reading is entered on his form without any sign; and, if the deflection of the needle is below the zero, the reading larly constructed, are used for comparative work—com- is entered with the sign — before it. If the deflections of the needle are both below and above the zero at the same place they are entered (to use arbitrary figures) as — 2.50 to 3.25. To assist in the prevention of mistakes, it should be impressed on the reader that he should always read and enter from a lower reading to a higher reading.

Fig. 10 is a reproduction of a photograph of a duplex potential meter (two instruments like that before described, but with the scales graduated for millivolt readings), also designed by the writer. The lid was removed while the photograph was being taken so that the special arrange-

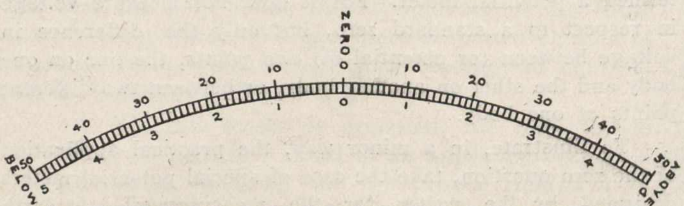

Fig. 8.—Arrangement of Scale for Single Centre-Zero Potential Meter.

ments would show up better. Duplex potential meters, simi- parison of the voltages of two bodies with that of the voltage of a third one used as the zero. Take the case when investigations are taking place in regard to a surface road, an elevated road and cable sheaths (all earthed). First:—The surface road rails can be connected to the two zero posts, while the other post of each side of the instrument is connected, respectively, to the elevated structure and the cable sheaths. Second:—A set of readings can then be taken with the zero posts attached to the elevated structural work, while one of the posts on each side of the instrument is connected, respectively, to the rails and sheaths. The wiring of these duplex instruments is such that the needles move in similar directions and equally under similar influencing conditions. The comparative results are very interesting and instructive.

Such explanations are rather long; but in practice it is remarkable with what rapidity and accuracy boys can take these readings, even if they have no electrical knowledge.

As a practical illustration of the foregoing method of taking potential readings and the method of analysis afterward adopted, take the case of one investigation made by the writer in a district where of two systems (one an elevated and the other an overhead trolley) only the trolley was being electrically operated. Investigations were carried out in reference to two conditions of operation, which two conditions are diagrammatically represented, the one in Fig. 11 and the other in Fig. 12. When the street rails had no load on them for some distance away from the elevated structural

POTENTIALS BETWEEN HYDRANTS AND RAILS.
(FIGURES GIVEN ARE VOLTAGES OF THE HYDRANTS TO THE RAILS.)

Readings taken by ————————

Date ————————

Weather ————————

Preceding Weather ———— *for* ———— *Days* ————

READING No.	LOCALITY.	TIME.	VOLTS.	REMARKS.
		TO	TO	
		TO	TO	
		TO	TO	

Fig. 9.—Printed Form for Records of Potential Tests.

ironwork, this is, when the nearest carload was as in Fig. 11, the structural ironwork was about five volts above the voltage of the street rails in proximity to it; or, vice versa, the street rails were about five volts below the voltage of the adjacent structural ironwork. The grounded portions of the two systems at this point had, therefore, a potential of five volts. When the carload was on the street rails close by the structural ironwork, however, as shown in Fig. 12, the structural ironwork was only about one volt above the voltage of the contiguous street rails; or, vice versa, the street rails were then about one volt below the voltage of the structural ironwork. The grounded portions of the two systems, therefore, had, under this changed condition of carload, a potential of only one volt. The lesser potential at this point indicated, therefore, the transmission of a much greater amount of energy by the grounded return of the street railway system than was indicated by the higher potential, which is explainable. For the voltage of the trolley wire of the street railway system was several hundred volts above the voltage of the street rails; and when a considerable amount of energy was being transmitted from the trolley wire through the cars to the street rails, the latter, as a result, were raised in voltage; that is, the voltage of the street rails near the structural ironwork were raised from — 5 to — 1. The zero which was used in this case—an assumed one—was that of the voltage of the structural ironwork at the point where the investigations were carried out.

Several cases have also come under the writer's observation where of the two returns (during operation) the street rails had the higher voltage. As a result, the partial balancing, equalizing or reversing of the comparative voltages of the elevated structural work and the street rails appeared to result when the elevated trains were passing, so that the potential nearly always increased as the distance of the elevated trains from the point of investigation increased. Care has to be exercised, therefore, in concluding, in such a case, that a gradually increasing potential is due to the gradual cutting out of resistances by the elevated motorman

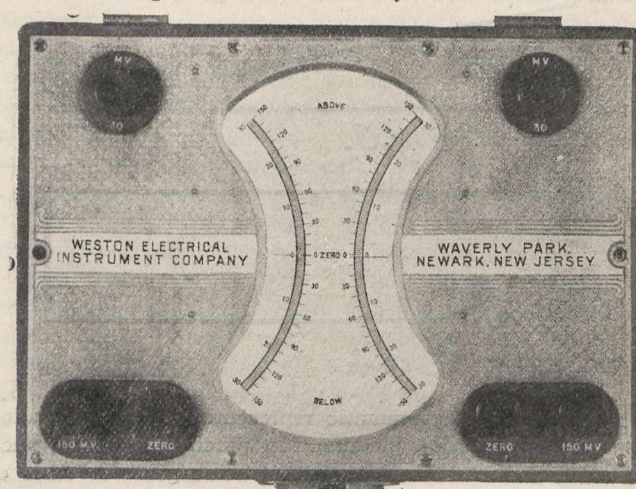

Fig. 10.—Duplex Potential Meter Used in Making Electrolytic Surveys.

at the controller; that is, an increasing potential between elevated structural work and street rails is due, in such case, to a decreasing elevated load at the point of measurement.

Earth Potential Readings.

When potential readings are taken, care should be used that the deflections of the needle of the potential meter (voltmeter) do not mislead one, due either to imperfect connections at the terminal leads or through the failure to fully consider the $C = \frac{I}{R}$ law analytically.

As an example of imperfect connections, take the case of a poor conductor or insulating material, such as a cement pavement. Naturally enough, if the terminal leads are simply laid on the cement at two different points, the contacts made are bad ones. To make good connections in a case like this, a liberal amount of water should be poured on the cement at the points between which the readings are to be taken. Then two tin pails, weighted with water and with the terminal leads attached to them, should be placed on these watered points, one pail on one point and the other pail on the other point.

As explanatory of an analytical consideration of the $C = \frac{I}{R}$ law, take the case of the complaint made to the writer by a railway company that the men handling the installation of its bare cables, intended as auxiliaries to its