

and many others yet the enumeration alone of which would exceed the limits of this notice, are opening up new horizons to science, and have justly attracted the admiration of the entire world to the author of them.

It was in 1880 that Mr. Pasteur began his new studies upon rabies. Aside from the attraction of an obscure problem, he felt that if he succeeded in discovering the etiology (possibly microbial) of such a malady he would convince every mind of the truth of his new theories. At the time of his first researches, Mr. Pasteur, after succeeding in transmitting rabies to a rabbit by means of the saliva of a child that had died of this terrible disease at the Trousseau Hospital, observed that the tissues and blood of this animal contained, in fact, a special microbe that was easily cultivatable in a state of purity, and the successive cultures of which caused other rabbits to perish.

Other and more important facts were soon to be shown. Mr. Pasteur and his collaborators were to recognize for the first time that the seat of rabies lies essentially in the brain. If a dog be trepanned and there be placed upon his brain a particle of the animal that has died of rabies, he will soon give the first signs of the rabid voice, and after rage and halluci-



FIG. 4.—A CULTURE BOTTLE.

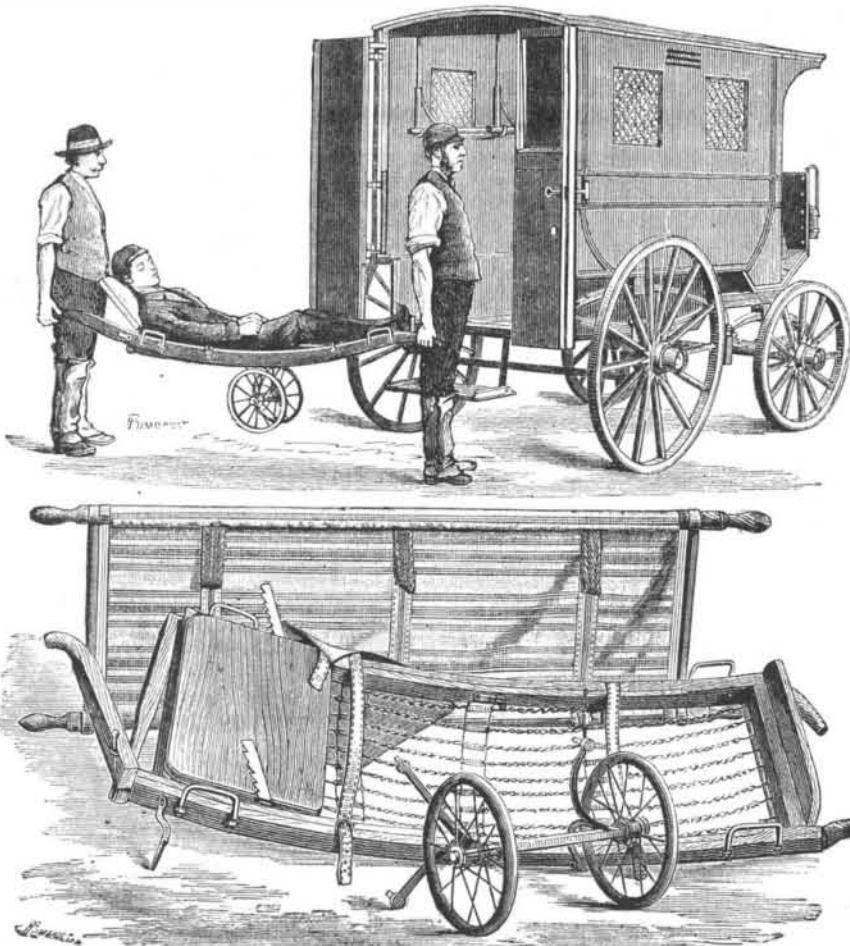
nations, will die in the convulsions characteristic of the disease. Besides this, it was soon established that not only is the brain rabid, but that the entire length of the spinal marrow may be so likewise, and that the nerves themselves, throughout their length from center to periphery, may contain the virus of rabies. If the salivary glands are rabid, this is due to the fact that the nerves that end there gradually empty the virus therein.

In his last communication to the Academy, Mr. Pasteur announced that he had already reached a great practical result. His collaborators and he had found that there existed dogs which were refractory to rabies with all modes of inoculation and with all kinds of rabid virus. Well, these animals were not refractory through their natural constitution. "We have, in fact," says Mr. Pasteur, "found quite a practical means of obtaining dogs that are refractory to rabies in as large a number as may be desired. We at this moment possess twenty-three dogs that are capable of undergoing virulent inoculations without danger."

The possibility of a long duration in the incubation has made prudence necessary, so Mr. Pasteur asks for a few months before making known the entirely new process of rabid prophylaxis. It is probable that the solution of a great problem is at hand, and that Mr. Pasteur is on the eve of giving a new confirmation to his doctrine of virulent maladies, and of bestowing upon society a new benefit.—*G. Tisandier, in La Nature.*

#### IMPROVED AMBULANCE.

We illustrate a new form of ambulance recently designed by Messrs. Atkinson and Philipson, Newcastle-on-Tyne.



IMPROVED AMBULANCE.

Fig. 1 is a general view of the ambulance, and it will be perceived that although the wheels are high, producing easy draught, the body is hung very low to facilitate the entry of the stretcher, on which the patient is placed, by the door at the back of the vehicle. The axles are fitted with India-rubber collars, which prevent noise, and check the jar and strain of the wheels and undercarriage being transferred to the body. The springs are very elastic, but strong. The step at the back is long and broad, and the doors open outward. The fore part of the body is planned to allow the front wheels to lock or turn without hindrance in narrow thoroughfares. The driver is protected by a canopy, and at his side there is sitting accommodation for another person. In the floor of the ambulance a grooved track is provided, to admit and hold the wheels of the stretcher or couch, shown in Fig. 2. This was designed for carrying helpless persons expeditiously and comfortably in a variety of ways. The couch is framed in ash, with a pair of handles at each end. These as well as the feet are jointed so that they may be folded when the width of a staircase or passage will not allow the stretcher to be turned in its full length. On the frame, a spring mattress is stretched, and at the top an air pillow is provided; a pair of light wheels with India-rubber tires are added, but these can be detached at will, together with some of the other parts, as shown in the sketch; thus the couch may be run along the floor of the hospital with some degree of speed and without unpleasant motion.

Another stretcher is suspended over the couch when the latter is deposited in the ambulance. This is the canvas stretcher on parallel poles (see Fig. 2). These poles may be slipped out of the stretcher when the invalid is placed upon a bed, without disturbing him—a great advantage when a man cannot bear handling. In the van this stretcher is hung on rubber-covered hooks from the roof, and is kept firmly in place by cross pieces. At the sides of the stretchers there are seats for three attendants, which with the invalids, the driver, and his companion, make seven in all, and with this load it is found that one horse works the ambulance with the greatest ease. Ample provision is made for ventilation and lighting, the latter by means of embossed glass windows during the daytime and by two ingeniously contrived lamps at night.—*Engineering.*

#### A NEW DENTAL AMALGAM.\*

By A. H. BEST, M.D., L.D.S.R.C.S., Savannah, Ga.

THE subject of dental amalgam is worn so nearly threadbare, that considerable moral courage is absolutely requisite for those who now venture to approach it. Nevertheless, though very much has been said, and, perhaps, even more written on this fertile subject, it is not to be hastily assumed that the dental mind should abandon it as exhausted. An interchange of ideas and experiences stimulates thought and leads to fresh investigations and experiments. These in their turn yield results not in all cases wholly satisfactory, but always contributory to our stock of knowledge, and tending to still further elevate the scientific character of dentistry.

Amalgam, in the usual form, is now employed daily by thousands of operators. It undoubtedly saves many teeth that would otherwise be irretrievably lost; and although its use is as yet attended with results more or less uncertain, the advantages its securer justify the favor with which it is regarded. Though not so pretty as gold, it can be used in teeth too frail for that filling, and though, in disadvantageous contrast to the oxyphosphates, it fails to preserve the color, yet it endures attrition so much better that its preference is, in a measure, obligatory.

If, then, notwithstanding the objectionable features of amalgam, such as discoloration, contraction or shrinking from the walls of the cavity, and in many preparations unnecessary expansion, it is still found desirable to use it, it seems also necessary to make some effort to rid it of these inconvenient properties, for just in proportion as we succeed in this attempt, will we progress toward perfection in filling material. The union of the desired qualities is most difficult to be attained, and will only be brought about as a reward

\* It was the intention of the author to read this paper at the Southern Dental Convention in Atlanta, but ill-health prevented.

of unceasing investigation and experiment, and of untiring study of metallurgy in all its bearings on this special form of alloys. It has, indeed, been found so very difficult to accomplish this result in alloys made by the usual processes that, notwithstanding the number of experiments that have been made with varying compositions and under the most varied circumstances, the results are still far from satisfactory, and we may reasonably doubt the possibility of solving this important problem by the methods and upon the principles hitherto usually employed.

Nearly all dental amalgam alloys are composed principally of silver and tin, to which in many cases just enough of the more precious metals has been added to render the process of alloying more difficult and more destructive to the tin, and to justify the venders in giving their compound a name which it is hoped will help its sale. In this connection I may mention a simple fact in my experience, which probably has its parallel in that of many other operators. For many years I used nothing but the most costly alloys, yet to my great regret the results obtained from them were anything but satisfactory, and in many cases decidedly inferior to those attending the use of cheaper grades of alloys, for which no claim of containing gold or platinum was urged as a recommendation. It would, in fact, seem that the degrees of heat necessary for the complete fusion of those metals differ so greatly—the fusing point of platinum being so very high and that of tin so low—that alloys containing platinum or gold are really and practically so much injured thereby that in many cases the propriety of such addition is questionable. Even in using but two metals, silver and tin, whose various combinations are supposed to represent the cheaper grades of amalgam alloys, the greatest possible care has not completely overcome that obstacle which so greatly affects the qualities of such alloys, viz., the "burning of the tin" (as it is familiarly styled) by contact with the molten silver. Neither is this a matter of surprise when the melting points of the two metals, and their behavior under such conditions, are taken into consideration. Pure silver melts at 1,873° Fahr., and possesses the remarkable quality of absorbing many times its volume of oxygen when strongly heated or melted in common air. Tin melts at 442° Fahr., and when heated above this point, oxidizes very rapidly.

Under these circumstances it would, *a priori*, appear impossible to melt together silver and tin without producing the well-known results so detrimental to the alloy, since, on the one hand, during the melting the silver is rapidly absorbing oxygen, which it holds in a state of solution, as it were, and not chemically combined with itself, but to be surrendered as soon as the temperature falls; and, on the other hand, the tin is necessarily heated far above its melting point, and is consequently in a condition favorable to the most rapid oxidation, whether it obtain the necessary oxygen from its solution in the molten silver, or from the surrounding atmosphere.

The addition of gold, platinum, and some other metals to silver removes this objectionable quality of absorption of oxygen while melted, but renders a great increase of heat necessary for perfect fusion; while increased temperature still more certainly oxidizes the tin, through its unavoidable contact with common air, and thus to a great extent destroys the practical utility of such alloys. Actual experience has further demonstrated that, whatever might be the advantages gained by the addition of small quantities of either or both of these less fusible metals to a perfectly combined alloy, they are not to be attained in a purely mechanical mixture of melted metal, which requires, to prevent a separation of the constituents, while still fluid, through the agency of gravitation or affinity, an almost impossible diligence of manipulation. In fact, so numerous are the difficulties that are encountered on the very threshold of the process, that we may well question the possibility of reaching a practical solution of the problem, at least so long as the metals are to be combined by fusion.

After much consideration of the question, at once so difficult, so important, and so interesting, it has occurred to me that alloys for dental fillings, which, when in use, are necessarily under water, should if possible be formed under similar conditions. The conditions under which such alloys are usually made are so diametrically opposed to those under which they are expected to endure wear, that the above conclusion seems justifiable; for how can we expect two seemingly inert substances to retain at ordinary temperatures that kind of mutual affinity which they only display under the exceptional influence of a heat amounting to thousands of degrees? All the metals usually employed in the manufacture of dental amalgam alloys are to be found naturally combined with each other and with other metals, in varying but always definite proportions. If these alloys or combinations are the result of electro-chemical actions, under humid conditions, in the laboratory of Nature, we may reasonably hope that her processes can be imitated by the chemist, and even that they may present fewer practical difficulties than the stereotyped method hitherto solely adopted.

It has also occurred to me that an alloy for dental amalgam should be a combination of metals on other principles than those of mechanical or physical laws. There is something more to be attained than mere hardness; something else to be sought for besides brightness of color; other disqualifications to be obviated than irregular expansion and contraction. Strange as some would think it, there are qualities more sedulously to be preserved, and of more importance to the real excellence of the material, than a certain percentage of precious, infusible, injurious metals, authorizing the high sounding names that in too many instances merely cover a deficiency of the very substances claimed to be used so liberally.





My position is that alloys for dental purposes should be definite in composition, as a departure from this principle disastrously affects their durability. By a "definite alloy" I intend a chemical combination of one metal with another, excluding all mere mechanical mixtures made by weight without reference to atomic affinity. Every metal which is to enter into an alloy of this nature needs to be most thoroughly studied; its nature and behavior, both when isolated and in combination, its power of affinity for other metals, and the quantity necessary to form a saturated alloy, should all be perfectly familiar to the operator. How can satisfactory results be expected by investigators unacquainted with the laws of molecular affinity governing the formation of definite compounds through the polar attraction of atoms. I mean by "definite compound" a combination of elements, each of which loses the properties that characterized it in its isolation, to acquire new properties common to the whole, though perhaps totally dissimilar to those of the several constituents. It is, therefore, quite plain, that each metal entering into the formation of an alloy for dental purposes must have a special part assigned it in establishing and maintaining the chemical and electrical equilibrium of the







mass. Each atom of metal should be completely saturated by the attraction of some other atom of the other metals entering into the composition, so that its affinities may be completely satisfied and set at rest. Alloys formed upon these principles have physical properties so distinct and in many cases so vastly different from those of their constituents, whether separately or in mechanical mixture, as to mislead the closest observer. On the other hand, mixtures of metals not governed by these laws do not form saturated or even definite compounds, and are therefore for the most part as readily separable into their original simplicity as in the well-known example of iron filings mixed with sulphur, out of which composition, as every one knows, the iron can be drawn with a magnet; yet let the mixture be subjected to a certain temperature at which chemical union takes place, for a certain time, and we have a distinctly different and saturated chemical compound as a result. The iron is no longer attracted by the magnet, nor is the sulphur soluble in sulphide of carbon, so that the simple mixture has become a definite combination again.

"When a clean piece of sodium" (I quote from Essig's "Dental Metallurgy") "is rubbed in a mortar with dry mercury, the former dissolves and a peculiar seething sound, resembling that caused by the immersion of a hot body in water, is produced, due to the evolution of heat which accompanies the combination, the mercury rising rapidly in temperature as the pieces of sodium are added. As the mercury cools, the resulting alloy, which is brilliantly white, crystallizes in long, needle-like forms from the middle of the liquid, and the excess of mercury may be poured off." Now, in this place, the mercury is plainly in excess, and what takes place in consequence, *i. e.*, the complete separation by crystallization of the alloy from the uncombined metal, would also become apparent in other cases of indefinite compounding, if the metal in excess were only liquid at ordinary temperatures, so as to be decantable like mercury. But we must not suppose that the solidification of the excess would have any influence upon the crystallization of the compound. I may quote the same author's example:

"The tendency on the part of the metals to unite in definite proportions may be studied in connection with platinum, iridium, gold, rhodium, ruthenium, and silver, when fused with tin. If the latter metal is in excess after cooling, a metallic ingot is obtained resembling closely the original substance; but by the action of strong hydrochloric acid the excess of tin may be dissolved, leaving crystals of a definite alloy of the tin and the noble metal, which cannot be further dissolved by the same acid, but which are soluble in nitrohydrochloric acid, even when the precious metal contained, whether rhodium, ruthenium, or iridium, is in the free state absolutely insoluble therein."

We have here an example of a definite alloy in which each constituent loses its individual characteristics and acquires new ones peculiar to the compound. Now, supposing the alloy in the experiment to consist of tin and silver, its formation would take place by molecular union, which in its turn would occur in accordance with the various laws regulating such combination, and particularly with the principles of atomic affinity. A molecule of silver is of the same size as an atom, or, in other words, the molecule is indivisible. Silver is, therefore, a molecule of non-atomic affinity (univalent) uniting with a molecule of tin (quadrivalent) in the proportion of four to one. We accordingly, for illustration, represent a molecule of silver by a parallelogram with a single point in the center, thus , and a molecule of tin by a similar parallelogram containing four points or centers of attraction, thus , replacing as a molecule four atoms of hydrogen, , and hence termed a "tetraatomic" or "quadrivalent" molecule. Therefore, in the case before us the definite compound of tin and silver will be represented by the following figure  or one molecule of tin saturated by four of silver. On this principle must all definite compounds or alloys of these (and the other) metals be prepared, *Ag. Ag. Ag. Ag.* or, as is the case in the experiment under consideration, the excess of either constituent may be demonstrated to exist uncombined.

Now, all are familiar with the various metals commonly used in making amalgams and the proportions commonly employed; and I do not require to ask a question, which, as it were, carries its own answer, whether it would be possible to obtain a definite compound by uniting metals, in promiscuous proportions, and with disregard of such laws of union as we have seen to exist.

Silver, as we have already observed, is monatomic or univalent (). Tin and platinum are alike tetraatomic or quadrivalent (). Gold is triatomic (trivalent) (), copper and mercury are alike of the class of biatomic (bivalent) metals, and are represented by the sign (). When definite chemical intercompounds are expected of these metals, these facts should be kept in mind, in order that by utilizing every point of union no atom is left free, unsaturated, and prone to be acted on by new agents as if isolated; that the very affinity should be at rest and the mass be in absolute harmony—a harmony as complete as the most perfect chord of music.

The failure of so many compositions is evidently due to a want of this very harmony of composition, the component parts not being in proportions that favor atomic equilibrium; and those molecules of metal not saturated to the extent of their affinity are free to unite with any other active unsaturated molecule, or to decompose any suitable compound that they meet, and in many cases by this union set agents free which immediately attack the tooth.

It was, then, due to a thorough appreciation of the principles involved and the objects which were to be attained, that I mapped out for myself a new line of thought in reference to the whole matter of dental amalgam alloys. Figuratively speaking, I had waded through the pathless morass of speculative mixtures, finding not one to suit my purpose, so that I saw, if I must use the material, I had to try my own hand at making it, in the hope of producing something fit for use. It was evident that an alloy was what was required, and the chief question that presented itself was, "How shall I effect a combination of metals?" "Combination is favored," says an eminent French chemist,\* "by heat, light, electricity, the nascent state, attractive force, bulks, and a certain active property." As we have seen that heat is injurious to alloys of the kind under consideration, and being familiar with some of the powers of electricity, I determined to attempt to produce my alloy by the process of electrolysis. Success was by no means the work of a day, even after the conception of this idea; for many difficulties were to be overcome before results of an encouraging nature were arrived at. Even then a long series

of experiments was required. I am pleased to acknowledge in these experiments the kindly assistance accorded me by some of the most eminent chemists in this country and Europe, which was secured in order to arrive at anything at all satisfactory. Even after a promising result had been attained, practical considerations forced a sacrifice of some qualities obtained, in order to utilize others more essentially important, since by the isolation of these absolute permanence and durability seemed assured.

I shall not now enumerate the various experiments or modes of procedure by which we finally succeeded, but merely intimate that the principles governing electro-deposition of metals were employed by us, and success was due to a complication of apparatus for distribution of the current, which resulted in depositing from a chemical bath definite quantities of the metals held in solution, in such a manner that the strength of the solution was continually kept up by the same electric current.

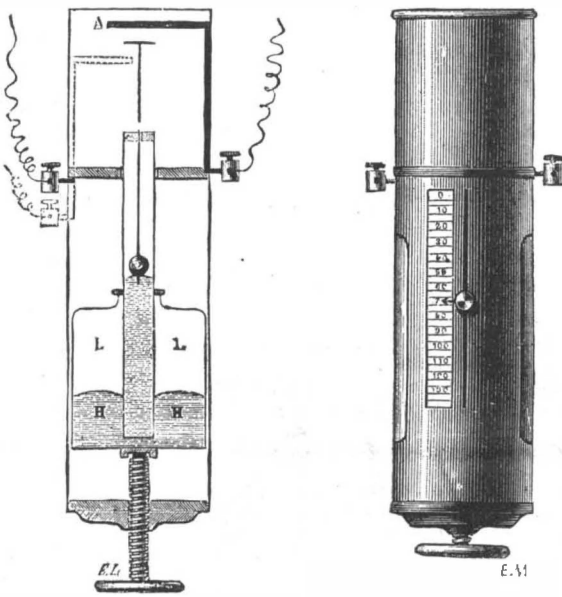
And now to the practical results and the physical properties of the alloy produced, which is precipitated in the requisite quantity of mercury, adjusted in the bath by scales, which turn the beam and break the current when the definite deposition has taken place. We thus obtain a standard quality of alloy, which, by a proper process, is then reduced to an impalpable powder, in which state it is ready for consumption. This compound has now been practically in use and under observation for some years, and I have never seen a case of failure, or of discoloration of tooth structure, though its agency. When used without removing surplus mercury—a little of which is provided for greater ease and convenience of manipulation, and to have the mass of any required consistence—it is found to adhere to the walls of the cavity like cement. It is the only amalgam known that will adhere to a burnisher—which it will do in its soft state—permitting that instrument to be used to convey it to the cavity. When it is intended to be used on grinding surfaces, or where exposed to severe attrition, it may be made almost as hard as adamant by pressing out all superfluous mercury and packing with warm instruments. When it is to be used over exposed and capped nerves, where we may be necessitated to remove it before long, if permitted to retain the excess of mercury, it will set very soft, thus permitting its easy removal. It has many qualities of great value, but not the least recommendation, in my eyes, is that so far I have not seen a failure. I have not the slightest hesitation in saying that it is the only amalgam I know that will absolutely preserve, and not discolor, the tooth. In some mouths the filling turns quite black, but the tooth is never discolored.

In conclusion, I feel that it is proper to say that I have not undertaken the manufacture of this alloy for the trade. I find it requires the most expensive apparatus and much skillful handling to do this. On a small scale the production proceeds so slowly that, since our last meeting in Baltimore, one year ago, I have made scarcely twenty ounces; and yet I have done my best to have a few samples here for exhibition.—*Dental Cosmos.*

#### LECHNE & LERKSCH'S THERMOGRAPH.

THE apparatus represented in the accompanying cut is designed to show changes in temperature, and to act as a fire alarm.

Into a small vessel, L, made of metal of peculiar compo-



LECHNE AND LERKSCH'S THERMOGRAPH.

sition, is poured a definite quantity of mercury, H. A tube of the same metal enters this vessel through a hermetic packing, and is so fixed as to almost touch the bottom. When the temperature rises, the air expands and causes the mercury to mount into the tube. In the latter there is placed an ivory float that carries an aluminum wire surmounted by a strip of platinum, which closes an electric circuit when it abuts against platinum contact, A. The lower the vessel, L, is placed, the higher the strip of platinum will have to rise to reach the contact, A, and, consequently, the higher the temperature will have to be to bring about a closing of the circuit. This stated, it is easy to imagine a combination through which a signal shall be obtained, at any temperature whatever, upon varying the height of the vessel, L, which is provided with an index that travels over a scale whose degrees correspond to the different temperatures.

A second, and movable, contact, shown by dotted lines in the figure, serves to signal depressions in the temperature, and the bell connected with it, and interposed in the circuit, has a different tone from the arc connected with the preceding. The apparatus are regulated to a mean barometric height, and, in industrial applications, no account need be taken of the influence of variations in the pressure of the atmosphere. The apparatus are completed by the addition of a regulating device.

Every part of the instrument is of metal, and herein it possesses an essential advantage over glass apparatus, which break under the influence of a sudden variation in the temperature such is produced by a fire that breaks out all at once, and which are therefore incapable of operating precisely at the moment of danger.

The thermograph is applicable in cases where it is desired

to keep the temperature of any space whatever below a certain limit, such, for example, as 80, 40, or 50 degrees. It is only necessary to place the index upon the degree that corresponds to the maximum of temperature that is not to be exceeded in order to obtain an electric signal as soon as the temperature rises, be it only one degree, above such maximum.

The double thermograph indicates in the same way a depression of the temperature below any limit whatever. The apparatus may therefore be employed for stoves used in drying inflammable materials, wood, and woolen, and for matting. In case there are several stoves, the apparatus indicates the corresponding number.

If the apparatus is to operate only as a fire alarm, the lower screw is done away with, and the vessel, L, is provided with a screw that permits the air to slowly flow in and out. In this case the apparatus requires no regulating, for it is insensible to normal variations in the temperature, and only gives warning of fires.—*La Lumiere Electrique.*

#### ON THE MAGNETIC SUSCEPTIBILITY AND RETENTIVENESS OF IRON AND STEEL.

By J. A. EWING, B.Sc., F.R.S.E., Professor of Engineering in University College, Dundee, formerly Professor of Mechanical Engineering and Physics in the University of Tokio.\*

DURING three years the writer has been engaged, while in Japan, in prosecuting researches on the magnetization of iron and steel, and on the effects of stress on magnetic susceptibility and thermo-electric quality. Preliminary notices of some of his earlier results have appeared in the "Proceedings of the Royal Society," but a detailed account of the work has still to be given. Meanwhile, the following points, not previously noticed, are perhaps of sufficient interest to justify their separate publication.

In the experiments on magnetization, iron and steel wires were used, either welded into rings or in the form of straight pieces of such great length that the influence of the ends was negligible. Curves were obtained, in some cases by the ballistic method, and in others by the direct magnetometric method, showing the changes of magnetization which occurred when magnetizing force was gradually applied, withdrawn, reapplied, reversed, and so on.

The results of many experiments with several specimens of carefully annealed soft iron wires have shown that they possess in very high degree a property not generally credited to soft iron—the property of remaining strongly magnetic when the magnetizing force is removed.

As an example, the case may be cited of an annealed iron wire which was subjected to a magnetizing force of 22.4 C.G.S. units. This gave it a magnetic induction amounting to 16,000 C.G.S. units. When the magnetizing force was gradually and completely removed, the induction fell only to 15,000 units. In other words, the intensity of residual magnetization was equal to nearly 1,200 C.G.S. units.

Here more than 93 per cent. of the whole induced magnetization survived the removal of the magnetizing force; while in many other cases the residual magnetism amounted to nearly 90 per cent. The somewhat extraordinary spectacle was thus presented of a piece of soft iron, entirely free from magnetic influence, and nevertheless holding (per unit of its volume) an amount of magnetism far in excess of what is ever held by permanent magnets of the best tempered steel.

In this condition, however, the magnetic character of the iron is highly unstable. The application of a reverse magnetizing force quickly causes demagnetization; and the slightest mechanical disturbance has a similar effect. Gentle tapping removes the residual magnetism almost completely. Variations of temperature reduce it greatly, and so does any application of stress. On the other hand, if the iron be carefully protected from disturbance, it seems that the residual magnetism disappears only very slowly, if at all, with the mere lapse of time.

If, after magnetization, the magnetizing force be removed suddenly, the residual magnetism is, as might be expected, less than if the force be removed gradually.

The ratio of residual to total magnetization is always small when the intensity of magnetization is small, and passes a maximum when the intensity is increased. This maximum is particularly distinct in wires which have been hardened by stretching; but it also occurs in soft annealed wires. In one instance, where the wire had been hardened by stretching, the maximum ratio of residual to total magnetism was 0.60, which was given by the application of a magnetizing force of about 10 C.G.S. units; but after the application of a force of 90 units the ratio fell to 0.33. In steel the maximum in this ratio is less sharp, but still distinct. Neither in hard iron nor in steel is the ratio, even at its maximum, so great as it is in soft iron, where (as has been said) it frequently reaches 0.9.

During the magnetization of soft-iron wires the greatest ratio ( $\lambda$ ) of intensity of magnetization ( $I$ ) to magnetizing force was generally about 200, sometimes nearly 300. And by gently tapping the wire during the application of magnetizing force, this coefficient was on one occasion raised to the enormous value of 1,590. In the case alluded to the magnetization went on so rapidly as the magnetizing force was increased, that a force of 1 C.G.S. unit gave an induction of 10,000.

In this and other particulars the experiments have been strongly confirmatory of the idea that there is in soft iron a static frictional resistance to the rotation of the magnetic molecules, which is the principal cause of the remarkable retentiveness described above, and which is overcome by gentle mechanical agitation.

Numerous measurements have been made of the energy expended in taking iron and steel through cyclic changes of a magnetization. For example, in changing the magnetism of a specimen of annealed iron wire from  $I=1,250$  to  $I=-1,240$ , and back, the amount of work done against magnetic friction (apart from any induction of currents) was 1,670 centimeterdynes per cubic centimeter of the metal. In hardened iron, and especially in steel, the work done is much greater.

The effects of stress on existing magnetism and on magnetic susceptibility have been investigated at great length. The most remarkable effects occur in wires which have been hardened by stretching. In them the presence of a moderate longitudinal tensile stress increases the magnetic susceptibility immensely at low values of the magnetizing force, but diminishes it at high values. It also increases very greatly the ratio of residual to temporary magnetization. Each of these effects passes a maximum when the stress is sufficiently increased.

\* M. Naquet.

\* Read before Section A of the British Association at Southport, 1883.