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THE STOKER'S CATECHISM

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BY

W. J. CONNOR.

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Minor typographical errors have been corrected without note. Variant spellings have been retained.

PREFACE. [iv]

There is no trade or calling that a working man is more handicapped in than that of a Steam Boiler Stoker; there are no books on stoking; the man leaving his situation is not anxious to communicate with the man who is taking his place anything that might help or instruct him; and the new man will be shy of asking for information for fear of being thought incapable for the post he is seeking; and the transfer takes place almost in silence, and the new man has to find out all the ways and means at his own risk, sometimes at his employer's expense.

My object is to instruct that man in his business without his knowing it, or hurting his very sensitive opinion on stoking and other matters; for I am well aware that it is only the least experienced who are the hardest to convince, or instruct—against their will. I have therefore ventured to devise this simple method of question and answer, which I have named "The Stoker's [v]
Catechism," which I hope may instruct and interest him.

I will not encumber this preface with my personal qualifications for this little work—the answers to the questions might suffice.

W. J. C.

THE STOKER'S CATECHISM. [7]

1. *Question.*—**How would you proceed to get steam up in a boiler?**

Answer.—Having filled the boiler with water to the usual height, that is to say, about four inches over the crown of the fire-tube, I throw in several shovelfuls of coal or coke towards the bridge, left and right, keeping the centre clear; then I place the firewood in the centre, throw some coals on it, light up, and shut the door. Then I open the side-gauge cocks to allow the heated air to escape, and keep them open till all the air has cleared out and steam taken the place of it; by this time the fire will require more fuel, and when the steam is high enough I connect her by opening the stop-valve a little at a time till it is wide open and ready for work.

2. *Question.*—**Supposing there are boilers working on each side of the one you got steam up in, how would you act?**

Answer.—I would light the fire by putting in a few shovelfuls of live coal from one of them instead [8]
of using firewood; that is all the difference I would make.

3. *Question.*—**What is the cause of the rapid motion of the water in the gauge-glass at times? Is that motion general throughout the boiler?**

Answer.—No; air enters the boiler with the feed-water, and the gauge-glass tube being in the vicinity of the incoming water, some of the air enters the glass and flies up rapidly through the top cock and into the boiler again; in fact there is very little motion of the water in the boiler at any time while working. I have proved this to be so, and in this manner: the boiler cleaners having finished the cleaning, hurriedly scrambled out of the boiler and left several tools they had been using on the crown of the fire-box, namely, a bass hand brush, a tin can, and a tin candlestick, and a small iron pail; the manhole cover was put on and boiler filled and put to work before the things were thought of, and then it was too late and they had to remain there until the next cleaning time, which was thirteen weeks; and when the boiler was at last blown out and the
manhole cover removed, the things were on the crown of the fire-box exactly as they were left [9]
three months previously. In order to satisfy myself of this, to me, extraordinary discovery, I placed several articles on the crown of the fire-box, things that could not stop up the blow-off pipe if they were swept off, and got up steam as usual, and after three months' hard steaming I blew out the water and steam, took off the manhole cover, and there were the things as I had left them thirteen weeks previously; of course they were all coated with fine mud, but no signs of having moved a hair's breadth.

4. *Question.*—**But water in an open caldron with a fire under it, as in the steam boiler, will madly sweep the sides and bottom with terrific ebullition. How would you account for the great agitation in the open caldron while the steam boiler had hardly any, although both vessels had fierce fires under them?**

Answer.—In the matter of the open caldron the action of the water has no resistance but that of the atmosphere, whereas in the steam boiler the movement of the water is resisted from the moment it is heated, for then a vapour rises above it, and, as the heat increases, the resistance to
the movement of the water is proportionally increased, and as the heat of the steam increases the [10]
pressure on the water increases proportionally all through, the steam being above the water. Any old stoker knows that when getting steam up in a boiler the lower parts are often only warm when there may be eight or ten lb. on the square inch in the upper portions; when the water begins to boil the steam rises in the form of minute globular particles, and remains above the water until there is an outlet for it by opening the stop-valve or through the safety-valve; and as the pressure is the same throughout every part, nook and corner, and angle, there can be no

dominating force to cause any agitation within the boiler.

5. *Question.*—**What is superheated steam, and why is it used?**

Answer.—If a boiler is placed at a long distance from the engine or whatever the steam may be used for, there is much or little condensation according to the distance and the weather, so that there would always be water mixing with the steam, and that is most objectionable where a steam engine is concerned, and by super-heating the steam it comes to the engine as hot and dry as if the boiler were close by; but whatever the heat of the steam may be, the pressure cannot be increased after the steam has left the boiler. In proportion to the pressure of steam so is the heat [11]
of it; the higher the pressure the hotter the steam.

6. *Question.*—**If your water gauge-glass broke while the boiler was working, how would you proceed to rectify the mishap?**

Answer.—By immediately shutting off both cocks, the water-cock first, then I would open the blow-out cock (at the bottom of the gauge-glass) and keep it open to the finish, and commence unscrewing the nuts, clearing them of any bits of india-rubber that adhered to them, also the sockets. Get one of the half dozen glasses already cut, and my string of rubber rings, enter two rings on the bottom end of the glass, slip the nut over them, slip two rings on the top part of the glass after having slipped the nut on, and enter the rings in the sockets, then screw up both top and bottom nuts by hand alternately, and when screwed up evenly, open the steam cock a shade to warm the glass, and when it is hot enough, open it more and commence closing the blow-out cock, by tapping it lightly by hand, then open the steam cock a little more and open the water cock a little also, and shut off the blow-out cock, and presently the water enters the glass, and both top and bottom cocks may now be opened to their full extent, and the job is done. [12]

7. *Question.*—**How would you cut a water gauge-glass to the proper length?**

Answer.—I usually cut a piece of iron wire the length the glass should be, in this way: I measure the length from under the top nut to the top of the bottom nut, and cut my iron wire to that measurement; then I cut several glasses in my spare time, instead of doing it when the glass breaks. I mark a circle where I wish to cut the glass, and with a three-corner file I run it round this circle to a depth of the 16th of an inch, and break it off on the edge of the vice, bench, or other solid woodwork; of course this iron-wire gauge will perhaps only answer for this particular boiler, but in some stoke-hold the boilers are all alike with regard to the gauge-glasses.

8. *Question.*—**What is the cause of a vacuum in a boiler? And how does it affect her injuriously?**

Answer.—The vacuum is mostly caused by letting cold water into a hot boiler, the hotter the boiler the stronger the vacuum; when the water is hotter than the boiler, there will be little vacuum; a strong vacuum in the boiler will cause the air outside to press on the boiler in proportion—the stronger the vacuum inside, the greater the pressure outside. In this circumstance the pressure is misplaced for the boiler was constructed to bear an internal [13]
pressure and not an external pressure. And in getting steam up the pressure on the boiler has to be reversed, and this tends to loosen the plates and rivets and makes her leak, if she never leaked before. I have frequently known boilers to be filled with water over-night to be ready for lighting up in the morning, and have found the gauge-glass empty; this puzzled me at first, but on opening the blow-out cock of the water-gauge the air rushed into it with a gurgling noise, then I knew there was water in the boiler held up by the vacuum, but I soon altered that by opening the side-cocks, and letting air into her which soon killed the vacuum, and down came the water into the glass again to the proper level. When getting steam up, I always open one of the side gauge cocks and keep it open until steam issues from it; that permits the foul air to escape and prevents a vacuum being created; there used to be a vacuum valve in the vicinity of the steam dome, that opened inwards and prevented a vacuum from being created.

9. *Question.*—**If you had only one boiler and one engine at work, how would you manage to clean your one fire without letting the steam go down?**

Answer.—When pushed for steam, which usually occurs when the fire is getting dirty, I get ready [14]
all the tools and some of the best of the coals, and having a bright fire I take the long poker and skim all the fire to one side and throw a couple of shovelfuls of coals evenly over it and rake out all the clinkers on the opposite side, then with the long poker (some people call it Kennedy) I skim all the fire over to the opposite side and throw a couple of shovelfuls of coals evenly over the bright fire, and rake out the clinkers on the other side, then I spread the fire evenly over the bars and sprinkle some more coals over all, and shut the door. This performance from first to last need not take more than ten minutes, and the boiler was making steam all the time, and at the finish I had a better fire than at the beginning, and the steam hardly lost a pound; but the job must be done quickly.

10. *Question.*—**What is the cause of the humming noise that issues from a**

steam boiler at times, and how would you prevent it?

Answer.—It is caused chiefly through bad stoking, in having an uneven fire, full of holes, or crooked bars, the cold air rushing through where there is the least resistance, and into the tubes, causes the humming noise—a locomotive nearing home after her day's work has very little fire on the bars and will generally hum, so there is some excuse for her, but none for a stationary boiler. [15] Some stokers take credit to themselves for making the boiler "Hum"; when coals are thrown into the fire indiscriminately—small and large—the air finds the least resistance through the small coals, which soon burst into holes, while the lumps remain solid; then the air rushes into the holes and the humming commences; or, if the firebars are not equally separated, the air enters the widest space and the boiler hums; or it may be that the bars next the side of the fireplace are out of line and lets the air rush up against the side and the boiler hums. If the stoker would only drop a shovelful of coals dexterously into each hole the humming would stop immediately, or level the fire with the rake or long poker, or open the fire door if the rake is too heavy, and the noise will cease. The chief point is to have a good set of firebars and well placed; if they are too long they will hump in the middle or they will bulge sideways; if they are too close together they become red-hot because there is not room enough for the air to pass between them to keep them moderately cool, and if they are too short they will drop down into the ash-pit.

11. *Question.*—**Why is it more difficult to keep steam-tight the manhole cover of a portable boiler than the manhole cover of a stationary boiler?** [16]

Answer.—The portable cover is usually on the side of the boiler, and about half the cover is immersed in the water and half in the steam; the portion under water is about 212° of heat, the portion of the same cover in the steam is about 500° of heat, the hottest part expanding much more than the cooler part, and is constantly tending to tear itself away from the lower portion of the cover, and the joint cannot stand the unequal strain. The manhole cover of a stationary boiler is nearly always on top of the boiler, and the heat is equal all over it and no contraction and expansion to cause the joint to leak as in the portable cover.

12. *Question.*—**How would you prepare a boiler for the inspection of a boiler inspector?**

Answer.—I would blow her right out, take off the manhole cover, take out the safety valve, take out all firebars and the bridge, take down flue-port brickwork, have the boiler and flues thoroughly cleaned and swept, have a lamp or candle ready to light, a hand hammer and chisel, or scraper, a pailful of clean water, and a wad of cotton waste. When the inspector arrives, he quickly dons his overalls; I hand him the light and the tools and waste, and he is into the fireplace [17] in a jiffy; down the side flues, under the boiler, giving a whack with the hammer now and then, and scraping off any suspicious scale, etc.; and when he comes out, as black as any sweep, he slips out of the overalls, gives them a whack against the wall, folds them up tight, and crams them into the black bag; has a dive in the pail, and is soon ready to go off somewhere else. But he tells me something about the boiler before he goes—not to my discredit.

13. *Question.*—**How do you proceed to get her to work again, and what materials do you use?**

Answer.—I first proceed to build the bridge and flue-ports, put in the firebars, the thin bars at the sides; then I replace the safety-valve, taking care not to damage it or its seat, fill the boiler with clean water, put in the boiler the usual quantity of Naenaires Anti-Corrosion liquid, or the powder, make the manhole joint with plaited three-strand spun yarn and stiff putty (red lead and white lead) and lay the fire, which is done in this way: throw a dozen shovelfuls of coals towards the bridge, and to left and right of it till they reach near to the dead-plate, leaving the centre clear for the firewood; then throw in three or four shovelfuls of coals over the wood, with oily waste or paper in front, and she is ready for lighting, and the "fire is laid." The material for the [18] bridge and the flue ports are firebricks and fireclay; these are rather expensive, but I learnt a wrinkle in the building up of bridge and flues. Through the frequent removals of these for boiler inspection and the hitting of the end of the long poker, several bricks were broken every three months, and I came to the decision to try stock bricks faced with fireclay as mortar; and I was more than satisfied with the result, and ever since then I used stock bricks and fireclay only.

14. *Question.*—**How high should the top of the bridge be from the crown of the boiler or from the fire-tube?**

Answer.—The bridge should be about nine inches from the crown of the fire-tube, if it were eight the draught would be curtailed, if it were ten the draught under the bars would be diminished, through much air passing over the bridge instead of under the firebars. As I had permission from my employers to build the bridge to the best advantage for myself in keeping up the steam, and having tried different heights for many years, I found that nine inches was the nearest to perfection. And in these experiments two additional bridges were built in one boiler; six feet behind the ordinary bridge was a concave bridge and six feet behind that was a convex bridge. The concave bridge was built close up to the bottom of the fire-tube, and resembled a small [19] archway, and extended down to within nine inches of the bottom or shell of the fireplace; the convex bridge was built on the bottom of the shell and reached to within nine inches of the fire-tube. When the flame from the furnace shot over the ordinary bridge, it clashed down under the concave bridge, then rose up and swept through the convex bridge and away to the bottom flues; the object of these three bridges, in one tube and for one fire, was to keep the flame and heat in the boiler as long as possible, instead of the heat flying swiftly over the bridge and out of the boiler. This experiment seemed to answer very well, but as there were several other boilers connected with this one there was no opportunity of testing it correctly, but the three bridges remained established, and were frequently shown to engineers and others.

15. *Question.*—**What advantage is there in having the blow-off pipe of a boiler entering it from the top instead of at the bottom?**

Answer.—I am not aware of any advantage in it, but I am aware of a disadvantage in it, and it is this, that while the boiler is being blown right out for the purpose of cleaning, or other reasons, the stoker will often commence doing some other work, and in due course the boiler is filled up [20]
with water, and the fire lighted, and by-and-by the stoker comes to see what progress she is making; he looks at the water-gauge but sees no water in it because it has syphoned out of the boiler; at first the heated air pressed on the water and forced it through the blow-off pipe, and then the pipe became a syphon, and the pressure increasing as the water leaves the boiler, she is soon emptied, and if the fire is not raked out, soon burnt. Such a mishap could not happen to a boiler with the blow-off pipe at the bottom, for when the stoker blows out his boiler he must shut the cock before he can fill her, and when filled there is no chance of the water escaping out again.

16. *Question.*—**Is there not some disadvantage in having the blow-out cock at the bottom of the boiler?**

Answer.—Yes; the cock and pipe are subject to corrosion on account of water dripping down on them from the stoke-hold floor, as some stokers quench their clinkers and ashes while they are up against the front of the boiler, instead of drawing them forward a few inches from the front: and as the pipe is out of sight under the plates of the floor, nobody takes the trouble to lift them and examine—not only the pipe and the cock, but that part of the boiler where the water streams [21]
down from the drenched ashes so frequently. So there are disadvantages in both methods of blowing out the boiler, and always will be, until the stoker learns his business, and takes an interest in his work, not only for his own sake, but his employer's also.

17. *Question.*—**What is the most important appendage to a steam boiler?**

Answer.—The safety-valve, but it is not always a safety-valve, when it is weighted to twice the amount the boiler is certified to be worked at safely. As an instance: Amongst the many engines employed at the Midland Extension Works, St. Pancras, was a light steam crane for hoisting earth from the deep excavations, there were in use small wooden skips, and the pressure of steam was forty-five lb.; but after a time there arrived large iron skips that the crane could not lift, even when empty; there were about twenty men depending on the crane for their work and the navvy-ganger was anxious for "something to be done," and the crane man hinted about weighting the safety-valve, and no sooner said than almost done; the safety spring balance was screwed down, and a railway chair suspended from it by strong copper wire, and the steam allowed to rise until it reached ninety lb. on the inch, and the big iron skips were hoisted with their load of heavy [22]
ballast as easily as the wooden ones had been. The boiler *happened* to stand it.

18. *Question.*—**Have you any other instance?**

Answer.—Yes; in an establishment in Hammersmith some years ago, the stoker was in the habit of putting a bit of iron on the end of the horizontal lever of a safety valve when the steam rose too high, and the manager was about, and when it went down he would take off the bit of iron and put it where he could find it for the next occasion. The manager had gone away one day, and advantage was taken of it to have a little carouse in which most of the men took a part; and when the steam rose the stoker popped his bit of iron on the lever and all was quiet for a time, when another noisy safety-valve began to blow off, and on went another bit of iron that stopped the noise, and during all this time the fires of seven or eight boilers were burning fiercely, and the stoker should have checked his fires instead of what he had done; but in the midst of the carouse all the boilers began to belch forth steam when the manager came on the scene. The stoker tried to pick off the bits of iron before the manager could see them, but the steam was to high for that; and when at last the noise subsided and the steam had cleared away, the whole of the revellers [23]
were on view, caught in a trap, as there was only one exit. Most of the men were fined or suspended, the bits of iron were discovered on the levers, and the stoker had a week's notice to clear out, and lock-up valves were fitted on every boiler and the keys kept in the manager's desk ever after.

19. *Question.*—**Can you always depend on the safety-valve lifting when the steam rises?**

Answer.—I always keep an eye on the pressure gauge, and if I find that the safety-valve does not lift at the pressure it ought to lift at I know that the valve is sticking, and I lift the lever and let the steam out; the cause of the sticking may be that the valve has worn down in its seat and becomes conical, or there may be a shoulder on the valve that would cause it to stick, or it may be that the lever and fulcrum were smeared with oily dirty waste in the process of cleaning and not wiped off, but left to bake between the parts, which would prevent the free action of the safety valve.

20. *Question.*—**Why is the safety-valve lifted at times, especially when getting steam up?**

Answer.—It is often done by old stokers as well as new ones, and is more of a silly habit than of [24] trying the pressure of the steam, especially as there is nowadays a pressure gauge for every boiler in a stoke-hold. By lifting the safety-valve while steam is in the boiler and dropping it down again is a dangerous practice; there is a rush of steam to the valve when lifted, and when it drops the rush of steam is instantly stopped, and rebounds like an india-rubber ball hit against the wall, and this commotion within the boiler is likely to blow the stop-valve to pieces or the manhole cover off. Besides that, there is always dust floating on the surface of the water, especially in a boiler just cleaned, and when the valve is lifted the dust is carried up with the steam, and when the valve is dropped the dust is caught under it and often causes the valve to leak.

21. *Question.*—**When the water in the gauge-glass appears motionless while the boiler is working, what does it portend, and how would you proceed to rectify the stagnation of the water?**

Answer.—It portends that the passage for the water is choked and requires clearing, and I would lose no time in commencing to rectify the stoppage; as a stoker who is responsible for the safety of the boiler I am always prepared for emergencies. I commence by shutting both cocks of the glass, the steam and the water, and unscrew the small bolt in the water gauge, which is fixed [25] there for the purpose of clearing the tube that conveys the water to the glass, and with an iron wire in one hand, I open the water cock with the other hand, and push the wire into the small hole from which I took the bolt, giving several pushes and pulls while the water and steam are flying out, until the tube is quite clear; then I withdraw the wire, shut the cock, and serve the steam cock in like manner; and while I was doing all this the bottom cock of the gauge (the blow-out cock) was open from the beginning. Then I commence to put the pressure on the glass by warming it with steam from the top cock slowly; then I open the water cock a little, and so on, alternately; then I commence shutting the blow-out cock a little. By these manœuvres the pressure on the glass is put on gradually instead of popping it on too suddenly and breaking the glass, as is often done by the *more-haste-the-less-speed* stoker; now I shut the bottom cock and open the other two, and the water bounds into the glass quite frisky, and the boiler is safe for the present.

22. *Question.*—**What would be the consequence if the steam cock of the water gauge was choked, while the water cock was clear, or vice versa?** [26]

Answer.—The consequence would be most serious for the boiler, as the water would be forced up into the glass by the steam under it, and would make it appear as if too much water was in the boiler, and the stoker would proceed in the usual way to blow out some of this, apparently, surplus water; and then watch to see it come down to the working level in the glass, but he watches in vain—it will never come down. He might empty the boiler dry, and the water in the glass will be there as long as a breath of steam remains in the boiler to keep it up. And in the event of the water-cock being choked while the steam-cock was clear the consequence would be equally dangerous, for the water that was in the glass before the stoppage occurred would remain in it, for the stoppage would not allow it to drop down into the boiler again; so there it would remain, and when the stoker came round to look at his boiler, unless he happened to notice that no movement of the water was visible, he would pass on without further ado, and remain in total ignorance of his danger. Hence the necessity for the stoker to blow out his water gauge every time he comes in front of his boiler, and if the water enters the glass in a sluggish or dilatory way the cocks need to be cleared of the partial stoppage, and let the water enter the glass with a rush. [27]

23. *Question.*—**Could a boiler collapse without affecting the fusible plug?**

Answer.—Yes; the tank that supplied the boiler with water leaked badly, and to stop the leaks a quantity of fine oatmeal was mixed with water and poured into it, and in due time reached the boiler; but instead of the oatmeal permeating the whole of the water in the boiler, it never got beyond the parts surrounding the fireplace; it stuck on the sides and top thickly, and was baked hard on them. After a few days the sides of the fire-tube bulged inwards nearly twelve inches, and the boiler had to be stopped and blown out, and the fusible plug was found to be unaffected—it was one selected by a Boiler Insurance Company, who had to repair this damage, and the stoker was exonerated from blame, but there is little doubt that if the plug had leaked the mishap would have been attributed to shortness of water and the stoker would be blamed for what he did not do, and get the sack into the bargain.

24. *Question.*—**Why is it that an injector can force water into a boiler from which the steam comes to work the injector at a greater pressure than is in the boiler?**

Answer.—The secret of the working of the injector is due to the velocity of the steam issuing from [28] the point of a conical tube, and water issuing from another conical tube somewhat larger than the steam cone, and a partial vacuum created in the barrel by the steam and cold water meeting —as both cones face each other. The cones are about four inches long, one and a quarter inch wide at the mouths, and about one half of an inch at the points. The suction pipe, steam pipe and delivery pipe are about one inch diameter, and the overflow pipe half an inch diameter, and the water tank three feet below the level of the injector, the space within the barrel might be twelve square inches; the water and steam cocks are supposed to be always open, and this is how the injector is started working. The water-wheel is turned partly round, and a figured disc behind it indicates the quantity of water let into the barrel, while the steam is let in by turning a wheel attached to a quick-screw spindle; then there are ructions inside—the steam and water have come together, and the water overflows through the half-inch pipe; but by a little manipulation of the water, air will soon start it working; then the overflow ceases, and the air rushes into the pipe and hums, and the injector is working. And the reason of its working is, in my humble opinion, the concentration of water and steam, with the vacuum thrown in, that gives additional pressure to the water in the injector. I might venture to say it gives fully ten lb. on the square inch over [29] and above the pressure of steam within the boiler.

25. *Question.*—**The noise created by the injector while working being very objectionable, could it be mitigated? And, if so, how?**

Answer.—Yes; I succeeded in quieting an injector in one establishment where anything louder than the scratching of a goose-quill was considered a nuisance. I first began by putting a piece of paper against the mouth of the overflow pipe while the injector was working, and the noise ceased, but soon after that the paper was sucked up into the injector. I then applied a leathern disc, which answered well, and proved just the right thing; sometimes the water blurted out, but not often, and the leathern disc was permanently established; but the injector would not work with water above 100 degrees of heat; so I would start with cold water and gradually turn on the hot water and shut off the cold, and she never noticed the change, but the noise was stopped.

26. *Question.*—**How would you quiet a noisy pump—one of those stuck up in a corner of the stoke-hold that can be heard, but not often seen?** [30]

Answer.—I had one of them once—a very good little "Manchester Donkey Pump," but as noisy as they make 'em—and it became a question whether she should be discarded for an injector; she was bolted to a wall in the basement of a block of offices and could be heard throughout the building, and my employer told me that he would willingly give a 5*l.* note to anyone who would stop the noise. The donkey was vertical; I took off both valve covers and drilled a ⅜-inch hole in each projection from the cover that gave the valve its lift, and drove a wooden peg into each hole from the under side, and rasped them down to give the required lift, and put the covers on again and started the donkey, and after some more raspings of the plugs I started her again, and this time was successful; she worked like india-rubber, no noise whatever, and I gained more than was offered to quiet her—a cheque of 21*l.* This happened in Draper's Gardens, Throgmorton Avenue, E.C.

27. *Question.*—**When several boilers are working in a row, and one of the middle ones has to be cleaned, what would you do to keep it cool enough to enable the men to do the cleaning, and also to protect them while in the boiler?**

Answer.—Having blown her right out I would take off the wheel of the stop-valve spindle, tie a [31] piece of canvas on the top of the spindle and lock the wheel up, so that no one should open the stop-valve while the men were in the boiler. Many dreadful things have happened through some thoughtless or meddlesome idiot opening the stop-valve while men were working in the boiler. I also cover the blow-off cocks of the boilers in steam, as there is usually a pipe into which the steam and water is carried off running parallel with the cocks, and take charge of the spanner used in opening them, in case an absent-minded stoker might attempt to blow some of the muddy water out of his boiler when the men were in the empty one, and scald them to death, the steam rushing up through the blow-off. I then fill the boiler up with cold water several times, and allow cold water to play into the boiler from the manhole by means of the hose pipe, and the blow-off cock being open there is always a cool atmosphere for the men to work in; they can remain longer in the boiler, do twice the amount of work, and in less time than in a scorching atmosphere. When the cleaning is done and the boiler rinsed out, I shut the blow-off cock and fill her with clean water to the usual height; take off the canvas on the spindle, replace the wheel, and the boiler is ready for lighting up the fire. [32]

28. *Question.*—**Does familiarity with one's work as stoker sometimes lead to carelessness and then to mishaps? And, if so, give an instance?**

Answer.—Yes; familiarity in doing things frequently during work, tends to a careless off-hand style of self-importance that has often caused trouble and mishap. A crane driver employed at the Midland Railway Extension at St. Pancras, came to work one winter's morning and the steam being already up, turned it on to warm the steam chest and cylinder, preparatory to commencing work for the day, forgetting that it had been freezing hard all night, and split the steam chest to pieces. His plea of defence was that steam had remained in the chest and condensed, and become ice, then expanding, burst the steam chest; this plea served all right, but the following summer he was less successful. He came to me during the dinner hour and said, "Jack, I can't get any water into my boiler, will you come over and look at her?" I did go over, and on looking at the water gauge saw it was empty, opened the cocks, but dry steam came forth, opened the fire door and found a bright fire of coke; while the engine was pegging away to get water into the boiler. I said, "Bill, stop your engine and draw your fire at once, and my name's Walker." I went back quicker than I came; and an hour later he came over to me looking very down, and said, "Jack, [33] I've done it." I knew what he meant and went over with him to look at the boiler. It was as complete wreck, and I told him to fly off and get any money that was owing him before he got locked up; he did go, and I never saw him since. This man was an engine fitter before he took to engine driving—poor fellow, I was very sorry for him. Another instance. A stoker had to fill a boiler and get up steam in her one Sunday morning, there was a big tank over the stoke-hold from which water was taken to fill cold boilers, a two-inch pipe with stop-cock led to the top of each boiler from the bottom of the tank. But the tank was empty on this occasion; a donkey pump close by was used to keep the tank filled, but this boiler was the one from which the donkey took her steam, and was now empty, but the stoker solved the puzzle: a boiler with steam was in use about fifty yards away, and having a steam-pipe connection to the empty one he opened the cock and commenced letting the steam into her, but it was condensing as fast as it went in; and being one of the extra clever ones, he lighted a fire in the grate so as to stop the condensing, and did stop it, and let in sufficient steam to work the donkey-pump and partly filled the tank, and was proceeding to open the two-inch cold water pipe when one of the workmen passing by saw some [34] cotton waste smoking strongly on top of the boiler, which induced him to open the furnace door, and he saw that the boiler was red-hot and collapsed; he rushed up to the stoker who had his hand already on the stop-cock to let water into her when he was forcibly pulled away from it, much against his will, but when he saw the damage he had caused he sheered off and we saw no more of him. This case occurred at the London Hydro-Carbon Oil Works, Southall, W. One more: On a Sunday morning a stoker came in to break the joint of a manhole, empty the boiler and fill her up again with water. After taking the dogs off and securing the cover from falling into the boiler, the stoker gave the cover a tap with the end of the spanner to loosen the joint, but the cover showed no signs of slackening, and the end of a crowbar was requisitioned but without result; and in this case, as in a former one, my opinion was solicited as well as help. I used the crowbar end harder every blow; when at last the cover seemed to spring downwards and upwards, I dropped the bar instantly, thinking the devil had a hold of the cover. After a moment's thought I went down into the stoke-hold and opened one of the gauge cocks and steam rushed out; there were no pressure gauges in this establishment; every one of the twenty boilers had eight weights suspended from the lever of the safety-valve, each weight representing five lb. [35] pressure. I took off the weights one by one, and when five of them had been removed steam began to blow off, showing that fifteen lb. pressure was in the boiler while I was trying to knock the manhole cover in. On inquiry it transpired that the man whose duty it was to blow out this boiler the previous day asked his mate to do it, and the mate forgot all about it (it being Saturday night), and these omissions nearly caused a catastrophe. This occurred in Pimlico, S.W.

29. *Question.*—**What advantage to the employer is the self-acting stoker for steam boilers?**

Answer.—He can use the very cheapest and smallest coals; the cold air is never permitted to enter the boiler; there is no cleaning out fires with the door wide open; the steam is more uniform in pressure; the boiler will last longer, and little or no smoke. There is a drawback to these advantages: there must be a live stoker to keep the automatic stoker up to its work; he has to keep the coals supplied to the "Jacob's Ladder"; he has to regulate the supply of coals to the boxes over each boiler, and regulate the supply of coals dropping down into the fireplace, regulate the speed of the travelling furnace by means of the ratchet, clean out the ash-hole of [36] clinkers every two hours and wheel them out of the stoke-hold, regulate the water-supply to the boilers, and keep the steam at the proper pressure, and rectify any and every derangement and mishap that occurs to the self acting stoker.

30. *Question.*—**But are not these "self-acting stokers" smoke consumers as well?**

Answer.—The self-acting stokers have to be kept working by the live stoker, and are smoke consumers so long as the coals let down on the travelling furnace is exactly proportionate to the requirements of it, but if the supply should exceed what is necessary, the grate becomes choked with coals and has to be cleared of some of them, and in doing this with coals partly burnt, smoke is inevitable; and if the supply is insufficient, the grate becomes bare of fuel, and cold air finds its way through the bars and checks the steam. To remedy this, the coal is let down and carried onward by the moving grate before they can be ignited, and soon begin to smoke, so that in these two extremes, too much or too little coals will cause smoke; but if this type of furnace is in charge of a competent stoker, there is little chance of the bars being choked with coals, or starved for want of them.

31. *Question.*—**Is it not possible to consume the smoke of a boiler furnace independent of patents and mechanical contrivances that can only be worked [37] by an experienced stoker?**

Answer.—I have proved it possible where several boilers were connected and working, and using small and smoky coals. In an establishment in West London the system in vogue was in this manner: all the bridges were built hollow, and an iron flap covered the bottom of the bridge, and a long iron rod from the flap was carried to the front of the boiler, and an inch steam pipe with cock attached entered the fireplace above the door, and was joined to a two-inch perforated pipe that was fixed from left to right over and above the dead-plate. When the fires required replenishing, the flap was opened, then the door and steam cock, and six shovelfuls of coals were hastily thrown in evenly over the fire, and the door was then shut. The result of this performance was a mixture of steam and smoke observable at the chimney top, the steam was kept on while any smoke was visible; then the next boiler was served in like manner, and was a continual round of work to the exclusion of other things. This method prevailed for many years before I came on the scene, and noticing that a great quantity of steam was wasted for the purpose of hiding the smoke, and the six shovelfuls of coals hardly compensated for the steam spread over them, I [38] induced the man who built the bridges, after inspection, to build them solid, and then I commenced a new method of firing, in this manner: I sprinkle the small coals with water from a hose-pipe, and burn one fire down low, but bright; I shut the damper nearly close and commence firing towards the bridge and sides, until the grate is full nearly to the crown of the fireplace, allowing the gas to remain in the furnace and flues for twenty minutes, then I open the damper a couple of inches; by this time there are numerous jets of flame flickering all over the coals, and now I open the damper to the full extent and I soon have a rousing steam-making fire. I serve the next low fire in like manner, and so on. But it is necessary always while burning one fire down for the purpose of banking it up, to have all the other fires in good condition and capable of keeping up the steam independently of the one to be banked up; if the others should burn down too low before one of them is banked, smoke will follow the neglect. I remained several years in this employ; my method was very successful, with proper care and watchfulness, and was adopted in a similar establishment in South London. The former establishment was the West Middlesex Water Works, and the latter the Southwark and Vauxhall Water Works. One ton of Welsh coals was allowed every twenty-four hours to get the seven fires up after cleaning. Here is another [39] method for consuming the smoke, but is a very wasteful one; four or five shovelfuls of small smoky coals are thrown on or near the dead-plate, where they remain until they become sufficiently heated to ignite, and are then pushed on to the bars by the rake, and a similar quantity again thrown on the dead-plate, and when ignited pushed on to the bars as before, and so it is continued. It is expected that the smoke while passing over the bright fire towards the bridge will be ignited, but only a very small portion of it becomes flame, and the smoke tends to deaden the bright fire to a great extent. The door has to be opened so frequently in this method, and in pushing the coals from the dead-plate to the bars a large amount of live fuel drops down into the ash-pit, and if this should be thrown into the furnace again, the fire is deadened immediately. There is no economy in this method, which I tried years ago but never continued since.

32. *Question.*—**Is there any difference, and if so, what is it, in locomotive and stationary boiler stoking?**

Answer.—There is a wide difference between the methods, not only of firing but of the general work of the firemen and the stoker. (I cannot see why one should be called stoker and the other fireman, for they both have to keep the fire going and the steam up). The loco. fireman had to be [40] at the engine shed forty-five minutes, and the driver thirty minutes, before the time of the train starting; the fireman gets the stores necessary for the journey, such as oil, tallow, cotton waste, yellow grease, and perhaps fog signals, gets his lamps from the lamp room already trimmed—these are the head lamp, side lamp, water gauge lamp, tail lamp and hand lamp; he places the head lamp on the right hand side of the buffer plank, the side lamp on the left side of the tender, the gauge lamp close to the glass, the tail lamp behind the tender; he has to take his engine to be coaled (it used to be coke in my early days on the L. & N. W. R.), and fills his tender with water, and brings his engine over a pit, fills the axle-boxes of engine and tender; by this time the driver shows up, and goes under the engine and thoroughly examines every part of the gear; then he oils her, and both men sign on for the particular train that the engine's number is in line with, and run down the incline to Euston, where they hook on to their train and wait. If it should turn out to be a particularly heavy train, the driver will request the pilot-engine driver to hook on and go perhaps as far as Tring or Wolverton with the train, otherwise the pilot will detach at the top of the incline at Camden; if it should be a night train, with the pilot in front, it is an experience [41] never to be forgotten by a young stoker. (I was not far in my teens when I had this experience, but an old man now). And at last the signal is given us to start; we blow the whistle and off we go, two engines panting, puffing, sending up showers of sparks, and soon we leave Camden behind, and by the time we reach Watford we are travelling about fifty miles an hour; this is the speed to test the stoker who has to light his lamps the while, travel round the foot-plate and keep his balance, and replenish his fire and climb the tender frequently; but the passenger trains are a luxury in comparison to the luggage trains. The luggage engines being bigger and stronger than the passenger engine requires more steam and water, because she has more than double the load

to run with, and at the stations wagons have to be shunted frequently and often re-shunted; some are left and others taken to far-off places; the guard's van has to be detached always in order to have it at the end of the train; the stoker is hard at work with the brake putting it on and off, jumping down to hold the points, or coupling wagons—this is not his business, but he does it to facilitate the work. When the luggage train had to get into a siding to let a passenger train go by, there was no pit (except at a station) for the engine to stand over, and both men would have to [42]
crawl under the engine to do anything necessary, through wet, or snow, or mud; and when starting the engine out of the siding or from a station, and the driving wheels slipping round, the stoker had to jump down with his shovel and scrape up a bit of gravel, or sand, or clay, and pop it on the rail in front of the driving wheel, and if that should stop the slipping, the engine gave a bound forward and the stoker had to run to keep up with the engine, throw his shovel on to the foot-plate, and scramble up the best way he could, or be left behind. In bad weather, if it rained, hailed, or snowed, both driver and stoker had to keep a look-out by holding their hands up before their eyes and looking between their fingers; when it rained, and one side of each man was wet through, they would change places till the other side got wet through also. These were the good old times. Drivers and firemen in the present time may thank their stars that the way was well paved for them before they started. So there is hardly any similarity between a stationary boiler stoker and a locomotive stoker, except keeping the steam up perhaps; the loco. stoker is the king of all stokers.

33. *Question.*—**How is the stoking done on a big steam ship?**

Answer.—In a Royal West Indian Mail Steam Packet, in which I was stoker, there were forty-five [43]
stokers and coal trimmers, forty-five sailors, besides a number of stewards, stewardesses, six engineers, six ship's officers, several mail officials, butchers, bakers, and a brass band of eighteen musicians. There were two stoke-holds, one fore and one abaft the funnel, and four boilers in each, and four furnaces in each boiler, and three stokers in each stoke-hold, also three trimmers in each stoke-hold. There was the same method of working in both stoke-holds, and a constant and continual round of firing kept up day and night. When going down on watch I have a piece of waste in each hand to protect them from the hot handrails; I commence work by cleaning the small tubes of four furnaces, then clean out the four furnaces, rake out the ashes from the pit and fill them and the clinkers into iron buckets, which the sailors haul up and empty over the ship's side. And while I am engaged in this work my two mates are doing my firing for me—which is in this way: one man fires every other fire of the sixteen fires, then goes round again and fires those he missed the first round, then his mate takes the shovel from his hands and fires every other fire, then fires those he missed the first round; the third man does likewise, and so it is constant firing all through. And having towering hot boilers both sides of us and roaring furnaces behind and in front, the sweat pours from us continually, and we are glad to pop into the engine [44]
room after firing to get a draught of somewhat cooler air. I happened to have the middle watch—12 midnight to 4 a.m.—which is the worst of the watches, for when I came off at four the hands on deck were always doing something to make a noise, and there is little chance of getting a sleep, and hammocks must be stowed away before eight; then breakfast, and the brass band strikes up for half an hour; but if there had been dog-watches all of us would share in the middle watch—as follows:—

Brown	Morning	Watch	4 to 8 a.m.
Jones	Forenoon	"	8 to 12 noon.
Robinson	Afternoon	"	12 to 4 p.m.
Brown	First Dog	"	4 to 6 p.m.
Jones	Second Dog	"	6 to 8 p.m.
Robinson	First	"	8 to 12 midnight.
Brown	Middle	"	12 to 4 a.m.
Jones	Morning	"	4 to 8 a.m. = 24 hours.

A few hours after leaving Southampton all hands are mustered and apportioned to man the seventeen boats hanging from the davits, eight on each side, and the captain's gig under the stern; after this ceremony we get an allowance of grog. The fires are now beginning to be dirty, having clinkers seven or eight inches thick, which are not allowed to be pulled out until the whole fire is cleaned at the usual time; this order from the chief engineer surprised me at the time, as [45]
clinkers are not calculated to increase the steam, so I left them there to deaden the fire, but later on I found the solution; I was told by an old stoker that there was sharp competition between the chief engineers as to who could do the voyage at the least expense of coals, and that information explained the action of our chief engineer who would often perambulate the deck till midnight, watching the windsails that they should remain with their backs to the wind in order to prevent a breath of cool air reaching the fires, that would cause them to burn a few more pounds of coals, while some of the stokers were often hauled up in the ash-bucket fainting from the stifling heat of the foul-smelling stoke-hold. We were all supplied with fishing-lines and hooks of three different sizes, and extra grog when getting steam up. The method of cleaning and polishing the engines and all bright work was very effectual, and did the stokers great credit; after having scoured and polished the steel and bright ironwork they were frosted, in imitation of hoar frost. A pot of hot tallow and white lead in which a clean piece of cotton waste was dipped, and the parts smeared evenly in line with the metal, and when this dried it was dabbed, or patted, with another clean piece of waste also dipped in the hot tallow, which gave the metal a good imitation of hoar frost; [46]
the brass and copper work were burnished and shone like gold. The boat drill and fire drill create

some wonder for the passengers, as they always happen unexpectedly; the former begins in this way: a large gong is rapidly hit with a mallet by the quartermaster, and all those stokers and sailors, who belong to the seventeen boats hanging from the davits, immediately make their way towards them and commence to clear the falls, and the word is given to lower all boats, while the men hold their oars ready to push off, and the boats are run down nearly to the water's edge; then it is up all boats, and those on deck run them up in a jiffy to their places under the davits, and coil the tails up, and this ends the boat drill. The fire drill takes place on another day, and commences in this manner: the ship's bell is rapidly rung by the quartermaster; the unusual rapidity of the ringing attracts the attention of all the passengers who commence to crowd the upper deck; the stokers drop down a dozen hose-pipes on the deck and run them out straight, and screw them to nozzles leading down to the engine room. The engineers pop the pumps on and up comes the water; every hose is now stiffened and the branches are all directed over the ship's side, where they make a grand display. All those of the ship's company who take no watches, as cooks, stewards, bandsmen, etc., have each a pail full of water in hand, others a [47]
blanket over their arm, all in exact line, and ready to help if required; and after a few minutes' display of the hose-pipes, the boatswain's whistle ends this drill for this voyage, and the hose-pipes are disconnected, rolled up, and hung up, to be ready at any moment if required. There are plenty of amusements on board, such as single-stick, glove-boxing, wrestling, etc. But the game of the "Man in the Chair," is one of the most laughable. A piece of board, 12 inches by 18 inches, in which a strong rope is inserted in a hole in each corner and knotted on the underside, the four ropes are carried upwards and made fast to the forestay, and the "chair" has to be 6 feet from the deck. There are perhaps thirty stokers in this game, and each one has twisted his black silk neckerchief into rope shape, and a volunteer sits on the chair, holding on to one of the chair-ropes with one hand and in the other his silken rope. During these preliminary tactics the passengers are crowding round to see what may happen. At last the man on the chair gives the word "Ready Boys," and then commences a real slogging match, hitting the chairman on legs, arms, face, neck, anywhere they can hit him, and every hit being a matter of chance the passengers roar when the man in the chair delivers a stinger to his tormentors; his blows come with double force, as he is high above them, and swinging round and round, and to and fro, they [48]
come unexpectedly and cause roars of laughter; while this is going on a little tub, called a spitkin, is surreptitiously pushed in view, and a few silver coins dropped into it by one of our men, which causes the audience to dip their hands in their pockets and a few pounds in silver are quickly thrown in; and after half an hour's play this game comes to an end. One more specimen of the many games that delight the passengers: about twenty men stand close together and in line, their faces to the ship's head, the front man has a bandage on his eyes, any one in the rank is at liberty to step out and go up to him and slap his cheek, and dart off to his place in the rank before the blindfold touches him; if he does, the touched one has to don the bandage, and the other pulls his bandage off and takes a place in the rank. When the slap is delivered, the slapper darts back to his place in the rank with all possible speed, and the slapped one darts after the other like greased lightning, and touches the wrong man perhaps, and pulls the bandage off, only to have to put on again, while the passengers roar with delight; the little tub is not forgotten in this game; and then the climax comes when we think the blindfold has had enough of it, and when a burly stoker steps out to deliver his slap, the rank closes up tightly, and on rushing back to his place with the blindfold at his heels, and the wild exertions of the man to squeeze himself into the rank [49]
before he is touched and the joy of the blindfold who has just touched his man, creates loud cheers and laughter, and the burly man has to don the bandage and take his stand in front. Before arriving at St. Thomas, there is a general clean up, bilges pumped out, engines cleaned, boiler fronts and lagging polished; the passengers are preparing for another voyage to some of the islands further west, as Trinidad, St. Vincent, Barbadoes, Martinique, St. Kitts, St. Lucia, etc. On entering the harbour guns are fired in our honour, and we return the compliment by firing our six-pounder from the forecastle, the Colonial steamer comes alongside our ship, when there are cheers and waving of handkerchiefs and handshaking; the bumboats come alongside also and many people, and board our ship, offering us a great variety of things for sale; women galavanting over every part soliciting the officers' washing, etc., etc. Our engines receive a thorough overhaul, boilers are cleaned, cabins and stairways painted, and all bright metal cleaned and repolished; our coals are delivered on board by a swarm of men, women and youths, of both sexes, carrying them in small wicker baskets on their heads, and stepping on a scale or counter on their way to the ship, the process occupying about three days for about 800 tons of Welsh coal. At last the time has come for starting for home; all visitors are ordered off the ship: [50]
moorings are cast off, and a man at the voice-pipe speaks to the engineers down below, and the great paddle-wheels revolve slowly for a minute, while the band strikes up some appropriate air, as "Afloat on the Ocean my days gaily fly," or "Afloat on the Ocean Wave." Then commence the wild cheering and waving of hats and handkerchiefs while the great paddles have lashed the water into white foam, and we are fairly off for a fourteen days' voyage home. In all our games on board in which I took part I noticed the distinguished presence of our highly respected captain, which I am sure greatly enhanced our takings in the little dish.

34. *Question.*—**How is a hydraulic pump constructed?**

Answer.—There are various sizes, ranging from a ¼-inch to 4 inches in the diameter of the plunger or piston, as it is sometimes called; the larger size would be constructed in this manner; the barrel of the pump is 3 feet long, and on its top, and in line with it, and in the same casting, an air chamber is situate into which water and air enter at every suction of plunger, and serve as a buffer or cushion in the delivery stroke. The spindle of the plunger is connected to the piston of the steam engine by a hole and stuffing box in the cylinder cover, and a connecting crosshead secures the spindle of the plunger and the extra piston, so that would bring the crank of the engine, the connecting rod, piston, extra piston, and plunger all in a straight line, and a direct stroke. About 6 inches of the plunger is occupied by the packing at the outer end; a solid ring of iron an inch wide, and an inch high, and securely pinned to the plunger, has a leather cup pushed on to it, then a loose ring is slid up against the back of the leather cup and another cup, and another ring, until the space for the packing is filled up; then a nut is screwed up behind these which brings cups and rings tightly together, and a jam-nut with a split-pin going through nut and spindle and opened wide enough to clear the sides of the barrel, and the hydraulic pump is ready for work. [51]

35. *Question.*—How is a hydraulic accumulator constructed, and why is it necessary?

Answer.—By having an accumulator, a lift, crane, or press, works smoothly, as there is a steady and smooth supply of the power; whereas without it, the lift, crane, or press, would work in jerks or jumps; with every stroke of the pumps there would be a jerk; it would be an intermittent not a continual power. The accumulator consists of a cylinder of cast iron about 9 feet in height, 4 feet [52] outside diameter and 3 feet internal diameter; it rests on massive oaken timbers about 4 feet from the ground; inside the cylinder is a ram 9 feet high, also 2 feet outside measurement, and 12 inches diameter inside; it is lathe-turned, smooth and bright; four slabs of cast iron, each a quarter of the circumference of the base of the cylinder, are placed over four steel bolts that have to support the dead weight, each bolt being about 12 feet high, 4 inches in diameter, with square necks and flat heads, and a hole in each slab to receive the bolts; the flat heads of the bolts are to facilitate the accumulator resting level on the oaken timbers; the slabs would be 2 tons each. On the slabs are fixed small segments all round and round the base of the cylinder until the required number (perhaps 150) is placed one on top of the other, each segment weighing 2 cwt.; then the crosshead is placed over the top tier, and having a hole in each of its four arms it is entered on the bolts which have a screw-thread; the nuts are put on and screwed up tightly, and the accumulator is erected.

36. *Question.*—How is the accumulator started working?

Answer.—The engines are started pumping into the ram and cylinder, whose drain-cocks have previously been opened, and air and water issues from them; when the air has escaped they are [53] shut off, and then the great mass of iron and steel begins to tremble and totter and moves upwards and upwards, and on nearing the limit of its journey the top of the accumulator lifts a projecting lever which has a small chain attached to it, the bottom end of the chain is attached to the steam throttle valve, and when the chain is pulled up at the top the steam is shut off at the throttle-valve and the engine stops, but will start as soon as any water is taken from the accumulator.

37. *Question.*—Is there any similarity in terms used in hydraulic work and steam boiler work?

Answer.—There are several terms common to hydraulics and steam; the steam boiler might be called an accumulator of power; there is a slide-valve in hydraulics as in the steam engine, to admit the power and to allow the exhaust to escape; there are stop-valves and intermediate valves in hydraulics, as in steam pipes, also air-vessels in each: there are suction and delivery pipes and valves in each, and relieve valves also in each; there is a cylinder in each in which the power is concentrated; there are reversing levers in a hydraulic crane, as in a steam crane. [54]

38. *Question.*—Who invented the atmospheric engine, and how was it constructed?

Answer.—Savory, a mining agent, invented the first method, which he called an engine, of drawing water up from a well by means of a vacuum which he happened accidentally to discover a method to create, and the pressure of the atmospheric combined with it. He procured a real steam boiler with a safety valve and gauge cocks and erected two vessels in which to create a vacuum; a suction pipe from the bottom of each vessel led down into a well beneath the vessels, and a valve that opened upwards was on the end of each pipe. When about to start work, steam from the boiler was turned into one of the vessels, and kept on until it was as hot as the boiler itself, while a drain cock was kept open the while, and when air and water had been forced out of the vessel steam was shut off, and water from a tank above the vessel was allowed to flow on it, which soon made a vacuum inside the vessel, and water was sucked up through the valves opening upwards and delivered into a tank placed for the purpose. While this performance was in progress, the other vessel was being charged with steam to repeat the performance, etc. This is the extent as far as I know of Savory's claim to be the inventor of the atmospheric engine. [55]

39. *Question.*—Who was the real inventor then?

Answer.—Newcomen and his partner Cawly adopted a working beam, that is, a beam working on a centre or trunnion. At one end of the beam was the pump, at the other was an iron cylinder

with an iron piston in it; both ends of the beam were arched or sexton-shaped, and had a chain on each, one connected to the pump rod, the other to the piston rod. When about to start work, the piston being up near the top of the cylinder, steam was let in under it and a jet of water was let in which soon condensed the steam and created a vacuum within the cylinder, and the piston was drawn down to the bottom and the pump drawn up with its load of water; and a counter weight was attached to the pump-rod to always bring the piston to the top of the cylinder after each descent. This is a very brief description of this atmospheric engine; there were now only two cocks to open and close—the steam cock and water cock, and the engine only required a boy for this purpose, but the boy himself added a share in this engine. In order to have a relief from the monotony of opening and shutting the cocks alternately, he tied strings to the handles and then connected to the working beam in such a manner that the cocks were opened and closed exactly at the nick of time; this caused the engine to work far more regularly and to do twice the work it [56]
had done previously, the boy's name was Humphrey Potter.

40. *Question.*—**What did James Watt do in connection with the atmospheric engine?**

Answer.—Watt being a mathematical instrument maker, was requested to repair an old engine used by some students of Glasgow University; having finished the repairs, and in working this model (the best type of the atmospheric engine), he found and proved by many and various experiments, that an enormous waste of fuel was absolutely necessary in working the engine; he found great difficulty in keeping the air from entering the cylinder, and the cylinder top was so exposed to the atmosphere that the steam was much condensed when it entered the cylinder, and he came to the conclusion to put a cover on the top of the cylinder, and allow the piston-rod to play in a hole in the cover with a gland and stuffing box, and *to press down the piston with steam instead of the atmosphere*. This engine was no longer atmospheric, it was a real steam engine, the first ever seen or constructed, for steam was used to create the vacuum, and steam was used to work the piston; but this was only the beginning of his great improvements. This engine though suitable for the purpose of pumping water, was totally unsuitable for continuous rotary [57]
motion, the steam acting only on the downward stroke after the piston had been pulled up to the top of the cylinder by means of the additional weight fixed on the pump end of the beam. He devised a method to admit steam under the piston as well as above it, but the flexible chains although suitable for the down stroke of the piston were powerless in the up stroke, they would hang listless and useless. This being so, he determined to get rid of the chains at both ends of the beam, and also both arched ends, and substitute a ridged connection at both ends of the beam. He put an iron connecting rod from the end of the beam to the pump rod, and the other end of the beam was connected to the piston rod by a crosshead; to this engine he attached that grand appendage the "Parallel Motion" which is the pride of the beam engine up to to-day. He devised the improvement of the separate condenser for the exhaust steam, instead of the jet of water under the piston. He invented the crank for his engine, also the sun and planet motion, also the throttle valve, also the counter to indicate the number of revolutions the engine had performed, also the "Cut off," the steam moving the piston by expansion when it was cut off at one-third the length of the cylinder, and thus saving two-thirds of the steam and a more uniform rate of speed. [58]

41. *Question.*—**Give a description of the Sun and Planet method, and why he invented it?**

Answer.—The sun and planet were two cog-wheels geared into each other, the sun being 3 feet diameter and the planet 2 feet diameter, the latter was keyed tightly on the bottom end of the connecting rod, and the sun which was keyed tightly on the end of the shaft, that was to revolve and work the machinery. But although this method did make the machinery revolve, it was not smoothly, for when the planet wheel was at either top or bottom of the sun wheel, the power of the engine was less effective than it was half way in the opposite positions. This led Watt to add a large wheel on the shaft of the sun wheel, called the fly wheel, which equalised the rate of motion to uniformity. Watt invented the crank for his engine, but one of his men gave the tip to an engineer at Bristol, who forthwith took out a patent for it and forestalled Watt, who had to invent another means—the sun and planet. But when the term of the patent expired, Watt resumed the crank method instead of the sun and planet, which was noisy, the wear and tear very great, and also expensive.

42. *Question.*—**What other things did Watt do towards the perfection of the steam engine?** [59]

Answer.—He added the air pump to his engine to draw the condensed steam and water from his separate condenser; he invented the throttle valve and the governor, in order to sustain a uniform rate of speed in the engine, whatever pressure of steam might be on, or variation of work, whether heavy or light.

43. *Question.*—**Why is the power of the engine called horse-power?**

Answer.—Before the invention of the engine, horses were employed in mills and mines, and other places; the number of horses employed in a mill or mine, indicating the amount of work going on, and the necessity of employing them, and when the steam engine came on the scene, and a purchaser wanted, he was told that the engine was equal to so many horses; that comparison gave the purchaser a clear idea of the engine he required. Savory was the first to suggest this comparison, but Watt knew that horses differed in size and strength, and in order to be sure of a safe standard for his engine power he experimented with big horses in some London breweries, and after careful calculation and comparison he fixed a horse-power at 32,000 lb., that is to say, that a horse could lift that weight of water one foot above the ground in a minute for eight hours per day. This standard has remained ever since, although it is above the average of the power of [60] the average horse, it is in favour of the purchaser of an engine, as well as being capable of working more than eight hours a day, or twenty hours if required.

44. *Question.*—**What is meant by "nominal horse-power"?**

Answer.—It is a rough and ready way of giving some idea of the power of an engine or engines on the basis of the number of inches in the area of the cylinder or cylinders, but when the process of taking the diagram of the engine is gone through the term nominal is dropped, and indicated horse-power is then expressed, because it was proved by actual experiment and certainty.

45. *Question.*—**How is that performance accomplished?**

Answer.—In horizontal engines there are generally two gun-metal screw-plugs on the top of the cylinder, one over each end and in front of the piston; when a diagram is to be taken, these plugs are taken out and other screws put in their places, to which a copper pipe is attached; the screw plugs are 1 inch in diameter, also the copper pipes; and exactly mid-way on the copper pipe is a small cylinder which moves on a pivot, by means of a string with a turn round it. One end of the [61] string is fixed by a clip on the connecting rod, the other end anywhere to keep the string tight, so that by the movement of the steam entering the cylinder at either end, and the connecting rod working backwards and forwards, the small cylinder is made to turn frontways and backways; and within the small cylinder is another cylinder very much smaller; it has a tiny piston within it, and as the steam presses on the little piston at every stroke of the engine, a pencil from the outer cylinder is fixed in a slot and marks the movements of the little piston on a roll of prepared paper, slid over the inner cylinder for that purpose, the pencil being kept up to the paper by means of a small steel spring. This diagram on the paper cylinder, not only is used for determining the power of the engine, but for detecting any irregularity in the slide-valve movements. Every hour during the trial the finished diagram is torn off the roll and a fresh one started, and when time is up the engine is stopped and the diagrams compared. Then commence the calculations, which are gone through somewhat in this manner: the common multiplier is found by multiplying the area of the piston in inches by the speed of the piston in feet per minute and the product divided by 32,000 (Watt's horse-power), then the effective mean pressure found on the diagram is multiplied by the common multiplier, and the quotient will be the *indicated* horse-power of the engine. [62]

46. *Question.*—**How is the consumption of coals apportioned to the horse-power of the engine at the finish of the trial?**

Answer.—The consumption of coals in pounds is divided by the product of the indicated horse-power and the time in hours. The quotient is the quantity consumed per horse-power per hour.

47. *Question.*—**Would the quality of the coals used in the trial be of the same quality as will be used in the ordinary working of the boiler after the trial is ended?**

Answer.—No; the coals which are used in the trial are generally the best Welsh, not shovelled up indiscriminately, but carefully hand-picked, weighed and wheeled into the stoke-hold; the engine during the trial is lavishly supplied with oils and tallow, with great regularity. After the trial, and the horse-power is indicated, the boiler resumes her ordinary work; the stoker is ever after expected to create sufficient steam with very inferior coals to develop the same amount of power in the engine as was done in the trial. I think that is very unfair to the stoker.

"Let the finish give you pleasure" was the last headline in my last school copybook in the long, [63] long ago; and it has given me as much pleasure to begin this catechism as to finish it; it has given me pleasure to offer to brother stokers my very long experience in stoking, and kindred vocations, such as hydraulics, steam-pipe joint making, water-pipe joint making, engine driving, etc., in the hope that in the perusal of this catechism they may find something to their advantage. And with my best wishes for their future success, remain their true friend.

W. J. C.

1906.

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