Current measured by us in some experiments:

Using electrometer..... = almost infinitely small currents.
Using delicate galvanometer = 0.00,000,000,040 weber.
Current received from Atlantic cable, when 25 words per minute are being sent ..... = 0.000,001 weber.
Current in ordinary land telegraph lines ..... = 0.003
Current from dynamo machine... = 5 to 100

In any circuit, current in webers = electro-motive force in volts ÷ resistance in ohms.

RATE OF PRODUCTION OF HEAT, CALCULATED IN THE SHAPE OF HORSE-POWER.

In the whole of a circuit = current in webers × electro-motive force in volts ÷ 746.

In any part of circuit = current in webers × difference of potential at the two ends of the part of the circuit in question ÷ 746.

Or, = square of current in webers × resistance of the part in ohms ÷ 746.

If there are a number of generators of electricity in a circuit, whose electromotive forces in volts are E_1, E_2 , etc., and if there are also opposing electro-motive forces, F_1, F_2 , etc., volts, and if C is the current in webers, R the whole resistance of the current in ohms, P the total horse-power taken at the generators, Q the total horse-power converted into some other form of energy, and given out at the places where there are opposing electro-motive forces, H the total horse-power wasted in heat, because of resistance, then:

$$C = \frac{(E_1 + E_2 + \text{etc.}) - (F_1 + F_2 + \text{etc.})}{R}$$

$$P = \frac{C}{746} (E_1 + E_2 + \text{etc.}); \quad Q = \frac{C}{746} (F_1 + F_2 + \text{etc.})$$

$$H = \frac{C^2 R}{746}$$

The lifting power of an electro-magnet of given volume is proportional to the heat generated against resistance in the wire of the magnet.

The future of many electrical appliances depends on how general is the public comprehension of the lessons taught by these wall sheets. If a few capitalists in London would only spend a few days in learning thoroughly what these mean, electrical appliances of a very distant future would date from a few months hence.

A number of experiments were shown, in some of which electrical energy was converted into heat, in others into sound, in others into work. At this part of the lecture reference was made to the work of Prof. Ayrton and his pupils at Cowper street (City and Guilds of London Institute Classes). They measure (1) the gas consumed by the engine, (2) the horse-power given to the dynamo machine, (3) the current in the circuit in webers, and (4) the resistance of the circuit. Thus exact calculations can now be made as to the horse-power expended in any part of the circuit, and the light given out in any given period by an electric lamp. The dynamometers used in these measurements were described, but at present, in some cases, the description given is for various reasons incomplete, so that we shall take a future opportunity of writing of these instruments. To measure the light a photometer, constructed by Profs. Ayrton and Perry, is used, which obviates the necessity of large rooms, and enables the operator to give the intensity in a very short period of time. A number of measurements of the illuminating power of an electric lamp were rapidly made during the lecture with this photometer. By means of a small dynamo machine, driven by an electric current generated in the Adelphi arches, a ventilator, a sewing machine, a lathe, etc., were driven; in the latter a piece of wood was turned. "What," said the lecturer, "do these examples show you?" "They show that if I have a steam-engine in my back yard I can transmit power to various machines in my house, but if you measured the power given to these machines you would find it to be less than half of what the engine driving the outside electrical machine gives out. Further, when we wanted to think of heating of buildings and the boiling of water, it was all very well to speak of the conversion of electrical energy into heat, but now we find that not only do the two electrical machines get heated and give out heat, but heat is given out by our connecting wires. We have then to consider our most important question. Electrical energy can be transmitted to a distance, and even to many thousands of miles, but can it be transformed at the distant place into mechanical or any other required form of energy, nearly equal in amount to what was supplied? Unfortunately, I must say that hitherto the practical answer made to us by existing machines is, 'No'; there is always a great waste due to the heat spoken of above. But, fortunately, we have faith in the measurements, of which I have already spoken, in the facts given us by Joule's experiments and formulated in ways we can understand. And these facts tell us that in electric machines of the future, and in their connecting wires, there will be little heating, and therefore little loss. We shall, I believe, at no distant date, have great central stations, possibly situated at the bottom of coal-pits where enormous steam engines will drive enormous electric machines. We shall have wires laid along every street, tapped into every house, as gas-pipes are at present; we shall have the quantity of electricity used in each house registered, as gas is at present, and it will be passed through little electric machines to drive machinery, to produce ventilation, to replace stoves and fires, to work apple-parers and mangles and barbers' brushes, among other things, as well as to give everybody an electric light."

It is possible, as Prof. Ayrton first showed in his Sheffield lecture, that electrical energy can be transmitted through long distances by means of small wires, and that the opinion that wires of enormous thickness would be required is erroneous. The desideratum required was good insulation. He also showed that, instead of a limiting efficiency of 50 per cent., the only thing preventing our receiving the whole of our power was the mechanical friction which occurs in the machines. He showed, in fact, how to get rid of electrical friction. A machine at Niagara receives mechanical power, and generates electricity. Call this the generator. Let there be wires to another electric machine in New York, which will receive electricity, and give out mechanical work. Now this machine, which may be called the motor, produces a back electromotive force, and the mechanical power given out is proportional to the back electromotive force multiplied into the current. The current, which is, of course, the same at Niagara as at New York, is proportional to the difference of the two electromotive forces, and the heat

wasted is proportional to the square of the current. You see, from the last table, that we have the simple proportion: power utilized is to power wasted, as the back electromotive force of the motor is to the difference between electromotive forces of generator and motor. This reason is very shortly and yet very exactly given as follows:

Let electromotive force of generator be E ; of motor F . Let total resistance of circuit be R . Then if we call P the horse-power received by the generator at Niagara, Q , the horse-power given out by motor at New York, that is, utilized; H , the horse-power wasted as heat in machines and circuit; C , the current flowing through the circuit:

$$C = \frac{E - F}{R}$$

$$P = \frac{E(E - F)}{746 R}$$

$$Q = \frac{F(E - F)}{746 R}$$

$$H = \frac{(E - F)^2}{746 R}$$

$$Q : H :: F : E - F$$

The water analogy was again called into play in the shape of a model for the better demonstration of the problem. The defects in existing electric machines and the means of increasing the E.M.F. were discussed, the conclusions pointing to the future use of very large machines and very high velocities. The future of telephonic communication received a passing remark, and attention called to the future of electric railways. The small experiments of Siemens have determined the ultimate success of this kind of railway. Their introduction is merely a question of time and capital. The first cost of electric railways would be smaller than that of steam railways; the working expenses would also be reduced. The rails would be lighter, the rolling stock lighter, the bridges and viaducts less costly, and in the underground railways the atmosphere would not be vitiated.

About two years ago, it struck Professor Ayrton and myself, when thinking how very faint musical sounds are heard distinctly from the telephone, in spite of loud noises in the neighborhood, that there was an application of this principle of recurrent effects of far more practical importance than any other, namely, in the use of musical notes for coast warnings in thick weather. You will say that fog bells and horns are an old story, and that they have not been particularly successful, since in some states of the weather they are audible, in others not.

Now, it seems to be forgotten by everybody that there is a medium of communicating with a distant ship, namely, the water, which is not at all influenced by changes in the weather. At some twenty or thirty feet below the surface there is exceedingly little disturbance of the water, although there may be large waves at the surface. Suppose a large water-siren like this—experiment shown—is working at as great a depth as is available, off a dangerous coast, the sound it gives out is transmitted so as to be heard at exceedingly great distances by an ear pressed against a strip of wood or metal dipping into the water. If the strip is connected with a much larger wooden or metallic surface in the water the sound is heard much more distinctly. Now, the sides of a ship form a very large collecting surface, and at the distance of several miles from such a water siren as might be constructed, we feel quite sure that, above the noise of engines and flapping sails, above the far more troublesome noise of waves striking the ship's side, the musical note of the distant siren would be heard, giving warning of a dangerous neighborhood. In considering this problem, you must remember that Messrs. Colladon and Sturtevant heard distinctly the sound of a bell struck under water at the distance of nearly nine miles, the sound being communicated by the water of Lake Geneva.

The next portion of the lecture discussed the great value of a rapid recurrence of effects, the obtaining of sound by means of a rapid intermission of light rays on selenium joined up in an electric circuit being instanced as an example. Then recent experiments on the refractive power of ebonite were detailed—the rough results tending to give greater weight to Clerk-Maxwell's electro-magnetic theory of light. The index of refraction of ebonite was found by Profs. Ayrton and Perry to be roughly 1.7. Clerk-Maxwell's theory requires that the square of this number should be equal to the electric specific inductive capacity of the substance. For ebonite this electric constant varies from 2.2 to 3.5 for different specimens, the mean of which is almost exactly equal to the square of 1.7.

RESEARCHES ON THE RADIANT MATTER OF CROOKES AND THE MECHANICAL THEORY OF ELECTRICITY.

By DR. W. F. GINTL, abstracted by DR. VON GERICHTEN.

The author discusses the question whether, according to the experiments of Crookes, the assumption of an especial fourth state of aggregation is necessary, or whether the facts may be satisfactorily explained without such hypothesis? He shows that the latter alternative is possible with the aid of a mechanical theory of electricity. If the radiant matter produced in the vacuum is a phenomenon *sui generis*, produced by the action of electricity and beat upon the molecules of gas remaining in the receiver, it is, in the first place, doubtful to apply to it the conception of an aggregate condition. The author considers it impossible to form a clear understanding of the phenomena in accordance with the theory of Crookes, or to find in the facts any evidence of the existence of radiant matter. An explanation of the latter phenomenon is thus given: Particles become separated from the surface of the substance of the negative pole, they are repelled, and they move away from the pole with a speed resulting from the antagonistic forces in a parallel and rectilinear direction, preserving their speed and their initial path so long as they do not meet with obstacles which influence their movement. At a certain density of the gases present in the exhausted space, these particles, in consequence of the impact of gaseous molecules more or less opposed to their direction of movement, lose their velocity after traveling a short distance and soon come to rest. The more dilute the gas the smaller is the number of the impacts of the gaseous molecules encountering the molecules of the poles, and at a certain degree of dilution the repelled polar particles will be able to traverse the space open to them without any essential alteration in their speed, the small number of the existing gaseous molecules being no longer able to retard the molecules of the polar in their journey through the

apparatus. The luminous phenomena of the Geissler tubes the author supposes to be produced by the intense blows which the gaseous molecules receive from the polar molecules flying rapidly through the apparatus. The intensity of the luminous phenomena will naturally decrease with the number of the phosphorous particles occupying the space. Accordingly in the experiments of Crookes, on continued rarefaction of the gas, a condition was reached where a display of light is no longer perceptible, or can be made visible merely by the aid of fluorescent bodies. A condition may also appear, as is shown by Crookes' experiment, with the metallic plate intercalated as negative pole in the middle of a Geissler tube, with the positive poles at the ends. In this case the gaseous molecules are, so to speak, driven away by the polar particles endowed with an equal initial velocity, till at a certain distance from the pole the mass of the gaseous molecules and their speed become so great that a luminous display begins. In an analogous manner the author explains the phenomena of phosphorescence which Crookes' elicits by the action of his radiant matter. In like manner the thermic and the mechanical effects are most simply explained, according to the expression selected by Crookes himself, as the results of a "continued molecular bombardment." The attraction of the so-called radiant matter, regarded as a stream of metallic particles by the magnet, will not appear surprising.

ECONOMY OF THE ELECTRIC LIGHT.

MR. W. H. PREECE writes to the *Journal of Arts* as follows:

At the South Kensington Museum, very careful observations have been made on the relative cost of the two systems, *i. e.*, gas and electricity. The court lighted is that known as the "Lord President's" (or the Lean) Court. It is 138 feet long by 114 feet wide, and has an average height of about 42 feet. It is divided down the middle lengthwise by a central gallery. There are cloisters all around it on the ground floor, and the walls above are decorated in such a way that they do not assist in the reflection or diffusion of the light. The absence of a ceiling—the court being sky-lighted—is to some extent compensated for by drawing the blinds under the sky-lights.

The experiments commenced about twelve months ago, with eight lamps only on one side of the court. The system was that of Brush. The dynamo machine was driven by an eight horse-power Otto gas engine, supplied by Messrs. Crossley. The comparison with the gas was so much in favor of electricity, and the success of the experiment so encouraging, that it was determined to light up the whole court.

The gas engine, which was not powerful enough, was replaced by a 14-horse power "semi-portable" steam engine, by Ransomes & Co., of Ipswich—an engine of sufficient power to drive double the required number of lights. The dynamo machine is a No. 7 Brush. There are sixteen lamps in all—eight on each side of the court. The machine has given no trouble whatever, and it has, as yet, shown no signs of wear. The lamps were not all good, and it was found that they required careful adjustment, but when once they were got to go right they continued to do so, and have, up to the present, shown no signs of deterioration, although the time during which they have been in operation is nine months.

The first outlay has been as follows:

Engine and fixing, including shafting and belting.....	£420
Dynamo machine	400
Lamps, apparatus, and conducting wire....	384
	£1,204

The cost of working has been, from June 22, to December 31, during which period the lights were going on 87 nights for a total time of 359 hours:

	£	s.	d.
Carbons.....	18	9	0
Oil, etc.....	4	11	6
Coal	11	14	0
Wages.....	34	7	6
	£69	2	0

being at the rate of 3s. 10d. per hour of light.

Now, the consumption of gas in the court would have been 4,800 cubic feet per hour, which, at 3s. 4d. per 1,000 cubic feet, would amount to 16s. per hour, thus showing a saving of working expenses of 12s. 2d. per hour, or, since the museum is lit up for 700 hours every year, a total saving at the rate of £426 per annum.

In estimating the cost as applied to this court, only half the cost of the engine should be taken, for a second dynamo machine has lately been added to light up some of the picture galleries, and the "Life" room of the Art School. The capital outlay should, therefore, be £994. In making a fair estimate of the annual cost, we should also allow something for percentage on capital, and something for wear and tear. Take—

	£	s.
5 per cent. on the capital.....	49	10
5 per cent. for wear and tear of electrical apparatus.....	39	0
5 per cent. for depreciation of engines, etc.....	21	0
Total.....	£109	10

leaving a handsome balance to the good of £316 10s. as against gas. The results of the working, both practically and financially, have proved to be, at South Kensington, a decided success.

I am indebted to Colonel Festing, R.E., who has charge of the lighting, for these details.

The same comparison cannot be made at the British Museum, for no gas was used in the reading-room before the introduction of the electric light, but the cost of lighting has proved to be 5s. 6d. per hour—at least one-third of that which would be required for gas. The system in use at the Museum is Siemens', the engine being by Wallis and Stevens, of Basingstoke.

An excellent example of economic electric lighting, is that of Messrs. Henry Tate & Sons, sugar refinery, Silver-town. A small Tangye engine, placed under the supervision of the driver of a large engine of the works, drives an 'A' size 'Gramme' machine, which feeds a 'Crompton' 'E' lamp. This is hung at a height of about 12 feet from the ground in a single story shed, about 80 feet long, and 50 feet wide, and having an open trussed roof. The light, placed about midway, lengthways, has a flat canvas frame,