

ism has to explain is: Iron, nickel, and cobalt, all enormously magnetic; other substances practically non-magnetic. A second fact is: With most bodies the action of the primary current on the secondary circuit is strictly proportional to the primary current; with magnetic bodies it is by no means so.

You will observe that the ordinates in these curves, which are proportional to the kicks or elongations of the galvanometer, are called induction, and that the abscissæ are called magnetizing force. Let us see a little more precisely what we mean by the terms, and what are the units of measurement taken. The elongation of the galvanometer measures an impulsive force—an electromotive force acting for a very short time. Charge a condenser to a known potential, and discharge it through the galvanometer: the needle of the galvanometer will swing aside through a number of divisions proportional to the quantity of electricity in the condenser—that is, to the capacity and the potential. From this we may calculate the quantity of electricity required to give a unit elongation. Multiply this by the actual resistance of the secondary circuit, and we have the impulsive electromotive force in volts and seconds, which will, in the particular secondary circuit, give a unit elongation. We must multiply this by 10 to have it in absolute C. G. S. units. Now the induction is the impulsive electromotive force in absolute C. G. S. units divided by the number of secondary coils and by the area of section of the ring in square centimeters. The line integral of magnetizing force is the current in the primary in absolute C. G. S. units—that is, one-tenth of the current in amperes—multiplied by  $4\pi$ . The magnetizing force is the line integral divided by the length of the line over which that line integral is distributed. This is, in truth, not exactly the same for all points of the section of the ring—an imperfection so far as it goes in the ring method of experiment. The absolute electromagnet C. G. S. units have been so chosen that if the ring be perfectly non-magnetic, the induction is equal to the magnetizing force. We may refer later to the permeability, as Sir W. Thomson calls it: it is the ratio of the induction to the magnetizing force causing it, and is usually denoted by  $\mu$ .

There is a further difference between the limited class of magnetic bodies and the great class which are non-magnetic. To show this, we may suppose our experiment with the ring to be varied in one or other of two or three different ways. To fix our ideas, let us suppose that the secondary coil is collected in one part of the ring, which, provided that the number of turns in the secondary is maintained the same, will make no difference in the result in the galvanometer. Let us suppose, further, that the ring is divided so that its parts may be plucked from together, and the secondary coil entirely withdrawn from the ring. If now the primary current have a certain value, and if the ring be plucked apart and the secondary coil withdrawn, we shall find that, whatever be the substance of which the ring is composed, the galvanometer deflection is one-half of what it would have been if the primary current had been reversed. I should perhaps say approximately one-half, as it is not quite strictly the case in some samples of steel, although, broadly speaking, it is one-half. This is natural enough, for the exciting cause is reduced from, let us call it a positive value, to nothing when the secondary coil is withdrawn; it is changed from a positive value to an equal and opposite negative value when the primary current is reduced. Now comes the third characteristic difference between the magnetic bodies and the non-magnetic. Suppose that, instead of plucking the ring apart when the current had a certain value, the current was raised to this value and then gradually diminished to nothing, and that then the ring was plucked apart and the secondary coil withdrawn. If the ring be non-magnetic, we find that there is no deflection of the galvanometer; but, on the other hand, if the ring be of iron, we find a very large deflection, amounting, it may be, to 80 or 90 per cent. of the deflection caused by the withdrawal of the coil when the current had its full value. Whatever be the property that the passing of the primary current has imparted to the iron, it is clear that the iron retains a large part of this property after the current has ceased.

We may push the experiment a stage further. Suppose that the current in the primary is raised to a great value, and is then slowly diminished to a smaller value, and that the ring is opened and the secondary coil withdrawn. With most substances we find that the galvanometer deflection is precisely the same as if the current had been simply raised to its final value. It is not so with iron; the galvanometer deflection depends not alone upon the current at the moment of withdrawal, but on the current to which the ring has been previously subjected. We may then draw another curve (Fig. 2) representing the galvanometer deflections

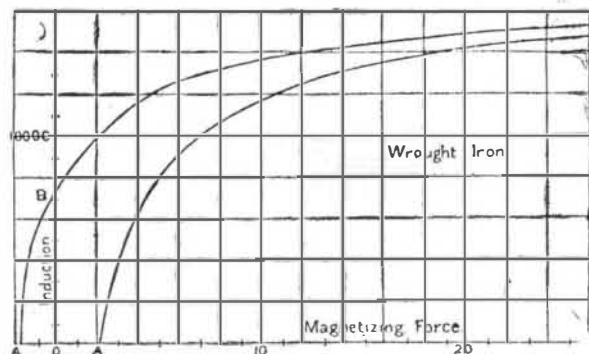


FIG. 2.

produced when the current has been raised to a high value and has been subsequently reduced to a value indicated by the abscissæ. This curve may be properly called a descending curve. In the case of ordinary bodies this curve is a straight line coincident with the straight line of the ascending curve, but for iron is a curve such as is represented in the drawing. You observe that this curve descends to nothing like zero when the current is reduced to zero: and that when the current is not only diminished to zero, but is reversed, the galvanometer deflection only becomes zero when the reversed current has a substantial value.

This property possessed by magnetic bodies of retaining that which is impressed upon them by the primary current has been called by Prof. Ewing "hysteresis," or, as similar properties have been observed in quite other connections, "magnetic hysteresis." The name is a good one and has been adopted. Broadly speaking, the induction as measured by the galvanometer deflection is independent of the time during which the successive currents have acted, and depends only upon their magnitude and order of succession. Some recent experiments of Prof. Ewing, however, seem to show a well marked time effect. There are curious features in these experiments which require more elucidation.

It has been pointed out by Warburg, and subsequently by Ewing, that the area of curve 2 is a measure of the quantity of energy expended in changing the magnetism of the mass of iron from that produced by the current in one direction to that produced by the current in the opposite direction and back again. The energy expended with varying amplitude of magnetizing forces has been determined for iron, and also for large magnetizing forces for a considerable variety of samples of steel. Different sorts of iron and steel differ from each other very greatly in this respect. For example, the energy lost in a complete cycle of reversals in a sample of Whitworth's mild steel was about 10,000 ergs per cubic centimeter; in oil-hardened hard steel, it was near 100,000; and in tungsten steel it was near 200,000—a range of variation of 21 to 1. It is of course of the greatest possible importance to keep this quantity low in the case of armatures of dynamos and in that of the cores of transformers. If the armature of a dynamo machine be made of good iron, the loss from hysteresis may easily be less than one per cent.; if, however, to take an extreme case, it were made of tungsten steel, it would readily amount to twenty per cent. In the case of transformers and alternate current dynamo machines, where the number of reversals per second is great, the loss of power by hysteresis of the iron and the consequent heating becomes very important. The loss of power by hysteresis increases more rapidly than does the induction. Hence it is not well in such machines to work the iron to anything like the same intensity of induction as is desirable in ordinary continuous current machines. The quantity,  $O A$ , when measured in proper units, as already explained—that is to say, the reversed magnetic force, which just suffices to reduce the induction as measured by the kick on the galvanometer to nothing after the material has been submitted to a very great magnetizing force—is called the "coercive force," giving a definite meaning to a term which has long been used in a somewhat indefinite sense. The quantity is really the important one in judging the magnetism of short permanent magnets. The residual magnetism,  $O B$ , is then practically of no interest at all; the magnetic moment depends almost entirely upon the coercive force. The range of magnitude is somewhat greater than in the case of the energy dissipated in a complete reversal. For very soft iron the coercive force is  $1\frac{1}{2}$  C. G. S. units; for tungsten steel, the most suitable material for magnets, it is 51 in the same units. A very good guess may be made of the amount of coercive force in a sample of iron or steel by the form of the ascending curve, determined as I described at first. This is readily seen by inspection of Fig. 3, which shows the curves in the

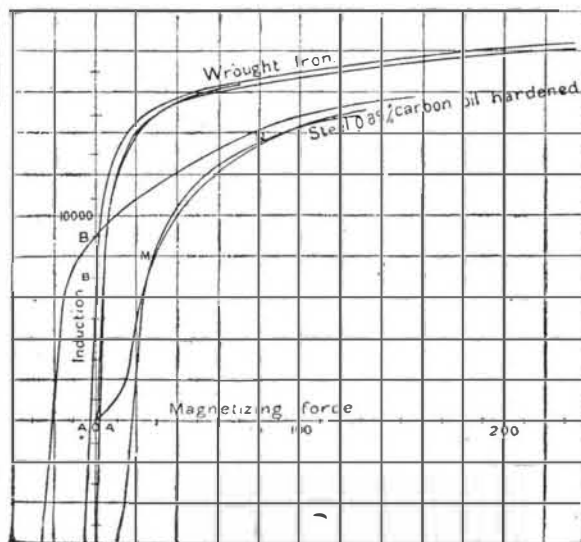


FIG. 3.

cases of wrought iron, and steel containing 0.9 per cent. of carbon. With the wrought iron a rapid ascent of the ascending curve is made, when the magnetizing force is small and the coercive force is small; in the case of the hard steel the ascent of the curve is made with a larger magnetizing current, and the coercive force is large. There is one curious feature shown in the curve for hard steel which may, so far as I know, be observed in all magnetizable substances: the ascending curve twice cuts the descending curve, as at M and N. This peculiarity was, so far as I know, first observed by Prof. G. Wiedemann.

(To be continued.)

#### THE RENARD PRIMARY BATTERY.

It would appear that there is a revival of invention in respect of primary batteries, inasmuch as after a silence of about two years in this respect we have within the last two months or so recorded the particulars of two new batteries, and we now do so in respect of a third.

This last is the invention of Major Renard, a French officer, who attracted attention with his battery in his own country during the Paris exhibition. This battery, which we recently inspected at Messrs. Aron's offices, Bridewell Place, London, has for its electrodes platinum, silvered by lamination, and zinc. The exciter is a solution of chromic acid, hydrochloric acid, and sulphuric acid.

A battery, 2 ft. 9 in. high and 12 in. in diameter over all, weighs 25 pounds when charged, and is said to afford a glow light of from 20 to 25 candle power for from five to eight hours without replenishing the bat-

tery, the cost of each charge of the solution being 2s. The current produced is stated to be of 10 volts, 4 amperes, and 45 watts.

The special feature of this battery appears to be the method of working it. The electrodes are placed in tubular cells, which reach to the bottom of the battery and which are open at their lower ends. The elements themselves reach only half way down these tubes, and the exciting solution only reaches half way up them. Hence, in their normal position the electrodes are out of reach of the solution, and there can be no current produced; consequently no waste is going on. To start, the light air is forced into the body of the battery by a small hand pump, and the compressed air impinging on the surface of the solution forces it upward into the tubular cells, and it thus surrounds the electrodes. The greater the compression given to the air, the brighter the light, in consequence of the electrodes being more deeply immersed in the fluid, and therefore producing a greater current. If it is desired to diminish the amount of light, a small valve is opened, and the air pressure is thus reduced, which causes the level of the fluid to become lowered. To extinguish the light the valve is fully opened until the air pressure inside the battery is the same as that outside. It is stated that this battery has earned a good reputation in France, where it is being adopted by the military and naval authorities. By means of larger batteries than that we inspected, it is stated that arc lamps of 300 candle power are run with satisfactory results.—*London Times*.

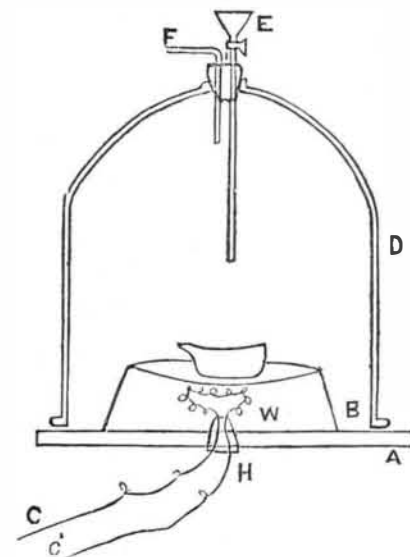
#### ELECTRICITY IN CHEMICAL MANIPULATIONS.

By REGINALD FESSENDEN, Chemist, Edison Laboratory, Orange, New Jersey.

A DESCRIPTION of a few pieces of chemical apparatus in which electricity is employed may be of interest.

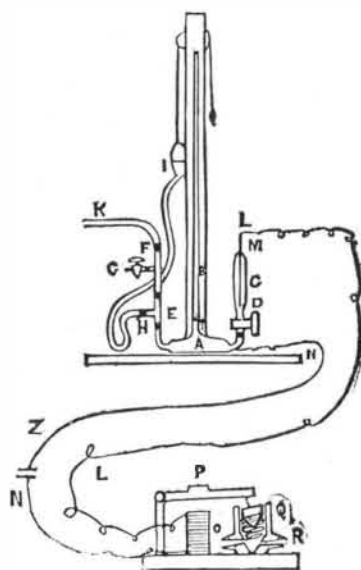
The current is derived from a simple primary battery, such as described above.

1. *For Rapid Evaporation in Vacuum.*—A is a piece of plate glass, through the center of which a hole is



bored by means of a brass tube and emery; in the hole a cork, H, is inserted, and two wires, G G, run through it, each connected to one end of the platinum loop, W, which latter is packed with magnesia or any such material. The operation is as follows: The dish, C, containing the substance to be evaporated, is placed on the stand, B, and the bell jar placed over all. The tube, F, is connected to the filter pump, and the wires, G G, to the terminals of the battery. Evaporation proceeds with extreme rapidity. More liquid is added from time to time through the separatory funnel, E. Where the current is obtainable, electric incandescent lamps may be used, in place of wire, with advantage.

2. *Automatic Heat Regulator and Air Thermometer.*—A is a piece of glass tube, 4 inches long and one inch in diameter, having three nipples, one connected to a piece of thermometer tubing, B, one to a short piece of tubing, C, drawn out very fine at D, and having a cock



at its lower extremity, and the third to the T-piece, E. K is a tube connecting with the air bulb, which may be of Bohemian glass; I is a bottle of mercury, connecting by a rubber tube with H; N is a platinum wire, fused into A; M is a thin carbon rod, resting on the capillary portion of C, and connected to the wire, L. There are cocks at H and T. O is an electromagnet, connected to the wires, L and M. Q is a plunger, held up by a spring in a piston, so that the gas can pass freely through the opening, R, to the burners so long as the magnet is not acting. The operation is

as follows: Cocks, H and T, open, cocks, G and D, shut; it is a simple air thermometer, readings being taken on the tube, D. To use it as a regulator, the bath is raised to the required temperature, cocks, G and D, are opened, and the mercury adjusted so that it nearly touches the carbon rod, M. Cocks, G, H, and T, are then closed. It will be seen that if the temperature rises ever so slightly the mercury will touch M, and the current from the battery, Z, flowing through the wires, L and N, will pull down the armature, P, driving the cylinder, Q, down and shutting off the gas, except so much as may be necessary to keep the burners lighted.

This apparatus will maintain the temperature constant for days to half a degree; hence it is of use in accurate and long fractional distillations. It works with any kind or pressure of gas, and one cell will keep it going for months.—*Chem. News.*

#### THE PYROMETRIC TELESCOPE.

THE exact determination of the temperature of incandescent bodies is a problem that presents a great practical importance in a large number of industries founded upon the application of high temperatures.

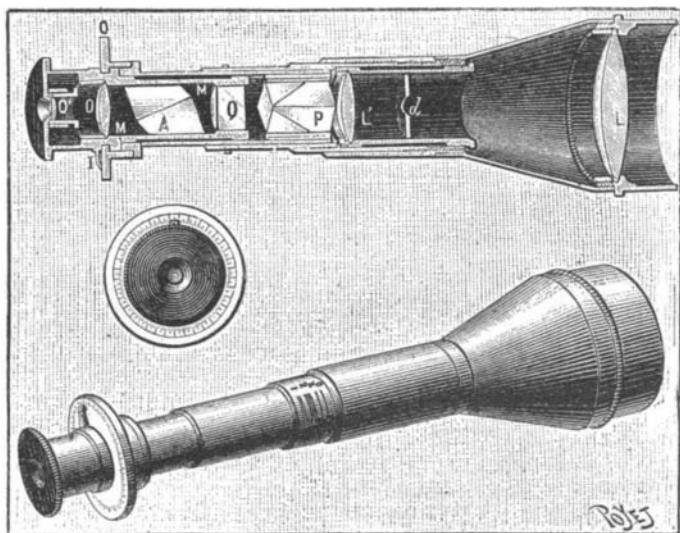


FIG. 1.—MESURE & NOUEL'S PYROMETRIC TELESCOPE.

Such is the case, for example, in metallurgy, in furnaces for melting steel and for reheating ingots, in blast furnaces, in glass works, in porcelain manufactories, etc.

The chemical reactions developed in these furnaces may, in fact, vary with the temperature, and this is even often the case with the physical properties. A piece of porcelain baked under proper conditions, at a given temperature, is incapable of supporting, without danger, a stronger heat, as this would cause cracks in the glazing, and, at a lower temperature, the reactions would be incomplete, and the enamel would be insufficiently fused, etc. So too, in steel furnaces, the degree of temperature is capable of completely modifying the direction of the oxidizing or reducing reaction, and seems in all cases to bring about a great modification in the proportion of the carbon combined or dissolved. The most recent theories, in fact, admit that such proportion is regulated by a sort of dissociation of tension variable with the temperature, etc. There evidently results from this an absolute necessity, for the success of the operations, of defining temperatures in a pretty precise manner, independent of all causes of error, in order to make it possible to reproduce with certainty, and under precisely identical conditions, the reaction that we have in view.

This can be done by observing the color of the incandescent objects. We know, in fact, that, in measure as the temperature rises, the color passes to bright red and gradually reaches the shades of yellow, red, orange, straw yellow, and finally a more or less dazzling white. There is a gamut of colors, well known to all, of which

paratus have unfortunately not given entirely satisfactory results.

The regulation of water pyrometers is one of the most delicate of operations, and photometers properly so called, like those of Mr. Crova or Mr. Trannin, are rather laboratory apparatus, which cannot be carried into manufactories.

The pyrometric telescope, on the contrary, furnishes a solution of the problem at once. It permits of estimating the temperature by a simple inspection, which gives the exact color of the incandescent piece.

It is a small, simple, accurate, and portable apparatus, thanks to which observers can, without error, define the temperature that they wish to obtain, and thus assure themselves that they are always operating under exactly identical conditions.

We have here one of the most important questions in every industry that makes use of high temperatures, and thus is explained the immediate success of the apparatus.

The pyrometric telescope is due to the two engineers of the St. Jacques works of Montluçon, belonging to the Chatillon-Commentry Company of Forges, whose large rolling mill we have already described,\* and which has gained a special renown for itself in the world

of metallurgy through the scientific interest of its work. This telescope is shown in Figs. 1 and 2 under two forms. The model shown in Fig. 2, which is the simpler type of the two, is scarcely more than 10 in. in length, and is easily portable; but the two types exhibit hardly any essential difference.

The apparatus is based upon the application of the phenomena of rotary polarization. It consists of two Nicol prisms, an analyzer, A, and another polarizer, P, whose principal sections make an angle of 90°, between which is interposed a disk of quartz, Q. As we know, the ordinary luminous ray, on coming from the first prism, P, is polarized in a plane determined by the principal section of this polarizer, and is consequently entirely extinguished on traversing the second prism, A, whose principal section is at right angles with the first. The interposed quartz, which is at right angles with the axis, has the effect, on the other hand, of turning the plane of polarization, which becomes oblique upon the principal section of the analyzer, and can therefore traverse it without being completely extinguished. According to the well known law of Biot, the angle of deviation is proportional to the thickness of the quartz, and nearly inversely proportional to the square of the length of the wave. As the length of the latter depends upon the color, which itself depends upon the respective proportion of the simple rays of the light transmitted in the ordinary ray, it will be at once seen that the deviation observed will depend directly upon the color of the ordinary ray, and that if we have a means of measuring such deviation we shall at once be able therefrom to judge of the temperature

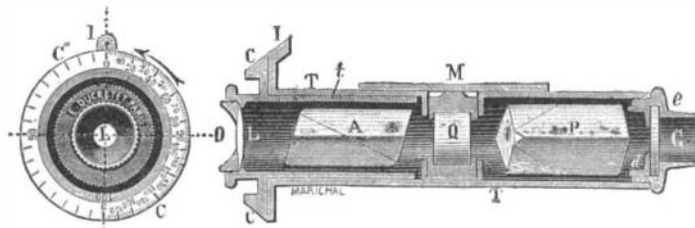


FIG. 2.—SMALLER FORM OF THE APPARATUS.

Pouillet, in his scale, has given the correspondence in degrees with the indications of the thermometer. It furnishes the characteristic of the variations in temperature; but from this point of view, a simple direct observation became insufficient, for it is impossible wholly to avoid errors that are due to the personal estimation of the observer. The eye cannot distinguish shades of color in an absolute manner, and scarcely judges of them except by comparison.

Dark red will appear like a bright red in a dark place, and, on the contrary, bright red may appear like a dark red in a strongly illuminated place. In a word, we have here an indisputable cause of error, well showing the necessity of having recourse to an instrument whose indications shall be indifferent to the external surroundings.

Such was the starting point of the numerous types of apparatus designed for estimating high temperatures through the measurement of a well defined phenomenon; some of them, pyrometers, based upon the use of a mass of clay whose shrinkage is measured, or of a current of water circulating under determinate conditions, whose rise in temperature is measured, etc., and others, photometers, based upon the use of optical processes for the measurement of the luminous intensity of incandescent bodies. The majority of such ap-

paratus have unfortunately not given entirely satisfactory results. To this effect, the analyzer is made movable, and is so mounted that it can revolve in the interior of the telescope so as to cause the principal section to make any angle whatever with the polarizer. An index, I, fixed in front of a marble graduated circle, C (Fig. 2), permits of ascertaining this deviation, the zero of which corresponds to complete extinction, the quartz being removed. If the incandescent body be observed while the analyzer is being slowly revolved, the light perceived is of a determinate tint which varies with the temperature, and this light disappears at a corresponding angle of rotation, and it is therefore this angle that is capable of serving to ascertain the temperature observed. Generally an endeavor is made to observe a determinate tint of easy distinction. It is found, in fact, that upon a very slight rotation of the analyzer, the tint perceived almost immediately changes from green to red, passing the while through a special tint—dirty lemon color, which lasts for but a moment, and which for this reason has received the special name of transition tint. It is to this tint that the measured angles are referred.

Besides these parts, the telescope, as shown in the

section in Fig. 2, is provided with a lens, L, or a plain glass, Z, forming an objective for collecting the ordinary rays and directing them upon the polarizer, and another lens, D, forming an eye piece, which receives the rays coming from the analyzer, and which is movable with the latter in its tube.

This telescope was constructed by Mr. Ducretet according to instructions furnished by Messrs. Nouel and Mesure, and has now been in use for more than a year in the Saint Jacques works, where the use of it has become familiar to all the under-engineers, and, by assuring the perfect identity of all the operations, it has much to do with the remarkable quality of the products obtained at this establishment.—*La Nature.*

(Continued from SUPPLEMENT, No. 738, p. 11798.)

#### RABIES AND ITS PREVENTIVE TREATMENT.\*

By ARMAND RUFFER, M.A., M.D.

DURING the period extending from November, 1885, to January, 1886, 2,164 human beings, bitten by animals proved to be rabid, were inoculated at M. Pasteur's Institute in Paris. Of these, thirty-two died (mortality 1.47 per cent.) On the other hand, 518 persons bitten by animals strongly suspected of rabies were submitted to the same treatment. Of these, three died (mortality 0.58 per cent.)

Notice that in the statistics are reckoned those even who died immediately after treatment, and before, in many cases at least, it could have had any beneficial effect.

The two following tables will show you better than any words of mine the result of M. Pasteur's treatment during the years 1887 and 1888:

TABLE I.—JANUARY 1 TO DECEMBER 31, 1887.

	A.	B.	C.
Number of persons inoculated.....	1,778	1,501	277
Mortality, per cent., a.....	1.34	1.52	0.78
b.....	12.1	1.26	nil.

TABLE II.—JANUARY 1 TO DECEMBER 31, 1888.

	A.	B.	C.
Number of persons inoculated....	1,626	1,371	255
Mortality, per cent., a.....	1.16	1.31	0.39
b.....	0.79	0.94	nil.

*Explanation.*—Column A in each table includes all the cases inoculated at the Pasteur Institute during the year. Column B includes only patients bitten by animals proved to be rabid at the time they inflicted the wound. (This corresponds to columns A and B in M. Pasteur's own table.) Column C gives the number of patients bitten by animals which, though presumably rabid, could not be proved to have been so.

Mortality a.—Total mortality, including patients dying during the progress of treatment. Mortality b.—Mortality after those dying during treatment have been excluded. The lowest mortality in people bitten by rabid animals and not inoculated amounts to fifteen per cent. at least.

As animals proved to be rabid, only those are counted in which the disease has been proved to be present by the test of inoculation, or by certificate from veterinary surgeons who have seen the animal alive or performed a post mortem on it.

You will notice that the mortality has been steadily decreasing each year as the methods of inoculation have improved, and I may tell you that this year the total mortality will probably not amount to 0.50 per cent.

If we remember that among these cases there are no less than 280 cases of face bites, and that the mortality among people bitten in the face and not inoculated amounted to 80 per cent., and if we also bear in mind that the lowest mortality among non-inoculated persons bitten in any part of the body amounts to 15 per cent., at least, we can form an opinion of the value of M. Pasteur's treatment.

But we medical men belong to a skeptical corporation, and for the following reason: When we read in one of our medical papers of a new mode of treatment or drug, we are well aware that at first this mode of treatment or remedy is always extremely successful. It cures everything (in the hands of its promoters at least), from polypus of the nose to gout in the big toe. Then, as the drug gets into the hands of other men, it is found that it is not the panacea which it was at first supposed to be, and it is but rarely that a new mode of treatment or a new remedy stands the test of time and criticism at the hands of independent observers.

Let us see now whether this applies to rabies also, for it would be an error to think that M. Pasteur is the only one who has applied this treatment. The experiments on which it is based have been repeated and proved to be correct by Mr. Horsley, and published in the report of the Royal Commission appointed at Sir Henry Roscoe's instigation. Antirabic institutes have been established in many parts, so that at the present time there are more than twenty of these establishments scattered all over the world. There are no less than seven of them in Russia alone.

When, in the month of August last, I was asked to read a paper before the British Medical Association on the same subject, I took care to write and obtain information as to the results obtained in these institutes. I give you here the various data as I was able to obtain them from official letters, without withholding one syllable of what might tell against M. Pasteur's treatment.

In the last six months of the year 1886, Bujwid inoculated 104 persons bitten by animals proved to be rabid, or which were most probably so. He lost one patient. He then tried a weaker treatment on 193 patients; eight of these died, among them being all those who had been bitten in the face. M. Bujwid then determined to give the intensive treatment a trial. He inoculated 370 persons bitten by animals undoubtedly rabid; four had been bitten in the face by wolves, thirty by rabid dogs in the face. All these 370

\* SCIENTIFIC AMERICAN of Feb. 9, 1889.

\* A paper recently read before the Society of Arts, London. From the *Journal.*