ON AN IMPROVED LOCOMOTIVE BOILER.

Without discussing the merits of the various arrangements and dispositions of the working parts of Locomotive Engines, the author of the present paper proposes to make a few observations respecting the most vital part of these machines, that upon which the satisfactory performance of all the details must necessarily depend, namely, the Boiler.

Before proceeding to the immediate subject of this paper, it is proposed to point out one or two objections to locomotive boilers as at present constructed, which experience has brought under the author's notice; and then to describe a form of boiler which appears to him in some degree calculated to remedy the defects which will be referred to.

It is scarcely necessary to observe that the absolute power of a Locomotive, or any other steam engine, is strictly proportioned to the quantity of steam which the boiler of such engine can produce in a given time; and chemists are generally agreed that the quantity of atmospheric air required, (or oxygen which is the supporter of combustion), as well as the quantity of fuel, is in direct proportion to the quantity of water evaporated; or in other words, to produce more steam, it is not only necessary to supply more fuel, but also more atmospheric air in proportion to the quantity of steam produced.

It is well known that some of the Locomotive Engines built at the present day have from two to three times as much heating surface as those built about eight or ten years ago, and consequently when performing a proportionately increased amount of duty, they require from two to three times the quantity of air forcing through the fire in the same time.

The working parts of these Engines have also been increased in dimensions; the cylinders from 12 inches to 15 and 16 inches diameter, the stroke from 16 inches to 20 and 24 inches, and the driving wheels from 4 feet 6 inches to 6 feet diameter, and in many cases even more.

Notwithstanding all these enlargements and improvements there are however two elements which have been but slightly changed; namely, *the diameter of the blast pipe*, and the diameter of the *cylindrical part of the boiler;* and as the whole of the steam (after having performed its office in the cylinders) is driven in a forcible jet up the chimney for the purpose of producing the necessary draught through the fire, and as the power required to produce this jet is so much taken from the gross power of the engine, it follows that the smaller the blast pipe is in proportion to the total heating surface of the boiler, the greater will be the resistance to the action of the piston, and the greater the loss of power on this account.

From observations made upon Engines under the author's immediate superintendence, it appears that whilst the heating surface of Locomotive boilers has been increased from 400 square feet (in the year 1842) to 987 square feet (in the year 1846), the blast pipe has not been in the slightest degree enlarged, but on the contrary in the latter case has been reduced in area in the proportion of $12\frac{1}{2}$ to $8\frac{1}{4}$ square inches.

So that upon dividing the total heating surface or *area of production*, as it may be termed, by the size of the blast pipe, or *area of eduction*, (assumed as unity), the following very instructive results are obtained.

No. of Engine.	When built.	Area of Blast Pipe.	Heating Surface.
24	1842	1	4608
20	1842	1	5044
25	1845	1	7961
30	1846	1	12960

In the last case, then, it appears that the heating surface has been increased nearly *three-fold* in proportion to the size of the blast pipe, as compared with Engine No. 24; and the reason will be obvious when it is stated that the boiler No. 30 is only of the same diameter as the first named (No. 24), and consequently that the flue room, (which as a general rule will be as the square of the diameter of the boiler), has been but slightly increased, the extra heating surface having been mainly obtained by enlarging the fire-box, by putting in a mid-feather, and by increasing the length rather than the number of tubes.

It is not necessary to enquire how far the diameter of the cylinders may affect the size of the blast pipe, nor to ascertain the amount of power which the blast pipe absorbs, though it may be stated that experience proves it to range from 10 to 20 per cent. of the gross power of the engine, according to the number diameter and length of tubes, and also the speed of the engine. It may be remarked, however, that on the average a degree of exhaustion is required in the fire-box under ordinary circumstances equal to a column of water 4 inches in height, and the degree of exhaustion in the smoke-box must of course be greater than this by the resistance offered by the tubes to the passage of the heated gases from the fire-box to the smoke-box.

From experiments made about 2½ years ago upon an Engine with a total heating surface of 987 feet, carrying 147 tubes of 1¾ inch external diameter and 13 feet 10 inches long, the author found that the latter force was at all velocities *three times* as great as the former; or in other words, that 66 per cent. of the total force of the blast was required to overcome the resistance offered by the tubes to the passage of the heated gases, leaving 33 per cent. only to operate upon the fuel; and it is this evil which results from the comparatively limited flue area of the boilers as at present constructed, to which attention is now more particularly called, and which it is proposed to remedy in the manner now to be explained.

From what has been said it will readily be inferred that there is some difficulty in materially increasing the power of Locomotive Engines, as the necessary amount of heating surface cannot be obtained without increasing the diameter or the length of the boiler, or making it oval, to all of which plans there are some objections; but by the method now proposed it will be easy to enlarge both the fire-box and tube surface from 35 to 40 per cent., without increasing either the diameter of the boiler or its length, as will be now shewn.

It is proposed to construct the copper fire-box with an arched roof, the top of which shall be nearly as high as the top of the cylindrical part of the boiler, as shewn in the Drawing, Fig. 1, which represents a transverse section through the fire-box. This box may of course be made any length without sensibly reducing the strength of the roof, and will require none of the stay-bars which are so essential to the security of the flat-roofed box, and which for a moderate sized engine weigh not less than 400 lbs.

With such a box the whole of the cylindrical part of the boiler can be filled with tubes, and of course the whole of the longitudinal stays be removed; and in the present instance there are 225 tubes of 2 inches external diameter, the shell of the boiler being 3 feet 8 inches diameter and 10 feet long; the total heating surface of the fire-box is 80 feet, and of the tubes 1177 feet, making a total heating surface of 1257 feet.

Such an arrangement involves the necessity of keeping the boiler full of water, and it is therefore requisite that a separate steam chamber should be provided. This, as will be perceived from the Drawing, consists of a cylinder which is 13 feet long and 20 inches diameter, fixed over and parallel to the cylindrical part of the boiler, or, as it may now be termed, the generator. This tube, which has a cubic capacity of 28⅓ feet, is connected at each end with the generator, as shewn in the Drawing at A B, Fig. 2, which represents a longitudinal section of the boiler. It is proposed that the water shall occupy about one-fourth of the capacity of this tube, leaving a clear space of say of 21 cubic feet for steam; this is rather more steam-room than most modern boilers possess, and for reasons which are afterwards mentioned, the author thinks it will be sufficient, although it may readily be increased by slightly enlarging the diameter of the steam chamber, which as at present shewn, is not so high as the ordinary steam dome by about 12 inches.

It has been proved experimentally by Mr. Robert Stephenson that the generative power of the copper fire-box is three times as great per unit of surface as that of the tubes; and independent of this authority, Locomotive Engineers are generally agreed that the great bulk of the steam generated in a Locomotive boiler is formed upon the surface of the copper fire-box and the first 18 or 20 inches length of the tubes. As the whole of the steam has to rise through the body of the water, with which it is for the time mechanically mixed, and as the specific gravity of these mixed fluids will be much less than the comparatively *un*mixed water at the smoke-box end of the boiler, it follows that there will be a brisk circulation through the generator and steam chamber, in the direction indicated by the arrows upon the Drawing. The mixed steam and water will be driven into the upper vessel, and will there be effectually separated; the former passing off to the cylinders by the longitudinal pipe C D, Fig. 2, which has a number of small holes upon its upper surface, and the latter running again into the generator through the vertical connection at the front end, and thus keeping up the circulation.

That the specific gravity of the mixed steam and water at the fire-box end is often reduced to at least one-half that of water alone, is proved by the fact that the water guage will frequently show a downward current through the glass tube, even though the circulating fluids be one half water and one half steam, shewing as it does that the column of the mixed fluids (F G, Fig. 4) in the boiler is specifically lighter than the column H I in the glass guage; and from this fact it is also evident that this great expansion is confined to the water in the vicinity of the fire-box, since if it extended to the whole mass, the boiler would not contain the requisite quantity.

From the circumstance that no bubble of steam can rise into the steam chamber between the points marked A and B, Fig. 2, it is concluded that this boiler will not be so liable to prime as the common one, and therefore that the steam chamber as shewn is sufficiently large. As to the water surface, which in this boiler it may be objected is smaller than in others, it is conceived that the great facilities this boiler will give to the engineer for raising steam, will leave him comparatively at liberty to put in water when and where he chooses, and consequently that but little difficulty need be apprehended on this point. It is evident however that the objection may be fully met by constructing the outer fire-box with a pyramidical roof in the way so common.

In conclusion, the author would express his conviction that this boiler, combining as it does a great increase of heating surface, *and corresponding increase of flue area*, with a relative diminution of bulk and weight, and great simplicity of construction, is calculated to remove some of the difficulties experienced by Locomotive Engineers, and to promote the best interests of the Railway world in general.

The CHAIRMAN said, that in the unavoidable absence of Mr. Ramsbottom, he would observe that his object in the foregoing paper was to obtain a considerably larger area of flue-room than in the present locomotive boilers, and to make a boiler of a large heating-surface with less weight.

Mr. SLATE was of opinion that for the weight the engine carried, it would have a considerably greater effective heating-surface than any previous form of boiler; but he thought the boiler would have as great a tendency to prime as any other.

Mr. COWPER was also of opinion there would be a great tendency to prime in the proposed boiler; the surface from which the steam had to rise was the entire surface of the fire-box and tubes, and all the steam had to pass through the two openings into the steam-chamber, and it appeared to him the water would be carried up there in a complete state of froth.

Mr. McCONNELL, while agreeing to a certain extent as to the liability of the boiler to prime, thought it might be obviated by having a more continuous communication between the generator and the steam-chamber; perhaps the steam-chamber could be fixed close upon the top of the generator, and a continuous longitudinal opening be made, communicating between them throughout their entire length. He thought the proposition of Mr. Ramsbottom was a very good one, as it was a received opinion that the proportion of the flue-room to the fire-grate surface could not be too large, supposing that full advantage was taken of the flue surface before the heated air reached the chimney. Whether long tubes or short tubes as applied to locomotives were most advantageous, was a question not yet decided, and he thought they had scarcely data enough to determine as to the advantage of long tubes on the ground of economy. It was a very important matter to determine what length of tubes was most advantageous for use in proportion to the area of the fire-grate.

Mr. C. COWPER was not aware whether there was any authority respecting the proportionate heating power of the tubes and the fire-box, besides the experiment of Mr. Stephenson alluded to in the paper.

Mr. McCONNELL remarked, that it appeared from experiments made by Mr. Stephenson and Mr. Beyer, that a very considerable heat was lost in the smoke-box even at the end of the longest tubes that were used; and he thought that the air in the centre of the tubes might have a considerably higher temperature than the air at the sides of the tubes, and that much of the heat might be carried through by a stream of air like a solid bar in the centre of each tube, without ever coming in contact with the sides of the tube, and consequently without being communicated to the water of the boiler. He had been informed that it was found to be a useful practice in marine and stationary boilers, to create a disturbance in the currents of air passing through the flues, for the purpose of mixing up the particles as much as possible; and a similar advantage might probably be obtained by mixing the air in the tubes of locomotive boilers.

Mr. GIBBONS said, he had observed a similar advantage from mixing the particles of air in heating the air for his blast furnaces near Dudley; the pipes through which the air was passed for the purpose of heating it were bent like a syphon, so as to cause all the particles of air to come in contact with the sides of the pipes, and the air was found to be heated much more efficiently by these bent pipes than by straight pipes.

Mr. ALLAN said, he had tried an engine with a ½ inch iron rod fixed in the centre of each tube; the rods were as long as the tubes and supported at intervals by short projecting pins to hold them in the centre of the tubes. The engine had been worked with them for some time between Birmingham and Liverpool, but no difference was found in the working and consumption of coke, as compared with the same engine doing the same work without the rods in the tubes; the result was found to be exactly the same in both cases.

Mr. C. COWPER remarked, that the rods in the tubes would have the effect of contracting considerably the flue area, and increasing proportionately the amount of power requisite to draw the air through the tubes, and consequently the rods in the tubes would cause a loss of power to the engine from the increased resistance to the blast. He thought therefore the rods must have caused an equal amount of gain to neutralize this loss, by bringing the air into more effective contact with the sides of the tubes, as the result showed no loss on the whole.

Mr. McConnell thought it was certain at least that the use of the rods did no harm; and it must either be considered that there was no advantage in a large flue area, or that there was considerable advantage in mixing the air in passing through the tubes.

Mr. Slate was of opinion, that even on the ground of economy a large number of tubes was advisable, because with the violent and frequent action of the pieces of coke the tubes were soon worn out; whereas by increasing the number of tubes the velocity of the draught would be diminished, and the tubes would be less worn and would last longer.

The Chairman remarked, that the larger the area of the flue, the better it was for the engine, as it must offer less resistance to the blast-pipe; but he was not certain what this resistance actually amounted to.

Mr. Cowper said, that Mr. Daniel Gooch had found from his indicator cards, that the resistance of the blast-pipe amounted to 11 or 12 lbs. per square inch, at a moderate velocity of about 30 miles an hour.

Mr. McConnell observed, that as a certain quantity of heated air had to be conveyed from the fire-box to the chimney, and a certain area of heating surface was also required, there would be an important reduction effected in the resistance of the blast-pipe by increasing the number of tubes, so as to increase the area of passage and reduce the length of the tubes, diminishing proportionately the resistance of the air passing through the tubes.

The Chairman said, he was present when the experiments were tried that were mentioned by Mr. Ramsbottom, to ascertain the difference between the degree of exhaustion in the smoke-box and in the fire-box; the experiments were tried with a long boiler engine, and a glass water guage was fitted into the smoke-box and another into the fire-box. The degree of exhaustion in the smoke-box averaged three times as great as that in the fire-box, and this proportion was found to be nearly the same at all velocities; the greatest amount of exhaustion observed in the smoke-box supported a column of water 13 inches high. He thought that the whole resistance of the blast-pipe and the back pressure in the cylinder, did not amount to more than 15 per cent of the power of the engine.

Mr. Slate remarked, that assuming it to be 15 per cent, it followed that 10 per cent of the whole power of the engine was absorbed by the friction of the air in passing through the tubes, as the exhaustion in the smoke-box was three times as great as in the fire-box; or one-third only of the pressure of the blast was effectively acting in the fire-box.

Mr. McConnell thought it was an important subject for investigation, to ascertain the actual power lost by the resistance of blast-pipes of different sizes, and under the different circumstances of size and number of tubes. In his own practice he had found that small tubes and many of them produced the best effect; the limit in reducing the size of the tubes was their stopping up with pieces of coke whilst working.

The Chairman said, he thought there was some advantage in the form of boiler proposed by Mr. Ramsbottom, and that amongst the various modifications that had been proposed of the locomotive boiler there was not one that was so likely to be useful.

A vote of thanks was passed to Mr. Ramsbottom for his paper.

The following paper by Mr. Benjamin Gibbons, of Shut End House, near Dudley, was then read.