the same time after the removal of the disability. When the defendant was “beyond seas” (*i.e.* outside the United Kingdom and the adjacent islands) an extension of time was allowed, but by the Real Property Limitation Act of 1874 such an allowance is excluded as to real property, and as to other matters by the Mercantile Law Amendment Act 1856.

An acknowledgment, whether by payment on account or by mere spoken words, was formerly sufficient to take the case out of the statute. The Act 699
9 Geo. IV. c. 14 (Lord Tenterden’s act) requires any promise or admission of liability to be in writing and signed by the party to be charged, otherwise it will not bar the statute.

Contracts under seal are governed as to limitation by the act of 1883, which provides that actions for rent upon any indenture of demise, or of covenant, or debt or any bond or other specialty, and on recognizances, must be brought within twenty years after cause of action. Actions of debt on an award (the submission being not under seal), or for a copyhold fine, or for money levied on a writ of *fieri facias*, must be brought within six years. With regard to the rights of the crown, the principle obtains that *nullum tempus occurrit regi*, so that no statute of limitation affects the crown without express mention. But by the Crown Suits Act 1769, as amended by the Crown Suits Act 1861, in suits relating to land, the claims of the crown to recover are barred after the lapse of sixty years. For the prosecution of criminal offences generally there is no period of limitation, except where they are punishable on summary conviction. In such case the period is six months by the Summary Jurisdiction Act 1848. But there are various miscellaneous limitations fixed by various acts, of which the following may be noticed. Suits and indictments under penal statutes are limited to two years if the forfeiture is to the crown, to one year if the forfeiture is to the common informer. Penal actions by persons aggrieved are limited to two years by the act of 1833. Prosecutions under the Riot Act can only be sued upon within twelve months after the offence has been committed, and offences against the Customs Acts within three years. By the Public Authorities Protection Act 1893, a prosecution against any person acting in execution of statutory or other public duty must be commenced within six months. Prosecutions under the Criminal Law Amendment Act, as amended by the Prevention of Cruelty to Children Act 1904, must be commenced within six months after the commission of the offence.

Trustees are expressly empowered to plead statutes of limitation by the Trustees Act 1888; indeed, a defence under the statutes of limitations must in general be specially pleaded. Limitation is regarded strictly as a law of procedure. The English courts will therefore apply their own rules to all actions, although the cause of action may have arisen in a country in which different rules of limitation exist. This is also a recognized principle of private international law (see J. A. Foote, *Private International Law*, 3rd ed., 1904, p. 516 seq.).

United States.—The principle of the statute of limitations has passed with some modification into the statute-books of every state in the Union except Louisiana, whose laws of limitation are essentially the prescriptions of the civil law drawn from the *Partidas*, or “Spanish Code.” As to personal actions, it is generally provided that they shall be brought within a certain specified time—usually six years or less—from the time when the cause of action accrues, and not after, while for land the “general if not universal limitation of the right to bring action or to make entry is to twenty years after the right to enter or to bring the action accrues” (Bouvier’s *Law Dictionary*, art. “Limitations”). The constitutional provision prohibiting states from passing laws impairing the obligation of contracts is not infringed by a law of limitations, unless it bars a right of action already accrued without giving a reasonable term within which to bring the action.

See Darby and Bosanquet, *Statutes of Limitations* (1899); Hewitt, *Statutes of Limitations* (1893).

LIMOGES, a town of west-central France, capital of the department of Haute-Vienne, formerly capital of the old province of Limousin, 176 m. S. by W. of Orleans on the railway to Toulouse. Pop. (1906) town, 75,906; commune, 88,597. The station is a junction for Poitiers, Angoulême, Périgueux and Clermont-Ferrand. The town occupies a hill on the right bank of the Vienne, and comprises two parts originally distinct, the *Cité* with narrow streets and old houses occupying the lower slope, and the town proper the summit. In the latter a street known as the Rue de la Boucherie is occupied by a powerful and ancient corporation of butchers. The site of the fortifications which formerly surrounded both quarters is occupied by boulevards, outside which are suburbs with wide streets and spacious squares. The cathedral, the most remarkable building in the Limousin, was begun in 1273. In 1327 the choir was completed, and before the middle of the 16th century the transept, with its fine north portal and the first two bays of the nave; from 1875 to 1890 the construction of the nave was continued, and it was united with the west tower (203 ft. high), the base of which belongs to a previous Romanesque church. In the interior there are a magnificent rood loft of the Renaissance, and the tombs of Jean de Langeac (d. 1541) and other bishops. Of the other churches of Limoges, St Michel des Lions (14th and 15th centuries) and St Pierre du Queyroix (12th and 13th centuries) both contain interesting stained glass. The principal modern buildings are the town hall and the law-courts. The Vienne is crossed by a railway viaduct and four bridges, two of which, the Pont St Étienne and the Pont St Martial, date from the 13th century. Among the chief squares are the Place d'Orsay on the site of a Roman amphitheatre, the Place Jourdan with the statue of Marshal J. B. Jourdan, born at Limoges, and the Place d'Aine with the statue of J. L. Gay-Lussac. President Carnot and Denis Dussoubs, both of whom have statues, were also natives of the town. The museum has a rich ceramic collection and art, numismatic and natural history collections.

Limoges is the headquarters of the XII. army corps and the seat of a bishop, a prefect, a court of appeal and a court of assizes, and has tribunals of first instance and of commerce, a board of trade arbitration, a chamber of commerce and a branch of the Bank of France. The educational institutions include a *lycée* for boys, a preparatory school of medicine and pharmacy, a higher theological seminary, a training college, a national school of decorative art and a commercial and industrial school. The manufacture and decoration of porcelain give employment to about 13,000 persons in the town and its vicinity. Shoe-making and the manufacture of clogs occupy over 2000. Other industries are liqueur-distilling, the spinning of wool and cloth-weaving, printing and the manufacture of paper from straw. Enamelling, which flourished at Limoges in the middle ages and during the Renaissance (see Enamel), but subsequently died out, was revived at the end of the 19th century. There is an extensive trade in wine and spirits, cattle, cereals and wood. The Vienne is navigable for rafts above Limoges, and the logs brought down by the current are stopped at the entrance of the town by the inhabitants of the Naveix quarter, who form a special gild for this purpose.

Limoges was a place of importance at the time of the Roman conquest, and sent a large force to the defence of Alesia. In 11 B.C. it took the name of Augustus (*Augustoritum*); but in the 4th century it was anew called by the name of the *Lemovices*, whose capital it was. It then contained palaces and baths, had its own senate and the right of coinage. Christianity was introduced by St Martial. In the 5th century Limoges was devastated by the Vandals and the Visigoths, and afterwards suffered in the wars between the Franks and Aquitanians and in the invasions of the Normans. Under the Merovingian kings Limoges was celebrated for its mints and its goldsmiths' work. In the middle ages the town was divided into two distinct parts, each surrounded by walls, forming separate fiefs with a separate system of administration, an arrangement which survived till 1792. Of these the more important, known as the *Château*, which grew up round the tomb of St Martial in the 9th century, and was surrounded with walls in the 10th and again in the 12th, was under the jurisdiction of the viscounts of Limoges, and contained their castle and the monastery of St Martial; the other, the *Cité*, which was under the jurisdiction of the bishop, had but a sparse population, the habitable ground being practically covered by the cathedral, the episcopal palace and other churches and religious buildings. In the Hundred Years' War the bishops sided with the French, while the viscounts were unwilling vassals of the English. In 1370 the *Cité*, which had opened its gates to the French, was taken by the Black Prince and given over to fire and sword.

The religious wars, pestilence and famine desolated Limoges in turn, and the plague of 1630-1631 carried off more than 20,000 persons. The wise 700
administrations of Henri d'Aguesseau, father of the chancellor, and of Turgot enabled Limoges to recover its former prosperity. There have been several great fires, destroying whole quarters of the city, built, as it then was, of wood. That of 1790 lasted for two months, and destroyed 192 houses; and that of 1864 laid under ashes a large area. Limoges celebrates every seven years a curious religious festival (Fête d'Ostension), during which the relics of St Martial are exposed for seven weeks, attracting large numbers of visitors. It dates from the 10th century, and commemorates a pestilence (mal des ardents) which, after destroying 40,000 persons, is believed to have been stayed by the intercession of the saint.

Limoges was the scene of two ecclesiastical councils, in 1029 and 1031. The first proclaimed the title of St Martial as "apostle of Aquitaine"; the second insisted on the observance of the "truce of God." In 1095 Pope Urban II. held a synod of bishops here in connexion with his efforts to organize a crusade, and on this occasion consecrated the basilica of St Martial (pulled down after 1794).

See Célestin Poré, *Limoges*, in Joanne's guides, *De Paris à Ager* (1867); Ducourtieux, *Limoges d'après ses anciens plans* (1884) and *Limoges et ses environs* (3rd ed., 1894). A very full list of works on Limoges, the town, viscounty, bishopric, &c., is given by U. Chevalier in *Répertoire des sources hist. du moyen âge. Topo-bibliogr.* (Mont Céliard, 1903), t. ii. *s.v.*

LIMON, or Port Limon, the chief Atlantic port of Costa Rica, Central America, and the capital of a district also named Limon, on a bay of the Caribbean Sea, 103 m. E. by N. of San José. Pop. (1904) 3171. Limon was founded in 1871, and is the terminus of the transcontinental railway to Puntarenas which was begun in the same year. The swamps behind the town, and the shallow coral lagoon in front of it, have been filled in. The harbour is protected by a sea-wall built along the low-water line, and an iron pier affords accommodation for large vessels. A breakwater from the harbour to the island of Uvita, about 1200 yds. E. would render Limon a first-class port. There is an excellent water-supply from the hills above the harbour. Almost the entire coffee and banana crops of Costa Rica are sent by rail for shipment at Limon to Europe and the United States. The district (*comarca*) of Limon comprises the whole Atlantic littoral, thus including the Talamanca country inhabited by uncivilized Indians; the richest banana-growing territories in the country; and the valuable forests of the San Juan valley. It is annually visited by Indians from the Mosquito coast of Nicaragua, who come in canoes to fish for turtle. Its chief towns, after Limon, are Reventazon and Matina, both with fewer than 3000 inhabitants.

LIMONITE, or Brown Iron Ore, a natural ferric hydrate named from the Gr. λειμών (meadow), in allusion to its occurrence as "bog-ore" in meadows and marshes. It is never crystallized, but may have a fibrous or microcrystalline structure, and commonly occurs in concretionary forms or in compact and earthy masses; sometimes mammillated, botryoidal, reniform or stalactitic. The colour presents various shades of brown and yellow, and the streak is always brownish, a character which distinguishes it from haematite with a red, or from magnetite with a black streak. It is sometimes called brown haematite.

Limonite is a ferric hydrate, conforming typically with the formula $Fe_4O_3(OH)_6$, or $2Fe_2O_3 \cdot 3H_2O$. Its hardness is rather above 5, and its specific gravity varies from 3.5 to 4. In many cases it has been formed from other iron oxides, like haematite and magnetite, or by the alteration of pyrites or chalybite.

By the operation of meteoric agencies, iron pyrites readily pass into limonite often with retention of external form; and the masses of "gozzan" or "gossan" on the outcrop of certain mineral-veins consist of rusty iron ore formed in this way, and associated with cellular quartz. Many deposits of limonite have been found, on being worked, to pass downwards into ferrous carbonate; and crystals of chalybite converted superficially into limonite are well known. Minerals, like glauconite, which contain ferrous silicate, may in like manner yield limonite, on weathering. The ferric hydrate is also readily deposited from ferruginous waters, often by means of organic agencies. Deposits of brown iron ore of great economic value occur in many sedimentary rocks, such as the Lias, Oolites and Lower Greensand of various parts of England. They appear in some cases to be altered limestones and in others altered glauconitic sandstones. An oolitic structure is sometimes present, and the ores are generally phosphatic, and may contain perhaps 30% of iron. The oolitic brown ores of Lorraine and Luxemburg are known as "minette," a diminutive of the French *mine* (ore), in allusion to their low content of metal. Granular and concretionary limonite accumulates by organic action on the floor of certain lakes in Sweden, forming the curious "lake ore." Larger concretions formed under other conditions are known as "bean ore." Limonite often forms a cementing medium in ferruginous sands and gravels, forming "pan"; and in like manner it is the agglutinating agent in many conglomerates, like the South African "banket," where it is auriferous. In iron-shot sands the limonite may form hollow concretions, known in some cases as "boxes." The "eagle stones" of older writers were generally concretions of this kind, containing some substance, like sand, which rattled when the hollow nodule was shaken. Bog iron ore is an impure limonite, usually formed by the influence of micro-organisms, and containing silica, phosphoric acid and organic matter, sometimes with manganese. The various kinds of brown and yellow ochre are mixtures of limonite with clay and other impurities; whilst in umber much manganese oxide is present. Argillaceous brown iron ore is often known in Germany as *Thoneisenstein*; but the corresponding term in English (clay iron stone) is applied to nodular forms of impure chalybite. J. C. Ullmann's name of stilpnosiderite, from the Greek στιλπνός (shining) is sometimes applied to such kinds of limonite as have a pitchy lustre. Deposits of limonite in cavities may have a rounded surface or even a stalactitic form, and may present a brilliant lustre, of blackish colour, forming what is called in Germany *Glaskopf* (glass head). It often happens that analyses of brown iron ores reveal a larger proportion of water than required by the typical formula of limonite, and hence new species have been recognized. Thus the yellowish brown ore called by E. Schmidt xanthosiderite, from ξανθός (yellow) and σίδηρος (iron), contains $Fe_2O(OH)_4$, or $Fe_2O_3 \cdot 2H_2O$; whilst the bog ore known as limnite, from λίμνη (marsh) has the formula $Fe(OH)_3$, or $Fe_2O_3 \cdot 3H_2O$. On the other hand there are certain forms of ferric hydrate containing less water than limonite and approaching to haematite in their red colour and streak: such is the mineral which was called hydrohaematite by A. Breithaupt, and is now generally known under R. Hermann's name of turgite, from the mines of Turginsk, near Bogoslovsk in the Ural Mountains. This has the formula $Fe_4O_5(OH)_2$, or $2Fe_2O_3 \cdot H_2O$. It probably represents the partial dehydration of limonite, and by further loss of water may pass into haematite or red iron ore. When limonite is dehydrated and deoxidized in the presence of carbonic acid, it may give rise to chalybite.

LIMOUSIN (or Limosin), **LÉONARD** (*c.* 1505-*c.* 1577), French painter, the most famous of a family of seven Limoges enamel painters, was the son of a Limoges innkeeper. He is supposed to have studied under Nardon Pénicaud. He was certainly at the beginning of his career influenced by the German school—indeed, his earliest authenticated work, signed L. L. and dated 1532, is a series of eighteen plaques of the "Passion of the Lord," after Albrecht Dürer, but this influence was counter-balanced by that of the Italian masters of the school of Fontainebleau, Primaticcio, Rosso, Giulio Romano and Solario, from whom he acquired his taste for arabesque ornament and for mythological subjects. Nevertheless the French tradition was sufficiently ingrained in him to save him from becoming an imitator and from losing his personal style. In 1530 he entered the service of Francis I. as painter and *varlet de chambre*, a position which he retained under Henry II. For both these monarchs he executed many portraits in enamel—among them quite a number of plaques depicting Diane de Poitiers in various characters,—plates, vases, ewers, and cups, besides decorative works for the royal palaces, for, though he is best known as an enameller distinguished for rich colour, and for graceful designs in grisaille on black or bright blue backgrounds, he also enjoyed a great reputation as an oil-painter. His last signed works bear the date 1574, but the date of his death is uncertain, though it could not have been later than the beginning of 1577. It is on record that he executed close upon two thousand enamels. He is best represented at the Louvre, which owns his two famous votive tablets for the Sainte Chapelle, each consisting of twenty-three plaques, signed L. L. and dated 1553; "La Chasse," depicting Henry II. on a white horse, Diane de Poitiers behind him on horseback; and many portraits, including the kings by whom he was employed, Marguerite de Valois, the duc de Guise, and the cardinal de Lorraine. Other representative examples are at the Cluny and Limoges museums. In England some magnificent examples of his work are to be found at the Victoria and Albert Museum, the British Museum, and the Wallace Collection. In the collection of Signor Rocchi, in Rome, is an exceptionally interesting plaque representing Frances I. consulting a fortune-teller. 701

See *Léonard Limousin: peintre de portraits* (*L'Œuvre des peintres émailleurs*), by L. Boudery and E. Lachenaud (Paris, 1897)—a careful study, with an elaborate catalogue of the known existing examples of the artist's work. The book deals almost exclusively with the portraits illustrated. See also Alleaume and Duplessis, *Les Douze Apôtres—émaux de Léonard Limousin*, &c. (Paris, 1865); L. Boudery, *Exposition retrospective de Limoges en 1886* (Limoges, 1886); L. Boudery, *Léonard Limousin et son œuvre* (Limoges, 1895); *Limoges et le Limousin* (Limoges, 1865); A. Meyer, *L'Art de l'émail de Limoges, ancien et moderne* (Paris, 1896); Émile Molinier, *L'Émaillerie* (Paris, 1891).

LIMOUSIN (Lat. *Pagus Lemovicinus, ager Lemovicensis, regio Lemovicum, Lemozinum, Limosinium*, &c.), a former province of France. In the time of Julius Caesar the *pagus Lemovicinus* covered the county now comprised in the departments of Haute-Vienne, Corrèze and Creuse, with the *arrondissements* of Confolens in Charente and Nontron in Dordogne. These limits it retained until the 10th century, and they survived in those of the diocese of Limoges (except a small part cut off in 1317 to form that of Tulle) until 1790. The break-up into great fiefs in the 10th century, however, tended rapidly to disintegrate the province, until at the close of the 12th century Limousin embraced only the viscounties of Limoges, Turenne and Comborn, with a few ecclesiastical lordships, corresponding roughly to the present *arrondissements* of Limoges and Saint Yrien in Haute-Vienne and part of the *arrondissements* of Brive, Tulle and Ussel in Corrèze. In the 17th century Limousin, thus constituted, had become no more than a small *gouvernement*.

Limousin takes its name from the *Lemovices*, a Gallic tribe whose county was included by Augustus in the province of *Aquitania Magna*. Politically its history has little of separate interest; it shared in general the vicissitudes of Aquitaine, whose dukes from 918 onwards were its over-lords at least till 1264, after which it was sometimes under them, sometimes under the counts of Poitiers, until the French kings succeeded in asserting their direct over-lordship. It was, however, until the 14th century, the centre of a civilization of which the enamelling industry (see Enamel) was only one expression. The Limousin dialect, now a mere *patois*, was regarded by the troubadours as the purest form of Provençal.

See A. Lerœux, *Géographie et histoire du Limousin* (Limoges, 1892). Detailed bibliography in Chevalier, *Répertoire des sources. Topo-bibliogr.* (Montbéliard, 1902), t. ii. *s.v.*

LIMPOPO, or Crocodile, a river of S.E. Africa over 1000 m. in length, next to the Zambezi the largest river of Africa entering the Indian Ocean. Its head streams rise on the northern slopes of the Witwatersrand less than 300 m. due W. of the sea, but the river makes a great semicircular sweep across the high plateau first N.W., then N.E. and finally S.E. It is joined early in its course by the Marico and Notwani, streams which rise along the westward continuation of the Witwatersrand, the ridge forming the water-parting between the Vaal and the Limpopo basins. For a great part of its course the Limpopo forms the north-west and north frontiers of the Transvaal. Its banks are well wooded and present many picturesque views. In descending the escarpment of the plateau the river passes through rocky ravines, piercing the Zoutpansberg near the north-east corner of the Transvaal at the Toli Azimé Falls. In the low country it receives its chief affluent, the Olifants river (450 m. long), which, rising in the high veld of the Transvaal east of the sources of the Limpopo, takes a more direct N.E. course than the main stream. The Limpopo enters the ocean in 25° 15′ S. The mouth, about 1000 ft. wide, is obstructed by sandbanks. In the rainy season the Limpopo loses a good deal of its water in the swampy region along its lower course. High-water level is 24 ft. above low-water level, when the depth in the shallowest part does not exceed 3 ft. The river is navigable all the year round by shallow-draught vessels from its mouth for about 100 m., to a spot known as Gungunyana's Ford. In flood time there is water communication south with the river Komati (*q.v.*). At this season stretches of the Limpopo above Gungunyana's Ford are navigable. The river valley is generally unhealthy.

The basin of the Limpopo includes the northern part of the Transvaal, the eastern portion of Bechuanaland, southern Matabeleland and a large area of Portuguese territory north of Delagoa Bay. Its chief tributary, the Olifants, has been mentioned. Of its many other affluents, the Macloutsie, the Shashi and the Tuli are the most distant north-west feeders. In this direction the Matoppos and other hills of Matabeleland separate the Limpopo basin from the valley of the Zambezi. A little above the Tuli confluence is Rhodes's Drift, the usual crossing-place from the northern Transvaal into Matabeleland. Among the streams which, flowing north through the Transvaal, join the Limpopo is the Nylstroom, so named by Boers trekking from the south in the belief that they had reached the river Nile. In the coast region the river has one considerable affluent from the north, the Chengane, which is navigable for some distance.

The Limpopo is a river of many names. In its upper course called the Crocodile that name is also applied to the whole river, which figures on old Portuguese maps as the Oori (or Oira) and Bembe. Though claiming the territory through which it ran the Portuguese made no attempt to trace the river. This was first done by Captain J. F. Elton, who in 1870 travelling from the Tati goldfields sought to open a road to the sea via the Limpopo. He voyaged down the river from the Shashi confluence to the Toli Azimé Falls, which he discovered, following the stream thence on foot to the low country. The lower course of the river had been explored 1868-1869 by another British traveller—St Vincent Whitshed Erskine. It was first navigated by a sea-going craft in 1884, when G. A. Chaddock of the British mercantile service succeeded in crossing the bar, while its lower course was accurately surveyed by Portuguese officers in 1895-1896. At the junction of the Lotsani, one of the Bechuanaland affluents, with the Limpopo, are ruins of the period of the Zimbabwes.

LINACRE (or Lynaker), **THOMAS** (*c.* 1460-1524), English humanist and physician, was probably born at Canterbury. Of his parentage or descent nothing certain is known. He received his early education at the cathedral school of Canterbury, then under the direction of William Celling (William Tilly of Selling), who became prior of Canterbury in 1472. Celling was an ardent scholar, and one of the earliest in England who cultivated Greek learning. From him Linacre must have received his first incentive to this study. Linacre entered Oxford about the year 1480, and in 1484 was elected a fellow of All Souls' College. Shortly afterwards he visited Italy in the train of Celling, who was sent by Henry VIII. as an envoy to the papal court, and he accompanied his patron as far as Bologna. There he became the pupil of Angelo Poliziano, and afterwards shared the instruction which that great scholar imparted at Florence to the sons of Lorenzo de' Medici. The younger of these princes became Pope Leo X., and was in after years mindful of his old companionship with Linacre. Among his other teachers and friends in Italy were Demetrius Chalcondylas, Hermolaus Barbaras, Aldus Romanus the printer of Venice, and Nicolaus Leonicenus of Vicenza. Linacre took the degree of doctor of medicine with great distinction at Padua. On his return to Oxford, full of the learning and imbued with the spirit of the Italian Renaissance, he formed one of the brilliant circle of Oxford scholars, including John Colet, William Grocyn and William Latimer, who are mentioned with so much warm eulogy in the letters of Erasmus.

Linacre does not appear to have practised or taught medicine in Oxford. About the year 1501 he was called to court as tutor of the young prince Arthur. On the accession of Henry VIII. he was appointed the king's physician, an office at that time of considerable influence and importance, and practised medicine in London, having among his patients most of the great statesmen and prelates of the time, as Cardinal Wolsey, Archbishop Warham and Bishop Fox.

After some years of professional activity, and when in advanced life, Linacre received priest's orders in 1520, though he had for some years previously held several clerical benefices. There is no doubt that his ordination was connected with his retirement from active life. Literary labours, and the cares of the foundation which owed its existence chiefly to him, the Royal College of Physicians, occupied Linacre's remaining years till his 702
death on the 20th of October 1524.

Linacre was more of a scholar than a man of letters, and rather a man of learning than a scientific investigator. It is difficult now to judge of his practical skill in his profession, but it was evidently highly esteemed in his own day. He took no part in political or theological questions, and died too soon to have to declare himself on either side in the formidable controversies which were even in his lifetime beginning to arise. But his career as a scholar was one eminently characteristic of the critical period in the history of learning through which he lived. He was one of the first Englishmen who studied Greek in Italy, whence he brought back to his native country and his own university the lessons of the "New Learning." His teachers were some of the greatest scholars of the day. Among his pupils was one—Erasmus—whose name alone would suffice to preserve the memory of his instructor in Greek, and others of note in letters and politics, such as Sir Thomas More, Prince Arthur and Queen Mary. Colet, Grocyn, William Lilye and other eminent scholars were his intimate friends, and he was esteemed by a still wider circle of literary correspondents in all parts of Europe.

Linacre's literary activity was displayed in two directions, in pure scholarship and in translation from the Greek. In the domain of scholarship he was known by the rudiments of (Latin) grammar (*Progymnasmata Grammatices vulgaria*), composed in English, a revised version of which was made for the use of the Princess Mary, and afterwards translated into Latin by Robert Buchanan. He also wrote a work on Latin composition, *De emendata structura Latini sermonis*, which was published in London in 1524 and many times reprinted on the continent of Europe.

Linacre's only medical works were his translations. He desired to make the works of Galen (and indeed those of Aristotle also) accessible to all readers of Latin. What he effected in the case of the first, though not trifling in itself, is inconsiderable as compared with the whole mass of Galen's writings; and of his translations from Aristotle, some of which are known to have been completed, nothing has survived. The following are the works of Galen translated by Linacre: (1) *De sanitate tuenda*, printed at Paris in 1517; (2) *Methodus medendi* (Paris, 1519); (3) *De temperamentis et de Inaequali Intemperie* (Cambridge, 1521); (4) *De naturalibus facultatibus* (London, 1523); (5) *De symptomatum differentiis et causis* (London, 1524); (6) *De pulsuum Usu* (London, without date). He also translated for the use of Prince Arthur an astronomical treatise of Proclus, *De sphaera*, which was printed at Venice by Aldus in 1499. The accuracy of these translations and their elegance of style were universally admitted. They have been generally accepted as the standard versions of those parts of Galen's writings, and frequently reprinted, either as a part of the collected works or separately.

But the most important service which Linacre conferred upon his own profession and science was not by his writings. To him was chiefly owing the foundation by royal charter of the College of Physicians in London, and he was the first president of the new college, which he further aided by conveying to it his own house, and by the gift of his library. Shortly before his death Linacre obtained from the king letters patent for the establishment of readerships in medicine at Oxford and Cambridge, and placed valuable estates in the hands of trustees for their endowment. Two readerships were founded in Merton College, Oxford, and one in St John's College, Cambridge, but owing to neglect and bad management of the funds, they fell into uselessness and obscurity. The Oxford foundation was revived by the university commissioners in 1856 in the form of the Linacre professorship of anatomy. Posterity has done justice to the generosity and public spirit which prompted these foundations; and it is impossible not to recognize a strong constructive genius in the scheme of the College of Physicians, by which Linacre not only first organized the medical profession in England, but impressed upon it for some centuries the stamp of his own individuality.

The intellectual fastidiousness of Linacre, and his habits of minute accuracy were, as Erasmus suggests, the chief cause why he left no more permanent literary memorials. It will be found, perhaps, difficult to justify by any extant work the extremely high reputation which he enjoyed among the scholars of his time. His Latin style was so much admired that, according to the flattering eulogium of Erasmus, Galen spoke better Latin in the version of Linacre than he had before spoken Greek; and even Aristotle displayed a grace which he hardly attained to in his native tongue. Erasmus praises also Linacre's critical judgment ("vir non exacti tantum sed severi judicii"). According to others it was hard to say whether he were more distinguished as a grammarian or a rhetorician. Of Greek he was regarded as a consummate master; and he was equally eminent as a "philosopher," that is, as learned in the works of the ancient philosophers and naturalists. In this there may have been some exaggeration; but all have acknowledged the elevation of Linacre's character, and the fine moral qualities summed up in the epitaph written by John Caius: "Fraudes dolosque mire perosus; fidus amicis; omnibus ordinibus juxta carus."

The materials for Linacre's biography are to a large extent contained in the older biographical collections of George Lilly (in Paulus Jovius, *Descriptio Britanniae*), Bale, Leland and Pits, in Wood's *Athenae Oxonienses* and in the *Biographia Britannica*; but all are completely collected in the *Life of Thomas Linacre*, by Dr Noble Johnson (London, 1835). Reference may also be made to Dr Munk's *Roll of the Royal College of Physicians* (2nd ed., London, 1878); and the Introduction, by Dr J. F. Payne, to a facsimile reproduction of Linacre's version of *Galen de temperamentis* (Cambridge, 1881). With the exception of this treatise, none of Linacre's works or translations has been reprinted in modern times.

LINARES, an inland province of central Chile, between Talca on the N. and Ńuble on the S., bounded E. by Argentina and W. by the province of Maule. Pop. (1895) 101,858; area, 3942 sq. m. The river Maule forms its northern boundary and drains its northern and north-eastern regions. The province belongs partly to the great central valley of Chile and partly to the western slopes of the Andes, the S. Pedro volcano rising to a height of 11,800 ft. not far from the sources of the Maule. The northern part is fertile, as are the valleys of the Andean foothills, but arid conditions prevail throughout the central districts, and irrigation is necessary for the production of crops. The vine is cultivated to some extent, and good pasturage is found on the Andean slopes. The province is traversed from N. to S. by the Chilean Central railway, and the river Maule gives access to the small port of Constitucion, at its mouth. From Parral, near the southern boundary, a branch railway extends westward to Cauquenes, the capital of Maule. The capital, Linares, is centrally situated, on an open plain, about 20 m. S. of the river Maule. It had a population of 7331 in 1895 (which an official estimate of 1902 reduced to 7256). Parral (pop. 8586 in 1895; est. 10,219 in 1902) is a railway junction and manufacturing town.

LINARES, a town of southern Spain, in the province of Jaen, among the southern foothills of the Sierra Morena, 1375 ft. above sea-level and 3 m. N.W. of the river Guadalimar. Pop. (1900) 38,245. It is connected by four branch railways with the important argentiferous lead mines on the north-west, and with the main railways from Madrid to Seville, Granada and the principal ports on the south coast. The town was greatly improved in the second half of the 19th century, when the town hall, bull-ring, theatre and many other handsome buildings were erected; it contains little of antiquarian interest save a fine fountain of Roman origin. Its population is chiefly engaged in the lead-mines, and in such allied industries as the manufacture of gunpowder, dynamite, match for blasting purposes, rope and the like. The mining plant is entirely imported, principally from England; and smelting, desilverizing and the manufacture of lead sheets, pipes, &c., are carried on by British firms, which also purchase most of the ore raised. Linares lead is unsurpassed in quality, but the output tends to decrease. There is a thriving local trade in grain, wine and oil. About 2 m. S. is the village of Cazlona, which shows some remains of the ancient *Castulo*. The ancient mines some 5 m. N., which are now known as Los Pozos de Anibal, may possibly date from the 3rd century B.C., when this part of Spain was ruled by the Carthaginians.

LINCOLN, EARLS OF.

LINCOLN, EARLS OF. The first earl of Lincoln was probably William de Roumare (*c.* 1095-*c.* 1155), who was created earl about 1140, although it is possible that William de Albini, earl of Arundel, had previously held the earldom. Roumare's grandson, another William de Roumare (*c.* 1150-*c.* 1198), is sometimes called earl of Lincoln, but he was never recognized as such, and about 1148 King Stephen granted the earldom to one of his supporters, Gilbert de Gand (d. 1156), who was related to the former earl. After Gilbert's death the earldom was dormant for about sixty years; then in 1216 it was given to another Gilbert de Gand, and later it was claimed by the great earl of Chester, Ranulf, or Randulph, de Blundevill (d. 1232). From Ranulf the title to the earldom passed through his sister Hawise to the family of Lacy, John de Lacy (d. 1240) being made earl of Lincoln in 1232. He was son of Roger de Lacy (d. 1212), justiciar of England and constable of Chester. It was held by the Lacys until the death of Henry, the 3rd earl. Henry served Edward I. in Wales, France and Scotland, both as a soldier and a diplomatist. He went to France with Edmund, earl of Lancaster, in 1296, and when Edmund died in June of this year, succeeded him as commander of the English forces in Gascony; but he did not experience any great success in this capacity and returned to England early in 1298. The earl fought at the battle of Falkirk in July 1298, and took some part in the subsequent conquest of Scotland. He was then employed by Edward to negotiate successively with popes Boniface VIII. and Clement V., and also with Philip IV. of France; and was present at the death of the English king in July 1307. For a short time Lincoln was friendly with the new king, Edward II., and his favourite, Piers Gaveston; but quickly changing his attitude, he joined earl Thomas of Lancaster and the baronial party, was one of the "ordainers" appointed in 1310 and was regent of the kingdom during the king's absence in Scotland in the same year. He died in London on the 5th of February 1311, and was buried in St Paul's Cathedral. He married Margaret (d. 1309), granddaughter and heiress of William Longsword, 2nd earl of Salisbury, and his only surviving child, Alice (1283-1348), became the wife of Thomas, earl of Lancaster, who thus inherited his father-in-law's earldoms of Lincoln and Salisbury. Lincoln's Inn in London gets its name from the earl, whose London residence occupied this site. He founded Whalley Abbey in Lancashire, and built Denbigh Castle.

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In 1349 Henry Plantagenet, earl (afterwards duke) of Lancaster, a nephew of Earl Thomas, was created earl of Lincoln; and when his grandson Henry became king of England as Henry IV. in 1399 the title merged in the crown. In 1467 John de la Pole (*c.* 1464-1487), a nephew of Edward IV., was made earl of Lincoln, and the same dignity was conferred in 1525 upon Henry Brandon (1516-1545), son of Charles Brandon, duke of Suffolk. Both died without sons, and the next family to hold the earldom was that of Clinton.

Edward Fiennes Clinton, 9th Lord Clinton (1512-1585), lord high admiral and the husband of Henry VIII.'s mistress, Elizabeth Blount, was created earl of Lincoln in 1572. Before his elevation he had rendered very valuable services both on sea and land to Edward VI., to Mary and to Elizabeth, and he was in the confidence of the leading men of these reigns, including William Cecil, Lord Burghley. From 1572 until the present day the title has been held by Clinton's descendants. In 1768 Henry Clinton, the 9th earl (1720-1794), succeeded his uncle Thomas Pelham as 2nd duke of Newcastle-under-Lyne, and since this date the title of earl of Lincoln has been the courtesy title of the eldest son of the duke of Newcastle.

See G. E. C.(okayne), *Complete Peerage*, vol. v. (1893).

LINCOLN, ABRAHAM

LINCOLN, ABRAHAM (1809-1865), sixteenth president of the United States of America, was born on "Rock Spring" farm, 3 m. from Hodgenville, in Hardin (now Larue) county, Kentucky, on the 12th of February 1809.[1] His grandfather,[2] Abraham Lincoln, settled in Kentucky about 1780 and was killed by Indians in 1784. His father, Thomas (1778-1851), was born in Rockingham (then Augusta) county, Virginia; he was hospitable, shiftless, restless and unsuccessful, working now as a carpenter and now as a farmer, and could not read or write before his marriage, in Washington county, Kentucky, on the 12th of June 1806, to Nancy Hanks (1783-1818), who was, like him, a native of Virginia, but had much more strength of character and native ability, and seemed to have been, in intellect and character, distinctly above the social class in which she was born. The Lincolns had removed from Elizabethtown, Hardin county, their first home, to the Rock Spring farm, only a short time before Abraham's birth; about 1813 they removed to a farm of 238 acres on Knob Creek, about 6 m. from Hodgenville; and in 1816 they crossed the Ohio river and settled on a quarter-section, 1½ m. E. of the present village of Gentryville, in Spencer county, Indiana. There Abraham's mother died on the 5th of October 1818. In December 1819 his father married, at his old home, Elizabethtown, Mrs Sarah (Bush) Johnston (d. 1869), whom he had courted years before, whose thrift greatly improved conditions in the home, and who exerted a great influence over her stepson. Spencer county was still a wilderness, and the boy grew up in pioneer surroundings, living in a rude log-cabin, enduring many hardships and knowing only the primitive manners, conversation and ambitions of sparsely settled backwoods communities. Schools were rare, and teachers qualified only to impart the merest rudiments. "Of course when I came of age I did not know much," wrote he years afterward, "still somehow I could read, write and cipher to the rule of three, but that was all. I have not been to school since. The little advance I now have upon this store of education I have picked up from time to time under the pressure of necessity." His entire schooling, in five different schools, amounted to less than a twelvemonth; but he became a good speller and an excellent penman. His own mother taught him to read, and his stepmother urged him to study. He read and re-read in early boyhood the Bible, Aesop, *Robinson Crusoe*, *Pilgrim's Progress*, Weems's *Life of Washington* and a history of the United States; and later read every book he could borrow from the neighbours, Burns and Shakespeare becoming favourites. He wrote rude, coarse satires, crude verse, and compositions on the American government, temperance, &c. At the age of seventeen he had attained his full height, and began to be known as a wrestler, runner and lifter of great weights. When nineteen he made a journey as a hired hand on a flatboat to New Orleans.

In March 1830 his father emigrated to Macon county, Illinois (near the present Decatur), and soon afterward removed to Coles county. Being now twenty-one years of age, Abraham hired himself to Denton Offutt, a migratory trader and storekeeper then of Sangamon county, and he helped Offutt to build a flatboat and float it down the Sangamon, Illinois and Mississippi rivers to New Orleans. In 1831 Offutt made him clerk of his country store at New Salem, a small and unsuccessful settlement in Menard county; this gave him moments of leisure to devote to self-education. He borrowed a grammar and other books, sought explanations from the village schoolmaster and began to read law. In this frontier community law and politics claimed a large proportion of the stronger and the more ambitious men; the law early appealed to Lincoln and his general popularity encouraged him as early as 1832 to enter politics. In this year Offutt failed and Lincoln was thus left without employment. He became a candidate for the Illinois House of Representatives; and on the 9th of March 1832 issued an address "To the people of Sangamon county" which betokens talent and education far beyond mere ability to "read, write and cipher," though in its preparation he seems to have had the help of a friend. Before the election the Black Hawk Indian War broke out; Lincoln volunteered in one of the Sangamon county companies on the 21st of April and was elected captain by the members of the company. It is said that the oath of allegiance was administered to Lincoln at this time by Lieut. Jefferson Davis. The company, a part of the 4th Illinois, was mustered out after the five weeks' service for which it volunteered, and Lincoln re-enlisted as a private on the 29th of May, and was finally mustered out on the 16th of June by Lieut. Robert Anderson, who in 1861 commanded the Union troops at Fort Sumter. As captain Lincoln was twice in disgrace, once for firing a pistol near camp and again because nearly his entire company was intoxicated. He was in no battle, and always spoke lightly of his military record. He was defeated in his campaign for the legislature in 1832, partly because of his unpopular adherence to Clay and the American system, but in his own election precinct, he received nearly all the votes cast. With a friend, William Berry, he then bought a small country store, which soon failed chiefly because of the drunken habits of Berry and because Lincoln preferred to read and to tell stories—he early gained local celebrity as a story-teller—rather than sell; about this time he got hold of a set of Blackstone. In the spring of 1833 the store's stock was sold to satisfy its creditors, and Lincoln assumed the firm's debts, which he did not fully pay off for fifteen years. In May 1833, local friendship, disregarding politics, procured his appointment as postmaster of New Salem, but this paid him very little, and in the same year the county surveyor of Sangamon county opportunely offered to make him one of his deputies. He hastily qualified himself by study, and entered upon the practical duties of surveying farm lines, roads and town sites. "This," to use his own words, "procured bread, and kept body and soul together."

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In 1834 Lincoln was elected (second of four successful candidates, with only 14 fewer votes than the first) a member of the Illinois House of Representatives, to which he was re-elected in 1836, 1838 and 1840, serving until 1842. In his announcement of his candidacy in 1836 he promised to vote for Hugh L. White of Tennessee (a vigorous opponent of Andrew Jackson in Tennessee politics) for president, and said: "I go for all sharing the privileges of the government who assist in bearing its burdens. Consequently, I go for admitting all whites to the right of suffrage, who pay taxes or bear arms (by no means excluding females)"—a sentiment frequently quoted to prove Lincoln a believer in woman's suffrage. In this election he led the poll in Sangamon county. In the legislature, like the other representatives of that county, who were called the "Long Nine," because of their stature, he worked for internal improvements, for which lavish appropriations were made, and for the division of Sangamon county and the choice of Springfield as the state capital, instead of Vandalia. He and his party colleagues followed Stephen A. Douglas in adopting the convention system, to which Lincoln had been strongly opposed. In 1837 with one other representative from Sangamon county, named Dan Stone, he protested against a series of resolutions, adopted by the Illinois General Assembly, expressing disapproval of the formation of abolition societies and asserting, among other things, that "the right of property in slaves is sacred to the slave holding states under the Federal Constitution"; and Lincoln and Stone put out a paper in which they expressed their belief "that the institution of slavery is founded on both injustice and bad policy, but that the promulgation of abolition doctrines tends rather to increase than abate its evils," "that the Congress of the United States has no power under the Constitution to interfere with the institution of slavery in the different states," "that the Congress of the United States has the power, under the Constitution, to abolish slavery in the District of Columbia, but that the power ought not to be exercised unless at the request of the people of the District." Lincoln was very popular among his fellow legislators, and in 1838 and in 1840 he received the complimentary vote of his minority colleagues for the speakership of the state House of Representatives. In 1842 he declined a renomination to the state legislature and attempted unsuccessfully to secure a nomination to Congress. In the same year he became interested in the Washingtonian temperance movement.

In 1846 he was elected a member of the National House of Representatives by a majority of 1511 over his Democratic opponent, Peter Cartwright, the Methodist preacher. Lincoln was the only Whig member of Congress elected in Illinois in 1846. In the House of Representatives on the 22nd of December 1847 he introduced the "Spot Resolutions," which quoted statements in the president's messages of the 11th of May 1846 and the 7th and 8th of December that Mexican troops had invaded the territory of the United States, and asked the president to tell the precise "spot" of invasion; he made a speech on these resolutions in the House on the 12th of January 1848. His attitude toward the war and especially his vote for George Ashmun's amendment to the supply bill at this session, declaring that the Mexican War was "unnecessarily and unconstitutionally commenced by the President," greatly displeased his constituents. He later introduced a bill regarding slavery in the District of Columbia, which (in accordance with his statement of 1837) was to be submitted to the vote of the District for approval, and which provided for compensated emancipation, forbade the bringing of slaves into the District of Columbia, except by government officials from slave states, and the selling of slaves away from the District, and arranged for the emancipation after a period of apprenticeship of all slave children born after the 1st of January 1850. While he was in Congress he voted repeatedly for the principle of the Wilmot Proviso. At the close of his term in 1848 he declined an appointment as governor of the newly organized Territory of Oregon and for a time worked, without success, for an appointment as Commissioner of the General Land Office. During the presidential campaign he made speeches in Illinois, and in Massachusetts he spoke before the Whig State Convention at Worcester on the 12th of September, and in the next ten days at Lowell, Dedham, Roxbury, Chelsea, Cambridge and Boston. He had become an eloquent and influential public speaker, and in 1840 and 1844 was a candidate on the Whig ticket for presidential elector.

In 1834 his political friend and colleague John Todd Stuart (1807-1885), a lawyer in full practice, had urged him to fit himself for the bar, and had lent him text-books; and Lincoln, working diligently, was admitted to the bar in September 1836. In April 1837 he quitted New Salem, and removed to Springfield, which was the county-seat and was soon to become the capital of the state, to begin practice in a partnership with Stuart, which was terminated in April 1841; from that time until September 1843 he was junior partner to Stephen Trigg Logan (1800-1880), and from 1843 until his death he was senior partner of William Henry Herndon (1818-1891). Between 1849 and 1854 he took little part in politics, devoted himself to the law and became one of the leaders of the Illinois bar. His small fees—he once charged $3.50 for collecting an account of nearly $600.00—his frequent refusals to take cases which he did not think right and his attempts to prevent unnecessary litigation have become proverbial. Judge David Davis, who knew Lincoln on the Illinois circuit and whom Lincoln made in October 1862 an associate justice of the Supreme Court of the United States, said that he was "great both at *nisi prius* and before an appellate tribunal." He was an excellent cross-examiner, whose candid friendliness of manner often succeeded in eliciting important testimony from unwilling witnesses. Among Lincoln's most famous cases were: one (*Bailey* v. *Cromwell*, 4 Ill. 71; frequently cited) before the Illinois Supreme Court in July 1841 in which he argued against the validity of a note in payment for a negro girl, adducing the Ordinance of 1787 and other authorities; a case (tried in Chicago in September 1857) for the Rock Island railway, sued for damages by the owners of a steamboat sunk after collision with a railway bridge, a trial in which Lincoln brought to the service of his client a surveyor's knowledge of mathematics and a riverman's acquaintance with currents and channels, and argued that crossing a stream by bridge was as truly a common right as navigating it by boat, thus contributing to the success of Chicago and railway commerce in the contest against St Louis and river transportation; the defence (at Beardstown in May 1858) on the charge of murder of William ("Duff") Armstrong, son of one of Lincoln's New Salem friends, whom Lincoln freed by controverting with the help of an almanac the testimony of a crucial witness that between 10 and 11 o'clock at night he had seen by moonlight the defendant strike the murderous blow—this dramatic incident is described in Edward Eggleston's novel, *The Graysons*; and the defence on the charge of murder (committed in August 1859) of "Peachy" Harrison, a grandson of Peter Cartwright, whose testimony was used with great effect.

From law, however, Lincoln was soon drawn irresistibly back into politics. The slavery question, in one form or another, had become the great 705 overshadowing issue in national, and even in state politics; the abolition movement, begun in earnest by W. L. Garrison in 1831, had stirred the conscience of the North, and had had its influence even upon many who strongly deprecated its extreme radicalism; the Compromise of 1850 had failed to silence sectional controversy, and the Fugitive Slave Law, which was one of the compromise measures, had throughout the North been bitterly assailed and to a considerable extent had been nullified by state legislation; and finally in 1854 the slavery agitation was fomented by the passage of the Kansas-Nebraska Act, which repealed the Missouri Compromise and gave legislative sanction to the principle of "popular sovereignty"—the principle that the inhabitants of each Territory as well as of each state were to be left free to decide for themselves whether or not slavery was to be permitted therein. In enacting this measure Congress had been dominated largely by one man—Stephen A. Douglas of Illinois—then probably the most powerful figure in national politics. Lincoln had early put himself on record as opposed to slavery, but he was never technically an abolitionist; he allied himself rather with those who believed that slavery should be fought within the Constitution, that, though it could not be constitutionally interfered with in individual states, it should be excluded from territory over which the national government had jurisdiction. In this, as in other things, he was eminently clear-sighted and practical. Already he had shown his capacity as a forcible and able debater; aroused to new activity upon the passage of the Kansas-Nebraska Bill, which he regarded as a gross breach of political faith, he now entered upon public discussion with an earnestness and force that by common consent gave him leadership in Illinois of the opposition, which in 1854 elected a majority of the legislature; and it gradually became clear that he was the only man who could be opposed in debate to the powerful and adroit Douglas. He was elected to the state House of Representatives, from which he immediately resigned to become a candidate for United States senator from Illinois, to succeed James Shields, a Democrat; but five opposition members, of Democratic antecedents, refused to vote for Lincoln (on the second ballot he received 47 votes—50 being necessary to elect) and he turned the votes which he controlled over to Lyman Trumbull, who was opposed to the Kansas-Nebraska Act, and thus secured the defeat of Joel Aldrich Matteson (1808-1883), who favoured this act and who on the eighth ballot had received 47 votes to 35 for Trumbull and 15 for Lincoln. The various anti-Nebraska elements came together, in Illinois as elsewhere, to form a new party at a time when the old parties were disintegrating; and in 1856 the Republican party was formally organized in the state. Lincoln before the state convention at Bloomington of "all opponents of anti-Nebraska legislation" (the first Republican state convention in Illinois) made on the 29th of May a notable address known as the "Lost Speech." The National Convention of the Republican Party in 1856 cast 110 votes for Lincoln as its vice-presidential candidate on the ticket with Fremont, and he was on the Republican electoral ticket of this year, and made effective campaign speeches in the interest of the new party. The campaign in the state resulted substantially in a drawn battle, the Democrats gaining a majority in the state for president, while the Republicans elected the governor and state officers. In 1858 the term of Douglas in the United States Senate was expiring, and he sought re-election. On the 16th of June 1858 by unanimous resolution of the Republican state convention Lincoln was declared "the first and only choice of the Republicans of Illinois for the United States Senate as the successor of Stephen A. Douglas," who was the choice of his own party to succeed himself. Lincoln, addressing the convention which nominated him, gave expression to the following bold prophecy:—

> "A house divided against itself cannot stand. I believe this Government cannot endure permanently half slave and half free. I do not expect the Union to be dissolved—I do not expect the house to fall—but I do expect it will cease to be divided. It will become all one thing or all the other. Either the opponents of slavery will arrest the further spread of it, and place it where the public mind shall rest in the belief that it is in course of ultimate extinction; or its advocates will push it forward, till it shall become alike lawful in all the states, old as well as new—North as well as South."

In this speech, delivered in the state House of Representatives, Lincoln charged Pierce, Buchanan, Taney and Douglas with conspiracy to secure the Dred Scott decision. Yielding to the wish of his party friends, on the 24th of July, Lincoln challenged Douglas to a joint public discussion.[3] The antagonists met in debate at seven designated places in the state. The first meeting was at Ottawa, La Salle County, about 90 m. south-west of Chicago, on the 21st of August. At Freeport, on the Wisconsin boundary, on the 27th of August, Lincoln answered questions put to him by Douglas, and by his questions forced Douglas to "betray the South" by his enunciation of the "Freeport heresy," that, no matter what the character of Congressional legislation or the Supreme Court's decision "slavery cannot exist a day or an hour anywhere unless it is supported by local police regulations." This adroit attempt to reconcile the principle of popular sovereignty with the Dred Scott decision, though it undoubtedly helped Douglas in the immediate fight for the senatorship, necessarily alienated his Southern supporters and assured his defeat, as Lincoln foresaw it must, in the presidential campaign of 1860. The other debates were: at Jonesboro, in the southern part of the state, on the 15th of September; at Charleston, 150 m. N.E. of Jonesboro, on the 18th of September; and, in the western part of the state, at Galesburg (Oct. 7), Quincy (Oct. 13) and Alton (Oct. 15). In these debates Douglas, the champion of his party, was over-matched in clearness and force of reasoning, and lacked the great moral earnestness of his opponent; but he dexterously extricated himself time and again from difficult argumentative positions, and retained sufficient support to win the immediate prize. At the November election the Republican vote was 126,084, the Douglas Democratic vote was 121,940 and the Lecompton (or Buchanan) Democratic vote was 5091; but the Democrats, through a favourable apportionment of representative districts, secured a majority of the legislature (Senate: 14 Democrats, 11 Republicans; House: 40 Democrats, 35 Republicans), which re-elected Douglas. Lincoln's speeches in this campaign won him a national fame. In 1859 he made two speeches in Ohio—one at Columbus on the 16th of September criticising Douglas's paper in the September *Harper's Magazine*, and one at Cincinnati on the 17th of September, which was addressed to Kentuckians,—and he spent a few days in Kansas, speaking in Elwood, Troy, Doniphan, Atchison and Leavenworth, in the first week of December. On the 27th of February 1860 in Cooper Union, New York City, he made a speech (much the same as that delivered in Elwood, Kansas, on the 1st of December) which made him known favourably to the leaders of the Republican party in the East and which was a careful historical study criticising the statement of Douglas in one of his speeches in Ohio that "our fathers when they framed the government under which we live understood this question [slavery] just as well and even better than we do now," and Douglas's contention that "the fathers" made the country (and intended that it should remain) part slave. Lincoln pointed out that the majority of the members of the Constitutional Convention of 1787 opposed slavery and that they did not think that Congress had no power to control slavery in the Territories. He spoke at Concord, Manchester, Exeter and Dover in New 706 Hampshire, at Hartford (5th March), New Haven (6th March), Woonsocket (8th March) and Norwich (9th March). The Illinois State Convention of the Republican party, held at Decatur on the 9th and 10th of May 1860, amid great enthusiasm declared Abraham Lincoln its first choice for the presidential nomination, and instructed the delegation to the National Convention to cast the vote of the state as a unit for him.

The Republican national convention, which made “No Extension of Slavery” the essential part of the party platform, met at Chicago on the 16th of May 1860. At this time William H. Seward was the most conspicuous Republican in national politics, and Salmon P. Chase had long been in the fore-front of the political contest against slavery. Both had won greater national fame than had Lincoln, and, before the convention met, each hoped to be nominated for president. Chase, however, had little chance, and the contest was virtually between Seward and Lincoln, who by many was considered more “available,” because it was thought that he could (and Seward could not) secure the vote of certain doubtful states. Lincoln’s name was presented by Illinois and seconded by Indiana. At first Seward had the strongest support. On the first ballot Lincoln received only 102 votes to 173½ for Seward. On the second ballot Lincoln received 181 votes to Seward’s 184½. On the third ballot the 50½ votes formerly given to Simon Cameron[4] were given to Lincoln, who received 231½ votes to 180 for Seward, and without taking another ballot enough votes were changed to make Lincoln’s total 354 (233 being necessary for a choice) and the nomination was then made unanimous. Hannibal Hamlin, of Maine, was nominated for the vice-presidency. The convention was singularly tumultuous and noisy; large claques were hired by both Lincoln’s and Seward’s managers. During the campaign Lincoln remained in Springfield, making few speeches and writing practically no letters for publication. The campaign was unusually animated—only the Whig campaign for William Henry Harrison in 1840 is comparable to it: there were great torchlight processions of “wide-awake” clubs, which did “rail-fence,” or zigzag, marches, and carried rails in honour of their candidate, the “rail-splitter.” Lincoln was elected by a popular vote of 1,866,452 to 1,375,157 for Douglas, 847,953 for Breckinridge and 590,631 for Bell—as the combined vote of his opponents was so much greater than his own he was often called “the minority president”; the electoral vote was: Lincoln, 180; John C. Breckinridge, 72; John Bell, 39; Stephen A. Douglas, 12. On the 4th of March 1861 Lincoln was inaugurated as president. (For an account of his administration see United States: *History*.)

During the campaign radical leaders in the South frequently asserted that the success of the Republicans at the polls would mean that the rights of the slave-holding states under the Federal constitution, as interpreted by them, would no longer be respected by the North, and that, if Lincoln were elected, it would be the duty of these slave-holding states to secede from the Union. There was much opposition in these states to such a course, but the secessionists triumphed, and by the time President Lincoln was inaugurated, South Carolina, Georgia, Alabama, Florida, Mississippi, Louisiana and Texas had formally withdrawn from the Union. A provisional government under the designation “The Confederate States of America,” with Jefferson Davis as president, was organized by the seceding states, which seized by force nearly all the forts, arsenals and public buildings within their limits. Great division of sentiment existed in the North, whether in this emergency acquiescence or coercion was the preferable policy. Lincoln’s inaugural address declared the Union perpetual and acts of secession void, and announced the determination of the government to defend its authority, and to hold forts and places yet in its possession. He disclaimed any intention to invade, subjugate or oppress the seceding states. “You can have no conflict,” he said, “without being yourselves the aggressors.” Fort Sumter, in Charleston harbour, had been besieged by the secessionists since January; and, it being now on the point of surrender through starvation, Lincoln sent the besiegers official notice on the 8th of April that a fleet was on its way to carry provisions to the fort, but that he would not attempt to reinforce it unless this effort were resisted. The Confederates, however, immediately ordered its reduction, and after a thirty-four hours’ bombardment the garrison capitulated on the 13th of April 1861. (For the military history of the war, see American Civil War.)

With civil war thus provoked, Lincoln, on the 15th of April, by proclamation called 75,000 three months’ militia under arms, and on the 4th of May ordered the further enlistment of 64,748 soldiers and 18,000 seamen for three years’ service. He instituted by proclamation of the 19th of April a blockade of the Southern ports, took effective steps to extemporize a navy, convened Congress in special session (on the 4th of July), and asked for legislation and authority to make the war “short, sharp and decisive.” The country responded with enthusiasm to his summons and suggestions; and the South on its side was not less active.

The slavery question presented vexatious difficulties in conducting the war. Congress in August 1861 passed an act (approved August 6th) confiscating rights of slave-owners to slaves employed in hostile service against the Union. On the 30th of August General Fremont by military order declared martial law and confiscation against active enemies, with freedom to their slaves, in the State of Missouri. Believing that under existing conditions such a step was both detrimental in present policy and unauthorized in law, President Lincoln directed him (2nd September) to modify the order to make it conform to the Confiscation Act of Congress, and on the 11th of September annulled the parts of the order which conflicted with this act. Strong political factions were instantly formed for and against military emancipation, and the government was hotly beset by antagonistic counsel. The Unionists of the border slave states were greatly alarmed, but Lincoln by his moderate conservatism held them to the military support of the government.[5] Meanwhile he sagaciously prepared the way for the supreme act of statesmanship which the gathering national crisis already dimly foreshadowed. On the 6th of March 1862, he sent a special message to Congress recommending the passage of a resolution offering pecuniary aid from the general government to induce states to adopt gradual abolishment of slavery. Promptly passed by Congress, the resolution produced no immediate result except in its influence on public opinion. A practical step, however, soon followed. In April Congress passed and the president approved (6th April) an act emancipating the slaves in the District of Columbia, with compensation to owners—a measure which Lincoln had proposed when in Congress. Meanwhile slaves of loyal masters were constantly escaping to military camps. Some commanders excluded them altogether; others surrendered them on demand; while still others sheltered and protected them against their owners. Lincoln tolerated this latitude as falling properly within the military discretion pertaining to local army operations. A new case, however, soon demanded his official interference. On the 9th of May 1862 General David Hunter, commanding in the limited areas gained along the southern coast, issued a short order declaring his department under martial law, and adding—“Slavery and martial law in a free country are altogether incompatible. The persons in these three States—Georgia, Florida and South Carolina—heretofore held as slaves are, therefore, declared for ever 707 free.” As soon as this order, by the slow method of communication by sea, reached the newspapers, Lincoln (May 19) published a proclamation declaring it void; adding further, “Whether it be competent for me as commander-in-chief of the army and navy to declare the slaves of any state or states free, and whether at any time or in any case it shall have become a necessity indispensable to the maintenance of the government to exercise such supposed power, are questions which under my responsibility I reserve to myself, and which I cannot feel justified in leaving to the decision of commanders in the field. These are totally different questions from those of police regulations in armies or camps.” But in the same proclamation Lincoln recalled to the public his own proposal and the assent of Congress to compensate states which would adopt voluntary and gradual abolishment. “To the people of these states now,” he added, “I must earnestly appeal. I do not argue. I beseech you to make the argument for yourselves. You cannot, if you would, be blind to the signs of the times.” Meanwhile the anti-slavery sentiment of the North constantly increased. Congress by express act (approved on the 19th of June) prohibited the existence of slavery in all territories outside of states. On July the 12th the president called the representatives of the border slave states to the executive mansion, and once more urged upon them his proposal of compensated emancipation. “If the war continues long,” he said, “as it must if the object be not sooner attained, the institution in your states will be extinguished by mere friction and abrasion—by the mere incidents of the war. It will be gone, and you will have nothing valuable in lieu of it.” Although Lincoln’s appeal brought the border states to no practical decision—the representatives of these states almost without exception opposed the plan—it served to prepare public opinion for his final act. During the month of July his own mind reached the virtual determination to give slavery its *coup de grâce*; on the 17th he approved a new Confiscation Act, much broader than that of the 6th of August 1861 (which freed only those slaves in military service against the Union) and giving to the president power to employ persons of African descent for the suppression of the rebellion; and on the 22nd he submitted to his cabinet the draft of an emancipation proclamation substantially as afterward issued. Serious military reverses constrained him for the present to withhold it, while on the other hand they served to increase the pressure upon him from anti-slavery men. Horace Greeley having addressed a public letter to him complaining of “the policy you seem to be pursuing with regard to the slaves of the rebels,” the president replied on the 22nd of August, saying, “My paramount object is to save the Union, and not either to save or destroy slavery. If I could save the Union without freeing any slave, I would do it; if I could save it by freeing all the slaves, I would do it; and, if I could do it by freeing some and leaving others alone, I would also do that.” Thus still holding back violent reformers with one hand, and leading up halting conservatives with the other, he on the 13th of September replied among other things to an address from a delegation: “I do not want to issue a document that the whole world will see must necessarily be inoperative like the pope’s bull against the comet.... I view this matter as a practical war measure, to be decided on according to the advantages or disadvantages it may offer to the suppression of the rebellion.... I have not decided against a proclamation of liberty to the slaves, but hold the matter under advisement.”

The year 1862 had opened with important Union victories. Admiral A. H. Foote captured Fort Henry on the 6th of February, and Gen. U. S. Grant captured Fort Donelson on the 16th of February, and won the battle of Shiloh on the 6th and 7th of April. Gen. A. E. Burnside took possession of Roanoke island on the North Carolina coast (7th February). The famous contest between the new ironclads “Monitor” and “Merrimac” (9th April), though indecisive, effectually stopped the career of the Confederate vessel, which was later destroyed by the Confederates themselves. (See Hampton Roads.) Farragut, with a wooden fleet, ran past the twin forts St Philip and Jackson, compelled the surrender of New Orleans (26th April), and gained control of the lower Mississippi. The succeeding three months brought disaster and discouragement to the Union army. M’Clellan’s campaign against Richmond was made abortive by his timorous generalship, and compelled the withdrawal of his army. Pope’s army, advancing against the same city by another line, was beaten back upon Washington in defeat. The tide of war, however, once more turned in the defeat of Lee’s invading army at South Mountain and Antietam in Maryland on the 14th and on the 16th and 17th of September, compelling him to retreat.

With public opinion thus ripened by alternate defeat and victory, President Lincoln, on the 22nd of September 1862, issued his preliminary proclamation of emancipation, giving notice that on the 1st of January 1863, “all persons held as slaves within any state or designated part of a state the people whereof shall then be in rebellion against the United States shall be then, thenceforward and for ever free.” In his message to Congress on the 1st of December following, he again urged his plan of gradual, compensated emancipation (to be completed on the 1st of December 1900) “as a means, not in exclusion of, but additional to, all others for restoring and preserving the national authority throughout the Union.” On the 1st day of January 1863 the final proclamation of emancipation was duly issued, designating the States of Arkansas, Texas, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, and certain portions of Louisiana and Virginia, as “this day in rebellion against the United States,” and proclaiming that, in virtue of his authority as commander-in-chief, and as a necessary war measure for suppressing rebellion, “I do order and declare that all persons held as slaves within said designated states and parts of states are and henceforward shall be free,” and pledging the executive and military power of the government to maintain such freedom. The legal validity of these proclamations was never pronounced upon by the national courts; but their decrees gradually enforced by the march of armies were soon recognized by public opinion to be practically irreversible.[6] Such dissatisfaction as they caused in the border slave states died out in the stress of war. The systematic enlistment of negroes and their incorporation into the army by regiments, hitherto only tried as exceptional experiments, were now pushed with vigour, and, being followed by several conspicuous instances of their gallantry on the battlefield, added another strong impulse to the sweeping change of popular sentiment. To put the finality of emancipation beyond all question, Lincoln in the winter session of 1863-1864 strongly supported a movement in Congress to abolish slavery by constitutional amendment, but the necessary two-thirds vote of the House of Representatives could not then be obtained. In his annual message of the 6th of December 1864, he urged the immediate passage of the measure. Congress now acted promptly: on the 31st of January 1865, that body by joint resolution proposed to the states the 13th amendment of the Federal Constitution, providing that "neither slavery nor involuntary servitude, except as a punishment for crime, whereof the party shall have been duly convicted, shall exist within the United States or any place subject to their jurisdiction." Before the end of that year twenty-seven out of the thirty-six states of the Union (being the required three-fourths) had ratified the amendment, and official proclamation made by President Johnson on the 18th of December 1865, declared it duly adopted. 708

The foreign policy of President Lincoln, while subordinate in importance to the great questions of the Civil War, nevertheless presented several difficult and critical problems for his decision. The arrest (8th of November 1861) by Captain Charles Wilkes of two Confederate envoys proceeding to Europe in the British steamer "Trent" seriously threatened peace with England. Public opinion in America almost unanimously sustained the act; but Lincoln, convinced that the rights of Great Britain as a neutral had been violated, promptly, upon the demand of England, ordered the liberation of the prisoners (26th of December). Later friendly relations between the United States and Great Britain, where, among the upper classes, there was a strong sentiment in favour of the Confederacy, were seriously threatened by the fitting out of Confederate privateers in British ports, and the Administration owed much to the skilful diplomacy of the American minister in London, Charles Francis Adams. A still broader foreign question grew out of Mexican affairs, when events culminating in the setting up of Maximilian of Austria as emperor under protection of French troops demanded the constant watchfulness of the United States. Lincoln's course was one of prudent moderation. France voluntarily declared that she sought in Mexico only to satisfy injuries done her and not to overthrow or establish local government or to appropriate territory. The United States Government replied that, relying on these assurances, it would maintain strict non-intervention, at the same time openly avowing the general sympathy of its people with a Mexican republic, and that "their own safety and the cheerful destiny to which they aspire are intimately dependent on the continuance of free republican institutions throughout America." In the early part of 1863 the French Government proposed a mediation between the North and the South. This offer President Lincoln (on the 6th of February) declined to consider, Seward replying for him that it would only be entering into diplomatic discussion with the rebels whether the authority of the government should be renounced, and the country delivered over to disunion and anarchy.

The Civil War gradually grew to dimensions beyond all expectation. By January 1863 the Union armies numbered near a million men, and were kept up to this strength till the end of the struggle. The Federal war debt eventually reached the sum of $2,700,000,000. The fortunes of battle were somewhat fluctuating during the first half of 1863, but the beginning of July brought the Union forces decisive victories. The reduction of Vicksburg (4th of July) and Port Hudson (9th of July), with other operations, restored complete control of the Mississippi, severing the Southern Confederacy. In the east Lee had the second time marched his army into Pennsylvania to suffer a disastrous defeat at Gettysburg, on the 1st, 2nd and 3rd of July, though he was able to withdraw his shattered forces south of the Potomac. At the dedication of this battlefield as a soldiers' cemetery in November, President Lincoln made the following oration, which has taken permanent place as a classic in American literature:—

> "Fourscore and seven years ago our fathers brought forth on this continent a new nation conceived in liberty and dedicated to the proposition that all men are created equal. Now we are engaged in a great civil war testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field as a final resting-place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this. But, in a larger sense, we cannot dedicate, we cannot consecrate, we cannot hallow this ground. The brave men, living and dead, who struggled here have consecrated it far above our poor power to add or detract. The world will little note nor long remember what we say here, but it can never forget what they did here. It is for us the living rather to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us—that from these honoured dead we take increased devotion to that cause for which they gave the last full measure of devotion—that we here highly resolve that these dead shall not have died in vain, that this nation under God shall have a new birth of freedom, and that government of the people, by the people, for the people, shall not perish from the earth."

In the unexpected prolongation of the war, volunteer enlistments became too slow to replenish the waste of armies, and in 1863 the government was forced to resort to a draft. The enforcement of the conscription created much opposition in various parts of the country, and led to a serious riot in the city of New York on the 13th-16th of July. President Lincoln executed the draft with all possible justice and forbearance, but refused every importunity to postpone it. It was made a special subject of criticism by the Democratic party of the North, which was now organizing itself on the basis of a discontinuance of the war, to endeavour to win the presidential election of the following year. Clement L. Vallandigham of Ohio, having made a violent public speech at Mt. Vernon, Ohio, on the 1st of May against the war and military proceedings, was arrested on the 5th of May by General Burnside, tried by military commission, and sentenced on the 16th to imprisonment; a writ of *habeas corpus* had been refused, and the sentence was changed by the president to transportation beyond the military lines. By way of political defiance the Democrats of Ohio nominated Vallandigham for governor on the 11th of June. Prominent Democrats and a committee of the Convention having appealed for his release, Lincoln wrote two long letters in reply discussing the constitutional question, and declaring that in his judgment the president as commander-in-chief in time of rebellion or invasion holds the power and responsibility of suspending the privilege of the writ of *habeas corpus*, but offering to release Vallandigham if the committee would sign a declaration that rebellion exists, that an army and navy are constitutional means to suppress it, and that each of them would use his personal power and influence to prosecute the war. This liberal offer and their refusal to accept it counteracted all the political capital they hoped to make out of the case; and public opinion was still more powerfully influenced in behalf of the president's action, by the pathos of the query which he propounded in one of his letters: "Must I shoot the simple-minded soldier boy who deserts, while I must not touch a hair of a wily agitator who induces him to desert?" When the election took place in Ohio, Vallandigham was defeated by a majority of more than a hundred thousand.

Many unfounded rumours of a willingness on the part of the Confederate States to make peace were circulated to weaken the Union war spirit. To all such suggestions, up to the time of issuing his emancipation proclamation, Lincoln announced his readiness to stop fighting and grant amnesty, whenever they would submit to and maintain the national authority under the Constitution of the United States. Certain agents in Canada having in 1864 intimated that they were empowered to treat for peace, Lincoln, through Greeley, tendered them safe conduct to Washington. They were by this forced to confess that they possessed no authority to negotiate. The president thereupon sent them, and made public, the following standing offer:—

> "To whom it may concern:
>
> "Any proposition which embraces the restoration of peace, the integrity of the whole Union, and the abandonment of slavery, and which comes by and with an authority that can control the armies now at war against the United States, will be received and considered by the Executive Government of the United States, and will be met by liberal terms on substantial and collateral points, and the bearer or bearers thereof shall have safe conduct both ways.
>
> "July 18, 1864."
>
> "Abraham Lincoln."

A noteworthy conference on this question took place near the close of the Civil War, when the strength of the Confederacy was almost exhausted. F. P. Blair, senior, a personal friend of Jefferson Davis, acting solely on his own responsibility, was permitted to go from Washington to Richmond, where, on the 12th of January 1865, after a private and unofficial interview, Davis in writing declared his willingness to enter a conference "to secure peace to the two countries." Report being duly made to President Lincoln, he wrote a note (dated 18th January) consenting to receive any agent sent informally "with the view of securing peace to the people of our common country." Upon the basis of this latter proposition three 709 Confederate commissioners (A. H. Stevens, J. A. C. Campbell and R. M. T. Hunter) finally came to Hampton Roads, where President Lincoln and Secretary Seward met them on the U.S. steam transport "River Queen," and on the 3rd of February 1865 an informal conference of four hours' duration was held. Private reports of the interview agree substantially in the statement that the Confederates proposed a cessation of the Civil War, and postponement of its issues for future adjustment, while for the present the belligerents should unite in a campaign to expel the French from Mexico, and to enforce the Monroe doctrine. President Lincoln, however, although he offered to use his influence to secure compensation by the Federal government to slave-owners for their slaves, if there should be "voluntary abolition of slavery by the states," a liberal and generous administration of the Confiscation Act, and the immediate representation of the southern states in Congress, refused to consider any alliance against the French in Mexico, and adhered to the instructions he had given Seward before deciding to personally accompany him. These formulated three indispensable conditions to adjustment: first, the restoration of the national authority throughout all the states; second, no receding by the executive of the United States on the slavery question; third, no cessation of hostilities short of an end of the war, and the disbanding of all forces hostile to the government. These terms the commissioners were not authorized to accept, and the interview ended without result.

As Lincoln's first presidential term of four years neared its end, the Democratic party gathered itself for a supreme effort to regain the ascendancy lost in 1860. The slow progress of the war, the severe sacrifice of life in campaign and battle, the enormous accumulation of public debt, arbitrary arrests and suspension of *habeas corpus*, the rigour of the draft, and the proclamation of military emancipation furnished ample subjects of bitter and vindictive campaign oratory. A partisan coterie which surrounded M'Clellan loudly charged the failure of his Richmond campaign to official interference in his plans. Vallandigham had returned to his home in defiance of his banishment beyond military lines, and was leniently suffered to remain. The aggressive spirit of the party, however, pushed it to a fatal extreme. The Democratic National Convention adopted (August 29, 1864) a resolution (drafted by Vallandigham) declaring the war a failure, and demanding a cessation of hostilities; it nominated M'Clellan for president, and instead of adjourning *sine die* as usual, remained organized, and subject to be convened at any time and place by the executive national committee. This threatening attitude, in conjunction with alarming indications of a conspiracy to resist the draft, had the effect to thoroughly consolidate the war party, which had on the 8th of June unanimously renominated Lincoln, and had nominated Andrew Johnson of Tennessee for the vice-presidency. At the election held on the 8th of November 1864, Lincoln received 2,216,076 of the popular votes, and M‘Clellan (who had openly disapproved of the resolution declaring the war a failure) but 1,808,725; while of the presidential electors 212 voted for Lincoln and 21 for M‘Clellan. Lincoln’s second term of office began on the 4th of March 1865.

While this political contest was going on the Civil War was being brought to a decisive close. Grant, at the head of the Army of the Potomac, followed Lee to Richmond and Petersburg, and held him in siege to within a few days of final surrender. General W. T. Sherman, commanding the bulk of the Union forces in the Mississippi Valley, swept in a victorious march through the heart of the Confederacy to Savannah on the coast, and thence northward to North Carolina. Lee evacuated Richmond on the 2nd of April, and was overtaken by Grant and compelled to surrender his entire army on the 9th of April 1865. Sherman pushed Johnston to a surrender on the 26th of April. This ended the war.

Lincoln being at the time on a visit to the army, entered Richmond the day after its surrender. Returning to Washington, he made his last public address on the evening of the 11th of April, devoted mainly to the question of reconstructing loyal governments in the conquered states. On the evening of the 14th of April he attended Ford’s theatre in Washington. While seated with his family and friends absorbed in the play, John Wilkes Booth, an actor, who with others had prepared a plot to assassinate the several heads of government, went into the little corridor leading to the upper stage-box, and secured it against ingress by a wooden bar. Then stealthily entering the box, he discharged a pistol at the head of the president from behind, the ball penetrating the brain. Brandishing a huge knife, with which he wounded Colonel Rathbone who attempted to hold him, the assassin rushed through the stage-box to the front and leaped down upon the stage, escaping behind the scenes and from the rear of the building, but was pursued, and twelve days afterwards shot in a barn where he had concealed himself. The wounded president was borne to a house across the street, where he breathed his last at 7 A.M. on the 15th of April 1865.

President Lincoln was of unusual stature, 6 ft. 4 in., and of spare but muscular build; he had been in youth remarkably strong and skilful in the athletic games of the frontier, where, however, his popularity and recognized impartiality oftener made him an umpire than a champion. He had regular and prepossessing features, dark complexion, broad high forehead, prominent cheek bones, grey deep-set eyes, and bushy black hair, turning to grey at the time of his death. Abstemious in his habits, he possessed great physical endurance. He was almost as tender-hearted as a woman. “I have not willingly planted a thorn in any man’s bosom,” he was able to say. His patience was inexhaustible. He had naturally a most cheerful and sunny temper, was highly social and sympathetic, loved pleasant conversation, wit, anecdote and laughter. Beneath this, however, ran an undercurrent of sadness; he was occasionally subject to hours of deep silence and introspection that approached a condition of trance. In manner he was simple, direct, void of the least affectation, and entirely free from awkwardness, oddity or eccentricity. His mental qualities were—a quick analytic perception, strong logical powers, a tenacious memory, a liberal estimate and tolerance of the opinions of others, ready intuition of human nature; and perhaps his most valuable faculty was rare ability to divest himself of all feeling or passion in weighing motives of persons or problems of state. His speech and diction were plain, terse, forcible. Relating anecdotes with appreciative humour and fascinating dramatic skill, he used them freely and effectively in conversation and argument. He loved manliness, truth and justice. He despised all trickery and selfish greed. In arguments at the bar he was so fair to his opponent that he frequently appeared to concede away his client’s case. He was ever ready to take blame on himself and bestow praise on others. “I claim not to have controlled events,” he said, “but confess plainly that events have controlled me.” The Declaration of Independence was his political chart and inspiration. He acknowledged a universal equality of human rights. “Certainly the negro is not our equal in colour,” he said, “perhaps not in many other respects; still, in the right to put into his mouth the bread that his own hands have earned, he is the equal of every other man white or black.” He had unchanging faith in self-government. “The people,” he said, “are the rightful masters of both congresses and courts, not to overthrow the constitution, but to overthrow the men who pervert the constitution.” Yielding and accommodating in non-essentials, he was inflexibly firm in a principle or position deliberately taken. “Let us have faith that right makes might,” he said, “and in that faith let us to the end dare to do our duty as we understand it.” The emancipation proclamation once issued, he reiterated his purpose never to retract or modify it. “There have been men base enough,” he said, “to propose to me to return to slavery our black warriors of Port Hudson and Olustee, and thus win the respect of the masters they fought. Should I do so I should deserve to be damned in time and eternity. Come what will, I will keep my faith with friend and foe.” Benevolence and forgiveness were the very basis of his character; his world-wide humanity is aptly embodied in a phrase of his second inaugural: “With malice toward none, with charity for all.” His nature was deeply religious, but he belonged to no denomination.

Lincoln married in Springfield on the 4th of November 1842, Mary Todd (1818-1882), also a native of Kentucky, who bore him four sons, of whom the only one to grow up was the eldest, Robert Todd Lincoln (b. 1843), who graduated at Harvard in 1864, served as a captain on the staff of General Grant in 1865, was admitted to the Illinois bar in 1867, was secretary of war in the cabinets of Presidents Garfield and Arthur in 1881-1885, and United States Minister to Great Britain in 1889-1893, and was prominently connected with many large corporations, becoming in 1897 president of the Pullman Co.

Of the many statues of President Lincoln in American cities, the best known is that, in Chicago, by St Gaudens. Among the others are two by 710
Thomas Ball, one in statuary hall in the Capitol at Washington, and one in Boston; two—one in Rochester, N.Y., and one in Springfield, Ill.—by Leonard W. Volk, who made a life-mask and a bust of Lincoln in 1860; and one by J. Q. A. Ward, in Lincoln Park, Washington. Francis B. Carpenter painted in 1864 “Lincoln signing the Emancipation Proclamation,” now in the Capitol at Washington.

See *The Complete Works of Abraham Lincoln* (12 vols., New York, 1906-1907; enlarged from the 2-volume edition of 1894 by John G. Nicolay and John Hay). There are various editions of the Lincoln-Douglas debates of 1858; perhaps the best is that edited by E. E. Sparks (1908). There are numerous biographies, and biographical studies, including: John G. Nicolay and John Hay, *Abraham Lincoln: A History* (10 vols., New York, 1890), a monumental work by his private secretaries who treat primarily his official life; John G. Nicolay, *A Short Life of Abraham Lincoln* (New York, 1904), condensed from the preceding; John T. Morse, Jr., *Abraham Lincoln* (2 vols., Boston, 1896), in the “American Statesmen” series, an excellent brief biography, dealing chiefly with Lincoln’s political career; Ida M. Tarbell, *The Early Life of Lincoln* (New York, 1896) and *Life of Abraham Lincoln* (2 vols., New York, 1900), containing new material to which too great prominence and credence is sometimes given; Carl Schurz, *Abraham Lincoln: An Essay* (Boston, 1891), a remarkably able estimate; Ward H. Lamon, *The Life of Abraham Lincoln from his Birth to his Inauguration as President* (Boston, 1872), supplemented by *Recollections of Abraham Lincoln 1847-1865* (Chicago, 1895), compiled by Dorothy Lamon, valuable for some personal recollections, but tactless, uncritical, and marred by the effort of the writer, who as marshal of the District of Columbia, knew Lincoln intimately, to prove that Lincoln’s melancholy was due to his lack of religious belief of the orthodox sort; William H. Herndon and Jesse W. Weik, *Abraham Lincoln, the True Story of a Great Life* (3 vols., Chicago, 1889; revised, 2 vols., New York, 1892), an intimate and ill-proportioned biography by Lincoln’s law partner who exaggerates the importance of the petty incidents of his youth and young manhood; Isaac N. Arnold, *History of Abraham Lincoln and the Overthrow of Slavery* (Chicago, 1867), revised and enlarged as *Life of Abraham Lincoln* (Chicago, 1885), valuable for personal reminiscences; Gideon Welles, *Lincoln and Seward* (New York, 1874), the reply of Lincoln’s secretary of the navy to Charles Francis Adams’s eulogy (delivered in Albany in April 1873) on Lincoln’s secretary of state, W. H. Seward, in which Adams claimed that Seward was the premier of Lincoln’s administration; F. B. Carpenter, *Six Months in the White House* (New York, 1866), an excellent account of Lincoln’s daily life while president; Robert T. Hill, *Lincoln the Lawyer* (New York, 1906); A. Rothschild, *Lincoln, the Master of Men* (Boston, 1906); J. Eaton and E. O. Mason, *Grant, Lincoln, and the Freedmen* (New York, 1907); R. W. Gilder, *Lincoln, the Leader, and Lincoln’s Genius for Expression* (New York, 1909); M. L. Learned, *Abraham Lincoln: An American Migration* (Philadelphia, 1909), a careful study of the Lincoln family in America; W. P. Pickett, *The Negro Problem: Abraham Lincoln’s Solution* (New York, 1909); James H. Lea and J. R. Hutchinson, *The Ancestry of Abraham Lincoln* (Boston, 1909), a careful genealogical monograph; and C. H. McCarthy, *Lincoln’s Plan of Reconstruction* (New York, 1901). For an excellent account of Lincoln as president see J. F. Rhodes, *History of the United States from the Compromise of 1850* (7 vols., 1893-1906).

(J. G. N.; C. C. W.)

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1 Lincoln’s birthday is a legal holiday in California, Colorado, Connecticut, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Montana, Nevada, New Jersey, New York, North Dakota, Pennsylvania, South Dakota, Utah, Washington, West Virginia and Wyoming.

2 Samuel Lincoln (*c.* 1619-1690), the president’s first American ancestor, son of Edward Lincoln, gent., of Hingham, Norfolk, emigrated to Massachusetts in 1637 as apprentice to a weaver and settled with two older brothers in Hingham, Mass. His son and grandson were iron founders; the grandson Mordecai (1686-1736) moved to Chester county, Pennsylvania. Mordecai’s son John (1711-*c.* 1773), a weaver, settled in what is now Rockingham county, Va., and was the president’s great-grandfather.

3 Douglas and Lincoln first met in public debate (four on a side) in Springfield in December 1839. They met repeatedly in the campaign of 1840. In 1852 Lincoln attempted with little success to reply to a speech made by Douglas in Richmond. On the 4th of October 1854 in Springfield, in reply to a speech on the Nebraska question by Douglas delivered the day before, Lincoln made a remarkable speech four hours long, to which Douglas replied on the next day; and in the fortnight immediately following Lincoln attacked Douglas’s record again at Bloomington and at Peoria. On the 26th of June 1857 Lincoln in a speech at Springfield answered Douglas’s speech of the 12th in which he made over his doctrine of popular sovereignty to suit the Dred Scott decision. Before the actual debate in 1858 Douglas made a speech in Chicago on the 9th of July, to which Lincoln replied the next day; Douglas spoke at Bloomington on the 16th of July and Lincoln answered him in Springfield on the 17th.

4 Without Lincoln’s knowledge or consent, the managers of his candidacy before the convention bargained for Cameron’s votes by promising to Cameron a place in Lincoln’s cabinet, should Lincoln be elected. Cameron became Lincoln’s first secretary of war.

5 In November 1861 the president drafted a bill providing (1) that all slaves more than thirty-five years old in the state of Delaware should immediately become free; (2) that all children of slave parentage born after the passage of the act should be free; (3) that all others should be free on attaining the age of thirty-five or after the 1st of January 1893, except for terms of apprenticeship; and (4) that the national government should pay to the state of Delaware $23,200 a year for twenty-one years. But this bill, which Lincoln had hoped would introduce a system of “compensated emancipation,” was not approved by the legislature of Delaware, which considered it in February 1862.

6 It is to be noted that slavery in the border slave states was not affected by the proclamation. The parts of Virginia and Louisiana not affected were those then considered to be under Federal jurisdiction; in Virginia 55 counties were excepted (including the 48 which became the separate state of West Virginia), and in Louisiana 13 parishes (including the parish of Orleans). As the Federal Government did not, at the time, actually have jurisdiction over the rest of the territory of the Confederate States, that really affected, some writers have questioned whether the proclamation really emancipated any slaves when it was issued. The proclamation had the most important political effect in the North of rallying more than ever to the support of the administration the large anti-slavery element.

The adoption of the 13th amendment to the Federal Constitution in 1865 rendered unnecessary any decision of the U.S. Supreme Court upon the validity of the proclamation.

LINCOLN, a city and county of a city, municipal, county and parliamentary borough, and the county town of Lincolnshire, England. Pop. (1901) 48,784. It is picturesquely situated on the summit and south slope of the limestone ridge of the Cliff range of hills, which rises from the north bank of the river Witham, at its confluence with the Foss Dyke, to an altitude of 200 ft. above the river. The cathedral rises majestically from the crown of the hill, and is a landmark for many miles. Lincoln is 130 m. N. by W. from London by the Great Northern railway; it is also served by branches of the Great Eastern, Great Central and Midland railways.

Lincoln is one of the most interesting cities in England. The ancient British town occupied the crown of the hill beyond the Newport or North Gate. The Roman town consisted of two parallelograms of unequal length, the first extending west from the Newport gate to a point a little west of the castle keep. The second parallelogram, added as the town increased in size and importance, extended due south from this point down the hill towards the Witham as far as Newland, and thence in a direction due east as far as Broad Street. Returning thence due north, it joined the south-east corner of the first and oldest parallelogram in what was afterwards known as the Minster yard, and terminated its east side upon its junction with the north wall in a line with the Newport gate. This is the oldest part of the town, and is named "above hill." After the departure of the Romans, the city walls were extended still farther in a south direction across the Witham as far as the great bar gate, the south entrance to the High Street of the city; the junction of these walls with the later Roman one was effected immediately behind Broad Street. The "above hill" portion of the city consists of narrow irregular streets, some of which are too steep to admit of being ascended by carriages. The south portion, which is named "below hill," is much more commodious, and contains the principal business premises. Here also are the railway stations.

The glory of Lincoln is the noble cathedral of the Blessed Virgin Mary, commonly known as the Minster. As a study to the architect and antiquary this stands unrivalled, not only as embodying the earliest purely Gothic work extant, but as containing within its compass every variety of style from the simple massive Norman of the central west front, and the later and more ornate examples of that style in the west doorways and towers; onward through all the Gothic styles, of each of which both early and late examples appear. The building material is the oolite and calcareous stone of Lincoln Heath and Haydor, which has the peculiarity of becoming hardened on the surface when tooled. Formerly the cathedral had three spires, all of wood or leaded timber. The spire on the central tower, which would appear to have been the highest in the world, was blown down in 1547. Those on the two western towers were removed in 1808.

The ground plan of the first church, adopted from that of Rouen, was laid by Bishop Remigius in 1086, and the church was consecrated three days after his death, on the 6th of May 1092. The west front consists of an Early English screen (*c.* 1225) thrown over the Norman front, the west towers rising behind it. The earliest Norman work is part of that of Remigius; the great portals and the west towers up to the third storey are Norman *c.* 1148. The upper parts of them date from 1365. Perpendicular windows (*c.* 1450) are inserted. The nave and aisles were completed *c.* 1220. The transepts mainly built between 1186 and 1235 have two fine rose windows, that in the N. is Early English, and that in the S. Decorated. The first has beautiful contemporary stained glass. These are called respectively the Dean's Eye and Bishop's Eye. A Galilee of rich Early English work forms the entrance of the S. transept. Of the choir the western portion known as St Hugh's (1186-1204) is the famous first example of pointed work; the eastern, called the Angel Choir, is a magnificently ornate work completed in 1280. Fine Perpendicular canopied stalls fill the western part. The great east window, 57 ft. in height, is an example of transition from Early English to Decorated *c.* 1288. Other noteworthy features of the interior are the Easter sepulchre (*c.* 1300), the foliage ornamentation of which is beautifully natural; and the organ screen of a somewhat earlier date. The great central tower is Early English as far as the first storey, the continuation dates from 1307. The total height is 271 ft.; and the tower contains the bell, Great Tom of Lincoln, weighing over 5 tons. The dimensions of the cathedral internally are—nave, 252 × 79.6 × 80 ft.; choir, 158 × 82 × 72 ft.; angel choir, which includes presbytery and lady chapel, 166 × 44 × 72 ft.; main transept, 220 × 63 × 74 ft.; choir transept, 166 × 44 × 72 ft. The west towers are 206 ft. high.

The buildings of the close that call for notice are the chapter-house of ten sides, 60 ft. diameter, 42 ft. high, with a fine vestibule of the same height, built *c.* 1225, and therefore the earliest of English polygonal chapter-houses, and the library, a building of 1675, which contains a small museum. The picturesque episcopal palace contains work of the date of St Hugh, and the great hall is mainly Early English. There is some Decorated work, and much Perpendicular, including the gateway. It fell into disuse after the Reformation, but by extensive restoration was brought back to its proper use at the end of the 19th century. Among the most famous bishops were St Hugh of Avalon (1186-1200); Robert Grosseteste (1235-1253); Richard Flemming (1420-1431), founder of Lincoln College, Oxford; William Smith (1495-1514), founder of Brasenose College, Oxford; William Wake (1705-1716); and Edmund Gibson (1716-1723). Every stall has produced a prelate or cardinal. The see covers almost the whole of the county, with very small portions of Norfolk and Yorkshire, and it included Nottinghamshire until the formation of the bishopric of Southwell in 1884. At its earliest formation, when Remigius, almoner of the abbey of Fécamp, removed the seat of the bishopric here from Dorchester in Oxfordshire shortly after the Conquest, it extended from the Humber to the Thames, eastward beyond Cambridge, and westward beyond Leicester. It was reduced, however, by the formation of the sees of Ely, Peterborough and Oxford, and by the rearrangement of diocesan boundaries in 1837.

The remains of Roman Lincoln are of the highest interest. The Newport Arch or northern gate of *Lindum* is one of the most perfect specimens of Roman architecture in England. It consists of a great arch flanked by two smaller arches, of which one remains. The Roman Ermine Street runs through it, leading northward almost in a straight line to the Humber. Fragments of the town wall remain at various points; a large quantity of coins and other relics have been discovered; and remains of a burial-place and buildings unearthed. Of these last the most important is the series of column-bases, probably belonging to a Basilica, beneath a house in the street called Bail Gate, adjacent to the Newport Arch. A villa in Greetwell; a tesselated pavement, a milestone and other relics in the cloister; an altar unearthed at the church of St Swithin, are among many other discoveries. Among churches, apart from the minster, two of outstanding interest are those of St Mary-le-Wigford and St Peter-at-Gowts (*i.e.* sluice-gates), both in the lower part of High Street. Their towers, closely similar, are fine examples of perhaps very early Norman work, though they actually possess the characteristics of pre-Conquest workmanship. Bracebridge church shows similar early work; but as a whole the churches of Lincoln show plainly the results of the siege of 1644, and such buildings as St Botolph's, St Peter's-at-Arches and St Martin's are of the period 1720-1740. Several churches are modern buildings on ancient sites. There were formerly three small priories, five friaries and four hospitals in or near Lincoln. The preponderance of friaries over priories of monks is explained by the fact that the cathedral was served by secular canons. Bishop Grosseteste was the devoted patron of the friars, particularly the Franciscans, who were always in their day the town missionaries. The Greyfriars, near St Swithin's church, is a picturesque two-storied building of the 13th century. Lincoln is rich in early domestic architecture. The building known as John of Gaunt's stables, actually St Mary's Guild Hall, is of two storeys, with rich Norman doorway and moulding. The Jews' House is another fine example of 12th-century building; and Norman remains appear in several other houses, such as Deloraine Court and the House of Aaron the Jew. Lincoln Castle, lying W. of the cathedral, was newly founded by William the Conqueror when Remigius decided to found his minster under its protection. The site, with its artificial mounds, is of much earlier, probably British, date. There are Norman remains in the Gateway Tower; parts of the walls are of this period, and the keep dates from the middle of the 12th century. Among medieval gateways, the Exchequer Gate, serving as the finance-office of the chapter, is a fine specimen of 13th-century work. Pottergate is of the 14th century, and Stonebow in High Street of the 15th, with the Guildhall above it. St Dunstan's Lock is the name, corrupted from Dunestall, now applied to the entrance to the street where a Jewish quarter was situated; here lived the Christian boy afterwards known as "little St Hugh," who was asserted to have been crucified by the Jews in 1255. His shrine remains in the S. choir aisle of the minster. Other antiquities are the Perpendicular conduit of St Mary in High Street and the High Bridge, carrying High Street over the Witham, which is almost unique in England as retaining some of the old houses upon it. 711

Among modern public buildings are the county hall, old and new corn exchanges and public library. Educational establishments include a grammar school, a girls' high school, a science and art school and a theological college. The arboretum in Monks Road is the principal pleasure-ground; and there is a race-course. The principal industry is the manufacture of agricultural machinery and implements; there are also iron foundries and maltings, and a large trade in corn and agricultural produce. The parliamentary borough, returning one member, falls between the Gainsborough division of the county on the N., and that of Sleaford on the S. Area, 3755 acres.

History.—The British Lindun, which, according to the geography of Claudius Ptolemaeus, was the chief town of the Coritani, was probably the nucleus of the Roman town of Lindum. This was at first a Roman legionary fortress, and on the removal of the troops northward was converted into a municipality with the title of *colonia.* Such important structural remains as have been described attest the rank and importance of the place, which, however, did not attain a very great size. Its bishop attended the council of Arles in 314, and Lincoln (*Lindocolina*, *Lincolle*, *Nicole*) is mentioned in the Itinerary of Antoninus written about 320. Although said to have been captured by Hengest in 475 and recovered by Ambrosius in the following year, the next authentic mention of the city is Bede's record that Paulinus preached in Lindsey in 628 and built a stone church at Lincoln in which he consecrated Honorius archbishop of Canterbury. During their inroads into Mercia, the Danes in 877 established themselves at Lincoln, which was one of the five boroughs recovered by King Edmund in 941. A mint established here in the reign of Alfred was maintained until the reign of Edward I. (Mint Street turning from High Street near the Stonebow recalls its existence.) At the time of the Domesday Survey Lincoln was governed by twelve Lawmen, relics of Danish rule, each with hereditable franchises of sac and soc. Whereas it had rendered £20 annually to King Edward, and £10 to the earl, it then rendered £100. There had been 1150 houses, but 240 had been destroyed since the time of King Edward. Of these 166 had suffered by the raising of the castle by William I. in 1068 partly on the site of the Roman camp. The strength of the position of the castle brought much fighting on Lincoln. In 1141 King Stephen regained both castle and city from the empress Maud, but was attacked and captured in the same year at the "Joust of Lincoln." In 1144 he besieged the castle, held by the earl of Chester, and recovered it as a pledge in 1146. In 1101 it was held by Gerard de Camville for Prince John and was besieged by William Longchamp, Richard's chancellor, in vain; in 1210 it stood a siege by the partisans of the French prince Louis, who were defeated at the battle called Lincoln Fair on the 19th of May 1217. Granted by Henry III. to William Longepée, earl of Salisbury, in 1224, the castle descended by the marriage of his descendant Alice to Thomas Plantagenet, and became part of the duchy of Lancaster.

In 1157 Henry II. gave the citizens their first charter, granting them the city at a fee-farm rent and all the liberties which they had had under William II., with their gild merchant for themselves and the men of the county as they had then. In 1200 the citizens obtained release from all but pleas of the Crown without the walls, and pleas of external tenure, and were given the pleas of the Crown within the city according to the customs of the city of London, on which those of Lincoln were modelled. The charter also gave them quittance of toll and lastage throughout the kingdom, and of certain other dues. In 1210 the citizens owed the exchequer £100 for the privilege of having a mayor, but the office was abolished by Henry III. and by Edward I. in 1290, though restored by the charter of 1300. In 1275 the citizens claimed the return of writs, assize of bread and ale and other royal rights, and in 1301 Edward I., when confirming the previous charters, gave them quittance of murage, pannage, pontage and other dues. The mayor and citizens were given criminal jurisdiction in 1327, when the burghmanmot held weekly in the gildhall since 1272 by the mayor and bailiffs was ordered to hear all local pleas which led to friction with the judges of assize. The city became a separate county by charter of 1409, when it was decreed that the bailiffs should henceforth be sheriffs and the mayor the king's escheator, and the mayor and sheriffs with four others justices of the peace with defined jurisdiction. As the result of numerous complaints of inability to pay the fee-farm rent of £180 Edward IV. enlarged the bounds of the city in 1466, while Henry VIII. in 1546 gave the citizens four advowsons, and possibly also in consequence of declining trade the city markets were made free of tolls in 1554. Incorporated by Charles I. in 1628 under a common council with 13 aldermen, 4 coroners and other officers, Lincoln surrendered its charters in 1684, but the first charter was restored after the Revolution, and was in force till 1834.

Parliaments were held at Lincoln in 1301, 1316 and 1327, and the city returned two burgesses from 1295 to 1885, when it lost one member. After the 13th century the chief interests of Lincoln were ecclesiastical and commercial. As early as 1103 Odericus declared that a rich citizen of Lincoln kept the treasure of King Magnus of Norway, supplying him with all he required, and there is other evidence of intercourse with Scandinavia. There was an important Jewish colony, Aaron of Lincoln being one of the most influential financiers in the kingdom between 1166 and 1186. It was probably jealousy of their wealth that brought the charge of the crucifixion of "little St Hugh" in 1255 upon the Jewish community. Made a staple of wool, leather and skins in 1291, famous for its scarlet cloth in the 13th century, Lincoln had a few years of great prosperity, but with the transference of the staple to Boston early in the reign of Edward III., its trade began to decrease. The craft gilds remained important until after the Reformation, a pageant still being held in 1566. The fair now held during the last whole week of April would seem to be identical with that granted by Charles II. in 1684. Edward III. authorized a fair from St Botolph's day to the feast of SS Peter and Paul in 1327, and William III. gave one for the first Wednesday in September in 1696, while the present November fair is, perhaps, a survival of that granted by Henry IV. in 1409 for fifteen days before the feast of the Deposition of St Hugh. 712

See *Historical Manuscripts Commission, Report*, xiv., appendix pt. 8; John Ross, *Civitas Lincolina, from its municipal and other Records* (London, 1870); J. G. Williams, "Lincoln Civic Insignia," *Lincolnshire Notes and Queries*, vols. vi.-viii. (Horncastle, 1901-1905); *Victoria County History, Lincolnshire*.

LINCOLN, a city and the county-seat of Logan county, Illinois, U.S.A., in the N. central part of the state, 156 m. S.W. of Chicago, and about 28 m. N.E. of Springfield. Pop. (1900) 8962, of whom 940 were foreign-born; (1910 census) 10,892. It is served by the Illinois Central and the Chicago & Alton railways and by the Illinois Traction Interurban Electric line. The city is the seat of the state asylum for feeble-minded children (established at Jacksonville in 1865 and removed to Lincoln in 1878), and of Lincoln College (Presbyterian) founded in 1865. There are also an orphans' home, supported by the Independent Order of Odd Fellows, and a Carnegie library. The old court-house in which Abraham Lincoln often practised is still standing. Lincoln is situated in a productive grain region, and has valuable coal mines. The value of the factory products increased from $375,167 in 1900 to $784,248 in 1905, or 109%. The first settlement on the site of Lincoln was made in 1835, and the city was first chartered in 1857.

LINCOLN, a city of S.E. Nebraska, U.S.A., county-seat of Lancaster county and capital of the state. Pop. (1900) 40,169 (5297 being foreign-born); (1910 census) 43,973. It is served by the Chicago, Burlington & Quincy, the Chicago, Rock Island & Pacific, the Union Pacific, the Missouri Pacific and the Chicago & North-Western railways. Lincoln is one of the most attractive residential cities of the Middle West. Salt Creek, an affluent of the Platte river, skirts the city. On this side the city has repeatedly suffered from floods. The principal buildings include a state capitol (built 1883-1889); a city-hall, formerly the U.S. government building (1874-1879); a county court-house; a federal building (1904-1906); a Carnegie library (1902); a hospital for crippled children (1905) and a home for the friendless, both supported by the state; a state penitentiary and asylum for the insane, both in the suburbs; and the university of Nebraska. In the suburbs there are three denominational schools, the Nebraska Wesleyan University (Methodist Episcopal, 1888) at University Place; Union College (Seventh Day Adventists, 1891) at College View; and Cotner University (Disciples of Christ, 1889, incorporated as the Nebraska Christian University) at Bethany. Just outside the city limits are the state fair grounds, where a state fair is held annually. Lincoln is the see of a Roman Catholic bishopric. The surrounding country is a beautiful farming region, but its immediate W. environs are predominantly bare and desolate salt-basins. Lincoln's "factory" product increased from $2,763,484 in 1900 to $5,222,620 in 1905, or 89%, the product for 1905 being 3.4% of the total for the state. The municipality owns and operates its electric-lighting plant and water-works.

The salt-springs attracted the first permanent settlers to the site of Lincoln in 1856, and settlers and freighters came long distances to reduce the brine or to scrape up the dry-weather surface deposits. In 1886-1887 the state sank a test-well 2463 ft. deep, which discredited any hope of a great underground flow or deposit. Scarcely any use is made of the salt waters locally. Lancaster county was organized extra-legally in 1859, and under legislative act in 1864; Lancaster village was platted and became the county-seat in 1864 (never being incorporated); and in 1867, when it contained five or six houses, its site was selected for the state capital after a hard-fought struggle between different sections of the state (see Nebraska).[1] The new city was incorporated as Lincoln (and formally declared the county-seat by the legislature) in 1869, and was chartered for the first time as a city of the second class in 1871; since then its charter has been repeatedly altered. After 1887 it was a city of the first class, and after 1889 the only member of the highest subdivision in that class. After a "reform" political campaign, the ousting in 1887 of a corrupt police judge by the mayor and city council, in defiance of an injunction of a federal court, led to a decision of the U.S. Supreme Court, favourable to the city authorities and important in questions of American municipal government.

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1 Lincoln was about equally distant from Pawnee City and the Kansas border, the leading Missouri river towns, and the important towns of Fremont and Columbus on the N. side of the Platte.

LINCOLN JUDGMENT, THE. In this celebrated English ecclesiastical suit, the bishop of Lincoln (Edward King, *q.v.*) was cited before his metropolitan, the archbishop of Canterbury (Dr Benson), to answer charges of various ritual offences committed at the administration of Holy Communion in the church of St Peter at Gowts, in the diocese of Lincoln, on the 4th of December 1887, and in Lincoln cathedral on the 10th of December 1887. The promoters were Ernest de Lacy Read, William Brown, Felix Thomas Wilson and John Marshall, all inhabitants of the diocese of Lincoln, and the last two parishioners of St Peter at Gowts. The case has a permanent importance in two respects. First, certain disputed questions of ritual were legally decided. Secondly, the jurisdiction of the archbishop of Canterbury alone to try one of his suffragan bishops for alleged ecclesiastical offences was considered and judicially declared to be well founded both by the archbishop of Canterbury with the concurrence of his assessors. The proceedings were begun on the 2nd of June 1888 by a petition presented by the promoters to the archbishop, praying that a citation to the bishop of Lincoln might issue calling on him to answer certain ritual charges. On the 26th of June 1888 the archbishop, by letter, declined to issue citation, on the ground that until instructed by a competent court as to his jurisdiction, he was not clear that he had it. The promoters appealed to the judicial committee of the privy council, to which an appeal lies under 25 Henry VIII. c. 19 for "lack of justice" in the archbishop's court. The matter was heard on the 20th of July 1888, and on the 8th of August 1888 the committee decided (i.) that an appeal lay from the refusal of the archbishop to the judicial committee, and (ii.) that the archbishop had jurisdiction to issue a citation to the bishop of Lincoln and to hear the promoters' complaint, but they abstained from expressing an opinion as to whether the archbishop had a discretion to refuse citation—whether, in fact, he had any power of "veto" over the prosecution. The case being thus remitted to the archbishop, he decided to entertain it, and on the 4th of January 1889 issued a citation to the bishop of Lincoln.

On the 12th of February 1889 the archbishop of Canterbury sat in Lambeth Palace Library, accompanied by the bishops of London (Dr Temple), Winchester (Dr Harold Browne), Oxford (Dr Stubbs) and Salisbury (Dr Wordsworth), and the vicar-general (Sir J. Parker Deane) as assessors. The bishop of Lincoln appeared in person and read a "Protest" to the archbishop's jurisdiction to try him except in a court composed of the archbishop and all the bishops of the province as judges. The court adjourned in order that the question of jurisdiction might be argued. On the 11th of May the archbishop gave judgment to the effect that whether sitting alone or with assessors he had jurisdiction to entertain the charge. On the 23rd and 713
24th of July 1889 a further preliminary objection raised by the bishop of Lincoln's counsel was argued. The offences alleged against the bishop of Lincoln were largely breaches of various rubrics in the communion service of the Prayer Book which give directions to the "minister." These rubrics are by the Acts of Uniformity (1 Elizabeth c. 2, and 13 & 14 Car. II. c. 4) made legally binding. But it was argued that a bishop is not a "minister" so as to be bound by the rubrics. The archbishop, however, held otherwise, and the assessors (except the bishop of Salisbury, who dissented) concurred in this decision. At this and subsequent hearings the bishop of Hereford (Dr Atlay) took the place of the bishop of Winchester as an assessor, and the bishop of Rochester (Dr Thorold), originally appointed an assessor, but absent from England at the outset, was present.

Charges and decisions.

The case was heard on its merits in February 1890, before the archbishop and all the assessors, and the archbishop delivered his judgment on the 21st of November 1890. The alleged offences were eight in number. No facts were in dispute, but only the legality of the various matters complained of. I. The bishop was charged with having mixed water with wine in the chalice during the communion service, and II. with having administered the chalice so mixed to the communicants. It was decided that the mixing of the water with the wine during service was illegal, because an additional ceremony not enjoined in the Prayer Book, but that the administration of the mixed chalice, the mixing having been effected before service, was in accordance with primitive practice and not forbidden in the Church of England. III. The bishop was charged with the ceremonial washing of the vessels used for the holy communion, and with drinking the water used for these ablutions. It was decided that the bishop had committed no offence, and that what he had done was a reasonable compliance with the requirement of the rubric that any of the consecrated elements left over at the end of the celebration should be then and there consumed. IV. The bishop was charged with taking the eastward position (*i.e.* standing at the west side of the holy table with his face to the east and his back to the congregation) during the ante-communion service (*i.e.* the part of the communion service prior to the consecration prayer). The rubric requires the celebrant to stand at the north side of the table. A vast amount of research convinced the archbishop that this is an intentionally ambiguous phrase which may with equal accuracy be applied to the north end of the table as now arranged in churches, and to the long side of the table, which, in Edward VI.'s reign, was often placed lengthwise down the church, so that the long sides would face north and south. It was therefore decided (one of the assessors dissenting) that both positions are legal, and that the bishop had not offended in adopting the eastward position. V. The bishop was charged with so standing during the consecration prayer that the "Manual Acts" of consecration were invisible to the people gathered round. It should be stated that the courts (see *Ridsdale* v. *Clifton*, L.R. 1 P.D. 316; 2 P.D. 276) had already decided that the eastward position during the consecration prayer was legal, but that it must not be so used by the celebrant as to conceal the "Manual Acts." The archbishop held that the bishop of Lincoln had transgressed the law in this particular. VI. The bishop was charged with having, during the celebration of holy communion, allowed two candles to be alight on a shelf or retable behind the altar when they were not necessary for giving light. The archbishop decided that the mere presence of two altar candles burning during the service, but lit before it began, was lawful under the First Prayer Book of Edward VI., and has never been made unlawful, and, therefore, that the bishop was justified in what he had done. VII. The bishop was charged with having permitted the hymn known as *Agnus Dei* to be sung immediately after the consecration of the elements at a celebration of the holy communion. The archbishop decided that the use of hymns in divine service was too firmly established to be legally questioned, and that there was nothing to differentiate the use of this particular hymn at this point of the service from the use of other hymns on other occasions in public worship. VIII. The bishop was charged with making the sign of the Cross in the air with his hand in the benediction and at other times during divine service. The archbishop held that these crossings were ceremonies not enjoined and, therefore, illegal. The judgment confined itself to the legal declarations here summarized, and pronounced no monition or other sentence on the bishop of Lincoln in respect of the matters in which he appeared to have committed breaches of the ecclesiastical law.

The promoters appealed to the judicial committee. The bishop did not appear on the appeal, which was therefore argued on the side of the promoters only. The appeal was heard in June and July 1891, before Lords Halsbury, Hobhouse, Esher, Herschell, Hannen and Shand and Sir Richard Couch, with the bishop of Chichester (Dr Durnford), the bishop of St Davids (Dr Basil Jones) and the bishop of Lichfield (Dr Maclagan) as episcopal assessors. The points appealed were those above numbered II., III., IV., VI., VII. Judgment was given on the 2nd of August 1892, and the appeal failed on all points. As to II., III., IV., and VII. the Committee agreed with the archbishop. As to VI. (altar lights) they held that, as it was not shown that the bishop was responsible for the presence of lighted candles, the charge could not be sustained against him, and so dismissed it without considering the general question of the lawfulness of altar lights. They also held that the archbishop was within his right in pronouncing no sentence against the bishop, who, it should be added, conformed his practice to the judgment from the date of its delivery.

(L. T. D.)

LINCOLNSHIRE, an eastern county of England, bounded N. by the Humber, E. by the German Ocean and the Wash, S.E. for 3 m. by Norfolk, S. by Cambridgeshire and Northamptonshire, S.W. by Rutland, W. by Leicestershire and Nottinghamshire and N.W. by Yorkshire. The area is 2646 sq. m., the county being second to Yorkshire of the English counties in size.

The coast-line, about 110 m. in length, including the Humber shore, is generally low and marshy, and artificial banks for guarding against the inroads of the sea are to be found, in places, all along the coast. From Grimsby to Skegness traces of a submarine forest are visible; but while the sea is encroaching upon some parts of the coast it is receding from others, as shown by Holbeach, which is now 6 m. from the sea. Several thousand acres have been reclaimed from this part of the Wash, and round the mouth of the Nene on the south-east. The deep bay between the coasts of Lincolnshire and Norfolk, called the Wash, is full of dangerous sandbanks and silt; the navigable portion off the Lincolnshire coast is known as the Boston Deeps. The rapidity of the tides in this inlet, and the lowness of its shores, which are generally indistinct on account of mist from a moderate offing, render this the most difficult portion of the navigation of the east coast of England. On some parts of the coast there are fine stretches of sand, and Cleethorpes, Skegness, Mablethorpe and Sutton-on-Sea are favourite resorts for visitors.

The surface of Lincolnshire is generally a large plain, small portions of which are slightly below the level of the sea. The south-east parts are perfectly flat; and about one-third of the county consists of fens and marshes, intersected in all directions by artificial drains, called locally dykes, delphs, drains, becks, leams and eaux. This flat surface is broken by two ranges of calcareous hills running north and south through the county, and known as the Lincoln Edge or Heights, or the Cliff, and the Wolds. The former range, on the west, runs nearly due north from Grantham to Lincoln, and thence to the Humber, traversing the Heaths of Lincolnshire, which were formerly open moors, rabbit warrens and sheep walks, but are now enclosed and brought into high cultivation. The Wolds form a ridge of bold hills extending from Spilsby to Barton-on-Humber for about 40 m., with an average breadth of about 8 m. The Humber separates Lincolnshire from Yorkshire. Its ports on the Lincolnshire side are the small ferry-ports of Barton and New Holland, and the important harbour of Grimsby. The Trent forms part of the boundary with Nottinghamshire, divides the Isle of 714
Axholme (*q.v.*) from the district of Lindsey, and falls into the Humber about 30 m. below Gainsborough. The Witham rises on the S.W. border of the county, flows north past Grantham to Lincoln, and thence E. and S.E. to Boston, after a course of about 80 m. The Welland rises in north-west Northamptonshire, enters the county at Stamford, and, after receiving the Glen, flows through an artificial channel into the Fosdyke Wash. The Nene on the south-east has but a small portion of its course in Lincolnshire; it flows due north through an artificial outfall, called the Wisbech Cut. Between the Wolds and the sea lie the Marshes, a level tract of rich alluvial soil extending from Barton-on-Humber to Wainfleet, varying in breadth from 5 to 10 m. Between the Welland and the Nene in the south-east of the county are Gedney Marsh, Holbeach Marsh, Moulton Marsh and Sutton Marsh.

The Fens (*q.v.*), the soil of which has been formed partly by tidal action and partly by the decay of forests, occupy the Isle of Axholme on the north-west, the vale of Ancholme on the north, and most of the country south-east of Lincoln. The chief of these are the Holland, Wildmore, West and East Fens draining into the Witham; and the Deeping, Bourn, Great Porsand, and Whaplode Fens draining into the Welland.

The low lands adjoining the tidal reaches of the Trent and Humber, and part of those around the Wash have been raised above the natural level and enriched by the process of warping, which consists in letting the tide run over the land, and retaining it there a sufficient time to permit the deposit of the sand and mud held in solution by the waters.

Geology.—The geological formations for the most part extend in parallel belts, nearly in the line of the length of the county, from north to south, and succeed one another in ascending order from west to east. The lowest is the Triassic Keuper found in the Isle of Axholme and the valley of the Trent in the form of marls, sandstone and gypsum. Fish scales and teeth, with bones and footprints of the *Labyrinthodon*, are met with in the sandstone. The red clay is frequently dug for brick-making. The beds dip gently towards the east. At the junction between the Trias and Lias are series of beds termed Rhaetics, which seem to mark a transition from one to the other. These belts are in part exposed in pits near Newark, and extend north by Gainsborough to where the Trent flows into the Humber, passing thence into Yorkshire. The characteristic shells are found at Lea, 2 m. south of Gainsborough, with a thin bone-bed full of fish teeth and scales. The Lower Lias comes next in order, with a valuable bed of ironstone now largely worked. This bed is about 27 ft. in thickness, and crops out at Scunthorpe and Frodingham, where the workings are open and shallow.

The Middle Lias, which enters the county near Woolsthorpe, is about 20 or 30 ft. thick, and is very variable both in thickness and mineralogical character; the iron ores of Denton and Caythorpe belong to this horizon. The Upper Lias enters the county at Stainby, passing by Grantham and Lincoln where it is worked for bricks. The Lias thus occupies a vale about 8 or 10 m. in width in the south, narrowing until on the Humber it is about a mile in width. To this succeed the Oolite formations. The Inferior Oolite, somewhat narrower than the Lias, extends from the boundary with Rutland due north past Lincoln to the vicinity of the Humber; it forms the Cliff of Lincolnshire with a strong escarpment facing westward. At Lincoln the ridge is notched by the river Witham. The principal member of the Inferior Oolite is the Lincolnshire limestone, which is an important water-bearing bed and is quarried at Lincoln, Ponton, Ancaster, and Kirton Lindsey for building stone. Eastward of the Inferior Oolite lie the narrow outcrops of the Great Oolite and Cornbrash. The Middle Oolite, Oxford clay and Corallian is very narrow in the south near Wilsthorpe, widening gradually about Sleaford. It then proceeds north from Lincoln with decreasing width to the vicinity of the Humber. The Upper Oolite, Kimeridge clay, starts from the vicinity of Stamford, and after attaining its greatest width near Horncastle, runs north-north-west to the Humber. The Kimeridge clay is succeeded by the Spilsby sandstone, Tealby limestone, Claxby ironstone, and carstone which represent the highest Jurassic and lowest Cretaceous rocks. In the Cretaceous system of the Wolds, the Lower Greensand runs nearly parallel with the Upper Oolite past South Willingham to the Humber. The Upper Greensand and Gault, represented in Lincolnshire by the Red Chalk, run north-west from Irby, widening out as far as Kelstern on the east, and cross the Humber. The Chalk formation, about equal in breadth to the three preceding, extends from Burgh across the Humber. The rest of the county, comprising all its south-east portions between the Middle Oolite belt and the sea, all its north-east portions between the chalk belt and the sea, and a narrow tract up the course of the Ancholme river, consists of alluvial deposits or of reclaimed marsh. In the northern part boulder clay and glacial sands cover considerable tracts of the older rocks. Bunter, Permian, and Coal Measure strata have been revealed by boring to underlie the Keuper near Haxey.

Gypsum is dug in the Isle of Axholme, whiting is made from the chalk near the shores of the Humber, and lime is made on the Wolds. Freestone is quarried around Ancaster, and good oolite building stone is quarried near Lincoln and other places. Ironstone is worked at several places and there are some blast furnaces.

At Woodhall Spa on the Horncastle branch railway there is a much-frequented bromine and iodine spring.

Climate, Soil and Agriculture.—The climate of the higher grounds is healthy, and meteorological observation does not justify the reputation for cold and damp often given to the county as a whole. The soils vary considerably, according to the geological formations; ten or twelve different kinds may be found in going across the country from east to west. A good sandy loam is common in the Heath division; a sandy loam with chalk, or a flinty loam on chalk marl, abounds on portions of the Wolds; an argillaceous sand, merging into rich loam, lies on other portions of the Wolds; a black loam and a rich vegetable mould cover most of the Isle of Axholme on the north-west; a well-reclaimed marine marsh, a rich brown loam, and a stiff cold clay variously occupy the low tracts along the Humber, and between the north Wolds and the sea; a peat earth, a deep sandy loam, and a rich soapy blue clay occupy most of the east and south Fens; and an artificial soil, obtained by “warping,” occupies considerable low strips of land along the tidal reaches of the rivers.

Lincolnshire is one of the principal agricultural, especially grain-producing, counties in England. Nearly nine-tenths of the total area is under cultivation. The wide grazing lands have long been famous, and the arable lands are specially adapted for the growth of wheat and beans. The largest individual grain-crop, however, is barley. Both cattle and sheep are bred in great numbers. The cattle raised are the Shorthorns and improved Lincolnshire breeds. The dairy, except in the vicinity of large towns, receives little attention. The sheep are chiefly of the Lincolnshire and large Leicestershire breeds, and go to the markets of Yorkshire and London. Lincolnshire has long been famous for a fine breed of horses both for the saddle and draught. Horse fairs are held every year at Horncastle and Lincoln. Large flocks of geese were formerly kept in the Fens, but their number has been diminished since the drainage of these parts. Where a large number of them were bred, nests were constructed for them one above another; they were daily taken down by the gooseherd, driven to the water, and then reinstated in their nests, without a single bird being misplaced. Decoys were once numerous in the undrained state of the Fens.

Industries and Communications.—Manufactures are few and, relatively to the agricultural industry, small. The mineral industries, however, are of value, and there are considerable agricultural machine and implement factories at Lincoln, Boston, Gainsborough, Grantham and Louth. At Little Bytham a very hard brick, called adamantine clinker, is made of the siliceous clay that the Romans used for similar works. Bone-crushing, tanning, the manufacture of oil-cake for cattle, and rope-making are carried on in various places. Grimsby is an important port both for continental traffic and especially for fisheries; Boston is second to it in the county; and Gainsborough has a considerable traffic on the Trent. Sutton Bridge is a lesser port on the Wash.

The principal railway is the Great Northern, its main line touching the county in the S.W. and serving Grantham. Its principal branches are from Peterborough to Spalding, Boston, Louth and Grimsby; and from Grantham to Sleaford and Boston, and to Lincoln, and Boston to Lincoln. This company works jointly with the Great Eastern the line from March to Spalding, Lincoln, Gainsborough and Doncaster, and with the Midland that from Saxby to Bourn, Spalding, Holbeach, Sutton Bridge and King’s Lynn. The Midland company has a branch from Newark to Lincoln, and the Lancashire, Derbyshire, and East Coast line terminates at Lincoln. The Great Central railway connects the west, Sheffield and Doncaster with Grimsby, and with Hull by ferry from New Holland. Canals connect Louth with the Humber, Sleaford with the Witham, and Grantham with the Trent near Nottingham; but the greater rivers and many of the drainage cuts are navigable, being artificially deepened and embanked.

Population and Administration.—The area of the ancient county is 1,693,550 acres, with a population in 1891 of 472,878 and in 1901 of 498,847. The primary divisions are three trithings or Ridings (*q.v.*). The north division is called the Parts of Lindsey, the south-west the Parts of Kesteven, and the south-east the Parts of Holland. Each of these divisions had in early times its own reeve or gerefa. Each constitutes an administrative county, the Parts of Lindsey having an area of 967,689 acres; Kesteven, 465,877 acres; and Holland, 262,766 acres. The Parts of Lindsey contain 17 wapentakes; Kesteven, exclusive of the soke and borough of Grantham and the borough of Stamford, 9 wapentakes; and Holland, 3 wapentakes. The municipal boroughs and urban districts are as follows:—

1. Parts of Lindsey.—Municipal boroughs—Grimsby, a county borough (pop. 63,138), Lincoln, a city and county borough and the county town (48,784), Louth (9518). Urban districts—Alford (2478), Barton-upon-Humber (5671), Brigg (3137), Broughton (1300), Brumby and Frodingham 715 (2273), Cleethorpes with Thrunscoe (12,578), Crowle (2769), Gainsborough (17,660), Horncastle (4038), Mablethorpe (934), Market Rasen (2188), Roxby-cum-Risby (389), Scunthorpe (6750), Skegness (2140), Winterton (1361), Woodhall Spa (988).

2. Parts of Kesteven.—Municipal boroughs—Grantham (17,593), Stamford (8229). Urban districts—Bourne (4361), Bracebridge (1752), Ruskington (1196), Sleaford (5468).

3. Parts of Holland.—Municipal borough—Boston (15,667). Urban districts—Holbeach (4755), Long Sutton (2524), Spalding (9385), Sutton Bridge (2105). In the Parts of Holland the borough of Boston has a separate commission of the peace and there are two petty sessional divisions. Lincolnshire is in the Midland circuit. In the Parts of Kesteven the boroughs of Grantham and Stamford have each a separate commission of the peace and separate courts of quarter sessions, and there are 4 petty sessional divisions. In the Parts of Lindsey the county boroughs of Grimsby and Lincoln have each a separate commission of the peace and a separate court of quarter sessions, while the municipal borough of Louth has a separate commission of the peace, and there are 14 petty sessional divisions. The three administrative counties and the county boroughs contain together 761 civil parishes. The ancient county contains 580 ecclesiastical parishes and districts, wholly or in part. It is mostly in the diocese of Lincoln, but in part also in the dioceses of Southwell and York. For parliamentary purposes the county is divided into seven divisions, namely, West Lindsey or Gainsborough, North Lindsey or Brigg, East Lindsey or Louth, South Lindsey or Horncastle, North Kesteven or Sleaford, South Kesteven or Stamford, and Holland or Spalding, and the parliamentary boroughs of Boston, Grantham, Grimsby and Lincoln, each returning one member.

History.—Of the details of the English conquest of the district which is now Lincolnshire little is known, but at some time in the 6th century Engle and Frisian invaders appear to have settled in the country north of the Witham, where they became known as the Lindiswaras, the southern districts from Boston to the Trent basin being at this time dense woodland. In the 7th century the supremacy over Lindsey alternated between Mercia and Northumbria, but few historical references to the district are extant until the time of Alfred, whose marriage with Ealswitha was celebrated at Gainsborough three years before his accession. At this period the Danish inroads upon the coast of Lindsey had already begun, and in 873 Healfdene wintered at Torksey, while in 878 Lincoln and Stamford were included among the five Danish boroughs, and the organization of the districts dependent upon them probably resulted about this time in the grouping of Lindsey, Kesteven and Holland to form the shire of Lincoln. The extent and permanence of the Danish influence in Lincolnshire is still observable in the names of its towns and villages and in the local dialect, and, though about 918 the confederate boroughs were recaptured by Edward the Elder, in 993 a Viking fleet again entered the Humber and ravaged Lindsey, and in 1013 the district of the five boroughs acknowledged the supremacy of Sweyn. The county offered no active resistance to the Conqueror, and though Hereward appears in the Domesday Survey as a dispossessed under-tenant of the abbot of Peterborough at Witham-on-the-Hill, the legends surrounding his name do not belong to this county. In his northward march in 1068 the Conqueror built a castle at Lincoln, and portioned out the principal estates among his Norman followers, but the Domesday Survey shows that the county on the whole was leniently treated, and a considerable number of Englishmen retained their lands as subtenants.

The origin of the three main divisions of Lincolnshire is anterior to that of the county itself, and the outcome of purely natural conditions, Lindsey being in Roman times practically an island bounded by the swamps of the Trent and the Witham on the west and south and on the east by the North Sea, while Kesteven and Holland were respectively the regions of forest and of fen. Lindsey in Norman times was divided into three ridings—North, West and South—comprising respectively five, five and seven wapentakes; while, apart from their division into wapentakes, the Domesday Survey exhibits a unique planning out of the ridings into approximately equal numbers of 12-carucate hundreds, the term hundred possessing here no administrative or local significance, but serving merely as a unit of area for purposes of assessment. The Norman division of Holland into the three wapentakes of Elloe, Kirton and Skirbeck has remained unchanged to the present day. In Kesteven the wapentakes of Aswardhurn, Aveland, Beltisloe, Haxwell, Langoe, Loveden, Ness, Winnibriggs, and Grantham Soke have been practically unchanged, but the Domesday wapentakes of Boothby and Graffo now form the wapentake of Boothby Graffo. In Northriding Bradley and Haverstoe have been combined to form Bradley Haverstoe wapentake, and the Domesday wapentake of Epworth in Westriding has been absorbed in that of Manley. Wall wapentake in Westriding was a liberty of the bishop of Lincoln, and as late as 1515 the dean and chapter of Lincoln claimed delivery and return of writs in the manor and hundred of Navenby. In the 13th century Baldwin Wake claimed return of writs and a market in Aveland. William de Vesci claimed liberties and exemptions in Caythorpe, of which he was summoned to render account at the sheriff's tourn at Halton. The abbot of Peterborough, the abbot of Tupholme, the abbot of Bardney, the prior of Catleigh, the prior of Sixhills, the abbot of St Mary's, York, the prioress of Stixwould and several lay owners claimed liberties and jurisdiction in their Lincolnshire estates in the 13th century.

The shire court for Lincolnshire was held at Lincoln every forty days, the lords of the manor attending with their stewards, or in their absence the reeve and four men of the vill. The ridings were each presided over by a riding-reeve, and wapentake courts were held in the reign of Henry I. twelve times a year, and in the reign of Henry III. every three weeks, while twice a year all the freemen of the wapentake were summoned to the view of frankpledge or tourn held by the sheriff. The boundaries between Kesteven and Holland were a matter of dispute as early as 1389 and were not finally settled until 1816.

Lincolnshire was originally included in the Mercian diocese of Lichfield, but, on the subdivision of the latter by Theodore in 680, the fen-district was included in the diocese of Lichfield, while the see for the northern parts of the county was placed at "Sidnacester," generally identified with Stow. Subsequently both dioceses were merged in the vast West-Saxon bishopric of Dorchester, the see of which was afterwards transferred to Winchester, and by Bishop Remigius in 1072 to Lincoln. The archdeaconry of Lincoln was among those instituted by Remigius, and the division into rural deaneries also dates from this period. Stow archdeaconry is first mentioned in 1138, and in 1291 included four deaneries, while the archdeaconry of Lincoln included twenty-three. In 1536 the additional deaneries of Hill, Holland, Loveden and Graffoe had been formed within the archdeaconry of Lincoln, and the only deaneries created since that date are East and West Elloe and North and South Grantham in Lincoln archdeaconry. The deaneries of Gartree, Grimsby, Hill, Horncastle, Louthesk, Ludborough, Walshcroft, Wraggoe and Yarborough have been transferred from the archdeaconry of Lincoln to that of Stow. Benedictine foundations existed at Ikanho, Barrow, Bardney, Partney and Crowland as early as the 7th century, but all were destroyed in the Danish wars, and only Bardney and Crowland were ever rebuilt. The revival of monasticism after the Conquest resulted in the erection of ten Benedictine monasteries, and a Benedictine nunnery at Stainfield. The Cistercian abbeys at Kirkstead, Louth Park, Revesby, Vaudey and Swineshead, and the Cistercian nunnery at Stixwould were founded in the reign of Stephen, and at the time of the Dissolution there were upwards of a hundred religious houses in the county.

In the struggles of the reign of Stephen, castles at Newark and Sleaford were raised by Alexander, bishop of Lincoln, against the king, while Ranulf "Gernons," earl of Chester, in 1140 garrisoned Lincoln for the empress. The seizure of Lincoln by Stephen in 1141 was accompanied with fearful butchery and devastation, and by an accord at Stamford William of Roumare received Kirton in Lindsey, and his tenure of Gainsborough Castle was confirmed. In the baronial outbreak of 1173 Roger Mowbray, who had inherited the Isle of Axholme from Nigel d'Albini, garrisoned Ferry East, or Kinnard's Ferry, and Axholme against the king, and, after the destruction of their more northern fortresses in this campaign, Epworth in Axholme became the principal seat of the Mowbrays. In the struggles between John and his barons Lincoln in 1216 made peace with the king by 716
surrendering hostages for the payment of a fine of 1000 marks, but after the landing of Louis the city was captured by Gilbert de Gant, then earl of Lincoln. After his disastrous march to Swineshead Abbey, John journeyed through Sleaford to Newark, where he died, and in the battle of Lincoln in 1217 Gilbert de Gant was captured and the city sacked. At the time of the Wars of the Roses the county, owing to territorial influence, was mainly Lancastrian, and in 1461 the Yorkist strongholds of Grantham and Stamford were sacked to such effect that the latter never recovered. The Lincolnshire rising of 1470 was crushed by the defeat of the rebels in the skirmish known as "Losecoat Field" near Stamford. In the Civil War of the 17th century, Lindsey for the most part declared for the king, and the Royalist cause was warmly supported by the earl of Lindsey, Viscount Newark, Sir Peregrine Bertie and the families of Dymoke, Heneage and Thorold. Lord Willoughby of Parham was a prominent Parliamentary leader, and the Isle of Axholme and the Puritan yeomanry of Holland declared for the parliament. In 1643 Cromwell won a small victory near Grantham, and the Royalist garrisons at Lynn and Lincoln surrendered to Manchester. In 1644, however, Newark, Gainsborough, Lincoln, Sleaford and Crowland were all in Royalist hands, and Newark only surrendered in 1646. Among other historic families connected with Lincolnshire were the Wakes of Bourne and the d'Eyncourts, who flourished at Blankney from the Conquest to the reign of Henry VI.; Belvoir Castle was founded by the Toenis, from whom it passed by the Daubeneys, then to the Barons Ros and later to the Manners, earls of Rutland. In the Lindsey Survey of 1115-1118 the name of Roger Marmion, ancestor of the Marmion family, who had inherited the fief of Robert Despenser, appears for the first time.

At the time of the Domesday Survey there were between 400 and 500 mills in Lincolnshire; 2111 fisheries producing large quantities of eels; 361 salt-works; and iron forges at Stow, St Mary and at Bytham. Lincoln and Stamford were flourishing centres of industry, and markets existed at Kirton-in-Lindsey, Louth, Old Bolingbroke, Spalding, Barton and Partney. The early manufactures of the county are all connected with the woollen trade, Lincoln being noted for its scarlet cloth in the 13th century, while an important export trade in the raw material sprang up at Boston. The disafforesting of Kesteven in 1230 brought large areas under cultivation, and the same period is marked by the growth of the maritime and fishing towns, especially Boston (which had a famous fish-market), Grimsby, Barton, Saltfleet, Wainfleet and Wrangle. The Lincolnshire towns suffered from the general decay of trade in the eastern counties which marked the 15th century, but agriculture was steadily improving, and with the gradual drainage of the fen-districts culminating in the vast operations of the 17th century, over 330,000 acres in the county were brought under cultivation, including more than two-thirds of Holland. The fen-drainage resulted in the extinction of many local industries, such as the trade in goose-feathers and the export of wild fowl to the London markets, a 17th-century writer terming this county "the aviary of England, 3000 mallards with other birds having been caught sometimes in August at one draught." Other historic industries of Lincolnshire are the breeding of horses and dogs and rabbit-snaring; the Witham was noted for its pike; and ironstone was worked in the south, now chiefly in the north and west.

As early as 1295 two knights were returned to parliament for the shire of Lincoln, and two burgesses each for Lincoln, Grimsby and Stamford. In the 14th century Lincoln and Stamford were several times the meeting-places of parliament or important councils, the most notable being the Lincoln Parliament of 1301, while at Stamford in 1309 a truce was concluded between the barons, Piers Gaveston and the king. Stamford discontinued representation for some 150 years after the reign of Edward II.; Grantham was enfranchised in 1463 and Boston in 1552. Under the act of 1832 the county was divided into a northern and southern division, returning each two members, and Great Grimsby lost one member. Under the act of 1868 the county returned six members in three divisions and Stamford lost one member. Under the act of 1885 the county returned seven members in seven divisions; Lincoln, Boston and Grantham lost one member each and Stamford was disfranchised.

Antiquities.—At the time of the suppression of the monasteries in the reign of Henry VIII. there were upwards of one hundred religious houses; and among the Fens rose some of the finest abbeys held by the Benedictines. The Gilbertines were a purely English order which took its rise in Lincolnshire, the canons following the Austin rule, the nuns and lay brothers that of the Cistercians. They generally lived in separate houses, but formed a community having a common church in which the sexes were divided by a longitudinal wall. These houses were at Alvingham, Catley, Holland Brigg, Lincoln, before the gate of which the first Eleanor Cross was erected by Edward I. to his wife, Newstead in Lindsey, Sempringham, the chief house of the order, founded by St Gilbert of Gaunt in 1139, of which the Norman nave of the church is in use, Stamford (a college for students) and Wellow. There were nunneries of the order at Haverholme, Nun Ormsby and Tunstal.

The following are a few of the most famous abbeys. Barlings (Premonstratensian), N.E. of Lincoln, was founded 1154, for fourteen canons. The tower, Decorated, with arcading pierced with windows, and the east wall of the south wing remain. The Benedictine Mitred Abbey of Crowland (*q.v.*) was founded 716, and refounded in 948. Part of the church is still in use. Thornton Abbey (Black Canons) in the north near the Humber was founded in 1139. There remain a fragment of the south wing of the transept, two sides of the decagonal chapter-house (1282) and the beautiful west gate-house, Early Perpendicular (1332-1388), with an oriel window on the east. Kirkstead Abbey (Cistercian) was founded in 1139. Little remains beyond an Early English chapel of singular beauty.

In the Parts of Lindsey several churches present curious early features, particularly the well-known towers of St Peter, Barton-on-Humber, St Mary-le-Wigford and St Peter at Gowts, Lincoln, which exhibit work of a pre-Conquest type. Stow church for Norman of various dates, Bottesford and St James, Grimsby, for Early English, Tattershall and Theddlethorpe for Perpendicular are fine examples of various styles.

In the Parts of Kesteven the churches are built of excellent stone which abounds at Ancaster and near Sleaford. The church of St Andrew, Heckington, is the best example of Decorated architecture in the county; it is famed for its Easter sepulchre and fine sedilia. The noble church of St Wulfram, Grantham, with one of the finest spires in England, is also principally Decorated; this style in fact is particularly well displayed in Kesteven, as in the churches of Caythorpe, Claypole, Navenby and Ewerby. At Stamford (*q.v.*) there are five churches of various styles.

It is principally in the Parts of Holland that the finest churches in the county are found; they are not surpassed by those of any other district in the kingdom, which is the more remarkable as the district is composed wholly of marsh land and is without stone of any kind. It is highly probable that the churches of the south part of this district owe their origin to the munificence of the abbeys of Crowland and Spalding. The church of Long Sutton, besides its fine Norman nave, possesses an Early English tower and spire which is comparable with the very early specimen at Oxford cathedral. Whaplode church is another noteworthy example of Norman work; for Early English work the churches of Kirtop-in-Holland, Pinchbeck and Weston may be noticed; for Decorated those at Donington and Spalding; and for Perpendicular, Gedney, together with parts of Kirton church. Of the two later styles, however, by far the most splendid example is the famous church of St Botolph, Boston (*q.v.*), with its magnificent lantern-crowned tower or "stump."

There are few remains of medieval castles, although the sites of a considerable number are traceable. Those of Lincoln and Tattershall (a fine Perpendicular building in brick) are the most noteworthy, and there are also fragments at Boston and Sleaford, Country seats worthy of note (chiefly modern) are Aswarby Hall, Belton House, Brocklesby, Casewick, Denton Manor, Easton Hall, Grimsthorpe (of the 16th and 18th centuries, with earlier remains), Haverholm Priory, Nocton Hall, Panton Hall, Riby Grove, Somerby Hall, Syston Park and Uffington. The city of Lincoln is remarkably rich in remains of domestic architecture from the Norman period onward, and there are similar examples at Stamford and elsewhere. In this connexion the remarkable triangular bridge at Crowland of the 14th century (see Bridges) should be mentioned.

See *Victoria County History, Lincolnshire*; Thomas Allen, *The History of the County of Lincoln* (2 vols., London, 1834); C. G. Smith, *A Translation of that portion of the Domesday Book which relates to Lincolnshire and Rutlandshire* (London, 1870); G. S. Streatfield, *Lincolnshire and the Danes* (London, 1884); *Chronicle of the Rebellion in Lincolnshire, 1470*, ed. J. E. Nicholls, Camden Society, *Camden Miscellany*, vol. i. (London, 1847); *The Lincolnshire Survey, temp. Henry I.*, ed. James Greenstreet (London, 1884); *Lincolnshire Notes and Queries* (Horncastle, 1888); *Lincolnshire Record Society* (Horncastle, 1891).

LIND, JENNY (1820-1887), the famous Swedish singer, was born at Stockholm on the 6th of October 1820, the daughter of a lace 717
manufacturer. Mlle Lundberg, an opera-dancer, first discovered her musical gift, and induced the child’s mother to have her educated for the stage; during the six or seven years in which she was what was called an “actress pupil,” she occasionally appeared on the stage, but in plays, not operas, until 1836, when she made a first attempt in an opera by A. F. Lindblad. She was regularly engaged at the opera-house In 1837. Her first great success was as Agathe, in Weber’s *Der Freischütz*, in 1838, and by 1841, when she started for Paris, she had already become identified with nearly all the parts in which she afterwards became famous. But her celebrity in Sweden was due in great part to her histrionic ability, and there is comparatively little said about her wonderful vocal art, which was only attained after a year’s hard study under Manuel Garcia, who had to remedy many faults that had caused exhaustion in the vocal organs. On the completion of her studies she sang before G. Meyerbeer, in private, in the Paris Opera-house, and two years afterwards was engaged by him for Berlin, to sing in his *Feldlager in Schlesien* (afterwards remodelled as *L’ Étoile du nord*); but the part intended for her was taken by another singer, and her first appearance took place in *Norma* on the 15th of December 1844. She appeared also in Weber’s *Euryanthe* and Bellini’s *La Sonnambula*, and while she was at Berlin the English manager, Alfred Bunn, induced her to sign a contract (which she broke) to appear in London in the following season. In December 1845 she appeared at a Gewandhaus concert at Leipzig, and made the acquaintance of Mendelssohn, as well as of Joachim and many other distinguished German musicians. In her second Berlin season she added the parts of Donna Anna (Mozart’s *Don Giovanni*), Julia (Spontini’s *Vestalin*) and Valentine (Meyerbeer’s *Les Huguenots*) to her repertory. She sang in operas or concerts at Aix-la-Chapelle, Hanover, Hamburg, Vienna, Darmstadt and Munich during the next year, and took up two Donizetti rôles, those of Lucia and “la Figlia del Reggimento,” in which she was afterwards famous. At last Lumley, the manager of Her Majesty’s Theatre, succeeded in inducing Mlle Lind to visit England, in spite of her dread of the penalties threatened by Bunn on her breach of the contract with him, and she appeared on the 4th of May 1847 as Alice in Meyerbeer’s *Robert le Diable*. Her début had been so much discussed that the *furore* she created was a foregone conclusion. Nevertheless it exceeded everything of the kind that had taken place in London or anywhere else; the sufferings and struggles of her well-dressed admirers, who had to stand for hours to get into the pit, have become historic. She sang in several of her favourite characters, and in that of Susanna in Mozart’s *Figaro*, besides creating the part of Amalia in Verdi’s *I Masnadieri*, written for England and performed on the 22nd of July. In the autumn she appeared in operas in Manchester and Liverpool, and in concerts at Brighton, Birmingham, Hull, Edinburgh, Glasgow, Perth, Norwich, Bristol, Bath and Exeter. At Norwich began her acquaintance with the bishop, Edward Stanley (1779-1849), which was said to have led to her final determination to give up the stage as a career. After four more appearances in Berlin, and a short visit to Stockholm, she appeared in London in the season of 1848, when she sang in Donizetti’s *L’Elisire d’amore* and Bellini’s *I Puritani*, in addition to her older parts. In the same year she organized a memorable performance of *Elijah*, with the receipts of which the Mendelssohn scholarship was founded, and sang at a great number of charity and benefit concerts. At the beginning of the season of 1849 she intended to give up operatic singing, but a compromise was effected by which she was to sing the music of six operas, performed without action, at Her Majesty’s Theatre; but the first, a concert performance of Mozart’s *Il Flauto magico*, was so coldly received that she felt bound, for the sake of the manager and the public, to give five more regular representations, and her last performance on the stage was on the 10th of May 1849, in *Robert le Diable*. Her decision was not even revoked when the king of Sweden urged her to reappear in opera at her old home. She paid visits to Germany and Sweden again before her departure for America in 1850. Just before sailing she appeared at Liverpool, for the first time in England, in an oratorio of Handel, singing the soprano music in *The Messiah* with superb art. She remained in America for nearly two years, being for a great part of the time engaged by P. T. Barnum. In Boston, on the 5th of February 1852, she married Otto Goldschmidt (1829-1907), whom she had met at Lübeck in 1850. For some years after her return to England, her home for the rest of her life, she appeared in oratorios and concerts, and her dramatic instincts were as strongly and perhaps as advantageously displayed in these surroundings as they had been on the stage, for the grandeur of her conceptions in such passages as the “Sanctus” of *Elijah*, the intensity of conviction which she threw into the scene of the widow in the same work, or the religious fervour of “I know that my Redeemer liveth,” could not have found a place in opera. In her later years she took an active interest in the Bach Choir, conducted by her husband, and not only sang herself in the chorus, but gave the benefit of her training to the ladies of the society. For some years she was professor of singing at the Royal College of Music. Her last public appearance was at Düsseldorf on the 20th of January 1870 when she sang in *Ruth*, an oratorio composed by her husband. She died at Malvern on the 2nd of November 1887. The supreme position she held so long in the operatic world was due not only to the glory of her voice, and the complete musicianship which distinguished her above all her contemporaries, but also to the naïve simplicity of her acting in her favourite parts, such as Amina, Alice or Agathe. In these and others she had the precious quality of conviction, and identified herself with the characters she represented with a thoroughness rare in her day. Unharmed by the perils of a stage career, she was a model of rectitude, generosity and straightforwardness, carrying the last quality into a certain blunt directness of manner that was sometimes rather startling.

(J. A. F. M.)

LINDAU, PAUL (1839-   ), German dramatist and novelist, the son of a Protestant pastor, was born at Magdeburg on the 3rd of June 1839. He was educated at the gymnasium in Halle and subsequently in Leipzig and Berlin. He spent five years in Paris to further his studies, acting meanwhile as foreign correspondent to German papers. After his return to Germany in 1863 he was engaged in journalism in Düsseldorf and Elberfeld. In 1870 he founded *Das neue Blatt* at Leipzig; from 1872 to 1881 he edited the Berlin weekly, *Die Gegenwart*; and in 1878 he founded the well-known monthly, *Nord und Süd*, which he continued to edit until 1904. Two books of travel, *Aus Venetien* (Düsseldorf, 1864) and *Aus Paris* (Stuttgart, 1865). were followed by some volumes of critical studies, written in a light, satirical vein, which at once made him famous. These were *Harmlose Briefe eines deutschen Kleinstädters* (Leipzig, 2 vols., 1870), *Moderne Märchen für grosse Kinder* (Leipzig, 1870) and *Literarische Rücksichtslosigkeiten* (Leipzig, 1871). He was appointed intendant of the court theatre at Meiningen in 1895, but removed to Berlin in 1899, where he became manager of the Berliner Theater, and subsequently, until 1905, of the Deutsches Theater. He had begun his dramatic career in 1868 with *Marion*, the first of a long series of plays in which he displayed a remarkable talent for stage effect and a command of witty and lively dialogue. Among the more famous were *Maria und Magdalena* (1872), *Tante Therese* (1876), *Gräfin Lea* (1879), *Die Erste* (1895), *Der Abend* (1896), *Der Herr im Hause* (1899), *So ich dir* (1903), and he adapted many plays by Dumas, Augier and Sardou for the German stage. Five volumes of his plays have been published (Berlin, 1873-1888). Some of his volumes of short stories acquired great popularity, notably *Herr und Frau Bewer* (Breslau, 1882) and T*oggenburg und andere Geschichten* (Breslau, 1883). A novel-sequence entitled *Berlin* included *Der Zug nach dem Westen* (Stuttgart, 1886, 10th ed. 1903), *Arme Mädchen* (1887, 9th ed. 1905) and *Spitzen* (1888, 8th ed. 1904). Later novels were *Die Gehilfin* (Breslau, 1894), *Die Brüder*, (Dresden, 1895), *Der König von Sidon* (Breslau, 1898). His earlier books on *Molière* (Leipzig, 1871) and *Alfred de Musset* (Berlin, 1877) were 718
followed by some volumes of dramatic and literary criticism, *Gesammelte Aufsätze* (Berlin, 1875), *Dramaturgische Blätter* (Stuttgart, 2 vols., 1875; new series, Breslau, 1878, 2 vols.), *Vorspiele auf dem Theater* (Breslau, 1895).

His brother, Rudolf Lindau (b. 1829), was a well-known diplomatist and author. His novels and tales were collected in 1893 (Berlin, 6 vols.). The most attractive, such as *Reisegefährten* and *Der lange Holländer*, deal with the life of European residents in the Far East.

See Hadlich, *Paul Lindau als dramatischer Dichter* (2nd ed., Berlin, 1876).

LINDAU, a town and pleasure resort in the kingdom of Bavaria, and the central point of the transit trade between that country and Switzerland, situated on two islands off the north-eastern shore of Lake Constance. Pop. (1905) 6531. The town is a terminus of the Vorarlberg railway, and of the Munich-Lindau line of the Bavarian state railways, and is connected with the mainland both by a wooden bridge and by a railway enbankment erected in 1853. There are a royal palace and an old and a new town-hall (the older one having been built in 1422 and restored in 1886-1888), a museum and a municipal library with interesting manuscripts and a collection of Bibles, also classical, commercial and industrial schools. The harbour is much frequented by steamers from Constance and other places on the lake. There are also some Roman remains, the Heidenmauer, and a fine modern fountain, the Reichsbrunnen. Opposite the custom-house is a bronze statue of the Bavarian king Maximilian II., erected in 1856.

On the site now occupied by the town there was a Roman camp, the *castrum Tiberii*, and the authentic records of Lindau date back to the end of the 9th century, when it was known as Lintowa. In 1274, or earlier, it became a free imperial town; in 1331 it joined the Swabian league, and in 1531 became a member of the league of Schmalkalden, having just previously accepted the reformed doctrines. In 1647 it was ineffectually besieged by the Swedes. In 1804 it lost its imperial privileges and passed to Austria, being transferred to Bavaria in 1805.

See Boulan, *Lindau, vor altem und jetzt* (Lindau, 1872); and Stettners, *Führer durch Lindau und Umgebungen* (Lindau, 1900).

LINDEN, a town in the Prussian province of Hanover, 3 m. S.W. by rail from the city of that name, of which it practically forms a suburb, and from which it is separated by the Ihme. Pop. (1905) 57,941. It has a fine modern town-hall, and a classical and other schools. Chief among its industries are machine building, weaving, iron and steel works and the manufacture of chemicals, india-rubber goods and carpets.

LINDESAY, ROBERT, of Pitscottie (*c.* 1530-*c.* 1590), Scottish historian, of the family of the Lindesays of the Byres, was born at Pitscottie, in the parish of Ceres, Fifeshire, which he held in lease at a later period. His *Historie and Cronicles of Scotland*, the only work by which he is remembered, is described as a continuation of that of Hector Boece, translated by John Bellenden. It covers the period from 1437 to 1565, and, though it sometimes degenerates into a mere chronicle of short entries, is not without passages of great picturesqueness. Sir Walter Scott made use of it in *Marmion*; and, in spite of its inaccuracy in details, it is useful for the social history of the period. Lindesay's share in the *Cronicles* was generally supposed to end with 1565; but Dr Aeneas Mackay considers that the frank account of the events connected with Mary Stuart between 1565 and 1575 contained in one of the MSS. is by his hand and was only suppressed because it was too faithful in its record of contemporary affairs.

The *Historie and Cronicles* was first published in 1728. A complete edition of the text (2 vols.), based on the Laing MS. No. 218 in the university of Edinburgh, was published by the Scottish Text Society in 1899 under the editorship of Aeneas J. G. Mackay. The MS., formerly in the possession of John Scott of Halkshill, is fuller, and, though in a later hand, is, on the whole, a better representative of Lindesay's text.

LINDET, JEAN BAPTISTE ROBERT (1749-1825), French revolutionist, was born at Bernay (Eure). Before the Revolution he was an *avocat* at Bernay. He acted as *procureur-syndic* of the district of Bernay during the session of the Constituent Assembly. Appointed deputy to the Legislative Assembly and subsequently to the Convention, he attained considerable prominence. He was very hostile to the king, furnished a *Rapport sur les crimes imputés à Louis Capet* (10th of December 1792), and voted for the death of Louis without appeal or respite. He was instrumental in the establishment of the Revolutionary Tribunal and contributed to the downfall of the Girondists. As member of the Committee of Public Safety, he devoted himself particularly to the question of food-supplies, and it was only by dint of dogged perseverance and great administrative talent that he was successful in coping with this difficult problem. He had meanwhile been sent to suppress revolts in the districts of Rhône, Eure, Calvados and Finistère, where he had been able to pursue a conciliatory policy. Without being formally opposed to Robespierre, he did not support him, and he was the only member of the Committee of Public Safety who did not sign the order for the execution of Danton and his party. In a like spirit of moderation he opposed the Thermidorian reaction, and defended Barère, Billaud-Varenne the Collot d'Herbois from the accusations launched against them on the 22nd of March 1795. Himself denounced on the 20th of May 1795, he was defended by his brother Thomas, but only escaped condemnation by the vote of amnesty of the 4th of Brumaire, year IV. (26th of October 1795). He was minister of finance from the 18th of June to the 9th of November 1799, but refused office under the Consulate and the Empire. In 1816 he was proscribed by the Restoration government as a regicide, and did not return to France until just before his death on the 17th of February 1825. His brother Thomas made some mark as a Constitutional bishop and member of the Convention.

See Amand Montier, *Robert Lindet* (Paris, 1899); H. Turpin, *Thomas Lindet* (Bernay, 1886); A. Montier, *Correspondance de Thomas Lindet* (Paris, 1899).

LINDLEY, JOHN (1799-1865), English botanist, was born on the 5th of February 1799 at Catton, near Norwich, where his father, George Lindley, author of *A Guide to the Orchard and Kitchen Garden*, owned a nursery garden. He was educated at Norwich grammar school. His first publication, in 1819, a translation of the *Analyse du fruit* of L. C. M. Richard, was followed in 1820 by an original *Monographia Rosarum*, with descriptions of new species, and drawings executed by himself, and in 1821 by *Monographia Digitalium*, and by "Observations on Pomaceae," contributed to the Linnean Society. Shortly afterwards he went to London, where he was engaged by J. C. Loudon to write the descriptive portion of the *Encyclopaedia of Plants*. In his labours on this undertaking, which was completed in 1829, he became convinced of the superiority of the "natural" system of A. L. de Jussieu, as distinguished from the "artificial" system of Linnaeus followed in the *Encyclopaedia*; the conviction found expression in *A Synopsis of British Flora, arranged according to the Natural Order* (1829) and in *An Introduction to the Natural System of Botany* (1830). In 1829 Lindley, who since 1822 had been assistant secretary to the Horticultural Society, was appointed to the chair of botany in University College, London, which he retained till 1860; he lectured also on botany from 1831 at the Royal Institution, and from 1836 at the Botanic Gardens, Chelsea. During his professoriate he wrote many scientific and popular works, besides contributing largely to the *Botanical Register*, of which he was editor for many years, and to the *Gardener's Chronicle*, in which he had charge of the horticultural department from 1841. He was a fellow of the Royal, Linnean and Geological Societies. He died at Turnham Green on the 1st of November 1865.

Besides those already mentioned, his works include *An Outline of the First Principles of Horticulture* (1832), *An Outline of the Structure and Physiology of Plants* (1832), *A Natural System of Botany* (1836), *The Fossil Flora of Great Britain* (with William Hutton, 1831-1837), *Flora Medica* (1838), *Theory of Horticulture* (1840), *The Vegetable Kingdom* (1846), *Folia Orchidacea* (1852), *Descriptive Botany* (1858).

LINDLEY, NATHANIEL LINDLEY, Baron (1828-), English judge, son of John Lindley (*q.v.*), was born at Acton Green, Middlesex, on the 29th of November 1828. He was educated at University College School, and studied for a time at University College, London. He was called to the bar at the Middle Temple in 1850, and began practice in the Court of Chancery. In 1855 he published *An Introduction to the Study of Jurisprudence*, consisting of a translation of the general part of Thibaut's *System des Pandekten Rechts*, with copious notes. In 1860 he published in two volumes his *Treatise on the Law of Partnership, including its Application to Joint Stock and other Companies*, and in 1862 a supplement including the Companies Act of 1862. This work has since been developed into two text-books well known to lawyers as *Lindley on Companies* and *Lindley on Partnership*. He became a Q.C. in January 1872. In 1874 he was elected a bencher of the Middle Temple, of which he was treasurer in 1894. In 1875 he was appointed a justice of common pleas, the appointment of a chancery barrister to a common-law court being justified by the fusion of law and equity then shortly to be brought about, in theory at all events, by the Judicature Acts. In pursuance of the changes now made be became a justice of the common pleas division of the High Court of Justice, and in 1880 of the queen's bench division. In 1881 he was raised to the Court of Appeal and made a privy councillor. In 1897, Lord Justice Lindley succeeded Lord Esher as master of the rolls, and in 1900 he was made a lord of appeal in ordinary with a life peerage and the title of Baron Lindley. He resigned the judicial post in 1905. Lord Lindley was the last serjeant-at-law appointed, and the last judge to wear the serjeant's coif, or rather the black patch representing it, on the judicial wig. He married in 1858 Sarah Katherine, daughter of Edward John Teale of Leeds. 719

LINDLEY, WILLIAM (1808-1900), English engineer, was born in London on the 7th of September 1808, and became a pupil under Francis Giles, whom he assisted in designing the Newcastle and Carlisle and the London and Southampton railways. Leaving England about 1837, he was engaged for a time in railway work in various parts of Europe, and then returned, as engineer-in-chief to the Hamburg-Bergedorf railway, to Hamburg, near which city he had received his early education, and to which he was destined to stand in much the same relation as Baron Haussmann to Paris. His first achievement was to drain the Hammerbrook marshes, and so add some 1400 acres to the available area of the city. His real opportunity, however, came with the great fire which broke out on the 5th of May 1842 and burned for three days. He was entrusted with the direction of the operations to check its spread, and the strong measures he adopted, including the blowing-up of the town hall, brought bis life into danger with the mob, who professed to see in him an English agent charged with the destruction of the port of Hamburg. After the extinction of the fire he was appointed consulting engineer to the senate and town council, to the Water Board and to the Board of Works. He began with the construction of a complete sewerage system on principles which did not escape criticism, but which experience showed to be good. Between 1844 and 1848 water-works were established from his designs, the intake from the Elbe being at Rothenburgsort. Subsidence tanks were used for clarification, but in 1853, when he designed large extensions, he urged the substitution of sand-filtration, which, however, was not adopted until the cholera epidemic of 1892-1893 had shown the folly of the opposition directed against it. In 1846 he erected the Hamburg gas-works; public baths and wash-houses were built, and large extensions to the port executed according to his plans in 1854; and he supervised the construction of the Altona gas and water works in 1855. Among other services he rendered to the city may be mentioned the trigonometrical survey executed between 1848 and 1860, and the conduct of the negotiations which in 1852 resulted in the sale of the "Steelyard" on the banks of the Thames belonging to it jointly with the two other Hanseatic towns, Bremen and Lübeck. In 1860 he left Hamburg, and during the remaining nineteen years of his professional practice he was responsible for many engineering works in various European cities, among them being Frankfort-on-the-Main, Warsaw, Pesth, Düsseldorf, Galatz and Basel. In Frankfort he constructed sewerage works on the same principles as those he followed in Hamburg, and the system was widely imitated not only in Europe, but also in America. He was also consulted in regard to water-works at Berlin, Kiel, Stralsund, Stettin and Leipzig; he advised the New River Company of London on the adoption of the constant supply system in 1851; and he was commissioned by the British Government to carry out various works in Heligoland, including the big retaining wall "Am Falm." He died at Blackheath, London, on the 22nd of May 1900.

LINDO, MARK PRAGER (1819-1879), Dutch prose writer, of English-Jewish descent, was born in London on the 18th of September 1810. He went to Holland when nineteen years of age, and once established there as a private teacher of the English language, he soon made up his mind to remain. In 1842 he passed his examination at Arnhem, qualifying him as a professor of English in Holland, subsequently becoming a teacher of the English language and literature at the gymnasium in that town. In 1853 he was appointed in a similar capacity at the Royal Military Academy in Breda. Meanwhile Lindo had obtained a thorough grasp of the Dutch language, partly during his student years at Utrecht University, where in 1854 he gained the degree of doctor of literature. His proficiency in the two languages led him to translate into Dutch several of the works of Dickens, Thackeray and others, and afterwards also of Fielding, Sterne and Walter Scott. Some of Lindo's translations bore the imprint of hasty and careless work, and all were very unequal in quality. His name is much more likely to endure as the writer of humorous original sketches and novelettes in Dutch, which he published under the pseudonym of De Oude Herr Smits ("Old Mr Smits"). Among the most popular are; *Brieven en Ontboezemingen* ("Letters and Confessions," 1853, with three "Continuations"); *Familie van Ons* ("Family of Ours," 1855); *Bekentenissen eener Jonge Dame* ("Confessions of a Young Lady," 1858); *Uittreksels uit het Dagboek van Wijlen den Heer Janus Snor* ("Extracts from the Diary of the late Mr Janus Snor," 1865); *Typen* ("Types," 1871); and, particularly, *Afdrukken van Indrukken* ("Impressions from Impressions," 1854, reprinted many times). The last-named was written in collaboration with Lodewyk Mulder, who contributed some of its drollest whimsicalities of Dutch life and character, which, for that reason, are almost untranslatable. Lodewyk Mulder and Lindo also founded together, and carried on, for a considerable time alone, the *Nederlandsche Spectator* ("The Dutch Spectator"), a literary weekly, still published at The Hague, which bears little resemblance to its English prototype, and which perhaps reached its greatest popularity and influence when Vosmaer contributed to it a brilliant weekly letter under the fanciful title of Vlugmaren ("Swifts"). Lindo's serious original Dutch writings he published under his own name, the principal one being *De Opkomst en Ontwikkeling van het Engelsche Volk* ("The Rise and Development of the British People," 2 vols. 1868-1874)—a valuable history. Lodewyk Mulder published in 1877-1879 a collected edition of Lindo's writings in five volumes, and there has since been a popular reissue. Lindo was appointed an inspector of primary schools in the province of South Holland in 1865, a post he held until his death at The Hague on the 9th of March 1879.

LINDSAY, the family name of the earls of Crawford. The family is one of great antiquity in Scotland, the earliest to settle in that country being Sir Walter de Lindesia, who attended David, earl of Huntingdon, afterwards King David I., in his colonization of the Lowlands early in the 12th century. The descendants of Sir Walter divided into three branches, one of which held the baronies of Lamberton in Scotland, and Kendal and Molesworth in England; another held Luffness and Crawford in Scotland and half Limesi in England; and a third held Breneville and Byres in Scotland and certain lands, not by baronial tenure, in England. The heads of all these branches sat as barons in the Scottish parliament for more than two hundred years before the elevation of the chief of the house to an earldom in 1398. The Lindsays held the great mountain district of 720
Crawford in Clydesdale, from which the title of the earldom is derived, from the 12th century till the close of the 15th, when it passed to the Douglas earls of Angus. See Crawford, Earls of.

See A. W. C. Lindsay, afterwards earl of Crawford, *Lives of the Lindsays, or a Memoir of the Houses of Crawford and Belcarres* (3 vols., 1843 and 1858).

LINDSAY, a town and port of entry of Ontario, Canada, and capital of Victoria county, on the Scugog river, 57 m. N.E. of Toronto by rail, on the Canadian Pacific railway, and at the junction of the Port Hope and Haliburton branches and the Midland division of the Grand Trunk railway. Pop. (1901) 7003. It has steamboat communication, by way of the Trent canal, with Lake Scugog and the ports on the Trent system. It contains saw and grist mills, agricultural implement and other factories.

LINDSEY, THEOPHILUS (1723-1808), English theologian, was born in Middlewich, Cheshire, on the 20th of June 1723, and was educated at the Leeds Free School and at St John's College, Cambridge, where in 1747 he became a fellow. For some time he held a curacy in Spitalfields, London, and from 1734 to 1756 he travelled on the continent of Europe as tutor to the young duke of Northumberland. He was then presented to the living of Kirkby-Wiske in Yorkshire, and after exchanging it for that of Piddletown in Dorsetshire, he removed in 1763 to Catterick in Yorkshire. Here about 1764 he founded one of the first Sunday schools in England. Meanwhile he had begun to entertain anti-Trinitarian views, and to be troubled in conscience about their inconsistency with the Anglican belief; since 1769 the intimate friendship of Joseph Priestley had served to foster his scruples, and in 1771 he united with Francis Blackburne, archdeacon of Cleveland (his father-in-law), John Jebb (1736-1786), Christopher Wyvill (1740-1822) and Edmund Law (1703-1787), bishop of Carlisle, in preparing a petition to parliament with the prayer that clergymen of the church and graduates of the universities might be relieved from the burden of subscribing to the thirty-nine articles, and “restored to their undoubted rights as Protestants of interpreting Scripture for themselves.” Two hundred and fifty signatures were obtained, but in February 1772 the House of Commons declined even to receive the petition by a majority of 217 to 71; the adverse vote was repeated in the following year, and in the end of 1773, seeing no prospect of obtaining within the church the relief which his conscience demanded, Lindsey resigned his vicarage. In April 1774 he began to conduct Unitarian services in a room in Essex Street, Strand, London, where first a church, and afterwards the Unitarian offices, were established. Here he remained till 1793, when he resigned his charge in favour of John Disney (1746-1816), who like himself had left the established church and had become his colleague. He died on the 3rd of November 1808.

Lindsey’s chief work is *An Historical View of the State of the Unitarian Doctrine and Worship from the Reformation to our own Times* (1783); in it he claims, amongst others, Burnet, Tillotson, S. Clarke, Hoadly and Sir I. Newton for the Unitarian view. His other publications include *Apology on Resigning the Vicarage of Catterick* (1774), and *Sequel to the Apology* (1776); *The Book of Common Prayer reformed according to the plan of the late Dr Samuel Clarke* (1774); *Dissertations on the Preface to St John’s Gospel and on praying to Jesus Christ* (1779); *Vindiciae Priestleianae* (1788); *Conversations upon Christian Idolatry* (1792); and *Conversations on the Divine Government, showing that everything is from God, and for good to all* (1802). Two volumes of *Sermons, with appropriate prayers annexed*, were published posthumously in 1810; and a volume of Memoirs, by Thomas Belsham, appeared in 1812.

LINDSTRÖM, GUSTAF (1829-1901), Swedish palaeontologist, was born at Wisby in Gotland on the 27th of August 1829. In 1848 he entered the university at Upsala, and in 1854 he took his doctor’s degree. Having attended a course of lectures in Stockholm by S. L. Lovén, he became interested in the zoology of the Baltic, and published several papers on the invertebrate fauna, and subsequently on the fishes. In 1856 he became a school teacher, and in 1858 a master in the grammar school at Wisby. His leisure was devoted to researches on the fossils of the Silurian rocks of Gotland, including the corals, brachiopods, gasteropods, pteropods, cephalopods and crustacea. He described also remains of the fish *Cyathaspis* from Wenlock Beds, and (with T. Thorell) a scorpion *Palaeaphonus* from Ludlow Beds at Wisby. He determined the true nature of the operculated coral *Calceola*; and while he described organic remains from other parts of northern Europe, he worked especially at the Palaeozoic fossils of Sweden. He was awarded the Murchison medal by the Geological Society of London in 1895. In 1876 he was appointed keeper of the fossil Invertebrata in the State Museum at Stockholm, where he died on the 16th of May 1901.

See obituary (with portrait), by F. A. Bather, in *Geol. Mag.* (July 1901), p. 333.

LINDUS, one of the three chief cities of the island of Rhodes, before their synoecism in the city of Rhodes. It is situated on the E. side of the island, and has a finely placed acropolis on a precipitous hill, and a good natural harbour just N. of it. Recent excavations have discovered the early temple of Athena Lindia on the Acropolis, and splendid Propylaea and a staircase, resembling those at Athens. The sculptors of the Laocoon are among the priests of Athena Lindia, whose names are recorded by inscriptions. Some early temples have also been found, and inscriptions cut on the rock recording the sacrifices known as Βουκάτια. There are also traces of a theatre and rock-cut tombs. On the Acropolis is a castle, built by the knights in the 14th century, and many houses in the town show work of the same date.

See Rhodes; also Chr. Blinkenberg and K. F. Kinch, *Exploration arch. de Rhodes* (Copenhagen, 1904-1907).

LINE, a word of which the numerous meanings may be deduced from the primary ones of thread or cord, a succession of objects in a row, a mark or stroke, a course or route in any particular direction. The word is derived from the Lat. *linea*, where all these meanings may be found, but some applications are due more directly to the Fr. *ligne*. *Linea*, in Latin, meant originally “something made of hemp or flax,” hence a cord or thread, from *linum*, flax. “Line” in English was formerly used in the sense of flax, but the use now only survives in the technical name for the fibres of flax when separated by heckling from the tow (see Linen). The ultimate origin is also seen in the verb “to line,” to cover something on the inside, originally used of the “lining” of a garment with linen.

In mathematics several definitions of the line may be framed according to the aspect from which it is viewed. The synthetical genesis of a line from the notion of a point is the basis of Euclid’s definition, γραμμὴ, δὲ μῆκος ἀπλατές (“a line is widthless length”), and in a subsequent definition he affirms that the boundaries of a line are points, γραμμῆς δὲ πέρατα σημεῖα. The line appears in definition 6 as the boundary of a surface: ἐπιφανείας δὲ πέρατα γραμμαί (“the boundaries of a surface are lines”). Another synthetical definition, also treated by the ancient Greeks, but not by Euclid, regards the line as generated by the motion of a point (ῥύσις σημείου), and, in a similar manner, the “surface” was regarded as the flux of a line, and a “solid” as the flux of a surface. Proclus adopts this view, styling the line ἀρχή in respect of this capacity. Analytical definitions, although not finding a place in the Euclidean treatment, have advantages over the synthetical derivation. Thus the boundaries of a solid may define a plane, the edges a line, and the corners a point; or a section of a solid may define the surface, a section of a surface the line, and the section of a line the “point.” The notion of dimensions follows readily from either system of definitions. The solid extends three ways, *i.e.* it has length, breadth and thickness, and is therefore three-dimensional; the surface has breadth and length and is therefore two-dimensional; the line has only extension and is unidimensional; and the point, having neither length, breadth nor thickness but only position, has no dimensions.

The definition of a “straight” line is a matter of much complexity. Euclid defines it as the line which lies evenly with respect to the points on itself—εὐθεῖα γραμμή ἐστιν ἥτις ἐξ ἴσου τοῖς ἐφ᾽ ἑαυτῆς σημείοις κεῖται: Plato defined it as the line having its middle point hidden by the ends, a definition of no purpose since it only defines the line by the path of a ray of light. Archimedes defines a straight line as the shortest distance 721
between two points.

A better criterion of rectilinearity is that of Simplicius, an Arabian commentator of the 5th century: *Linea recta est quaecumque super duas ipsius extremitates rotata non movetur de loco suo ad alium locum* (“a straight line is one which when rotated about its two extremities does not change its position”). This idea was employed by Leibnitz, and most auspiciously by Gierolamo Saccheri in 1733.

The drawing of a straight line between any two given points forms the subject of Euclid’s first postulate—ᾐτήσθω ἀπὸ παντὸς σημείου ἐπὶ πᾶν σημεῖον εὐθεῖαν γραμμὴν ἀγάγειν, and the producing of a straight line continuously in a straight line is treated in the second postulate—καὶ πεπερασμένην εὐθεῖαν κατὰ τὸ συνεχὲς ἐπ᾽ εὐθείας ἐκβαλεῖν.

For a detailed analysis of the geometrical notion of the line and rectilinearity, see W. B. Frankland, *Euclid’s Elements* (1905). In analytical geometry the right line is always representable by an equation or equations of the first degree; thus in Cartesian coordinates of two dimensions the equation is of the form $Ax + By + C = 0$, in triangular coordinates $Ax + By + Cz = 0$. In three-dimensional coordinates, the line is represented by two linear equations. (See Geometry, Analytical.) *Line geometry* is a branch of analytical geometry in which the line is the element, and not the point as with ordinary analytical geometry (see Geometry, Line).

LINE ENGRAVING, on plates of copper or steel, the method of engraving (*q.v.*), in which the line itself is hollowed, whereas in the woodcut when the line is to print black it is left in relief, and only white spaces and white lines are hollowed.

The art of line engraving has been practised from the earliest ages. The prehistoric Aztec hatchet given to Humboldt in Mexico was just as truly *engraved* as a modern copper-plate which may convey a design by Flaxman; the Aztec engraving is ruder than the European, but it is the same art. The important discovery which made line engraving one of the multiplying arts was the discovery how to print an incised line, which was hit upon at last by accident, and known for some time before its real utility was suspected. Line engraving in Europe does not owe its origin to the woodcut, but to the chasing on goldsmiths' work. The goldsmiths of Florence in the middle of the 15th century were in the habit of ornamenting their works by means of engraving, after which they filled up the hollows produced by the burin with a black enamel made of silver, lead and sulphur, the result being that the design was rendered much more visible by the opposition of the enamel and the metal. An engraved design filled up in this manner was called a *niello*. Whilst a niello was in progress the artist could not see it so well as if the enamel were already in the lines, yet he did not like to put in the hard enamel prematurely, as when once it was set it could not easily be got out again. He therefore took a sulphur cast of his niello in progress, on a matrix of fine clay, and filled up the lines in the sulphur with lampblack, thus enabling himself to judge of the state of his engraving. At a later period it was discovered that a proof could be taken on damped paper by filling the engraved lines with a certain ink and wiping it off the surface of the plate, sufficient pressure being applied to make the paper go into the hollowed lines and fetch the ink out of them. This was the beginning of plate printing. The niello engravers thought it a convenient way of proving their work—the metal itself—as it saved the trouble of the sulphur cast, but they saw no further into the future. They went on engraving nielli just the same to ornament plate and furniture; nor was it until the 16th century that the new method of printing was carried out to its great and wonderful results. There are, however, certain differences between plate-printing and block-printing which affect the essentials of art. When paper is driven *into* a line so as to fetch the ink out of it, the line may be of unimaginable fineness, it will print all the same; but when the paper is only pressed *upon* a raised line, the line must have some appreciable thickness; the wood engraving, therefore, can never—except in a *tour de force*—be so delicate as plate engraving. Again, not only does plate-printing excel block-printing in delicacy; it excels it also in force and depth. There never was, and there will never be, a woodcut line having the power of a deep line in a plate, for in block-printing the line is only a blackened surface of paper slightly impressed, whereas in plate-printing it is a *cast* with an additional thickness of printing ink.

The most important of the tools used in line-engraving is the burin, which is a bar of steel with one end fixed in a handle rather like a mushroom with one side cut away, the burin itself being shaped so that the cutting end when sharpened takes the form of a lozenge, point downwards. The burin acts exactly like a plough; it makes a furrow and turns out a shaving of metal as the plough turns the soil of a field. The burin, however, is pushed while the plough is pulled, and this peculiar character of the burin, or graver, as a pushed instrument at once establishes a wide separation between it and all the other instruments employed in the arts of design, such as pencils, brushes, pens and etching needles.

> The elements of engraving with the burin upon metal will be best understood by an example of a very simple kind, as in the engraving of letters. The capital letter B contains in itself the rudiments of an engraver's education. As at first drawn, before the blacks are inserted, this letter consists of two perpendicular straight lines and four curves, all the curves differing from each other. Suppose, then, that the engraver has to make a B, he will scratch these lines, reversed, very lightly with a sharp point or style. The next thing is to cut out the blacks (not the whites, as in wood engraving), and this would be done with two different burins. The engraver would get his vertical black line by a powerful ploughing with the burin between his two preparatory first lines, and then take out some copper in the thickest parts of the two curves. This done, he would then take a finer burin and work out the gradation from the thick line in the midst of the curve to the thin extremities which touch the perpendicular. When there is much gradation in a line the darker parts of it are often gradually ploughed out by returning to it over and over again. The hollows so produced are afterwards filled with printing ink, just as the hollows in a niello were filled with black enamel; the surplus printing ink is wiped from the smooth surface of the copper, damped paper is laid upon it, and driven into the hollowed letter by the pressure of a revolving cylinder; it fetches the ink out, and you have your letter B in intense black upon a white ground.
>
> When the surface of a metal plate is sufficiently polished to be used for engraving, the slightest scratch upon it will print as a black line, the degree of blackness being proportioned to the depth of the scratch. An engraved plate from which visiting cards are printed is a good example of some elementary principles of engraving. It contains thin lines and thick ones, and a considerable variety of curves. An elaborate line engraving, if it is a pure line engraving and nothing else, will contain only these simple elements in different combinations. The real line engraver is always engraving a line more or less broad and deep in one direction or another; he has no other business than this.

In the early Italian and early German prints, the line is used with such perfect simplicity of purpose that the methods of the artists are as obvious as if we saw them actually at work.

The student may soon understand the spirit and technical quality of the earliest Italian engraving by giving his attention to a few of the series which used erroneously to be called the "Playing Cards of Mantegna," but which have been shown by Mr Sidney Colvin to represent "a kind of encyclopaedia of knowledge."

The history of these engravings is obscure. They are supposed to be Florentine; they are certainly Italian; and their technical manner is called that of Baccio Baldini. But their style is as clear as a style can be, as clear as the artist's conception of his art. In all these figures the outline is the main thing, and next to that the lines which mark the leading folds of the drapery; lines quite classical in purity of form and severity of selection, and especially characteristic in this, that they are always really engraver's lines, such as may naturally be done with the burin, and they never imitate the freer line of the pencil or etching needle. Shading is used in the greatest moderation with thin straight strokes of the burin, that never overpower the stronger organic lines of the design. Of chiaroscuro, in any complete sense, there is none. The sky behind the figures is represented by white paper, and the foreground is sometimes occupied by flat decorative engraving, much nearer in feeling to calligraphy than to modern painting. Sometimes there is a cast shadow, but it is not studied, and is only used to give relief. In this early metal engraving the lines are often 722 crossed in the shading, whereas in the earliest woodcuts they are not; the reason being that when lines are incised they can as easily be crossed as not, whereas, when they are reserved, the crossing involves much labour of a non-artistic kind. Here, then, we have pure line-engraving with the burin, that is, the engraving of the pure line patiently studied for its own beauty, and exhibited in an abstract manner, with care for natural form combined with inattention to the effects of nature. Even the forms are idealized, especially in the cast of draperies, for the express purpose of exhibiting the line to better advantage. Such are the characteristics of those very early Italian engravings which were attributed erroneously to Mantegna. When we come to Mantegna himself we find a style equally decided. Drawing and shading were for him two entirely distinct things. He did not draw and shade at the same time, as a modern chiaroscurist would, but he first got his outlines and the patterns on his dresses all very accurate, and then threw over them a veil of shading, a very peculiar kind of shading, all the lines being straight and all the shading diagonal. This is the primitive method, its peculiarities being due, not to a learned self-restraint, but to a combination of natural genius with technical inexperience, which made the early Italians at once desire and discover the simplest and easiest methods. Whilst the Italians were shading with straight lines the Germans had begun to use curves, and as soon as the Italians saw good German work they tried to give to their burins something of the German suppleness.

The characteristics of early metal engraving in Germany are seen to perfection in Martin Schongauer and Albert Dürer, who, though with striking differences, had many points in common. Schongauer died in 1488; whilst the date of Dürer's death is 1528. Schongauer was therefore a whole generation before Dürer, yet not greatly inferior to him in the use of the burin, though Dürer has a much greater reputation, due in great measure to his singular imaginative powers. Schongauer is the first great German engraver known by name, but he was preceded by an unknown German master, called "the Master of 1466," who had Gothic notions of art (in strong contrast to the classicism of Baccio Baldini), but used the burin skilfully, conceiving of line and shade as separate elements, yet shading with an evident desire to follow the form of the thing shaded, and with lines in various directions. Schongauer's art is a great stride in advance, and we find in him an evident pleasure in the bold use of the burin. Outline and shade, in Schongauer, are not nearly so much separated as in Baccio Baldini, and the shading, generally in curved lines, is far more masterly than the straight shading of Mantegna. Dürer continued Schongauer's curved shading, with increasing manual delicacy and skill; and as he found himself able to perform feats with the burin which amused both himself and his buyers, he over-loaded his plates with quantities of living and inanimate objects, each of which he finished with as much care as if it were the most important thing in the composition. The engravers of those days had no conception of any necessity for subordinating one part of their work to another; they drew, like children, first one object and then another object, and so on until the plate was furnished from top to bottom and from the left side to the right. Here, of course, is an element of facility in primitive art which is denied to the modern artist. In Dürer all objects are on the same plane. In his "St Hubert" (otherwise known as "St Eustace") of c. 1505, the stag is quietly standing on the horse's back, with one hoof on the saddle, and the kneeling knight looks as if he were tapping the horse on the nose. Dürer seems to have perceived the mistake about the stag, for he put a tree between us and the animal to correct it, but the stag is on the horse's back nevertheless. This ignorance of the laws of effect is least visible and obtrusive in plates which have no landscape distances, such as "The Coat of Arms with the Death's Head" (1503) and "The Coat of Arms with the Cock" (*c.* 1512).

Dürer's great manual skill and close observation made him a wonderful engraver of objects taken separately. He saw and rendered all objects; nothing escaped him; he applied the same intensity of study to everything. Though a thorough student of the nude—witness his Adam and Eve (1504) and other plates—he would pay just as much attention to the creases of a gaiter as to the development of a muscle; and though man was his main subject, he would study dogs with equal care (see the five dogs in the "St Hubert"), as well as pigs (see the "Prodigal Son," *c.* 1495); and at a time when landscape painting was unknown he studied every clump of trees, every visible trunk and branch, nay, every foreground plant, and each leaf of it separately. In his buildings he saw every brick like a bricklayer, and every joint in the woodwork like a carpenter. The immense variety of the objects which he engraved was a training in suppleness of hand. His lines go in every direction, and are made to render both the undulations of surfaces (see the plane in the Melencolia, 1514) and their texture (see the granular texture of the stones in the same print).

From Dürer we come to Italy again, through Marcantonio, who copied Dürer, translating more than sixty of his woodcuts upon metal. It is one of the most remarkable things in the history of art, that a man who had trained himself by copying northern work, little removed from pure Gothicism, should have become soon afterwards the great engraver of Raphael, who was much pleased with his work and aided him by personal advice. Yet, although Raphael was a painter, and Marcantonio his interpreter, the reader is not to infer that engraving had as yet subordinated itself to painting. Raphael himself evidently considered engraving a distinct art, for he never once set Marcantonio to work from a picture, but always (much more judiciously) gave him drawings, which the engraver might interpret without going outside his own art; consequently Marcantonio's works are always genuine engravings, and are never pictorial. Marcantonio was an engraver of remarkable power. In him the real pure art of line-engraving reached its maturity. He retained much of the early Italian manner in his backgrounds, where its simplicity gives a desirable sobriety; but his figures are boldly modelled in curved lines, crossing each other in the darker shades, but left single in the passages from dark to light, and breaking away in fine dots as they approach the light itself, which is of pure white paper. A school of engraving was thus founded by Raphael, through Marcantonio, which cast aside the minute details of the early schools for a broad, harmonious treatment.

The group known as the engravers of Rubens marked a new development. Rubens understood the importance of engraving as a means of increasing his fame and wealth, and directed Vorsterman and others. The theory of engraving at that time was that it ought not to render accurately the local colour of painting, which would appear wanting in harmony when dissociated from the hues of the picture; and it was one of the anxieties of Rubens so to direct his engravers that the result might be a fine plate independently of what he had painted. To this end he helped his engravers by drawings, in which he sometimes indicated what he thought the best direction for the lines. Rubens liked Vorsterman’s work, and scarcely corrected it, a plate he especially approved being “Susannah and the Elders,” which is a learned piece of work well modelled, and shaded everywhere on the figures and costumes with fine curved lines, the straight line being reserved for the masonry. Vorsterman quitted Rubens after executing fourteen important plates, and was succeeded by Paul Pontius, then a youth of twenty, who went on engraving from Rubens with increasing skill until the painter’s death. Boetius a Bolswert engraved from Rubens towards the close of his life, and his brother Schelte a Bolswert engraved more than sixty compositions of Rubens, of the most varied character, including hunting scenes and landscapes. This brings us to the engraving of landscape as a separate study. Rubens treated landscape in a broad comprehensive manner, and Schelte’s way of engraving it was also broad and comprehensive. The lines are long and often undulating, the cross-hatchings bold and rather obtrusive, for they often substitute unpleasant reticulations for the refinement and mystery of nature, but it was a beginning, and a vigorous beginning. The technical developments of engraving under the influence of Rubens may be summed up briefly as follows: (1) The Italian outline had been discarded as the chief subject of 723
attention, and modelling had been substituted for it; (2) broad masses had been substituted for the minutely finished detail of the northern schools; (3) a system of light and dark had been adopted which was not pictorial, but belonged especially to engraving, which it rendered (in the opinion of Rubens) more harmonious.

The history of line-engraving, from the time of Rubens to the beginning of the 19th century, is rather that of the vigorous and energetic application of principles already accepted than any new development. From the two sources already indicated, the school of Raphael and the school of Rubens, a double tradition flowed to England and France, where it mingled and directed English and French practice. The first influence on English line-engraving was Flemish, and came from Rubens through Vandyck, Vorsterman, and others; but the English engravers soon underwent French and Italian influences, for although Payne learned from a Fleming, Faithorne studied in France under Philippe de Champagne the painter and Robert Nanteuil the engraver. Sir Robert Strange studied in France under Philippe Lebas, and then five years in Italy, where he saturated his mind with Italian art. French engravers came to England as they went to Italy, so that the art of engraving became in the 18th century cosmopolitan. In figure-engraving the outline was less and less insisted upon. Strange made it his study to soften and lose the outline. Meanwhile, the great classical Renaissance school, with Gérard Audran at its head, had carried forward the art of modelling with the burin, and had arrived at great perfection of a sober and dignified kind. Audran was very productive in the latter half of the 17th century, and died in 1703, after a life of severe self-direction in labour, the best external influence he underwent being that of the painter Nicolas Poussin. He made his work more rapid by the use of etching, but kept it entirely subordinate to the work of the burin. One of the finest of his large plates is “St John Baptizing,” from Poussin, with groups of dignified figures in the foreground and a background of grand classical landscape, all executed with the most thorough knowledge according to the ideas of that time. The influence of Claude Lorrain on the engraving of landscape was exercised less through his etchings than his pictures, which compelled the engravers to study delicate distinctions in the values of light and dark. Through Woollett and Vivarès, Claude exercised an influence on landscape engraving almost equal to that of Raphael and Rubens on the engraving of the figure, though he did not direct his engravers personally.

In the 19th century line-engraving received first an impulse and finally a check. The impulse came from the growth of public wealth, the increasing interest in art and the increase in the commerce of art, which, by means of engraving, fostered in England mainly by John Boydell, penetrated into the homes of the middle classes, as well as from the growing demand for illustrated books, which gave employment to engravers of first-rate ability. The check to line-engraving came from the desire for cheaper and more rapid methods, a desire satisfied in various ways, but especially by etching and by the various kinds of photography. Nevertheless, the 19th century produced most highly accomplished work in line-engraving, both in the figure and in landscape. Its characteristics, in comparison with the work of other centuries, were chiefly a more thorough and delicate rendering of local colour, light and shade, and texture. The elder engravers could draw as correctly as the moderns, but they either neglected these elements or admitted them sparingly, as opposed to the spirit of their art. In a modern engraving from Landseer may be seen the blackness of a man’s boots (local colour), the soft roughness of his coat (texture), and the exact value in light and dark of his face and costume against the cloudy sky. Nay more, there is to be found every sparkle on bit, boot and stirrup. Modern painting pays more attention to texture and chiaroscuro than classical painting did, and engraving necessarily followed in the same directions. But there is a certain sameness in pure line-engraving more favourable to some forms and textures than to others. This sameness of line-engraving, and its costliness, led to the adoption of mixed methods, extremely prevalent in commercial prints from popular artists. In the well-known prints from Rosa Bonheur, for example, by T. Landseer, H. T. Ryall, and C. G. Lewis, the tone of the skies is got by machine-ruling, and so is much undertone in the landscape; the fur of the animals is all etched, and so are the foreground plants, the real burin work being used sparingly where most favourable to texture. Even in the exquisite engravings after Turner, by Cooke, Goodall, Wallis, Miller, Willmore, and others, who reached a degree of delicacy in light and shade far surpassing the work of the old masters, the engravers had recourse to etching, finishing with the burin and dry point. Turner’s name may be added to those of Raphael, Rubens and Claude in the list of painters who have had a special influence upon engraving. The speciality of Turner’s influence was in the direction of delicacy of tone. In this respect the Turner vignettes to Roger’s poems were a high-water mark of human attainment, not likely ever to be surpassed.

The record of the art of line-engraving during the last quarter of the 19th century is one of continued decay. Technical improvements, it was hoped, might save the art; it was thought by some that the slight revival resultant on the turning back of the burin’s cutting-point—whereby the operator pulled the tool towards him instead of pushing it from him—might effect much, in virtue of the time and labour saved by the device. But by the beginning of the 20th century pictorial line-engraving in England was practically non-existent, and, with the passing of Jeens and Stacpoole, the spasmodic demand by publishers for engravers to engrave new plates remained unanswered. Mr C. W. Sherborn, the exquisite and facile designer and engraver of book-plates, has scarcely been surpassed in his own line, but his art is mainly heraldic. There are now no men capable of such work as that with which Doo, J. H. Robinson, and their fellows maintained the credit of the English School. Line-engraving has been killed by etching, mezzotint and the “mixed method.” The disappearance of the art is due not so much to the artistic objection that the personality of the line-engraver stands obtrusively between the painter and the public; it is rather that the public refuse to wait for several years for the proofs for which they have subscribed, when by another method they can obtain their plates more quickly. An important line plate may occupy a prodigious time in the engraving; J. H. Robinson’s “Napoleon and the Pope” took about twelve years. The invention of steel-facing a copper plate would now enable the engraver to proceed more expeditiously; but even in this case he can no more compete with the etcher than the mezzotint-engraver can keep pace with the photogravure manufacturer.

The Art Union of London in the past gave what encouragement it could; but with the death of J. Stephenson (1886) and F. Bacon (1887) it was evident that all hope was gone. John Saddler at the end was driven, in spite of his capacity to do original work, to spend most of his time in assisting Thomas Landseer to rule the skies on his plates, simply because there was not enough line-engraving to do. Since then there was some promise of a revival, and Mr Bourne engraved a few of the pictures by Gustave Doré. But little followed. The last of the line-engravers of Turner’s pictures died in the person of Sir Daniel Wilson (d. 1892), who, recognizing the hopelessness of his early profession, laid his graver aside, and left Europe for Canada and eventually became president of the university of Toronto.

If line-engraving still flourishes in France, it is due not a little to official encouragement and to intelligent fostering by collectors and connoisseurs. The prizes offered by the École des Beaux Arts would probably not suffice to give vitality to the art but for the employment afforded to the finished artist by the “Chalcographie du Musée du Louvre,” in the name of which commissions are judiciously distributed. At the same time, it must be recognized that not only are French engravers less busy than they were in days when line-engraving was the only “important” method of picture-translation, but they work for the most part for much smaller rewards. Moreover, the class of the work has entirely changed, partly through the reduction of prices paid for it, partly through the change of taste and fashion, and partly, again, through the necessities of the situation. That is 724
to say, that public impatience is but a partial factor in the abandonment of the fine broad sweeping trough cut deep into the copper which was characteristic of the earlier engraving, either simply cut or crossed diagonally so as to form the series of “lozenges” typical of engraving at its finest and grandest period. That method was slow; but scarcely less slow was the shallower work rendered possible by the steel plate by reason of the much greater degree of elaboration of which such plates were capable, and which the public was taught—mainly by Finden—to expect. The French engravers were therefore driven at last to simplify their work if they were to satisfy the public and live by the burin. To compensate for loss of colour, the art developed in the direction of elegance and refinement. Gaillard (d. 1887), Blanchard, and Alphonse François (d. 1888) were perhaps the earliest chiefs of the new school, the characteristics of which are the substitution of exquisite greys for the rich blacks of old, simplicity of method being often allied to extremely high elaboration. Yet the aim of the modern engraver has always been, while pushing the capability of his own art to the farthermost limit, to retain throughout the individual and personal qualities of the master whose work is translated on the plate. The height of perfection to which the art is reached is seen in the triptych of Mantegna by Achille Jacquet (d. 1909), to whom may perhaps be accorded the first place among several engravers of the front rank. This “Passion” (from the three pictures in the Louvre and at Tours, forming the predella of the San Zeno altarpiece in Verona) not only conveys the forms, sentiment, and colour of the master, but succeeds also in rendering the peculiar luminosity of the originals. Jacquet, who gained the *Prix de Rome* in 1870, also translated pictures of Sir Joshua Reynolds, and engraved fine plates after Paul Dubois, Cabanel, Bouguereau, Meissonier and Detaille. The freedom of much of his work suggests an affinity with etching and dry-point; indeed, it appears that he uses the etching-needle and acid to lay in some of his groundwork and outlines. Léopold Flameng’s engraving after Jan van Eyck’s “Virgin with the Donor,” in the Louvre, is one of the most admirable works of its kind, retaining the quality and sentiment of the master,

extreme minuteness and elaboration notwithstanding. Jules Jacquet is known for his work after Meissonier (especially the “Friedland”) and after Bonnat; Adrien Didier for his plates after Holbein (“Anne of Cleves”), Raphael, and Paul Veronese, among the Old Masters, and Bonnat, Bouguereau, and Roybet among the new. Jazinski (Botticelli’s “Primavera”), Sulpis (Mantegna and Gustave Moreau), Patricot (Gustave Moreau), Burney, and Champollion (d. 1901), have been among the leaders of the modern school. Their object is to secure the faithful transcript of the painter they reproduce, while readily sacrificing the power of the old method, which, whatever its force and its beauty, was easily acquired by mediocre artists of technical ability who were nevertheless unable to appreciate or reproduce anything beyond mechanical excellence.

The Belgian School of engraving is not without vitality. Gustave Biot was equally skilful in portraiture and subject (engraving after Gallait, Cabanel, Gustave Doré, among his best work); A. M. Danse executed plates after leading painters, and elaborated an effective “mixed method” of graver-work and dry-point; and de Meerman has engraved a number of good plates; but private patronage is hardly sufficient in Belgium to maintain the school in a state of prosperous efficiency.

In Germany, as might be expected, line-engraving retains not a little of its popularity in its more orthodox form. The novel Stauffer-Bern method, in which freedom and lightness are obtained with such delicacy that the fine lines, employed in great numbers, run into tone, and yield a supposed advantage in modelling, has not been without appreciation. But the more usual virtue of the graver has been best supported, and many have worked in the old-fashioned manner. Friedrich Zimmermann (d. 1887) began his career by engraving such prints as Guido Reni’s “Ecce Homo” in Dresden, and then devoted himself to the translation of modern German painters. Rudolph Pfnor was an ornamentist representative of his class; and Joseph Kohlschein, of Düsseldorf, a typical exponent of the intelligent conservative manner. His “Marriage at Cana” after Paul Veronese, “The Sistine Madonna” after Raphael, and “St Cecilia” after the same master, are all plates of a high order.

In Italy the art is well-nigh as moribund as in England. When Vittorio Pica (of Naples) and Conconi (of Milan) have been named, it is difficult to mention other successors to the fine school of the 19th century which followed Piranesi and Volpato. A few of the pupils of Rosaspina and Paolo Toschi lived into the last quarter of the century, but to the present generation Asiolo, Jesi, C. Raimondi, L. Bigola, and Antonio Isac are remembered rather for their efforts than for their success in supporting their art against the combined opposition of etching, “process” and public indifference.

Outside Europe line-engraving can no longer be said to exist. Here and there a spasmodic attempt may be made to appeal to the artistic appreciation of a limited public; but no general attention is paid to such efforts, nor, it may be added, are these inherently worthy of much notice. There are still a few who can engrave a head from a photograph or drawing, or a small engraving for book-illustration or for book-plates; there are more who are highly proficient in mechanical engraving for decorative purposes; but the engraving-machine is fast superseding this class. In short, the art of worthily translating a fine painting beyond the borders of France, Belgium, Germany and perhaps Italy can scarcely be said to survive, and even in those countries it appears to exist on sufferance and by hot-house encouragement.

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(P. G. H.; M. H. S.)

LINEN and **LINEN MANUFACTURES.** Under the name of linen are comprehended all yarns spun and fabrics woven from flax fibre (see Flax).

From the earliest periods of human history till almost the close of the 18th century the linen manufacture was one of the most extensive and widely disseminated of the domestic industries of European countries. The industry was most largely developed in Russia, Austria, Germany, Holland, Belgium, the northern provinces of France, and certain parts of England, in the north of Ireland, and throughout Scotland; and in these countries its importance was generally recognized by the enactment of special laws, having for their object the protection and extension of the trade. The inventions of Arkwright, Hargreaves and Crompton in the later part of the 18th century, benefiting almost exclusively the art of cotton-spinning, and the unparalleled development of that branch of textile manufactures, largely due to the ingenuity of these inventors, gave the linen trade as it then existed a fatal blow. Domestic spinning, and with it hand-loom weaving, immediately began to shrink; the trade which had supported whole villages and provinces entirely disappeared, and the linen manufacture, in attenuated dimensions and changed conditions, took refuge in special localities, where it resisted, not unsuccessfully, the further assaults of cotton, and, with varying fortunes, rearranged its relations in the community of textile industries. The linen industries of the United Kingdom were the first to suffer from the aggression of cotton; more slowly the influence of the rival textile reached other countries.

In 1810 Napoleon I. offered a reward of one million francs to any inventor who should devise the best machinery for the spinning of flax yarn. 725
Within a few weeks thereafter Philippe de Girard patented in France important inventions for flax spinning by both dry and wet methods. His inventions, however, did not receive the promised reward and were neglected in his native country. In 1815 he was invited by the Austrian government to establish a spinning mill at Hirtenberg near Vienna, which was run with his machinery for a number of years, but it failed to prove a commercial success. In the meantime English inventors had applied themselves to the task of adapting machines to the preparation and spinning of flax. The foundation of machine spinning of flax was laid by John Kendrew and Thomas Porthouse of Darlington, who, in 1787, secured a patent for “a mill or machine upon new principles for spinning yarn from hemp, tow, flax or wool.” By innumerable successive improvements and modifications, the invention of Kendrew and Porthouse developed into the perfect system of machinery with which, at the present day, spinning-mills are furnished; but progress in adapting flax fibres for mechanical spinning, and linen yarn for weaving cloth by power-loom was much slower than in the corresponding case of cotton.

Till comparatively recent times, the sole spinning implements were the spindle and distaff. The spindle, which is the fundamental apparatus in all spinning machinery, was a round stick or rod of wood about 12 in. in length, tapering towards each extremity, and having at its upper end a notch or slit into which the yarn might be caught or fixed. In general, a ring or “whorl” of stone or clay was passed round the upper part of the spindle to give it momentum and steadiness when in rotation, while in some few cases an ordinary potato served the purpose of a whorl. The distaff, or rock, was a rather longer and stronger bar or stick, around one end of which, in a loose coil or ball, the fibrous material to be spun was wound. The other extremity of the distaff was carried under the left arm, or fixed in the girdle at the left side, so as to have the coil of flax in a convenient position for drawing out to form the yarn. A prepared end of yarn being fixed into the notch, the spinster, by a smart rolling motion of the spindle with the right hand against the right leg, threw it out from her, spinning in the air, while, with the left hand, she drew from the rock an additional supply of fibre which was formed into a uniform and equal strand with the right. The yarn being sufficiently twisted was released from the notch, wound around the lower part of the spindle, and again fixed in the notch at the point insufficiently twisted; and so the rotating, twisting and drawing out operations went on till the spindle was full. So persistent is an ancient and primitive art of this description that in remote districts of Scotland—a country where machine spinning has attained a high standard—spinning with rock and spindle is still practised;[1] and yarn of extraordinary delicacy, beauty and tenacity has been spun by their agency. The first improvement on the primitive spindle was found in the construction of the hand-wheel, in which the spindle, mounted in a frame, was fixed horizontally, and rotated by a band passing round it and a large wheel, set in the same framework. Such a wheel became known in Europe about the middle of the 16th century, but it appears to have been in use for cotton spinning in the East from time immemorial. At a later date, which cannot be fixed, the treadle motion was attached to the spinning wheel, enabling the spinster to sit at work with both hands free; and the introduction of the two-handed or double-spindle wheel, with flyers or twisting arms on the spindles, completed the series of mechanical improvements effected on flax spinning till the end of the 18th century. The common use of the two-handed wheel throughout the rural districts of Ireland and Scotland is a matter still within the recollection of some people; but spinning wheels are now seldom seen.

The modern manufacture of linen divides itself into two branches, spinning and weaving, to which may be added the bleaching and various finishing processes, which, in the case of many linen textures, are laborious undertakings and important branches of industry. The flax fibre is received in bundles from the scutch mill, and after having been classed into various grades, according to the quality of the material, it is labelled and placed in the store ready for the flax mill. The whole operations in yarn manufacture comprise (1) hackling, (2) preparing and (3) spinning.

Hackling.—This first preparatory process consists not only in combing out, disentangling and laying smooth and parallel the separate fibres, but also serves to split up and separate into their ultimate filaments the strands of fibre which, up to this point, have been agglutinated together. The hackling process was originally performed by hand, and it was one of fundamental importance, requiring the exercise of much dexterity and judgment. The broken, ravelled and short fibres, which separate out in the hackling process, form tow, an article of much inferior value to the spinner. A good deal of hand-hackling is still practised, especially in Irish and continental mills; and it has not been found practicable, in any case, to dispense entirely with a rough preparation of the fibre by hand labour. In hackling by hand, the hackler takes a handful or “strick” of rough flax, winds the top end around his hands, and then, spreading out the root end as broad and flat as possible, by a swinging motion dashes the fibre into the hackle teeth or needles of the rougher or “ruffer.” The rougher is a board plated with tin, and studded with spikes or teeth of steel about 7 in. in length, which taper to a fine sharp point. The hackler draws his strick several times through this tool, working gradually up from the roots to near his hand, till in his judgment the fibres at the root end are sufficiently combed out and smoothed. He then seizes the root end and similarly treats the top end of the strick. The same process is again repeated on a similar tool, the teeth of which are 5 in. long, and much more closely studded together; and for the finer counts of yarn a third and a fourth hackle may be used, of still increasing fineness and closeness of teeth. In dealing with certain varieties of the fibre, for fine spinning especially, the flax is, after roughing, broken or cut into three lengths—the top, middle and root ends. Of these the middle cut is most valuable, being uniform in length, strength and quality. The root end is more woody and harsh, while the top, though fine in quality, is uneven and variable in strength. From some flax of extra length it is possible to take two short middle cuts; and, again, the fibre is occasionally only broken into two cuts. Flax so prepared is known as “cut line” in contradistinction to “long line” flax, which is the fibre unbroken. The subsequent treatment of line, whether long or cut, does not present sufficient variation to require further reference to these distinctions.

In the case of hackling by machinery, the flax is first roughed and arranged in stricks, as above described under hand hackling. In the construction of hackling machines, the general principles of those now most commonly adopted are identical. The machines are known as vertical sheet hackling machines, their essential features being a set of endless leather bands or sheets revolving over a pair of rollers in a vertical direction. These sheets are crossed by iron bars, to which hackle stocks, furnished with teeth, are screwed. The hackle stocks on each separate sheet are of one size and gauge, but each successive sheet in the length of the machine is furnished with stocks of increasing fineness, so that the hackling tool at the end where the flax is entered is the coarsest, say about four pins per inch, while that to which the fibre is last submitted has the smallest and most closely set teeth. The finest tools may contain from 45 to 60 pins per inch. Thus the whole of the endless vertical revolving sheet presents a continuous series of hackle teeth, and the machines are furnished with a double set of such sheets revolving face to face, so close together that the pins of one set of sheets intersect those on the opposite stocks. Overhead, and exactly centred between these revolving sheets, is the head or holder channel, from which the flax hangs down while it is undergoing the hackling process on both sides. The flax is fastened in a holder consisting of two heavy flat plates of iron, between which it is spread and tightly screwed up. The holder is 11 in. in length, and the holder channel is fitted to contain a line of six, eight or twelve such holders, according to the number of separate bands of hackling stocks in the machine. The head or holder channel has a falling and rising motion, by which it first presents the ends and gradually more and more of the length of the fibre to the hackle teeth, and, after dipping down the full length of the fibre exposed, it slowly rises and lifts the flax clear of the hackle stocks. By a reciprocal motion all the holders are then moved forward one length; that at the last and finest set of stocks is thrown out, and place is made for filling in an additional holder at the beginning of the series. Thus with a six-tool hackle, or set of stocks, each holder full of flax from beginning to end descends into and rises from the hackle teeth six times in travelling from end to end of the machine. The root ends being thus first hackled, the holders are shot back along an inclined plane, the iron plates unclamped, the flax reversed, and the top ends are then submitted to the same hackling operation. The tow made during the hackling process is carried down by the pins of the sheet, and is stripped from them by means of a circular brush placed immediately 726 under the bottom roller. The brush revolves in the same direction as, but quicker than the sheet, consequently the tow is withdrawn from the pins. The tow is then removed from the brush by a doffer roller, from which it is finally removed by a doffing knife. This material is then carded by a machine similar to, but finer than, the one described under Jute (*q.v.*). The hackled flax, however, is taken direct to the preparing department.

Preparing.—The various operations in this stage have for their object the proper assortment of dressed line into qualities fit for spinning, and the drawing out of the fibres to a perfectly level and uniform continuous ribbon or sliver, containing throughout an equal quantity of fibre in any given length. From the hackling the now smooth, glossy and clean stricks are taken to the sorting room, where they are assorted into different qualities by the “line sorter,” who judges by both eye and touch the quality and capabilities of the fibre. So sorted, the material is passed to the spreading and drawing frames, a series or system of machines all similar in construction and effect. The essential features of the spreading frame are: (1) the feeding cloth or creeping sheet, which delivers the flax to (2) a pair of “feed and jockey” rollers, which pass it on (3) to the gill frame or fallers. The gill frame consists of a series of narrow hackle bars, with short closely studded teeth, which travel between the feed rollers and the drawing or “boss and pressing” rollers to be immediately attended to. They are, by an endless screw arrangement, carried forward at approximately the same rate at which the flax is delivered to them, and when they reach the end of their course they fall under, and by a similar screw arrangement are brought back to the starting-point; and thus they form an endless moving level toothed platform for carrying away the flax from the feed rollers. This is the machine in which the fibres are, for the first time, formed into a continuous length termed a sliver. In order to form this continuous sliver it is necessary that the short lengths of flax should overlap each other on the spread sheet or creeping sheet. This sheet contains four or six divisions, so that four or six lots of overlapped flax are moving at the same time towards the first pair of rollers—the boss rollers or retaining rollers. The fibre passes between these rollers and is immediately caught by the rising gills which carry the fibre towards the drawing rollers. The pins of the gills should pass through the fibre so that they may have complete control over it, while their speed should be a little greater than the surface speed of the retaining rollers. The fibre is thus carried forward to the drawing rollers, which have a surface speed of from 10 to 30 times that of the retaining rollers. The great difference between the speeds of the retaining and drawing rollers results in each sliver being drawn out to a corresponding degree. Finally all the slivers are run into one and in this state are passed between the delivery rollers into the sliver cans. Each can should contain the same length of sliver, a common length being 1000 yds. A bell is automatically rung by the machine to warn the attendant that the desired length has been deposited into the can. From the spreading frame the cans of sliver pass to the drawing frames, where from four to twelve slivers combined are passed through feed rollers over gills, and drawn out by drawing rollers to the thickness of one. A third and fourth similar doubling and drawing may be embraced in a preparing system, so that the number of doublings the flax undergoes, before it arrives at the roving frame, may amount to from one thousand to one hundred thousand, according to the quality of yarn in progress. Thus, for example, the doublings on one preparing system may be $6 \times 12 \times 12 \times 12 \times 8 = 82{,}944$. The slivers delivered by the last drawing frame are taken to the roving frame, where they are singly passed through feed rollers and over gills, and, after drafting to sufficient tenuity, they are slightly twisted by flyers and wound on bobbins, in which condition the material—termed “rove” or “rovings”—is ready for the spinning frame.[2]

Spinning.—The spinning operation, which follows the roving, is done in two principal ways, called respectively dry spinning and wet spinning, the first being used for the lower counts or heavier yarns, while the second is exclusively adopted in the preparation of fine yarns. The spinning frame does not differ in principle from the throstle spinning machine used in cotton manufacture. The bobbins of flax rove are arranged in rows on each side of the frame (the spinning frames being all double) on pins in an inclined plane. The rove passes downwards through an eyelet or guide to a pair of nipping rollers between which and the final drawing rollers, placed in the case of dry spinning from 18 to 22 in. lower down, the fibre receives its final draft while passing over and under cylinders and guide-plate, and attains that degree of tenuity which the finished yarn must possess. From the last rollers the now attenuated material, in passing to the flyers receives the degree of twist which compacts the fibres into the round hard cord which constitutes spun yarn; and from the flyers it is wound on the more slowly rotating spool within the flyer arms, centred on the top of the spindle. The amount of twist given to the thread at the spinning frame varies from 1.5 to 2 times the square root of the count. In wet spinning the general sequence of operations is the same, but the rove, as unwound from its bobbin, first passes through a trough of water heated to about 120° Fahr.; and the interval between the two pairs of rollers in which the drawing out of the rove is accomplished is very much shorter. The influence of the hot water on the flax fibre appears to be that it softens the gummy substance which binds the separate cells together, and thereby allows the elementary cells to a certain extent to be drawn out without breaking the continuity of the fibre; and further it makes a finer, smoother and more uniform strand than can be obtained by dry spinning. The extent to which the original strick of flax as laid on the feeding roller for (say) the production of a 50 lea yarn is, by doublings and drawings, extended, when it reaches the spinning spindle, may be stated thus: 35 times on spreading frame, 15 times on first drawing frame, 15 times on second drawing frame, 14 times on third drawing frame, 15 times on roving frame and 10 times on spinning frame, in all 16,537,500 times its original length, with $8 \times 12 \times 16 = 1536$ doublings on the three drawing frames. That is to say, 1 yd. of hackled line fed into the spreading frame is spread out, mixed with other fibres, to a length of about 9400 m. of yarn, when the above drafts obtain. The drafts are much shorter for the majority of yarns.

The next operation is reeling from the bobbins into hanks. By act of parliament, throughout the United Kingdom the standard measure of flax yard is the “lea,” called also in Scotland the “cut” of 300 yds. The flax is wound or reeled on a reel having a circumference of 90 in. (2½ yds.) making “a thread,” and one hundred and twenty such threads form a lea. The grist or count of all fine yarns is estimated by the number of leas in 1 ℔; thus “50 lea” indicates that there are 50 leas or cuts of 300 yds. each in 1 ℔ of the yard so denominated. With the heavier yarns in Scotland the quality is indicated by their weight per “spyndle” of 48 cuts or leas; thus “3 ℔ tow yarn” is such as weighs 3 ℔ per spyndle, equivalent to “16 lea.”

The hanks of yarn from wet spinning are either dried in a loft with artificial heat or exposed over ropes in the open air. When dry they are twisted back and forward to take the wiry feeling out of the yarn, and made up in bundles for the market as “grey yarn.” English spinners make up their yarns into “bundles” of 20 hanks, each hank containing 10 leas; Irish spinners make hanks of 12 leas, 16⅔ of which form a bundle; Scottish manufacturers adhere to the spyndle containing 4 hanks of 12 cuts or leas.

Commercial qualities of yarn range from about 8 ℔ tow yarns (6 lea) up to 160 lea line yarn. Very much finer yarn up even to 400 lea may be spun from the system of machines found in many mills; but these higher counts are only used for fine thread for sewing and for the making of lace. The highest counts of cut line flax are spun in Irish mills for the manufacture of fine cambrics and lawns which are characteristic features of the Ulster trade. Exceedingly high counts have sometimes been spun by hand, and for the preparation of the finest lace threads it is said the Belgian hand spinners must work in damp cellars, where the spinner is guided by the sense of touch alone, the filament being too fine to be seen by the eye. Such lace yarn is said to have been sold for as much as £240 per ℔. In the Great Exhibition of 1851, yarn of 760 lea, equal to about 130 m. per ℔, was shown which had been spun by an Irish woman eighty-four years of age. In the same exhibition there was shown by a Cambray manufacturing firm hand-spun yarn equal to 1200 warp and 1600 weft or to more than 204 and 272 m. per ℔ respectively.

Bleaching.—A large proportion of the linen yarn of commerce undergoes a more or less thorough bleaching before it is handed over to the weaver. Linen yarns in the green condition contain such a large proportion of gummy and resinous matter, removable by bleaching, that cloths which might present a firm close texture in their natural unbleached state would become thin and impoverished in a perfectly bleached condition. Nevertheless, in many cases it is much more satisfactory to weave the yarns in the green or natural colour, and to perform all bleaching operations in the piece. Manufacturers allow about 20 to 25% of loss in weight of yarn in bleaching from the green to the fully bleached stage; and the intermediate stages of boiled, improved, duck, cream, half bleach and three-quarters bleach, all indicating a certain degree of bleaching, have corresponding degrees of 727 loss in weight. The differences in colour resulting from different degrees of bleaching are taken advantage of for producing patterns in certain classes of linen fabrics.

Linen thread is prepared from the various counts of fine bleached line yarn by winding the hanks on large spools, and twisting the various strands, two, three, four or six cord as the case may be, on a doubling spindle similar in principle to the yarn spinning frame, excepting, of course, the drawing rollers. A large trade in linen thread has been created by its use in the machine manufacture of boots and shoes, saddlery and other leather goods, and in heavy sewing-machine work generally. The thread industry is largely developed at Lisburn near Belfast, at Johnstone near Glasgow, Bridport, Dorsetshire, and at Paterson, New Jersey, United States. Fine cords, net twine and ropes are also twisted from flax.

Weaving.—The difficulties in the way of power-loom linen weaving, combined with the obstinate competition of hand-loom weavers, delayed the introduction of factory weaving of linen fabrics for many years after the system was fully applied to other textiles. The principal difficulty arose through the hardness and inelasticity of the linen yarns, owing to which the yarn frequently broke under the tension to which it was subjected. Competition with the hand-loom against the power-loom in certain classes of work is conceivable, although it is absolutely impossible for the work of the spinning wheel to stand against the rivalry of drawing, roving and spinning frames. To the present day, in Ireland especially, a great deal of fine weaving is done by hand-loom. Warden states that power was applied on a small scale to the weaving of canvas in London about 1812; that in 1821 power-looms were started for weaving linen at Kirkcaldy, Scotland; and that in 1824 Maberly & Co. of Aberdeen had two hundred power-looms erected for linen manufacture. The power-loom has been in uninterrupted use in the Broadford factory, Aberdeen, which then belonged to Maberly & Co., down to the present day, and that firm may be credited with being the effective introducers of power-loom weaving in the linen trade.

The various operations connected with linen weaving, such as winding, warping, dressing, beaming and drawing-in, do not differ in essential features from the like processes in the case of cotton weaving, &c., neither is there any significant modification in the looms employed (see Weaving). Dressing is a matter of importance in the preparation of linen warps for beaming. It consists in treating the spread yarn with flour or farina paste, applied to it by flannel-covered rollers, the lowermost of which revolves in a trough of paste. The paste is equalized on the yarn by brushes, and dried by passing the web over steam-heated cylinders before it is finally wound on the beam for weaving.

Fabrics.

Linen fabrics are numerous in variety and widely different in their qualities, appearance and applications, ranging from heavy sail-cloth and rough sacking to the most delicate cambrics, lawns and scrims. The heavier manufactures include as a principal item sail-cloth, with canvas, tarpaulin, sacking and carpeting. The principal seats of the manufacture of these linens are Dundee, Arbroath, Forfar, Kirkcaldy, Aberdeen and Barnsley. The medium weight linens, which are used for a great variety of purposes, such as tent-making, towelling, covers, outer garments for men, linings, upholstery work, &c., include duck, huckaback, crash, tick, dowlas, osnaburg, low sheetings and low brown linens. Plain bleached linens form a class by themselves, and include principally the materials for shirts and collars and for bed sheets. Under the head of twilled linens are included drills, diapers and dimity for household use; and damasks for table linen, of which two kinds are distinguished—single or five-leaf damask, and double or eight-leaf damask, the pattern being formed by the intersection of warp and weft yarns at intervals of five and eight threads of yarn respectively. The fine linens are cambrics, lawns and handkerchiefs; and lastly, printed and dyed linen fabrics may be assigned to a special though not important class. In a general way it may be said regarding the British industry that the heavy linen trade centres in Dundee; medium goods are made in most linen manufacturing districts; damasks are chiefly produced in Belfast, Dunfermline and Perth; and the fine linen manufactures have their seat in Belfast and the north of Ireland. Leeds and Barnsley are the centres of the linen trade in England.

Linen fabrics have several advantages over cotton, resulting principally from the microscopic structure and length of the flax fibre. The cloth is much smoother and more lustrous than cotton cloth; and, presenting a less “woolly” surface, it does not soil so readily, nor absorb and retain moisture so freely, as the more spongy cotton; and it is at once a cool, clean and healthful material for bed-sheeting and clothing. Bleached linen, starched and dressed, possesses that unequalled purity, gloss and smoothness which make it alone the material suitable for shirt-fronts, collars and wristbands; and the gossamer delicacy, yet strength, of the thread it may be spun into fits it for the fine lace-making to which it is devoted. Flax is a slightly heavier material than cotton, while its strength is about double.

As regards the actual number of spindles and power-looms engaged in linen manufacture, the following particulars are taken from the report of the Flax Supply Association for 1905:—

Country.	Year.	Number of Spindles for Flax Spinning.	Year.	Number of Power-looms for Linen Weaving.
Austria-Hungary	1903	280,414	1895	3357
Belgium	1902	280,000	1900	3400
England and Wales	1905	49,941	1905	4424
France	1902	455,838	1891	18,083
Germany	1902	295,796	1895	7557
Holland	1896	8000	1891	1200
Ireland	1905	851,388	1905	34,498
Italy	1902	77,000	1902	3500
Norway	..	..	1880	120
Russia	1902	300,000	1889	7312
Scotland	1905	160,085	1905	17,185
Spain	..	..	1876	1000
Sweden	..	..	1884	286

British Exports of Linen Yarn and Cloth.

	1891.	1896.	1901.	1906.
Weight of linen yarn in pounds	14,859,900	18,462,300	12,971,100	14,978,200
Length in yards of linen piece goods, plain, bleached or unbleached	144,416,700	150,849,300	137,521,000	173,334,200
Length in yards of linen piece goods, checked, dyed or printed, also damask and diaper	11,807,600	17,986,100	8,007,600	13,372,100
Length in yards of sail-cloth	3,233,400	5,372,600	4,686,700	4,251,400
Total length in yards of all kinds of linen cloth	159,457,700	174,208,000	150,215,300	190,957,700
Weight in pounds of linen thread for sewing	2,474,100	2,240,300	1,721,000	2,181,100

Authorities.—History of the trade, &c.: Warden’s *Linen Trade, Ancient and Modern*. Spinning: Peter Sharp, *Flax, Tow and Jute Spinning* (Dundee); H. R. Carter, *Spinning and Twisting of Long Vegetable Fibres* (London). Weaving: Woodhouse and Milne, *Jute and Linen Weaving*, part i., Mechanism, part ii., Calculations and Cloth Structure (Manchester); and Woodhouse and Milne, *Textile Design: Pure and Applied* (London).

(T. Wo.)

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1 See Sir Arthur Mitchell’s *The Past in the Present* (Edinburgh, 1880).

2 The preparation of tow for spinning differs in essential features from the processes above described. Tow from different sources, such as scutching tow, hackle tow, &c. differs considerably in quality and value, some being very impure, filled with woody shives &c., while other kinds are comparatively open and clean. A preliminary opening and cleaning is necessary for the dirty much-matted tows, and in general thereafter they are passed through two carding engines called respectively the breaker and the finisher cards till the slivers from their processes are ready for the drawing and roving frames. In the case of fine clean tows, on the other hand, passing through a single carding engine may be sufficient. The processes which follow the carding do not differ materially from those followed in the preparation of rove from line flax.

LINEN-PRESS, a contrivance, usually of oak, for pressing sheets, table-napkins and other linen articles, resembling a modern office copying-press. Linen presses were made chiefly in the 17th and 18th centuries, and are now chiefly interesting as curiosities of antique furniture. Usually quite plain, they were occasionally carved with characteristic Jacobean designs.

LINER, or Line of Battle Ship, the name formerly given to a vessel considered large enough to take part in a naval battle. The practice of distinguishing between vessels fit, and those not fit, to “lie in a line of battle,” arose towards the end of the 17th century. In the early 18th century all vessels of 50 guns and upwards were considered fit to lie in a line. After the Seven Years’ War (1756-63) the 50-gun ships were rejected as too small. When the great revolutionary wars broke out the smallest line of battle ship was of 64 guns. These also came to be considered as too small, and later the line of battle-ships began with those of 74 guns. The term is now replaced by “battleship”; “liner” being the colloquial name given to the great passenger ships used on the main lines of sea transport.

LING, PER HENRIK (1776-1839), Swedish medical-gymnastic practitioner, son of a minister, was born at Ljunga in the south of Sweden in 1776. He studied divinity, and took his degree in 1797, but then went abroad for some years, first to Copenhagen, where he taught modern languages, and then to Germany, France and England. Pecuniary straits injured his health, and he suffered much from rheumatism, but he had acquired meanwhile considerable proficiency in gymnastics and fencing. In 1804 he returned to Sweden, and established himself as a teacher in these arts at Lund, being appointed in 1805 fencing-master to the university. He found that his daily exercises had completely restored his bodily health, and his thoughts now turned towards applying this experience for the benefit of others. He attended the classes on anatomy and physiology, and went through the entire curriculum for the training of a doctor; he then elaborated a system of gymnastics, divided into four branches, (1) pedagogical, (2) medical, (3) military, (4) aesthetic, which carried out his theories. After several attempts to interest the Swedish government, Ling at last in 1813 obtained their co-operation, and the Royal Gymnastic Central Institute, for the training of gymnastic instructors, was opened in Stockholm, with himself as principal. The orthodox medical practitioners were naturally opposed to the larger claims made by Ling and his pupils respecting the cure of diseases—so far at least as anything more than the occasional benefit of some form of skilfully applied “massage” was concerned; but the fact that in 1831 Ling was elected a member of the Swedish General Medical Association shows that in his own country at all events his methods were regarded as consistent with professional recognition. Ling died in 1839, having previously named as the repositories of his teaching his pupils Lars Gabriel Branting (1799-1881), who succeeded him as principal of the Institute, and Karl Augustus Georgii, who became sub-director; his son, Hjalmar Ling (1820-1886), being for many years associated with them. All these, together with Major Thure Brandt, who from about 1861 specialized in the treatment of women (gynecological gymnastics), are regarded as the pioneers of Swedish medical gymnastics. 728

It may be convenient to summarize here the later history of Ling’s system of medical gymnastics. A *Gymnastic Orthopaedic Institute* at Stockholm was founded in 1822 by Dr Nils Åkerman, and after 1827 received a government grant; and Dr Gustaf Zander elaborated a medico-mechanical system of gymnastics, known by his name, about 1857, and started his Zander Institute at Stockholm in 1865. At the Stockholm Gymnastic Central Institute qualified medical men have supervised the medical department since 1864; the course is three years (one year for qualified doctors). Broadly speaking, there have been two streams of development in the Swedish gymnastics founded on Ling’s beginnings—either in a conservative direction, making certain forms of gymnastic exercises subsidiary to the prescriptions of orthodox medical science, or else in an extremely progressive direction, making these exercises a substitute for any other treatment, and claiming them as a cure for disease by themselves. Modern medical science recognizes fully the importance of properly selected exercises in preserving the body from many ailments; but the more extreme claim, which rules out the use of drugs in disease altogether, has naturally not been admitted. Modern professed disciples of Ling are divided, the representative of the more extreme section being Henrik Kellgren (b. 1837), who has a special school and following.

Ling and his earlier assistants left no proper written account of their treatment, and most of the literature on the subject is repudiated by one set or other of the gymnastic practitioners. Dr Anders Wide, M.D., of Stockholm, has published a *Handbook of Medical Gymnastics* (English edition, 1899), representing the more conservative practice. Henrik Kellgren’s system, which, though based on Ling’s, admittedly goes beyond it, is described in *The Elements of Kellgren’s Manual Treatment* (1903), by Edgar F. Cyriax, who before taking the M.D. degree at Edinburgh had passed out of the Stockholm Institute as a “gymnastic director.” See also the encyclopaedic work on *Sweden: its People and Industry* (1904), p. 348, edited by G. Sundbärg for the Swedish government.

LING[1] (*Molva vulgaris*), a fish of the family Gadidae, which is readily recognized by its long body, two dorsal fins (of which the anterior is much shorter than the posterior), single long anal fin, separate caudal fin, a barbel on the chin and large teeth in the lower jaw and on the palate. Its usual length is from 3 to 4 ft., but individuals of 5 or 6 ft. in length, and some 70 ℔ in weight, have been taken. The ling is found in the North Atlantic, from Spitzbergen and Iceland southwards to the coast of Portugal. Its proper home is the North Sea, especially on the coasts of Norway, Denmark, Great Britain and Ireland, it occurs in great abundance, generally at some distance from the land, in depths varying between 50 and 100 fathoms. During the winter months it approaches the shores, when great numbers are caught by means of long lines. On the American side of the Atlantic it is less common, although generally distributed along the south coast of Greenland and on the banks of Newfoundland. Ling is one of the most valuable species of the cod-fish family; a certain number are consumed fresh, but by far the greater portion are prepared for exportation to various countries (Germany, Spain, Italy). They are either salted and sold as “salt-fish,” or split from head to tail and dried, forming, with similarly prepared cod and coal-fish, the article of which during Lent immense quantities are consumed in Germany and elsewhere under the name of “stock-fish.” The oil is frequently extracted from the liver and used by the poorer classes of the coast population for the lamp or as medicine.

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[1] As the name of the fish, “ling” is found in other Teut. languages; cf. Dutch and Ger. *Leng*, Norw. *langa*, &c. It is generally connected in origin with “long,” from the length of its body. As the name of the common heather, *Calluna vulgaris* (see Heath) the word is Scandinavian; cf. Dutch and Dan. *lyng*, Swed. *ljung*.

LINGARD, JOHN (1771-1851), English historian, was born on the 5th of February 1771 at Winchester, where his father, of an ancient Lincolnshire peasant stock, had established himself as a carpenter. The boy’s talents attracted attention, and in 1782 he was sent to the English college at Douai, where he continued until shortly after the declaration of war by England (1793). He then lived as tutor in the family of Lord Stourton, but in October 1794 he settled along with seven other former members of the old Douai college at Crook Hall near Durham, where on the completion of his theological course he became vice-president of the reorganized seminary. In 1795 he was ordained priest, and soon afterwards undertook the charge of the chairs of natural and moral philosophy. In 1808 he accompanied the community of Crook Hall to the new college at Ushaw, Durham, but in 1811, after declining the presidency of the college at Maynooth, he withdrew to the secluded mission at Hornby in Lancashire, where for the rest of his life he devoted himself to literary pursuits. In 1817 he visited Rome, where he made researches in the Vatican Library. In 1821 Pope Pius VII. created him doctor of divinity and of canon and civil law; and in 1825 Leo XII. is said to have made him cardinal *in petto*. He died at Hornby on the 17th of July 1851.

Lingard wrote *The Antiquities of the Anglo-Saxon Church* (1806), of which a third and greatly enlarged addition appeared in 1845 under the title *The History and Antiquities of the Anglo-Saxon Church; containing an account of its origin, government, doctrines, worship, revenues, and clerical and monastic institutions*; but the work with which his name is chiefly associated is *A History of England, from the first invasion by the Romans to the commencement of the reign of William III.*, which appeared originally in 8 vols. at intervals between 1819 and 1830. Three successive subsequent editions had the benefit of extensive revision by the author; a fifth edition in 10 vols. 8vo appeared in 1849, and a sixth, with life of the author by Tierney prefixed to vol. x., in 1854-1855. Soon after its appearance it was translated into French, German and Italian. It is a work of ability and research; and, though Cardinal Wiseman’s claim for its author that he was “the only impartial historian of our country” may be disregarded, the book remains interesting as representing the view taken of certain events in English history by a devout, but able and learned, Roman Catholic in the earlier part of the 19th century.

LINGAYAT (from *linga*, the emblem of Siva), the name of a peculiar sect of Siva worshippers in southern India, who call themselves *Vira-Saivas* (see Hinduism). They carry on the person a stone *linga* (phallus) in a silver casket. The founder of the sect is said to have been Basava, a 729

Brahman prime minister of a Jain king in the 12th century. The Lingayats are specially numerous in the Kanarese country, and to them the Kanarese language owes its cultivation as literature. Their priests are called Jangamas. In 1901 the total number of Lingayats in all India was returned as more than 2½ millions, mostly in Mysore and the adjoining districts of Bombay, Madras and Hyderabad.

LINGAYEN, a town and the capital of the province of Pangasinán, Luzon, Philippine Islands, about 110 m. N. by W. of Manila, on the S. shore of the Gulf of Lingayen, and on a low and fertile island in the delta of the Agno river. Pop. (1903) 21,529. It has good government buildings, a fine church and plaza, the provincial high school and a girls' school conducted by Spanish Dominican friars. The climate is cool and healthy. The chief industries are the cultivation of rice (the most important crop of the surrounding country), fishing and the making of nipa-wine from the juice of the nipa palm, which grows abundantly in the neighbouring swamps. The principal language is Pangasinán; Ilocano is also spoken.

LINGEN, RALPH ROBERT WHEELER LINGEN, Baron (1819-1905), English civil servant, was born in February 1819 at Birmingham, where his father, who came of an old Hertfordshire family, with Royalist traditions, was in business. He became a scholar of Trinity College, Oxford, in 1837; won the Ireland (1838) and Hertford (1839) scholarships; and after taking a first-class in *Literae Humaniores* (1840), was elected a fellow of Balliol (1841). He subsequently won the Chancellor's Latin Essay (1843) and the Eldon Law scholarship (1846). After taking his degree in 1840, he became a student of Lincoln's Inn, and was called to the bar in 1847; but instead of practising as a barrister, he accepted an appointment in the Education Office, and after a short period was chosen in 1849 to succeed Sir J. Kay Shuttleworth as its secretary or chief permanent official. He retained this position till 1869. The Education Office of that day had to administer a somewhat chaotic system of government grants to local schools, and Lingen was conspicuous for his fearless discrimination and rigid economy, qualities which characterized his whole career. When Robert Lowe (Lord Sherbrooke) became, as vice-president of the council, his parliamentary chief, Lingen worked congenially with him in producing the Revised Code of 1862 which incorporated "payment by results"; but the education department encountered adverse criticism, and in 1864 the vote of censure in parliament which caused Lowe's resignation, founded (but erroneously) on an alleged "editing" of the school inspectors' reports, was inspired by a certain antagonism to Lingen's as well as to Lowe's methods. Shortly before the introduction of Forster's Education Act of 1870, he was transferred to the post of permanent secretary of the treasury. In this office, which he held till 1885, he proved a most efficient guardian of the public purse, and he was a tower of strength to successive chancellors of the exchequer. It used to be said that the best recommendation for a secretary of the treasury was to be able to say "No" so disagreeably that nobody would court a repetition. Lingen was at all events a most successful resister of importunate claims, and his undoubted talents as a financier were most prominently displayed in the direction of parsimony. In 1885 he retired. He had been made a C.B. in 1869 and a K.C.B. in 1878, and on his retirement he was created Baron Lingen. In 1889 he was made one of the first aldermen of the new London County Council, but he resigned in 1892. He died on the 22nd of July 1905. He had married in 1852, but left no issue.

LINGEN, a town in the Prussian province of Hanover, on the Ems canal, 43 m. N.N.W. of Münster by rail. Pop. 7500. It has iron foundries, machinery factories, railway workshops and a considerable trade in cattle, and among its other industries are weaving and malting and the manufacture of cloth. Lingen was the seat of a university from 1685 to 1819.

The county of Lingen, of which this town was the capital, was united in the middle ages with the county of Treklenburg. In 1508, however, it was separated from this and was divided into an upper and a lower county, but the two were united in 1541. A little, later Lingen was sold to the emperor Charles V., from whom it passed to his son, Philip II. of Spain, who ceded it in 1507 to Maurice, prince of Orange. After the death of the English king, William III., in 1702, it passed to Frederick I., king of Prussia, and in 1815 the lower county was transferred to Hanover, only to be united again with Prussia in 1866.

See Möller, *Geschichte der vormaligen Grafschaft Lingen* (Lingen, 1874); Herrmann, *Die Erwerbung der Stadt und Grafschaft Lingen durch die Krone Preussen* (Lingen, 1902); and Schriever, *Geschichte des Kreiges Lingen* (Lingen, 1905).

LINGUET, SIMON NICHOLAS HENRI (1736-1794), French journalist and advocate, was born on the 14th of July 1736, at Reims, whither his father, the assistant principal in the Collège de Beauvais of Paris, had recently been exiled by *lettre de cachet* for engaging in the Jansenist controversy. He attended the Collège de Beauvais and won the three highest prizes there in 1751. He accompanied the count palatine of Zweibrücken to Poland, and on his return to Paris he devoted himself to writing. He published partial French translations of Calderon and Lope de Vega, and wrote parodies for the *Opéra Comique* and pamphlets in favour of the Jesuits. Received at first in the ranks of the *philosophes*, he soon went over to their opponents, possibly more from contempt than from conviction, the immediate occasion for his change being a quarrel with d'Alembert in 1762. Thenceforth he violently attacked whatever was considered modern and enlightened, and while he delighted society with his numerous sensational pamphlets, he aroused the fear and hatred of his opponents by his stinging wit. He was admitted to the bar in 1764, and soon became one of the most famous pleaders of his century. But in spite of his brilliant ability and his record of having lost but two cases, the bitter attacks which he directed against his fellow advocates, especially against Gerbier (1725-1788), caused his dismissal from the bar in 1775. He then turned to journalism and began the *Journal de politique et de littérature*, which he employed for two years in literary, philosophical and legal criticisms. But a sarcastic article on the French Academy compelled him to turn over the Journal to La Harpe and seek refuge abroad. Linguet, however, continued his career of free lance, now attacking and now supporting the government, in the *Annales politiques, civiles et littéraires*, published from 1777 to 1792, first at London, then at Brussels and finally at Paris. Attempting to return to France in 1780 he was arrested for a caustic attack on the duc de Duras (1715-1789), an academician and marshal of France, and imprisoned nearly two years in the Bastille. He then went to London, and thence to Brussels, where, for his support of the reforms of Joseph II., he was ennobled and granted an honorarium of one thousand ducats. In 1786 he was permitted by Vergennes to return to France as an Austrian counsellor of state, and to sue the duc d'Aiguillon (1730-1798), the former minister of Louis XV., for fees due him for legal services rendered some fifteen years earlier. He obtained judgment to the amount of 24,000 livres. Linguet received the support of Marie Antoinette; his fame at the time surpassed that of his rival Beaumarchais, and almost excelled that of Voltaire. Shortly afterwards he visited the emperor at Vienna to plead the case of Van der Noot and the rebels of Brabant. During the early years of the Revolution he issued several pamphlets against Mirabeau, who returned his ill-will with interest, calling him "the ignorant and bombastic M. Linguet, advocate of Neros, sultans and viziers." On his return to Paris in 1791 he defended the rights of San Domingo before the National Assembly. His last work was a defence of Louis XVI. He retired to Marnes near Ville d'Avray to escape the Terror, but was sought out and summarily condemned to death "for having flattered the despots of Vienna and London." He was guillotined at Paris on the 27th of June 1794.

Linguet was a prolific writer in many fields. Examples of his attempted historical writing are *Histoire du siècle d'Alexandre le Grand* (Amsterdam, 1762), and *Histoire impartiale des Jésuites* (Madrid, 1768), the latter condemned to be burned. His opposition to the *philosophes* had its strongest expressions in *Fanatisme des philosophes* (Geneva and Paris, 1764) and *Histoire des révolutions de l'empire romain* (Paris, 1766-1768). His *Théorie des lois civiles* (London, 1767) is a vigorous defence of absolutism and attack on the politics of Montesquieu. His best legal treatise is *Mémoire pour le comte de Morangies* (Paris, 1772); Linguet's imprisonment in the Bastille afforded him the opportunity of writing his *Mémoires sur la Bastille*, first published in London in 1789; it has been translated into English (Dublin, 1783, and Edinburgh, 1884-1887), and is the best of his works though untrustworthy. 730

See A. Devérité, *Notice pour servir à l'histoire de la vie et des écrits de S. N. H. Linguet* (Liége, 1782); Gardoz, *Essai historique sur la vie et les ouvrages de Linguet* (Lyon, 1808); J. F. Barrière, *Mémoire de Linguet et de Latude* (Paris, 1884); Ch. Monselet, *Les Oubliés et les dédaignés* (Paris, 1885), pp. 1-41; H. Monin “Notice sur Linguet,” in the 1889 edition of *Mémoires sur la Bastille*; J. Cruppi, *Un avocat journaliste au 18^e siècle, Linguet* (Paris, 1895); A. Philipp. *Linguet, ein Nationalökonom des XVIII Jahrhunderts in seinen rechtlichen, socialen und volkswirtschaftlichen Anschauungen* (Zürich, 1896); A. Lichtenberger, *Le Socialisme utopique* (1898), pp. 77-131.

LINK. (1) (Of Scandinavian origin; cf. Swed. *länk*, Dan. *laenke*; cognate with “flank,” and Ger. *Gelenk*, joint), one of the loops of which a chain is composed; used as a measure of length in surveying, being $^1/_{100}$th part of a “chain.” In Gunter’s chain, a “link” = 7.92 in.; the chain used by American engineers consists of 100 links of a foot each in length (for “link work” and “link motions” see Mechanics: § *Applied*, and Steam Engine). The term is also applied to anything used for connecting or binding together, metaphorically or absolutely. (2) (O. Eng. *hlinc*, possibly from the root which appears in “to lean”), a bank or ridge of rising ground; in Scots dialect, in the plural, applied to the ground bordering on the sea-shore, characterized by sand and coarse grass; hence a course for playing golf. (3) A torch made of pitch or tow formerly carried in the streets to light passengers, by men or boys called “link-boys” who plied for hire with them. Iron link-stands supporting a ring in which the link might be placed may still be seen at the doorways of old London houses. The word is of doubtful origin. It has been referred to a Med. Lat. *lichinus*, which occurs in the form *linchinus* (see Du Cange, *Glossarium*); this, according to a 15th-century glossary, meant a wick or match. It is an adaptation of Gr. λύχνος, lamp. Another suggestion connects it with a supposed derivation of “linstock,” from “lint.” *The New English Dictionary* thinks the likeliest suggestion is to identify the word with the “link” of a chain. The tow and pitch may have been manufactured in lengths, and then cut into sections or “links.”

LINKÖPING, a city of Sweden, the seat of a bishop, and chief town of the district (*län*) of Östergötland. Pop. (1900) 14,552. It is situated in a fertile plain 142 m. by rail S.W. of Stockholm, and communicates with Lake Roxen (½ m. to the north) and the Göta and Kinda canals by means of the navigable Stångå. The cathedral (1150-1499), a Romanesque building with a beautiful south portal and a Gothic choir, is, next to the cathedral of Upsala, the largest church in Sweden. It contains an altarpiece by Martin Heemskerck (d. 1574), which is said to have been bought by John II. for twelve hundred measures of wheat. In the church of St Lars are some paintings by Per Horberg (1746-1816), the Swedish peasant artist. Other buildings of note are the massive episcopal palace (1470-1500), afterwards a royal palace, and the old gymnasium founded by Gustavus Adolphus in 1627, which contains the valuable library of old books and manuscripts belonging to the diocese and state college, and collection of coins and antiquities. There is also the Östergötland Museum, with an art collection. The town has manufactures of tobacco, cloth and hosiery. It is the headquarters of the second army division.

Linköping early became a place of mark, and was already a bishop’s see in 1082. It was at a council held in the town in 1153 that the payment of Peter’s pence was agreed to at the instigation of Nicholas Breakspeare, afterwards Adrian IV. The coronation of Birger Jarlsson Valdemar took place in the cathedral in 1251; and in the reign of Gustavus Vasa several important diets were held in the town. At Stångåbro (Stångå Bridge), close by, an obelisk (1898) commemorates the battle of Stångåbro (1598), when Duke Charles (Protestant) defeated the Roman Catholic Sigismund. A circle of stones in the Iron Market of Linköping marks the spot where Sigismund’s adherents were beheaded in 1600.

LINLEY, THOMAS (1732-1795), English musician, was born at Wells, Somerset, and studied music at Bath, where he settled as a singing-master and conductor of the concerts. From 1774 he was engaged in the management at Drury Lane theatre, London, composing or compiling the music of many of the pieces produced there, besides songs and madrigals, which rank high among English compositions. He died in London on the 19th of November 1795. His eldest son Thomas (1756-1778) was a remarkable violinist, and also a composer, who assisted his father; and he became a warm friend of Mozart. His works, with some of his father’s, were published in two volumes, and these contain some lovely madrigals and songs. Another son, William (1771-1835), who held a writership at Madras, was devoted to literature and music and composed glees and songs. Three daughters were similarly gifted, and were remarkable both for singing and beauty; the eldest of them Elizabeth Ann (1754-1792), married Richard Brinsley Sheridan in 1773, and thus linked the fortunes of her family with his career.

LINLITHGOW, JOHN ADRIAN LOUIS HOPE, 1st Marquess of (1860-1908), British administrator, was the son of the 6th earl of Hopetoun. The Hope family traced their descent to John de Hope, who accompanied James V.’s queen Madeleine of Valois from France to Scotland in 1537, and of whose great-grandchildren Sir Thomas Hope (d. 1646), lord advocate of Scotland, was ancestor of the earls of Hopetoun, while Henry Hope settled in Amsterdam, and was the ancestor of the famous Dutch bankers of that name, and of the later Hopes of Bedgebury, Kent. Sir Thomas’s son, Sir James Hope of Hopetoun (1614-1661), Scottish lord of session, was grandfather of Charles, 1st earl of Hopetoun in the Scots peerage (1681-1742), who was created earl in 1703; and his grandson, the 3rd earl, was in 1809 made a baron of the United Kingdom. John, the 4th earl (1765-1823), brother of the 3rd earl, was a distinguished soldier, who for his services in the Peninsular War was created Baron Niddry in 1814 before succeeding to the earldom. The marquessate of Linlithgow was bestowed on the 7th earl of Hopetoun in 1902, in recognition of his success as first governor (1900-1902) of the commonwealth of Australia; he died on the 1st of March 1908, being succeeded as 2nd marquess by his eldest son (b. 1887).

An earldom of Linlithgow was in existence from 1600 to 1716, this being held by the Livingstones, a Scottish family descended from Sir William Livingstone. Sir William obtained the barony of Callendar in 1346, and his descendant, Sir Alexander Livingstone (d. *c.* 1450), and other members of this family were specially prominent during the minority of King James II. Alexander Livingstone, 7th Lord Livingstone (d. 1623), the eldest son of William, the 6th lord (d. *c.* 1580), a supporter of Mary, queen of Scots, was a leading Scottish noble during the reign of James VI. and was created earl of Linlithgow in 1600. Alexander’s grandson, George, 3rd earl of Linlithgow (1616-1690), and the latter’s son, George, the 4th earl (*c.* 1652-1695), were both engaged against the Covenanters during the reign of Charles II. When the 4th earl died without sons in August 1695 the earldom passed to his nephew, James Livingstone, 4th earl of Callendar. James, who then became the 5th earl of Linlithgow, joined the Stuart rising in 1715; in 1716 he was attainted, being thus deprived of all his honours, and he died without sons in Rome in April 1723.

The earldom of Callendar, which was thus united with that of Linlithgow, was bestowed in 1641 upon James Livingstone, the third son of the 1st earl of Linlithgow. Having seen military service in Germany and the Netherlands, James was created Lord Livingstone of Almond in 1633 by Charles I., and eight years later the king wished to make him lord high treasurer of Scotland. Before this, however, Almond had acted with the Covenanters, and during the short war between England and Scotland in 1640 he served under General Alexander Leslie, afterwards earl of Leven. But the trust reposed in him by the Covenanters did not prevent him in 1640 from signing the “band of Cumbernauld,” an association for defence against Argyll, or from being in some way mixed up with the “Incident,” a plot for the seizure of the Covenanting leaders, Hamilton and Argyll. In 1641 Almond became an earl, and, having declined the offer of a high position in the army raised by Charles I., he led a division of the Scottish forces into England in 1644 and helped Leven to capture Newcastle. In 1645 Callendar, who often imagined himself slighted, left the army, and in 1647 he was one of the promoters of the “engagement” for the release of the king. In 1648, when the Scots marched into England, he served as lieutenant-general under the duke of Hamilton, but the duke found him as difficult to work with as Leven had done previously, and his advice was mainly responsible for the defeat at Preston. After this battle he escaped to Holland. In 1650 he was allowed to return to Scotland, but in 1654 his estates were seized and he was imprisoned; he came into prominence once more at the Restoration. Callendar died on March 1674, leaving no children, and, according to a special remainder, he was succeeded in the earldom by his nephew Alexander (d. 1685), the second son of the 2nd earl of Linlithgow; and he again was succeeded by his nephew Alexander (d. 1692), the second son of the 3rd earl of Linlithgow. The 3rd earl’s son, James, the 4th earl, then became 5th earl of Linlithgow (see *supra*).

LINLITHGOW, a royal, municipal and police burgh and county town of Linlithgowshire, Scotland. Pop. (1901) 4279. It lies in a valley on the south side of a loch, 17½ m. W. of Edinburgh by the North British railway. It long preserved an antique and picturesque appearance, with gardens running down to the lake, or climbing the lower slopes of the rising ground, but in the 19th century much of it was rebuilt. About 4 m. S. by W. lies the old village of Torphichen (pop. 540), where the Knights of St John of Jerusalem had their chief Scottish preceptory. The parish kirk is built on the site of the nave of the church of the establishment, but the ruins of the transept and of part of the choir still exist. Linlithgow belongs to the Falkirk district group of parliamentary burghs with Falkirk, Airdrie, Hamilton and Lanark. The industries include shoe-making, tanning and currying, manufactures of paper, glue and soap, and distilling. An old tower-like structure near the railway station is traditionally regarded as a mansion of the Knights Templar. Other public buildings are the first town house (erected in 1668 and restored in 1848 after a fire); the town hall, built in 1888; the county buildings and the burgh school, dating from the pre-Reformation period. There are some fine fountains. The Cross Well in front of the town house, a striking piece of grotesque work carved in stone, originally built in the reign of James V., was rebuilt in 1807. Another fountain is surmounted by the figure of St Michael, the patron-saint of the burgh. Linlithgow Palace is perhaps the finest ruin of its kind in Scotland. Heavy but effective, the sombre walls rise above the green knolls of the promontory which divides the lake into two nearly equal portions. In plan it is almost square (168 ft. by 174 ft.), enclosing a court (91 ft. by 88 ft.), in the centre of which stands the ruined fountain of which an exquisite copy was erected in front of Holyrood Palace by the Prince Consort. At each corner there is a tower with an internal spiral staircase, that of the north-west angle being crowned by a little octagonal turret known as "Queen Margaret's Bower," from the tradition that it was there that the consort of James IV. watched and waited for his return from Flodden. The west side, whose massive masonry, hardly broken by a single window, is supposed to date in part from the time of James III., who later took refuge in one of its vaults from his disloyal nobles; but the larger part of the south and east side belongs to the period of James V., about 1535; and the north side was rebuilt in 1619-1620 by James VI. Of James V.'s portion, architecturally the richest, the main apartments are the Lyon chamber or parliament hall and the chapel royal. The grand entrance, approached by a drawbridge, was on the east side; above the gateway are still some weather-worn remains of rich allegorical designs. The palace was reduced to ruins by General Hawley's dragoons, who set fire to it in 1746. Government grants have stayed further dilapidation. A few yards to the south of the palace is the church of St Michael, a Gothic (Scottish Decorated) building (180 ft. long internally excluding the apse, by 62 ft. in breadth excluding the transepts), probably founded by David I. in 1242, but mainly built by George Crichton, bishop of Dunkeld (1528-1536). The central west front steeple was till 1821 topped by a crown like that of St Giles', Edinburgh. The chief features of the church are the embattled and pinnacled tower, with the fine doorway below, the nave, the north porch and the flamboyant window in the south transept. The church contains some fine stained glass, including a window to the memory of Sir Charles Wyville Thomson (1830-1882), the naturalist, who was born in the parish.

Linlithgow (wrongly identified with the Roman *Lindum*) was made a royal burgh by David I. Edward I. encamped here the night before the battle of Falkirk (1298), wintered here in 1301, and next year built "a pele [castle] mekill and strong," which in 1313 was captured by the Scots through the assistance of William Bunnock, or Binning, and his hay-cart. In 1369 the customs of Linlithgow yielded more than those of any other town in Scotland, except Edinburgh; and the burgh was taken with Lanark to supply the place of Berwick and Roxburgh in the court of the Four Burghs (1368). Robert II. granted it a charter of immunities in 1384. The palace became a favourite residence of the kings of Scotland, and often formed part of the marriage settlement of their consorts (Mary of Guelders, 1449; Margaret of Denmark, 1468; Margaret of England, 1503). James V. was born within its walls in 1512, and his daughter Mary on the 7th of December 1542. In 1570 the Regent Moray was assassinated in the High Street by James Hamilton of Bothwellhaugh. The university of Edinburgh took refuge at Linlithgow from the plague in 1645-1646; in the same year the national parliament, which had often sat in the palace, was held there for the last time. In 1661 the Covenant was publicly burned here, and in 1745 Prince Charles Edward passed through the town. In 1859 the burgh was deprived by the House of Lords of its claim to levy bridge toll and custom from the railway company.

LINLITHGOWSHIRE, or West Lothian, a south-eastern county of Scotland, bounded N. by the Firth of Forth, E. and S.E. by Edinburghshire, S.W. by Lanarkshire and N.W. by Stirlingshire. It has an area of 76,861 acres, or 120 sq. m., and a coast line of 17 m. The surface rises very gradually from the Firth to the hilly district in the south. A few miles from the Forth a valley stretches from east to west. Between the county town and Bathgate are several hills, the chief being Knock (1017 ft.), Cairnpapple, or Cairnnaple (1000), Cocklerue (said to be a corruption of Cuckold-le-Roi, 912), Riccarton Hills (832) terminating eastwards in Binny Craig, a striking eminence similar to those of Stirling and Edinburgh, Torphichen Hills (777) and Bowden (749). In the coast district a few bold rocks are found, such as Dalmeny, Dundas (well wooded and with a precipitous front), the Binns and a rounded eminence of 559 ft. named Glower-o'er-'em or Bonnytoun, bearing on its summit a monument to General Adrian Hope, who fell in the Indian Mutiny. The river Almond, rising in Lanarkshire and pursuing a north-easterly direction, enters the Firth at Cramond after a course of 24 m., during a great part of which it forms the boundary between West and Mid Lothian. Its right-hand tributary, Breich Water, constitutes another portion of the line dividing the same counties. The Avon, rising in the detached portion of Dumbartonshire, flows eastwards across south Stirlingshire and then, following in the main a northerly direction, passes the county town on the west and reaches the Firth about midway between Grangemouth and Bo'ness, having served as the boundary of Stirlingshire, during rather more than the latter half of its course. The only loch is Linlithgow Lake (102 acres), immediately adjoining the county town on the north, a favourite resort of curlers and skaters. It is 10 ft. deep at the east end and 48 ft. at the west. Eels, perch and braise (a species of roach) are abundant.

Geology.—The rocks of Linlithgowshire belong almost without exception to the Carboniferous system. At the base is the Calciferous Sandstone series, most of which lies between the Bathgate Hills and the eastern boundary of the county. In this series are the Queensferry limestone, the equivalent of the Burdiehouse limestone of Edinburgh, and the Binny sandstone group with shales and clays and the Houston coal bed. At more than one horizon in this series oil shales are found. The Bathgate Hills are formed of basaltic lavas and tuffs—an interbedded volcanic group possibly 2000 ft. thick in the Calciferous Sandstone and Carboniferous Limestone series. A peculiar serpentinous variety of the prevailing rock is quarried at Blackburn for oven floors; it is known as "lakestone." Binns Hill is the site of one of the volcanic cones of the period. The Carboniferous Limestone series consists of an upper and lower limestone group—including the Petershill, Index, Dykeneuk and Craigenbuck limestones—and a middle group of shales, ironstones and coals; the Smithy, Easter Main, Foul, Red and Splint coals belong to this horizon. Above the Carboniferous Limestone the 732 Millstone grit series crops in a belt which may be traced from the mouth of the Avon southwards to Whitburn. This is followed by the true coal-measures with the Boghead or Torbanehill coal, the Colinburn, Main, Ball, Mill and Upper Cannel or Shotts gas coals of Armadale, Torbanehill and Fauldhouse.

Climate and Agriculture.—The average rainfall for the year is 29.9 in., and the average temperature 47.5° F. (January 38° F.; July 59.5° F.). More than three-fourths of the county, the agriculture of which is highly developed, is under cultivation. The best land is found along the coast, as at Carriden and Dalmeny. The farming is mostly arable, permanent pasture being practically stationary (at about 22,000 acres). Oats is the principal grain crop, but barley and wheat are also cultivated. Farms between 100 and 300 acres are the most common. Turnips and potatoes are the leading green crops. Much land has been reclaimed; the parish of Livingston, for example, which in the beginning of the 18th century was covered with heath and juniper, is now under rotation. In Torphichen and Bathgate, however, patches of peat moss and swamp occur, and in the south there are extensive moors at Fauldhouse and Polkemmet. Live stock does not count for so much in West Lothian as in other Scottish counties, though a considerable number of cattle are fattened and dairy farming is followed successfully, the fresh butter and milk finding a market in Edinburgh. There is some sheep-farming, and horses and pigs are reared. The wooded land occurs principally in the parks and "policies" surrounding the many noblemen's mansions and private estates.

Other Industries.—The shale-oil trade flourishes at Bathgate, Broxburn, Armadale, Uphall, Winchburgh, Philpstoun and Dalmeny. There are important iron-works with blast furnaces at Bo'ness, Kinneil, Whitburn and Bathgate, and coal is also largely mined at these places. Coal-mining is supposed to have been followed since Roman times, and the earliest document extant regarding coalpits in Scotland is a charter granted about the end of the 12th century to William Oldbridge of Carriden. Fire-clay is extensively worked in connexion with the coal, and ironstone employs many hands. Limestone, freestone and whinstone are all quarried. Binny freestone was used for the Royal Institution and the National Gallery in Edinburgh, and many important buildings in Glasgow. Some fishing is carried on from Queensferry, and Bo'ness is the principal port.

Communications.—The North British Railway Company's line from Edinburgh to Glasgow runs across the north of the county, it controls the approaches to the Forth Bridge, and serves the rich mineral district around Airdrie and Coatbridge in Lanarkshire via Bathgate. The Caledonian Railway Company's line from Glasgow to Edinburgh touches the extreme south of the shire. The Union Canal, constructed in 1818-1822 to connect Edinburgh with the Forth and Clyde Canal near Camelon in Stirlingshire, crosses the county, roughly following the N.B.R. line to Falkirk. The Union Canal, which is 31 m. long and belongs to the North British railway, is carried across the Almond and Avon on aqueducts designed by Thomas Telford, and near Falkirk is conveyed through a tunnel 2100 ft. long.

Population and Administration.—In 1891 the population amounted to 52,808, and in 1901 to 65,708, showing an increase of 24.43% in the decennial period, the highest of any Scottish county for that decade, and a density of 547 persons to the sq. m. In 1901 five persons spoke Gaelic only, and 575 Gaelic and English. The chief towns, with populations in 1901, are Bathgate (7549), Borrowstounness (9306), Broxburn (7099) and

Linlithgow (4279). The shire returns one member to parliament. Linlithgowshire is part of the sheriffdom of the Lothians and Peebles, and a resident sheriff-substitute sits at Linlithgow and Bathgate. The county is under school-board jurisdiction, and there are academies at Linlithgow, Bathgate and Bo'ness. The local authorities entrust the bulk of the "residue" grant to the County Secondary Education Committee, which subsidizes elementary technical classes (cookery, laundry and dairy) and science and art and technological classes, including their equipment.

History.—Traces of the Pictish inhabitants still exist. Near Inveravon is an accumulation of shells—mostly oysters, which have long ceased to be found so far up the Forth—considered by geologists to be a natural bed, but pronounced by antiquaries to be a kitchen midden. Stone cists have been discovered at Carlowrie, Dalmeny, Newliston and elsewhere; on Cairnnaple is a circular structure of remote but unknown date; and at Kipps is a cromlech that was once surrounded by stones. The wall of Antoninus lies for several miles in the shire. The discovery of a fine legionary tablet at Bridgeness in 1868 is held by some to be conclusive evidence that the great rampart terminated at that point and not at Carriden. Roman camps can be distinguished at several spots. On the hill of Bowden is an earthwork, which J. Stuart Glennie and others connect with the struggle of the ancient Britons against the Saxons of Northumbria. The historical associations of the county mainly cluster round the town of Linlithgow (*q.v.*). Kingscavil (pop. 629) disputes with Stonehouse in Lanarkshire the honour of being the birthplace of Patrick Hamilton, the martyr (1504-1528).

See Sir R. Sibbald, *History of the Sheriffdoms of Linlithgow and Stirlingshire* (Edinburgh, 1710); G. Waldie, *Walks along the Northern Roman Wall* (Linlithgow, 1883); R. J. H. Cunningham, *Geology of the Lothians* (Edinburgh, 1838).

LINNAEUS, the name usually given to Carl von Linné (1707-1778), Swedish botanist, who was born on the 13th of May, O.S. (May 23, N.S.) 1707 at Råshult, in the province of Småland, Sweden, and was the eldest child of Nils Linnaeus the comminister, afterwards pastor, of the parish, and Christina Brodersonia, the daughter of the previous incumbent. In 1717 he was sent to the primary school at Wexiö, and in 1724 he passed to the gymnasium. His interests were centred on botany, and his progress in the studies considered necessary for admission to holy orders, for which he was intended, was so slight that in 1726 his father was recommended to apprentice him to a tailor or shoemaker. He was saved from this fate through Dr Rothman, a physician in the town, who expressed the belief that he would yet distinguish himself in medicine and natural history, and who further instructed him in physiology. In 1727 he entered the university of Lund, but removed in the following year to that of Upsala. There, through lack of means, he had a hard struggle until, in 1729, he made the acquaintance of Dr Olaf Celsius (1670-1756), professor of theology, at that time working at his *Hierobotanicon*, which saw the light nearly twenty years later. Celsius, impressed with Linnaeus's knowledge and botanical collections, and finding him necessitous, offered him board and lodging.

During this period, he came upon a critique which ultimately led to the establishment of his artificial system of plant classification. This was a review of Sébastien Vaillant's *Sermo de Structura Florum* (Leiden, 1718), a thin quarto in French and Latin; it set him upon examining the stamens and pistils of flowers, and, becoming convinced of the paramount importance of these organs, he formed the idea of basing a system of arrangement upon them. Another work by Wallin, Γάμος φύτων, *sive Nuptiae Arborum Dissertatio* (Upsala, 1729), having fallen into his hands, he drew up a short treatise on the sexes of plants, which was placed in the hands of the younger Olaf Rudbeck (1660-1740), the professor of botany in the university. In the following year Rudbeck, whose advanced age compelled him to lecture by deputy, appointed Linnaeus his adjunctus; in the spring of 1730, therefore, the latter began his lectures. The academic garden was entirely remodelled under his auspices, and furnished with many rare species. In the preceding year he had solicited appointment to the vacant post of gardener, which was refused him on the ground of his capacity for better things.

In 1732 he undertook to explore Lapland, at the cost of the Academy of Sciences of Upsala; he traversed upwards of 4600 m., and the cost of the journey is given at 530 copper dollars, or about £25 sterling. His own account was published in English by Sir J. E. Smith, under the title *Lachesis Lapponica*, in 1811; the scientific results were published in his *Flora Lapponica* (Amsterdam, 1737). In 1733 Linnaeus was engaged at Upsala in teaching the methods of assaying ores, but was prevented from delivering lectures on botany for academic reasons. At this juncture the governor of Dalecarlia invited him to travel through his province, as he had done through Lapland. Whilst on this journey, he lectured at Fahlun to large audiences; and J. Browallius (1707-1755), the chaplain there, afterwards bishop of Åbo, strongly urged him to go abroad and take his degree of M.D. at a foreign university, by which means he could afterwards settle where he pleased. Accordingly he left Sweden in 1735. Travelling by Lübeck and Hamburg, he proceeded to Harderwijk, where he went through the requisite examinations, and defended his thesis on the cause of intermittent fever. His scanty funds were now nearly spent, but he passed on through Haarlem to Leiden; there he called on Jan Fredrik Gronovius (1600-1762), who, returning the visit, was shown the *Systema naturae* in MS., and was so greatly astonished at it that he sent it to press at his own expense. This famous system, which, artificial as it was, substituted order for confusion, largely made its way on account of the lucid and admirable laws, and comments on them, which were issued almost at the same time (see Botany). H. Boerhaave, whom Linnaeus saw after waiting eight days for admission, recommended him to J. Burman (1707-1780), the professor of botany at Amsterdam, with whom he stayed a twelvemonth. While there he issued his *Fundamenta Botanica*, an unassuming small octavo, which exercised immense influence. For some time also he lived with the wealthy banker, G. Clifford (1685-1750), who had a magnificent garden at Hartecamp, near Haarlem. 733

In 1736 Linnaeus visited England. He was warmly recommended by Boerhaave to Sir Hans Sloane, who seems to have received him coldly. At Oxford Dr Thomas Shaw welcomed him cordially; J. J. Dillenius, the professor of botany, was cold at first, but afterwards changed completely, kept him a month, and even offered to share the emoluments of the chair with him. He saw Philip Miller (1691-1771), the *Hortulanorum Princeps*, at Chelsea Physic Garden, and took some plants thence to Clifford; but certain other stories which are current about his visit to England are of very doubtful authenticity.

On his return to the Netherlands he completed the printing of his *Genera Plantarum*, a volume which must be considered the starting-point of modern systematic botany. During the same year, 1737, he finished arranging Clifford's collection of plants, living and dried, described in the *Hortus Cliffortianus*. During the compilation he used to "amuse" himself with drawing up the *Critica Botanica*, also printed in the Netherlands. But this strenuous and unremitting labour told upon him; the atmosphere of the Low Countries seemed to oppress him beyond endurance; and, resisting all Clifford's entreaties to remain with him, he started homewards, yet on the way he remained a year at Leiden, and published his *Classes Plantarum* (1738). He then visited Paris, where he saw Antoine and Bernard de Jussieu, and finally sailed for Sweden from Rouen. In September 1738 he established himself as a physician in Stockholm, but, being unknown as a medical man, no one at first cared to consult him; by degrees, however, he found patients, was appointed naval physician at Stockholm, with minor appointments, and in June 1730 married Sara Moræa. In 1741 he was appointed to the chair of medicine at Upsala, but soon exchanged it for that of botany. In the same year, previous to this exchange, he travelled through Öland and Gothland, by command of the state, publishing his results in *Öländska och Gothländska Resa* (1745). The index to this volume shows the first employment of specific names in nomenclature.

Henceforward his time was taken up by teaching and the preparation of other works. In 1745 he issued his *Flora Suecica* and *Fauna Suecica*, the latter having occupied his attention during fifteen years; afterwards, two volumes of observations made during journeys in Sweden, *Wästgöta Resa* (Stockholm, 1747), and *Skånska Resa* (Stockholm, 1751). In 1748 he brought out his *Hortus Upsaliensis*, showing that he had added eleven hundred species to those formerly in cultivation in that garden. In 1750 his *Philosophia Botanica* was given to the world; it consists of a commentary on the various axioms he had published in 1735 in his *Fundamenta Botanica*, and was dictated to his pupil P. Löfling (1720-1756), while the professor was confined to his bed by an attack of gout. But the most important work of this period was his *Species Plantarum* (Stockholm, 1753), in which the specific names are fully set forth. In the same year he was created knight of the Polar Star, the first time a scientific man had been raised to that honour in Sweden. In 1755 he was invited by the king of Spain to settle in that country, with a liberal salary, and full liberty of conscience, but he declined on the ground that whatever merits he possessed should be devoted to his country's service, and Löfling was sent instead. He was enabled now to purchase the estates of Säfja and Hammarby; at the latter he built his museum of stone, to guard against loss by fire. His lectures at the university drew men from all parts of the world; the normal number of students at Upsala was five hundred, but while he occupied the chair of botany there it rose to fifteen hundred. In 1761 he was granted a patent of nobility, antedated to 1757, from which time he was styled Carl von Linné. To his great delight the tea-plant was introduced alive into Europe in 1763; in the same year his surviving son Carl (1741-1783) was allowed to assist his father in his professorial duties, and to be trained as his successor. At the age of sixty his memory began to fail; an apoplectic attack in 1774 greatly weakened him; two years after he lost the use of his right side; and he died on the 10th of January 1778 at Upsala, in the cathedral of which he was buried.

With Linnaeus arrangement seems to have been a passion; he delighted in devising classifications, and not only did he systematize the three kingdoms of nature, but even drew up a treatise on the *Genera Morborum*. When he appeared upon the scene, new plants and animals were in course of daily discovery in increasing numbers, due to the increase of trading facilities; he devised schemes of arrangement by which these acquisitions might be sorted provisionally, until their natural affinities should have become clearer. He made many mistakes; but the honour due to him for having first enunciated the principles for defining genera and species, and his uniform use of specific names, is enduring. His style is terse and laconic; he methodically treated of each organ in its proper turn, and had a special term for each, the meaning of which did not vary. The reader cannot doubt the author's intention; his sentences are business-like and to the point. The omission of the verb in his descriptions was an innovation, and gave an abruptness to his language which was foreign to the writing of his time; but it probably by its succinctness added to the popularity of his works.

No modern naturalist has impressed his own character with greater force upon his pupils than did Linnaeus. He imbued them with his own intense acquisitiveness, reared them in an atmosphere of enthusiasm, trained them to close and accurate observation, and then despatched them to various parts of the globe.

His published works amount to more than one hundred and eighty, including the *Amoenitates Academicae*, for which he provided the material, revising them also for press; corrections in his handwriting may be seen in the Banksian and Linnean Society's libraries. Many of his works were not published during his lifetime; those which were are enumerated by Dr Richard Pulteney in his *General View of the Writings of Linnaeus* (1781). His widow sold his collections and books to Sir J. E. Smith, the first president of the Linnean Society of London. When Smith died in 1828, a subscription was raised to purchase the herbarium and library for the Society, whose property they became. The manuscripts of many of Linnaeus's publications, and the letters he received from his contemporaries, also came into the possession of the Society.

(B. D. J.)

LINNELL, JOHN (1792-1882), English painter, was born in London on the 16th of June 1792. His father being a carver and gilder, Linnell was early brought into contact with artists, and when he was ten years old he was drawing and selling his portraits in chalk and pencil. His first artistic instruction was received from Benjamin West, and he spent a year in the house of John Varley the water-colour painter, where he had William Hunt and Mulready as fellow-pupils, and made the acquaintance of Shelley, Godwin and other men of mark. In 1805 he was admitted a student of the Royal Academy, where he obtained medals for drawing, modelling and sculpture. He was also trained as an engraver, and executed a transcript of Varley's "Burial of Saul." In after life he frequently occupied himself with the burin, publishing, in 1834, a series of outlines from Michelangelo's frescoes in the Sistine chapel, and, in 1840, superintending the issue of a selection of plates from the pictures in Buckingham Palace, one of them, a Titian landscape, being mezzotinted by himself. At first he supported himself mainly by miniature painting, and by the execution of larger portraits, such as the likenesses of Mulready, Whately, Peel and Carlyle. Several of his portraits he engraved with his own hand in line and mezzotint. He also painted many subjects like the "St John Preaching," the "Covenant of Abraham," and the "Journey to Emmaus," in which, while the landscape is usually prominent the figures are yet of sufficient importance to supply the title of the work. But it is mainly in connexion with his paintings of pure landscape that his name is known. His works commonly deal with some scene of typical uneventful English landscape, which is made impressive by a gorgeous effect of sunrise or sunset. They are full of true poetic feeling, and are rich and glowing in colour. Linnell was able to command very large prices for his pictures, and about 1850 he purchased a property at Redhill, Surrey, where he resided till his death on the 20th of January 1882, painting with unabated power till within the last few years of his life. His leisure was greatly occupied with a study of the Scriptures in the original, and he published several pamphlets and larger treatises of Biblical criticism. Linnell was one of the best friends and kindest patrons of William Blake. He gave him the two largest commissions he ever received for single series of designs—£150 for drawings and engravings of *The Inventions to the Book of Job*, and a like sum for those illustrative of Dante. 734

LINNET, O. Eng. *Linete* and *Linet-wige*, whence seems to have been corrupted the old Scottish "Lintquhit," and the modern northern English "Lintwhite"—originally a somewhat generalized bird's name, but latterly specialized for the *Fringilla cannabina* of Linnaeus, the *Linota cannabina* of recent ornithologists. This is a common song-bird, frequenting almost the whole of Europe south of lat. 64°, and in Asia extending to Turkestan. It is known as a winter visitant to Egypt and Abyssinia, and is abundant at all seasons in Barbary, as well as in the Canaries and Madeira. Though the fondness of this species for the seeds of flax (*Linum*) and hemp (*Cannabis*) has given it its common name in so many European languages,[1] it feeds largely, if not chiefly in Britain on the seeds of plants of the order *Compositae*, especially those growing on heaths and commons. As these waste places have been gradually brought under the plough, in England and Scotland particularly, the haunts and means of subsistence of the linnet have been curtailed, and hence its numbers have undergone a very visible diminution throughout Great Britain. According to its sex, or the season of the year, it is known as the red, grey or brown linnet, and by the earlier English writers on birds, as well as in many localities at the present time, these names have been held to distinguish at least two species; but there is now no question among ornithologists on this point, though the conditions under which the bright crimson-red colouring of the breast and crown of the cock's spring and summer plumage is donned and doffed may still be open to discussion. Its intensity seems due, however, in some degree at least, to the weathering of the brown fringes of the feathers which hide the more brilliant hue, and in the Atlantic islands examples are said to retain their gay tints all the year round, while throughout Europe there is scarcely a trace of them visible in autumn and winter; but, beginning to appear in spring, they reach their greatest brilliancy towards midsummer; they are never assumed by examples in confinement. The linnet begins to breed in April, the nest being generally placed in a bush at no great distance from the ground. It is nearly always a neat structure composed of fine twigs, roots or bents, and lined with wool or hair. The eggs, often six in number, are of a very pale blue marked with reddish or purplish brown. Two broods seem to be common in the course of the season, and towards the end of summer the birds—the young greatly preponderating in number—collect in large flocks and move to the sea-coast, whence a large proportion depart for more southern latitudes. Of these emigrants some return the following spring, and are recognizable by the more advanced state of their plumage, the effect presumably of having wintered in countries enjoying a brighter and hotter sun.

Nearly allied to the foregoing species is the twite, so named from its ordinary call-note, or mountain-linnet, the *Linota flavirostris*, or *L. montium* of ornithologists, which can be distinguished by its yellow bill, longer tail and reddish-tawny throat. This bird never assumes any crimson on the crown or breast, but the male has the rump at all times tinged more or less with that colour. In Great Britain in the breeding-season it seems to affect exclusively hilly and moorland districts from Herefordshire northward, in which it partly or wholly replaces the common linnet, but is very much more local in its distribution, and, except in the British Islands and some parts of Scandinavia, it only appears as an irregular visitant in winter. At that season it may, however, be found in large flocks in the low-lying countries, and as regards England even on the sea-shore. In Asia it seems to be represented by a kindred form *L. brevirostris*.

The redpolls form a little group placed by many authorities in the genus *Linota*, to which they are unquestionably closely allied, and, as stated elsewhere (see Finch), the linnets seem to be related to the birds of the genus *Leucosticte*, the species of which inhabit the northern parts of North-West America and of Asia. *L. tephrocotis* is generally of a chocolate colour, tinged on some parts with pale crimson or pink, and has the crown of the head silvery-grey. Another species, *L. arctoa*, was formerly said to have occurred in North America, but its proper home is in the Kurile Islands or Kamchatka. This has no red in its plumage. The birds of the genus *Leucosticte* seem to be more terrestrial in their habit than those of *Linota*, perhaps from their having been chiefly observed where trees are scarce; but it is possible that the mutual relationship of the two groups is more apparent than real. Allied to *Leucosticte* is *Montifringilla*, to which belongs the snow-finch of the Alps, *M. nivalis*, often mistaken by travellers for the snow-bunting, *Plectrophanes nivalis*.

(A. N.)

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1 E.g. Fr. *Linotte*, Ger. *Hänfling*, Swed. *Hämpling*.

LINSANG, the native name of one of the members of the viverrine genus *Linsanga*. There are four species of the genus, from the Indo-Malay countries. Linsangs are civet-like creatures, with the body and tail greatly elongated; and the ground colour fulvous marked with bold black patches, which in one species (*L. pardicolor*) are oblong. In West Africa the group is represented by the smaller and spotted *Poiana richardsoni* which has a genet-like hind-foot. (See Carnivora.)

LINSEED, the seed of the common flax (*q.v.*) or lint, *Linum usitatissimum*. These seeds, the linseed of commerce, are of a lustrous brown colour externally, and a compressed and elongated oval form, with a slight beak or projection at one extremity. The brown testa contains, in the outer of the four coats into which it is microscopically distinguishable, an abundant secretion of mucilaginous matter; and it has within it a thin layer of albumen, enclosing a pair of large oily cotyledons. The seeds when placed in water for some time become coated with glutinous matter from the exudation of the mucilage in the external layer of the epidermis; and by boiling in sixteen parts of water they exude sufficient mucilage to form with the water a thick pasty decoction. The cotyledons contain the valuable linseed oil referred to below. Linseed grown in tropical countries is much larger and more plump than that obtained in temperate climes, but the seed from the colder countries yields a finer quality of oil.

Linseed formed an article of food among the Greeks and Romans, and it is said that the Abyssinians at the present day eat it roasted. The oil is to some extent used as food in Russia and in parts of Poland and Hungary. The still prevalent use of linseed in poultices for open wounds is entirely to be reprobated. It has now been abandoned by practitioners. The principal objections to this use of linseed is that it specially favours the growth of micro-organisms. There are numerous clean and efficient substitutes which have all its supposed advantages and none of its disadvantages. There are now no medicinal uses of this substance. Linseed cake, the marc left after the expression of the oil, is a most valuable feeding substance for cattle.

Linseed is subject to extensive and detrimental adulterations, resulting not only from careless harvesting and cleaning, whereby seeds of the flax dodder, and other weeds and grasses are mixed with it, but also from the direct admixture of cheaper and inferior oil-seeds, such as wild rape,
mustard, sesame, poppy, &c., the latter adulterations being known in trade under the generic name of "buffum." In 1864, owing to the serious 735
aspect of the prevalent adulteration, a union of traders was formed under the name of the "Linseed Association." This body samples all linseed oil arriving in England and reports on its value.

Linseed oil, the most valuable drying oil, is obtained by expression from the seeds, with or without the aid of heat. Preliminary to the operation of pressing, the seeds are crushed and ground to a fine meal. Cold pressing of the seeds yields a golden-yellow oil, which is often used as an edible oil. Larger quantities are obtained by heating the crushed seeds to 160° F. (71° C.), and then expressing the oil. So obtained, it is somewhat turbid and yellowish-brown in colour. On storing, moisture and mucilaginous matter gradually settle out. After storing several years it is known commercially as "tanked oil," and has a high value in varnish-making. The delay attendant on this method of purification is avoided by treating the crude oil with 1 to 2% of a somewhat strong sulphuric acid, which chars and carries down the bulk of the impurities. For the preparation of "artist's oil," the finest form of linseed oil, the refined oil is placed in shallow trays covered with glass, and exposed to the action of the sun's rays. Numerous other methods of purification, some based on the oxidizing action of ozone, have been suggested. The yield of oil from different classes of seed varies, but from 23 to 28% of the weight of the seed operated on should be obtained. A good average quality of seed weighing about 392 ℔ per quarter has been found in practice to give out 109 ℔ of oil.

Commercial linseed oil has a peculiar, rather disagreeable sharp taste and smell; its specific gravity is given as varying from 0.928 to 0.953, and it solidifies at about -27°. By saponification it yields a number of fatty acids—palmitic, myristic, oleic, linolic, linolenic and isolinolenic. Exposed to the air in thin films, linseed oil absorbs oxygen and forms "linoxyn," a resinous semi-elastic, caoutchouc-like mass, of uncertain composition. The oil, when boiled with small proportions of litharge and minium, undergoes the process of resinification in the air with greatly increased rapidity.

Its most important use is in the preparation of oil paints and varnishes. By painters both raw and boiled oil are used, the latter forming the principal medium in oil painting, and also serving separately as the basis of all oil varnishes. Boiled oil is prepared in a variety of ways—that most common being by heating the raw oil in an iron or copper boiler, which, to allow for frothing, must only be about three-fourths filled. The boiler is heated by a furnace, and the oil is brought gradually to the point of ebullition, at which it is maintained for two hours, during which time moisture is driven off, and the scum and froth which accumulate on the surface are ladled out. Then by slow degrees a proportion of "dryers" is added—usually equal weights of litharge and minium being used to the extent of 3% of the charge of oil; and with these a small proportion of umber is generally thrown in. After the addition of the dryers the boiling is continued two or three hours; the fire is then suddenly withdrawn, and the oil is left covered up in the boiler for ten hours or more. Before sending out, it is usually stored in settling tanks for a few weeks, during which time the uncombined dryers settle at the bottom as "foots." Besides the dryers already mentioned, lead acetate, manganese borate, manganese dioxide, zinc sulphate and other bodies are used.

Linseed oil is also the principal ingredient in printing and lithographic inks. The oil for ink-making is prepared by heating it in an iron pot up to the point where it either takes fire spontaneously or can be ignited with any flaming substance. After the oil has been allowed to burn for some time according to the consistence of the varnish desired, the pot is covered over, and the product when cooled forms a viscid tenacious substance which in its most concentrated form may be drawn into threads. By boiling this varnish with dilute nitric acid vapours of acrolein are given off, and the substance gradually becomes a solid non-adhesive mass the same as the ultimate oxidation product of both raw and boiled oil.

Linseed oil is subject to various falsifications, chiefly through the addition of cotton-seed, niger-seed and hemp-seed oils; and rosin oil and mineral oils also are not infrequently added. Except by smell, by change of specific gravity, and by deterioration of drying properties, these adulterations are difficult to detect.

LINSTOCK (adapted from the Dutch *lontstok*, *i.e.* "matchstick," from *lont*, a match, *stok*, a stick; the word is sometimes erroneously spelled "lintstock" from a supposed derivation from "lint" in the sense of tinder), a kind of torch made of a stout stick a yard in length, with a fork at one end to hold a lighted match, and a point at the other to stick in the ground. "Linstocks" were used for discharging cannon in the early days of artillery.

LINT (in M. Eng. *linnet*, probably through Fr. *linette*, from *lin*, the flax-plant; cf. "line"), properly the flax-plant, now only in Scots dialect; hence the application of such expressions as "lint-haired," "lint white locks" to flaxen hair. It is also the term applied to the flax when prepared for spinning, and to the waste material left over which was used for tinder. "Lint" is still the name given to a specially prepared material for dressing wounds, made soft and fluffy by scraping or ravelling linen cloth.

LINTEL (O. Fr. *lintel*, mod. *linteau*, from Late Lat. *limitellum*, *limes*, boundary, confused in sense with *limen*, threshold; the Latin name is *supercilium*, Ital. *soprasogli*, and Ger. *Sturz*), in architecture, a horizontal piece of stone or timber over a doorway or opening, provided to carry the superstructure. In order to relieve the lintel from too great a pressure a "discharging arch" is generally built over it.

LINTH, or Limmat, a river of Switzerland, one of the tributaries of the Aar. It rises in the glaciers of the Tödi range, and has cut out a deep bed which forms the Grossthal that comprises the greater portion of the canton of Glarus. A little below the town of Glarus the river, keeping its northerly direction, runs through the alluvial plain which it has formed, towards the Walensee and the Lake of Zürich. But between the Lake of Zürich and the Walensee the huge desolate alluvial plain grew ever in size, while great damage was done by the river, which overflowed its bed and the dykes built to protect the region near it. The Swiss diet decided in 1804 to undertake the "correction" of this turbulent stream. The necessary works were begun in 1807 under the supervision of Hans Conrad Escher of Zürich (1767-1823). The first portion of the undertaking was completed in 1811, and received the name of the "Escher canal," the river being thus diverted into the Walensee. The second portion, known as the "Linth canal," regulated the course of the river between the Walensee and the Lake of Zürich and was completed in 1816. Many improvements and extra protective works were carried out after 1816, and it was estimated that the total cost of this great engineering undertaking from 1807 to 1902 amounted to about £200,000, the date for the completion of the work being 1911. To commemorate the efforts of Escher, the Swiss diet in 1823 (after his death) decided that his male descendants should bear the name of "Escher von der Linth." On issuing from the Lake of Zürich the Linth alters its name to that of “Limmat,” it does not appear wherefore, and, keeping the north-westerly direction it had taken from the Walensee, joins the Aar a little way below Brugg, and just below the junction of the Reuss with the Aar.

(W. A. B. C.)

LINTON, ELIZA LYNN (1822-1898), English novelist, daughter of the Rev. J. Lynn, vicar of Crosthwaite, in Cumberland, was born at Keswick on the 10th of February 1822. She early manifested great independence of character, and in great measure educated herself from the stores of her father’s library. Coming to London about 1845 with a large stock of miscellaneous erudition, she turned this to account in her first novels, *Azeth the Egyptian* (1846) and *Amymone* (1848), a romance of the days of Pericles. Her next story, *Realities*, a tale of modern life (1851), was not successful, and for several years she seemed to have abandoned fiction. When, in 1865, she reappeared with *Grasp your Nettle*, it was as an expert in a new style of novel-writing—stirring, fluent, ably-constructed stories, retaining the attention throughout, but affording little to reflect upon or to remember. Measured by their immediate success, they gave her an honourable position among the writers of her day, and secure of an audience, she continued to write with vigour nearly until her death. *Lizzie Lorton of Greyrigg* (1866), *Patricia Kemball* (1874), *The Atonement of Leam Dundas* (1877) are among the best examples of this more mechanical side of her talent, to which there were notable exceptions in *Joshua Davidson* (1872), a bold but not irreverent adaptation of the story of the Carpenter of Nazareth to that of the French Commune; and *Christopher Kirkland*, a veiled autobiography (1885). Mrs Linton was a practised and constant writer in the journals of the day; her articles on the “Girl of the Period” in the *Saturday Review* produced a great sensation, and she was a constant contributor to the *St James’s Gazette*, the *Daily News* and other leading newspapers. Many of her detached essays have been collected. In 1858 she married W. J. Linton, the engraver, but the union was soon terminated by mutual consent; she nevertheless brought up one of Mr Linton’s daughters by a former marriage. A few years before her death she retired to Malvern. She died in London on the 14th of July 1898. 736

Her reminiscences appeared after her death under the title of *My Literary Life* (1899) and her life has been written by G. S. Layard (1901).

LINTON, WILLIAM JAMES (1812-1897), English wood-engraver, republican and author, was born in London. He was educated at Stratford, and in his sixteenth year was apprenticed to the wood-engraver G. W. Bonner. His earliest known work is to be found in Martin and Westall’s *Pictorial Illustrations of the Bible* (1833). He rapidly rose to a place amongst the foremost wood-engravers of the time. After working as a journeyman engraver with two or three firms, losing his money over a cheap political library called the “National,” and writing a life of Thomas Paine, he went into partnership (1842) with John Orrin Smith. The firm was immediately employed on the *Illustrated London News*, just then projected. The following year Orrin Smith died, and Linton, who had married a sister of Thomas Wade, editor of *Bell’s Weekly Messenger*, found himself in sole charge of a business upon which two families were dependent. For years he had concerned himself with the social and European political problems of the time, and was now actively engaged in the republican propaganda. In 1844 he took a prominent part in exposing the violation by the English post-office of Mazzini’s correspondence. This led to a friendship with the Italian revolutionist, and Linton threw himself with ardour into European politics. He carried the first congratulatory address of English workmen to the French Provisional Government in 1848. He edited a twopenny weekly paper, *The Cause of the People*, published in the Isle of Man, and he wrote political verses for the Dublin *Nation*, signed “Spartacus.” He helped to found the “International League” of patriots, and, in 1850, with G. H. Lewes and Thornton Hunt, started *The Leader*, an organ which, however, did not satisfy his advanced republicanism, and from which he soon withdrew. The same year he wrote a series of articles propounding the views of Mazzini in *The Red Republican*. In 1852 he took up his residence at Brantwood, which he afterwards sold to John Ruskin, and from there issued *The English Republic*, first in the form of weekly tracts and afterwards as a monthly magazine—“a useful exponent of republican principles, a faithful record of republican progress throughout the world; an organ of propagandism and a medium of communication for the active republicans in England.” Most of the paper, which never paid its way and was abandoned in 1855, was written by himself. In 1852 he also printed for private circulation an anonymous volume of poems entitled *The Plaint of Freedom*. After the failure of his paper he returned to his proper work of wood-engraving. In 1857 his wife died, and in the following year he married Eliza Lynn (afterwards known as Mrs Lynn Linton) and returned to London. In 1864 he retired to Brantwood, his wife remaining in London. In 1867, pressed by financial difficulties, he determined to try his fortune in America, and finally separated from his wife, with whom, however, he always corresponded affectionately. With his children he settled at Appledore, New Haven, Connecticut, where he set up a printing-press. Here he wrote *Practical Hints on Wood-Engraving* (1879), *James Watson, a Memoir of Chartist Times* (1879), *A History of Wood-Engraving in America* (1882), *Wood-Engraving, a Manual of Instruction* (1884), *The Masters of Wood-Engraving*, for which he made two journeys to England (1890), *The Life of Whittier* (1893), and *Memories*, an autobiography (1895). He died at New Haven on the 29th of December 1897. Linton was a singularly gifted man, who, in the words of his wife, if he had not bitten the Dead Sea apple of impracticable politics, would have risen higher in the world of both art and letters. As an engraver on wood he reached the highest point of execution in his own line. He carried on the tradition of Bewick, fought for intelligent as against merely manipulative excellence in the use of the graver, and championed the use of the “white line” as well as of the black, believing with Ruskin that the former was the truer and more telling basis of aesthetic expression in the wood-block printed upon paper.

See W. J. Linton, *Memories*; F. G. Kitton, article on “Linton” in *English Illustrated Magazine* (April 1891); G. S. Layard, *Life of Mrs Lynn Linton* (1901).

(G. S. L.)

LINTOT, BARNABY BERNARD (1675-1736), English publisher, was born at Southwater, Sussex, on the 1st of December 1675, and started business as a publisher in London about 1698. He published for many of the leading writers of the day, notably Vanbrugh, Steele, Gay and Pope. The latter’s *Rape of the Lock* in its original form was first published in *Lintot’s Miscellany*, and Lintot subsequently issued Pope’s translation of the *Iliad* and the joint translation of the *Odyssey* by Pope, Fenton and Broome. Pope quarrelled with Lintot with regard to the supply of free copies of the latter translation to the author’s subscribers, and in 1728 satirized the publisher in the *Dunciad*, and in 1735 in the *Prologue to the Satires*, though he does not appear to have had any serious grievance. Lintot died on the 3rd of February 1736.

LINUS, one of the saints of the Gregorian canon, whose festival is celebrated on the 23rd of September. All that can be said with certainty about him is that his name appears at the head of all the lists of the bishops of Rome. Irenaeus (*Adv. Haer.* iii. 3. 3) identifies him with the Linus mentioned by St Paul in 2 Tim. iv. 21. According to the *Liber Pontificalis*, Linus suffered martyrdom, and was buried in the Vatican. In the 17th century an inscription was found near the confession of St Peter, which was believed to contain the name Linus; but it is not certain that this epitaph has been read correctly or completely. The apocryphal Latin account of the death of the apostles Peter and Paul is falsely attributed to Linus.

See *Acta Sanctorum*, Septembris, vi. 539-545; C. de Smedt, *Dissertatione selectae in primam aetatem hist. eccl.* pp. 300-312 (Ghent, 1876); L. Duchesne’s edition of the *Liber Pontificalis*, i. 121 (Paris, 1886); R. A. Lipsius, *Die apokryphen Apostelgeschichten*, ii. 85-96 (Brunswick, 1883-1890); J. B. de Rossi, *Bullettino di archeologia cristiana*, p. 50 (1864).

(H. De.)

LINUS, one of a numerous class of heroic figures in Greek legend, of which other examples are found in Hyacinthus and Adonis. The connected legend is always of the same character: a beautiful youth, fond of hunting and rural life, the favourite of some god or goddess, suddenly perishes by a terrible death. In many cases the religious background of the legend is preserved by the annual ceremonial that commemorated it. At Argos this religious character of the Linus myth was best preserved: the secret child of Psamathe by the god Apollo, Linus is exposed, nursed by sheep and torn in pieces by sheep-dogs. Every year at the festival Arnis or Cynophontis, the women of Argos mourned for Linus and propitiated Apollo, who in revenge for his child's death had sent a female monster (Poinē), which tore the children from their mothers' arms. Lambs were sacrificed, all dogs found running loose were killed, and women and children raised a lament for Linus and Psamathe (Pausanias i. 43. 7; Conon, *Narrat.* 19). In the Theban version, Linus, the son of Amphimarus and the muse Urania, was a famous musician, inventor of the Linus song, who was said to have been slain by Apollo, because he had challenged him to a contest (Pausanias ix. 29. 6). A later story makes him the teacher of Heracles, by whom he was killed because he had rebuked his pupil for stupidity (Apollodorus ii. 4. 9). On Mount Helicon there was a grotto containing his statue, to which sacrifice was offered every year before the sacrifices to the Muses. From being the inventor of musical methods, he was finally transformed by later writers into a composer of prophecies and legends. He was also said to have adapted the Phoenician letters introduced by Cadmus to the Greek language. It is generally agreed that Linus and Ailinus are of Semitic origin, derived from the words *ai lanu* (woe to us), which formed the burden of the Adonis and similar songs popular in the East. The Linus song is mentioned in Homer; the tragedians often use the word αἴλινος as the refrain in mournful songs, and Euripides calls the custom a Phrygian one. Linus, originally the personification of the song of lamentation, becomes, like Adonis, Maneros, Narcissus, the representative of the tender life of nature and of the vegetation destroyed by the fiery heat of the dog-star. 737

The chief work on the subject is H. Brugsch, *Die Adonisklage und das Linoslied* (1852); see also article in Roscher's *Lexikon der Mythologie*; J. G. Frazer, *Golden Bough* (ii. 224, 253), where, the identity of Linus with Adonis (possibly a corn-spirit) being assumed, the lament is explained as the lamentation of the reapers over the dead corn-spirit; W. Mannhardt, *Wald- und Feldculte*, ii. 281.

LINZ, capital of the Austrian duchy and crownland of Upper Austria, and see of a bishop, 117 m. W. of Vienna by rail. Pop. (1900) 58,778. It lies on the right bank of the Danube and is connected by an iron bridge, 308 yds. long, with the market-town of Urfahr (pop. 12,827) on the opposite bank. Linz possesses two cathedrals, one built in 1669-1682 in rococo style, and another in early Gothic style, begun in 1862. In the Capuchin church is the tomb of Count Raimondo Montecucculi, who died at Linz in 1680. The museum Francisco-Carolinum, founded in 1833 and reconstructed in 1895, contains several important collections relating to the history of Upper Austria. In the Franz Josef-Platz stands a marble monument, known as Trinity Column, erected by the emperor Charles VI. in 1723, commemorating the triple deliverance of Linz from war, fire, and pestilence. The principal manufactories are of tobacco, boat-building, agricultural implements, foundries and cloth factories. Being an important railway junction and a port of the Danube, Linz has a very active transit trade.

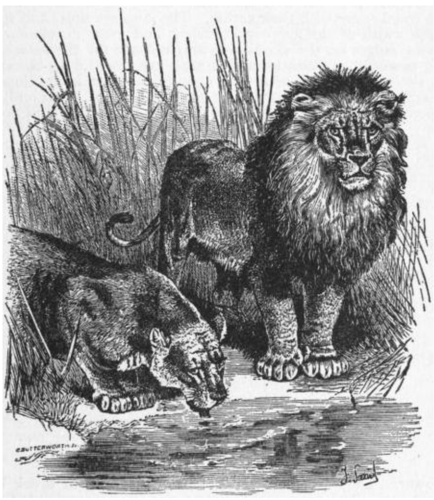
Linz is believed to stand on the site of the Roman station *Lentia*. The name of Linz appears in documents for the first time in 799 and it received municipal rights in 1324. In 1490 it became the capital of the province above the Enns. It successfully resisted the attacks of the insurgent peasants under Stephen Fadinger on the 21st and 22nd of July 1626, but its suburbs were laid in ashes. During the siege of Vienna in 1683, the castle of Linz was the residence of Leopold I. In 1741, during the War of the Austrian Succession, Linz was taken by the Bavarians, but was recovered by the Austrians in the following year. The bishopric was established in 1784.

See F. Krackowitzer, *Die Donaustadt Linz* (Linz, 1901).

LION (Lat. *leo*, *leonis*; Gr. λέων). From the earliest historic times few animals have been better known to man than the lion. Its habitat made it familiar to all the races among whom human civilization took its origin. The literature of the ancient Hebrews abounds in allusions to the lion; and the almost incredible numbers stated to have been provided for exhibition and destruction in the Roman amphitheatres (as many as six hundred on a single occasion by Pompey, for example) show how abundant these animals must have been within accessible distance of Rome.

Even within the historic period the geographical range of the lion covered the whole of Africa, the south of Asia, including Syria, Arabia, Asia Minor, Persia and the greater part of northern and central India. Professor A. B. Meyer, director of the zoological museum at Dresden, has published an article on the alleged existence of the lion in historical times in Greece, a translation of which appears in the *Report* of the Smithsonian Institution for 1905. Meyer is of opinion that the writer of the *Iliad* was probably acquainted with the lion, but this does not prove its former existence in Greece. The accounts given by Herodotus and Aristotle merely go to show that about 500 B.C. lions existed in some part of eastern Europe. The Greek name for the lion is very ancient, and this suggests, although by no means demonstrates, that it refers to an animal indigenous to the country. Although the evidence is not decisive, it seems probable that lions did exist in Greece at the time of Herodotus; and it is quite possible that the representation of a lion-chase incised on a Mycenean dagger may have been taken from life. In prehistoric times the lion was spread over the greater part of Europe; and if, as is very probable, the so-called *Felis atrox* be inseparable, its range also included the greater part of North America.

At the present day the lion is found throughout Africa (save in places where it has been exterminated by man) and in Mesopotamia, Persia, and some parts of north-west India. According to Dr W. T. Blanford, lions are still numerous in the reedy swamps, bordering the Tigris and Euphrates, and also occur on the west flanks of the Zagros mountains and the oak-clad ranges near Shiraz, to which they are attracted by the herds of swine which feed on the acorns. The lion nowhere exists in the table-land of Persia, nor is it found in Balūchistān. In India it is confined to the province of Kathiawar in Gujerat, though within the 19th century it extended through the north-west parts of Hindustan, from Bahāwalpur and Sind to at least the Jumna (about Delhi) southward as far as Khāndesh, and in central India through the Sagur and Narbuda territories, Bundelkund, and as far east as Palamau. It was extirpated in Hariāna about 1824. One was killed at Rhyli, in the Dumaoh district, Sagur and Narbuda territories, so late as in the cold season of 1847-1848; and about the same time a few still remained in the valley of the Sind river in Kotah, central India.



After a Drawing by Woll in Elliot's Monograph of the *Felidae*.
Fig. 1.—Lion and Lioness (*Felis leo*).

The variations in external characters which lions present, especially in the colour and the amount of mane, as well as in the general colour of the fur, indicate local races, to which special names have been given; the Indian lion being *F. leo gujratensis*. It is noteworthy, however, that, according to Mr F. C. Selous, in South Africa the black-maned lion and others with yellow scanty manes are found, not only in the same locality, but even among individuals of the same parentage.

The lion belongs to the genus *Felis* of Linnaeus (for the characters and position of which see Carnivora), and differs from the tiger and leopard in its uniform colouring, and from all the other *Felidae* in the hair of the top of the head, chin and neck, as far back as the shoulder, being not only much longer, but also differently disposed from the hair elsewhere, being erect or directed forwards, and so constituting the characteristic ornament called the mane. There is also a tuft of elongated hairs at the end of the tail, one upon each elbow, and in most lions a copious fringe along the middle line of the under surface of the body, wanting, however, in some examples. These characters are, however, peculiar to the adults of the male sex; and even as regards coloration young lions show indications of the darker stripes and mottlings so characteristic of the greater number of the members of the genus. The usual colour of the adult is yellowish-brown, but it may vary from a deep red or chestnut brown to an almost silvery grey. The mane, as well as the long hair of the other parts of the body, sometimes scarcely differs from the general colour, but is usually darker and not unfrequently nearly black. The mane begins to grow when the animal is about three years old, and is fully developed at five 738
or six.

In size the lion is only equalled or exceeded by the tiger among existing *Felidae*; and though both species present great variations, the largest specimens of the latter appear to surpass the largest lions. A full-sized South African lion, according to Selous, measures slightly less than 10 ft. from nose to tip of tail, following the curves of the body. Sir Cornwallis Harris gives 10 ft. 6 in., of which the tail occupies 3 ft. The lioness is about a foot less.

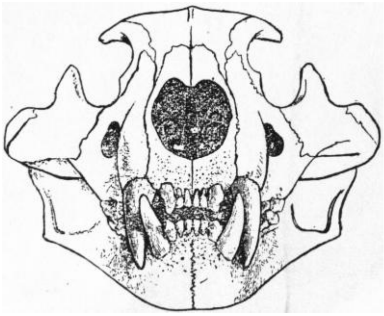


Fig. 2.—Front View of Skull of Lion.

The internal structure of the lion, except in slight details, resembles that of other *Felidae*, the whole organization being that of an animal adapted for an active, predaceous existence. The teeth especially exemplify the carnivorous type in its highest condition of development. The most important function they have to perform, that of seizing and holding firmly animals of considerable size and strength, violently struggling for life, is provided for by the great, sharp-pointed and sharp-edged canines, placed wide apart at the angles of the mouth, the incisors between them being greatly reduced in size and kept back nearly to the same level, so as not to interfere with their action. The jaws are short and strong, and the width of the zygomatic arches, and great development of the bony ridges on the skull, give ample space for the attachment of the powerful muscles by which they are closed. In the cheek-teeth the sectorial or scissor-like cutting function is developed at the expense of the tubercular or grinding, there being only one rudimentary tooth of the latter form in the upper jaw, and none in the lower. They are, however, sufficiently strong to break bones of large size. The tongue is long and flat, and remarkable for the development of the papillae of the anterior part of the dorsal surface, which (except near the edge) are modified so as to resemble long, compressed, recurved, horny spines or claws, which, near the middle line, attain the length of one-fifth of an inch. They give the part of the tongue on which they occur the appearance and feel of a coarse rasp. The feet are furnished with round soft pads or cushions covered with thick, naked skin, one on the under surface of each of the principal toes, and one larger one of trilobed form, behind these, under the lower ends of the metacarpal and metatarsal bones, which are placed nearly vertically in ordinary progression. The claws are large, strongly compressed, sharp, and exhibit the retractile condition in the highest degree, being drawn backwards and upwards into a sheath by the action of an elastic ligament so long as the foot is in a state of repose, but exerted by muscular action when the animal strikes its prey.

The lion lives chiefly in sandy plains and rocky places interspersed with dense thorn-thickets, or frequents the low bushes and tall rank grass and reeds that grow along the sides of streams and near the springs where it lies in wait for the larger herbivorous animals on which it feeds. Although occasionally seen abroad during the day, especially in wild and desolate regions, where it is subject to little molestation, the night is, as in the case of so many other predaceous animals, the period of its greatest activity. It is then that its characteristic roar is chiefly heard, as thus graphically described by Gordon-Cumming:—

> "One of the most striking things connected with the lion is his voice, which is extremely grand and peculiarly striking. It consists at times of a low deep moaning, repeated five or six times, ending in faintly audible sighs; at other times he startles the forest with loud, deep-toned, solemn roars, repeated in quick succession, each increasing in loudness to the third or fourth, when his voice dies away in five or six low muffled sounds very much resembling distant thunder. At times, and not unfrequently, a troop may be heard, roaring in concert, one assuming the lead, and two, three or four more regularly taking up their parts, like persons singing a catch. Like our Scottish stags at the rutting season, they roar loudest in cold frosty nights; but on no occasions are their voices to be heard in such perfection, or so intensely powerful, as when two or three troops of strange lions approach a fountain to drink at the same time. When this occurs, every member of each troop sounds a bold roar of defiance at the opposite parties; and when one roars, all roar together, and each seems to vie with his comrades in the intensity and power of his voice. The power and grandeur of these nocturnal concerts is inconceivably striking and pleasing to the hunter's ear."

"The usual pace of a lion," C. J. Andersson says, "is a walk, and, though apparently rather slow, yet, from the great length of his body, he is able to get over a good deal of ground in a short time. Occasionally he trots, when his speed is not inconsiderable. His gallop—or rather succession of bounds—is, for a short distance, very fast—nearly or quite equal to that of a horse."

"The lion, as with other members of the feline family," the same writer says, "seldom attacks his prey openly, unless compelled by extreme hunger. For the most part he steals upon it in the manner of a cat, or ambushes himself near to the water or a pathway frequented by game. At such times he lies crouched upon his belly in a thicket until the animal approaches sufficiently near, when, with one prodigious bound, he pounces upon it. In most cases he is successful, but should his intended victim escape, as at times happens, from his having miscalculated the distance, he may make a second or even a third bound, which, however, usually prove fruitless, or he returns disconcerted to his hiding-place, there to wait for another opportunity." His food consists of all the larger herbivorous animals of the country in which he resides—buffaloes, antelopes, zebras, giraffes or even young elephants or rhinoceroses. In cultivated districts cattle, sheep, and even human inhabitants are never safe from his nocturnal ravages. He appears, however, as a general rule, only to kill when hungry or attacked, and not for the mere pleasure of killing, as with some other carnivorous animals. He, moreover, by no means limits himself to animals of his own killing, but, according to Selous, often prefers eating game that has been killed by man, even when not very fresh, to taking the trouble to catch an animal himself.

The lion appears to be monogamous, a single male and female continuing attached to each other irrespectively of the pairing season. At all events the lion remains with the lioness while the cubs are young and helpless, and assists in providing her and them with food, and in educating them in the art of providing for themselves. The number of cubs at a birth is from two to four, usually three. They are said to remain with their parents till they are about three years old.

Though not strictly gregarious, lions appear to be sociable towards their own species, and often are found in small troops sometimes consisting of a pair of old ones with their nearly full-grown cubs, but occasionally of adults of the same sex; and there seems to be evidence that several lions will associate for the purpose of hunting upon a preconcerted plan. Their natural ferocity and powerful armature are sometimes turned upon one another; combats, often mortal, occur among male lions under the influence of jealousy; and Andersson relates an instance of a quarrel between a hungry lion and lioness over the carcase of an antelope which they had just killed, and which did not seem sufficient for the appetite of both, ending in the lion not only killing, but devouring his mate. Old lions, whose teeth have become injured with constant wear, become "man-eaters," finding their easiest means of obtaining a subsistence in lurking in the neighbourhood of villages, and dashing into the tents at night and carrying off one of the sleeping inmates. Lions never climb.

With regard to the character of the lion, those who have had opportunities of observing it in its native haunts differ greatly. The accounts of early 739
writers as to its courage, nobility and magnanimity have led to a reaction, causing some modern authors to accuse it of cowardice and meanness. Livingstone goes so far as to say, "nothing that I ever learned of the lion could lead me to attribute to it either the ferocious or noble character ascribed to it elsewhere," and he adds that its roar is not distinguishable from that of the ostrich. These different estimates depend to a great extent upon the particular standard of the writer, and also upon the circumstance that lions, like other animals, show considerable individual differences in character, and behave differently under varying circumstances.

(W. H. F.; R. L.*)

LIONNE, HUGUES DE

LIONNE, HUGUES DE (1611-1671), French statesman, was born at Grenoble on the 11th of October 1611, of an old family of Dauphiné. Early trained for diplomacy, his remarkable abilities attracted the notice of Cardinal Mazarin, who sent him as secretary of the French embassy to the congress of Münster, and, in 1642, on a mission to the pope. In 1646 he became secretary to the queen regent; in 1653 obtained high office in the king's household; and in 1654 was ambassador extraordinary at the election of Pope Alexander VII. He was instrumental in forming the league of the Rhine, by which Austria was cut off from the Spanish Netherlands, and, as minister of state, was associated with Mazarin in the Peace of the Pyrenees (1659), which secured the marriage of Louis XIV. to the infanta Maria Theresa. At the cardinal's dying request he was appointed his successor in foreign affairs, and, for the next ten years, continued to direct French foreign policy. Among his most important diplomatic successes were the treaty of Breda (1667), the treaty of Aix-la-Chapelle (1668) and the sale of Dunkirk. He died in Paris on the 1st of September 1671, leaving memoirs. He was a man of pleasure, but his natural indolence gave place to an unflagging energy when the occasion demanded it; and, in an age of great ministers, his consummate statesmanship placed him in the front rank.

See Ulysse Chevalier, *Lettres inédites de Hugues de Lionne ... précédées d'une notice historique sur la famille de Lionne* (Valence, 1879); J. Valfrey, *La diplomatie française au XVIIIe siècle: Hugues de Lionne, ses ambassadeurs* (2 vols., Paris, 1877-1881). For further works see Rochas, *Biogr. du Dauphiné* (Paris, 1860), tome ii. p. 87.

LIOTARD, JEAN ETIENNE

LIOTARD, JEAN ETIENNE (1702-1789), French painter, was born at Geneva. He began his studies under Professor Gardelle and Petitot, whose enamels and miniatures he copied with considerable skill. He went to Paris in 1725, studying under J. B. Massé and F. le Moyne, on whose recommendation he was taken to Naples by the Marquis Puysieux. In 1735 he was in Rome, painting the portraits of Pope Clement XII. and several cardinals. Three years later he accompanied Lord Duncannon to Constantinople, whence he went to Vienna in 1742 to paint the portraits of the imperial family. His eccentric adoption of oriental costume secured him the nickname of "the Turkish painter." Still under distinguished patronage he returned to Paris in 1744, visited England, where he painted the princess of Wales in 1753, and went to Holland in 1756, where, in the following year, he married Marie Fargues. Another visit to England followed in 1772, and in the next two years his name figures among the Royal Academy exhibitors. He returned to his native town in 1776 and died at Geneva in 1789.

Liotard was an artist of great versatility, and though his fame depends largely on his graceful and delicate pastel drawings, of which "La Liseuse," the "Chocolate Girl," and "La Belle Lyonnaise" at the Dresden Gallery are delightful examples, he achieved distinction by his enamels, copper-plate engravings and glass painting. He also wrote a *Treatise on the Art of Painting*, and was an expert collector of paintings by the old masters. Many of the masterpieces he had acquired were sold by him at high prices on his second visit to England. The museums of Amsterdam, Berne, and Geneva are particularly rich in examples of his paintings and pastel drawings. A picture of a Turk seated is at the Victoria and Albert Museum, while the British Museum owns two of his drawings. The Louvre has, besides twenty-two drawings, a portrait of General Hérault and a portrait of the artist is to be found at the Sala dei pittori, in the Uffizi Gallery, Florence.

See *La Vie et les œuvres de Jean Etienne Liotard (1702-1789), étude biographique et iconographique*, by E. Humbert, A. Revilliod, and J. W. R. Tilanus (Amsterdam, 1897).

LIP

LIP (a word common in various forms, to Teutonic languages, cf Ger. *Lippe*, Dan. *laebe*; Lat. *labium* is cognate), one of the two fleshy protuberant edges of the mouth in man and other animals, hence transferred to such objects as resemble a lip, the edge of a circular or other opening, as of a shell, or of a wound, or of any fissure in anatomy and zoology; in this last usage the Latin *labium* is more usually employed. It is also used of any projecting edge, as in coal-mining, &c. Many figurative uses are derived from the connexion with the mouth as the organ of speech. In architecture "lip moulding" is a term given to a moulding employed in the Perpendicular period, from its resemblance to an overhanging lip. It is often found in base mouldings, and is not confined to England, there being similar examples in France and Italy.

LIPA

LIPA, a town of the province of Batangas, Luzon, Philippine Islands, about 90 m. S. by E. of Manila. Pop. (1903) 37,934. Lipa is on high ground at the intersection of old military roads, is noted for its cool and healthy climate, and is one of the largest and wealthiest inland towns of the archipelago. Many of its houses have two storeys above the ground-floor, and its church and convent together form a very large building. The surrounding country is very fertile, producing sugar-cane, Indian corn, cacao, tobacco and indigo. The cultivation of coffee was begun here on a large scale about the middle of the 19th century and was increased gradually until 1889-1890 when an insect pest destroyed the trees. The language of Lipa is Tagalog.

LIPAN

LIPAN, a tribe of North American Indians of Athabascan stock. Their former range was central Texas. Later they were driven into Mexico. They were pure nomads, lived entirely by hunting, and were perhaps the most daring of the Texas Indians. A few survivors were brought back from Mexico in 1905 and placed on a reservation in New Mexico.

LIPARI ISLANDS

LIPARI ISLANDS (anc. Αἰόλου νῆσοι, or *Aeoliae Insulae*), a group of volcanic islands N. of the eastern portion of Sicily. They are seven in number—Lipari (*Lipara*, pop. in 1901, 15,290), Stromboli (*Strongyle*), Salina (*Didyme*, pop. in 1901, 4934), Filicuri (*Phoenicusa*), Alicuri (*Ericusa*), Vulcano (*Hiera*, *Therasia* or *Thermissa*), the mythical abode of Hephaestus, and Panaria (*Euonymus*). The island of Aiolie, the home of Aiolos, lord of the winds, which Ulysses twice visited in his wanderings, has generally been identified with one of this group. A colony of Cnidians and Rhodians was established on Lipara in 580-577 B.C.[1] The inhabitants were allied with the Syracusans, and were attacked by the Athenian fleet in 427 B.C., and by the Carthaginians in 397 B.C., while Agathocles plundered a temple on Lipara in 301 B.C. During the Punic wars the islands were a Carthaginian naval station of some importance until the Romans took possession of them in 252 B.C. Sextus Pompeius also used them as a naval base. Under the Empire the islands served as a place of banishment for political prisoners. In the middle ages they frequently changed hands. The island of Lipari contains the chief town (population in 1901, 5855), which bears the same name and had municipal rights in Roman times. It is the seat of a bishop. It is fertile and contains sulphur springs and vapour baths, which were known and used in ancient times. Pumicestone is exported.

Stromboli, 22 m. N.E. of Lipari, is a constantly active volcano, ejecting gas and lava at brief intervals, and always visible at night. Salina, 3 m. N.W. of Lipari, consisting of the cones of two extinct volcanoes, that on the S.E., Monte Salvatore (3155 ft.), being the highest point in the islands, is the most fertile of the whole group and produces good Malmsey wine: it takes its name from the salt-works on the south coast. Vulcano, ½ m. S. of 740
Lipari, contains a still smoking crater. Sulphur works were started in 1874, have since been abandoned.

See Archduke Ludwig Salvator of Austria, *Die Liparischen Inseln*, 8 vols. (for private circulation) (Prague, 1893 seqq.).

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1 Greek coins of the Lipari Islands are preserved in the museum at Cefalù.

LIPETSK, a town of Russia, in the government of Tambov, 108 m. by rail W. of the city of Tambov, on the right bank of the river Voronezh. Pop. (1897) 16,353. The town is built of wood and the streets are unpaved. There are sugar, tallow, and leather works, and distilleries, and an active trade in horses, cattle, tallow, skins, honey and timber. The Lipetsk mineral springs (chalybeate) came into repute in the time of Peter the Great and attract a good many visitors.

LIPPE, a river of Germany, a right-bank tributary of the Rhine. It rises near Lippspringe under the western declivity of the Teutoburger Wald, and, after being joined by the Alme, the Pader and the Ahse on the left, and by the Stever on the right, flows into the Rhine near Wesel, after a course of 154 m. It is navigable downwards from Lippstadt, for boats and barges, by the aid of twelve locks, drawing less than 4 ft. of water. The river is important for the transport facilities it affords to the rich agricultural districts of Westphalia.

LIPPE, a principality of Germany and constituent state of the German empire, bounded N.W., W. and S. by the Prussian province of Westphalia and N.E. and E. by the Prussian provinces of Hanover and Hesse-Nassau and the principality of Waldeck-Pyrmont. It also possesses three small enclaves—Kappel and Lipperode in Westphalia and Grevenhagen near Höxter. The area is 469 sq. m., and the population (1905) 145,610, showing a density of 125 to the sq. m. The greater part of the surface is hilly, and in the S. and W., where the Teutoburger Wald practically forms its physical boundary, mountainous. The chief rivers are the Weser, which crosses the north extremity of the principality, and its affluents, the Werre, Exter, Kalle and Emmer. The Lippe, which gives its name to the country, is a purely Westphalian river and does not touch the principality at any point. The forests of Lippe, among the finest in Germany, produce abundance of excellent timber. They occupy 28% of the whole area, and consist mostly of deciduous trees, beech preponderating. The valleys contain a considerable amount of good arable land, the tillage of which employs the greater part of the inhabitants. Small farms, the larger proportion of which are under 2½ acres, are numerous, and their yield shows a high degree of prosperity among the peasant farmers. The principal crops are potatoes, beetroot (for sugar), hay, rye, oats, wheat and barley. Cattle, sheep and swine are also reared, and the "Senner" breed of horses, in the stud farm at Lopshorn, is celebrated. The industries are small and consist mainly in the manufacture of starch, paper, sugar, tobacco, and in weaving and brewing. Lemgo is famous for its meerschaum pipes and Salzuflen for its brine-springs, producing annually about 1500 tons of salt, which is mostly exported. Each year, in spring, about 15,000 brickmakers leave the principality and journey to other countries, Hungary, Sweden and Russia, to return home in the late autumn.

The roads are well laid and kept in good repair. A railway intersects the country from Herford (on the Cologne-Hanover main line) to Altenbeken; and another from Bielefeld to Hameln traverses it from W. to E. More than 95% of the population in 1905 were Protestants. Education is provided for by two gymnasia and numerous other efficient schools. The principality contains seven small towns, the chief of which are Detmold, the seat of government, Lemgo, Horn and Blomberg. The present constitution was granted in 1836, but it was altered in 1867 and again in 1876. It provides for a representative chamber of twenty-one members, whose functions are mainly consultative. For electoral purposes the population is divided into three classes, rated according to taxation, each of which returns seven members. The courts of law are centred at Detmold, whence an appeal lies to the court of appeal at Celle in the Prussian province of Hanover. The estimated revenue in 1909 was £113,000 and the expenditure £116,000. The public debt in 1908 was £64,000. Lippe has one vote in the German Reichstag, and also one vote in the Bundesrat, or federal council. Its military forces form a battalion of the 6th Westphalian infantry.

History.—The present principality of Lippe was inhabited in early times by the Cherusii, whose leader Arminius (Hermann) annihilated in A.D. 9 the legions of Varus in the Teutoburger Wald. It was afterwards occupied by the Saxons and was subdued by Charlemagne. The founder of the present reigning family, one of the most ancient in Germany, was Bernard I. (1113-1144), who received a grant of the territory from the emperor Lothair, and assumed the title of lord of Lippe (*edler Herr von Lippe*). He was descended from a certain Hoold who flourished about 950. Bernard's successors inherited or obtained several counties, and one of them, Simon III. (d. 1410), introduced the principles of primogeniture. Under Simon V. (d. 1536), who was the first to style himself count, the Reformation was introduced into the country. His grandson, Simon VI. (1555-1613), is the ancestor of both lines of the princes of Lippe. In 1613 the country, as it then existed, was divided among his three sons, the lines founded by two of whom still exist, while the third (Brake) became extinct in 1709. Lippe proper was the patrimony of the eldest son, Simon VII. (1587-1627), upon whose descendant Frederick William Leopold (d. 1802) the title of prince of the empire was bestowed in 1789, a dignity already conferred, though not confirmed, in 1720. Philip, the youngest son of Simon VI., received but a scanty part of his father's possessions, but in 1640 he inherited a large part of the countship of Schaumburg, including Bückeburg, and adopted the title of count of Schaumburg-Lippe. The ruler of this territory became a sovereign prince in 1807. Simon VII. had a younger son, Jobst Hermann (d. 1678), who founded the line of counts of Lippe-Biesterfeld, and a cadet branch of this family were the counts of Lippe-Weissenfeld. In 1762 these two counties—Biesterfeld and Weissenfeld—passed by arrangement into the possession of the senior and ruling branch of the family. Under the prudent government of the princess Pauline (from 1802 to 1820), widow of Frederick William Leopold, the little state enjoyed great prosperity. In 1807 it joined the Confederation of the Rhine and in 1813 the German Confederation. Pauline's son, Paul Alexander Leopold, who reigned from 1820 to 1851, also ruled in a wise and liberal spirit, and in 1836 granted the charter of rights upon which the constitution is based. In 1842 Lippe entered the German Customs Union (*Zollverein*), and in 1866 threw in its lot with Prussia and joined the North German Confederation.

The Lippe succession dispute.

The line of rulers in Lippe dates back, as already mentioned, to Simon VI. But besides this, the senior line, the two collateral lines of counts, Lippe-Biesterfeld and Lippe-Weissenfeld and the princely line of Schaumburg-Lippe, also trace their descent to the same ancestor, and these three lines stand in the above order as regards their rights to the Lippe succession, the counts being descended from Simon's eldest son and the princes from his youngest son. These facts were not in dispute when in March 1895 the death of Prince Woldemar, who had reigned since 1875, raised a dispute as to the succession. Woldemar's brother Alexander, the last of the senior line, was hopelessly insane and had been declared incapable of ruling. On the death of Woldemar, Prince Adolph of Schaumburg-Lippe, fourth son of Prince Adolph George of that country and brother-in-law of the German emperor, took over the regency by virtue of a decree issued by Prince Woldemar, but which had until the latter's death been kept secret. The Lippe house of representatives consequently passed a special law confirming the regency in the person of Prince Adolph, but with the proviso that the regency should be at an end as soon as the disputes touching the succession were adjusted; and with a further proviso that, should this dispute not have been settled before the death of Prince Alexander, then, if a competent court of law had been secured before that event happened, the regency of Prince Adolph should continue until such court had given its decision. The dispute in question had arisen because the heads of the two collateral countly lines had entered a *caveat*. In order 741
to adjust matters the Lippe government moved the *Bundesrat*, on the 5th of July 1895, to pass an imperial law declaring the *Reichsgericht* (the supreme tribunal of the empire) a competent court to adjudicate upon the claims of the rival lines to the succession. In consequence the Bundesrat passed a resolution on the 1st of February 1896, requesting the chancellor of the empire to bring about a compromise for the appointment of a court of arbitration between the parties. Owing to the mediation of the chancellor a compact was on the 3rd of July 1896 concluded between the heads of the three collateral lines of the whole house of Lippe, binding "both on themselves and on the lines of which they were the heads." By clause 2 of this compact, a court of arbitration was to be appointed, consisting of the king of Saxony and six members selected by him from among the members of the supreme court of law of the empire. This court was duly constituted, and on the 22nd of June 1897 delivered judgment to the effect that Count Ernest of Lippe-Biesterfeld, head of the line of Lippe-Biesterfeld, was entitled to succeed to the throne of Lippe on the death of Prince Alexander. In consequence of this judgment Prince Adolph resigned the regency and Count Ernest became regent in his stead. On the 26th of

September 1904 Count Ernest died and his eldest son, Count Leopold, succeeded to the regency; but the question of the succession was again raised by the prince of Schaumburg-Lippe, who urged that the marriage of Count William Ernest, father of Count Ernest, with Modeste von Unruh, and that of the count regent Ernest himself with Countess Carline von Wartensleben were not *ebenbürtig* (equal birth), and that the issue of these marriages were therefore excluded from the succession. Prince George of Schaumburg-Lippe and the count regent, Leopold, thereupon entered into a compact, again referring the matter to the Bundesrat, which requested the chancellor of the empire to agree to the appointment of a court of arbitration consisting of two civil senates of the supreme court, sitting at Leipzig, to decide finally the matter in dispute. It was further provided in the compact that Leopold should remain as regent, even after the death of Alexander, until the decision of the court had been given. Prince Alexander died on the 13th of January 1905; Count Leopold remained as regent, and on the 25th of October the court of arbitration issued its award, declaring the marriages in question (which were, as proved by document, contracted with the consent of the head of the house in each case) *ebenbürtig*, and that in pursuance of the award of the king of Saxony the family of Lippe-Biesterfeld, together with the collateral lines sprung from Count William Ernest (father of the regent, Count Ernest) were in the order of nearest agnates called to the succession. Leopold (b. 1871) thus became prince of Lippe.

See A. Falkmann, *Beiträge zur Geschichte des Fürstenthums Lippe* (Detmold, 1857-1892; 6 vols.); Schwanold, *Das Fürstentum Lippe, das Land und seine Bewohner* (Detmold, 1899); Piderit, *Die lippischen Edelherrn im Mittelalter* (Detmold, 1876); A. Falkmann and O. Preuss, *Lippische Regenten* (Detmold, 1860-1868); H. Triepel, *Der Streit um die Thronfolge im Fürstentum Lippe* (Leipzig, 1903); and P. Laband, *Die Thronfolge im Fürstentum Lippe* (Freiburg, 1891); and *Schiedsspruch in dem Rechtstreit über die Thronfolge im Fürstentum Lippe vom 25 Okt. 1905* (Leipzig, 1906).

LIPPI, the name of three celebrated Italian painters.

I. Fra Filippo Lippi (1406-1469), commonly called Lippo Lippi, one of the most renowned painters of the Italian quattrocento, was born in Florence —his father, Tommaso, being a butcher. His mother died in his childhood, and his father survived his wife only two years. His aunt, a poor woman named Monna Lapaccia, then took charge of the boy; and in 1420, when fourteen years of age, he was registered in the community of the Carmelite friars of the Carmine in Florence. Here he remained till 1432, and his early faculty for fine arts was probably developed by studying the works of Masaccio in the neighbouring chapel of the Brancacci. Between 1430 and 1432 he executed some works in the monastery, which were destroyed by a fire in 1771; they are specified by Vasari, and one of them was particularly marked by its resemblance to Masaccio’s style. Eventually Fra Filippo quitted his convent, but it appears that he was not relieved from some sort of religious vow; in a letter dated in 1439 he speaks of himself as the poorest friar of Florence, and says he is charged with the maintenance of six marriageable nieces. In 1452 he was appointed chaplain to the convent of S. Giovannino in Florence, and in 1457 rector (*Rettore Commendatario*) of S. Quirico at Legania, and his gains were considerable and uncommonly large from time to time; but his poverty seems to have been chronic, the money being spent, according to one account, in frequently recurring amours.

Vasari relates some curious and romantic adventures of Fra Filippo, which modern biographers are not inclined to believe. Except through Vasari, nothing is known of his visits to Ancona and Naples, and his intermediate capture by Barbary pirates and enslavement in Barbary, whence his skill in portrait-sketching availed to release him. This relates to a period, 1431-1437, when his career is not otherwise clearly accounted for. The doubts thrown upon his semi-marital relations with a Florentine lady appear, however, to be somewhat arbitrary; Vasari’s account is circumstantial, and in itself not greatly improbable. Towards June 1456 Fra Filippo was settled in Prato (near Florence) for the purpose of fulfilling a commission to paint frescoes in the choir of the cathedral. Before actually undertaking this work he set about painting, in 1458, a picture for the convent chapel of S. Margherita of Prato, and there saw Lucrezia Buti, the beautiful daughter of a Florentine, Francesco Buti; she was either a novice or a young lady placed under the nuns’ guardianship. Lippi asked that she might be permitted to sit to him for the figure of the Madonna (or it might rather appear of S. Margherita); he made passionate love to her, abducted her to his own house, and kept her there spite of the utmost efforts the nuns could make to reclaim her. The fruit of their loves was a boy, who became the painter, not less celebrated than his father, Filippino Lippi (noticed below). Such is substantially Vasari’s narrative, published less than a century after the alleged events; it is not refuted by saying, more than three centuries later, that perhaps Lippo had nothing to do with any such Lucrezia, and perhaps Lippino was his adopted son, or only an ordinary relative and scholar. The argument that two reputed portraits of Lucrezia in paintings by Lippo are not alike, one as a Madonna in a very fine picture in the Pitti gallery, and the other in the same character in a Nativity in the Louvre, comes to very little; and it is reduced to nothing when the disputant adds that the Louvre painting is probably not done by Lippi at all. Besides, it appears more likely that not the Madonna in the Louvre but a S. Margaret in a picture now in the Gallery of Prato is the original portrait (according to the tradition) of Lucrezia Buti.

The frescoes in the choir of Prato cathedral, being the stories of the Baptist and of St Stephen, represented on the two opposite wall spaces, are the most important and monumental works which Fra Filippo has left, more especially the figure of Salome dancing, and the last of the series, showing the ceremonial mourning over Stephen’s corpse. This contains a portrait of the painter, but which is the proper figure is a question that has raised some diversity of opinion. At the end wall of the choir are S. Giovanni Gualberto and S. Alberto, and on the ceiling the four evangelists.

The close of Lippi’s life was spent at Spoleto, where he had been commissioned to paint, for the apse of the cathedral, some scenes from the life of the Virgin. In the semidome of the apse is Christ crowning the Madonna, with angels, sibyls and prophets. This series, which is not wholly equal to the one at Prato, was completed by Fra Diamante after Lippi’s death. That Lippi died in Spoleto, on or about the 8th of October 1469, is an undoubted fact; the mode of his death is again a matter of dispute. It has been said that the pope granted Lippi a dispensation for marrying Lucrezia, but that, before the permission arrived, he had been poisoned by the indignant relatives either of Lucrezia herself, or of some lady who had replaced her in the inconstant painter’s affections. This is now generally regarded as a fable; and indeed a vendetta upon a man aged sixty-three for a seduction committed at the already mature age of fifty-two seems hardly plausible. Fra Filippo lies buried in Spoleto, with a monument 742
erected to him by Lorenzo the Magnificent; he had always been zealously patronized by the Medici family, beginning with Cosimo, Pater Patriae. Francesco di Pesello (called Pesellino) and Sandro Botticelli were among his most distinguished pupils.

In 1441 Lippi painted an altarpiece for the nuns of S. Ambrogio which is now a prominent attraction in the Academy of Florence, and has been celebrated in Browning’s well-known poem. It represents the coronation of the Virgin among angels and saints, of whom many are Bernardine monks. One of these, placed to the right, is a half-length portrait of Lippo, pointed out by an inscription upon an angel’s scroll “Is perfecit opus.” The price paid for this work in 1447 was 1200 Florentine lire, which seems surprisingly large. For Germiniano Inghirami of Prato he painted the “Death of St Bernard,” a fine specimen still extant. His principal altarpiece in this city is a Nativity in the refectory of S. Domenico—the Infant on the ground adored by the Virgin and Joseph, between Sts George and Dominic, in a rocky landscape, with the shepherds playing and six angels in the sky. In the Uffizi is a fine Virgin adoring the infant Christ, who is held by two angels; in the National Gallery, London, a “Vision of St Bernard.” The picture of the “Virgin and Infant with an Angel,” in this same gallery, also ascribed to Lippi, is disputable.

Few pictures are so thoroughly enjoyable as those of Lippo Lippi; they show the naiveté of a strong, rich nature, redundant in lively and somewhat whimsical observation. He approaches religious art from its human side, and is not pietistic though true to a phase of Catholic devotion. He was perhaps the greatest colourist and technical adept of his time, with good draughtsmanship—a naturalist, with less vulgar realism than some of his contemporaries, and with much genuine episodical animation, including semi-humorous incidents and low characters. He made little effort after perspective and none for foreshortenings, was fond of ornamenting pilasters and other architectural features. Vasari says that Lippi was wont to hide the extremities in drapery to evade difficulties. His career was one of continual development, without fundamental variation in style or in colouring. In his great works the proportions are larger than life.

Along with Vasari’s interesting and amusing, and possibly not very unauthentic, account of Lippo Lippi, the work of Crowe and Cavalcaselle should be consulted. Also: E. C. Strutt, *Fra Lippo Lippi* (1901); C. M. Phillimore, *Early Florentine Painters* (1881); B. Supino, *Fra Filippo Lippi* (illustrated) (1902). It should be observed that Crowe and Cavalcaselle give 1412 as the date of the painter’s birth, and this would make a considerable difference in estimating details of his after career. We have preferred to follow the more usual account. The self-portrait dated 1441 looks like a man much older than twenty-nine.

II. Filippino, or Lippino Lippi (1460-1505), was the natural son of Fra Lippo Lippi and Lucrezia Buti, born in Florence and educated at Prato. Losing his father before he had completed his tenth year, the boy took up his avocation as a painter, studying under Sandro Botticelli and probably under Fra Diamante. The style which he formed was to a great extent original, but it bears clear traces of the manner both of Lippo and of Botticelli—more ornamental than the first, more realistic and less poetical than the second. His powers developed early; for we find him an accomplished artist by 1480, when he painted an altarpiece, the “Vision of St Bernard,” now in the Badia of Florence; it is in tempera, with almost the same force as oil painting. Soon afterwards, probably from 1482 to 1490, he began to work upon the frescoes which completed the decoration of the Brancacci chapel in the Carmine, commenced by Masolino and Masaccio many years before. He finished Masaccio’s “Resurrection of the King’s Son,” and was the sole author of “Paul’s Interview with Peter in Prison,” the “Liberation of Peter,” the “Two Saints before the Proconsul” and the “Crucifixion of Peter.” These works are sufficient to prove that Lippino stood in the front rank of the artists of his time. The dignified and expressive figure of St Paul in the second-named subject has always been particularly admired, and appears to have furnished a suggestion to Raphael for his “Paul at Athens.” Portraits of Luigi Pulci, Antonio Pollajuolo, Lippino himself and various others are in this series. In 1485 he executed the great altarpiece of the “Virgin and Saints,” with several other figures, now in the Uffizi Gallery. Another of his leading works is the altarpiece for the Nerli chapel in S. Spirito—the “Virgin Enthroned,” with splendidly living portraits of Nerli and his wife, and a thronged distance. In 1489 Lippino was in Rome, painting in the church of the Minerva, having first passed through Spoleto to design the monument for his father in the cathedral of that city. Some of his principal frescoes in the Minerva are still extant, the subjects being in celebration of St Thomas Aquinas. In one picture the saint is miraculously commended by a crucifix; in another, triumphing over heretics. In 1496 Lippino painted the "Adoration of the Magi" now in the Uffizi, a very striking picture, with numerous figures. This was succeeded by his last important undertaking, the frescoes in the Strozzi chapel, in the church of S. Maria Novella in Florence—"Drusiana Restored to Life by St John, the Evangelist," "St John in the Cauldron of Boiling Oil" and two subjects from the legend of St Philip. These are conspicuous and attractive works, yet somewhat grotesque and exaggerated—full of ornate architecture, showy colour and the distinctive peculiarities of the master. Filippino, who had married in 1497, died in 1505. The best reputed of his scholars was Raffaellino del Garbo.

Like his father, Filippino had a most marked original genius for painting, and he was hardly less a chief among the artists of his time than Fra Filippo had been in his; it may be said that in all the annals of the art a rival instance is not to be found of a father and son each of whom had such pre-eminent natural gifts and leadership. The father displayed more of sentiment and candid sweetness of motive; the son more of richness, variety and lively pictorial combination. He was admirable in all matters of decorative adjunct and presentment, such as draperies, landscape backgrounds and accessories; and he was the first Florentine to introduce a taste for antique details of costume, &c. He formed a large collection of objects of this kind, and left his designs of them to his son. In his later works there is a tendency to a mannered development of the extremities, and generally to facile overdoing. The National Gallery, London, possesses a good and characteristic though not exactly a first-rate specimen of Lippino, the "Virgin and Child between Sts Jerome and Dominic"; also an "Adoration of the Magi," of which recent criticism contests the authenticity. Crowe and Cavalcaselle, supplemented by the writings of Berenson, should be consulted as to this painter. An album of his works is in Newnes' Art-library.

III. Lorenzo Lippi (1606-1664), painter and poet, was born in Florence. He studied painting under Matteo Rosselli, the influence of whose style, and more especially of that of Santi di Tito, is to be traced in Lippi's works, which are marked by taste, delicacy and a strong turn for portrait-like naturalism. His maxim was "to poetize as he spoke, and to paint as he saw." After exercising his art for some time in Florence, and having married at the age of forty the daughter of a rich sculptor named Susini, Lippi went as court painter to Innsbruck, where he has left many excellent portraits. There he wrote his humorous poem named *Malmantile Racquistato*, which was published under the anagrammatic pseudonym of "Perlone Zipoli." Lippi was somewhat self-sufficient, and, when visiting Parma, would not look at the famous Correggios there, saying that they could teach him nothing. He died of pleurisy in 1664, in Florence.

The most esteemed works of Lippi as a painter are a "Crucifixion" in the Uffizi gallery at Florence, and a "Triumph of David" which he executed for the saloon of Angiolo Galli, introducing into it portraits of the seventeen children of the owner. The *Malmantile Racquistato* is a burlesque romance, mostly compounded out of a variety of popular tales; its principal subject-matter is an expedition for the recovery of a fortress and territory whose queen had been expelled by a female usurper. It is full of graceful or racy Florentine idioms, and is counted by Italians as a "testo di lingua." Lippi is more generally or more advantageously remembered by this poem than by anything which he has left in the art of painting. It was not published until 1688, several years after his death. Lanzi as to Lorenzo Lippi's pictorial work, and Tiraboschi and other literary historians as to his writings, are among the best authorities.

(W. M. R.)

LIPPSPRINGE,

a town and watering-place in the Prussian province of Westphalia, lying under the western slope of the Teutoburger Wald, 5 m. N. of Paderborn. Pop. (1905) 3100. The springs, the Arminius Quelle and the Liborius Quelle, for which it is famous, are saline waters of a temperature of 70° F., and are utilized both for bathing and drinking in cases of pulmonary consumption and chronic diseases of the respiratory organs. The annual number of visitors amounts to about 6000. Lippspringe is mentioned in chronicles as early as the 9th century, and here in the 13th century the order of the Templars established a stronghold. It received civic rights about 1400. 743

See Dammann, *Der Kurort Lippspringe* (Paderborn, 1900); Königer, *Lippspringe* (Berlin, 1893); and Frey, *Lippspringe, Kurort für Lungenkranke* (Paderborn, 1899).

LIPPSTADT,

a town in the Prussian province of Westphalia, on the river Lippe, 20 m. by rail W. by S. of Paderborn, on the main line to Düsseldorf. Pop. (1905) 15,436. The Marien Kirche is a large edifice in the Transitional style, dating from the 13th century. It has several schools, among them being one which was originally founded as a nunnery in 1185. The manufactures include cigar-making, distilling, carriage-building and metal-working.

Lippstadt was founded in 1168 by the lords of Lippe, the rights over one half of the town passing subsequently by purchase to the counts of the Mark, which in 1614 was incorporated with Brandenburg. In 1850 the prince of Lippe-Detmold sold his share to Prussia when this joint lordship ceased. In 1620 Lippstadt was occupied by the Spaniards and in 1757 by the French.

See Chalybäus, *Lippstadt, ein Beitrag zur deutschen Städtegeschichte* (Lippstadt, 1876).

LIPSIUS, JUSTUS

(1547-1606), the Latinized name of Joest (Juste or Josse) Lips, Belgian scholar, born on the 18th of October (15th of November, according to Amiel) 1547 at Overyssche, a small village in Brabant, near Brussels. Sent early to the Jesuit college in Cologne, he was removed at the age of sixteen to the university of Louvain by his parents, who feared that he might be induced to become a member of the Society of Jesus. The publication of his *Variarum Lectionum Libri Tres* (1567), dedicated to Cardinal Granvella, procured him an appointment as Latin secretary and a visit to Rome in the retinue of the cardinal. Here Lipsius remained two years, devoting his spare time to the study of the Latin classics, collecting inscriptions and examining MSS. in the Vatican. A second volume of miscellaneous criticism (*Antiquarum Lectionum Libri Quinque*, 1575), published after his return from Rome, compared with the *Variae Lectiones* of eight years earlier, shows that he had advanced from the notion of purely conjectural emendation to that of emending by collation. In 1570 he wandered over Burgundy, Germany, Austria, Bohemia, and was engaged for more than a year as teacher in the university of Jena, a position which implied an outward conformity to the Lutheran Church. On his way back to Louvain, he stopped some time at Cologne, where he must have comported himself as a Catholic. He then returned to Louvain, but was soon driven by the Civil War to take refuge in Antwerp, where he received, in 1579, a call to the newly founded university of Leiden, as professor of history. At Leiden, where he must have passed as a Calvinist, Lipsius remained eleven years, the period of his greatest productivity. It was now that he prepared his *Seneca*, perfected, in successive editions, his *Tacitus* and brought out a series of works, some of pure scholarship, others collections from classical authors, others again of general interest. Of this latter class was a treatise on politics (*Politicorum Libri Sex*, 1589), in which he showed that, though a public teacher in a country which professed toleration, he had not departed from the state maxims of Alva and Philip II. He lays it down that a government should recognize only one religion, and that dissent should be extirpated by fire and sword. From the attacks to which this avowal exposed him, he was saved by the prudence of the authorities of Leiden, who prevailed upon him to publish a declaration that his expression, *Ure, seca*, was a metaphor for a vigorous treatment. In the spring of 1590, leaving Leiden under pretext of taking the waters at Spa, he went to Mainz, where he was reconciled to the Roman Catholic Church. The event deeply interested the Catholic world, and invitations poured in on Lipsius from the courts and universities of Italy, Austria and Spain. But he preferred to remain in his own country, and finally settled at Louvain, as professor of Latin in the Collegium Buslidianum. He was not expected to teach, and his trifling stipend was eked out by the appointments of privy councillor and historiographer to the king of Spain. He continued to publish dissertations as before, the chief being his *De militia romana* (Antwerp, 1595) and *Lovanium* (Antwerp, 1605; 4th ed., Wesel, 1671), intended as an introduction to a general history of Brabant. He died at Louvain on the 23rd of March (some give 24th of April) 1606.

Lipsius's knowledge of classical antiquity was extremely limited. He had but slight acquaintance with Greek, and in Latin literature the poets and Cicero lay outside his range. His greatest work was his edition of Tacitus. This author he had so completely made his own that he could repeat the whole, and offered to be tested in any part of the text, with a poniard held to his breast, to be used against him if he should fail. His *Tacitus* first appeared in 1575, and was five times revised and corrected—the last time in 1606, shortly before his death. His *Opera Omnia* appeared in 8 vols. at Antwerp (1585, 2nd ed., 1637).

A full list of his publications will be found in van der Aa, *Biographisch Woordenboek der Nederlanden* (1865), and in *Bibliographie Lipsienne* (Ghent, 1886-1888). In addition to the biography by A. le Mire (Aubertus Miraeus) (1609), the only original account of his life, see M. E. C. Nisard, *Le Triumvirat littéraire au XVI^e^ siècle* (1852); A. Räss, *Die Convertiten seit der Reformation* (1867); P. Bergman’s *Autobiographie de J. Lipse* (1889); L. Galesloot, *Particularités sur la vie de J. Lipse* (1877); E. Amiel, *Un Publiciste du XVI^e^ siècle. Juste Lipse* (1884); and L. Müller, *Geschichte der klassischen Philologie in den Niederlanden*. The articles by J. J. Thonissen of Louvain in the *Nouvelle Biographie générale*, and L. Roersch in *Biographie nationale de Belgique*, may also be consulted.

LIPSIUS, RICHARD ADELBERT (1830-1892), German Protestant theologian, son of K. H. A. Lipsius (d. 1861), who was rector of the school of St Thomas at Leipzig, was born at Gera on the 14th of February 1830. He studied at Leipzig, and eventually (1871) settled at Jena as professor ordinarius. He helped to found the “Evangelical Protestant Missionary Union” and the “Evangelical Alliance,” and from 1874 took an active part in their management. He died at Jena on the 19th of August 1892. Lipsius wrote principally on dogmatics and the history of early Christianity from a liberal and critical standpoint. A Neo-Kantian, he was to some extent an opponent of Albrecht Ritschl, demanding “a connected and consistent theory of the universe, which shall comprehend the entire realm of our experience as a whole. He rejects the doctrine of dualism in a truth, one division of which would be confined to ‘judgments of value,’ and be unconnected with our theoretical knowledge of the external world. The possibility of combining the results of our scientific knowledge with the declarations of our ethico-religious experience, so as to form a consistent philosophy, is based, according to Lipsius, upon the unity of the personal ego, which on the one hand knows the world scientifically, and on the other regards it as the means of realizing the ethico-religious object of its life” (Otto Pfleiderer). This, in part, is his attitude in *Philosophie und Religion* (1885). In his *Lehrbuch der evang.-prot. Dogmatik* (1876; 3rd ed., 1893) he deals in detail with the doctrines of “God,” “Christ,” “Justification” and the “Church.” From 1875 he assisted K. Hase, O. Pfleiderer and E. Schrader in editing the *Jahrbücher für prot. Theologie*, and from 1885 till 1891 he edited the *Theol. Jahresbericht*.

His other works include *Die Pilatusakten* (1871, new ed., 1886), *Dogmatische Beiträge* (1878), *Die Quellen der ältesten Ketzergeschichte* (1875), *Die apokryphen Apostelgeschichten* (1883-1890), *Hauptpunkte der christl. Glaubenslehre im Umriss dargestellt* (1889), and commentaries on the Epistles to the Galatians, Romans and Philippians in H. J. Holtzmann’s *Handkommentar zum Neuen Testament* (1891-1892).

LIPTON, SIR THOMAS JOHNSTONE, Bart. (1850-), British merchant, was born at Glasgow in 1850, of Irish parents. At a very early age he was employed as errand boy to a Glasgow stationer; at fifteen he emigrated to America, where at first he worked in a grocery store, and afterwards as a tram-car driver in New Orleans, as a traveller for a portrait firm, and on a plantation in South Carolina. Eventually, having saved some money, he returned to Glasgow and opened a small provision shop. Business gradually increased, and by degrees Lipton had provision shops first all over Scotland and then all over the United Kingdom. To supply his retail shops on the most favourable terms, he purchased extensive 744 tea, coffee and cocoa plantations in Ceylon, and provided his own packing-house for hogs in Chicago, and fruit farms, jam factories, bakeries and bacon-curing establishments in England. In 1898 his business was converted into a limited liability company. At Queen Victoria’s diamond jubilee in 1897 he gave £20,000 for providing dinners for a large number of the London poor. In 1898 he was knighted, and in 1902 was made a baronet. In the world of yacht-racing he became well known from his repeated attempts to win the America Cup.

LIQUEURS, the general term applied to perfumed or flavoured potable spirits, sweetened by the addition of sugar. The term “liqueur” is also used for certain wines and unsweetened spirits of very superior quality, or remarkable for their bouquet, such as tokay or fine old brandy or whisky. The basis of all the “liqueurs” proper consists of (*a*) relatively strong alcohol or spirit, which must be as pure and neutral as possible; (*b*) sugar or syrup; and (*c*) flavouring matters. There are three distinct main methods of manufacturing liqueurs. The first, by which liqueurs of the highest class are prepared, is the “distillation” or “alcoholate” process. This consists in macerating various aromatic substances such as seeds, leaves, roots and barks of plants, &c., with strong spirit and subsequently distilling the infusion so obtained generally in the presence of a whole or a part of the solid matter. The mixture of spirit, water and flavouring matters which distils over is termed the “alcoholate.” To this is added a solution of sugar or syrup, and frequently colouring matter in the shape of harmless vegetable extracts or burnt sugar, and a further quantity of flavouring matter in the shape of essential oils or clear spirituous vegetable extracts. The second method of making liqueurs is that known as the “essence” process. It is employed, as a rule, for cheap and inferior articles; the process resolving itself into the addition of various essential oils, either natural or artificially prepared, and of spirituous extracts to strong spirit, filtering and adding the saccharine matter to the clear filtrate. The third method of manufacturing liqueurs is the “infusion” process, in which alcohol and sugar are added to various fresh fruit juices. Liqueurs prepared by this method are frequently called “cordials.” It has been suggested that “cordials” are articles of home manufacture, and that liqueurs are necessarily of foreign origin, but it is at least doubtful whether this is entirely correct. The French, who excel in the preparation of liqueurs, grade their products, according to their sweetness and alcoholic strength, into *crêmes*, *huiles* or *baumes*, which have a thick, oily consistency; and *eaux*, *extraits* or *élixirs*, which, being less sweetened, are relatively limpid. Liqueurs are also classed, according to their commercial quality and composition, as *ordinaires*, *demi-fines*, *fines* and *sur-fines*. Certain liqueurs, containing only a single flavouring ingredient, or having a prevailing flavour of a particular substance, are named after that body, for instance, *crême de vanille*, *anisette*, *kümmel*, *crême de menthe*, &c. On the other hand, many well-known liqueurs are compounded of very numerous aromatic principles. The nature and quantities of the flavouring agents employed in the preparation of liqueurs of this kind are kept strictly secret, but numerous “recipes” are given in works dealing with this subject. Among the substances frequently used as flavouring agents are aniseed, coriander, fennel, wormwood, gentian, sassafras, amber, hyssop, mint, thyme, angelica, citron, lemon and orange peel, peppermint, cinnamon, cloves, iris, caraway, tea, coffee and so on. The alcoholic strength of liqueurs ranges from close on 80% of alcohol by volume in some kinds of absinthe, to 27% in anisette. The liqueur industry is a very considerable one, there being in France some 25,000 factories. Most of these are small, but some 600,000 gallons are annually exported from France alone. For absinthe, benedictine, chartreuse, curaçoa, kirsch and vermouth see under separate headings. Among other well-known trade liqueurs may be mentioned maraschino, which takes its name from a variety of cherry—the marasca—grown in Dalmatia, the centre of the trade being at Zara; kümmel, the flavour of which is largely due to caraway seeds; allasch, which is a rich variety of kümmel; and cherry and other “fruit” brandies and whiskies, the latter being perhaps more properly termed cordials.

See Duplais, *La Fabrication des liqueurs*; and Rocques, *Les Eaux-de-vie et liqueurs*.

LIQUIDAMBAR, Liquid Amber or Sweet Gum, a product of *Liquidambar styraciflua* (order Hamamelideae), a deciduous tree of from 80 to 140 ft. high, with a straight trunk 4 or 5 ft. in diameter, a native of the United States, Mexico and Central America. It bears palmately-lobed leaves, somewhat resembling those of the maple, but larger. The male and female inflorescences are on different branches of the same tree, the globular heads of fruit resembling those of the plane. This species is nearly allied to *L. orientalis*, a native of a very restricted portion of the south-west coast of Asia Minor, where it forms forests. The earliest record of the tree appears to be in a Spanish work by F. Hernandez, published in 1651, in which he describes it as a large tree producing a fragrant gum resembling liquid amber, whence the name (*Nov. Plant.*, &c., p. 56). In Ray’s *Historia Plantarum* (1686) it is called *Styrax liquida*. It was introduced into Europe in 1681 by John Banister, the missionary collector sent out by Bishop Compton, who planted it in the palace gardens at Fulham. The wood is very compact and fine-grained—the heart-wood being reddish, and, when cut into planks, marked transversely with blackish belts. It is employed for veneering in America. Being readily dyed black, it is sometimes used instead of ebony for picture frames, balusters, &c.; but it is too liable to decay for outdoor work.

The gum resin yielded by this tree has no special medicinal virtues, being inferior in therapeutic properties to many others of its class. Mixed with tobacco, the gum was used for smoking at the court of the Mexican emperors (Humboldt iv. 10). It has long been used in France as a perfume for gloves, &c. It is mainly produced in Mexico, little being obtained from trees growing in higher latitudes of North America, or in England.

LIQUIDATION (*i.e.* making "liquid" or clear), in law, the clearing off or settling of a debt. The word was more especially used in bankruptcy law to define the method by which, under the Bankruptcy Act 1869, the affairs of an insolvent debtor were arranged and a composition accepted by his creditors without actual bankruptcy. It was abolished by the Bankruptcy Act 1883 (see Bankruptcy). In a general sense, liquidation is used for the act of adjusting debts, as the Egyptian Law of Liquidation, July 1880, for a general settlement of the liabilities of Egypt. In company law, liquidation is the winding up and dissolving a company. The winding up may be either voluntary or compulsory, and an officer, termed a liquidator, is appointed, who takes into his custody all the property of the company and performs such duties as are necessary on its behalf (see Company).