Another very important feature is the means afforded those not in possession of laboratory appliances of verifying the scale value by applying a single cell of some constant form, such as is to be found in any telegraph-office, to the terminals of the coil giving the lower scale-reading. The deflection noted serves as a standard for future comparison with the same or a similar cell, should doubt arise as to the effect of accidental rough usage.

All scale-readings begin at zero, and extend by practically uniform increments to the maximum reading. The range of scale-readings for instruments of a given maximum scale is thus greater than is common; and, as the divisions of each scale are the result of individual calibration and checking, the scale-readings are uniformly accurate. The temperature correction is negligible, and the instruments can be kept constantly in circuit, as their resistance is so high (averaging twenty thousand ohms) as to prevent any appreciable heating error. The ammeters have the same general appearance as the voltmeters, and possess the same merits of permanency and reliability.

In the hands of electricians and electrical engineers, these instruments are claimed to afford the means of obtaining measurements

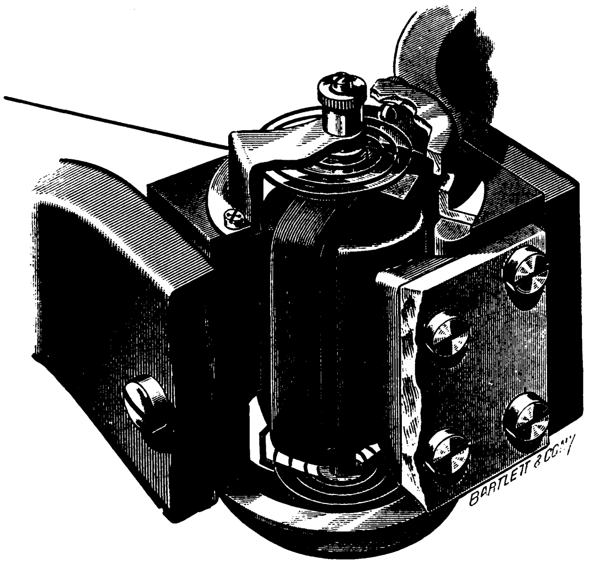


FIG. 3.

correct to within one-fifth of one per cent, and special instruments are made correct to within one-tenth of one per cent. If the limits of error were even ten times as great as claimed, these instruments would, it is said, possess greater accuracy than has been heretofore attainable in commercial voltmeters and ammeters. It is most certainly to be hoped that actual practice wlll substantiate the accuracy of these claims.

ELECTRICAL NEWS.

Hertz's Researches on Electric Oscillations.[1]

IN order to get resonance phenomena between two circuits, Hertz used an arrangement consisting of a straight copper wire divided into two parts by a discharger, the two halves being connected with the secondary of an induction-coil, while two hollow zinc spheres were arranged to slide on the halves. The micrometer circuit was made of such dimensions as to have a slightly shorter period than that of the discharge circuit, supposing the oscillations were really as rapid as was calculated. The experiments were made in two ways. First, the period of the micrometer circuit was increased: the result was an increase in the length of the spark that could be obtained in it, followed by a decrease, as the capacity, and therefore the period, became too great. Afterwards, the micrometer circuit remaining constant, the period of the discharge circuit was decreased, the result being, as before, an increase in spark-length in the micrometer circuit, followed by a decrease.

[1] Continued from No. 313.

We may fairly conclude, then, from all of these experiments, that the effects observed in the micrometer circuit were produced by oscillations in the discharge circuit of a period approximately equal to that calculated from the dimensions of the apparatus, in the neighborhood of a hundred-millionth of a second.

Hertz concluded, that, if vibrations were caused in the micrometer wire, there must be nodes (points of zero disturbance) somewhere

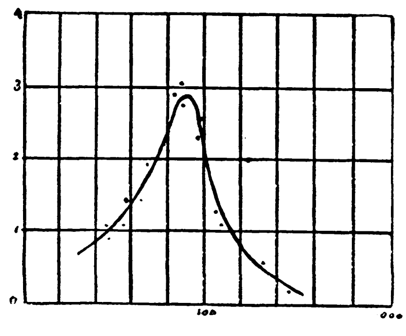


FIG. 5.

Curve showing relation between length of side of rectangle (taken as abscissa) and maximum sparking distance (taken as ordinate), the sides consisting of straight wires of varying lengths.

along its length. To prove this, he adjusted his micrometer circuit to resonance with the discharge circuit, making the gap in the former so wide that sparks were just able to pass. Then a sphere was made to touch different points along the wire, the result being a cessation of the sparks except when the point of contact was at the middle, showing that there was a node at that point. Again, by using a second micrometer circuit similar to the first, as in Fig. 5 (Fig. 7 in the paper), nodes were found to occur on *cd* and *gh*. When the wire connecting 2 and 4 was removed, the vibrations were not disturbed; but when the knobs at these points were brought close together, a slight spark was observed between them, the spark corresponding to a vibration with a single node at *ae*. We can, then, in the same conductor have vibrations with one or two nodes, according as we wish; that is, we can excite in it its fundamental

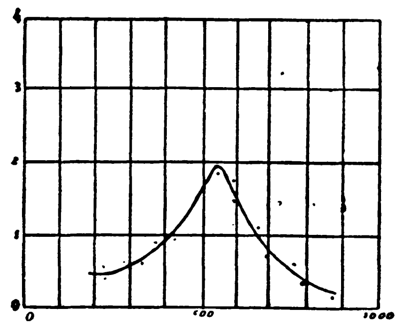


FIG. 6.

Curve showing relation between length of side of rectangle (taken as abscissa) and maximum sparking distance (taken as ordinate), the sides consisting of spirals gradually drawn out.

note or its first overtone. As to the higher overtones, Hertz considers it doubtful whether it is possible to produce them, for the results show that the damping effects must be considerable; and there are many secondary phenomena which show that irregular vibrations are superposed on the regular ones. To obtain the best results, Hertz observes that there is a longer spark in the secondary when it is exposed to the light of the discharge circuit.

Let us now call the discharge circuit the primary, and the micrometer circuit the secondary. The next experiment Hertz tried was with a primary circuit of straight copper wire, carrying at its ends zinc spheres, and having a break in the middle for the discharge spark; the secondary being a circle of copper wire, broken by an air-space which was capable of adjustment by means of a micrometer screw. The two were adjusted until they were in unison, and the effect of the primary on the secondary was observed for different positions of the latter. There are in reality two electro-motive forces acting upon the secondary, — one an electro-static force, due to the rapid variation of the distribution of charge on the primary; the other an electro-magnetic effect, due to the current oscillating back and forth on the primary wire. Now, it is a matter of very great im-

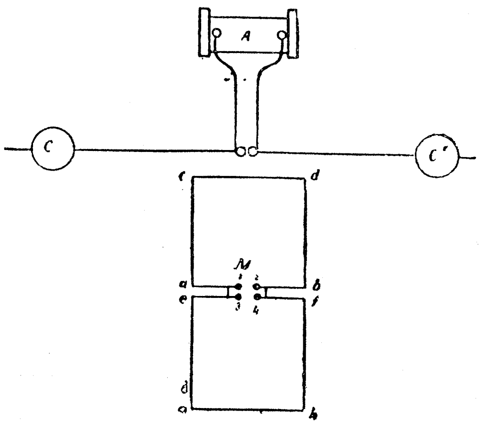


FIG. 7.

portance to find the effects of these two. In the lower part of Fig. 6 (Fig. 8 in the paper) the lines *mn* represent different positions of the secondary, which was vertical. The sparks in the secondary disappeared when the air-space was in the horizontal plane passing through the primary, and were a maximum for points at right angles to these. The arrows give the resultant force, which does not differ greatly from the electro-static distribution due to charges on *A* and *A'*.

When the secondary was horizontal, as in the upper part of Fig. 6, in position *I* there were two maxima of spark distance, when the air-space was at a_1 and a'_1; in position *II* the maxima were at a_2 and a'_2, the distance at a_2 being the greater; in position *III* there was but one maximum, at a_3, with a point of disappearance at a_3; at *IV* there was a maximum at a_4, a minimum at a'_4; at *V* there was a maximum at a_5, a minimum at a'_5. From the position *III*

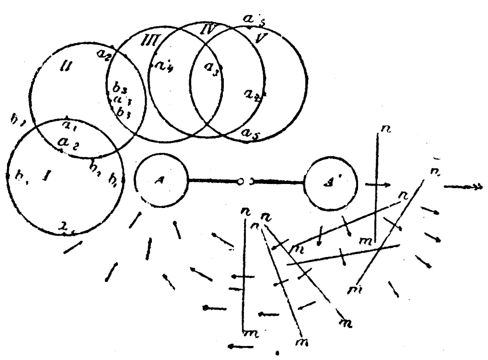


FIG. 8.

to the position *V* the line *aa'* swung rapidly from a direction parallel to *AA'* to one perpendicular to it.

Now, what all these experiments mean is this: the electro-static force is more important than the electro-magnetic within the distances at which observations were made, excepting in the last cases, *IV* and *V*, where the electro-magnetic force comes in. But, as it is of the greatest importance to find out what takes place at a distance from the primary, Hertz extended his observations until the secondary was as much as 14 metres from the primary. At a distance of about 1.5 metres the maxima and minima became indistinct, but beyond this they were clearly defined again. From his observations, Hertz plotted out the distribution of force in the room, the result being like Fig. 7 (Fig. 9 in the paper), where the lines indicate the direction of the force, the stars representing the points where the direction is indeterminate. We see that at distances beyond three metres the electro-motive force is everywhere parallel to the primary, — that is, the electro-static effect is negligible, — and we find that the effect diminishes very much more rapidly in the direction of the vibration than at right angles to it. For less distances than one metre, the distribution of electro-motive force is practically that of the electro-static force.

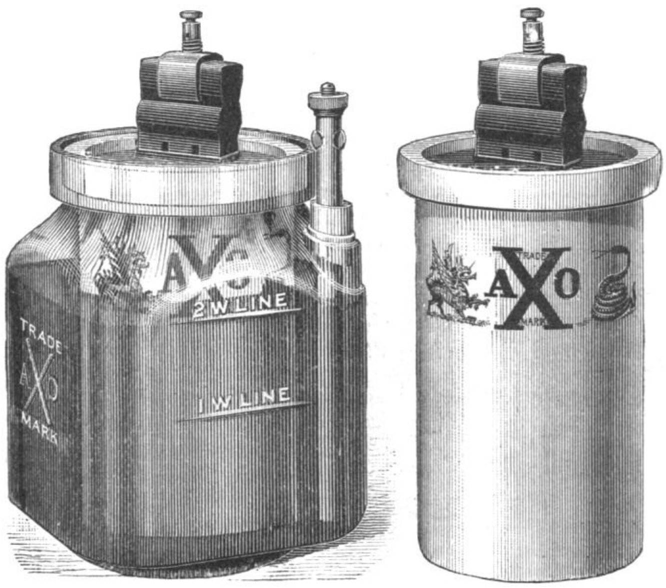
There are two lines at all points of which the direction of the electro-motive force is determinate, — the line in which the primary oscillation takes place, and a line at right angles to it. But there are regions in which the electro-motive force becomes indeterminate: these form two rings around the primary, the projections being the stars in the figure. Since the electro-motive force within them acts very nearly equally in every direction, it must assume different directions in succession, for of course it cannot act in different directions simultaneously. The observations, then, lead to the conclusion that within these regions the magnitude of the electro-motive force remains nearly constant, while its direction varies through all the points of the compass during each oscillation. Dr. Hertz thinks the results very difficult of explanation, unless we suppose the electro-static and electro-magnetic electro-motive forces are propagated with unequal velocities, in which case we have within the annular regions two electro-motive forces at right angles, and differing in phase; and as a consequence the resultant will turn through all the points of the compass at each oscillation.

One great value of the above series of experiments lies in the fact that they enable us to put aside such theories as do not agree with the observed results; and, as there are a considerable number of theories, we are thus saved much confusion.

The next subject which Hertz took up was the idea of displacement currents in a dielectric, — an idea which underlies so much of Maxwell's work. Briefly, the assumption made by Maxwell is, that, if two conductors are charged positively and negatively respectively, then in the dielectric between them there is a corresponding displacement of electricity across any surface surrounding either. The displacement current lasts as long as the conductors are being charged, and has magnetic effects, just as a current in a conductor has. To show the existence of these displacement currents, Hertz arranged the experiment shown in Fig. 8 (Fig. 10 in the paper). Here the primary circuit consisted of the two conductors *A A'*, joined by a wire with the air-space for the discharge in the middle. The secondary circuit was adjusted in unison with the primary, and was placed in such a position that there was no sparking. If, now, a conductor *C* be held near *A A'*, equilibrium was disturbed, and sparks passed at *f*. On removing *C*, and approaching a dielectric, if no effect was observed, then the dielectric would be shown to have no magnetic action, and Maxwell's theory would fall to the ground. But on trying the experiment, a decided effect was produced, thus proving that the dielectric exerted magnetic actions, and that Maxwell's notion of displacement currents is in all probability correct.

ELECTRIC PLANTS IN THE NAVY. — The report of the naval inspector of electric lighting, Lieut. R. B. Bradford, contains a summary of the work performed under the supervision of this office. After describing the installations on the "Trenton," the "Omaha," the "New Hampshire," the "Atlanta," the "Boston," the "Chicago," the "Yorktown," the "Baltimore," the "Charleston," and the "Pensacola," the report goes on to say that search-lights are at times very useful, but discretion must be exercised as to when and how to use them. During the recent English evolutionary squadron exercises, the search-lights of the blockading squadron failed to detect the escaping ships of the enemy, which had, of course, all lights out, and every thing visible carefully colored a dead black. On the other hand, the enemy's ships which were not trying to escape used their search-lights to blind the eyes of the blockaders and interfere with the rays of their searchers. Recent experiments in Russia indicate that it is not an easy matter to disable a search-light with machine-guns and shoulder-rifles, on account of the light blinding the eyes and interfering with the aim. It is found in Germany, however, that if search-lights are placed behind men with the beam of light on a target, very good practice can be made, so long as the men are in the beam, the sights of the guns then being illuminated; if, however, the men are out of the beam, and consequently invisible, the accuracy of the practice is much reduced.

THE AXO BATTERY. — The most widely used galvanic cell for "open-circuit" work — that is, for bells, burglar-alarms, telephones, etc., where the current is only taken out for short times — is the Leclanché, or some of its modifications. The cell has many advantages: it needs very little attention, its electro-motive force is comparatively nigh, there is no eating-away of the zinc when the cell is not working. The only troubles have been in the evaporation of the liquid, the creeping of the solution over the edges of the jar, and the corrosion of the



binding-post contact at the carbon pole. These defects are remedied in the new Axo type of Leclanché cell shown by the illustrations. Here the porous cup forms of itself the cover of the cell, which is hermetically sealed by pouring wax or paraffine in the space between the top of the cup and the edge of the jar. As the depolarization of the battery requires that there be a certain amount of ventilation, this is secured by deep grooves in the sides of the carbon, coming above the cover of the jar. It will be seen that the zinc passes through a separate hole in the side of the jar, which is closed by a rubber stopper. The connection with the carbon is made by a patented metallic clamp and thumb-screw, shown in the figure. Taken altogether, the Axo is an advance in galvanic cells. It can be sealed and left to itself, until, as must finally happen in every battery, the zinc and solution have to be replaced, when with very little trouble it can be practically renewed. For ordinary bell-work it would probably last a year or more without attention.

NOTES AND NEWS.

PROFESSOR SHALER of Harvard has returned from his tour of geological exploration through the Dismal Swamp.

— The Rev. Dr. George E. Reed, pastor of the Trinity Methodist Church of New Haven, is now at work upon his letter of acceptance as president of Dickinson College of Carlisle, Penn.

— Mr. F. Küstner has made a very interesting series of observations on the aberration of fixed stars, and, from certain discrepancies between early observations made by Struve and recent ones made by himself, arrives at the conclusion that the altitude of the pole, which is assumed to be a constant in the formula applied, is in fact variable. He found that in the fall of 1884, at Berlin, the polar altitude must have been 0.2″ greater than before and after that season. As this result appeared somewhat startling, he subjected other observations made at Pulkowa and Gotha to a thorough investigation, which proved the correctness of his view. Mr. Küstner attributes these variations to meteorological and hydrological phenomena which are caused by the action of the sun. Helmert's investigations tended to show that these irregular movements of matter might result in changes of latitude not exceeding a few hundredths of a second, while William Thomson concluded that these changes might be as great as half a second. From Küstner's observations, it appears that the real changes are intermediate between these two values.

— Professor Hill of the School of Geology of the University of Texas plans the establishment at the university of an educational museum which will represent in the broadest sense the geologic conditions — structural, economic, organic, and general — of the earth, and to illustrate these features as far as possible by Texas material accompanied by maps, models, and labels. This museum will exhibit not merely the extraordinary, but also the far more important and too little valued ordinary features of that State; so that any person, citizen or stranger, will find compactly arranged in the halls of the university a complete and instructive synoptical exhibit of all the diverse natural features of Texas. The museum will also be a medium of exchange with similar institutions outside the State. The attention which will be attracted abroad by properly prepared and representative specimens from Texas, conveying clear and accurate scientific information that can be disseminated in no other manner, will attract the earnest interest of a class of intelligent people who cannot be otherwise reached. The functions of the museum will also be distributive as well as collective, and its utility not confined to the university building, but disseminated throughout the State, it being the intention to select from its duplicates typical educational series for distribution to high schools connected with the university wherein the natural sciences are taught.

— A movement has been started in Norway, says *Nature*, for the despatch in the summer of 1890 of an expedition which will try to reach the north pole, and it is proposed that the leadership shall be offered to Dr. Nansen. Those who are arranging the plans maintain that no other country could furnish such a crew of experienced and hardy ice-men and arctic travellers as Norway, and that a winter or two in the arctic regions would affect these men very little. The intention is that an attempt shall be made to reach the pole by way of Franz Josef's Land, — a route advocated by the most experienced Norwegian arctic travellers as well as by several well-known men of science who have studied the problem. *Ski*, which have played such a prominent part in the Nordenskiöld and Nansen Greenland expeditions, would no doubt again be of great service.

— The board of overseers of Harvard College, at a meeting held Jan 30, adopted, after prolonged dicussion, the following vote: "Voted, that, in the opinion of this board, it is expedient that every undergraduate be requested to report in person early every morning, with a moderate and fixed allowance for occasional absences; that attendance at the exercises of each course be more rigidly enforced; that the system of advisers, somewhat as applied to special students, be extended to the freshman class; that the reports of the presence and absence of students be collected daily by monitors, and daily entered on the books; that no choice of studies made by a student be valid if it calls for more than three lectures or recitations on any day of the week, unless the choice has been specially allowed by the dean; that, in order to make it more difficult for students to prepare by a brief period of cramming to meet the tests applied, the faculty require all the instructors to provide tests of the progress of their students with sufficient frequency to enable them to enforce effectively Section 7 of the Regulations; that admonition be administered by the dean on his sole authority, and that the powers of that officer be so enlarged, at whatever increased expense it may be necessary to incur, that the records of attendance may always be ready for inspection by the proper officers; that the faculty be asked to prepare and report a series of rules, which, in their judgment, will give practical effect to these recommendations." This was adopted by a vote of 16 yeas to 4 nays, those voting in the negative being President Eliot, Dr. Phillips Brooks, Dr. Walcot, and Charles R. Codman. The carrying-out of these recommendations will depend on the faculty, which, it is understood, are opposed to their spirit.