"The diversity as to illuminating power was surprisingly great, and such as will appear incredible to any one who has not ascertained the facts by careful experiment. They also found the kinds of burners in common use are extremely defective, thereby entailing upon the public a heavy pecuniary loss, as well as other disadvantages. In order to examine this important matter more fully, the referees, with the ready permission of the proprietors, inspected several large establishments in the city, where, owing to the prevalence of night work, an unusually large amount of gas was consumed. The inspection in every case confirmed the apprehensions which the referees had formed from their examination of the burners which they had procured from the leading gas-fitting establishments. In the offices of two of the leading daily newspapers (establishments which consume more gas than any other), they found that the burners principally in use gave only 55 per cent. of light compared with the Sugg-Letheby burner, or with Leoni's Albert Crutch burner, and yet the price of the last-named burner is almost identical with that of the very bad burners employed in these offices. Tested by the Bengel burner, or by Sugg's new burner, the amount of light given by these imperfect burners is only between 47 and 49 per cent. of what is obtainable from the gas."

In a communication to the Philosophical Society of Glasgow in 1874 Dr Wallace, the official gas examiner of that city, dealing with the rich cannel gas of a minimum illuminating power of 25 candles there supplied, estimated that there is in ordinary consumption a loss of 40 per cent. of illuminating power which, under favourable circumstances, might be obtained, and that in practice, while not more than 16-candle power is procured, from 20 to 23-candle illumination ought to be readily obtainable.

This universal wasteful misuse of gas is not merely a question of economy, although the aggregate pecuniary loss must be very great. It affects in no small degree the health and comfort of the consumers of gas; the products of combustion of the purest gas vitiate the atmosphere, and overheat the apartments in which it is burned. Moreover, the light from gas properly burned is much steadier and purer, and less trying to the eyesight, than that wastefully consumed.

The principal circumstances which demand attention in the fitting of burners are the average pressure and illuminating power of the gas to be consumed. How pressure may be controlled has already been shown in connexion with governors. The quality or illuminating power of gas has a most important bearing on the nature of burners proper for use, so that a clear distinction must be drawn between common coal-gas and cannel-gas, the burners for the one kind being quite unsuited for the other variety. The maximum amount of light is obtained from any gas just at that point where the flame is on the verge of smoking, and the conditions under which 14-candle gas would be perfectly consumed would, with 26 or 30-candle gas, produce a large amount of smoke. Indeed, the richer gas is, the greater is the difficulty in developing its full illuminating power, and at all times it must be burned in a much thinner sheet or stream than is proper in the case of poor gas, which requires less access of air for its complete luminiferous combustion. The opening or slit in burners used for common gas is therefore much larger than in those devoted to the consumption of cannel-gas.

There are two principal kinds of burners in use—Argand and flat-flame burners. The Argand burner in its usual form is useful only for common or low illuminating power gas, and it has, in the hands of various inventors, especially by Mr William Sugg of London, been so improved that for amount and steadiness of light it leaves little further improvement to be hoped for. The common Argand consists of an annular tube with a circle of small holes pierced in the end of the ring. It thus produces a circular or tubular flame, which requires to be protected with a glass chimney, by which the admission of air is regulated. The burner made by Sugg in 1869, known as the Sugg-Letheby, or Sugg's No. 1, is the standard burner adopted for the United Kingdom in Acts of Parliament, and the same standard has been adopted in the United States, in Canada, and in various European states. At the time it was made, the Sugg No. 1 was esteemed the best known burner, but since that time Mr Sugg has perfected his London Argand, whereby with London gas results equal to about 2 candles better than the standard are obtained. Fig. 20 is a sectional view of Sugg's London Argand with the latest improvements.

At the point at which the gas enters is a brass nose-piece A, screwed to fit the usual three-eighth thread, intended by the manufacturers of all kinds of gas fittings to receive the burner. This is drilled through its length, and slightly trumpeted at the top so as to fit the cone-shaped piece of metal projecting from the roof of the inlet chamber B. The outside of the upper portion of the nose-piece A is screwed to fit the inside of the inlet chamber B, and thus, by an adjustment of this screw by means of paper washers put on the shoulder at AB, it is possible to enlarge or decrease the area of the passage through which the gas has to pass in order to supply three tubes (two of which, C and D, only are shown in the drawing), by which it is further conducted to the combustion chamber E. This chamber is made of steatite, a material which is capable of resisting the corroding action of heat or damp, and is a good non-conductor of heat. It is pierced with a number of holes, so arranged as regards size and number that the quantity of gas the burner is required to consume shall pass out at an inappreciable or the least possible pressure. This is in order that the oxygen of the atmosphere, slowly ascending through the centre opening F, the annulus formed by the edge of the air cone G, and the outside of the combustion chamber E, shall combine with the burning gas by natural affinity only, leaving the nitrogen to pass freely out at the top of the flame. H is one of the three springs which are intended to keep the chimney glass steady in its place. JJ are two of three stubs or rests for a screen, globe, or moon; and K is a peg to steady the current of air which passes up the centre opening F.

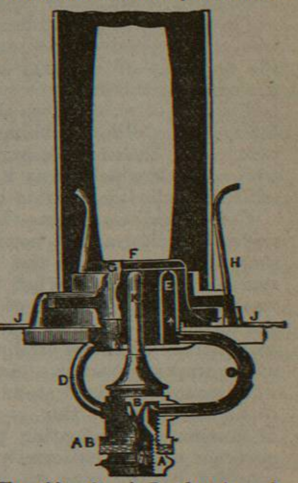


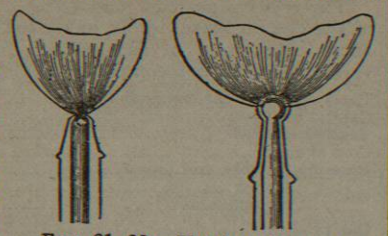
FIG. 20.—Sugg's London Argand Burner.

With the view of competing in illuminating power with the electric light, Mr Sugg has recently devised a modified form of Argand burner calculated to yield a large illuminating power by increased but still economical consumption of gas. These burners are made of two or more concentric Argand rings, the outer being of large diameter, and in operation they give out a large solid, white, steady flame. With London gas, a two-ring burner consuming 19 feet per hour yields 80-candle light; 3-ring burners which consume 23 feet give 100 candles; 4-ring burners fed with 45 feet of gas gave an illumination equal to 200 candles.

As regular pressure is essential for the proper use of these burners, a self-acting governor is frequently fitted to them. The pressure at which the best results are obtained with London gas is about ·7 inch. In a series of experiments with Argand burners made by Mr John Pattinson of Newcastle-on-Tyne the following results were obtained:—

Burner.	Cubic feet per hour.	Illuminating power in Candles.	Illuminating power per 5 cubic feet per hour.
Sugg-Letheby Standard	5·0	14·10	14·10
Sugg's London Argand	5·0	15·90	15·90
Sugg's Improved London Argand	4·5	16·08	17·86
Silber's Argand	5·0	17·80	17·80
Common Argand	5·0	11·20	11·20
Do. do.	7·0	17·80	12·70

Flat-flame burners, or burners which spread their flame in a broad thin sheet, are of two principal kinds known respectively as "fishtail" (fig. 21) and "batwing" (fig. 22) burners. The fishtail or union burner has two orifices drilled in its surface, which are inclined towards each other at an angle of 90°, so that the issuing currents impinge and spread the flame in a broad sheet. The gas in the batwing issues from a narrow slit cut right across the surface. In the best forms of all kinds of burners now in use steatite or adamas (pottery) tops are employed. In Sugg's Christiania burner the slit is circular, and the light issues in two thin sheets which coalesce in their upper luminiferous part, producing a most beneficial result when common gas is consumed. The common metal and steatite-tipped burners in use permit the current of gas to strike against their orifices without any control or regulation, but in the numerous patented forms of both fishtail and batwing jets certain mechanical obstructions, or small governors, are inserted, which break or retard the current. Screws, wire gauze, calico, cotton wool, iron filings, and constriction of the lower part of the burner are all devices in use. Of all these one of the simplest and most effective is the plan on which the Brönner burner is constructed, which is simply to have the opening at the lower part of the burner smaller than the upper orifice. For different qualities and pressures of gas the Brönner burner presents a great variety of combinations by having several distinct sizes of lower constriction which can be adjusted to a large number of tip orifices. Thus, with six distinct openings at each end, 36 combinations can be made. As Argand burners are not suited for measuring the illuminating power of rich cannel-gas, flat flame-burners have to be employed; and in the Act of Parliament under which the Glasgow Corporation supplies gas, it is provided that "all the gas supplied by the corporation shall be at least of such quality as to produce from a union jet burner, capable of consuming 5 cubic feet of gas per hour under a pressure equal to a column of water ·5 of an inch in height, a light equal in intensity to the light produced by 25 sperm candles of 6 in the pound, burning 120 grains per hour."


FIGS. 21, 22.—Flat-flame Burners.

Dr Wallace, in a communication on the "Economical Combustion of Coal-Gas" (*Proc. Phil. Soc. Glasgow*, vol. ix.), tabulates an extensive series of experiments made with flat-flame burners of various sizes with about 28-candle gas at different degrees of pressure. The general result of these experiments shows that, to obtain the highest luminiferous effect with burners of small aperture, a low pressure of gas (not more than ·5 inch) must be maintained, although, as the size of the jet increases within certain limits, the pressure may be increased with favourable results. With 9 sizes of Bray's regulator fishtail (a burner having an obstruction consisting of a double fold of cotton cloth) Dr Wallace obtained the following results, calculated to 5 cubic feet per hour:—

Burner	0	1	2	3	4	5	6	7	8
At ½-inch pressure......	14·5	17·4	20·0	23·6	25·0	26·15	27·0	28·16	28·08
At 1-inch „	11·7	13·3	17·6	20·6	23·6	26·2	28·7	30·2	32·0
At 1½-inch „	8·8	9·8	13·9	17·5	19·4	23·7	25·9	gas	blows.

The gas used in the ½-inch experiments was 27·72-candle standard, for the 1-inch series it was 29·05, and for the 1½-inch set it was 28·61-candle. With 30 combinations of Brönner burners Dr Wallace obtained from 28·2-candle gas at 1 inch pressure an average of 25·7, and at 1½-inch 25·8-candle power, most of the combinations giving fairly equal results.

Of all burners the ordinary fishtails, and they are the most frequently used, give the most inferior results when used for burning common coal-gas. The results tabulated below are derived from the series of experiments by Mr Pattinson of Newcastle already quoted. The experiments were made with 14·10-candle gas, from which it must be remembered 17·86-candle power was developed in Sugg's improved London Argand:—

	Cubic feet per hour.	Illuminating power.	Illuminating power at 5 ft. per hour.
Fishtail, No. 3, steatite top ...	4	3·0	3·75
„ „ metal top	3·5	4·10	5·85
„ No. 4, steatite top....	4·9	5·20	5·31
„ No. 5, „	5·0	7·80	7·80
Batwing, metal top..............	5·0	9·26	9·26
Fishtail, Bray's, No. 4.........	4·0	5·02	6·28
„ „ No. 8.........	5·0	11·80	11·80
„ „ „	7·0	14·21	10·15
Batwing, Brönner's. No. 4	4·0	10·10	12·62
„ „ „	5·0	11·60	11·60
„ Sugg's. „	4·0	8·40	10·50
„ „ „	5·0	10·90	10·90

From these experiments it appears that there are burners in common use which, consuming the same amount of gas, differ in light-giving effect from 3·75 to 12·62-candles, one giving more than three times as much light as the other; and if we take the best Argand burner into account, the range of variation is from 3·75 to 17·80, or as one to five nearly. Another important deduction from these observations is that large-sized burners as a rule give much more illuminating power than the smaller sizes. Thus a burner passing 7 feet of gas per hour will almost invariably distribute more light than two each burning 3·5 feet.

Gas Testing.—The universally recognized and practised method of valuing gas is by comparing its light with that yielded by a standard light, which can be obtained as nearly as possible of an unvarying intensity. In making such a photometric comparison it is essential that the conditions under which the lights to be compared are burned shall be uniform, and that the materials be consumed at a definite rate. The standard recognized by legislative authority in Great Britain and America is the burning of a sperm candle 6 to the ℔. consuming at the rate of 120 grains of sperm per hour, compared with gas burning at the rate of 5 cubic feet per hour. The burner prescribed for common gas is the Sugg-Letheby-Argand, in Acts of Parliament defined as a 15-holed Argand with a 7-inch glass chimney; and for rich cannel-gas a union or fishtail jet passing 5 feet per hour is employed. The apparatus employed for making the comparison is generally the Bunsen photometer, or some modification of that instrument; and the ratio of comparative illumination is established by the well-known principle that the intensity of light diminishes in inverse proportion to the square of the distance from its source. The Bunsen photometer consists of a bar of wood 98 inches long, with a candle holder at one end and at the other the standard gas burner. A balance for weighing the candle as it burns, an indexed meter for the gas, and a clock are also provided. The bar is graduated from the centre to each end, and on it is set a sliding holder into which a screen of prepared paper is placed. The screen is so prepared that a spot or disc is more opaque than the remainder of the paper, so that when light passes through it from one side, that particular spot is seen distinctly darker than the rest. When, however, equal amounts of light fall on it from both sides the spot disappears, and the whole surface presents a uniform appearance. Therefore, with both candle and gas burning under the stipulated conditions in a darkened chamber, by moving the screen on the graduated bar from the one light and towards the other till the dark spot on the paper disappears, the comparative illuminating power of the light is ascertained by the position of the screen on the graduated bar, or by a simple arithmetical calculation. Thus, the lights being 100 inches apart, if at the conclusion of the experiment the screen is 20 inches from the candle and 80 from the gas jet, since 80^2 is 16 times 20^2, the gas is 16-candle power.

Comparisons of the quality of gas are also made by the jet photometer, an apparatus which depends on the principle that gas of uniform quality burned at invariable pressure, through a small orifice, yields a flame of uniform height. If the flame is to be maintained at a uniform height the pressure in the pipes must increase as the quality of the gas decreases. The jet photometer forms a ready and convenient means of ascertaining any variations in the quality of gas supply; but it is not available for purposes of comparison.

Analysis of gas does not yield so satisfactory evidence of its illuminating value as photometric comparisons, but various methods of ascertaining the proportion of luminiferous olefines contained in any gas are occasionally practised. The absorption of the heavy hydrocarbons by chlorine or by bromine, and Dr Fyfe's durability test, are of theoretical rather than practical importance.

Residual Products.—Under this term are embraced coke, ammoniacal liquor, and gas-tar, all of which are sources of income in the gas manufacture. Indeed the value of these products has increased so rapidly of late years, and they now form the basis of manufactures of such consequence, that the residual products can scarcely be regarded as of secondary importance, and they will certainly play no small part in determining the future maintenance of gas-lighting in the face of other competing systems. The change in the valuation of ammonia and tar liquors is well illustrated by the circumstance that, during the year 1878, the corporation of Bradford was offered £10,000 per annum for these products, which about eight years previously had been disposed of for a yearly payment of £800.

Coke is a substance which varies much in value, according to local circumstances, and the nature of the coal distilled. When shale is used, there remains in the retorts an ashy residue which is absolutely worthless; and the coke of cannel coal is also comparatively of little value, owing to the amount of ash it yields. Indeed, in Scotch works where ashy cannel alone is distilled, the retorts have to be partly fired with common coal. The coke obtained from the distillation of caking coal, on the other hand, is of high value, and after a supply is set aside for heating the retorts there generally remains from 65 to 85 per cent. of the whole amount to be disposed of by sale.

Ammoniacal liquor is more abundantly produced by the distillation of cannel than by common coal, from 18 to 22 ℔ of ammonia, as sulphate, being obtained from each ton of cannel distilled, as against about 16 ℔ derived from ordinary coal. Gas liquor is now almost the sole source of ammonia, which, among other purposes, is very largely employed as an agricultural fertilizer.

Tar liquor yields by destructive distillation a wide range of products possessing a great and increasing industrial value. The cannel coals, and other varieties rich in volatile matter, are also the kinds which yield the largest proportion of tar. In the distillation of coal-tar, after some ammoniacal and watery vapours have been given off, there is distilled over a proportion of highly volatile fluid hydrocarbons which consist principally of benzol; and afterwards a large amount of a light oil, known as coal naphtha (also a mixture of various hydrocarbons), is obtained. At this point the residue in the retort is called artificial asphalt, and as such is a commercial article; but if the heat is forced, and the distillation continued, a large amount of "heavy" or "dead oils" is obtained, and the mass left in the still is "hard pitch." The heavy oils are a mixture of naphthalin, phenol (carbolic acid), cresol (cresylic acid), and anthracene, &c. The benzol obtained in the first stage of the distillation is the basis of aniline and its various dyes; naphtha is used as a solvent, and for lighting and other purposes; carbolic acid, in addition to its employment as an antiseptic, is the basis of many valuable dyes; anthracene forms the source of the now most important dye, artificial alizarin; and most of the substances have other applications of minor importance.

The relative position and value of the various products of the gas manufacture is exhibited by the following condensed statement of the position and operations of the various London gas companies during the year 1875:—

Total capital of the companies	£12,516,009
Capital called up	11,005,589
Total gas rental	2,606,818
Cost of coal	1,455,407
Receipts for coke and breeze	492,927
,, for tar	162,151
,, for ammonia	111,951
Gas produced	14,888,133 thousand feet.
Gas sold	13,622,639 ,, ,,
Coal carbonized (4 per cent. cannel)	1,505,000 tons.
Coke produced, 34 bushels per ton	1,417,654 chaldrons.
Coke used as fuel in retorts, 31 per cent.	440,685 ,,
Coke sold, 69 per cent.	976,969 ,,
Average yield of gas per ton of coal	9,892 cubic feet.

Gas from Sources other than Coal.

Petroleum-Gas.—Petroleum being a substance obtained in great abundance, notably in America, is used, not only directly as an illuminating agent, but also for the production of gas; and as an enricher of common coal-gas it is applied at several works in New York and Brooklyn. Its preparation is effected by distilling it first at a low temperature into a rich vapour, which, when passed into highly heated retorts, is converted into permanent gas of an illuminating power about five times greater than common gas, and which is, moreover, absolutely free from ammonia, sulphur compounds, and carbonic acid. On account of its great richness, petroleum-gas must be consumed in special burners of very fine aperture, at a rate varying from 5 to 2 feet per hour.

Oil-Gas.—In the early stages of gas manufacture many attempts were made to substitute gas distilled from inferior oils for coal-gas. The oil was distilled by allowing it to percolate into highly heated retorts, in which a quantity of coke or a like porous solid was placed, and the distillate was a richly luminiferous gas free from hurtful impurities. Although oil in this form yields a convenient and powerful illuminant, its direct combustion is much more economical; and as all oils and fats are highly valuable for many purposes besides illumination, they cannot compete with gas coal as a source of gas. Nevertheless the New York Gas Light Company manufactured oil-gas exclusively from 1824 till 1828, and sold their product at $10 per 1000 feet. The distillation of suint from wool washing, and of recovered spent soap, are examples of the application of oleaginous substances for gas-making.

Resin-Gas.—In its treatment and results resin, as a source of gas, is very similar to oil. It yields a pure gas of great illuminating power, and for twenty years (1828–48) it was supplied in New York at $7 per 1000 feet. Previous to the civil war of 1861–65 it was a good deal used on the European continent.

Wood-Gas.—The original experiments of Lebon, it will be remembered, were made with wood-gas, but he failed to obtain from his product an illuminating power that would compare with that of coal-gas. Lebon's failure was in later years shown to arise from distilling at a temperature which gave off chiefly carbonic acid with non-luminous carbonic oxide and light carburetted hydrogen, leaving in the retort a tar which the application of a higher heat would have resolved into highly luminiferous gases and vapours. Pettenkofer, who pointed out the fact, devised a system of wood-gas making in which the products of the low-heat distillation were volatilized by passing through a range of red-hot pipes; but now it is found that ordinary retorts, properly heated and fed with small charges, answer perfectly well for the operation. Wood-gas, owing to its high specific gravity and the proportion of carbonic oxide it contains, must be burned at considerable pressure, in specially constructed burners with a large orifice. It is largely used in Germany, Switzerland, and Russia, where wood is more easily obtained than coal. It was used at Philadelphia gas-works in 1856, where it was affirmed to be cheaper and of greater luminosity than coal-gas.

Peat-Gas is evolved under circumstances the same as occur in connexion with the wood-gas manufacture, but the amount of moisture contained in peat is a serious obstacle to its successful use in this as in most other directions. Earnest and persistent efforts have been made to use peat as a source of gas, but these have met but little commercial success. To a limited extent it is used in various German factories which happen to be situated in the immediate neighbourhood of extensive peat deposits.

Carburetted Gas.—Under this head may be embraced all the methods for impregnating gaseous bodies with vapours of fluid or solid hydrocarbons. The objects aimed at in the carburetting processes are—(1) to increase the illuminating power of ordinary coal-gas; (2) to render non-luminous combustible gases, such as water-gas, luminiferous; and (3) so to load non-combustible gases with hydrocarbon vapour as to make the combination at once luminiferous and a supporter of combustion. The plans which have been proposed, and the patents which have been secured for processes of carburetting, coming under one or other of these heads, have been almost endless; and while the greater part of them have failed to obtain commercial success, they are sufficient to indicate that there is still a possibility of doing much to increase the effect and cheapen the cost of production of gas. Further, although for extensive use none of the gas-making plans can compete with coal-gas manufacture, some of them are of much value for private establishments, country houses, factories, and similar places, where connexion with coal-gas works cannot be obtained.

The carburetting of common coal-gas with the vapour of benzol obtained by the distillation of gas-tar was originally suggested by Lowe as early as 1832, and subsequently by the late Charles Mansfield, who showed that by passing gas over sponge saturated with benzol a very great addition was made to the illuminating power; and he introduced an apparatus by which common gas could thus be benzolized at a point very near the burner. The facts, however, that benzol is a highly inflammable liquid, that the benzolized gas varied in richness owing to the gas taking up much more benzol when the carburetter was newly charged than it did afterwards, and consequently that it often produced a smoky flame, and that sulphur compounds accumulated in the carburetter, as well as the trouble connected with charging the apparatus, all combined to prevent the extensive introduction of the process. In later times the value of benzol for aniline manufacture and other purposes would have been a serious bar to its use. Mr Bowditch introduced the use of a heavier hydrocarbon—a mixture of naphthalin with cymol—which he called carbolin, and which possesses the advantage of giving off no inflammable vapour at ordinary temperatures, and is, moreover, a substance for which no commercial demand exists. The carburetting appliance had to be placed in immediate proximity to the burners, and either heated by them direct, or by a small subsidiary jet, as the vapour of naphthalin solidifies on a very small fall of temperature and chokes up pipes. Carburetting by means of a solid block of naphthalin introduced into a gas-tight box, and partly volatilized by a strip of copper passing from the burner flame into the box, has recently been proposed, and is now being carried into effect with every prospect of great increase of illuminating power, and consequent economy, by the Albo-Carbon Light Company.

The efforts to introduce carburetted water-gas have been numerous and persistent; and the sanguine statements of the various inventors have led to the loss of much capital through experiments undertaken on a great scale which have always resulted unfavourably. The whole of the proposed processes depended on the decomposition of water by passing it over highly-heated surfaces in presence of glowing charcoal, whereby free hydrogen, carbonic oxide, and carbonic acid gases are produced, the carbonic acid being eliminated by a subsequent process of purification. The combustible gas so obtained was in earlier experiments charged with luminiferous hydrocarbons by being passed into a retort in which coal, resin, or oil was being distilled, as in Selligue's and other processes; or, as in White's hydrocarbon process, both steam and coal were treated together in a special form of retort. Since the introduction of American petroleum, however, most methods of carburetting water-gas have been by impregnating it with the vapour of gasolin, the highly volatile portion of petroleum which comes over first in its distillation for the preparation of "kerosene" lamp oil. Water-gas has been proposed, not only as an illuminating agent, but at least as much as a source of heat; but the heat expended in the decomposition of water is much greater than can in practice be given out by the resulting gases.

Several of the processes introduced for rendering ordinary atmospheric air at once combustible and luminiferous, by saturating it with the vapour of gasolin, have been so satisfactory that this air-gas is now largely used both in America and Europe for lighting mansions, churches, factories, and small rural districts. The general principle of the air-machines will be understood from the following description of the "sun auto-pneumatic" apparatus (Hearson's patent), which is, in extensive use throughout Great Britain. Hearson's machine is cylindrical in form (fig. 23), and is

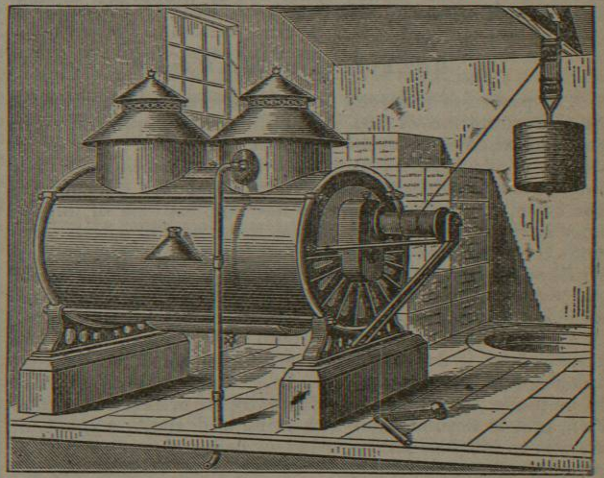


Fig. 23.—Sun Auto-Pneumatic Apparatus.

surmounted by two turrets. Internally the cylinder is divided into two compartments by a transverse portion, one being occupied by a rotary blower, an apparatus similar in construction to the drum of a water-meter, and the other by an elevator or dipper wheel, the function of which is to raise gasolin into the blower chamber, where the gasolin must be maintained at a constant level. The blower and the elevator mechanism are set in operation by being mounted on a spindle which passes through and outside the cylinder, and is turned either by a weight attached to a length of steel wire or, where convenient, by hydraulic power. The turrets contain (1) a gas-holder which supplies gas while the machine is being wound up, should any light be then burning, and (2) a governor to regulate the pressure of the issuing gas. The apparatus works only when gas is being burned, and moves in proportion to the demand on it up to its limit of production. There is therefore no necessity for storing, as indeed would be impracticable with this form of carburetted gas. The function of the blower is not only, by its revolution, to press forward the gas into the supply pipes, but also to carburet the air by exposing continually renewed thin films of the liquids to its influence on the moist metallic surfaces. The revolution of the blower, moreover, maintains an unceasing agitation in the gasolin, vaporizes the liquid in an equal and uniform manner, and keeps the entire volume at the same temperature throughout. The quantity of gasolin operated on being comparatively large, the temperature of the liquid decreases only slowly, and is in ordinary conditions sufficiently recouped from the external air to keep it in good working order throughout any length of time.

M. Tessie du Motay, who for many years advocated a modified system of lime-light, latterly abandoned that system in favour of a form of carburetted gas. His system necessitates two sets of pipes and a special form of burner,—one pipe supplying ordinary coal-gas or highly carburetted hydrogen, and the other leading in a supply of oxygen, whereby a powerful, steady, white light is maintained at the burner. Philipps of Cologne has also utilized oxygen in a comparatively pure state for burning in a lamp with a wick a mixture of heavy hydrocarbons, which in common air would burn with a very smoky flame.

Other sources of gas, such as tar, and even fæcal matters, have been proposed; and many modified forms of gaseous illumination have been brought forward which, even to name here, would occupy space out of proportion to their importance.

The Future of Coal-Gas.

The processes involved in the preparation, distribution, and consumption of coal-gas still remain essentially the same as when the system was first elaborated; but in all details of the industry numerous improvements have been introduced, resulting in marked economy and efficiency of the system. In the meantime new applications of importance have been found for coal-gas in connexion with heating and cooking, and as a motive power in gas-engines. Further, collateral industries have been superadded to the gas manufacture, which in themselves are of such value and importance that, were the distillation of coal as a source of artificial light to cease, it would certainly continue to be practised as a source of the raw materials of the coal-tar colours, and of carbolic acid, &c. Were coal-gas to cease to be made primarily and principally for artificial illumination, and to become more a heating and cooking agent, or were it to fall into the position of being a mere collateral product of the manufacture of tar, it is certain that the manufacturing processes would be very materially modified. Costly cannel-gas, with its high illuminating power, is no better suited for a gas engine than common gas; and for heating purposes a much greater yield of gas might be obtained, which, in burning, would evolve more heat than is sought in making illuminating gas. But as matters now stand, the fact that illumination, heat, motive power, and dye-stuffs are all obtained by means of the manufacture as at present conducted is a consideration of much weight in dealing with rival systems of artificial lighting.

Throughout the whole experience of gas manufacture the efforts of inventors have been directed, not only to improve the manufacture of coal-gas, but also to supersede its ordinary processes, and to supplant it by gas yielded by other raw materials or by new systems of illumination. The persistent efforts which have been made to improve coal-gas, and the success which many of the plans exhibit in their experimental stage, warrant the conclusion that the processes and results of the manufacture are still susceptible of much improvement. When it is considered how exceedingly small is the total proportion of illuminants in coal-gas to the bulk of the materials dealt with, it is not difficult to imagine that modifications of processes may be devised whereby a great increase of lighting effect might be practically available, and at the same time a greater percentage of the total heat-giving power of the coal secured for domestic and manufacturing purposes. Notwithstanding the confessed imperfections of the system of coal gas-making,—the evil odours which attach to the works, the yet more offensive exhalations given off from streets through which the main-pipes are led, the destructive accidents which occasionally occur from gas explosions, and the heat and sulphurous fumes evolved during its combustion,—not one of the numerous substitutes which have been proposed has been able to stand in competition against it in any large town or city where coal is a marketable commodity. As against the system of electric lighting, which is now being brought into competition with it, the ultimate fate of gas may be different. It may be regarded as already demonstrated that for busy thoroughfares—almost, it may be said, for open-air lighting generally—and for large halls and enclosed spaces, electric lighting will, in the near future, supersede gas. The advantages of the electric light for such positions in brilliancy, penetration, and purity are so manifest that its use must ultimately prevail, irrespective of the question of comparative cost, and of the fact that municipalities and wealthy corporations have an enormous pecuniary stake in gas-property. That the electric light will be equally available for domestic illumination is, however, not yet so certain; and until it is demonstrated that a current may be subdivided practically without limit, that the supply can adapt itself to the demand with the same ease that the pressure of gas is regulated, and that the lights can be raised and lowered equally with gas-lights—till these and other conditions are satisfied, the disuse of gas-lighting is still out of sight. Should these conditions, however, be satisfied, there can be little doubt that gas-lighting will enter on a period of severe competition and struggle for existence; and in the end the material which at one time was regarded as a most troublesome and annoying waste—the gas-tar—will, in all probability, exercise a decisive influence on the continuance of the gas manufacture.

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GASCOIGNE, George (*c.* 1535–1577), one of the great pioneers of Elizabethan poetry, was born about 1535—as is believed, in Westmoreland. He was the son and heir of Sir John Gascoigne. He studied at Cambridge, and was admitted to Gray's Inn in 1555. His youth was unsteady, and his father disinherited him. In 1565 he had written his tragi-comedy of *The Glass of Government*, not printed until 1576. In 1566 his first published verses were prefixed to a book called *The French Littleton*, and he brought out on the stage of Gray's Inn two very remarkable dramas, *Supposes*, the earliest existing English play in prose, and *Jocasta*, the first attempt to naturalize the Greek tragedy. Of the latter only the second, third, and fourth acts were from his hand. Soon after this he married. In 1572 there was published *A Hundred sundry Flowers bound up in one small Posy*, a pirated collection of Gascoigne's lyrics, he having started in March of that year to serve as a volunteer under the Prince of Orange. He was wrecked on the coast of Holland and nearly lost his life, but obtained a captain's commission, and acquired considerable military reputation. An intrigue, however, with a lady in the Hague, nearly cost him his life. He regained his position, and fought well at the siege of Middleburg, but was captured under the walls of Leyden, and sent back to England after an imprisonment of four months. In 1575 he issued an authoritative edition of his poems under the name of *Posies*. In the summer of the same year he devised a poetical entertainment for Queen Elizabeth, then visiting Kenilworth; this series of masques was printed in 1576 as *The Princely Pleasures*. Later on in 1575 he greeted the queen at Woodstock with his *Tale of Hemetes*, and presented her on next New Year's day with the MS. of the same poem, which is now in the British Museum. He completed in 1576 his two most important works, *The Complaint of Philomene*, and *The Steel Glass*, the first of which had occupied him since 1562; they were printed in a single volume. Later on in the same year he published *A delicate Diet for dainty-mouthed Drunkards*. He fell into a decline and died at Stamford on the 7th of October 1577. We are indebted for many particulars of his life to a rare poem published in the same year by George Whetstone, and entitled *A Remembrance of the Well-employed Life and Godly End of George Gascoigne, Esquire*. In his poem of *The Steel Glass*, in blank verse, Gascoigne introduced the Italian style of satire into our literature. He was a great innovator in point of metrical art, and he prefixed to the work in question a prose essay on poetry, which contains some very valuable suggestions. His great claim to remembrance was well summed up in the next generation by Thomas Nash, who remarked in his preface to Greene's *Menaphon*, that "Master Gascoigne is not to be abridged of his deserved esteem, who first beat the path to that perfection which our best poets aspired to since his departure, whereto he did ascend by comparing the Italian with the English." The works of Gascoigne were collected in 1587, and partly republished in 1810 and 1821. The best modern edition of the principal poems is that edited, with full bibliographical notes, by E. Arber in 1868.

GASCOIGNE, Sir William, was chief-justice of England in the reign of Henry IV. Both history and tradition testify to the fact that he was one of the great lawyers who in times of doubt and danger have asserted the principle that the head of the state is subject to law, and that the traditional practice of public officers, or the expressed voice of the nation in parliament, and not the will of the monarch or any part of the legislature, must guide the tribunals of the country. The judge was a descendant of an ancient Yorkshire family. The date of his birth is uncertain, but it appears from the Year Books that he practised as an advocate in the reigns of Edward III. and Richard II. On the banishment of Henry of Lancaster, Gascoigne was appointed one of his attorneys, and soon after Henry's accession to the throne was made chief-justice of the Court of King's Bench. After the suppression of the rising in the north in 1405, Henry eagerly pressed the judge to pronounce sentence upon Scrope, the archbishop of York, and the earl marshal Thomas Mowbray, who had been implicated in the revolt. The judge absolutely refused to do so, asserting the right of the prisoners to be tried by their peers. Although both were afterwards executed, the chief-justice had no part in the transaction. The often told tale of his committing the Prince of Wales to prison has of course been doubted by modern critics, but it is both picturesque and characteristic. The judge had directed the punishment of one of the prince's riotous companions, and the prince who was present and enraged at the sentence struck or grossly insulted the judge. Gascoigne immediately committed him to prison, using firm and forcible language, which brought him to a more reasonable mood, and secured his voluntary obedience to the sentence. The king is said to have approved of the act, but there appears to be good ground for the supposition that Gascoigne was removed from his post or resigned soon after the accession of Henry V. He died in 1419, and was buried in the parish church of Harewood in Yorkshire. Some biographies of the judge have stated that he died in 1412, but this is clearly disproved by Foss in his *Lives of the Judges*; and although it is clear that Gascoigne did not hold office long under Henry V., it is not absolutely impossible that the scene in the fifth act of the second part of Shakespeare's *Henry IV.* has some historical basis, and that the judge's resignation was voluntary.

GASCONY, an old province in the S.W. of France, nearly identical with the *Novempopulania* or *Aquitania Tertia* of the Romans. Its original boundaries cannot be stated with perfect accuracy, but it included what are now the departments of Landes, Gers, and Hautes-Pyrénées, and parts of those of Haute-Garonne and Ariége. Its capital was Auch. About the middle of the 6th century there was an incursion into this region of *Vascons* or *Vasques* from Spain, but whether of a hostile kind or not is uncertain; but as the original inhabitants, in common with those of the rest of Aquitaine were also *Vasques*, it is probable that the province owes its name Gascony less to this new incursion than to the fact that its inhabitants continued so long to maintain their independence. In 602 they suffered defeat from the Franks and were compelled to pay tribute, but they continued to be governed by their own hereditary dukes, and gradually extended the limits of their dominions to the Garonne. The province was overrun by Charlemagne but never completely subdued, and in 872 it formally renounced the authority of the French kings; but through the extinction of the male line of hereditary dukes of Gascony in 1054 it came into the possession of the dukes of Guienne (or Aquitaine), with which province its history was from that time identified (see Aquitania and Guienne).

GASKELL, Elizabeth Cleghorn (1810–1865), one of the most distinguished of England's women-novelists, was born at Cheyne Row, Chelsea, September 29, 1810. She was the second child of William Stevenson, of whom an account is given in the *Annual Biography and Obituary* for 1830. Mr Stevenson, who began life as classical tutor in the Manchester Academy, and preached also at Doblane, near that town, afterwards relinquished his ministry and became a farmer in East Lothian; and later, on the failure of his farming enterprises, he kept a boarding-house for students in Drummond Street, Edinburgh, where he also became editor of the *Scots Magazine*, and contributed largely to the *Edinburgh Review*. At the time of his daughter's birth Mr Stevenson had been appointed Keeper