

but it occurred to me that if I could add some such intense light to my large gas-burners, so arranged that it need not be used except in thick weather, I would, at comparatively small expense, produce a fog light combining both quantity and great intensity. I made many experiments, and at length arranged for what I termed a core for my gas-burners. Any of the intense lights I have mentioned might form this core. I first used, as the simplest and least expensive, a rich hydro-carbon flame intensified by oxygen, but I prefer the electric light because of its greater intensity, and because of the facility with which, owing to the recent improvements in the Gramme magneto-electric machine, it can be applied. When the Jablockhoff electric candle, which is now so much used in Paris, has been so constructed that it may be burned without variation for many hours together, it may be very easily utilized for the core of which we have been speaking; but, in the meantime, the light from carbon points regulated by a Serrin lamp is quite available for that purpose. By a simple alteration in the arms which hold the carbons, and of the clockwork by which those arms are moved, we can bring the light into the precise focus of the gas-burner, and apply it in a moment when occasion arises. By means of a gas-engine, which, of course, can be used at all gas stations, it can be applied in a moment. With respect to this light, I will ask you to remember that its application is simply intended to add intensity to a large fog light, and that it is only designed to be used during fogs, so that no expense is incurred except while the fog lasts, and during that time it appears to me that no expense should be considered too great when the possibility of saving human life is taken into account. By the kindness of the Commissioners of Irish Lights, one of these combined lights will be fixed at Howth Bailey Lighthouse, and an opportunity will be afforded to the members of the British Association of judging of its effect in connection with the great quadriform light which, as I before mentioned, will also be placed in the experiment house of that station. I have read the programme of this Association at Salthill by the light transmitted from this combined light at Howth Bailey Lighthouse, about six miles distant—a test of the power of a lighthouse light more severe than has ever before been applied, so far as I am aware.

I will only add that what I have said in the early part of this paper, respecting the useful effect of sudden flashes, in catching the eye of the sailor by what may be termed a momentary thrill in fogs and haze, peculiarly applies to this combined gas and electric light; this light when suddenly exhibited produces an exceedingly striking effect, well calculated to arrest the attention of the mariner.

#### A MODE OF LIGHTING SEA BEACONS FROM A POSITION ON SHORE.

When it is desired to establish and maintain lights upon beacons where space is limited, and to which access by boat is difficult or expensive, gas properly dried by chloride of calcium may be very conveniently applied as the means of illumination. A gas station on shore will command any desired number of beacons, and the lights may be simultaneously lighted and extinguished from the shore. The plan I have adopted, and exhibited in operation to the Commissioners of Irish Lights, is very simple. During the daytime the gas is supplied at a pressure, say, equal to a column of water 6 inches high, to maintain a small light about the size of a pea in the lantern of each beacon. The gas for this light is driven through a by-pass in the valve of an automatic gas governor of suitable size fixed on each burner, and the high pressure at which the gas is supplied prevents wind or any slight movement of the supply-pipe from causing the extinction of the small flame, which thus remains as the permanent lamplighter of the beacon.

I will illustrate the tenacity of small flames burning at very high pressure by this simple experiment. I will supply a small flame with gas at 6 inches pressure of water, and then at 1 inch pressure. It will be seen that the least motion of the supply-pipe will extinguish it in the latter case, while it is comparatively difficult, if not impossible, by that means to extinguish it in the former case. At nightfall, when the time arrives for exhibiting the light in the beacon, the pressure at the shore station is diminished from 6 inches to, say, 1 inch, and this reduction of pressure immediately acts upon the governors which are attached to each light, causing their valves to open, and thus admit gas for a full-sized flame.

When the beacon light requires to be extinguished, the reverse process is gone through, the pressure on shore is increased, the governor-valve rises and extinguishes the light, leaving, however, the small by-pass pea-sized flame ready for the performance of its function as a lamplighter on the next occasion.

The little apparatus which I have here will clearly illustrate this method of illuminating beacons. I will put it into action. You will see that to light and extinguish the light at the opposite side of the room I simply reverse the ordinary plan to which we are accustomed. I turn off this cock to cause the lights to spring up, and I turn it on to extinguish the light.

#### TEMPERATURE OF FLAME.

By F. ROSSETTI (*Gazzetta Chimica Italiana*).

WHEN a gas flame is used, and the pressure of the gas is varied, the temperature increases but very slightly with the pressure for the same part of the flame (not more than 20°), although the size of the flame may vary greatly.

1. *Luminous Gas Flame.*—The flame of a Bunsen burner of which the air holes are closed, consists of an obscure internal nucleus and an outer luminous envelope, which at the lower part is surrounded by an external zone of a pale blue color. The internal cone has a temperature of 280° at its base, which gradually increases toward the apex, where it is the same as that of the luminous envelope; this is sensibly constant and about 1050°; the blue portion has a temperature of about 1300°.

In the ordinary fish-tail or bat's-wing burner the edges of the flame are about 1100°, and in the most luminous part 1150°.

2. *Non-luminous Flame.*—The temperature of the different layers in a Bunsen flame are slightly different from those given in the former paper, namely, 1360° for the external layer, and 1263° for the violet colored layer immediately beneath this.

3. In Bunsen's apparatus for showing the absorption of the yellow sodium light by sodium vapor, two flames are employed, the one having a much higher temperature than the other; these were found to be 940° and 1290° respectively.

4. *Flame of a Stearin Candle.*—The blue zone at the lower part of the flame is about 770°; the interior obscure cone 640° at the summit of the wick, and 840° at the apex; the external luminous envelope has a temperature of about 940°.

5. *Flame of a Locatelli Lamp.*—At the base of the flame, just above the wick, the temperature is 575°; the apex of the internal obscure cone, 875°; the luminous envelope at the same level, 890°; apex of luminous envelope, 920°.

6. *Flame of a Petroleum Lamp.*—This flame, with a chimney, has a temperature of 1030° in the luminous part; without a chimney, 780° in the smoky part; 920° in the most luminous part.

7. *Alcohol Flame.*—The temperature of this flame varies from 900° at the base to 1180° at the apex. The proportion of water present, within certain limits (sp. gr. of alcohol 0.912 and 0.8225), does not materially influence the temperature.

8. *Mixture of Gas and Air.*—Such a mixture in known proportions was burned in a Bunsen lamp, the air holes being closed. I give the temperature obtained with equal volumes of gas and air; II, one vol. gas to two of air; III, one vol. gas to two and a half of air; IV, one vol. gas to three of air.

	I.	II.	III.	IV.
Apex of flame. ....	1150°	1260°	1150°	1116°
Base of internal cone.	570	330	270	240

A mixture of one vol. gas to four of air could not be burned in a Bunsen lamp, but with an ordinary statite burner it gave a temperature of 930°. It will be seen that the highest temperature was obtained with a mixture of two vols. air to one of gas; the mixture in a Bunsen burner, under ordinary conditions, was found to be in the proportion 2:2:1.

9. *Mixture of Gas and Nitrogen.*—The conditions of experiment were the same as those in 8. I give the temperature at the apex of the luminous flame; II, that at the base of the internal cone.

Gas to nitrogen =	I.	II.
2 : 3	1240°	345°
1 : 1	1180	280
1 : 2	1150	240
1 : 2.5	1080	"
1 : 3	1040	210
1 : 4	960	160

When the proportion of nitrogen to gas exceeds 2:1, the flame is no longer luminous.

10. *Mixture of Gas and Carbonic Anhydride.*—With this mixture the space intervening between the flame and the top of the burner is distinctly marked: I and II have the same signification as in 9.

Gas to carbonic anhydride =	I.	II.
2 : 1	1190°	280°
3 : 2	1170	270
1 : 1	1100	270
2 : 3	1020	270
1 : 2	880	"
1 : 3	780	250

A comparison of the results in 9 and 10 shows that for equal volumes, carbonic anhydride has a more powerful cooling effect on the flame than nitrogen; this is in accordance with the specific heats of the two gases, which are in the proportion of 100:71.

The author also describes an electric pyrometer of carbon and platinum for temperatures up to 2000°, but it is not yet perfected.

#### THE ELECTRO-MAGNET A RECEIVING TELEPHONE.\*

THE result I have arrived at while experimenting in this direction seems so interesting, and at the same time, I believe, novel, viz., that a good receiving telephone can be made from electro-magnets alone without any vibrating diaphragm, that I hope by prior publication, to prevent the possibility of a string of those patents which nowadays so greatly hamper true scientific invention.

In my earlier experiments I made an electro-magnet out of a piece of  $\frac{3}{4}$  inch iron gas pipe,  $\frac{3}{4}$  inch long, filed flat on one side, and split sufficiently only to allow the wire (No. 24) to be wound on, which was done till it was full inside. The poles were therefore together about  $\frac{3}{4}$  inch square. This was fixed inside a small cigar box, under a ferrotype plate, covering a rectangular hole cut in the lid,  $2\frac{1}{4}$  inches by  $1\frac{1}{2}$  inch. With a Hughes carbon-pencil-microphone tilted to an angle of 45° as a transmitter, a small musical box as a source of sound, in a distant part of the house, and one of Leclanché's cells in circuit, the box gave out tunes plainly heard by all sitting in the room.

While experimenting with another similar magnet, I stood it loose, poles downward, but still connected with the line wires on a flat tin gunpowder canister with the ends cut off, but still retaining the paper label on which the magnet lay; the tune of the musical box was given out loudly and resonant, but buzzing and jangling; also words spoken to the transmitter were heard, but confused together.

Now this was a very interesting result, which led to the next discovery, for, having a small ordinary electro-magnet, with its armature in front (as used in electric bells), fixed to a piece of board, I was about to unship it to try experiments in various tin cans, etc., when it occurred to me to connect it as it was, to the line wires, placing only a slip of paper between the poles and armature to prevent actual contact. To my astonishment, on putting the ear close to the board at any part, the music of the box was heard clearly, every note from highest to lowest being distinctly given. Now here seemed to be a telephone without a vibrating diaphragm; but, to make more sure, the armature was unscrewed from its support and attached to the magnet only by an India-rubber band, with the slip of paper between it and the poles, so that it touched no other part of the apparatus. On listening to the supporting board, the sounds were heard as distinctly as before.

But even here forensic ingenuity might claim and attempt to prove that this ordinary armature was a vibrating diaphragm; therefore, an armature being itself nothing but an induced magnet, it was replaced by another electro-magnet, thus:

Two ordinary electro-magnets (unscrewed from a couple of large electric bells) were fastened, by means of two little wooden saddles and a screw each, to a small piece of deal

board about  $4\frac{1}{2}$  inches square and  $\frac{5}{8}$  inch thick, in such a way that the poles were all but touching. Their wires were then joined so that poles of opposite denominations faced each other, i. e., north opposite south and *vice versa*. This placed on an empty cigar box and four Leclanché cells in circuit, gave out the tune of the musical box clearly and loudly in the room. When both the poles were made to touch, the sound ceased; but with a thin piece of paper or stout tinfoil between them, without any intervening air space, the sound was heard. On gradually separating the magnets, the sounds grew fainter and fainter till they became inaudible.

By putting the base-board close to the ear, whistling and singing to the microphone were very clearly and loudly heard, also the voice of the person speaking could be recognized; but words were hardly sufficiently defined to distinguish all that was said, though now and then parts were intelligible.

One of the electro-magnets was afterward replaced by a small permanent steel horse-shoe magnet fastened to the board in a similar manner; the result was the same, but, I imagined, slightly louder, probably from there being less resistance.

By varying the strength of battery, size, or mode of mounting magnets, or adjustment of the microphone, I have no doubt that perfect definition can be obtained. The loudness and volume of the sound are ample; but before making further experiments, for which I have at present little time, I hasten to communicate the fact that the electro-magnet, without any diaphragm whatever, can be made a reproducer of sounds transmitted by a Hughes microphone, and thus a complete and practical telephone system produced without the possibility of infringing anybody's patent.

I must add that the same arrangement is also a feeble transmitter, using a good Bell's telephone as a receiver, which is a very strange fact. I abstain at present from all theory on the subject.

F. G. LLOYD.

#### THE PROVINCE OF MATHEMATICS.\*

IT is as the supreme result of all experience, the framework in which all the varied manifestations of nature have been set, that our science has laid claim to be the arbiter of all knowledge. She does not indeed contribute elements of fact, which must be sought elsewhere; but she sifts and regulates them; she proclaims the laws to which they must conform if those elements are to issue in precise results. From the data of a problem she can infallibly extract all possible consequences, whether they be those first sought or others not anticipated; but she can introduce nothing which was not latent in the original statement. Mathematics cannot tell us whether there be or be not limits to time or space; but to her they are both of definite extent, and this in a sense which neither affirms nor denies that they are either infinite or finite. Mathematics cannot tell us whether matter be continuous or discrete in its structure; but to her it is indifferent whether it be one or the other, and her conclusions are independent of either particular hypothesis. Mathematics can tell us nothing of the origin of matter, of its creation, or its annihilation; she deals only with it in a state of existence; but within that state its mode of existence may vary from our most elementary conception to our most complex experience. Mathematics can tell us nothing beyond the problems which she specifically undertakes; she will carry them to their limit, but there she stops, and upon the great region beyond which she is imperturbably silent.

Conterminous with space and coeval with time is the kingdom of mathematics; within this range her dominion is supreme; otherwise than according to her order nothing can exist; in contradiction to her laws nothing takes place. On her mysterious scroll is to be found written, for those who can read it, that which has been, that which is, and that which is to come. Everything material which is the subject of knowledge has number, order, or position; and these are her first outlines for a sketch of the universe. If our more feeble hands cannot follow out the details, still her part has been drawn with an unerring pen, and her work cannot be gainsaid. So wide is the range of mathematical science, so indefinitely may it extend beyond our actual powers of manipulation, that at some moments we are inclined to fall down with even more than reverence before her majestic presence. But so strictly limited are her promises and powers, about so much that we might wish to know does she offer no information whatever, that at other moments we are fain to call her results but a vain thing, and to reject them as a stone when we had asked for bread. If one aspect of the subject encourages our hopes, so does the other tend to chasten our desires; and he is perhaps the wisest, and in the long run the happiest among his fellows, who has learned not only mathematics, but also the larger lesson which they indirectly teach, namely, to temper our aspirations to that which is possible, to moderate our desires to that which is attainable, to restrict our hopes to that of which accomplishment, if not immediately practicable, is at least distinctly within the range of conception. That which is at present beyond our ken may, at some period and in some manner as yet unknown to us, fall within our grasp; but our science teaches us, while ever yearning with Goethe for "Light, more light," to concentrate our attention upon that of which our powers are capable, and contentedly to leave for future experience the solution of problems to which we can at present say neither yea nor nay.

It is within the region thus indicated that knowledge in the true sense of the word is to be sought. Other modes of influence there are in society and in individual life, other forms of energy besides that of intellect. There is the potential energy of sympathy, the actual energy of work; there are the vicissitudes of life, the diversity of circumstance, health, and disease, and all the perplexing issues, whether for good or for evil, of impulse and of passion. But although the book of life cannot at present be read by the light of science alone, nor the wayfarers be satisfied by the few loaves of knowledge now in our hands, yet it would be difficult to overstate the almost miraculous increase which may be produced by a liberal distribution of what we already have, and by a restriction of our cravings within the limits of possibility.

In proportion as method is better than impulse, deliberate purpose than erratic action, the clear glow of sunshine than irregular reflection, and definite utterances than an uncertain sound; in proportion as knowledge is better than surmise, proof than opinion; in that proportion will the mathematician value a discrimination between the certain and the uncertain, and a just estimate of the issues which depend upon one motive power or the other. While, on the one hand, he accords to his neighbors full liberty to regard the unknown in whatever way they are led by the noblest powers that they possess, so on the other he claims an equal right to draw a

\* From President Spottiswoode's Inaugural Address before the British Association.

\* *Nature*.