greatest possible utilization of the heat and the production of the greatest possible differences of temperature. Collateral advantages are rapidity and ease in starting work and a minimum requirement of space, since batteries to be heated by gas may be mounted upon a bracket. As valuable features must be mentioned the durability and firmness of the separate elements, as also the possibility of removing damaged rings either for repairs or for the substitution of new ones, which may be procured singly from the makers.

The three smallest models to be heated with gas and suitable for the electrolytic production of metals, for galvanoplasty, etc., consume hourly 300, 500, and 900 liters of gas (or about 11, 18, and 30 cubic feet), having strengths of current of 10, 20, and 40 amperes with an electromotive force of 3 volts. For an hourly consumption of 1 cubic meter these batteries give a useful effect of 80 volt-amperes, while those of former constructions yielded at most 27.—*Electrical Review*.

A NEW PATTERN OF REFLECTING GALVANOMETER WITH LAMP AND SCALE.*

By G. L. ADDENBROOKE.

THE instruments which I am about to describe are the outcome of improvements and modifications which have suggested themselves from time to time as the result of a good deal of experience in electrical testing for telephonic, electric lighting and general experimental purposes. As usually constructed, the reflecting galvanometer is essentially a laboratory instrument, demanding care and skill for its management, besides being costly. Perhaps the greatest objections to it are, however, the difficulty of moving it and setting it up, and the time usually taken to put it right when it gets out of order.

When, however, it is in good working order, there is so much satisfaction in working with it that one returns with reluctance to the use of other instruments. It is needless for me here to point out the various ways in which such galvanometers are now used, practically and experimentally, nor does it exactly come within

FIG. 1.

the scope of the paper to enumerate the uses to which this instrument can and probably will be put, in connection with the great extension of electrical engineering which is now taking place.

In the instrument before you it has been my aim, while preserving to the full the sensitiveness usually obtained in good laboratory instruments, to simplify and alter the construction, and thus fit it better for everyday needs, without at the same time diminishing its efficiency for the work with which it is now more particularly associated. It is constructed as follows:

Fig. 1 shows the instrument complete. The base is circular, and five inches in diameter. The case is of brass, its top being six inches above the base. The adjusting magnet, which is removed for carriage, rises eight inches further. The instrument is thus very small and compact. The adjusting magnet works up and down on its rod, a slot in the rod preventing lateral movement. Lateral movement is provided for by rotating the top of the case, which is marked with degrees, so that the magnet can always be brought back to the same position again directly, if it is necessary to move it.

The spirit level or levels for setting the instrument are on the top of the lid. The case itself is provided with two L pieces at the bottom engaging in two screws with milled heads on the base. By giving them half a turn, and rotating the case slightly, it can be lifted off.

Fig. 2 shows the appearance of the instrument when the case is taken off. Rising from the base are two parallel uprights of ebonite; four brass rods pass up through these, holding them in their places on the base and forming the means of connecting the terminals with the wire on the bobbins. Further, there are four small thumb screws which will be seen near the top of the ebonite uprights, two on each. These screws pass through the brass rods I have mentioned and into the outside cheeks of the bobbins.

The shape of the bobbins themselves will readily be seen in the figure. The outside cheeks are left much thicker than the inside, and all the cheeks project about $\frac{1}{2}$ inch beyond the coils of wire. The lower halves of these projecting cheeks are cut away at the

sides, as can be seen in the figure, leaving the upper portions projecting so that the coils rest on the projecting portions on the ebonite uprights and slide exactly into their places. The cut-away portions of the thick ends of the bobbins are faced with brass plates to which the ends of the coils are soldered. The thumb screws above mentioned screwing into the brass plates complete the connections and hold the bobbins firmly in their places. Both bobbins can thus be taken out in a moment without disturbing the needle, there are no awkward connections to make or to get out of order, and if desirable several sets of bobbins can be made,

FIG. 2.

wound with different lengths and sizes of wire to fit the same instrument, which can be interchanged without trouble at any time.

Now we come to the needle. The suspension is of quite a different type from that usually employed. A brass hoop will be observed passing over the center of the bobbins and screwed at either end to the ebonite uprights. The whole galvanometer is put in the lathe and a very small hole bored centrally through this brass hoop. A V-shaped slot is then cut in the brass hoop from the front toward the back of the instrument, the point of the V groove ending in the small central hole. About $\frac{1}{2}$ inch on each side of the hole two brass uprights are fixed; they are forked at the top and hold a little ebonite rod with milled heads at each end. One end of a silk fiber is attached anywhere on this rod, the other end is attached to the needle. The fiber may be a yard long if desired. The ebonite rod is then turned, winding the fiber round it until it (the fiber) is about the right length, and then the ebonite rod is slipped into its place. The fiber then, if it is wound the right way round the rod, at once automatically centers itself, and by rotating the rod the needle can be set exactly. By this means a long suspension is secured, and if it is desired several rods and needles can be kept for different purposes. Say one with damper for general use, and a finely balanced astatic one for delicate testing, a ballistic needle for condenser work, etc. When the instrument has to be carried about a great deal, spare needles ready suspended can be kept and be put in, in a minute at any time, should an accident happen. If the suspension of a needle does break, it is often at a critical moment when time is important. To replace it as usually suspended is, as a rule, a long and tedious job; much valuable time may therefore be sometimes saved by the use of a suspension of this character. It will readily be seen that attaching a new fiber is a very simple and short operation as compared with that necessary with the ordinary type of instrument. The needle itself consists of a stiff aluminum wire carrying the magnets and mirror.

For all ordinary testing work I prefer to bend the lower end of the aluminum wire round into a loop and flatten it out. This makes an excellent damper; it is sufficient to prevent long swinging and annoying vibrations without rendering the instrument dead and sluggish. This damper works in a little glass jar fixed in the base of the instrument. The jar has its edges turned over to prevent the liquid being spilled when carried about. It is, of course, easy to add a second pair of coils on the same principles as the two in the

FIG. 3.

instrument before you, should it be desired, but a constant of 1 degree deflection with 1 volt through 1,000 megohms can easily be got with a single pair of coils, which is more than sufficient for most purposes.

In using reflecting galvanometers, a lamp and scale are required. All who have had experience in work-

ing with such instruments know that there is often as much trouble with the lamp and scale as with the galvanometer.

In the lamp and scale I have here I have tried, while securing the maximum efficiency, to reduce the whole within as small a compass as possible. The lamp itself consists of a copper tube about 12 inches long and $\frac{1}{4}$ inches in diameter. The bottom of the tube forms the reservoir, the top portion acting as a screen. This tube is supported by guides at the sides attached to a metal base, and which permits of the lamp being moved up and down through a total range of 6 inches.

In order to fill the lamp easily, a funnel is provided in the top of the reservoir with a tube attached which reaches nearly to the bottom of the reservoir. In this way the lamp can be quickly and cleanly filled, and there is no need of a screw stopper to keep the paraffin from spilling or evaporating.

Most essential points in the construction of a lamp are that the longer axis of the flame and the axis of the lens or slot should coincide, and further that the intensest part of the flame should be opposite the center of the lens. In this lamp, by prolonging the rod carrying the milled head for adjusting the wick, and causing it to fall in a slot in the tube just below the door at the back, the longer axis of the flame is always kept in the proper place. Again, the height of the burner is carefully adjusted to be right when the lens is in a horizontal position. Further, to allow the lamp to be used in various positions and with different instruments, the lens tube is made adjustable through a considerable angle, its axis of rotation being the center of the flame. In this way a beam of light can be thrown upward or downward, as well as in the horizontal direction. This is in working often a matter of great convenience.

For use with the lamp I have arranged a specially portable scale and shade. The scale itself consists of $\frac{1}{2}$ a meter, divided into millimeters. It is mounted on a thin board, as usual; this board is attached to a shade of the same length by long hinges. The whole is then cut through the middle, and a hinge fixed on the back of the shade. By this means the whole folds into half its length. Guides are fixed on the back of the scale, which engage in lock fixed to a cross piece on the front of the lamp, so that the scale slides easily backward or forward, and means are provided for raising or lowering the scale by itself, which is often convenient.

For carrying about or putting on one side, a box is arranged to take both galvanometer and lamp, with room for shunts and other accessories. The size of this case is rather less than is required for the ordinary pattern of lamp alone.

The maker of the instruments is Mr. J. J. Hicks, of 8, 9, and 10 Hatton Garden.

IMPERIAL QUICKSILVER MINES AT IDRIA, AUSTRIA.

It will soon be four hundred years since the discovery of mercury in Idria by a cooper who had set a pail under a dripping spring. He found metallic mercury on the bottom of the vessel, and told a *Landsknecht* named Cancian Anderle of his discovery. The latter, with the discoverer and others, formed a company for getting out the ore. In 1504 this company sold out to a corporation, which began operations energetically. In 1507 the Emperor Maximilian opened a mine in Idria on his own account, but in the same year the Venetians invaded the country and seized the mine. In 1510, however, they were driven away again by the imperial troops. The mines were then rented by Maximilian to the St. Achazi Mining Company. Between 1521 and 1531 the Castle Gewerkenege was built by the company for the protection of their property, and here the directors of the works can still be found. In 1580 all of the mines came into the possession of the ruling prince, and the Mining Reservation for Montanwerk was founded by the "Carolina Mining Law for Idria," which still stands. Since that time the mines at Idria have belonged to the state.

The old mountain town is separated from the world by the steep hills which surround it; it has over 4,000 inhabitants, and contains 400 scattered houses. The Idria, which is as clear as crystal and rich in trout, runs through the city and supplies the works with the water power for turning the water wheels which operate the pumps and the hoisting machinery. Besides the castle already mentioned, other buildings were erected, among which are twenty-one dwellings for the officers and workmen, the church, the parsonage, the pretty schoolhouse and theater belonging to the works, the shaft buildings, the spalling house, the powder tower, and the dynamite magazine. The principal entrance to the mine (the "Antoni-Stollen") is in the center of the city, and there, in the large entrance room, the visitor is supplied with mine clothes, although the excellent condition of the mine renders them almost unnecessary. Generally one of the officers offers his own services as guide, but sometimes the visitor is left to the care of an experienced overseer.

The imperial quicksilver mines cover an area of about 111 acres and are provided with six shafts. There are now 959,430 cubic meters of ore in the mines, which, with a yearly output of 13,630 cubic meters, will last 70½ years. The quicksilver at Idria occurs partly as native silver in globules (this is collected in leather bags), but most of it is found in combination with other substances, one of which is *Brandervz* (burning ore). This latter has received the name *idriantín*; it is found at great depths and is very inflammable, and is, therefore, thought by many to be the cause of fires in the mines. In the deepest idriantín shafts a temperature of about 90° F. prevails, although the best appliances for ventilation known are employed.

The ore which has been blasted or hewn out is delivered to the stamping mill, where it is prepared dry and is finally treated in shaft and reverberatory furnaces. The shaft furnace consists of a cylindrical shaft with small fire boxes built on, and it is covered on the outside with iron plates. In the reverberatory furnace the ore is spread on the floor of the furnace and is roasted by the flame which sweeps over it. The gases from the furnaces of both kinds pass through condensation tubes which are sprayed on the outside and into a common condensation chamber, from which they pass through an enormous chimney to the open air. On account of the great length of the cold tubes through which the quicksilver fumes have to pass, the metal

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