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OPTICAL PROJECTION

A TREATISE ON THE USE OF THE LANTERN IN EXHIBITION AND SCIENTIFIC DEMONSTRATION

BY

LEWIS WRIGHT

AUTHOR OF 'LIGHT: A COURSE OF EXPERIMENTAL OPTICS'

5TH EDITION

RE-WRITTEN AND BROUGHT UP-TO-DATE BY

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IN TWO PARTS

PART I

THE PROJECTION OF LANTERN SLIDES

WITH ILLUSTRATIONS

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PREFACE

TO

THE FIFTH EDITION

The first edition of this work was written by my father, the late Mr. Lewis Wright, and was published in 1890.

The reception that it received testified to the fact that it met a long-felt want, and successive editions were published in 1895, 1901, and 1906.

My father, unfortunately, met his death in a railway accident in 1905, and the corrections and additions to the last edition, which had been to a certain extent prepared by him, were completed and written by myself, and the work as published then was again reprinted in 1911.

As the original text is now thirty years old, it has seemed better entirely to re-write the whole book rather than make fresh revisions, the more so as the last ten years have seen great advances in the science of Lantern Projection, and especially in the developments of Acetylene and Electric Lighting.

It has also seemed best at the present juncture to issue the book in two parts, the first dealing with the Projection of Lantern Slides only, and the second with the Demonstration of Opaque and Microscopic Objects, Scientific Phenomena and accessory apparatus, including Cinematograph Projection.

It must of necessity be many months before this second volume can be produced, for the simple reason that Optical Instrument Makers have as yet hardly had time to turn round after the war {vi} and produce their new models, and therefore any such book written now could do little more than describe apparatus that was on the market prior to 1914.

The present work, therefore, deals solely with the exhibition of Lantern Slides in the Optical Lantern, and as such I trust will be found of value to Schoolmasters, Social Workers, Lecturers, and, in fact, to all who use the lantern as a means of illustration.

RUSSELL S. WRIGHT.
January 1920.

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A TREATISE ON THE USE OF THE OPTICAL LANTERN

CHAPTER I

INTRODUCTORY

Lantern Projection, as commonly understood, may be broadly subdivided into two branches: (A) The Projection of Lantern Slides, and (B) The Projection of Scientific Phenomena, Opaque Objects, Microscopic Specimens, &c., usually referred to broadly under the heading of 'Scientific Demonstration.'

To these two classes may perhaps now be added a third, viz. The Projection of So-called Living Pictures, or, in other words, the Cinematograph. In the earlier editions of this work both A and B were dealt with in the same volume, but, as there are thousands who require to use a lantern for the demonstration of lantern slides only, and who have no interest or concern with Science Projection, it has seemed to the writer that the work might, with advantage, be divided into two portions, Vol. I. dealing with slides only, and Vol. II. with the various adaptations of the science lantern. This present book therefore only deals with the exhibition of lantern slides, and as such it will, I trust, be found to be of real assistance to the ordinary user of the optical lantern, including clergymen, schoolmasters, army and cadet officers, and others who require advice and {2}
instruction in the purchase or use of a lantern.

The essential parts of a lantern are: (*a*) A *slide-holder* or *carrier* to hold the slide; (*b*) a *lens* to 'focus' it on the screen; (*c*) a *condenser* to converge the light upon slide and lens; (*d*) a source of light or *radiant* to provide the necessary illumination; and (*e*) a *body* or framework to hold the whole together. All possible variations in choice of a suitable lantern relate to one or another of the above parts, and will be treated of in turn; but, fortunately, we have this all-important simplification that every ordinary English lantern slide is the same *standard size*, viz. 3¼ inches square. Some Continental and American slides differ in one dimension from the above, but not enough to cause any serious difficulty, and the convenient English standard is being gradually adopted throughout the world.

The varieties of slide-holders or carriers are therefore comparatively few and are chiefly concerned with the question of rapidly and easily changing the slides. The choice of a focussing lens or objective is mainly a matter of the size of picture required, and the most convenient distance from the screen for the lantern to be placed. Variations in condensers, which are comparatively small, are usually only a matter of conforming these with the size or type of objective to be used, and should be left to the manufacturer's judgment. The question of a suitable radiant is partly a matter of the amount of illumination required, and partly that of the practical possibilities; for example, if electric current is available some form of electric light is usually the most convenient, as well as the least expensive, but where this is not the case, paraffin-oil, methylated spirit, incandescent gas, acetylene, limelight, &c., are alternatives which all have their uses and must be considered on their own merits.

Sometimes, as for example in the case of a travelling lecturer, a lantern is required fitted with a range of lenses for halls of different size, and also with a variety of illuminants, and this in most {3}
lanterns can be easily provided for.

The body is usually a matter of taste and price only, and may range from a simple but efficient shell of Russian iron to an elaborate mahogany instrument with a brass front, screw tilting arrangements and other adornments; but of late years there has been a wholesome reaction against unnecessary finish, and a simple metal body of some description is now chiefly the order of the day. In the foregoing remarks the various parts of a lantern have been mentioned in what I should consider the correct order, starting from the slide and slide-holder, and so to speak building up the rest of the instrument round these items; but I now propose somewhat to vary the procedure and for convenience deal in detail first with the Radiant, or *Illuminant*.

CHAPTER II

THE ILLUMINANT

The first necessity for lantern projection is a strong light, and this can be obtained from a variety of sources, the principal means in common use being approximately in order of excellence as follows: paraffin-oil, incandescent spirit, incandescent gas, acetylene, acetylene air blast, oxyhydrogen (limelight), oxyether, and electric light in its various forms. The ideal characteristics to be sought for are (1) great intrinsic brilliancy; (2) minimum *size* of luminous spot; (3) freedom from flicker; (4) freedom from smell; (5) absence of any preponderating colour; (6) cheapness; and (7) convenience. There is no question whatever as to which of the available sources of light most perfectly combines all the above if it is available, viz. the electric arc. If a current supply is in the building, this form of lighting easily excels all others, except possibly in the matter of {4}
flicker, and even in this respect there is very little fault to be found with it.

From all other points of view it is wellnigh perfect, inasmuch as it provides an extremely concentrated and intensely luminous spot, of almost perfect whiteness (if anything slightly bluish), no smell, comparatively little heat, convenient and inexpensive. So great is the advantage of the electric arc that attempts have been made to use it from accumulators in places where a current supply is not available, but this cannot be seriously recommended, except in special cases. Where an electric supply is, however, available there can be no real choice, whether the lantern is required for use in a large hall or a small class-room. The advantages of using the arc are so great that no other method need be seriously considered.

The one real objection that I have heard urged against it is due, curiously enough, to its very perfection, and that is, that it lends itself to such exceedingly sharp definition that any slight imperfection in the slide is too faithfully reproduced on the screen, for which reason it is sometimes recommended that the operator shall work with the objective the least fraction out of focus; but this is a matter for individual taste and judgment.

If, however, there is no possibility of using the electric current, one of the other sources of illumination must perforce be adopted, and for a *large* hall this can only be limelight in one of its many forms, viz. oxyhydrogen, oxyether, oxyacetylene, &c. As regards results on the screen, this light compares well even against the electric arc, but it involves the expense and trouble of compressed gas cylinders, or the infinitely worse recourse to the now obsolete method of filling gas-bags.

Limelight is therefore now but little used in this country, as the majority of large halls are equipped with the electric current, and for smaller buildings it is deemed unnecessary and too {5}
expensive.

Acetylene is undoubtedly the illuminant most in favour next to electric light, as the light is brilliant enough to illuminate a picture 12 feet in diameter at a distance up to, say, 30 feet from the screen, and this suffices in a large majority of cases, and acetylene is comparatively cheap, and reasonably simple to work.

Incandescent-gas is often employed for small class-rooms and is fairly effective for a picture not exceeding 9 or 10 feet in diameter, and the same can be said of the same type of burner heated by methylated spirit.

Paraffin-oil is the poorest of all present-day forms of lantern illuminants. The flame is large, impairing the definition, yellow in colour, uneven in illumination, liable to smoke and smell, and barely equal to incandescent gas in illuminating power.

It is therefore going gradually out of use in this country, but in out-of-the-way places, especially abroad, it is sometimes the only practicable light, and is therefore still employed from the best of all reasons, necessity.

It is not the intention of the author to give precise working instruction for all and every variety of the above illuminants as manufactured by different firms. For such the reader must be referred to the directions usually issued by the makers themselves, but a general description of the various types offered for choice will not be out of place, and it will be more convenient to begin with the poorest, viz. paraffin-oil, and finish with the most perfect, the electric arc.

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CHAPTER III

PARAFFIN-OIL LAMPS, INCANDESCENT GAS AND SPIRIT BURNERS

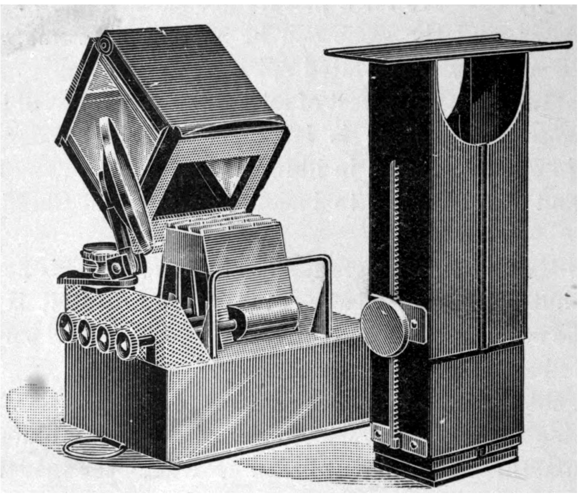

Fig. 1.—Oil Lamp.

There are several varieties of oil lamps on the market, but in practically every case they take the same general form, a metal reservoir sliding in grooves in the lantern body and holding approximately a pint of oil with (usually) four wicks *nearly* parallel, but slightly converging from rear to front, these enclosed in a flame chamber of Russian iron, with *loose* well-annealed ends of sheet glass and an adjustable reflector at the back, or sometimes the reflector itself forms the rear end of the flame chamber. The chimney must be tall and is now usually made adjustable, though I have never been able to trace any real advantage from this complication (Fig. 1). The {7} whole secret of obtaining the best results from these lamps may be summed up—*good oil and perfect cleanliness*; and it is wonderful what can be done when these points are properly attended to.

Care should be taken in trimming the wicks to see that no charred parts fall down between the wick holders, but it makes little difference whether the trimming is done with scissors or by rubbing with the finger. Special lamp scissors are sold by all makers with a large flat on one side to catch the portions cut off.

These lamps should be well rubbed over the last thing before use, as paraffin-oil is apt to 'creep,' and the operator does not want to be told that his apparatus is suggestive of a fried fish shop. In working with these lamps it is difficult to avoid a dark streak down the centre of the sheet, representing the space between the two centre wicks; to a certain extent this can be obviated by adjusting the reflector, and in any case is not very obvious when the slide is in place. Lamps constructed with either three or five wicks are better in this respect, but the former are usually considered to be too poor in illuminating power, and the latter are apt to crack the sheet-glass ends by excessive heat.

Incandescent Gas.—Incandescent gas burners do not need much description, as they are practically similar to those in general use for house lighting. They may be either of the erect or inverted forms, the latter being preferable owing to the light being more concentrated, and a reflector is provided to increase the illumination (Fig. 2).

These reflectors should be *spherical* and so adjusted that the radiant is in the centre of curvature, thus ensuring that the light from the reflector passes again through the original source. If this point is not attended to, we shall be dealing with essentially two sources of light instead of one, to the detriment of the definition.

The same remark applies to every lantern illuminant which is supplemented by a reflector, and it {8} is extraordinary how often it is neglected by the manufacturer. Of course the opacity of the illuminant destroys much of the efficiency of the reflector, and hence in the case of incandescent gas mantles there is not much real gain in making use of them, but with these comparatively weak illuminants every fraction tells, and the reflector does not add much to the cost.

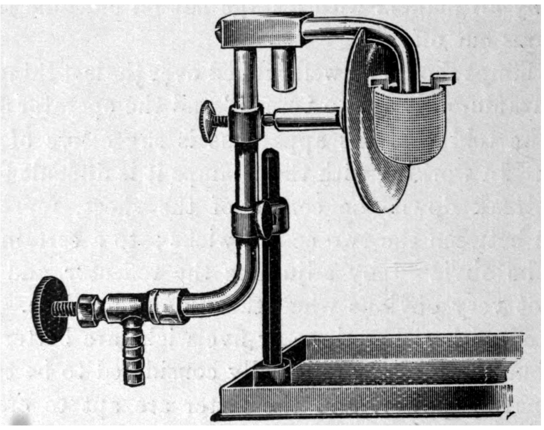

Fig. 2.—Inverted Incandescent Lamp.

In light the inverted gas burner is very little superior to oil, but it is whiter, slightly more concentrated, and freer from smell, and therefore to be regarded as preferable if a supply of gas is available.

Methylated Spirit Burners.—Incandescent mantles heated by methylated spirit are also largely used, and provide a light decidedly superior to gas and nearly equal to acetylene. Some arrangement must be made for volatilising the spirit and driving the vapour out under pressure, and the most usual contrivance is somewhat as illustrated in Fig. 3.

In this apparatus the spirit is contained in a metal reservoir at the rear and air pressure is provided by a pair of rubber balls and valves after the manner of a medical spray. Sufficient pressure having been obtained, the liquid spirit is forced into a vaporising chamber immediately {9}
behind the mantle, and a kind of miniature pitchfork, with its prongs wrapped in asbestos wool, is soaked in spirit, and pushed over the brass fitting of the burner in such a way that when lighted the flame heats the chamber and volatilises the spirit. The burner can now be lit, and although the fork burns out in the course of a minute or so, the heat from the mantle itself is thereafter sufficient to vaporise the spirit as rapidly as required. This lamp works exceedingly well in practice, but has one drawback, viz. that it is possible to obtain too much pressure and squirt *liquid* spirit through the burner, when it naturally catches fire and may even run on to the floor.

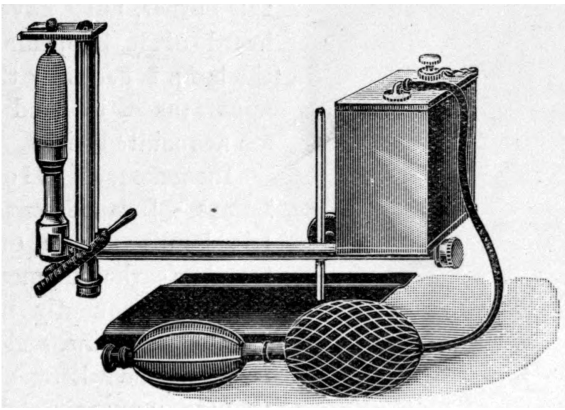

Fig. 3.—Methylated Spirit Burner.

An accident of this sort is rare and usually harmless even if it does occur, but an audience is easily frightened, and hence this burner should only be used by *an operator with experience*. An altogether better arrangement is that made by Messrs. Hughes of Kingsland and known as the 'Luna' Lamp (Fig. 4).

In this burner there is no pump and no volatilising chamber; the spirit is contained as before in a {10}
metal reservoir and a separate burner underneath is used to keep this sufficiently hot to both vaporise the spirit and provide the necessary pressure. The heat can be regulated by means of an adjustable sheath to the burner, and a simple safety valve provides against an excess of vapour.

I do not say that an accident of the sort previously referred to is impossible even with this burner, but I have never heard of it happening, and the lamp is certainly the best apparatus of its kind that I am acquainted with.

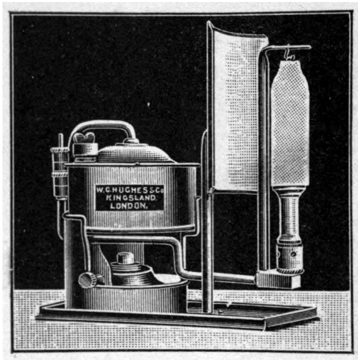

Fig. 4.—Luna Lamp.

Incandescent Electric Lamps.—Incandescent electric lamps of the ordinary metal or carbon filament type are also frequently used in small class-rooms, and should be mentioned here, as they provide approximately the same illumination as a gas mantle, or in some cases rather better. It will, however, be more convenient to deal with the question of electric lighting as a whole in the chapter devoted to it.

It will suffice here to say that lamps are made for the purpose with a special filament arranged to provide a concentrated light, the ordinary type being almost useless in this respect, and that small battery lamps, worked by a suitable accumulator, can also be used, but except under very special circumstances are hardly worth the trouble of keeping the batteries charged.

CHAPTER IV {11}

ACETYLENE

There is no doubt that at present acetylene holds second place to electric light in popularity for optical lantern work. The light is good; not, it is true, *so* good as limelight or the electric arc, but still sufficient for a picture up to 12 feet in diameter at a working distance from the screen of not more than 30 feet, and this suffices for the large majority of halls.

It has great advantages over limelight in convenience and cheapness, although on both these points it must yield place to the electric arc, always providing that current is available, and therefore it is chiefly used in country districts and in gas-lit halls in large towns.

Acetylene gas is formed, as is well known, by the action of water upon carbide of calcium, and the generators constructed for lantern work are essentially the same in construction as for other purposes.

The alterations introduced are chiefly directed towards obtaining a light as *steady* as possible from a comparatively small generator, and, secondly, towards the entire elimination of smell, which obviously is far more serious in a lecture hall than, for instance, on a motor car. The generators in most common use may be divided into two classes, i.e. those on the gasometer principle in which the carbide is gradually lowered into the water, and those in which the water is allowed slowly to gain access to the carbide. A good example of the former is perhaps that made by Messrs. Moss of Birmingham, though there are several others equally good, and clear and explicit directions for working should be supplied by the makers. The Moss Generator (Fig. 5) consists of a tall iron vessel A fitted with a gas tap at bottom, this communicating with a {12} vertical iron tube within the vessel. Into this container fits the inner bell or container B, divided internally into two concentric portions entirely separated from each other, but connected by the pipe P P and the tap T.

A guide inside the bell encircles the iron tube in the outer tank and prevents rotation. Into the inner portion fits again the carbide-container (shown separately on the left), which is locked when in place by giving it a half turn, when a hook inside the bell engages with the lower edge of the carbide container and prevents it from falling.

The carbide container is fitted with a series of shelves, and the contents of a 2 lb. tin of carbide should be roughly divided among them; there is no need to make any accurate division. The carbide used should be that known as ½ inch mesh, and should be *pure*. That described as 'chemically' treated is apt to give trouble by over-generation in these gasometers and should be scrupulously avoided.

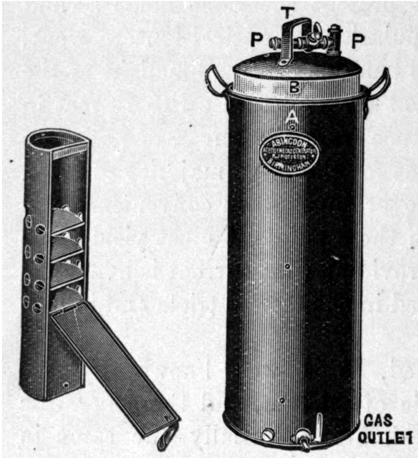

Fig. 5.—The Moss Generator.

The carbide having been placed in the receptacles, these should be closed by means of the loose flap and the whole pushed into the bell and secured.

Water should be poured into the outer vessel up to a mark on the iron tube, and the bell placed in position. The lower tap being then turned on and the upper one closed, air from the outer portion of the bell can gradually escape by means of the iron tube and lower tap, and the bell gradually sinks by its own weight until it is on the bottom, but still no water can reach the carbide, the air {13}
imprisoned in the inner portion of the bell effectually excluding it.

The lower tap should now be connected by means of india-rubber or flexible metallic tubing to the burner in the lantern (of which more anon), and the upper tap on the generator turned on, the tap or taps on the burner being likewise opened. The air from the inner portion of the bell can now escape by the pipe P P into the outer part, and thence through the iron tube, and out through tubing and jet, and as it does so water will rise in the interior and attack the carbide.

In a few moments the burner can be lit; but the gas, being generated far in excess of requirements, and filling both the inner and outer portions of the bell faster than it can escape, lifts the latter until the carbide is entirely out of the water, when in a few minutes generation ceases.

If the jet is left burning the bell will gradually sink again as the gas is used up, and should thereafter maintain an automatic balance without attention.

It can be turned off at any moment by simply closing the taps at the jet or, better, the lower tap at the generator, when the bell rises sufficiently to take the carbide out of the water; but if it is required to leave the generator unlit for a considerable time, it is better to turn off the tap on the top first. This causes the inner portion of the bell to fill with gas which cannot escape, and as that in the outer part burns out, the bell sinks to the bottom and remains there, the gas itself imprisoned in the inner chamber excluding the water from the carbide. The exact arrangement varies in different patterns of generator, but the above may be taken as roughly indicating the action, and further information may always be obtained from the maker or dealer.

Emptying should always be done out of doors, as the odour of acetylene gas is most objectionable, and for the same reason rubber tubes, &c., should be securely tied on, so that the slightest escape may be avoided. {14}

If the exhibition has been a short one it will often be found that the upper cells have not been affected by the water, in which case they may be put back in the tin and used again, but it is not generally advisable to put in less than the full charge to begin with as the weight of the carbide plays a definite part in securing the smooth action of the apparatus. The sludge should be thrown away (it forms a good manure for the garden) and the entire generator thoroughly dried, otherwise rust will quickly appear.

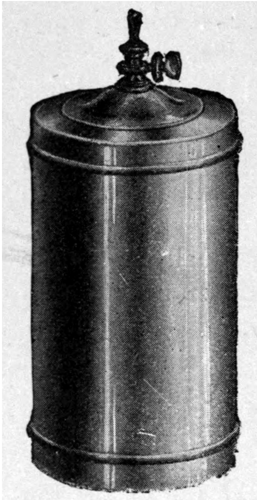

Fig. 6.—The A.L. or
'Popular' Model.

Theoretically one of these generators may be filled and left standing indefinitely, but in practice it is not advisable, as the damp in the atmosphere is apt to produce a very slow generation of gas, sufficient often to cause a decided smell.

Of generators which act by admitting water to the carbide perhaps the best known is the A.L. or 'Popular' Model (Fig. 6), this being, in fact, a pattern designed for motor-car head-lights, but which answers well for lantern work.

Its exact operation need hardly be described here in full detail. It will suffice to say that the water gains access to the carbide by 'creeping' up between two concentric copper cones, and in the event of over-generation the pressure of the gas automatically checks the flow.

This generator is smaller than the gasometer pattern, and hence can be recommended for portability; but in my experience the light is not quite so steady, and the control rather less delicate, thereby causing on occasions a perceptible smell, especially if left standing for a considerable time.

There are other types of generators, such as the 'Water dropping' variety, in which the water {15}
drips on to the carbide, and the reverse, in which fine granulated carbide drops a little at a time into water; but these types are not very frequently met with and need hardly be described.

It should never be forgotten that acetylene is an explosive gas and should be treated as such. Searching for a leak with a lighted match, though perhaps permissible when the operator knows his business, may be a dangerous proceeding when the contrary is the case.

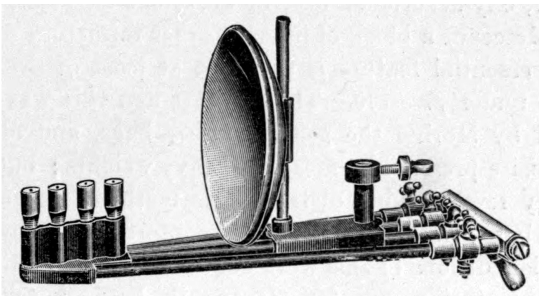

Fig. 7.—Acetylene Jet.

Acetylene burners are generally of the 'Batswing' type, and are as a rule four in number, mounted in a row with a reflector behind, each burner being separately controlled by its own tap (Fig. 7). An acetylene flame is very smoky, and care must be taken that the burners are not turned too high. A nipple cleaner, consisting of a fine wire in a short handle, can usually be obtained from any dealer, and is very handy.

Acetylene gas can also be used for lantern illumination in quite another way, viz. by a blast from a blowpipe, in combination with either air or oxygen, on to a special 'Pastille' provided for the purpose, or an ordinary limelight jet can be used. These methods entail the use of acetylene *under pressure*, and are so analogous to limelight that I shall for convenience deal with them in the chapter devoted to that illuminant.

CHAPTER V {16}

LIMELIGHT AND THE ACETYLENE BLAST

The illumination possible with this light is almost unlimited, and for really large halls it is, as remarked before, the *only* substitute for the electric arc. It consists essentially of a blowpipe flame, composed of oxyhydrogen, oxyether, oxyspirit, oxy-acetylene, &c., or acetylene air blast, heating to incandescence a block of lime, or other refractory material, and the essential feature is that one at least of these gases must be under *pressure*. Thirty years ago this was usually achieved by storing the gas in rubber bags, and obtaining the requisite pressure by means of heavy weights; but except in a very few outlying districts this method has now been completely superseded by the use of compressed gas cylinders. The earlier editions of this work contained very full directions for manufacturing gas for storage in bags, but it is so exceptional now to find an operator who uses this method that it seems hardly necessary to devote much space to it, and the same may be said of automatic oxygen 'generators.' The present work will therefore deal chiefly with compressed gas cylinders.

Most elaborate precautions are now enforced by the Board of Trade to ensure the absolute safety of these, and any doubt existing from occasional accidents of years ago may be promptly dismissed. Humanly speaking, an accident nowadays *cannot* happen, except by such wilful negligence on the part of the maker or filler as would almost render the culprit subject to criminal proceedings.

Compressed gas cylinders are painted a distinctive colour, oxygen for example being black and coal gas or hydrogen red; the screw connections to the pumps, and all nozzle and regulator {17}
fittings, are made with a totally different screw and therefore cannot be interchanged; the cylinders themselves are bound by law to be reannealed and retested under hydraulic pressure at regular intervals; the steel itself has to be of a guaranteed quality; and, in fact, every possible risk is guarded against.

The most usual sizes of cylinders supplied for lantern exhibitions are those containing 6, 12, 20, or 40 cubic feet, and are usually sent out in wooden or hemp cases.

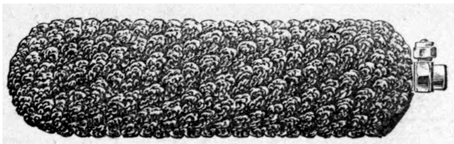

FIG. 8.—Oxygen Cylinder in hemp cover.

Fig. 8 shows a 12-foot cylinder in its hemp case, the approximate size without case being 22 in. by 4 in. This size cylinder will supply an average limelight jet for just over two hours. The extra powerful jets as used for cinematograph work or for illuminating a very large screen take a good deal more, but for the usual apparatus as supplied for ordinary lantern purposes this is a pretty safe figure.

A 12-foot cylinder is therefore the favourite size for a lantern exhibition lasting from an hour to one and a half hours, as it leaves a fair margin for gas used in adjusting the instrument, &c., and a 20-foot cylinder will usually suffice for *two* such exhibitions.

The price of gas per cubic foot varies with the size of the cylinder, being less for large cylinders than for small ones, and the cost of transit is also less in proportion—hence it is frequently an economy to hire a large cylinder and retain it for several exhibitions. On the other hand most suppliers charge a small rent if a cylinder is retained beyond a definite time, so this is a question {18}
to be decided by each user on its own merits.

Alternatively, of course, cylinders can be *purchased*, and the question of rent does not then come in; also gas is supplied a little cheaper in a customer's own cylinder than if sent on hire. If purchase is decided on it is frequently an economy to buy *two*, or two of each gas, if coal gas cylinders are required as well.

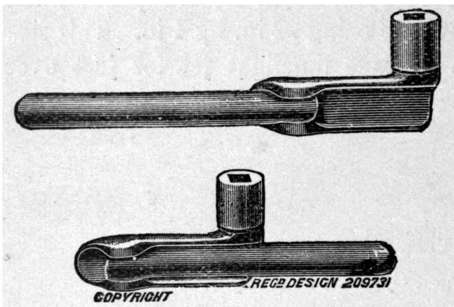

FIG. 9.—Double Lever Key.

The whole contents of the cylinders can then be used up without waste, as if a cylinder should become exhausted during the course of a lecture, it is only a matter of a minute or two to change over to the spare one, whereas the compressors are required by law to empty out every cylinder returned to them for refilling, and any remaining gas is thereby wasted.

It is extremely tantalising, to say the least of it, to find the pressure gauge indicating that there is, say, 8 feet of gas remaining in a cylinder, and to be compelled to waste this or else risk running short for the next exhibition, and duplicate cylinders are the only way of avoiding the loss.

The cylinders are filled to a pressure of 120 atmospheres, or 1800 lb. per square inch, and are closed by strong screw nozzles. The keys for opening or closing these are of three types, viz. the 'T' pattern, 'Spanner' pattern, and that known as the 'Double Lever' type. This latter is so made that in closing the valve it shuts up to half its length and opens out to double the leverage when {19}
being used to *open* the cylinder (Fig. 9). The idea is to avoid the possibility, which has been known to occur, of the cylinder valve being screwed down by a powerful wrist and defying the efforts of the despairing lanternist to open it.

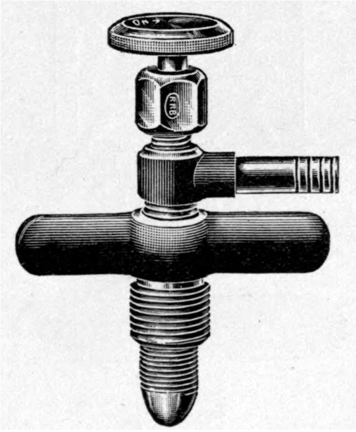

FIG. 10.—Fine Adjustment Valve.

Cylinder nozzles are unfortunately not yet standardised, but those most frequently met with in this country are those adopted by the British Oxygen Company, both oxygen and coal gas cylinders being fitted with corresponding *internal* screws ⅞ inch diameter, those for oxygen being *right-handed*, and those for coal gas *left-handed*, and in each case terminated at the bottom by a hollow metal cone.

As such an internal screw cannot obviously be connected to a piece of rubber tubing, some type of screw connector must be employed, and this may take one of three forms: (1) A simple connecting nozzle, (2) a fine adjustment valve, or (3) a regulator. The first is seldom used in practice for lantern work, for the reason that the direct pressure of a full cylinder (120 atmospheres) cannot be checked or controlled by a tap on the jet, as the intervening rubber tubing would either burst or blow off, and must therefore be regulated at the cylinder nozzle itself, and gradually readjusted as the pressure diminishes.

To achieve this regulation with the ordinary cylinder key is difficult, though possible to a careful operator, but for a slight extra expense a combined nozzle and *fine adjustment valve* (Fig. 10) can be obtained, and regulation with this is infinitely easier. The best plan of all, however, is to use {20}
an automatic regulator, which not only reduces the pressure so as to permit of the required adjustments being made at the jet-taps, but also maintains a practically steady supply as the cylinder empties, thereby obviating continual readjustments. Regulators are now so inexpensive that they have come into almost universal use, and are generally reckoned an indispensable part of a limelight lantern equipment. The form of regulator in most common use is that usually known as 'Beard's,' having been originally designed and patented by Messrs. R. Beard & Sons, though as the patent has now expired it is open to any firm to make the same article if they desire.

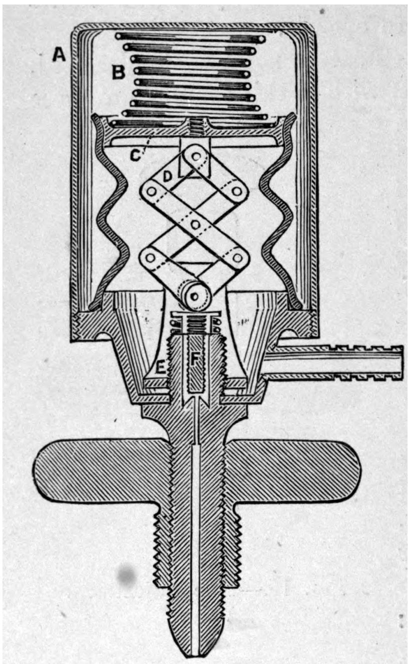

Fig. 11.—Construction of Beard's Regulator.

The construction of Beard's Regulator is shown in Fig. 11. The gas enters from below into a rubber bag, C, from which it can emerge through the nozzle.

Any accumulation of gas raises the bellows against the pressure of a spiral spring pressing it down, and this brings into action an arrangement of so-called 'Lazy Levers,' which in turn presses down a small conical valve and closes the supply from the cylinder, this valve re-opening immediately the pressure diminishes.

The outward form of this regulator is shown in Fig. 12, which incidentally also illustrates the usual form of connection to the cylinder, referred to later on. {21}

In Beard's Regulator the pressure at which the gas can be delivered is determined by the strength of the spiral spring, and can only be altered by changing this spring.

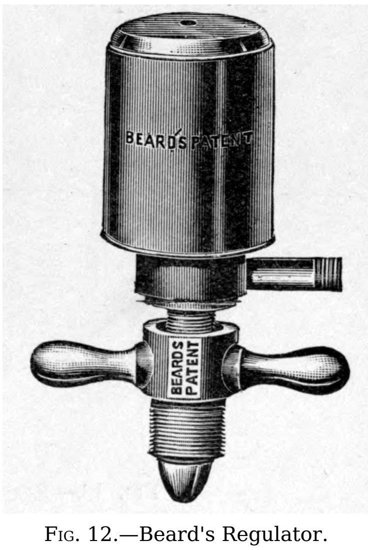

Fig. 12.—Beard's Regulator.

In practice Beard's Regulators are supplied set to a low pressure for ordinary mixed or 'blow-through' jets and for a higher pressure (14-16 inches) for 'injector' jets. At this latter pressure the rubber tubing used must be fairly thick and strong and well tied on, and even so the taps of the jet should not be turned entirely off unless the gas at the cylinder is likewise turned off immediately afterwards. The British Oxygen Company make a regulator which can be set to any desired pressure, but it is not quite so delicate in its action as Beard's, and Messrs. Clarkson also make a pattern regulator which is widely used and well spoken of. The attachment of any of these fittings to the cylinder is a somewhat peculiar one, as will be seen on reference to Fig. 10 or Fig. 12. The regulator or nozzle ends at its lower extremity in a screw and cone, the latter being intended to make a gas-tight connection with the internal cone on the cylinder, and over this screws a loose wing piece with another outer screw, this latter fitting the thread in the cylinder.

In making the connection care must be taken that the wing piece is not screwed too far down the inner screw, or the cone will not reach down and make a tight fit on its seating; in its correct {22}
position the wing piece when clamped down should leave a turn or two of its thread exposed, in

order to ensure that the cone does bed properly.

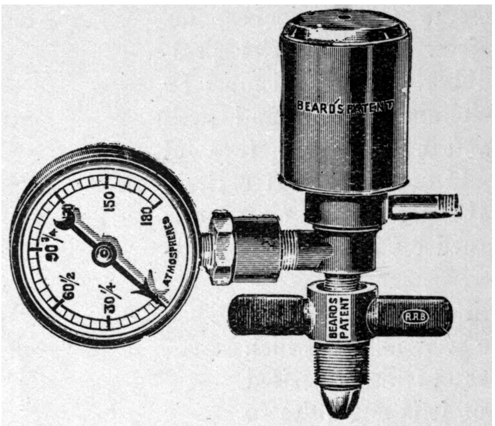

Fig. 13.—Regulator and Gauge.

Care should be taken that the nozzle of the cylinder is free from dust before attaching any of these fittings: the best plan is first to blow into it, and finally wipe it round with the finger. Most professional operators *hammer* the wing piece home with a spanner or other convenient implement a barbarous method and really unnecessary if the cones are in good condition, but, nevertheless, almost always adopted in practice.

Pressure Gauges.—These are useful in determining the amount of gas remaining in a cylinder and are of a very usual type; they may either be screwed on to the cylinder before commencing to work and taken off again to screw on the regulator, or they can be supplied fitted to the regulator itself, in which case they can be observed during the course of the exhibition (Fig. 13). As the same gauge may be used for cylinders of different sizes (though *never* for those containing different gases), they simply register in atmospheres, and knowing that a full cylinder shows a {23} pressure of 120 atmospheres, the requisite calculation must be made to determine how many cubic feet are unused.

In the case of oxygen cylinders an approximate idea of the amount of gas remaining can be got by *weighing* it carefully when known to be either absolutely full or absolutely empty, and re-weighing it when information is required. Oxygen weighs approximately 1.4 oz. per cubic foot, and this is easily detected by an average scale. Coal gas is too light to be gauged in this way.

Gas-Bags and Generators.—It has already been remarked that there are two alternative methods of obtaining gas under pressure for limelight purposes, viz. gas-bags and generators (the latter for oxygen alone: there is no good hydrogen generator that I know of). In both these cases the oxygen is generated by heating a mixture of chlorate of potash and manganese black oxide. In the case of gas-bags the gas is prepared beforehand and passed through suitable purifiers into a rubber gas-bag. With a generator the oxygen is evolved during the exhibition itself; but this method has never come into very general use.

Coal gas or hydrogen is very seldom home generated; a gas-bag can, if necessary, be filled a few miles away and brought full to the place of exhibition, or filled on the spot if gas is laid on; or, failing this, acetylene or ether, or even methylated spirit may be utilised instead.

The bags in use are placed between double pressure boards (if *both* gases are required under pressure) and weights sufficiently heavy placed on the top (Fig. 14), or with a 'blow-through' jet only the oxygen need be stored in a bag and the coal gas used from the supply main.

Cylinders have, however, so universally superseded these appliances, that space is hardly warranted in fully describing them, especially as any operator wishing to adopt the process can {24} obtain full directions from any responsible dealer.

Limelight Jets.—These are of three general types, viz. the 'Blow-through,' the 'Mixed,' and the 'Injector.'

Of these the 'Blow-through' is now very little made, having been largely superseded by the 'Injector' pattern, but, as there are hundreds in common use in this country, they cannot yet be regarded as a thing of the past.

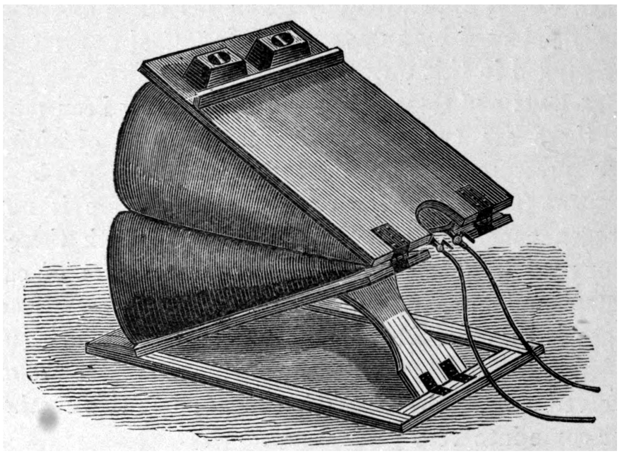

Fig. 14.—Gas-bags.

The exact design of this jet varies considerably, but all are alike in this, that a jet of coal gas is burned at the orifice of a more or less open nozzle, and a stream of oxygen *blown through* it on to a cylinder of lime which it thereby renders incandescent. Fig. 15 represents the various designs chiefly adopted for this jet, that marked A being perhaps the most usual, though C is also frequently met with.

In light-giving power there is not much to choose between the various types; probably D on the whole is the best in this respect, but so much depends upon the exact position of the two nozzles, and the *smoothness* or otherwise of that provided for the oxygen blast, that exact comparisons {25}
are difficult.

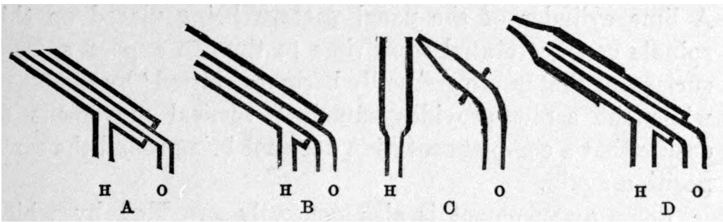

Fig. 15.—'Blow-through' Nozzles.

'Blow-through' jets are the weakest form of limelight as used at the present day, and may be taken roughly as some 50 per cent. better than acetylene, or in other words, sufficient to illuminate a 12-foot picture at a distance of some 40 to 50 feet; but their advantage is, or was, that they only required one gas (oxygen) under pressure, the coal gas supply being obtained from the ordinary house main.

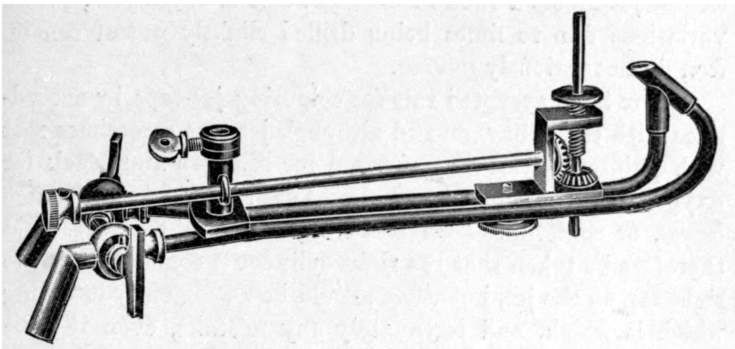

Fig. 16.—'Blow-through' Jet.

This advantage is now shared by the more recently introduced 'Injector' jets, which give a far better light, and have therefore rendered the 'Blow-through' type nearly extinct.

The general construction of a 'Blow-through' jet is shown in Fig. 16, and it will be seen that a
short vertical spindle is provided to carry the lime cylinder, and that this can be rotated from the {26}
back by means of bevelled gear wheels, which at the same time screw the spindle up and down. A lime cylinder of the usual pattern being placed on this spindle can be rotated from time to time to expose a fresh surface, as that in use gradually becomes 'pitted' by the blast, while the screw provides sufficient vertical movement to ensure that a complete rotation does not bring round the same position again.

Some arrangement is also generally provided by which the distance between the lime spindle and the jet can be adjusted. The exact position of this does not matter within a reasonable margin, but limes vary in size, and 'Pastilles,' and other substitutes for limes, which will be referred to later, vary still more, at any rate as regards this adjustment. The average distance which gives the best result is usually about half an inch, and once set need not be altered with that particular jet unless a lime of different size is employed; minor variations due to limes being drilled slightly out of centre, &c., do not seriously matter.

There is no accepted rule for colouring jet-taps in accordance with the cylinders, and although jets are sometimes met with painted in this way, *i.e.* red for coal gas and black for oxygen, it is more usual to find coal gas taps *black* and oxygen *bright*, or sometimes both black or both bright. Care must therefore be taken that the right cylinder is connected to the right tap on the jet, but there should be no difficulty in telling which is which, and fortunately any mistake, even if it be made, is quite harmless.

The Mixed-Gas or Double-Pressure Jet.—This jet is fundamentally different from the 'blow-through' form, inasmuch as the two gases are combined in one mixing chamber before combustion, and burn in their correct proportions at one nipple.

It is usually stated that this jet necessitates both gases being under equal or approximately equal pressure, but this is not literally accurate, and I have given many a lantern exhibition with one of {27}
these jets, using coal gas from the ordinary supply, and oxygen from a cylinder. To use a mixed jet in this way needs care, as a very slight excess of oxygen puts the light out with a 'pop' which, although not dangerous, is disconcerting, while the light obtained under these conditions is very little better than with a 'blow-through' jet, and far inferior to the 'Injector' jets to be described next.

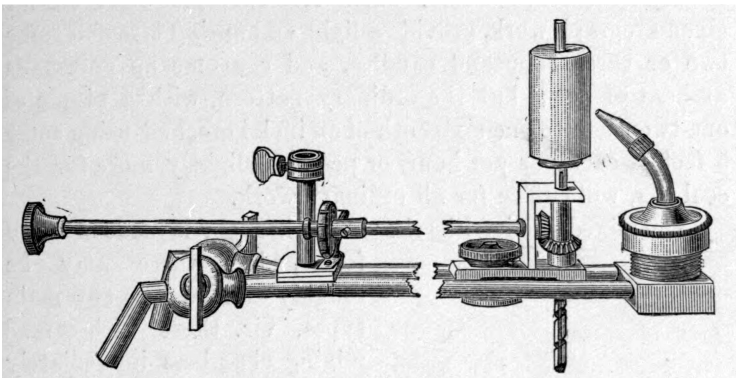

Fig. 17.—Mixed Jet.

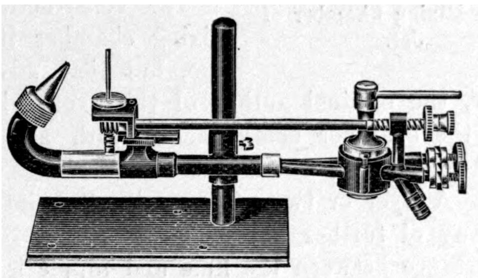

Fig. 18.—Mixed Jet, Gwyer pattern.

The mixed-gas jet is intended then to be used with both gases under pressure, and is the *only* jet to be seriously considered in cases where a really powerful light is required. The power of this jet {28}
is indeed almost unlimited, and those made with large bores, such for example as used for cinematograph work, provide a light amounting often to some two or three thousand candles, and consume an enormous amount of gas; but the ordinary pattern, with a nipple of one-twentieth to one-sixteenth of an inch bore, and using some 5 feet of each gas per hour, or perhaps slightly more for the coal gas, will suffice for all ordinary work.

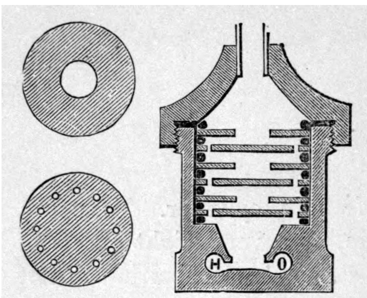

Fig. 19.—Mixing Chamber of Jet.

The mixed-gas jet, like the 'blow-through,' is made in many forms, but these may be roughly divided into two main types, viz. those with small mixing chambers immediately below the nipple (Fig. 17), and those with larger chambers in the horizontal part of the jet as in the 'Gwyer' pattern (Fig. 18).

The construction of the mixing chamber itself varies also, but that advocated by my father, the original author of this work, is generally followed, the chamber being packed with alternate discs pierced as in Fig. 19, which ensures a thorough mixture of the gases. A layer or two of gauze is often introduced as well by way of further improvement. The distance between the lime and nipple is much less than with the 'blow-through' jet, and the adjustment has to be more exactly made. About ⅛ inch is approximately correct for a jet of moderate power, and rather more for a bigger bore; also care must be taken to turn the lime frequently, as the latter 'pits' pretty quickly with these jets, and if it is neglected the jet may spurt back out of the hole, which is gradually formed, and crack the condenser. {29}

There is still an erroneous opinion extant that these jets are dangerous, and if the operator is working with the now obsolete gas-bags it is certainly a fact that an accident in careless hands is *possible*; but with cylinders there is, so far as I know, no possibility even of an accident under ordinary conditions.

It is true that if too much oxygen is turned on the jet may suddenly go out with a loud snap or pop, and this is in reality a miniature explosion in the mixing chamber; but it can in any case hardly be serious enough to matter, though I have found after such a snap that the gauze packing, inside the chamber above referred to, has been pierced right through, and, when first lit afterwards, the jet has for a few minutes burnt with a characteristic green flame, denoting the presence in the gas of fine copper or brass particles.

To obtain a good light with these jets, and in fact with *all* jets, great care must be taken that the nipple is absolutely smooth, otherwise the flame is bound to hiss. The simplest plan is to slightly roughen a suitable sized needle with emery paper and to burnish the inside of the nipple from time to time with this. Especially if there has been one of the 'snaps' referred to is it desirable to see that the inside of the nipple is thoroughly smooth and polished.

Manipulation of the Mixed-Gas Jet.—On this point there is not much to be said. A good hard stone lime must be used—'soft' limes are useless for this jet—and the coal gas flame should be lit first, and the lime thoroughly heated with this before the oxygen is slowly turned on. As the oxygen increases the flame will gradually disappear and the light increase, until it is at a maximum for that particular amount of coal gas. This latter can then be turned on a little more, and more oxygen passed to balance it until the jet begins to 'roar,' when we are getting the maximum light for that particular sized nipple. When the two gases are, however, in the proper proportion to give the best light, there will always be a slight excess of coal gas flame visible playing about the lime. {30}

The Injector Jet.—This is essentially a mixed jet, and in outward appearance differs but little from one of the ordinary type (Fig. 20), but is so constructed that the pressure of oxygen 'sucks' coal gas into the mixing chamber, and so obviates all necessity for the latter being under pressure.

With this jet there is little or no danger of the jet 'snapping' out through a surplus of oxygen, as the greater the flow of this gas, the greater the suction on the coal gas side.

The light is not quite equal to a good mixed jet, but very nearly so, and therefore this jet is deservedly gaining in favour every day.

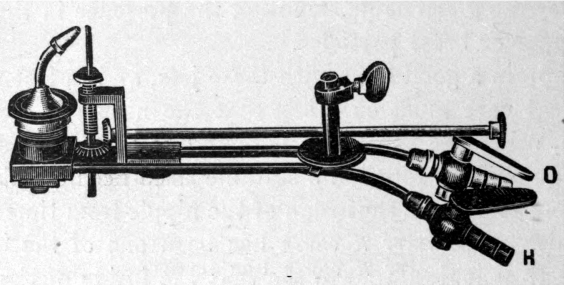

FIG. 20.—'Injector' Jet.

One point must be noted: the oxygen itself must be under greater pressure than with the ordinary mixed jet if the best light is to be obtained, and therefore a special regulator must be used, or one of ordinary type modified (which can easily be done by the maker), and rubber connections must be securely tied both on to jet and regulator, as the pressure required to work this jet to advantage, while not enough to burst a rubber tube, is enough to blow it off an easy fitting connection.

The Oxyether Light.—This is practically similar to the oxyhydrogen, except that ether vapour is used in place of the hydrogen or coal gas. The method adopted consists essentially of passing a stream of oxygen through a vessel packed with some porous material (such as cotton wool or cotton gauze) which is saturated with ether. The oxygen becomes saturated with ether vapour, {31}
and the mixture is then used in place of the coal gas supply in a double-pressure jet, an additional supply of free oxygen being still required through the ordinary oxygen tap.

The arrangement is cheap, as it dispenses with the necessity for a coal gas cylinder, and effective, as the light is little, if at all inferior to the oxyhydrogen, but differs from the latter in this, that with careless handling an accident is *possible*.

In competent hands there is no danger, and I have used ether saturators myself scores of times without one single contretemps; but it should *not* be entrusted to any chance amateur.

The use of the ether light has a curious history. In the earlier days before the proper construction of ether saturators was understood, and gas-bags were still in vogue, it was largely condemned on the score of danger. Modern improvements in apparatus rendered it perfectly safe against anything but gross carelessness or bungling, and the London County Council and other similar bodies immediately supplied it broadcast to elementary schools (in disregard of warnings offered by myself and others), where it was often entrusted to incompetent operators or even senior boys. So far as I know no serious accident ever resulted, a pretty conclusive proof that the light is really safe, but in time the London County Council realised that the universal adoption of this illuminant was not advisable, and I believe *now* prohibit it altogether in halls licensed by them for entertainments.

In time, no doubt, they will learn to adopt a sane policy between the two extremes, but at present the official attitude in many localities has placed ether saturators out of the running, and before purchasing one the would-be operator should ascertain that he will be allowed to use it.

Ether saturators as made at the present day may be divided into two principal patterns, viz. those in which saturator and jet are combined in one piece of apparatus which fits bodily into the lantern, and saturators which are used outside and connected by means of tubing to any ordinary oxyhydrogen double-pressure jet. {32}

Both forms have their advantages and disadvantages; the first pattern tends to become too warm from its position in the lantern and generates ether vapour too quickly, while the second has the fault of becoming too cold (owing to evaporation of the ether) and therefore not vaporising quickly *enough*.

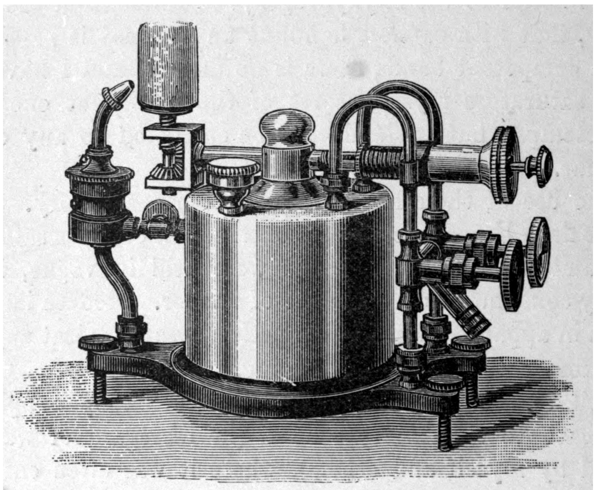

Fig. 21.—'Gridiron' Saturator.

Writing at the present date, when manufacturers are slowly beginning to resume their normal occupations after the stress of war work, it is impossible to say exactly what models will or will not be made, but I will mention one typical example of each pattern as made in pre-war days.

The first of these is the 'Gridiron' (Fig. 21), adopted largely by the London County Council in the days I have referred to, and certainly one of the best designed saturators ever put on the market.

In the 'Gridiron' saturator there are three taps: two at the rear and one in front, between the saturator and the mixing chamber. Between the rear taps is the inlet for the oxygen, which divides into two channels, that on the left passing upwards through the **U** tube shown in the illustration (the corresponding tube on the right is merely a dummy), and thence through the saturator and out through the horizontal tube and tap into the mixing chamber, whence the saturated stream of oxygen finally passes to the nipple, and the combination burns with a whitish flame closely resembling that produced by coal gas. {33}

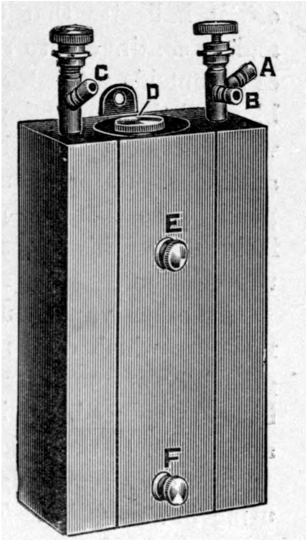

FIG. 22.—'Pendant' Saturator.

The other channel for the oxygen is to the right, down the vertical tube shown there (the lower vertical tube on the left is also a dummy), underneath the saturator, and finally coming up into the mixing chamber from below, transforming the white flame into an intensely hot blowpipe exactly as it does with a coal gas jet. The front tap controls the supply of saturated ether to the mixing chamber, and whereas at first a good stream of oxygen is needed to pick up enough ether, by degrees as the instrument warms in the lantern, the oxygen passing through the saturator can be cut off entirely, and even then the front tap must be gradually closed down to prevent the hot ether coming off too fast.

There is a disagreeable feeling of 'sitting on the safety-valve' in doing this, but in reality the pressure is never likely to become great enough to cause danger.

Of saturators for use outside the lantern the best-known is probably the 'Pendant' (Fig. 22). With this instrument the oxygen supply is connected to the inlet marked A; B goes direct to the oxygen {34}
tap of any ordinary mixed-gas jet; while C, from whence issues the saturated stream, is connected to the coal gas tap of the jet. Whichever pattern is used, the essential thing is to keep a good supply of oxygen well saturated. If the lime becomes incandescent without any free oxygen, or it is found that this requires gradually turning off, it indicates that the saturation is becoming defective, and to continue is to risk the jet snapping out. In the case of an outside saturator such as the 'Pendant,' this may even blow off the connecting tubes with a loud report, though no worse accident is likely to happen, and for this reason an outside saturator should be placed *as close* to the jet as possible, so that the rubber tube may be kept short, and incidentally this keeps the saturator warm and accelerates vaporisation.

As ether vapour usually contains a certain amount of moisture which does not vaporise to any great extent, this gradually accumulates and the capacity of the instrument becomes reduced. It is therefore usually necessary to return a saturator to the makers every now and again for repacking.

The only real danger with a modern saturator is not in using but in *filling*. This should be done if possible in the open air, and at any rate never near a light. Ordinary sulphuric ether of specific gravity 720-730 is usually considered the best, and a quarter of a pint will keep an ordinary small-bore jet going for nearly two hours.

More precise directions are usually sent out by the makers, and as the various patterns of saturator in use are pretty numerous, it would be useless here to attempt more detailed instructions for working.

Oxy-Acetylene Jets.—Any good mixed gas jet may be used with acetylene instead of coal gas, provided that it is under pressure more or less corresponding to that from an oxygen cylinder, and at the present day there is no difficulty in obtaining this, in civilised countries at all events, by means of compressed or, to speak more correctly, 'dissolved' acetylene cylinders, referred to {35}
later on.

With an 'Injector' jet there is no need for the acetylene gas to be under pressure at all, and a simple generator such as described on page 12 will answer perfectly, though in practice very seldom used. With such a generator the pressure is so low that in many cases the jet will not even burn until *some* oxygen is turned on; but this introduces no real difficulty, as with a good 'Injector' a snap is practically impossible, provided the generator is large enough to evolve sufficient acetylene. It is far better in every way, however, to use the acetylene from a cylinder, just as with coal gas. Only in this case the cylinder is completely filled with a porous material, and this again filled with liquid acetone or other suitable fluid, in which the acetylene is dissolved as rapidly as it is pumped into the cylinder.

To compress acetylene in the ordinary way is neither safe nor practicable; but these 'dissolved' cylinders are now used extensively for both oxy-acetylene welding and motor car lighting, and may be entirely relied upon.

The D.A. (Dissolved Acetylene) Company were the pioneers in this country of the industry, and their methods of business are peculiar and ingenious. The user is requested in the first place to purchase a cylinder, and he then becomes the owner of *a* cylinder, but not of one *particular* cylinder. A list is supplied to him of various depots in the country where the Company's cylinders are stored, and when empty he can, on payment of a fixed sum, exchange his empty cylinder for a full one, which then becomes *his* cylinder *pro tem*.

This saves the delay and expense of returning a cylinder to London, and incidentally clears the customer of any question of deterioration, this being obviously covered by degrees with each individual exchange. The system was first introduced in connection with the lighting of cars and only applies to the standard size for this purpose, viz. 20 cubic feet capacity, but as this is, on the {36}
whole, the most convenient size for lantern work also, the limitation is not a disadvantage. The arrangement is also in vogue to a less extent with cylinders of 6 feet capacity (a size sometimes used for motor *cycles*), but the depots of exchange are at present far fewer for this size.

The oxy-acetylene blast is much *hotter* than the ordinary oxyhydrogen, and therefore produces a more intense light. I have therefore used it with success on occasions when even the ordinary limelight would fail, and the choice has lain between an oxyhydrogen jet of enormous bore (and, of course, corresponding consumption of gas), and the oxy-acetylene.

For this very reason great care must be taken only to use the hardest limes, and even then to use the lime-turning movement frequently, or the lime will pit or crack and a broken condenser follow.

The Fallot Acetylene Light.—This light consists of a jet of acetylene under pressure, without oxygen, but producing its own *air blast* from the atmosphere by suction, much as the 'Injector' jet does, but the reverse way round.

The light is better than with an ordinary acetylene jet, though not quite so good as with a 'blow-through' jet; but as it only requires a cylinder of dissolved acetylene, or even a 'Pressure' generator, it is fast coming into favour.

The peculiarity of the Fallot apparatus is that, instead of providing a direct beam of light in the direction of the screen, it projects the beam *backwards* on to a concave mirror, and it is the reflected light from this that is used (Fig. 23).

Instead of a lime is used a spherical 'Pastille' of peculiar composition, and before use each pastille must be burnt off exactly like an incandescent gas mantle, after which it is extremely fragile and difficult to handle.

To use this illuminant one lens of the condenser must be removed, the curvature of the mirror taking its place, and it will be seen at once that the pastille itself will get in its own light and {37}
throw a shadow, which actually happens, but it is hardly perceptible unless specially looked for.

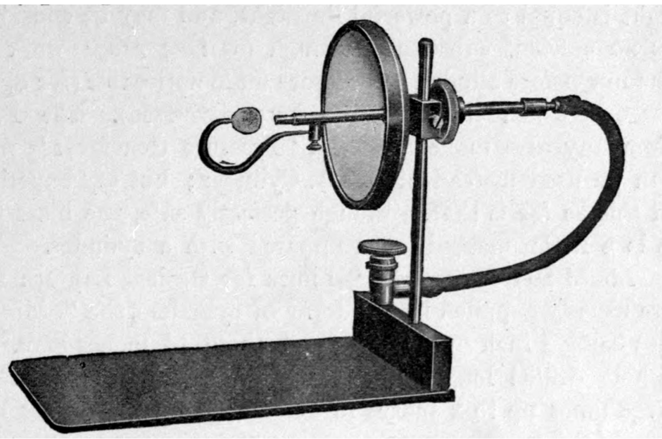

Fig. 23.—Fallot Air Blast.

A complete Fallot Air Blast Outfit, with cylinder, fine adjustment valve, pressure gauge and burner, with two spare pastilles, is shown in Fig. 24, but if preferred a regulator, such as previously described for oxygen, can be used instead of the fine adjustment valve.

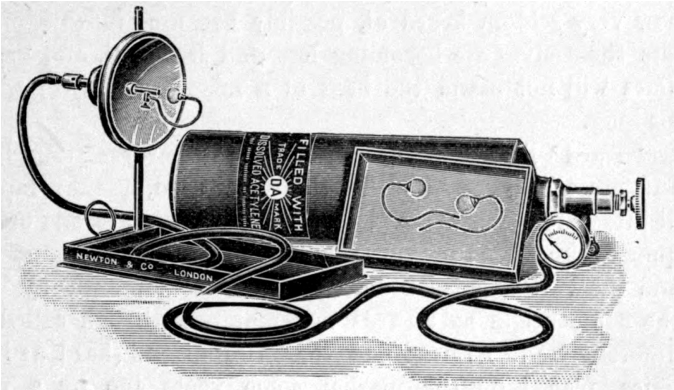

FIG. 24.—Fallot Air Blast, and Cylinder.

Fallot Oxy-Acetylene Blast.—This is similar to the foregoing, utilising oxygen from a cylinder {38} instead of air, and the light is equal to a powerful limelight, and may be considered as an efficient substitute, though for *long range* work the shadow before alluded to becomes more noticeable (for optical reasons which need not be here discussed). The Fallot Company also make a special 'Pressure Generator' which can be used instead of a D.A. Cylinder; but my experience of this so far is that, although perfectly safe, the blast from it is a little unsteady as compared with a cylinder.

Limes and Accessories.—Limes for Optical Lantern work are usually supplied in the form of cylinders, the 'ordinary' size being ⅞ inch in diameter and about 1½ inches long, with a hole drilled longitudinally to take the lime pin. Extra large limes up to 2 inches in diameter are supplied for more powerful jets.

So-called 'soft' limes used to be recommended for 'blow-through' jets as giving a better light than 'hard' limes, but the advantage, if any, is very little, and these limes are now very seldom heard of, possibly because 'blow-through' jets themselves are becoming less and less used, and 'soft' limes will not stand the heat of a mixed or 'Injector' jet for long.

'Hard' limes are turned out of the hardest stone lime, and must be kept in sealed tins until used, as they rapidly disintegrate when exposed to the air. There are one or two quarries known to provide the best lime for lantern purposes, and the various good brands on the market practically have the same origin as regards raw material, though called by different trade names; and the 'Hardazion' (hard as iron) limes, placed on the market some years ago by a well-known wholesale firm, to be countered shortly after by the 'Hardastil' (harder still) brand, are, I take it, legitimate though amusing instances of phonetic advertisement.

Even the best of limes is liable to crack under the heat of a powerful jet, and so a pair of lime- {39} tongs should always be provided, and there is nothing better than the simple form shown in Fig. 25, and which is, or should be, sold by all dealers.

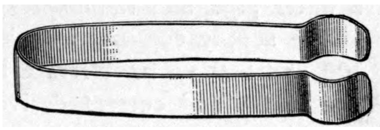

FIG. 25.—Lime-tongs.

Substitutes for Limes.—A good substitute for lime, that will give the same light, stand heat equally as well, and *not* deteriorate if exposed to the atmosphere, has long been sought for, and some of the more recently discovered refractory materials are more or less satisfactory. 'Mabor' limes, for example, belong to this class, and so do some of the 'pastilles,' which before the war came chiefly from France and to a less extent from Germany.

CHAPTER VI

THE ELECTRIC LIGHT

The electric current provides *the* light for an optical lantern, though it may take various forms, such as the incandescent glow-lamp in some shape or other, the comparatively new Ediswan 'Pointolite' lamp, the enclosed arc, and the open arc. This little book is not a treatise on electricity, but a few elementary notes may not be out of place, and may be of assistance to the non-technical lanternist.

The first point then to be considered in adopting the electric light for the purpose of lantern projection is the character of the supply, and the information required may be summed up thus: (1) *E.M.F.*, *voltage*, or *tension* (these three expressions having exactly the same meaning); (2) *ampèrage* or amount of current available; (3) whether current is (*a*) *continuous*, *constant*, or *direct* (again three words meaning the same thing), or (*b*) *alternating*. The E.M.F. or tension {40} corresponds to *pressure*, to use the mechanical analogy of a water pipe, and the *ampèrage* to volume, and the voltage of the supply currents in this country are usually between 100 and 250 volts. Private lighting sets are frequently as low as 50, and current derived from accumulators may be anything from a few volts and upwards. *Power* currents, such as commonly employed for tramways, &c., are usually about 500 volts, but the use of these currents for lighting purposes, though practicable, is not to be advocated.

Ampères and volts are convertible terms in a sense; that is to say, a current of 10 ampères at 100 volts requires the same horse-power to generate it as one of 5 ampères at 200 volts, or 20 ampères at 50 volts, but they are by no means convertible as regards their *efficient* use for our purpose. The ampères used multiplied by the number of volts give the total power consumed in *watts*, and 1000 watts used for one hour represent 1 *unit* as charged for on our dreaded lighting bills. The current available from a public supply may be said to be unlimited so far as our purpose is concerned, and the amount actually used depends only on the total electrical resistance of our circuit, and this is measured in *ohms*, the three factors, viz. volts, ampères, and resistance, being connected by the well-known and simple equation $C = E / R$, C representing the current in ampères, E the tension or E.M.F. (electro-motive force) in volts, and R the resistance in ohms. The total current we *can* use, however, is limited by the size of the cable laid on in the building, and this is automatically safeguarded (or should be) by the *fuses*, which consist, as is generally known, of thin wires or strips of tin or lead fixed on a fuse board in an easily accessible place, and which melt directly the current exceeds a safe amount in ampères. Whatever method of lighting we use therefore, *enough* resistance must always be kept in the circuit to ensure that no {41} more current can pass than has been provided for, and in the case of an arc lamp this usually means a *resistance* or rheostat being retained in the circuit in addition to the arc itself, through which the current is passed and absolutely wasted, though fortunately the waste in money is negligible, and for reasons to be discussed later such a resistance is necessary with an optical lantern arc lamp in any case.

In the case of a glow-lamp, the entire resistance is provided by the filament of the lamp itself, and that is why an ordinary metal or carbon filament lamp, for say 200 volts, has to be manufactured with an extremely long and slender, and therefore fragile, filament, while with an ordinary pocket-torch, which is usually supplied with current from a dry battery of some 3 or 4 volts only, the filament can be short and thick.

Speaking generally, glow-lamps on a low voltage current can be made more efficient than on a high one, and are also longer lived for very obvious reasons; but, on the other hand, the transmission of current over long distances is cheaper the higher the tension, as for a given number of watts the ampèrage is less, and therefore smaller cables can be employed. On the whole, then, currents of 200 to 250 volts have during recent years become more common than 100, in spite of greater difficulties in making the lamps; but occasionally one finds a hall where two or more lamps are wired in *series*, two 100-volt lamps for example being wired together in series on a 200-volt circuit. If we are using current for our lantern from an ordinary lamp socket, this is a possibility that must be borne in mind.

The same considerations, viz. the economy of transmitting power at high tension and of *using* it at a lower one, have been mainly responsible for the rapidly increasing number of alternating current circuits now met with, especially in sparsely populated districts. An alternating current main is one in which the current reverses its direction, usually in this country 50, but sometimes 60, 80, 90, or even 100 times per second (there being unfortunately in Great Britain no standard {42} 'Periodicity' or number of cycles per second), and for technical reasons which need not be entered upon here, with these alternating currents the tension and ampèrage can be mutually converted by means of *transformers*, so that current can be transmitted at so high a tension, for instance, as 10,000 volts, and used at a voltage of 50 or 100 or whatever is required, the ampèrage available being increased in inverse ratio as the tension is decreased. The same ready power of transformation unfortunately does not apply to the continuous current, or alternating currents would probably never have been heard of, but as it is they are very common. For glow-lamps it is immaterial which current is available, but for arc lamps the continuous is much to be preferred, though both can be utilised.

With these initial remarks, I will now take in order of illumination the various methods of utilising the electric current for optical lantern work.

The Electric Glow-Lamp.—The ordinary metal filament lamp is not very suitable for lantern work, the light not being sufficiently concentrated, but from what has already been said, it will be evident that this method of lighting is more suitable where currents of low voltage are available.

An extremely good and intense light can be obtained from a comparatively small battery of accumulators, which can easily be carried in the hand, and a short and thick metal filament lamp, similar to those supplied with a powerful electric torch; and this arrangement is actually used to some extent by travelling lecturers, but the mess and trouble of keeping the accumulators in order have prevented the method being generally adopted.

When *alternating* current is available such a lamp will work well with a transformer to step down the voltage to the required degree, and the arrangement is simple, cheap, and efficient, and produces a light at least equal to that from acetylene. In comparatively small halls, where the {43} current is alternating, this is undoubtedly the best method of working, as it is simpler than the arc and amply brilliant enough for all practical purposes.

With the continuous current the problem is not so simple, as transformation of voltage is not an easy matter, and a glow-lamp on; say, a 200-volt circuit involves a long and fragile filament, which it is difficult to arrange in a small space.

Many years ago the Ediswan Company produced a 'Focus' lamp for the purpose, with the filament arranged in the form of a square grid, and this lamp gave a light of about 100 candles, and was fairly successful for a small room. More recently the Osram Company introduced a similar lamp with a metal filament arranged somewhat in the form of a cone, and this lamp also sufficed for a small class-room. It was, I believe, made in Germany and was practically unobtainable during the war. I understand the Osram Company are at present arranging to manufacture it in this country, but up to the time of writing it has not made its appearance.

None of these lamps worked direct on a public lighting circuit can be regarded as really satisfactory, as it has been found impossible so far to get a *concentrated* light; the 100-volt lamps have, of course, been superior to those made for 200 or 250, but they are all for lantern purposes far behind low voltage lamps, which are really good when a suitable current can be obtained.

The Pointolite Lamp.—This lamp produced by the Ediswan Company is in reality a miniature arc with tungsten electrodes in a highly exhausted vacuum bulb. To attempt a technical description would be beyond the scope of this book; it will suffice to say that the action depends upon the same principle as the various wireless vacuum valves or the Coolidge X-ray tube.

This lamp requires a peculiar starting device which is supplied with it, and gives a good, intense, and concentrated light, not equal to the ordinary arc or to limelight, but comparing well with any {44} other form of illuminant. It can only be used with the continuous current.

The Nernst Lamp.—This lamp at the present moment is practically non-existent in this country, having been made exclusively in Germany. Also as recent improvements in metal filament lamps have rendered it almost obsolete for ordinary lighting purposes, it is, I think, very doubtful whether it is still manufactured even in that country, and hence I do not propose to waste space in an extensive description.

It will suffice to say that the lamp consists of one or more straight rods or filaments of a refractory material, which are semi-conducting to the electric current when hot, but non-conducting when cold. To commence with the filament must be heated, and in the lamps as supplied for lantern work this is usually done by means of a spirit lamp, which can be removed immediately the current begins to pass, as the filament is thereafter maintained at a white heat automatically.

A three-filament Nernst lamp gives as much as 1000 candles, but it is extremely hot, and the light rather diffuse. The filaments are also very fragile, so on the whole the lamp was never very much in favour; but on the other hand it consumed very little current, and could be worked from any ordinary house lighting main, points which led to its adoption in certain cases.

The Electric Arc.—We now come to *the* light for optical lantern work, the brightest, the most concentrated, the cheapest, the easiest to work, in fact, the illuminant which combines all the virtues and but few drawbacks, but of course requires one indispensable condition, viz. electric current laid on. This current may be of any voltage from 70-250, or even higher; it may be continuous or alternating, though the former is to be preferred; and it requires a cable for *at least* 5 ampères, and for a large hall 10 or 12 ampères.

The simplest form of arc lamp for lantern purposes is the hand-fed type as illustrated in Fig. 26. {45} The essential feature is the pair of carbon rods, the remainder of the apparatus consisting of mechanical adjustments to 'feed' these as they burn away, and to accurately maintain them in their proper positions and in the optical centre of the lantern. Just because the electric arc provides so small and concentrated a light, it is of extreme importance that the centring should be exact; and hence mechanical movements are usually provided for this which are unnecessary with other illuminants.

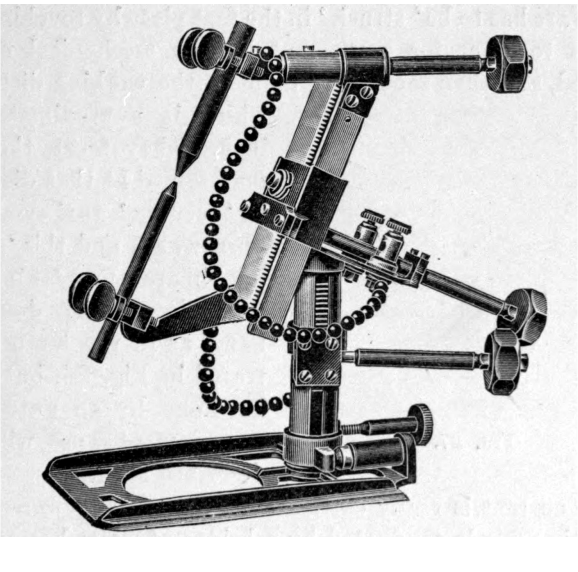

FIG. 26.—Hand-fed Arc Lamp.

The whole question of optical adjustments has, however, been left over for a future chapter, as it more or less applies to whatever illuminant is used.

The illustration shows a lamp arranged for continuous current, the upper carbon, which must be connected to the *positive* wire, being larger than the lower (the negative), and very slightly behind it. The light from a continuous current arc lamp comes chiefly from this upper or positive carbon, which 'craters' as it is used, and this arrangement has the effect of radiating the light in {46}
the direction required (Fig. 27).

The positive carbon is usually of the 'cored' type, that is provided with a core of softer carbon, as this assists the 'cratering' action, while the negative is generally used 'solid,' that is homogeneous right through.

The arc has to be 'struck' in the first place by touching the carbons together for a moment by the mechanical means provided, and then separating them to the working distance, which is approximately ⅛ inch. They must then be maintained at that distance by 'feeding' as they slowly burn away, and this 'feeding' in arc lamps for lantern work is usually done by hand, as in the lamp illustrated in Fig. 26, but may be done by an automatic arrangement, as will be described later.

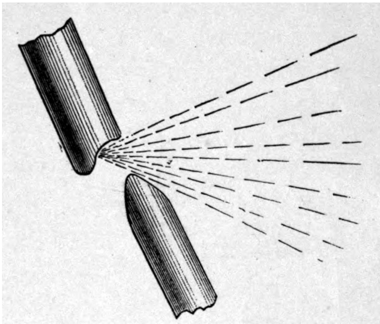

FIG. 27.

The current is really carried across the arc by *convection*, or in other words conducted by a bridge of white hot carbon particles, which continually stream across from the positive carbon to the negative, and this bridge, while conducting the current, interposes a very considerable *resistance* (otherwise it would not of course become hot).

A certain potential or tension is therefore necessary if a given current is to be maintained, and this potential has to be greater the longer the arc and also (though not in direct proportion) the smaller the carbons.

When, however, everything is in the best proportion, *i.e.* length of arc, size of carbons, and current passing, the potential at the arc lamp terminals required is approximately 45 volts, and this may be taken as a fixed figure for any current.

The length of arc to give the best results may also be taken as approximately fixed at ⅛ inch, and {47}
the *variable* factor for different currents as required is provided by altering the sizes of carbons employed.

The error must not be made, however, of assuming that an E.M.F. of 45 volts is sufficient to work an arc lamp, as the minimum in practice is at least 65 volts, and 100 or even 200 volts are advantageous.

I have come across more than one private generating installation where the innocent owner has put in a dynamo for 45 or 50 volts, depending upon some carelessly written statement that this is sufficient.

Why a higher E.M.F. is required can be simply explained.

Take for instance an average hand-fed arc lamp as used for lantern work and consuming, say, 10 ampères.

Take also, as a fact, the statement given above that the necessary E.M.F. at the actual terminals of the arc lamp may be accepted as a constant at 45 volts, and reverting to the equation given on page 40, C = E / R, and substituting these figures we get—

Current (10 ampères) = E (45 volts) / R (Resistance of Arc).

It is therefore obvious that under these exact conditions the resistance or back E.M.F. of the arc, as it is termed, must equal 4.5 ohms.

Now suppose the lamp left for a few seconds unattended, while the carbons are burning away and the arc is lengthening; in a very few moments the resistance will have increased, owing to the greater distance between the carbons, and we will suppose it to have become 5 ohms instead of 4.5.

The current passing will now be 45 / 5 = 9 ampères only.

In other words, a very slight lengthening of the arc has reduced the current, and therefore the light, by 10 per cent.

Not only so, but 45 volts being needed to maintain an arc of normal length, it is insufficient to {48}
maintain a longer one, and in practice the effect of leaving an arc under these conditions to itself for even a few seconds is that it *goes out*, to the annoyance of the lecturer and the confusion of the operator.

It is just *possible* to work an arc lamp with a total E.M.F. of 45 volts by giving one's whole attention to it and never taking the hand off the feeding handle; but in practice no one with any experience would attempt it. The arc would almost certainly go out several times during the exhibition.

Now, take an example of a similar arc lamp consuming 10 ampères but worked from a supply of 200 volts.

Our equation C = E / R must then obviously become

C (10 ampères) = E (200 volts) / Total Resistance (20 ohms).

The resistance of the arc itself being the same as before, viz. 4.5 ohms, it is obviously necessary to put an *extra* fixed resistance equal to 15.5 ohms in series with it in order to make up the total of 20 ohms.

Now leave the arc unattended until the resistance of 4.5 ohms has again become 5 ohms; the only effect is that our current, instead of remaining at 10 ampères, has become 200 / 20.5 or 9.8 nearly, a difference which is imperceptible.

This is not all, for it is an elementary rule in electrical science that the total E.M.F. of any circuit distributes itself along that circuit in proportion to the distribution of resistance.

In other words, our original E.M.F. of 200 volts will so distribute itself as to reserve, so to speak, an E.M.F. of 45 volts for the arc, while the resistance of this remains at 4.5 ohms, but directly this resistance increases, the E.M.F. at the arc lamp terminals automatically rises, and therefore
the actual diminution in current is even less than the figures above quoted. {49}

Should the arc tend to 'break' or go out, the resistance across it automatically becomes infinite and the *whole* 200 volts is at that moment available to prevent the occurrence.

Under these conditions, therefore, the operator can safely leave the arc for many minutes at a time. In carrying out experimental work I have often left the lantern, walked up to the screen, discussed results with a friend, and walked back, and the arc has shown no signs of misbehaviour whatever.

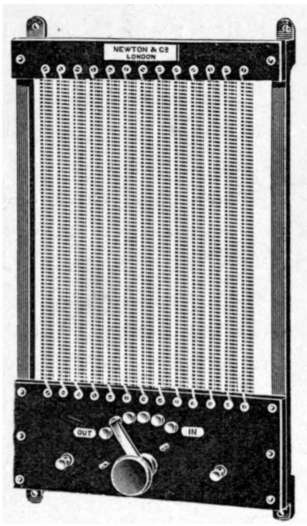

Fig. 28.—Resistance.

In practice any current from 100 volts to 250 volts may be considered as satisfactory for lantern work with a suitable resistance. Less than this involves feeding the arc rather frequently, and more may give a nasty shock, should the operator inadvertently touch a live wire, though I have worked an arc lamp on a current of as much as 500 volts.

The *resistance* usually consists of a suitable length of wire of high resistance (Iron, German Silver, or those alloys known as Platinoid, Eureka, Manganin, Beacon, &c., are most commonly used) wound in spirals on a frame, and is generally supplied adjustable (Fig. 28), so that more or less current may be used as desired. These resistances get pretty hot in use, and care must be taken that they are placed where they cannot scorch woodwork, &c., and in cases where the lantern is a fixture it is a good plan to have the resistance bolted up against a wall once and for all. The resistance may be placed anywhere in the circuit, so long as the current passes through

{50}

it, then through the arc lamp (or *vice versâ*), and back to the other pole of the supply main; it does not matter in the least whereabouts it comes.

In cases, however, where one pole of the supply main is *earthed*, it is a good thing to place the resistance in the 'live' side, as this keeps the arc lamp within 45 volts of earth potential while it is working, to the comfort of the operator should he touch a terminal or wire, though with an ordinary lighting main there is no real fear of a dangerous shock in any case.

The *amount of current required* depends of course on the size of the sheet, length of the hall, and density or otherwise of the slides; but it is usually accepted in practice that the efficient light from a continuous current arc lamp equals 100 candles per ampère, and therefore a 10-ampère arc will give 1000 candles. This is sufficient for all ordinary halls and slides, but where these latter are very dense, as for example with the Lumière three-colour process, as much as 20 or 25 ampères may be required.

In these cases some special precautions must be taken for keeping the slides cool, or the result may be disastrous, but this is a question that will be referred to in a later chapter. A current of 10 ampères is pretty safe for all ordinary slides, and may be taken as the normal current used in large halls, though in arranging for the wiring it is as well to stipulate for at least 12 or even 15 ampères, especially as there must necessarily be a momentary increase of current at the instant the arc is 'struck.'

Varieties of Hand-fed Arc Lamps.—The pattern of hand-fed arc lamp illustrated in Fig. 26 is only typical of many of the same general design, and there are others in which the design itself is fundamentally different. Of these the 'Scissors' arc lamp made by several firms deserves mention on account of its simplicity and cheapness. As its name implies, the mechanism resembles a pair of scissors, the carbons being attached to the ends of a pair of levers hinged together (Fig. 29). In {51} this lamp centring movements are usually dispensed with, the arc being clamped on to a tray pin as in the case of a limelight jet. This is not, of course, so convenient, and a further disadvantage of this pattern arc lamp is that the feeding process gradually alters the position and angle of the carbons. In fact, the one great merit of the lamp is cheapness, and where expense is an object, it should certainly be considered.

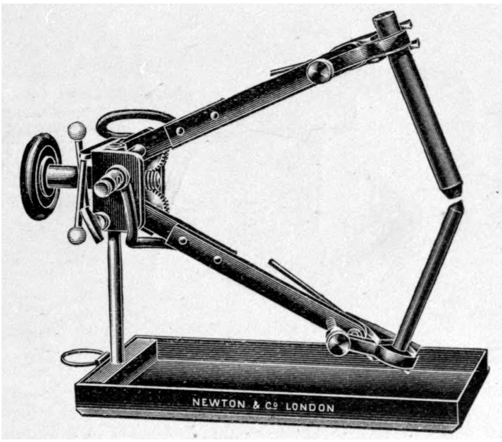

Fig. 29.—'Scissors' Arc Lamp.

Yet another arc lamp deserving of mention is the 'Parallel,' a name again very aptly chosen, as the two carbons are either exactly parallel to each other or very slightly inclined. In the former case the arc has to be 'struck' by touching the ends of the carbon rods with a piece of metal or carbon. Of the actual manipulation of this lamp I have had very little practical experience, but I have heard it well spoken of, though I believe it has so far only been made for currents of 5 ampères or so.

Yet another type which must not be ignored is the 'Right-angled' pattern (Fig. 30), a name again self-descriptive. The horizontal carbon is the positive, and the vertical the negative, and this lamp {52} again is made by several manufacturers in slightly different forms.

This pattern lamp is in my experience the best of all for *small* currents, say, of 5 ampères or so, but inferior to Fig. 26 for currents of 10 ampères or more. This last remark perhaps hardly applies to *alternating* currents, which, however, I have not yet discussed. I cannot conclude this brief category of arc lamps without referring to the *enclosed* pattern, of which the 'Westminster' is perhaps the best-known and most popular (Fig. 31).

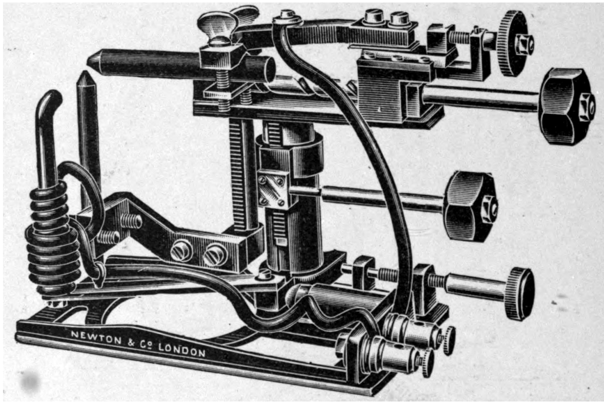

FIG. 30.—'Right-angled' Arc Lamp.

This is a lamp of the right-angled type, but the arc burns in a cylindrical glass chamber, not air-tight, but partially so. After burning a few minutes the oxygen in this chamber becomes used up and its place is taken by carbonic-acid gas and other products of combustion, after which the carbons burn away very much more slowly, and therefore require feeding at much greater intervals.

This lamp again is chiefly made for small currents not exceeding 5 ampères (and can therefore be used from any ordinary lamp socket), and for a moderate-sized hall is on the whole as cheap, {53} efficient and simple a lamp as any I am acquainted with. It can be supplied with or without mechanical centring movements as required, and is usually sent out with its own resistance for the particular current on which it is to be used, so that it only requires connecting up to the nearest lamp socket, and is ready for use.

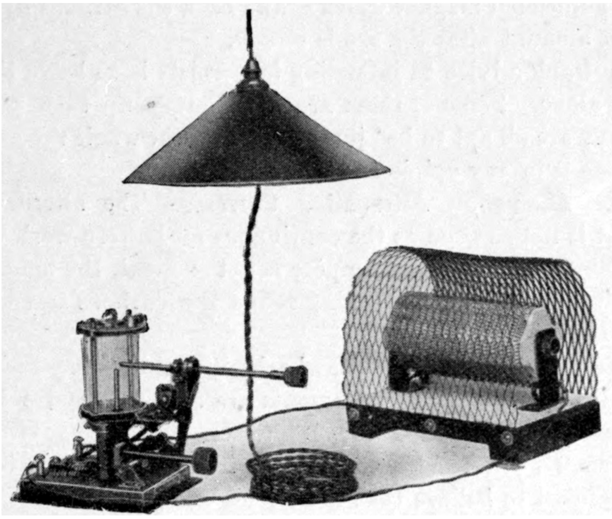

FIG. 31.—'Westminster' Arc Lamp.

It is *not* sufficient for anything larger than a 12-foot sheet or for working at a greater distance than, say, 40 feet, but within these limits the lamp, and in fact *any* good 5-ampère arc lamp, will be found quite satisfactory and saves the expense of putting in a special cable.

Automatic Arc Lamps.—Arc lamps for lantern work in which the feeding is done automatically are also made. Like hand-fed lamps, they vary in exact design, but all, or practically all, are so designed that the carbons are brought together by means of springs or weights, and some form of 'brake' controlled by a system of electro-magnets checks the movement. As the carbons burn {54} away the arc lengthens, the current weakens, the electro-magnets lose their grip, and the carbons move together until the increasing current puts on the brake again. Some of these lamps are 'semi-automatic' only, that is to say, the arc has to be struck by hand, while others perform this operation automatically as well, usually by an additional magnet which draws back the carbons by the correct amount after the arc is struck.

My frank advice to intending lanternists is to leave these lamps alone. Some of them are satisfactory up to a point, but they are all apt to be 'jumpy,' and on the whole the hand-fed type is in my opinion to be preferred.

Arc Lamps on Alternating Currents.—The alternating current is not so good as the continuous for lantern work with arc lamps: the light per ampère is not so great, the light has an irritating habit of travelling round the carbons and there is always a slight 'hum.'

The sum total of these drawbacks is nothing very serious, provided that proper arrangements are adopted, and I have frequently manipulated arc lamps on alternating circuits with such good results that professional lecturers have at first refused to believe that the circuit really *was* alternating.

As it is frequently stated that to obtain a steady light with an alternating current is impossible, I can understand their surprise, and I can also understand the statement in question, as the problem is usually tackled on entirely wrong lines.

It is almost always stated that arc lamps for alternating currents should be arranged with the carbons *vertical*, and many makers actually so construct their lamps as to allow of this.

To obtain a steady light under these conditions *is* impossible and I pity anyone who attempts it; but the statement that this is the best method of working has been repeated so often that it seems to have been taken for granted.

The best arrangement (in my hands at any rate) is to slant the carbons as for the continuous current, and also to have the upper carbon cored and the lower one solid, but to use a rather larger lower carbon than would be correct if the main were continuous. {55}

Also the upper carbon should not be *quite* so far back as with D.C.; to have the front edges of the two carbons practically in line is about correct, but the *exact* position should be carefully adjusted to obtain the steadiest light, and it will be found that a slight alteration makes a considerable difference.

It is also a great help to have a weak electro-magnet, or its equivalent, so arranged that it tends by its influence to keep the arc to the front. On some lamps this is provided for, as even with a continuous current it is quite harmless and, if anything, beneficial; but, if not, any competent mechanic can easily fit an 'Induction Ring,' consisting of a single turn of stout copper wire, which has sufficient magnetic influence to do all that is required (Fig. 32).

This ring must be wired in series with the arc itself, and as the current passing in it automatically reverses in synchronism with the arc, its effect is *always* to deflect the arc in the same direction, and care must of course be taken that it is so wired that the deflection is forward and not backward. This is the exact arrangement I have myself adopted, and I never experience any difficulty on the score of the arc wandering.

Right-angled arc lamps, as described on pages 52 and 53, are also very efficient on A.C. mains, and frequently these lamps are already equipped with electro-magnets for the purpose required. The 'hum' of an alternating current cannot be altogether eliminated, but can be reduced to a minimum *by reducing the voltage as far as possible*.

As has been already said, the A.C. lends itself readily to transformation of voltage, and I find in practice 90-100 to be ideal. More than this is inclined to be noisy, and less is apt to result in an {56}
unsteady arc.

The arrangement, therefore, which I recommend from long experience is to employ a transformer to reduce the E.M.F. to 100 volts or thereabouts, and then work with a resistance in the usual way (if the original current is 100 volts, of course *no* transformer is required) with a properly constructed arc lamp fitted with an induction ring or electro-magnet. No difficulty should then be experienced in obtaining a good, steady, and fairly quiet light.

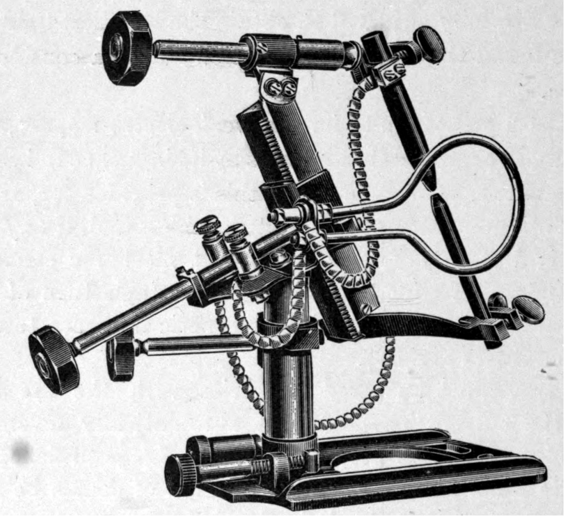

Fig. 32.—Arc Lamp with Induction Ring.

Any little 'hum' remaining can be silenced to a very considerable extent by placing the entire lantern on a thick block of saddlers' felt, but in practice I have never found this necessary with ordinary currents, though a few abnormal circuits where the 'periodicity' is very high are noisier than others.

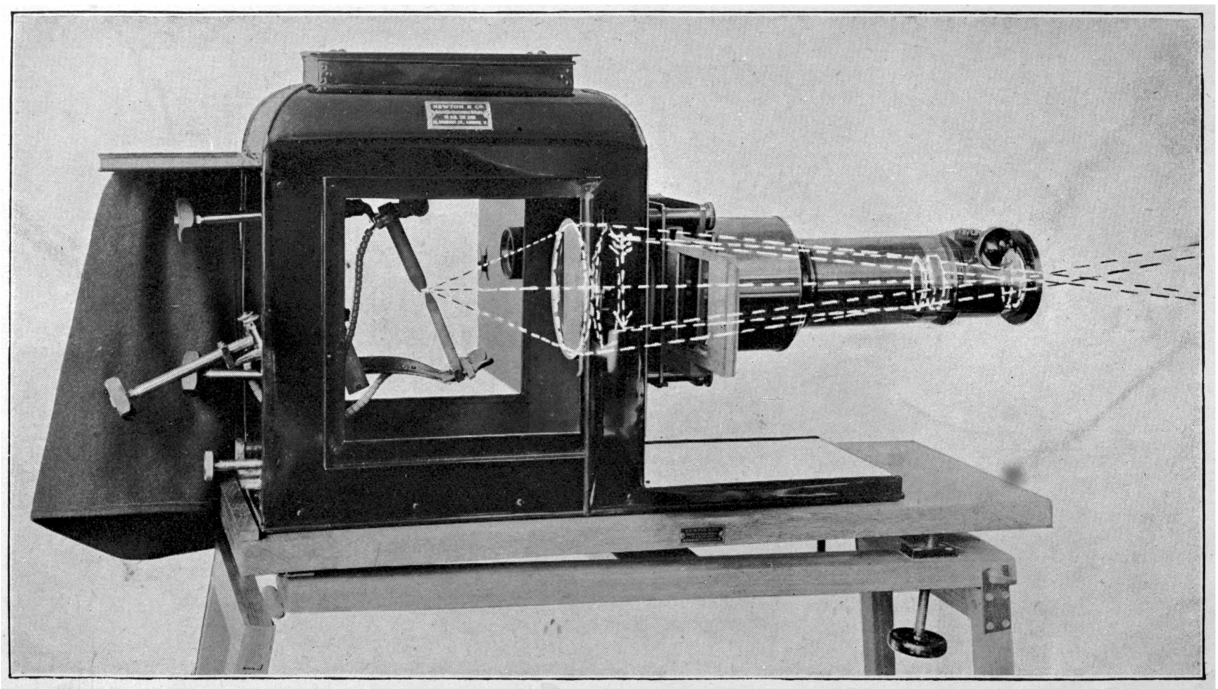

FIG. 33.—THE OPTICAL SYSTEM OF A LANTERN.

The following table gives the sizes and particulars of carbons for various currents that I have found best in actual practice: {57}

CONTINUOUS CURRENT

Ampères.	+ Carbon *Cored.*	- Carbon *Solid.*
7-10	12 mm.	7 mm.
10-15	13 ,,	8 ,,
15-20	16 ,,	10 ,,

ALTERNATING CURRENT

Ampères.	Upper Carbon *Cored.*	Lower Carbon *Solid.*
7-10	12 mm.	10 mm.
10-15	13 ,,	11 ,,
15-20	16 ,,	13 ,,

CHAPTER VII

THE OPTICAL SYSTEM OF A LANTERN

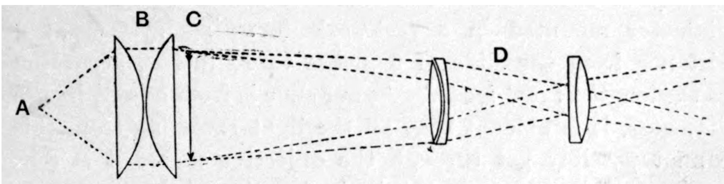

FIG. 33A.—Optical System of Lantern.

As previously noted, the essential parts of an Optical Lantern are, in order from rear to front: (1) The illuminant; (2) the condenser; (3) the slide and slide stage; (4) the objective, to which must be added, (5) the body or framework which holds the whole together. Fig. 33 is a diagrammatic representation of the entire optical system and Fig. 33A shows all the various parts *in situ*: A being the illuminant, shown in Fig. 33 as an arc lamp, B the condenser, C the slide stage, and D {58} the objective. The foundation, so to speak, of the whole instrument is of course the slide, which, as made in this country, consists of a square of glass 3¼ inches diameter, the slide itself being somewhat less than this on account of the binding, &c.; in making calculations it is usually taken as a 3-inch circle. Slides are usually made by binding together with strips of paper or cloth two such squares, on one of which is the photographic film or painting forming the picture, the other being simply a plain cover glass placed over the slide surface to protect it, and between the two being placed a paper mask with an aperture of whatever size or shape is required, that of the aforesaid 3-inch circle being usually taken as the standard or normal dimension for this aperture.

The slide being illuminated by one of the various methods discussed in the previous chapters, is focussed on the screen by the objective, which must be selected according to the size of picture required and the distance between lantern and screen.

These points will be gone into later, and also details as to various types of objectives and their respective advantages; but it may be said here that a lantern objective consists usually of a combination of lenses of 2 inches or 2½ inches diameter mounted in a rackwork focussing system at a distance from the slide of 6 inches to 18 inches, according to the length of its 'focus.' As our slide is from 3 to 3¼ inches diameter, it is evident that all the light radiating from this cannot possibly get through the objective unless it is *converged* upon it, and to do this is the function of the condenser. The following two diagrams, Figs. 34 and 35, will make the matter clear.

S represents our glass slide of 3 inches clear diameter, R the radiant or illuminant, and L our objective, shown here for the sake of simplicity as a single lens.

The slide is well illuminated by the light emanating from R, but it is obvious that the bulk of this light will never pass through the lens, and, in fact, only the very centre of the slide will under these circumstances appear upon the screen at all. {59}

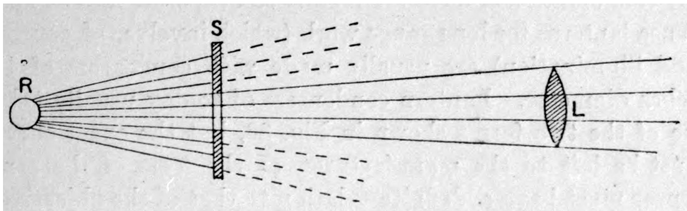

Fig. 34.—Optical System without Condenser.

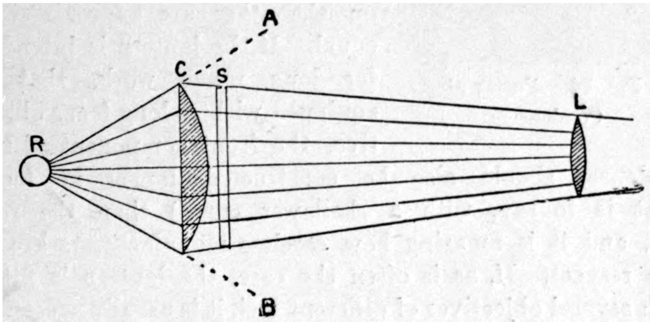

Fig. 35.—Action of Condenser.

What is evidently wanted is to *converge* these outer rays, or in other words to bend them in so that they also pass through the objective, and this is the function of the condenser as illustrated in Fig. 35. The condenser is here represented also by a single lens, but in practice it also is invariably constructed of two or even three lenses, for both optical and mechanical reasons. It is evident from the above diagrams that the condenser must be somewhat larger in diameter than the slide itself, and condensers for ordinary lantern work are usually 4 inches to 4½ inches diameter. The former size will suffice if the condenser is placed very close to the slide, but it is {60}
often advisable to leave a little intervening space, especially if the illuminant is a powerful one, in order to allow any condensation of moisture readily to evaporate and escape. Hence lanterns for long range work (which involve, of course, good illumination) are usually made with condensers of 4½ inches diameter. Lantern condensers of to-day usually take one of the two forms shown in Fig. 36, but the exact curve must be left to the manufacturer, as the focus of the condenser must have a definite relation to that of the objective. Taking, however, the design of E, the most common of all, the two lenses should not be exactly similar unless the objective is pretty short in focus, or, in other words, unless the distance of the illuminant on the one hand and that of the objective on the other are approximately equal. If the lantern is intended for long range work, that is equipped with a long focus objective, the front component of the condenser should also be constructed longer in focus (that is to say, with a shallower curve) than the rear one, and it is amazing how careless manufacturers are in this respect. If, as is often the case, the lantern is fitted with several objectives of different foci, it is usually necessary to supply alternative condensers also, or at least to supply an interchangeable front component.

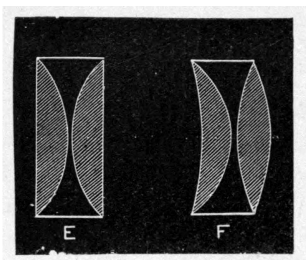

Fig. 36.—Forms of Condensers.

If the entire condenser is too long in focus, light is lost; if too short, it is impossible to obtain an even disc, as there is invariably a dark patch either in the centre or round the edges.

The mounting of the condenser also varies with different makers; but it must be remembered in any case that it gets extremely hot, especially the back component, and hence the glass must be {61} mounted *loose* in its cell, otherwise there is great danger of it cracking. Also the space between the components should be well ventilated, in order to provide for the escape of moisture which usually at the start of a lantern exhibition is deposited upon the glass, and should be got rid of before the actual lecture commences.

Even with all care, the back component of a condenser will sometimes crack, though such an accident should be a rare occurrence; and hence a professional operator will usually provide himself with a spare lens, and the condenser should be so constructed that it can readily be changed, and with as little delay as possible.

Condenser lenses as made in this country are usually ground from the glass known as 'English Crown,' and comparatively rarely crack; but they are very slightly green in colour. French condensers, on the other hand, are whiter, but the glass is more brittle, and a fracture a more common occurrence. The French variety are (or were before the war) cheaper and generally met with in cheaper instruments. More expensive lanterns are usually fitted with English condensers, as the tinge of green is almost imperceptible, and the advantage as regards greater security pretty considerable.

The Slide Carrier and Slide Stage.—Taking still the optical system of the lantern in order from back to front, we now come to the slide, slide carrier, and slide stage. The slide itself has already been described, and the carrier is simply a mechanical contrivance, usually of wood, designed for the purpose of readily changing the pictures and which in its turn fits into the stage of the lantern. It may be asked why, if slides are now always made to a standard size, the slide carrier should not itself be built into the lantern and form the stage; but the answer is, in the first place, that slides of a different size, *i.e.* American or Continental, *may* be met with, and also that there {62} are various mechanical slides on the market—for example, chromotropes or scientific models, such for instance as are made to illustrate the movements of the planetary bodies—and these slides are permanently mounted in wooden frames which could not be put into a carrier. The commonest form of carrier is that known as the 'Double Sliding' pattern (Fig. 37), which consists of a frame with two apertures for the slide, and an outer frame through which this itself slides and which fits the stage of the lantern.

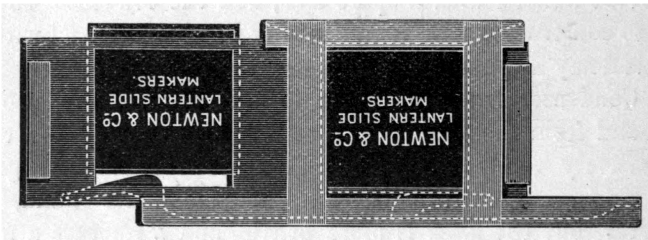

Fig. 37.—Double Sliding Carrier.

This carrier, as will be seen, allows the next picture to be placed in position in the second aperture while the former one is being projected, and at a signal from the lecturer, the inner frame slides smoothly through the outer, and the slides are thereby changed. This carrier is simple, cheap, and quiet in its action; its one disadvantage is that each alternate slide has to be inserted from opposite sides of the lantern, and unless the operator is fairly tall this almost necessitates an assistant. Nevertheless, the carrier is the most popular of any, its other advantages, especially as regards price, being so great. It is usually constructed in such a way that the slide, as it moves out from the central position, automatically rises in its groove in order to facilitate quick removal.

Another pattern deservedly popular is that known as 'Beard's Dissolving Carrier' and is shown in {63} Fig. 38. In this ingenious carrier all the slides are inserted from the same side, the oncoming slide being pushed *in front* of its predecessor, and being therefore somewhat out of focus it produces a blur on the screen.

The movement is performed by pushing in a projecting handle, and on withdrawing this the slide which is finished with comes with it, and the finish of the movement presses the new slide back until it is in its proper position and in focus.

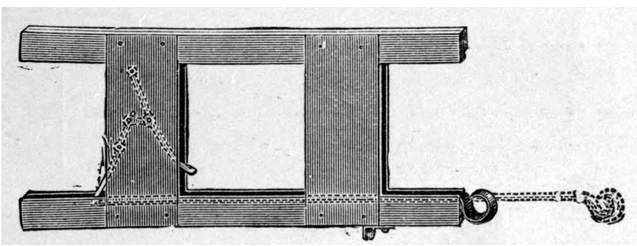

Fig. 38.—Beard's Dissolving Carrier.

The entire action is simpler than it sounds, and the temporary blurring of the image on the screen during the process of changing is supposed to give somewhat the effect of 'Dissolving

Views,' and hence the name 'Dissolving Carrier.'

This appliance is three times the price of the 'Double Sliding' pattern, but the fact that it is worked from one side only is a decided advantage, though on the other hand it is not (unless great care is used) quite so silent in its action as the 'Double Sliding' type.

A further modification of this carrier adapts it to take any of the recognised 'foreign' sizes of slides, so that if a few American ones, for instance, are met with among a collection of English manufacture, there is no need to change the carrier. {64}

There are other varieties of carriers on the market which there is no need particularly to describe, such as, for example, carriers fitted with roller curtains to give the effect of a curtain rolling up, magazine carriers to hold twenty-four or more slides and exhibit them in rotation, and other patterns too numerous to mention. Of these the reader must be left to judge for himself, but, generally speaking, *simplicity* in a carrier is the most important point to be looked for, and complications, however ingenious, should be avoided.

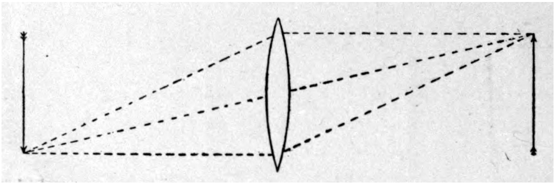

FIG. 39.—Focussing Action of Lens.

The lantern stage must also receive consideration, but it will be better to discuss it as part of the mechanical construction of the lantern.

The Objective is really the most vital part of a lantern, as the definition of the picture almost entirely depends upon the excellence or otherwise of this lens. This will be obvious at once when it is realised that the objective has to project on to the distant screen a greatly magnified image of the comparatively small lantern slide, and the intending purchaser is strongly advised to economise almost anywhere rather than on this item.

The action of a lens in focussing the image is perhaps best explained by a simple diagram (Fig. 39), from which it will be seen that all the rays proceeding from any one point on the object are re-converged (when the lens is in focus) to a definite point on the image, and the perfection of the picture depends upon the lens performing this function accurately. {65}

The imperfections are chiefly two, viz. those known as chromatic and spherical aberration respectively. Chromatic aberration simply means that all the colours composing the original beam of, say, white light are not equally refracted or converged, and therefore do not meet again at the same spot (the well-known prism or lustre effect), and reveals itself by coloured fringes round the edges of the various details in the picture.

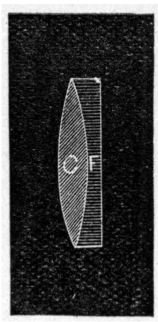

FIG. 40.—Achromatic Lens.

By spherical aberration we mean that the light falling upon the centre of a lens is not brought to a focus at exactly the same spot as the marginal rays, and a general want of definition is the result, usually accompanied also by a want of 'flatness' in the image, that is to say the edges of the picture do not focus at the same time as the centre.

Chromatic aberration is easily cured by using an achromatic or compound lens made by cementing together two lenses of crown and flint glass respectively, as in Fig. 40.

It will be seen that the flint glass component by itself is a *concave* lens and therefore neutralises in part, or in whole, the convex crown lens. Flint glass has both greater dispersive power and also greater refractive power than crown glass, but fortunately not to the same *degree*; hence a compound lens made in this way and with curves carefully worked out may have its chromatic effect entirely neutralised while retaining very considerable refractive or 'focussing' power, and simple achromatic objectives of this type are quite inexpensive.

In lanterns intended for Science demonstration, as distinct from the mere projection of slides, lenses of this pattern are very frequently used, as they will project the latter when required reasonably well, and for the demonstration of experiments or of apparatus on the screen have advantages that need not be discussed here. {66}

For very long focus lenses also they are sometimes employed, as the trouble from spherical aberration is much less apparent with lenses of long focus than with short, and the difference in expense is much more in the former case than in the latter. For short focus lenses, however, as used in moderate-sized halls, they are not good enough, and the type of lens almost universally employed is that known as the 'Petzval' combination (Fig. 41).

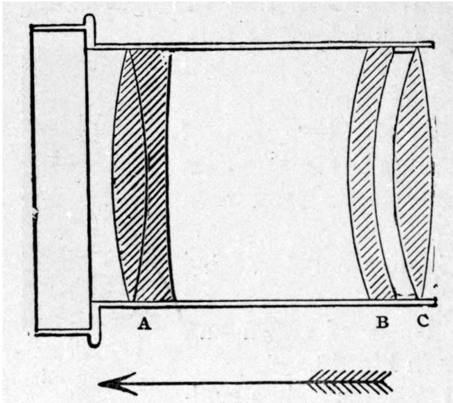

FIG. 41.—Petzval Combination.

This lens really consists of two achromatic combinations, the pair at the front being cemented together, and that at the rear having an air space between. The combination is so designed that the spherical aberration of the one pair neutralises that of the other, and the result is or should be a lens corrected both for chromatic and spherical aberration.

These lenses, however, vary very much in the perfection of their results, and as they are at present usually imported in bulk from France, the customer does well to insist upon a demonstration of his own particular lantern before acceptance.

The magnifying power of a lens depends upon its 'focus' multiplied by its distance from the screen, and the focus in the case of a simple lens is easily determined by the familiar 'burning-glass' experiment, that is by focussing an image of the sun upon a piece of paper and measuring accurately the distance the lens must be away to produce the most concentrated spot. {67}

In practice it is sufficiently accurate to focus a distant window, or other luminous object, upon the paper, any error obtained by this method being for ordinary purposes a negligible one.

With a compound lens, such as a 'Petzval' combination, this method does not hold good, as the optical centre of such a lens is not necessarily midway between its two components.

The actual focus can be got pretty approximately by focussing a window or other object as before and measuring the distance from one definite point (say the front edge of one of the lens cells) to the paper, then turning it round and taking a second measurement from the *same* point, the mean between the two measurements giving the actual focus.

In practice the 'simple equivalent focus,' as it is termed, of a lantern lens is usually determined by measuring the magnification of the image thrown upon the screen, when, by knowing the original size of the slide (a 'standard' slide of 3 inches diameter is usually taken) and the distance between lantern and screen, we get the focus from the following very simple equation:

Diameter of picture on screen (in feet) / Diameter of slide (in inches) =
Distance between lens and screen (in feet) / Focus of lens (in inches)

or perhaps more simply still:

{Distance between lens and screen (in feet) × Diameter of slide (in inches)} / Diameter of picture (in feet) = Focus of lens in inches;

or, if we know the focus of the lens but want to know how far from the screen we must go to produce a given-sized picture, the formula will be: {68}

{Diameter of picture (in feet) × Focus of lens (in inches)} / Diameter of slide (in inches) = Distance required (in feet).

It is handy for the lanternist to remember that, dealing with a standard 3-inch slide, a 6-inch lens will *always* give a picture whose diameter is *one-half* the distance from lens to screen, a 12-inch lens half this again or *one-quarter*, and a 9-inch lens half-way between the two.

Bearing these simple figures in mind, the approximate distance can usually be *guessed* sufficiently near for the first trial, and then the lantern shifted a little nearer or the reverse as required.

The following table may, however, be useful, as showing readily the magnification produced at different distances by lenses of given foci:

Disc wanted	Focus **4½** in.	Focus **6** in.	Focus **8** in.	Focus **10** in.	Focus **12** in.	Focus **15** in.	Focus **18** in.
feet.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
9	13 6	18 0	24 0	30 0	36 0	45 0	54 0
12	18 0	24 0	32 0	40 0	48 0	60 0	72 0
15	22 6	30 0	40 0	50 0	60 0	75 0	90 0
18	27 0	36 0	48 0	60 0	72 0	90 0	108 0
20	30 0	40 0	53 4	66 8	80 0	100 0	120 0
25	37 6	50 0	66 8	83 4	100 0	125 0	150 0
30	45 0	60 0	80 0	100 0	120 0	150 0	180 0

The Diameter of the Objective.—The diameter of the objective must depend to a certain extent upon its focus in the case of a double combination such as a Petzval. These lenses consist, as has already been said, of two achromatic components some distance apart, and for technical considerations, which need not be discussed here, the *distance* between these components is usually about two-thirds of the focal length. This is not a universal rule, as the lenses of different makers vary a good deal; but it is generally a fact that the longer the focus of the lens the greater {69} is usually the separation between the two lens systems.

The entire lens therefore mounted in its tube resembles a *tunnel* of varying length according to its focus, and through this tunnel a *cone* of light rays have to be passed. It is plain, therefore, that a lens of long focus, which in practice means a long tube length, must be made also of large diameter, or a portion of the cone will be cut off, with a consequent loss of light.

In practice lenses up to 6 inches focus are usually made of 2 inches diameter, and there is no advantage in a larger size. With a lens of 8 inches focus there is a slight gain in increasing the diameter to 2⅜ (the next 'standard' size), and lenses of longer focus than this should certainly be 2⅜ inches up to, say, 12 inches focus, when a lens of 3 inches diameter is preferable. These large lenses are, however, very expensive, both in themselves and also on account of the fact that their weight entails heavy and expensive brass mounting, and hence lenses up to 14 or 15 inches focus are often supplied in the 2⅜ size for reasons of economy.

To sum up, *short-range* lanterns, as they are called, are usually fitted with lenses of 2 inches diameter, and *long-range* instruments either with 3-inch lenses or the intermediate size of 2⅜ inches. If a lantern is purchased for either long or short-range work, it is usually fitted with a brass front for a large lens, and so arranged that a shorter focus lens of 2 inches diameter can easily be interchanged, utilising the same brass mounting.

Lenses of *variable* focus have also been designed, in which an additional lens can be added or subtracted to increase or decrease the focal length; but nothing very practical has yet been achieved in this direction, and therefore these 'Omnifocal' lenses have never come into general favour.

Objectives like condensers want cleaning at times, and care must be taken not to scratch the glass, as the concave lens of each component is of flint glass, and very soft. A clean chamois {70} leather is the best thing to use, but a soft cloth, or even a handkerchief, may be employed with care. It is very important that a lens be reassembled, after cleaning, the correct way, as a single lens reversed would utterly spoil the definition. The front component is usually balsamed together, and therefore all that is needed is to see that the whole combination is not reversed. In the Petzval system this lens should have its convex constituent towards the screen (Fig. 41). The back combination is usually loose, and the two lenses are sometimes separated by a thin brass ring. In the Petzval lens the concave element should be inside, with its concave surface outwards, the deep curve of the other lens should fit into this concavity, and the flatter curve face towards the condenser. One or two makers, however, have introduced a modification of the Petzval system in which the whole of this back combination is reversed, and the exact arrangement should therefore be noted very carefully when taking the lens to pieces.

CHAPTER VIII

THE BODY OF THE LANTERN

We now come to the mechanical construction of the optical lantern, and a great variety of design presents itself, according to price, type (*i.e.* short range or long range), and the individual ideas of the various makers.

Lantern bodies as a rule are now made of metal, although up till quite recently the better class instruments were more usually made of polished mahogany lined internally with iron; but there has of late been a consensus of opinion in favour of metal only.

In the cheaper lanterns this metal body is usually made either of Russian iron or of sheet-iron tinned and japanned, there being little to choose either in price or quality between the two {71} varieties, and in all but the very cheapest instruments the front is usually of brass.

In better lanterns the body is more often made of enamelled steel, the front as before being of brass; but brass, copper, or aluminium are also used occasionally for the body of the lantern.

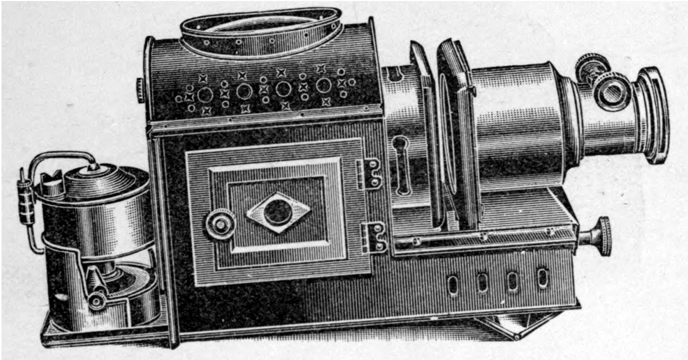

FIG. 42.—Hughes' Short-Range Lantern.

In deciding upon the type of body to be purchased the main considerations to be borne in mind are: (1) The type or types of illuminant to be used, a powerful arc lamp for example requiring a larger body than is necessary for a weaker radiant; (2) the size and position of the lens to be carried, a Petzval objective of say 3 inches diameter which has to be supported at the end of a long brass mount for long-range work obviously demanding a body of greater strength and rigidity than is required with a 6-inch focus lens of 2 inches diameter; (3) price.

Fig. 42 shows an extremely good lantern body for short-range work made by Messrs. Hughes, the illustration depicting the instrument complete with a 'Luna' methylated spirit lamp, though, of course, any other illuminant suitable for a small lantern could be used instead. {72}

This lantern illustrates well one point that has already been emphasised as important, viz. the ventilation of the condenser. It will be noticed that this is placed *outside* the body of the instrument instead of inside as is usual with larger bodies, and that wide slots are cut in the condenser mount to allow free escape of steam.

Other points of this excellent design are the screw adjustment to the slide stage (facilitating the use of special slides, such, for example, as those illustrating the movements of the planetary bodies which sometimes involve the use of extra thick frames) and a simple but efficient tilting arrangement to the base.

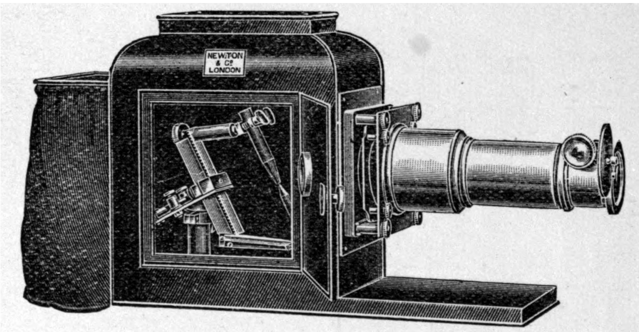

FIG. 43.—Long-Range Lantern.

Such a lantern is hardly suitable for a powerful arc lamp or limelight jet, or for heavy long-range lenses, but is a very good typical instrument for use in moderate-sized halls, and a lantern of this general type is usually found in lantern catalogues, though, of course, the exact designs vary according to the ideas of the manufacturer. Of lanterns for long-range work a good example is perhaps Messrs. Newton & Co.'s 'Intermediate' pattern (Fig. 43).

This again is only typical of many others by the various makers, but the principal points are common to all. These are: (1) The large and well-ventilated body; (2) the long baseboard; (3) the strong and massive brass front necessary to carry the large long-range lenses; (4) the velvet curtain at the back to close in any stray light from a powerful arc lamp. {73}

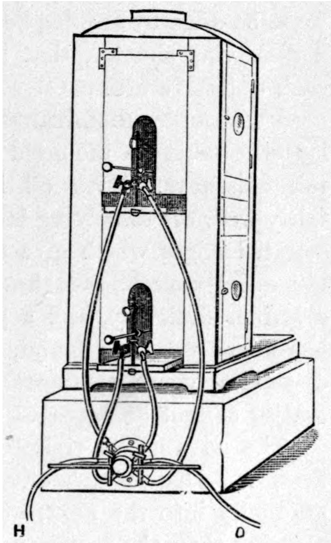

FIG. 44.—Connections for a Bi-unial Lantern.

The two foregoing designs are perhaps sufficiently typical of lantern bodies in general to make further detailed description of individual designs unnecessary; but reference should be made to features which special requirements may render advisable.

Under this heading mention must be made of *Bi-unials* or Double Lanterns, as used for the once famous 'Dissolving Views.'

A bi-unial lantern consists essentially of two different instruments, each complete with its limelight jet or other illuminant—front, condensers, objective, &c., usually mounted on one body—and with some arrangement for 'dissolving' or turning the light in each lantern gradually on and off.

Fig. 44 shows the back view of such a lantern with two limelight jets and dissolving tap, this piece of mechanism (shown below in the illustration) being so arranged that when the lever is horizontal *both* lanterns are on full, but moving the lever either way cuts off the gas supply to one lantern. In the case of limelight the tap should always operate by cutting off the oxygen supply in advance of the coal gas (in order to avoid a 'snap'), and the latter should never be cut off entirely, but a small bead of flame left to keep the jet alight, until the lantern is required for the next slide.

{74} This is usually arranged for by means of a bye-pass, and a bye-pass is sometimes provided on the oxygen side as well, but is usually discarded in practice.

A bi-unial lantern can be worked in the same way with acetylene gas, but with the electric arc it is impossible to turn the light on and off gradually, and in practice dissolving must be done by keeping both lanterns fully alight, and using a dissolving shutter, that is a movable shutter that covers each objective alternately. The same arrangement must be used with other illuminants, such as oil, only in this case the lanterns must be mounted side by side, on account of the tall chimneys. With oil lamps the arrangement answers fairly well, the dissolving fan, as it is termed, being made with serrated edges which give the *gradual* obliteration required; but with the electric arc the extremely sharp definition becomes a serious difficulty, and a good dissolver for this illuminant has never yet been found, though, in view of the fact that dissolving views are more or less a thing of the past, the matter cannot be regarded as important.

The advantages claimed for a double lantern are two: first, a 'Dissolving' effect by which one picture fades gradually into the next, and which is supposed to be more pleasing than the movement of a carrier; and second, 'Dissolving Effects' can be shown, such as exhibiting a landscape by day and changing it into a moonlight scene, or bringing on the appearance of a snowstorm, which can easily be done by means of a roller slide, with minute perforations shown in motion by the second lantern while the landscape remains on the screen from the first. In the days when dissolving views were all the vogue, a third or even a fourth lantern has been added for more complicated effects, and at the famous Polytechnic demonstrations of years ago, I believe that as many as six were sometimes employed.

In these days of the cinematograph it is doubtful how far interest in such effects could be revived, and a lantern has gradually come to be looked on more as an instrument for showing illustrations {75} as required by the lecturer rather than as a pleasing exhibition in itself, and as dissolving views have lost their attraction, the double or triple lantern has been relegated to the limbo of antiquity.

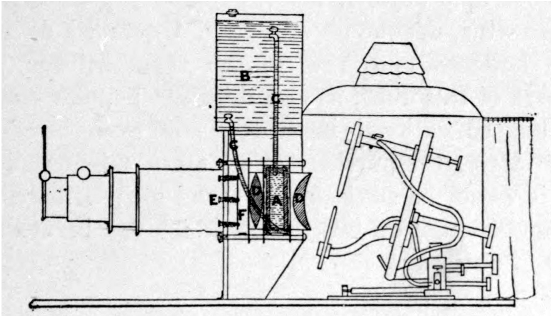

Fig. 45.—Beard's Circulating Water Tank.

Among other 'special' lanterns should be mentioned models made with water-cooled stages, for use with very delicate slides. This elaboration is not necessary with ordinary slides and illuminants of moderate power, but where very delicate slides, such as specimens of natural colour photography, have to be shown, it is an advisable precaution to pass the beam of light first through a tank of water in order to absorb the heat. Lanterns intended for this work are usually constructed with a kind of double stage, a glass trough of water fitting into the rear aperture and the slide-carrier into the front one. Such an arrangement answers quite well for most purposes, but for extreme cases lanterns are equipped with a trough connected to a large outside tank and complete circulatory system, after the manner of the cooling tank of a gas engine.

Such a lantern, constructed by Messrs. Beard, is illustrated in Fig. 45, and it will be seen that in this instrument the water trough is placed between the lenses of the condenser. This is a very {76}
good position, as the beam of light at this point is, or should be, parallel, whereas between the condenser and the slide it is convergent, and therefore a condenser of a larger diameter than the slide must be employed in the latter case if the trough is of considerable width.

While dealing with 'Special' lantern bodies, we should perhaps just mention here the numerous pattern lanterns made for the demonstration both of lantern slides and of Scientific Phenomena, such as the projection of insect life or other microscopic objects, polarised light experiments, electrical apparatus, opaque objects, &c. A detailed description of these lanterns and how to use them belongs to the second part of this work, as also does the popular cinematograph; but educational institutes, and even boys' clubs, when considering the purchase of a lantern, might well reflect whether it would be advisable to spend a little more money in the acquisition of an instrument which can be utilised for a variety of purposes.

CHAPTER IX

LANTERN BOXES, STANDS, READING LAMPS, ETC.

Having now discussed all the essential parts of a lantern, the next points to be considered are those of lantern boxes and stands. It is best to take these together, as more often than not a lantern is arranged to stand upon its box during use, and the plan is both convenient and simple. The whole question is one to be settled upon its own merits in each individual case. Sometimes neither box nor stand is wanted at all. The lantern is put away into a locked-up cupboard or other safe place, and used upon a permanent support or (as is often the case in a church) from a gallery at the back. {77}

In most cases, however, a box of some sort is desirable, and the two main considerations are strength and simplicity.

All patent arrangements, such, for example, as those in which the sides of the box fall down and provide trays for the slides, are beautiful in theory, but cannot be recommended in practice. A good, simple and substantial box is what is required, preferably painted black, and provided with strong handles.

One addition may be permitted, viz. a tilting top. Some means for tilting the lantern is always advisable, as it is seldom convenient to raise the instrument to the level of the centre of the screen, and a slight upward elevation does not appreciably distort the image. This arrangement for tilting may be either embodied in the lantern itself, as for instance in the instrument shown in Fig. 42, or may be provided for on the box or on the stand, if a stand is used.

It is, perhaps, an elaboration that may be regarded as not strictly necessary, as a book or two or other article may be placed under the lantern base as required; but a tilting arrangement is so convenient that it can be strongly recommended, and the addition is not expensive.

For large, long-range lanterns a strong deal box, on which the lantern can stand, is usually all that it is desirable to purchase in the way of a support. A good solid table can usually be found, which will do all the rest, as it must be remembered that a slight tilt at a long range means a good deal of total elevation.

Where this is not procurable a stand must be provided, and this for a large lantern should be strong and rigid. Anything in the way of a collapsible tripod should be avoided, but such an arrangement as Fig. 46 is quite good and rigid enough for all practical purposes.

For a *small* lantern a tripod stand is quite suitable, though care must be taken that one of the legs does not get kicked, either by accident or design, or the result may be a catastrophe. {78}

Slide Boxes.—On this subject not much need be said. The variety of patterns on the market is endless, some being designed from the point of view of safe transit by post, others for convenience of storage and classification. It is essentially a case where each individual user must use his or her taste, and in any case the question of the box is one for the owner of the slides rather than for the lanternist.

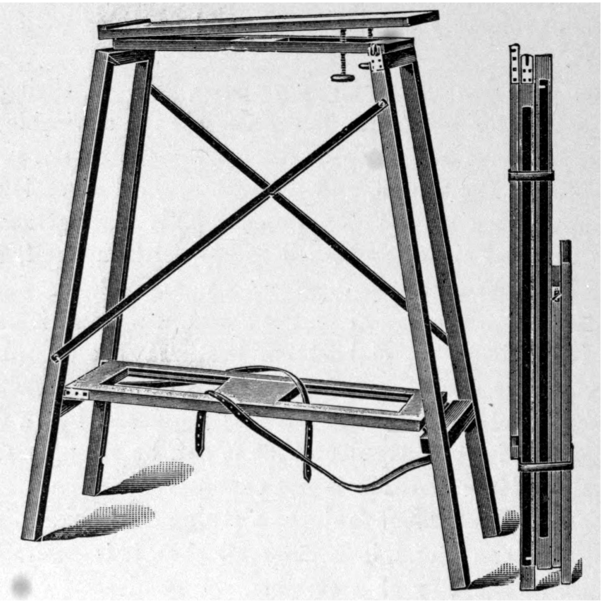

Fig. 46.—Quadruple Lantern Stand.

Reading-Desks, Lamps, and Signals.—Some form of reading lamp for the lecturer is generally considered to be part of a lanternist's equipment, and the most usual pattern is fitted with a candle, after the manner of a carriage lamp, or else constructed to burn colza or other vegetable oil, such as supplied for cycle lamps. Oil gives the brighter light, but is apt to get spilled in transit, hence a candle lamp is the more convenient for a travelling lecturer, while oil is to be {79}
preferred if transport is not a factor to be considered.

These lamps are usually constructed with a red flashing signal at the rear, actuated by a simple lever, by which the lecturer can communicate his wish for a change of slide, &c., to the lanternist (Fig. 47).

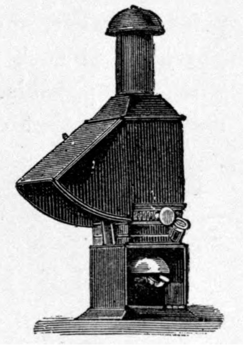

Fig. 47.—Reading Lamp.

There are various other devices used for the same purpose, such as a castanet, to be held in the lecturer's hand and clicked when necessary, an electric bell to ring in the lantern box, &c. If this latter is used it is usual to remove the gong, the buzz of the hammer being sufficiently loud without it. Some lecturers again prefer to use no such apparatus at all, but simply to say 'Next slide' as required, or to tap on the floor with a pointer, and the choice of a suitable means of communication between lecturer and lanternist must be largely a matter of individual selection. More elaborate *reading-desks* are also supplied by most makers, but here again judgment must largely come into play in what is hardly a technical matter.

CHAPTER X

The best of all screens for lantern purposes is undoubtedly a smooth whitewashed wall, and this is now provided in many halls where lantern exhibitions are usual. In places where this is not practicable the next best substitute is a canvas screen, which rolls up and down (Fig. 48). This {80} can be obtained from any good maker, but again can only really be used as a *fixture* in the hall where the lantern is to be used. It can, however, be fitted into a wooden box which can be painted or varnished to suit the other architecture, and the provision of such a screen is to be strongly recommended whenever possible. If portability is required, a linen or calico sheet that can be folded up is necessary, but this can never be hung absolutely flat, and also loses a considerable amount of light by transmission.

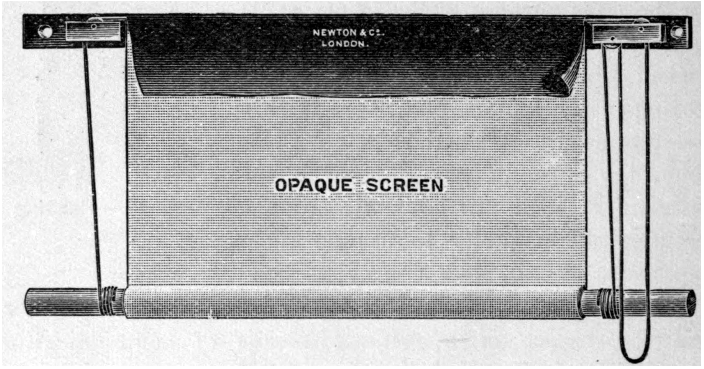

Fig. 48.—Roller Screen.

A so-called 'transparent' sheet is made of very thin linen, and intended to work with the lantern *behind* it, showing the picture through the linen to the audience on the other side, but this is seldom used except in the open air for religious or political meetings, &c.

An *opaque* sheet can be had in one piece up to 9 feet square; larger sizes than this must have at least one seam, and most skilful sewing is necessary, especially with large sheets consisting of several strips sewn together.

Sheets such as these are usually supplied with either eyelet holes round the edges or else linen tapes sewn on, and the exact method of hanging must be left to circumstances. {81}

In the case of a small sheet it will be sufficient to stretch it at the four corners, and this can often be done by screwing into the walls or some convenient girder two screw eyes and similar eyes into the floor, all four being considerably farther apart than the size of the sheet.

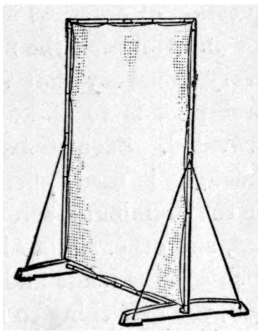

Fig. 49.—Portable Screen Stand.

A stout cord being then passed through the two upper eyes, long enough for both ends to reach near the floor, one end of each can be fastened to the two top corners of the sheet and the latter drawn up, the two bottom corners being afterwards stretched and tied down tightly to the lower eyes. In the case of large sheets this hardly suffices, and it will be found necessary to fasten the sheet at intervals all round or it will exhibit awkward creases, and this again is a matter where the lanternist must use his own initiative according to the possibilities.

In some halls the erection of a sheet in the way above described is a sheer impossibility, and in such cases a frame must be made by nailing strips of wood together, or better by utilising a portable screen stand (Fig. 49).

These stands are usually made of bamboo, with short brass connecting tubes, and the method of using them is so obvious that a description need hardly be given. The screen frames are supplied by all the leading opticians, but an intending purchaser would be well advised to see one erected before ordering. I have actually seen a 12-foot screen frame offered for sale that was too weak to carry its own weight, let alone the weight of the sheet!

{82}

CHAPTER XI

THE PRACTICAL MANIPULATION OF A LANTERN

Having now described the optical lantern in its various forms and the more important accessories, we come to the question of practical manipulation. In making arrangements for an exhibition the first thing to be seen to is to ensure that every accessory that will be required will be there, and the best plan is to make a complete list of all sundries to be provided. Such items as string (for the sheet), lime tongs if limelight is used, pliers for changing carbons if the arc is to be the illuminant, screw-driver, matches, the *key of the lantern box*, and other similar items, are likely to be left behind unless such a list is made and carefully checked. On arriving at the hall, the first thing to be done as a rule is to get up the sheet, after which the professional operator generally begins to feel happy again.

The next thing, if it has not been done first, is to determine the position of the lantern, and this, as has been explained in Chapter VII, is a matter of the size of picture to be shown and the focus of the objective.

It is a mistake to show too large a picture; a little 'white' round the edges is a good thing, and it is better to have a small disc well illuminated than a large one less bright. Convenience, however, must also be considered, and it is often justifiable to go back a few feet farther than other considerations would dictate in order to place the lantern in a gallery or other spot where it is out of the way.

Having fixed the position of the lantern, it should be got into place, the cable or tubing connected or whatever else is necessary, according to the illuminant to be used. It should then be lit up, the flasher of the lens opened, and the light centred sufficiently to produce some sort of disc upon {83}
the screen. (It is, of course, presumed that the lenses, &c., have previously been cleaned.)

A carrier should now be placed in the stage and a slide inserted into it, and the method of doing so requires a little explanation. The slide must be placed in the carrier upside down, as will be obvious to anyone who has studied Chapter VII, but in addition to this it must be turned the correct way, otherwise the picture will be reversed from left to right. This in the case of certain subjects, such as a copy of a picture, may not greatly matter; but in slides depicting buildings or landscapes with which the audience may be familiar, or worse still, printing or writing, is a serious blunder.

Slides made by a commercial firm will usually be 'spotted,' that is to say, will have two white spots on the face of the slide when the latter is viewed in its correct position, and at the top. The slides should be turned upside down and placed in the carrier with the spots, of course, now at the bottom and *towards the condenser*.

If a slide is not spotted it should be viewed as it is to appear on the screen, and then placed in the carrier with the face that was towards the operator as he viewed it turned to the condenser, and of course inverted.

The above remarks apply only in cases where the image is thrown *on* the screen; in the comparatively rare instances where it is shown *through* the latter the slides must be turned round laterally, but of course still inverted. The slide having been placed in the stage it should be 'focussed' by racking the objective in or out, and if necessary pulling out the draw tube as well until the image on the screen is sharply defined. So far the light has only been roughly centred, sufficiently so to enable the slide to be focussed, and to complete the operation both slide and carrier should next be taken out of the lantern, leaving a clear disc on the screen, and this disc may resemble any of the appearances shown in Fig. 50. {84}

If it resembles A the light must be moved to the left, if like B to the right, like C it must be lowered, like D it must be raised, always moving it to the side opposite to the dark shade until this is central on the disc. If it now resembles E, the light must be moved nearer the condenser; if, on the contrary, the centre is dark, it must be drawn back until finally the circle should be as nearly as possible clear and bright all over, as at F.

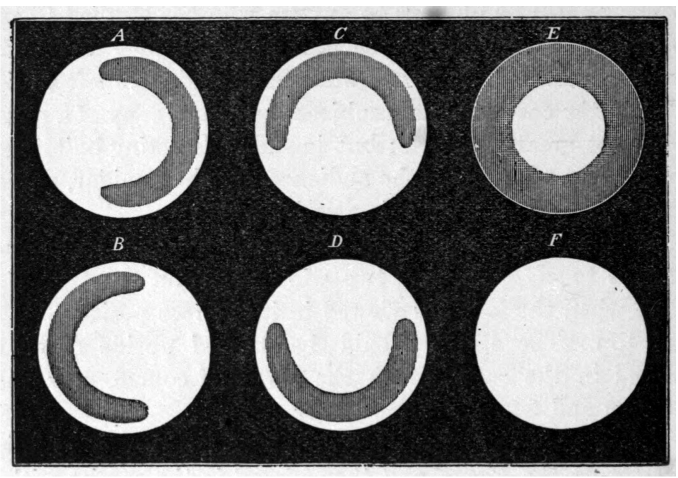

Fig. 50.—Adjustment of the Light.

It is important to note that this adjustment *cannot* be properly made while a slide is in position, and neither can it be made until the lantern has been focussed, so the above procedure is the only way to get a satisfactory result. With some of the larger illuminants, such as a paraffin-oil lamp, there are no centering adjustments, the size of the radiant rendering exact centering unnecessary, and generally speaking the smaller the luminous point, the more exact must the operation be.

In the case of such illuminants as acetylene or limelight care must be taken that they are turned {85}
fully on before centering, otherwise turning on the fuller amount afterwards will raise the position of the luminous spot.

The centering achieved, the slide carrier may be replaced, the first slides placed in position, the remainder arranged in their proper order, the system of signalling with the lecturer determined, and all is ready.

If there is still an interval before commencing, the light may be switched off or turned out, or in the case say of limelight, turned down very low until wanted.

It is of extreme importance to see that all the slides are in their right order, though the duty of seeing to this usually rests with the lecturer rather than with the operator. I remember hearing of one lecture on the life of Queen Victoria, when the lecturer announced, 'The next picture will be a photograph of the Royal Prince who for many years shared the Throne with our gracious Sovereign.' At the words the operator brought on the next slide, which proved to be *a restored specimen of a prehistoric monster* (tableaux!). Such mistakes 'bring down the house,' but in serious lectures, and especially at religious services, cannot be too carefully guarded against.

Mention has already been made of the liability of moisture to condense on the surfaces of the condensers or slides, and to avoid this, so far as the condensers are concerned, it is well to light up say ten minutes before the lantern is actually wanted, or alternatively to take out the condensers and thoroughly warm them in front of a stove, or to place them wrapped in a cloth on hot-water pipes. The slides should in the same manner be warmed before using and should be finally held above the lantern or placed on the top, if this is flat, the last thing before being placed in the carrier. If these precautions are omitted, on a cold night the first surface of the condenser will become so covered with moisture as to almost obscure the slide, and this will quickly disappear with the heat of the lantern. Next, the two inner surfaces of the condensers will {86}
behave in turn in the same way, and will take considerably longer to clear, especially if the ventilation of the condenser is poor; then the fourth surface will take up the running, and finally, when the lanternist is congratulating himself that the trouble is over, each successive slide will become affected in the same way. With an operator who knows his business, none of these troubles should occur.

Accidents.—These will occur sometimes, even in the best managed exhibition; the rubber tubing feeding a limelight jet gets kinked or trodden on, or a fuse melts if electric light is being used, &c., and out goes the light. In such cases a loud request such as, 'Would you mind turning up the light for a minute, please,' accompanied by a good-humoured laugh, usually allays the fears of 'nervy' people. An operator must never get 'nervy' himself. I have known of more than one fiasco because some little hitch occurred, and two or three timid ladies crowded round and asked anxious questions, till the lanternist lost his head. In one such case the cautious superintendent at a children's entertainment decided that it would be safer not to have the exhibition at all, simply because a regulator was not screwed tightly enough into a cylinder to prevent an escape of gas, only the operator (a somewhat youthful one) had been driven to the verge of lunacy by continual questions of the standard type, 'Are you sure it is safe?' 'Will it blow up?' 'Are you certain you understand it?' &c., &c. More serious accidents, such as the entire lantern getting upset, ought never to occur, and it is up to the lanternist to take whatever precautions he deems necessary to safeguard his instrument. With a juvenile audience, for example, it is often a good thing to arrange a barricade of forms round the lantern and to see that no one comes within it.

Finally, 'whatever is worth doing at all is worth doing well,' and this is as true of lantern
exhibiting as of anything else. There are a deplorable number of lantern exhibitions given with {87}
the sheet hanging in creases, dirty lenses, light poorly adjusted and centred, and occasionally slides shown upside down. A conscientious lanternist should see to *every* detail; slipshod methods, as in everything else, mean poor results.

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