

find some substance which can be decomposed into two others which will remain apart, even when joined by a liquid conductor, until a complete electric circuit is made. Then these two substances should be at considerable difference of potential, so as to give a strong electric current in uniting again to form the substance from which they were decomposed.

In 1859, M. Plante, taking advantage of the great affinity of peroxide of lead for hydrogen, made use of this substance to increase the effects of secondary batteries, and so was led to make use of lead electrodes instead of platinum, which has been the metal hitherto employed. He found that better results could be obtained with one cell with lead electrodes, than with two cells with platinum electrodes. So from this battery, plates of lead with a finely divided layer of lead upon them are taken as electrodes. A current from two Grove cells is sent through the cell containing them, immersed in dilute sulphuric acid of strength about 1 to 10. The current is sent for a quarter of an hour in one direction, then the cell is fully discharged, the current from the primary battery is then sent through it for a quarter of an hour in the opposite direction, after which the cell is again discharged. In this way it is charged over and over again in opposite directions for longer and longer periods, care being taken each time that the secondary cell is fully discharged. Then the battery is again charged, but when it is capable of giving out the charges slowly enough for the purpose for which it is to be used, then the successive charges should no longer be given in opposite directions, but always in the same direction. We may say that after the battery is formed, it should always be charged in the same direction.

In charging by sending a primary current through the cell, peroxide of lead is formed at the positive pole, and the negative pole becomes somewhat crystallized. When detached, the peroxide of lead forms the positive pole of the secondary battery, and the battery will remain in action until the two plates return to the same state, the positive pole being reduced from the peroxide to the oxide of lead, and the negative pole being transformed from lead to the oxide of lead.

M. Plante has especially aimed, by means of his battery, to convert electricity obtained from an ordinary battery into electricity of high tension, to do in a smaller degree what is done by means of the Ruhmkorff induction coil. By means of two cells of Grove or Bunsen he can charge a great number of cells, a dozen or more, arranged for quantity, *i. e.*, with all their positive poles together and all their negative poles together, and when they are charged by arranging them in series, *i. e.*, with the positive pole of one joined to the negative pole of the next, he can get great electromotive force, and at the same time obtain electricity in great quantity.

By his battery of 800 cells, which he has set up in Paris, and by the aid of his rheostatic machine, which I have not time to describe, he can imitate lightning discharges and remarkable luminous effects, somewhat analogous to the brilliant effects of the aurora borealis.

The electromotive force of a single cell of Plante's battery is about $2\frac{1}{2}$ volts, or $2\frac{1}{2}$ times that of a Daniell's cell, *i. e.*, about $1\frac{1}{2}$ times Grove's cell, hence, two cells of Grove will charge a Plante cell. The quantity of electricity that may be collected will depend on the amount of chemical action, *i. e.*, on the extent of the surface of the plates, and on the way in which that action has gone on. When the action has gone on rapidly the battery will not be so good as when the action is slow. The Plante battery, as usually formed, discharges itself too rapidly for many purposes for which electric accumulators are now required, and hence other secondary batteries or modifications of the Plante battery are now making their appearance. The cells may be charged by a dynamo-machine, and may also be used to drive a dynamo-machine like an electro-magnetic engine or motor, driving it in the same direction as it was driven when used as a generator to charge the cells.

The Plante cell will also heat a platinum wire of considerable diameter, for although the electromotive force is only $2\frac{1}{2}$ volts, yet the quantity is sufficient to make a platinum wire 3-10ths mm. in diameter and 4 cm. in length to glow for half an hour.

The secondary battery may be made use of in telegraphy to do away with the residual magnetism in an electro-magnet, so as to enable it to work more quickly after a current has been sent through it. The secondary cell should be attached with its positive pole to the line, and its negative pole to the key, the other end of the line or the earth being also attached to the key, so as to form a complete circuit when the key is up; the sending battery, consisting of two or more cells of Grove, or at least three Daniell's cells, should have its negative pole attached to the negative pole of the secondary cell and its positive pole to the key; so as to form a complete circuit with the line and secondary cell when the key is down. When contact is made with the sending battery by putting down the signaling key, the circuit is sent through the secondary cell into the line, thus giving a slight additional charge to the secondary cell, and bringing the electro-magnet into action; on breaking contact by releasing the key, the secondary cell, being still connected to the line, sends a reverse current into the line, and weakens or may even be strong enough to reverse the magnetism of the electro-magnet. If we work a Morse instrument first, with the sending battery alone, and afterward with the secondary cell in the circuit, we find that there is a very great increase in the rate of signaling when the secondary cell is used. The secondary current increases as the battery current increases, and, being in the reverse direction, instantly weakens the magnetism of the electro-magnet, so that signals may be sent as fast as the operator can make and break contact. Plante's secondary battery has been employed to work an electric brake on railway trains. With two Grove cells or three Daniell's cells and a Plante cell arranged as above described, the Plante cell is continually being charged, or is kept from getting weaker, except when the key is depressed which completes the electric circuit by which the brake is set in action. The quantity of electricity stored up in six Plante's cells suffices, with such an arrangement to prevent the cells from becoming exhausted, to work the brakes on a dozen railway carriages, and to last for a fortnight. To renew the charge in the Plante cell a battery of six Daniell's cells may conveniently be employed. It is important that the charging should be carried on with great regularity, so that the layer of peroxide of lead may be regularly laid on, otherwise it will not adhere well to the lead electrodes.

Several forms of secondary batteries have appeared quite recently, now that the demand has arisen for a reservoir in which to store up the electricity produced by the dynamo-electric machine, and the secondary action or polarization of batteries is no longer regarded as something to be avoided

as much as possible, but is eagerly sought after. Professors Houston and E. Thomson, of Philadelphia, have tried electrodes of copper in sulphate of zinc. When a current is sent through the cell, zinc is deposited on the negative pole, and sulphate of copper formed around the positive pole, the plates being laid horizontally, so that the sulphate of copper so formed, and the sulphate of zinc shall be prevented by their relative weights from mixing too readily.

This we may call a gravity secondary battery, and its electromotive force will be nearly the same as that of one Daniell's cell or 1 volt. M. d'Arsonval modifies this battery by using one electrode of lead and another of zinc in a solution of sulphate of zinc. The lead forming the positive electrode becomes coated, as in the Plante's cell, with peroxide of lead.

Several modifications of Plante's cell have been suggested, which have for their object the reduction of the weight of lead employed; such are the batteries of M. de Pezzer and of M. de Meritens, who fold their laminæ of lead in layers like the leaves of a book, so as to get as much surface as possible for a given weight of lead. M. de Pezzer also finds that the relative size of the positive and negative plates modifies the results obtained, a greater quantity of electricity is stored up when the negative electrode is double the size of the positive electrode than when the two electrodes are of the same size.

Other modifications, in which the negative pole is either palladium in dilute sulphuric acid or thin sheet iron in a solution of sulphate of ammonia, have been suggested and employed by M. Rouse, these substances being chosen on account of their great power of absorption of hydrogen. These can hardly be called secondary batteries, since two metals are employed as electrodes.

The method of charging secondary batteries may sometimes be conveniently made use of to renew ordinary batteries which have become used up. Thus, a Leclanche cell which has been in use for a long time, and become weak, may be recharged again by connecting up the positive pole of a stronger battery with the positive pole of the Leclanche battery, and allowing the current to pass through it for a considerable time. The secondary battery to which most attention has been drawn during the last few months is the Faure battery, in which M. Faure does not form the

a motor, or to drive a small electric engine, and the three or four cells are sufficient to cause a small Swan's incandescent lamp of small resistance to give out a very pleasant light of about two candles. There are many applications which may be made of secondary batteries. Six Plante cells have been found sufficient to drive a tricycle with 160 kilogrammes, or about 300 lb., upon it, at a rate of ten miles an hour, or to drive a boat containing three persons.

(1.) These secondary batteries may be used to carry a supply of electricity, where it is wanted.

(2.) They may accumulate supplies from a dynamo machine and store energy up for electric lighting or for motive power.

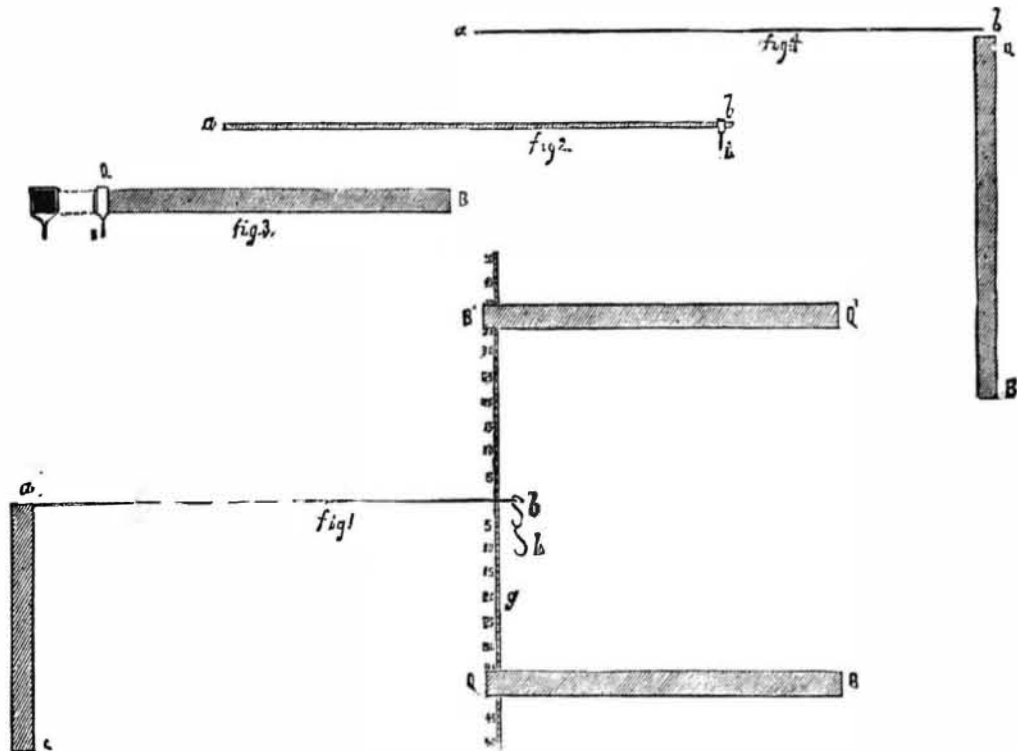
(3.) They may serve as regulators for the electric current, when as in electric lighting it is liable to fluctuations, either from the irregularity of the driving engine, or from the change of resistance in the electric arc or in the electric circuit. When so used, they would supply and keep up the light, even though the engine were suddenly to stop, or any accident to happen other than the cutting of the connecting wires.

The Faure's accumulator has been employed to light a railway train from London to Brighton by means of incandescent lamps, to work an electric motor so as to drive a circular saw or other mechanical tools, and it has been employed with very satisfactory results in driving a tramway in the streets of Paris, and in the Siemens electric railway between the Electrical Exhibition and the Place de la Concorde. The results already attained seem to show that there is no other secondary battery which can compare with this for storing up and keeping for a long time a supply of electric energy, and for using it slowly when in action.

MAGNETIC DYNAMOMETER.

By DR. ANTONIO COSTA SAYA, Professor of Physics in the University of Messina.

THE principal part of this instrument consists of two magnets, *a b*, *Q B*, and a scale, *d g* (Fig. 1), arranged upon a rectangular base of wood. The two magnets are placed one above another in such a manner that the axes of symmetry are horizontal and in the same vertical plane. Each of these two magnets carries a very slender index, *i* (Fig. 2). I



MAGNETIC DYNAMOMETER

cells by electrolysis, but coats the lead plates with a film of red lead or minium, inclosing or protecting the red lead coating with a layer of felt. His cells are of large size, and each is therefore capable of storing up a considerable quantity of electrical energy. The chemical action is similar to the action in a Plante cell, but the resistance is higher, and when in use the battery takes longer to discharge itself, so that for electric lighting and for many purposes for which a store of electricity is required it seems to be better adapted than the Plante cell. It has been said, and the statement has been confirmed by Sir William Thomson, that a "Faure accumulator, weighing 75 kilogrammes (165 lb.), can store, and give out again, energy to the extent of an hour's work of one horse-power," or two million foot-pounds. At first these cells were made cylindrical, and the Faure Accumulator Company have kindly lent me a box of four such cells in action, similar to the celebrated box of electrical energy or condensed lightning, so graphically described in the *Times* of May 16 last, which was carried from Paris to Glasgow for examination and measurement by Sir William Thomson. They have also lent me one of their latest forms, in which the plates are flat, and placed vertically in the box. It has been ascertained by Sir William Thomson that Faure's accumulators, amounting in weight to three-quarters of a ton, will continue to work for six hours from one charge at the uniform rate of one horse-power, and that probably 90 per cent. of the energy spent in charging will be transformed into useful work. Very few comparative trials have been made of the Plante and the Faure batteries, but from those which have been made by M. Achard, it appears, that, as might be expected, they are equal in electromotive force, that the Plante cell is of smaller resistance than the Faure cell, and, consequently, will heat a longer piece of platinum wire, and do its work three times as rapidly. The Plante cell kept a platinum wire 3-10ths mm. in diameter and 5 or 6 cm. long red hot for half an hour, and the Faure cell kept the same wire red hot for an hour and a half. We may readily see by a few experiments that the Faure's battery has collected a great quantity of electrical energy, for one box of it will cause a platinum wire of considerable length, and 1 mm. in diameter, to glow, and one cell is sufficient to drive a small dynamo-electric machine as

(Fig. 3), placed at right angles with the axis of symmetry and in the medium horizontal plane of the thickness.

The first magnet, *a b* (Fig. 1), is formed of a long, narrow and thin spring of steel, which is fixed horizontally at one end, *a*, to a perpendicular support, *a c*, and left free at the other extremity, *b*; the latter carries the index, *i*, which by bending *a b* slides along the scale, *d g*; this scale is finely divided into equal graduations, and can be raised or lowered. In order to secure the scale in its exact position before experimenting, the second magnet, *Q B*, is removed from its support and the scale fixed by means of a set-screw, so that its zero corresponds precisely to the index, *i*, of the spring *a b*. The plane upon which the magnetic dynamometer is placed during experimentation ought to be very firm, and it should not be affected by the oscillations of the floor.

The second magnet, *Q B*, is placed upon a movable toothed support, by means of which it can be approximated to the other magnet, *a b*, or removed from it. Upon the button of the rack-work is a set-screw to fix the support of the magnet, *Q B*, at the desired height.

In such an instrument the magnetic attraction or repulsion is counterbalanced by the elasticity of flexion. The following experiments will exemplify the method of working the apparatus.

FIRST EXPERIMENT.

The magnet, *Q B*, is removed from its support, and removed so far from the instrument that it cannot act upon the spring-magnet, *a b*; then it can be demonstrated that the inflection of *a b* is proportional to the force which produces it. At *b* there is suspended a very slender copper wire of the form of *S* for the purpose of lowering the index, *i*, a short distance, *l*, from the scale, *d g*; to the weight there is appended a second one, *h*, of equal weight, so that the index can be lowered to $2l$, and by means of other weights this lowering can be extended to any degree sufficient for the use for which the instrument is intended. If the chain of weights, *b h*, be removed, the index will return to the zero of the scale, *d g*. This experiment shows that within certain limits the inflections of the spring, *a b*, are proportional to the force which produces them.

SECOND EXPERIMENT.

The magnet, Q B, is placed upon its support in a direction parallel to *a b*, as is indicated in Fig. 1, and in such a manner that its magnetic pole, Q, corresponds to the contrary magnetic pole, *b*, of the spring magnet, *a b*; moreover it is placed near the scale, *d g*, before which extends the index, I, fixed to a ring. This arrangement enables the index, I, to be placed at a convenient distance from the scale upon which are marked the different heights at which the magnet, Q B, is placed on raising or lowering it.

This being done and the magnet, Q B, being always kept in a parallel position, it is brought to a certain distance from the spring, *a b*, in such a manner as to cause a lowering of the index, *i*; and preserving this, the magnet, Q B, is moved slowly backward and forward to find the position which corresponds to the maximum depression of the index, *i*; in such movements the axis of the magnet, Q B, ought not to change its distance from the other magnet, *a b*, nor be removed laterally. When such a position of the magnet, Q B, is found, it is fixed with a set-screw, and then the magnetic dynamometer is ready for experiments, by means of which it is demonstrated that magnetic attraction varies inversely as the square of the distance.

THIRD EXPERIMENT.

The magnet, Q B, is removed from the magnet, *a b*, until its index, *i*, marks a slight depression, *l*, and then the corresponding distance, *d*, of the two poles, *a b* (measured from the distance of the two indices, *i*, I), is noted.

This being done, the magnet, Q B, is approached to *a b*, it being always kept in the same parallel position, so as to reduce to $\frac{1}{2}d$ the distance of the two poles, *a b*; it will then be seen that there is a depression of the index, *i*, quadruple that formerly obtained, on $4l$. Thus it is shown that the magnetic attraction between the two poles, Q and *b*, varies in the inverse ratio of the squares of their distances. On reducing then the distances of the two poles to $\frac{1}{3}d$, the depression of the index will be $9l$, or ninefold the first, as it ought to be according to the law in question.

In making such experiments it is necessary to avoid a too close proximity of the magnets, and the first depression, *l*, must be very small.

If it is desired to make a large number of experiments in confirmation of the said law, the following method may be employed.

FOURTH EXPERIMENT.

Let *l*, *l'*, be equal depressions of the index, *i*; and *d*, *d'*, the relative distances of the two poles, Q and *b*, then in accordance with the known law

$$(1) \quad l, d^2 = l', d'^2$$

whence (2) $d' = d \sqrt{\frac{l}{l'}}$

Let us suppose that at the known distance, *d*, there is a known depression, *l* = 0.2 of the scale by the index, *i*, then (2) we have

$$(3) \quad d' = d \sqrt{\frac{0.2}{l'}}$$

If we wish to know the distances, *d'*, *d''*, *d'''*, etc., of the two poles, *a* and *b*, corresponding to the depressions, *l'* = 0.4; *l''* = 0.6; *l'''* = 0.8, etc., it is sufficient to substitute for *l*, in the equation 3 the numerical values of the distances *d'*, *d''*, *d'''*, and approximating successively the pole, Q, to the pole, *b*, there are obtained the depressions corresponding to the index, *i*, in conformity with the law above mentioned.

MAGNETIC REPULSION.

To prove the same law for magnetic repulsion, the magnet, Q B, is placed above *a b*, in the position B' Q' (Fig. 1), parallel to *a b*, so that the two homonymous poles, *b* and B, of the two magnets may correspond in the same perpendicular. To the latter is adapted the ring which carries the index, I, laying hold of the pole, Q, which, in this new position, will correspond to Q'.

By this arrangement of the two magnets, the index, *i*, of the magnet, *a b*, will be depressed by the magnetic repulsion between the two similar poles, B' and *b*. The experiments may be made in the same manner which was employed for demonstrating the law of magnetic attraction.

DISTRIBUTION OF MAGNETISM IN A MAGNET.

The instrument in question is useful for studying the distribution of magnetism in a magnet, Q B. For this purpose it is not placed in a parallel position, but in such a manner that the axes of symmetry of the two magnets, *a b*, Q B (Fig. 4), may be situated horizontally at different heights, and in two planes, vertical and perpendicular. This position of the magnet, Q B, is called the perpendicular position, to distinguish it better from the parallel position.

Let Q B be placed in the perpendicular position under *a b* (Fig. 4) so that the two contrary poles, *b*, *q*, may correspond in the same vertical, and at such a distance as to have a depression of the index, *i*, equal to $9l$. This being done, the needle, Q B, is moved very slowly, so that its different sections may correspond successively in the same vertical of the pole, *b*; the index, *i*, will be raised till it returns to zero, and if the movement of Q B is then continued, the index will be pushed in the opposite direction, passing above zero, and rising till the homonymous pole, B, of the magnet, Q B, will be placed below *b*.

A T-shaped support assists in maintaining the magnet, Q B, in the perpendicular position, so that the above mentioned experiment can be made convenient.

In this and other experiments, it is useful for the magnet, Q B, to be adapted to a scale for better determining the corresponding section, in the same vertical plane, which passes through *b*, when the index, *i*, marks a positive or a negative deviation or none.

MAGNETIC ACTIONS THROUGH BODIES.

It is easy to demonstrate with this instrument that magnetic action is propagated without becoming weakened through many bodies. It is sufficient to interpose the bodies, holding them in the hand, between the poles of the two magnets placed in the parallel position (Fig. 1) so as to have a certain depression of the index, *i*. The index will then be seen to remain motionless on interposing between the two poles copper, glass, wood, etc., and to suddenly change its position if a plate of iron is inserted.

ACTION OF SOLENOIDS UPON MAGNETS.

It will be understood that the dynamometer may give cope for new studies on the reciprocal action between a

solenoid and a magnet. It will be sufficient to substitute for the magnet, Q B, a solenoid, both in the parallel and in the perpendicular position.

ELECTRIC DYNAMOMETER.

It would be possible to have an electric dynamometer founded on the same principles. It would be sufficient to suspend to the extremity, *b*, of the spring, *a b* (Fig. 1), a disk of gilt paper, or a ball of elder pith, and charge it with electricity. For the magnet, Q B, must be substituted a rod of varnished glass, which supports at one of its ends another pith ball, which is charged either with the same or with the opposite kind of electricity, according as it is intended to study electric repulsion or attraction. The electric dynamometer must be enclosed in a well-fitting glass case, within which some desiccating substance must be constantly kept. The method of experimenting will be analogous to what has been already described. But special care must be had to take account of the loss of electricity in the interval of time between successive experiments.

The inventor shows that the magnetic dynamometer is preferable to the old instruments for demonstrating that magnetic action varies inversely as the squares of the distances, as well as for other magnetic and electric researches. —*Telegraphic Journal*.

IMPROVED DYNAMOMETER.

In the British section Mr. Paterson shows the transmission dynamometer of Professor Ayrton and Perry, which has been so recently illustrated in our columns that it is unnecessary to refer more to it. A transmission dynamometer is shown at the Paris Electrical Exhibition by Mr. F. J. Smith, of Taunton, England. The construction of this instrument is as follows: The two pulleys, A B, each carrying a bevel wheel, and running loose on the same fixed shaft, are in gear with a third bevel wheel, the axis of which is carried at right angles to the axis of the other two by the sector-shaped casting, C. This casting, while carrying the intermediate wheel, is capable of angular displacement, this displacement being controlled by a spiral spring within the case, F, which spring is attached to the sector in such a manner that its pull always acts tangentially to it. An upper sector of wood, H, fixed to the under sector and counterpoiser, carries on its edge a light rod, G D, attached to the sector by two cross cords. At D a tracing point records on the drum, E, an ordinate, which is a measure of the extension of the spring. The drum is driven by a screw and tangent wheel at a given

dare to pass. "And it is a fact," M. Nielsen states, "that when, twenty or more years ago, telegraph lines were carried over the mountains and along the valleys, the wolves totally disappeared, and a specimen is now a rarity." Whether the two circumstances are causally connected, M. Nielsen does not venture to say.

ELECTRIC LIGHTING — REPORT OF THE FRANKLIN INSTITUTE COMMITTEE.

At the October meeting of the Franklin Institute a committee, consisting of R. E. Rogers, M.D., Chairman; William P. Tatham, C. M. Cresson, M.D., David Brooks, E. Alex. Scott, Edwin T. Houston, and Isaac Norris, M.D., Secretary, was appointed to consider the "dangers incident to electric light, if any, and the means of overcoming them." Their report, which is now only awaiting final revision, says that "from a careful consideration of the evidence submitted, they believe that the use of electricity as an illuminant, as now generally employed, is not attended with any danger either to person or property that cannot be obviated by the adoption of the precautions hereinafter set forth."

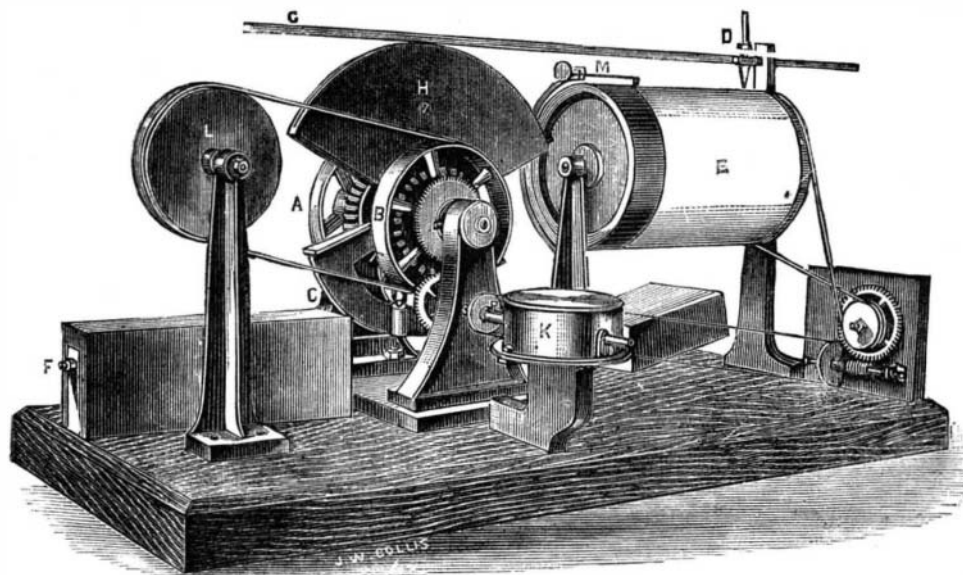
The report briefly describes the two systems of electric lighting—by incandescence and by the voltaic arc—explains the manner in which mechanical energy is converted into electric current by the dynamo machines, and particularly describes the difference in properties between the current produced by a frictional machine, which will leap through the air, and those from a dynamo machine, which do not possess this power.

The report says: "The currents from dynamo-electric machines or the currents employed in systems of electric lighting are not therefore at all comparable to strokes of lightning, to which they have often been ignorantly likened. Lightning discharges frequently pass through miles of air, but even in the largest machines the carbons employed in arc lamps must first be brought into contact and afterward separated before the arc is established and the current passes between them. The current will not, in fact, leap through the air. The momentary contact of the two carbons develops sufficient heat to form a cloud of carbon vapor between them, and this cloud, being an electrical conductor, permits the current to pass."

The report then describes the possible sources of danger from electric lighting, and sums up with the following

RECOMMENDATIONS OF THE COMMITTEE:

1. That the conducting wires leading into and out of the



SMITH'S DYNAMOMETER.

ratio to the speed of the pulleys, A or B. A counter, K, is used to record the number of revolutions. The force transmitted during the investigation is known by finding the area of the diagram. The wheel and handle, L, is connected to the pulley, B, by a bell, to show how the apparatus works. The tracer, D, indicates the tension of the belt. The time during which the investigation lasts is shown by a lever, M, which carries a tracer. The lever is actuated by an electro-magnet connected to a seconds pendulum, so that the record is given in seconds. The dynamometer shown at Paris is a model, suited only for simple laboratory work, but the constructor states that other instruments similar in design have been used to transmit from 5 to 10 h. p.

EFFECTS OF TELEGRAPH WIRES ON ANIMALS.

SOME interesting facts are brought out in a paper by M. C. Nielsen, of Christiania, on the impression produced upon animals by the resonance of the vibrations of telegraph wires. It is found that the black and green woodpeckers, for example, which hunt for insects in the bark and in the heart of decaying trees, often peck inside the circular hole made transversely through telegraph posts, generally near the top. The phenomenon is attributed to the resonance produced in the post by the vibration of the wire, which the bird mistakes as the result of the operations of worms and insects in the interior of the post. Every one knows the fondness of bears for honey. It has been noticed that in mountainous districts they seem to mistake the vibratory sound of the telegraph wires for the grateful humming bees, and, rushing to the post, look about for the hive. Not finding it on the post, they scatter the stones at its base which help to support it, and, disappointed in their search, give the post a parting pat with their paw, thus showing their determination at least to kill any bees that might be about it. Indisputable traces of bears about prostrate posts and scattered stones prove that this really happens.

With regard to wolves, again, M. Nielsen states that when a vote was asked at the time for the first great telegraph lines a member of the Storting said that, although his district had no direct interest in the line proposed, he would give his vote in its favor, because he knew the lines would drive the wolves from the districts through which they passed. It is well known that to keep off the ravages of hungry wolves in winter the farmers in Norway set up poles connected together by a line or rope, under which the wolves would not

building be suitably insulated throughout their entire extent both to and from the machine producing the current.

2. That an inspection be made at suitable intervals to determine whether or not the insulation has been preserved intact.

3. That conductors, formed of numerous short pieces of wire, be avoided as far as possible, and that, where their use is necessary, the joined ends be made as secure as possible by wrapping, so as to prevent short arcs being formed at imperfect junctions, should the joined ends be partially separated from each other.

4. That the wires be not grounded; that is, that no attempt be made to cause the current to pass back to the machine through the earth, but that a continuous line of wire be provided through which the current shall so return.

5. That the ready occurrence of cross contacts or short circuits be avoided as follows, viz.: That the conducting wires from different machines or from different parts of the same machine be kept as far apart as convenient, and never, except when necessary, be brought nearer together than the distance between the two binding posts on any electric lamp used in the circuit.

That, therefore, the wire leading from the machine into the room to be lighted should leave the room as far as convenient from the place it enters.

That the wires be securely fixed in position, and be not allowed to sag or bend in wide curves, except where it is necessary to permit the rising or lowering of the lamp.

That judgment be exercised in selecting the portions of the building in which to run the wires. To secure as far as possible, the absence of moisture, ceilings are to be preferred to walls or floors, the latter being highly objectionable unless the wires are placed under the flooring. As before stated, the location selected should be removed as far as possible from metallic conductors. Select the places least liable to be rendered partially conducting by moisture, from any source, in which to run wires.

6. That the conducting wires be of sufficient size to carry the most powerful current employed without dangerous heating.

7. In order to avoid the danger to life from the accidental discharge of the current through the body, the conducting wires should in all cases, if convenient, be placed out of reach, either by choice of location or the use of heavy and guarded insulation.

8. That where lamps of the arc type are used they be covered with a globe of glass, and the lower end of such