has a thought of and a longing for a future life; to him alone could the thought and hope of a future life have any meaning, for he alone is capable of that lofty desire for improvement, for spiritual perfection, for fuller knowledge of God, for love and light, which the life hereafter promises to satisfy. In a world where every other instinct and natural desire points to a corresponding satisfaction, who can believe that this desire for the life hereafter, and for what that life promises, is a mockery and a delusion?

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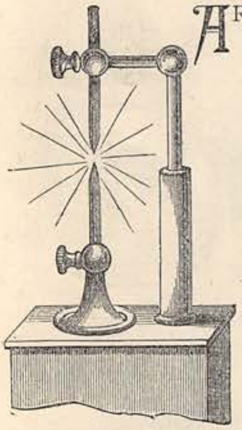
FROM GAS TO ELECTRICITY.



ARTIFICIAL gas is now distilled from a great variety of substances, among which are coal, shale, lignite, petroleum, turf, wood, resins, oil, fats, and vegetable refuse. The best of these processes for general purposes is the ordinary coal distillation now so common. The best kind of coal for gas-making is bituminous coal of the pitch and cannel sorts. As a rule, the coals which yield the highest percentage of gas furnish also that of highest illuminating power. The cannel or "gas-coals" of Scotland and Lancashire are the richest in gas, and hence it is that gas-lighting is so prevalent in Scotland, where, in the towns at least, every bedroom and passage has its jet.

The following simple experiment illustrates very well the distillation of coal-gas. "When," says a recent writer, "the bowl of an ordinary clay pipe is filled with small fragments of bituminous coal, covered over with clay, and placed in a bright fire, immediately smoke is seen to issue from the stalk which projects beyond the fire. The smoke soon ceases, and if a light is then applied to the orifice of the stalk, the issuing gas burns with a bright steady flame, while a proportion of a black, thin, tarry liquid oozes out from the stalk. After the combustion ceases, there is left in the bowl of the pipe a quantity of char or coke." As practised on a large scale, retorts of iron, clay, or brick take the place of the pipe. These are heated to a bright red in retort furnaces having fires of coke and coal, and charged or cleared by manual labour as the distillation proceeds. From the retorts within the furnace the crude gas passes by vertical "ascension" pipes to a long chamber containing water, termed the "hydraulic main," where tar is condensed out of it, and flows by a pipe to the tar-well. From the hydraulic main the gas, which is still of a high temperature, is next passed through a series of long pipes termed the "condenser," to cool it, and thereby free it from the heavier hydro-carbons which adulterate it. These pipes open at one end into a series of troughs filled with water, and the tar and ammoniacal liquor collect in these, the tar sinking to the bottom while the liquor floats on the top. The gas has yet to pass through the purifiers, and to help it on its way, and prevent a too great back pressure in the retorts, it is subjected to exhaustion by means of various contrivances termed "exhausters," which have in general a fan-like action. After this process the gas is relieved of ammonia, sulphuretted hydrogen, carbonic acid, and other impurities. The ammonia is separated by passing the gas through the "scrubber," which is usually a hollow tower divided vertically into two compartments, which are filled with coke and water. The gas flows up one side and down the other; the ammonia unites with the water, and the ammoniacal liquor is discharged at the top. The sulphuretted hydrogen and carbonic acid are both freed from the gas by the "lime purifier," which, consists of a chamber stored with tiers of trays containing slaked lime. The gas is allowed to diffuse itself over the surface of the lime, and thereby delivers up its impurities. Instead of slaked lime, quicklime and hydrated oxide of iron are also employed to separate the carbonic acid and sulphuretted hydrogen from the gas, the latter uniting with the oxide to form a sulphide of iron, while the quicklime absorbs the carbonic acid.

The gas is now ready for use, and after traversing the station meter it is stored in the gas-holders, from which it is distributed by main and service pipes to the consumers' homes, where a meter is placed to register the amount consumed.

Meters are of two kinds, wet and dry. In the wet meter the gas drives round a kind of drum partially immersed in water, and the drum actuates the hands on the indicating dial. In the dry meter the gas enters a kind of double bellows, which it causes, by means of valves, to expand and contract in such a way as to communicate motion to the hands of the indicator through the medium of a train of mechanism.

In order to make gas burn with perfect steadiness, the pressure at the burner itself should be quite uniform; but this is not so unless a special "consumer's governor" be employed. The principle of this device is the same as that which regulates the larger governor at the gas-works, namely, causing the pressure of the gas to regulate mechanically the size of the orifice through which the gas escapes to the flame. Among the best of these governors are those now so extensively applied to street lamps. In one kind the gas flows into an expansible chamber, or holder, the expansion of which under the pressure of the gas regulates the size of the outlet by means of a half-ball valve; while in the latter the same object is effected by causing the gas to press upon a thin diaphragm.

The gas-burners in common use are of a very inferior sort, and it is estimated that they only give about one-half of the light which the amount of gas consumed is capable of giving. This is chiefly due to the fact that it is against the interests of the gas companies to improve private burners; but when the enormous waste of gas and the vitiated air, as well as the trying light, which result from bad combustion, are considered, the great importance of securing good burners comes home to all. As rich cannel (or 30-candle) gas requires to be burnt in a thinner stream than poor coal (or 14-candle) gas, the slits in burners for the former require to be much thinner than for the latter. There are two kinds of burners in use—the Argand and the flat-flame. The Argand, which only burns poor gas, consists of an annular tube with a circle of small holes pierced in the end of the ring, and it consequently gives a tubular flame. It is principally used in offices, and is protected by a cylindrical glass chimney. That known as Sugg's No. 1 is the best, and has been adopted by Act of Parliament as the standard burner for the United Kingdom. Last winter, in order to compete with the electric light, Mr. Sugg devised a compound Argand consisting of several concentric simple burners, and these lights may now be seen illuminating several of the wider London streets—the four-ring pattern yielding a light of 200 candles. Flat-flame burners are of two kinds, the "fish-tail" and the "bat-wing." The former has two holes drilled at an angle, so that the two jets of gas impinge on one another in issuing, and the velocity of the particles being thereby impeded, a more complete combustion is the result. The light of a fish-tail is sensibly increased by inserting a "Scholl's platinum perfecter," which is simply a tiny slip or thin partition of platinum between the two jets. The bat-wing burner has a narrow slit cut across the point, and from this the gas issues. In all the best burners now used the tops are made of steatite or of "adamas" pottery. In the "Christiania" burner, the slit is circular, and the light issues in two thin sheets which blend in their upper parts, and produce a great increase of light over the ordinary burner. As the common metal and steatite burners allow the gas to rush from their orifices without any attempt at regulation, various devices have been patented for retarding the escaping current. The simplest and best of these is Brönner's burner, which has the opening in its lower part smaller than the upper orifice; and the width of either opening can be readily varied at will so as to suit different qualities and pressures of gas. Of all burners the ordinary fish-tails in general use give the poorest light. From experiments made by Mr. Pattison, with the usual 14-candle gas, it appears that the illuminating powers of different burners, each consuming five cubic feet of gas per hour, were represented by the following numbers:—Fish-tail, No. 3, steatite top, 3·75; do., do., metal top, 5·85; do., No. 4, steatite top, 5·31; do., No. 5, steatite top, 7·80; Bat-wing, metal top, 9·26; Fish-tail, Bray's No. 4, 6·28; do., Bray's No. 8, 11·80 and 10·15; Bat-wing, Brönner's No. 4, 12·62 and 11·60; Bat-wing, Sugg's No. 4, 10·50 and 10·90. From these figures it is evident that there are burners in use which for the same amount of gas consumed give three times the amount of light obtained from others, and if the best Argand burner be taken into account the range is actually from one to five times.

The latest competitor for public favour as an illuminant is the electric light, and though it has been in existence under some form or other for the last seventy years, it has only now established a sure footing in practice, a footing which has but to be advanced by a train of improvements in order to render it the chief light of the future.

Every solid body, whatever its nature, becomes luminous when raised to a temperature of 1,000° of Fahrenheit's thermometer, and emits a dull red light. As this temperature is increased the light comes brighter, in a proportion exceeding the corresponding rise of temperature. Thus at 1,300° the body emits orange rays, at 1,500° blue rays, at 2,000° violet rays, so that a body heated to a temperature of over 2,000° will yield all the rays of the sun. With candles, lamps, and gas, the heat necessary to produce these high temperatures of luminosity is generated, as we have seen, by chemical combination, but in the electric light is generated by a current of electricity. There are two modes of applying the current so as to transform it into heat and light: one is to make it jump through the air across a gap in the conducting circuit between two pieces of carbon or other refractory conductor; and the other is simply to make it flow through a narrow pencil of carbon, or a fine metal wire. In the first of these cases the current encounters great resistance in bridging the non-conducting air-space, and spends its energy in overcoming it, while at the same time it tears away the atoms of one of the carbon "poles" and, raising them to a dazzling white heat, produces the brilliant stream of light known as the "voltaic arc." In the second case the current, meeting with great resistance in the narrow channel of carbon or wire provided for it, raises the latter to a high temperature and a state of glow.

A good electric light should be brilliant, steady, and lasting; but while the first of these qualities is easily obtained with electricity, the other two are very difficult to achieve. Those lamps which depend on the "voltaic arc" are especially subject to variableness in the light, owing to the irregular wasting of one of the carbons; and the duration of the light is, because of this wasting, confined to the time which the carbon requires to be entirely consumed. Those lamps, on the other hand, which depend on the incandescence of a solid conductor are, if not the most brilliant, at least the steadiest and most durable; for in them, since there is no break in the circuit, it is only necessary to keep the current flowing and prevent the fusing of the wire or the oxidation of the carbon through which it flows, to secure a perfectly steady light, and hence Mr. Edison was on the right track when he adopted the incandescent mode. The "arc" is, however, by far the most economical source of the two, it being found that the same current will yield two and a half times the light by means of the arc that it will by the incandescence of a wire; and Mr.

Edison, when he startled the world a year ago, overlooked this fact. The light obtained from platinum or iridium wire, heated by electricity, is all that the most exacting could require, but it is too costly as yet. The important fact that the amount of light emitted by a heated body increases in a greater ratio than the temperature, affords good hope for the success of incandescent lights. For instance, platinum at 2,600° emits forty times more light than at 1,900°, therefore if a substance could be found which would bear a prodigious temperature without melting it might be possible to make incandescent lighting cheap; and it is with this aim that Mr. Edison has tried to render the highly infusible metals, platinum and iridium, more infusible still by tempering them *in vacuo*, and more recently has abandoned metals in favour of a thin arch or slip of charred drawing-paper, through which the current is passed.

There are various electric lamps of both kinds, but the best of these are—for the arc, the Serrin, which is very brilliant; the Rapieff, which is both brilliant and steady; the new Siemens, which is so perhaps in a lesser degree; and the Jablochkoff, which has for some time past been illuminating the Thames Embankment; while for incandescence may be cited the carbon lamps of Berderman and Reynier, and the platinum-iridium and carbon-flake lights of Edison.

The relative intensities of artificial lights are measured by instruments termed photometers, which all depend upon the estimate of the eye as regards brightness, and therefore are more or less inaccurate. In some the eye judges by the intensities of the shadows thrown by the two lights compared, in others by the intensities of the direct reflections. In order to compare lights properly, a fixed criterion of illumination is required. In England, this is the standard candle made of pure spermaceti, weighing a sixth of a pound, and burning 130 grains of spermaceti in an hour; in France it is the Carcel jet, consuming 42 grammes of pure colza oil an hour, and yielding about ten times more light than the standard candle. In Rumford's photometer the two lights to be compared are made simultaneously to project two shadows of an upright rod upon a screen behind, and the stronger light is shifted back until the eye judges the two shadows equally dark, when the intensities of the lights are respectively proportional to the *squares* of their distances from the shadows. For example, if one light be *twice* as far from the screen as the other when the shadows on the latter are equally dark, its intensity is *four* (2×2) times greater than the intensity of the other light; if *three* times as far, its intensity is *nine* (3×3) times that of the other, and so on. Bunsen's photometer, again, consists of a paper screen having a grease spot made with spermaceti dissolved in naphtha on it. One light is placed in front of the screen so as to cause the spot to appear dark, the other is then placed behind the screen, and since it tends to make the grease-spot appear bright it is shifted back until the spot is neither dark nor bright, but resembles the rest of the paper. The relative intensities of the two lights are then proportional to the squares of their distances from the screen. There are several other photometers, but those of Rumford and Bunsen are perhaps the best known.

According to trustworthy measurements by the photometer, the intensity of sunlight is equal to the light from 5,500 wax candles at the distance of a foot. The electric light produced by the current from a voltaic battery of fifty Bunsen cells is equal to about one-fourth of sunlight, or 1,400 candles; but some of the great electric lamps now employed in our lighthouses instead of oil lamps, with several concentric wicks, and fed by the current from a Siemens dynamo-electric machine, out-rival the sun himself in generating a light equivalent to 20,000 candles. The Drummond oxy-hydrogen or *lime-light* is almost as intense as the electric light. It is formed by a jet of oxygen gas and a jet of hydrogen impinging and mingling together on a small cylinder of lime, which is heated to whiteness by the heat from the combining gases. The lime-light, the "bude" light, produced by forcing an oil-flame with a current of oxygen, and gas, have all been tried for lighthouse purposes, but they are defective in practice. The ordinary gas-flame is equivalent to from 11 to 16 standard candles. According to Dr. Letheby, 754 ozokerit candles are equivalent to 891 paraffin ones, and 1,150 wax ones; and as regards economy, an estimate given by Dr. Ure represents the relative costs of different kinds of candles by the following scale:—For tallow candles, 6 to the pound, 9·8; for ditto, 8 to the pound, 12; for pressed tallow candles, 5 to the pound, 23.7; for wax, 5 to the pound, 48·6; for spermaceti, 5 to the pound 47.8; and for stearine, 5 to the pound, 37.1. Wax candles are therefore the dearest of all, and spermaceti candles come next.

From a recent comparison of oil lamps with gas, made by a chemist to a petroleum association, we gather that the cost of a light of one-candle for 1,000 hours is, for petroleum oil at 1s. per gallon, 9⅝d.; and for colza oil, at 3s. 6d. per gallon, 8d.; while for gas, at 3s. 6d. per 1,000 cubic feet, the cost for the same amount of light is only about 4½d., taking the ordinary light of a gas-jet as equivalent to twelve candles.

The cost of electric lighting is not yet well determined, but we may safely assume that for streets it will ultimately be as cheap as gas, while for large buildings and factories it is considerably cheaper.