GAS BURNERS.*

By WILLIAM SUGG, A.I.C.E.

COAL gas, as now supplied to the public, consists of hydrogen and marsh gas to the extent of about 80 per cent., and the remainder consists of luminous hydrocarbons of various qualities, with traces of sulphur in the form of disulphide.

The gas supply of London is watched over by a Commission, appointed by the Board of Trade, called gas referees, who are Professor Tyndall, Professor Vernon Harcourt, and Mr. Pole. They are empowered to prescribe the manner of verifying the illuminating power and purity of the gas, and they have also authority to act in cases of dispute in public lighting. Their prescriptions, as emanating from the only legal body of the kind in the kingdom, are accepted as the proper methods, so that in effect, though they are appointed in London, they may be said to be gas referees for the whole kingdom. But the use that is made of gas is a matter which is altogether out of the control of gas companies and their engineers, and here the proverb about food and bad cooks may be paraphrased. The great hinderance to the improvements in the use of gas has been the general public themselves, who have not taken sufficient interest in the kinds of apparatus employed, but have, as a rule, supplied themselves with the cheapest burners, stoves, and other apparatus, utterly regardless of the waste and annoyance which this system entailed; and when they have complained, they have always attributed the causes of failure to the quality or pressure of the gas, instead of ascribing it to the true cause.

In 1871, the gas referees made an examination of a number of gas-burners which they had collected from various large establishments, newspaper offices, warehouses, shops, and dwelling-houses, and they found that those burners (samples of those generally employed by the public) would only give about one-half the light that the gas was capable of yielding per cubic foot consumed, and several of the burners tested by them gave only one-fourth of the proper light of the gas.

They say in their report to Parliament: "The economy to the public, arising from the use of good gas-burners instead of bad ones, is so obvious as hardly to need remark. The gas-rental of London amounts annually to more than two millions sterling. Taking a very moderate estimate, upwards of one-fourth of this sum (£500,000 per annum) might be saved by the use of good burners. This is the saving which might be made in London alone; how much vaster the sum thus economized if good gas-burners were to come into general use throughout England."

Now, the quantity of gas used in London last year, according to the analysis of the London Gas Companies' accounts, prepared by Mr. John Field, was, in round numbers, 20,230,000,000 cubic feet, which is equal to a bulk of one mile square $\times$ 726 feet high, and its cost to the public was £2,911,000.

The result of careful trials, made with a number of burners taken lately from private houses and shops, shows that, as a rule, the amount of light obtained by the general public, from five cubic feet of gas, is less than one-half of that which it is capable of giving. The iron and metal burners, of which a great many are used, give the best result in light when they are worn out, although the shape of the flame is bad. The reason why, is that in order to obtain from what is a compound of hydrogen, marsh gas, and carbon, its best effect in light, the burner must be so made that the quantity of gas required to be consumed is proportionate to the size of the burner, so that it cannot exceed the maximum quantity which the burner is made for. Then the outlet of the burner itself, whether it be of the Argand or the flat-flame form, must be so arranged that the gas issues forth at a sufficiently low rate of velocity, so that it has time to get heated to a proper degree by the hydrogen and marsh gas before it comes into combustion with the oxygen of the atmosphere. When this rate of velocity is obtained in an Argand burner, the pressure at the point of ignition is almost *nil*. In flat-flame burners the pressure of the gas must be raised to a point sufficient to blow out the flame to a fan-like shape, but it must only be sufficient to do this if it is desired to obtain a good result per cubic foot of gas consumed.

One more point is of great importance in the construction of a gas burner—that is, that the gas should not be heated until it arrives at the point of ignition. The body of the chamber below the point of ignition must therefore be made of material which is a bad conductor of heat; so as not only to prevent the undue expansion of the gas before it arrives at the point of ignition, but also to maintain the heat in the flame.

Sir Frederick Bramwell very ingeniously pointed out, some time since, that the important point in the proper combustion of gas is not so much to keep the gas cool as to keep the flame hot. The distinction is extremely subtle; but, nevertheless, a non-conducting gas-chamber performs both these important functions. If a gas-chamber made of metal or any good conductor of heat is used, then the gas becomes expanded in bulk, and the velocity of the issuing gas is greatly increased; less time being given for chemical combinations necessary to produce a proper amount of light from it. In addition to this, as Sir Frederick Bramwell has pointed out, the heat which should remain in the flame is conducted away from it into the lower fittings of the burner, where it may burn the fingers of the incautious consumer, but it is of no manner of use in the evolution of light.

You will, perhaps, say it is not possible to conceive how the flame can be kept hot without keeping the gas cool at the same time, because if the heat is to be kept in the flame, and not conducted away down the stem of the burner, the gas must be kept cool by the means employed. But, nevertheless, there is a difference in the effects produced, and the ingenious definition of Sir Frederick is scientifically accurate. As an explanation of the expansion theory, it may be stated that if one cubic foot of gas is heated to about 500° Fahrenheit, it will occupy the same bulk that two cubic feet do at the mean temperature of the atmosphere. Now, supposing it is issuing in a cool state from the aperture of the burner at a velocity equal to one and a half miles per hour, it must then issue at the rate of three miles per hour, if the rate of consumption is equal in both cases. Therefore it has only half the time in the heated state to combine with the oxygen of the air that it had in the cooler state, and a loss of illuminating power is the result. Again, as regards the maintenance of the heat in the flame: supposing the chamber from which the gas issues is a conductor of heat. In this case the heat from the flame is conducted away from it down the stem of the burner, expanding the gas and leaving the flame so relatively cooled as to require more gas to raise

it to the necessary state of incandescence to allow the oxygen to combine with it in the proper proportions. In this case, as the two operations are simultaneous, it is difficult to apportion the effect produced. But that the effect is produced is proved by the following experiments, made some time since by the late Mr. F. J. Evans.

Two Argand burners were made precisely alike in every respect, except that one had a combustion chamber made in steatite, and the other in brass. The same quantity of gas was consumed through both of these, the result being that the burner with the non-conducting chamber gave more light per five cubic feet of gas consumed than the other, the proportion being as fifteen candles to thirteen. The burner with a non-conducting chamber was quite cool immediately below the chamber, while the other was so hot that it could not be touched without burning the hand. The metal burners which are now used in enormous quantities, in London and the provinces become exceedingly hot, so much so as to communicate the heat to a considerable distance down the fittings. The velocity of the issue of five cubic feet per hour of gas from these burners varies from ten to sixty miles an hour. The worn-out burners generally give the lowest velocity. As a rule, the metal burners give the lowest result in light per cubic foot of gas consumed.

For example, a metal burner of the flat-flame type, which has been stated in the columns of the *Journal of Gas Lighting* to be identical with the steatite hollow-top burner, invented in 1868, gives the following results: A large-sized burner, No. 8, burning five cubic feet per hour, gave a result equal to 11.5 candles, while the result obtained with a like quantity of gas from a steatite burner of corresponding size, which has a non-conducting gas chamber, was 14.6 candles, a difference in favor of the steatite of 3.1 candles, or nearly twenty-five per cent. more light. Another metal burner, of a size more generally in use by the public, only gave 6.2 candles for the five cubic feet, or considerably less than half the latent value of the gas, which was 16 candles.

The fact of the difference of illuminating power, with like quantities of gas, clearly shows that the two burners are not the same by any means. The statement gravely made in the columns of the *Journal of Gas Lighting* that they are identically the same, clearly shows that if this is the belief of the gas-trade generally with respect to these two burners, it is no wonder that the public, who rely on the recommendations of the trade, continue still to waste their gas in the manner pointed out by the gas referees in 1870 and 1871.

As before stated, careful tests of a collection of burners, bought from different gas-fitters and ironmongers in various towns in England, and from their recommendation, prove that the knowledge of the proper use of gas possessed by these persons is still most incomplete, and, therefore, the general public continue still to burn gas in the same wasteful manner as they did when the gas referees made their report.

The remedy for this enormous waste of gas is in the hands of the public only. Gas producers, whether they are corporate bodies or public companies, are almost powerless to oppose the vested interest which derives large profits from the sale of gas-burners constructed with a view to require frequent renewals. It is only fair to say that the producers of gas have always shown the greatest interest in the improved use of gas in every way; but the speculating builder and his colleague, the local plumber and gas-fitter, hold a final power for evil over the employment of gas, which, till very lately, has been paramount.

Happily for the gas interest, the general public are beginning to take a deep interest in gas, and are acquiring a great amount of information concerning it, through the numerous gas exhibitions which have been held under the auspices of gas companies and corporate gas committees throughout the kingdom, and it is to be hoped that the forthcoming exhibition at the Crystal Palace, in October next, will very largely aid the good work of instructing the public how to use gas to the best advantage. Thus we may hope that soon the ring of interest inimical to the progress of gas will be broken through, and fresh encouragement given to the inventors of improvements in the use of gas. It will be impossible, in the limits of this paper, to give you a complete idea of all the improvements which have been, and are still being made; but I propose to indicate the direction they are taking, and give you a general idea of what they are.

It has been found that a comparatively large quantity of gas, about four to six times that ordinarily used, will give a much better result from one burner per cubic foot of gas consumed than can be obtained from four or six separate burners consuming the aggregate quantity of gas equal to that consumed by the large one; and this is true of both Argand and flat-flame burners. This is by no means a new idea; it was known to Faraday and others before him. I have in my possession an old burner made many years ago; it has several rings and a silver top drilled with very fine holes. The quantity of gas used is large—the effect is small—in fact, it is more useful for boiling water than for giving light. But this old burner is a type of a large Argand of twenty or thirty years ago. They did not succeed, because although they produce a great amount of light, it was at the cost of too much gas. Modern Argands will produce just double the amount of light for the same quantity of gas.

There is also incorporated in some of the newest burners now before the public an idea which was originated by Professor Frankland more than ten years ago, viz., that if the air for combustion supplied to a burner be heated before it arrives at the point of ignition, a much better result per cubic foot of gas consumed can be realized. This you will perceive is a mode of carrying out Sir Frederick Bramwell's idea of keeping the flame hot, and undoubtedly a better result can be obtained. This burner, although it did not come much into use, has very lately been repeated, and is now being sold on the Continent. The burner is so much like Dr. Frankland's that there is no difficulty in recognizing it at once.

Of the modern Argands, there are now several kinds; one is made with two or three concentric rings of flame and a glass chimney, and is made with non-conducting steatite gas chambers, and apertures permitting the gas to issue under an almost inappreciable pressure at the point of ignition, the velocity per hour being only about 1½ miles. In this kind of burner the gas is kept cool and the flame hot. These were first used in the public lighting of Waterloo Road; in 1879, and in Waterloo Place and Queen Victoria Street.

Another kind, of newer type, is made on the theory of keeping the flame hot by making use of the products of combustion to heat the air-supply. This also combines the low velocity of emission theory, and likewise heats the gas itself. It is made by inverting the flame of the burner, the heat generated by the products of combustion being carried away by a concentric flue, fastened round the burner, through which metallic tubes convey the air necessary to produce combustion, which thus becomes heated.

A third is constructed on the principle of keeping the flame hot and the gas cool, but has besides an arrangement for admitting separate currents of cold air round the flame, for the purpose of keeping the chimney cool. It was important to observe that, although this burner does not warm the air admitted to it for promoting combustion, yet the results per cubic foot of gas consumed are stated to be as high as any of the others; showing clearly that there is no advantage in heating the gas before combustion. As to the advantage obtained by heating the air, the practical effect upon an Argand suitable for use by such ordinary unskilled labor as is usually employed to look after gaslights, has not yet been clearly demonstrated; although it is without doubt a great advantage to burners of the flat-flame type, because these have always too much cold air supplied to them.

The Argand, with its more complete regulation of air and its immunity from the effect of surrounding cold air, is able to evolve from 15 to 30 per cent. more light per cubic foot of gas consumed than can be obtained from the best flat-flame burner; but, although the general public have no objection to glass chimneys in paraffin, and other oil lamps, they do not appear to look with favor upon the general employment of glass chimneys for gas burners, no matter how much better the result to be obtained. I need not say that the cordial support of the ring inimical to the true interests of gas is given to the public on this point, and a great deal of very strong literature condemnatory of the Argand burners has been widely disseminated. But it is impossible, in the face of the improvements which are continually being made in gas burners of the Argand type, to believe otherwise than that they are destined to play an important part in the gas lighting arrangements of the future. The improvements in flat flame burners, though not producing such high results as those obtained from large Argands, are great, and, concurrently with improved lanterns, have placed the lighting of the public streets on a much improved footing. Here, again, about three times the amount of light per cubic foot of gas is obtained from the use of large burners than with the old fashioned small ones. The consumption of gas by the large ones is only equal to the aggregate consumption of four or six smaller burners. In addition to this, the improvements in the reflecting tops of the lanterns make the new lamps still more effective, and may fairly be said to double the effective power. In internal lighting, the progress of gas has been very considerable of late years. Small burners for rooms have been greatly improved. For large rooms and theaters new kinds of sun burners are made, to give three times the amount of light obtainable from the old ones, and to ventilate the buildings at the same time.

One of the greatest advantages of gas is that the heat generated by the combustion can, if properly applied, be made to do the work of ventilation, and it is in this direction that the future progress of gas lighting lies. There are many ways of utilizing this heat; some are extremely easy to put into practice, others require more preparation. Among the simplest, is the method of ventilating rooms by the fish-gill ventilator, invented by the late Goldsworthy Gurney. It consists simply in covering an opening made in the wall with strips of calico fastened across the hole by tacks put into the two upper corners of each band. The bands are made just long enough for the lower part of the superior band to cover the top part of the inferior one. When fixed properly, they open like the gill of a fish, hence the name. They can be used to let in fresh air, or carry off heated air from the top of a room.

These useful and simple ventilators, if employed in rooms where gas is used, would tend greatly to the comfort of the public who require a good light; but complain of the resulting heat. They work when closed by diffusion, the heated air passing through the porous medium of the calico, and the cooler air from outside the rooms passing in without draught. For the ventilation of ballrooms it is very easy to put into the windows a frame fitted with muslin or washed calico of half or even the full size of the window. Ventilation will thus take place by diffusion, and the draughts and danger resulting from incautiously opened windows will be avoided. If the wind blows hard on this opening it may be protected by a loose curtain of muslin or calico hanging in front of it.

You will perceive, therefore, from what I have said, that the progress of invention in gas lighting is great and continuous, and that in the future, if the public will only interest themselves just sufficiently to obtain a moderate amount of information on the subject of gas, they will be enabled to use it with great economy and comfort to themselves in every way. The facile manner in which gas can be employed to produce the light of a rushlight or the blaze of a thousand candles by the mere turn of the wrist, joined to the readiness with which it can be conveyed to great distances without any practical loss, will always insure a large and growing demand for it everywhere.

But it must be remembered that its extreme adaptability renders it capable of being used with the most crude apparatus as well as the most perfect; and when we see in the public streets the blazing pipe and shovel, a rough but powerful burner of from 160 to 600 candles power, rigged up in a few minutes by a navvy, we must not be surprised at the prevalence of crude apparatus of smaller dimensions put into practice by the public, who are not aware that they can do better with a more perfect burner.

MARTIN & DUTREMBLAY'S VACUUM BRAKE.

THERE are two systems of brakes in use on the French railways, the Westinghouse compressed air and the Smith & Hardy vacuum brake. The latter is employed by the Company of the North, and has been applied in numerous instances on English and American roads. For the purpose we have in view, it may be described succinctly as follows:

There is a tubing which runs along under each of the cars of a passenger train, and under each car there is fixed an iron plate cylinder which communicates with the general conduit. This cylinder contains a flexible membrane, held between two thin metallic plates. When a vacuum is created in the conduit, the membrane in the cylinder rises with the piston under the effect of atmospheric pressure, and the piston then acts on the brake block through the intermedium of levers whose operation is shown in the accompanying figures. The vacuum is produced instantaneously in the general conduit, and in the cylinder under each car, by the engineman sending a jet of steam into a cone. The velocity of the steam carries along the air, and produces a vacuum and an almost instantaneous locking of all the wheels of the cars. Such is the Smith & Hardy system. Now, we are far from accusing these honorable engineers of copying an invention that it may be that they did not know the existence of; but the similarity of their system to that of M. Martin, whose patents extend back to March 10, 1860, is worth nothing, since the poor inventor, at present forgotten and in a situa-

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