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THREE ADDITIONS TO THE KOHLRAUSCH-OSTWALD CONDUCTIVITY METHOD.

BY J. LIVINGSTON R. MORGAN.

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THE Kohlrausch-Ostwald method for determining the electrical conductivity of electrolytes by means of an alternating current and telephone is very accurate and easy to use so long as the induction coil gives a clear high note. This condition, however, is not easy to fulfil, for, owing to the magnetization of the steel spring current breaker, the adjustment is soon lost. This objection holds for all coils which use steel for the vibrator whether in the form of a spring or wire. In preparing four sets of apparatus for conductivity so much difficulty was experienced in adjusting the coils that it was decided to find, if possible, another form of interruptor which would be free from this objection. As a result of this search an attachment was found which not only gives a clear high note, and allows of rapid adjustment, but which can be used for one set or for a number of sets of apparatus so that in the latter case all may be adjusted by one operation. Each piece of apparatus is set up as usual except that the current breaker is removed from each coil, the interrupting being done for all in another room by an apparatus run by another source of electricity. This apparatus is a modified form of Professor M. I. Pupin's electro-dynamic interruptor. The modifications referred to consist in the use of an electromagnet instead of the somewhat uncommon Weston permanent one, and in the interruption of a separate circuit instead of that which causes the string to vibrate. A

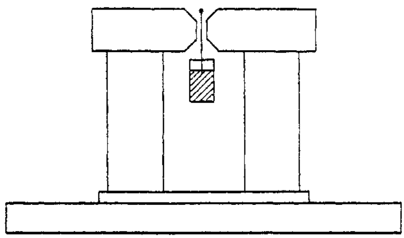

Fig. 1.

horseshoe electromagnet with special pole pieces (Fig. 1) is mounted vertically upon a base-board. On these pole pieces is fastened an oblong framework of brass, on the ends of which are screw devices to which the ends of a brass wire may be soldered and kept at any desired tension, between the pole pieces. Two mercury cups are placed the one in front and the other behind the magnet into each of which dips a short piece of amalgamated

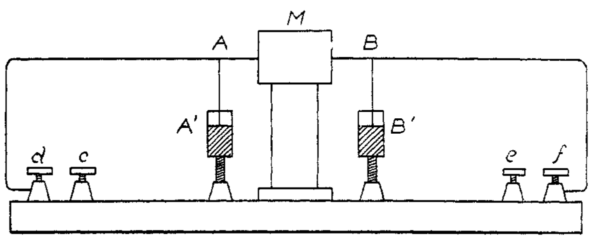

Fig. 2.—*c* is connected to B' and *e* to A' underneath the base. The current enters at *d* and *c* and one portion goes to the electro-magnet M by wires not shown in the figure.

copper wire which is soldered to the brass wire. These mercury cups are so arranged upon screws that they may be raised or lowered so as to be in contact with the copper dippers. Fig. 2 shows the arrangement of the wire, cups and magnet with their connections. The current (three to six volts, taken from the

[1] *Am. J. Sci.*, 3d series, 45, p. 325 (1893).

electric light circuit or from storage cells) enters at the two binding-posts *c* and *d* and divides one portion going to the magnet through wires not shown in the figure, the other going from *c* through the wire to B, to the mercury at B′ and back to *d*. When the current is flowing in this way, the wire is repelled by the magnet so that the contact at B′ is broken but made again instantaneously by the tension of the wire. In this way the wire is retained in rapid vibration, and, if the cup A is properly adjusted, any battery circuit connected through *e*, A′, A, and *f* will be interrupted. By connecting a Leclanché cell with an induction coil (with the breaker removed) through the two binding-posts *e* and *f* a rapidly alternating current is obtained and a clear high adjustable

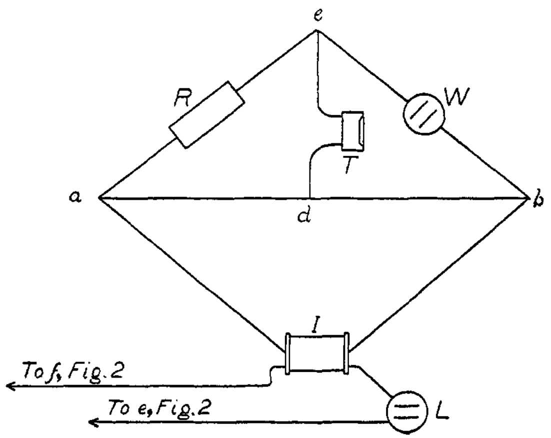

Fig. 3.—R is the known resistance, W the electrolytic cell, I the coil, L the Leclanché cell and T the telephone.

note produced in the telephone. Fig. 3 shows the connections for a piece of apparatus set up in the way described so that no further explanation is necessary. Naturally any number of sets may be connected in this way through the interruptor, the same tone being obtained in all, and all may be adjusted at once. If the current necessary for the operation of the vibrator were not so great only one mercury cup would be necessary, but it has been found more satisfactory to simply interrupt the current from a single cell and thus to avoid heating and polarization effects at the electrodes. The arrangement described has been in use in this laboratory for more than a year and has given great satisfaction.[1]

The second addition is designed for use in determining the conductivity of water or other substances of high resistance. In such cases in using the simple Ostwald form of bridge, the reading is very near one end so that the possible error, due to bad end contact, is very large. The arrangement proposed lengthens the bridge, only the one small portion represented by the one meter of wire being used, and so all readings are multiplied by a certain factor, and caused to approach the middle of the wire where the results are most accurate. This end is reached by placing certain lengths of insulated bridge wire on spools between the actual bridge wire and the arm of the bridge (between *b* and *W* Fig. 3). Spools containing four, nine, and nineteen meters of the bridge are prepared so that by inserting these, with mercury contacts, the readings are multiplied by five, ten, and twenty, respectively, that spool being used which brings the reading nearest the middle of the bridge. The idea is employed in the more elaborate bridges used by physicists, and also in the simple Ostwald form for the determination of electromotive force[2] but, so far as I know, it has never been used for conductivity. Its results, however, are very satisfactory and the idea is recommended to others.

The third addition proposed is for the purpose of ascertaining, as quickly and accurately as possible, that point on the bridge which gives the minimum tone in the telephone. The regular method of determining this point is first to locate it approximately and then to fix it by finding two points, one on either side of it, at which the tone has the same intensity. When these two points have been found the reading midway between them gives the minimum. In using this method it is hard to match the two tones since it takes an appreciable time to move the sliding contact. If the two tones could follow one another immediately it would be very much simpler. To do this the block of wood which is used as the holder for the sliding contact is provided with two press keys instead of one, both being connected by the same binding-post. The contact points of these two press keys should be

[1] Messrs. Eimer & Amend of New York City are prepared to make interruptors of this kind to order at a cost of ten dollars each.

[2] Goodwin: *Ztschr. phys. Chem.*, 13, 290 (1894).

either one-half or one centimeter apart and have vulcanite knobs upon which to rest the fingers. As soon as the approximate reading is found with one key the block is moved until both keys when pressed give a tone of the same intensity; the middle point is then the true minimum. It is well to have the one key movable so that the distance between the contacts may be reduced as the point is reached. By the use of this arrangement it is possible to find the point within a small fraction of a millimeter and much less experience is necessary for accurate results than by the ordinary process.

ON THE SURFACE-TENSIONS OF MIXTURES OF SULPHURIC ACID AND WATER, AND THE MOLECULAR MASS OF SULPHURIC ACID.

BY C. E. LINEBARGER.

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THE apparatus employed in making the measurements of the surface-tension was that described in a previous number of this Journal.[1]

The sulphuric acid used was Baker and Adamson's "chemically pure" (sp. gr. 1.84), and was found on analysis to contain 4.98 per cent. of water. This acid was mixed in varying proportions with water and the mixtures analyzed. The specific gravities of some of the mixtures were determined, but most of them were taken from Lunge and Isler's tables[2] and the corrections for temperature applied by means of the data given by Bineau.[3]

The thermostat consisted of a beaker filled with water and provided with a stirrer. A layer of heavy oil was poured over the water so as to prevent evaporation. Readings were taken (never less than three at the same temperature) at intervals of about 5°. These were plotted and a smoothed curve (which was approximately a straight line) drawn through them. From this curve, readings were taken at temperature-intervals of 10°, and these were used in calculating the surface-tensions.

Readings were taken in the same way with pure water, from which with the aid of Ramsay and Shields' data[4] on the surface-

1 This Journal, 18, 514 (1896).
2 *Ztschr. angew. Chem.*, 129 (1890). Landolt and Börnstein, 196.
3 *Ann. chim. phys.* (3), 26, 123 (1849).
4 *Ztschr. phys. Chem.*, 12, 433 (1893).