albo-carbon light is burned in clusters of burners, a much more striking effect, with a far higher result in lighting-power, is produced. An eight-light cluster tested on London 16-candle gas gave 8.84 candles per cubic foot, while with the larger clusters the increase in candle-power is still greater. This light may be seen in use every evening at 728 Broadway, this city, the office of the Albo-Carbon Light Company.

THE NEW WESTON VOLTMETER.

IT is a law of human progress, nowhere better exemplified than in the industrial and mechanic arts, that all systematic and permanent advance depends upon our ability to determine quantitatively, in terms of some standard, the value of the various factors involved in any given operation or transformation. An idea of the crudeness of men's notions of measurement in former times as compared with the present, may be gained from the names of units or standards which have been handed down to us. Thus three barley-corns made one inch, the foot was the length of the king's pedal extremity, the hand is a measure still in use in estimating the height of horses, etc. Compare such notions with the accuracy required in modern machine-shop practice. It is, in fact, only when the value of work already done becomes known, that one is prepared to make further progress, as every step in advance demands increased refinement in the means and methods of measurement. As an instance in point, witness the mutual development of the steam-engine and the steam-engine indicator. Just as the indicator has advanced to a state of perfection such that its records are universally relied upon to detect faults in present apparatus, and intelligently outline the direction of improvement, so has there been a gradual advance in the construction of commercial electrical measuring instruments, serving a similar purpose, and tending to effect a similar result, in electrical engineering.

While it is true that thousands of engines are never indicated, and thousands of electrical appliances are never carefully tested, it is equally true, as a consequence, that useful energy is wasted, property destroyed, and money lost.

In electrical as well as in mechanical engineering, success necessitates the elimination of guesswork and the substitution of knowledge. Engines, dynamos, batteries, electric motors and lamps, are sold with a guaranteed efficiency and life, subject, however, to definite conditions as to use. It is generally because of the absence of definite knowledge as to when the imposed conditions are actually observed, that losses so frequently exceed profits. When measurements of the value of electrical appliances are actually made, the results are often discredited because of doubt as to the accuracy of the instruments used, and probably the general indifference to accurate work manifested by many electricians may be justly ascribed to the absence of reliable measuring instruments.

Most of the commercial electrical measuring instruments in use in this country to-day are of foreign manufacture. They may be briefly described as either of the permanent or electro magnet type. The former are in general disfavor, and unjustly so, because their defects are not inherent in the types, but are, rather, the natural result of poor design and construction. Those who have had much

FIG. 1.

experience with these instruments, of which the Deprez and Ayrton & Perry are examples, will recognize the fact that while these instruments are new, they are subject to rapid and serious changes in their constant. The rate of change, however, diminishes with age and use, up to a certain period, when they assume a condition of stability, and are thenceforth, in so far as the controlling force is concerned, reasonably reliable. Uncertainty as to when this condition of stability is attained necessitates frequent calibration, and is thus a serious obstacle to accurate work. A second defect is the heating error introduced when the instruments were kept in circuit even for the short time necessary to make readings.

Instruments of the electro-magnet type are, on the other hand, more generally in demand, because of the prevalent idea that they are not subject to errors arising from a variable controlling force. Errors, however, fully as serious as have been ascribed to permanent magnets, are not only common, but seemingly inherent, in this type, because of the magnetic persistency of the softest iron, even when subdivided. This error is most noticeable when readings are made with a rising, succeeded by a falling current, and often amounts to as much as twenty-five or thirty per cent. The best forms of this type of instrument are, perhaps, the ingenious spring voltmeters and ammeters of Ayrton & Perry. These are, however, subject to serious heating and frictional errors.

Thus far we have mentioned only the most glaring defects common to commercial instruments. Another and almost universal defect is due to inaccuracies in the reading-scale. A great advance was certainly made when direct-reading instruments were substituted for those requiring a multiplying constant. It is a notable fact, however, that most of the direct-reading instruments, judged by the uniformity of their scale-divisions, follow the proportional law. This is extremely doubtful, however, and calibration generally reveals the fact that seldom are there more than two or three of the scale-marks correct. Printed or engraved scales may justly excite suspicion as to their accuracy.

The advent of an improved type of commercial electrical measuring instruments for direct-current circuits, in which the sources of error enumerated above are practically eliminated, and which are equally well adapted for both laboratory standards and commercial service, is justly to be regarded as an important step in the development of electrical engineering. The Weston Electrical Instrument Company of Newark, N.J., have recently placed upon the market a new form of commercial voltmeters and ammeters, designed by Edward Weston, the well-known electrician. The especial aim in designing these instruments has been not only to entirely eliminate such variable factors as have been enumerated above, but to add to the instrument certain valuable features mentioned below. To this end, the electrical, magnetic, and mechanical features have been so worked out as to insure permanence and reliability, coupled with simplicity, extreme accuracy, a wide range of scale-reading, and portability. The accompanying engravings (Figs. 1, 2, and 3) give general and detailed views of the voltmeter. It will be seen that the field of force is produced by a permanent magnet of peculiar form, while the deflecting body, carrying the index, is a light coil of insulated wire, whose motion, resulting from the dual fields established by the magnet and current circulating in the coil, is restrained by two coiled springs. The springs serve also to convey the current into and out of the moving coil.

That permanent magnets can be, and in fact are, daily made, which, after undergoing a process of artificial aging, remain thenceforth practically constant in strength when subject to ordinary use, is now generally acknowledged. In these instruments special care has been taken not only in the selection of steel and its proper magnetization and artificial aging, but the magnetic resistance of the acting field has been reduced to its lowest practical limit by the insertion of a central core of soft iron within the movable coil. This core is supported upon the magnet frame by a strap of diamagnetic material. The form of the pole-pieces is such that the deflecting coil constantly moves in a uniform field, and hence the deflections practically follow the proportional law; and a direct-reading scale, of nearly equal subdivisions, is obtained. The movable coil is wound upon a light frame of copper, which serves the double purpose of a support, and also, since it moves in an intense field of force, as a damper, thus making the instrument exceedingly dead-beat.

All of the more important parts of the instrument are made to gauge, and the bearings of the deflecting coil are jewelled. Interchangeability of parts, and the elimination of friction, are thus obtained. A difference of potential of about one and one-quarter volts, at the terminals of the movable coil, serves to deflect the index over the entire scale, the length of the scale being about six inches. This degree of sensitiveness permits, therefore, the construction of instruments having a wide range of maximum scale-reading by the simple insertion of differentially wound resistance-coils, in series with the movable coil.

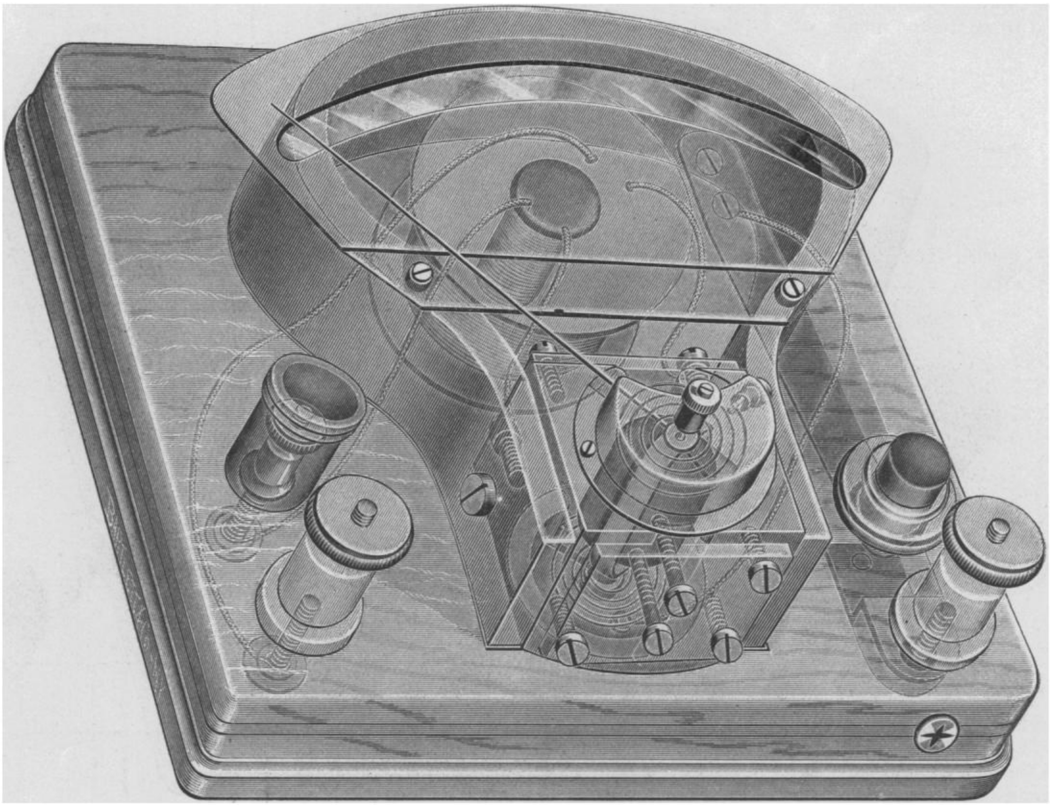

FIG. 2.

Figs. 1 and 2 exhibit the external and internal parts respectively of the new voltmeter, having a scale of double values, with a ratio of 20. The scale divisions for the upper values (Fig. 1) are single volts, while for the lower values they read one-twentieth of a volt. The single divisions are of such a size that one can easily read to one-tenth of a division; namely, to one-tenth of a volt on the upper values, and one two-hundredth of a volt on the lower. This form and ratio of scale values is useful for battery-work, and especially for storage-batteries. The lower scale values are used when examining single cells, or sets of two; and the upper scale values, when measuring the aggregate potential difference of a series of cells. In the former case, connection is made with the small binding-post (under the rubber cap) on the left, and with the larger binding-post on the right. In the latter case, connection is made with the two large binding-posts.

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

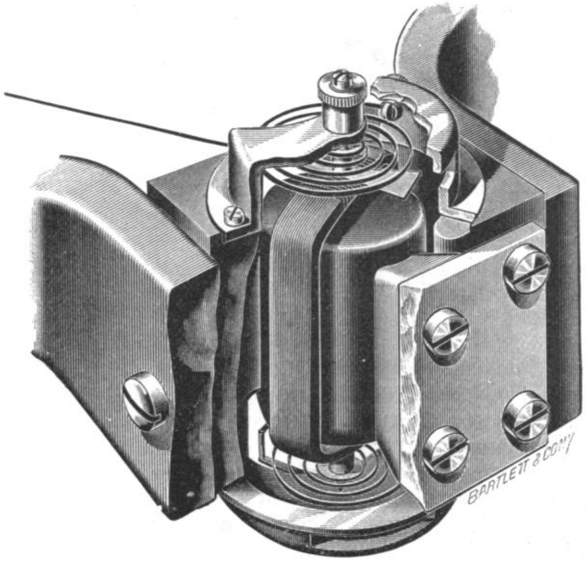

FIG. 3.

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

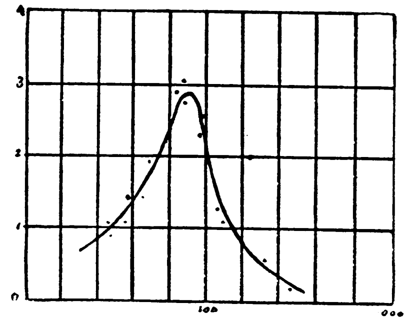

FIG. 5.

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

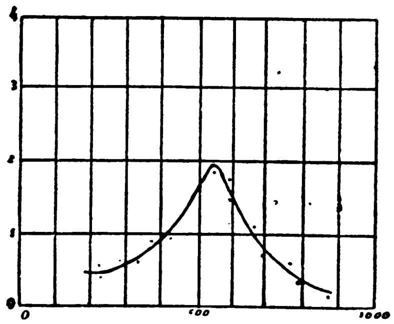

FIG. 6.

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