leave the pipe. Current measurements on pipes are, therefore, frequently made at two or more stations simultaneously in order to determine the change of current on the pipe between the stations. In Fig. 7 simultaneous current measurements made at two stations on a pipe are shown plotted where there is no change of current between the stations. In Fig. 8 simultaneous current measurements at two stations on a pipe where there is a considerable loss of current between the stations are likewise shown.

In order to determine the characteristic variations of a potential difference between pipe and rails, or of current flow on a pipe, 24-hour records of such potential difference, (or of current flow) may be obtained by means of a special Bristol, smoked-chart, recording instrument. This recorder has for its measuring system a sensitive Western millivoltmeter, and may be provided with a number of ranges. It is convenient to have the instrument provided with its zero in the centre of the scale, and with ranges of 5, 50 and 500 millivolts, and of 5 and 50 volts. Shunts of any desired ampere range can also be used in connection with the recording millivoltmeter, and the instrument used as a recording ammeter of a corresponding range. Convenient shunts for this are ordinary switchboard shunts adjusted for 50 millivolts drop, with rated capacities of 5, 50 and 500 amperes. Such potential and current records are conveniently plotted from these charts in rectangular co-ordinates. Sample 24-hour records of current on a pipe plotted in rectangular co-ordinates for one week are shown in Fig. 9, from which it will be seen that the current records for weekdays are practically alike, and show morning and early evening peaks. The record for Sunday is, however, very different and shows a very large peak throughout the whole afternoon. This is accounted for by the fact that the neighboring trolleys were carrying large crowds of excursionists on Sunday outings. By means of such 24-hour records it is often possible to positively identify the source of current flowing on a pipe as railway current from its similarity with the railway load curves. Twenty-four-hour records of current flowing on pipes may also be

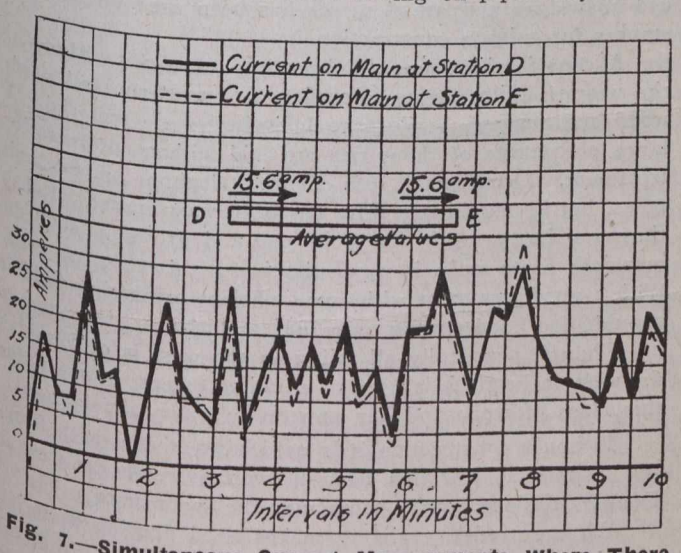

Fig. 7.—Simultaneous Current Measurements Where There is no Change in Current Between Stations.

obtained at two or more stations simultaneously, and the change of current between the stations for the 24 hours determined.

It is possible to trace the path of current flow through ground by measuring potential differences between points in the ground. Where small potential differences are measured between two points in ground and iron rods are used as electrodes, entirely incorrect results may be obtained, because of possible differences in polarization voltages at the surfaces of the electrodes. To overcome this difficulty, a "non-polarizable electrode" was devised by Prof. Haber. This consists of a glass tube, with a porous cup cemented to one end, containing a saturated solution of zinc sulphate, and of a zinc rod dipping into the solution. A wire is brought out from this zinc rod through a cork in the top of the tube. To make contact to ground with this electrode the porous cup is pressed against the part of the ground at which the potential is to be measured, thus establishing contact between the ground and the zinc sulphate solution. This establishment

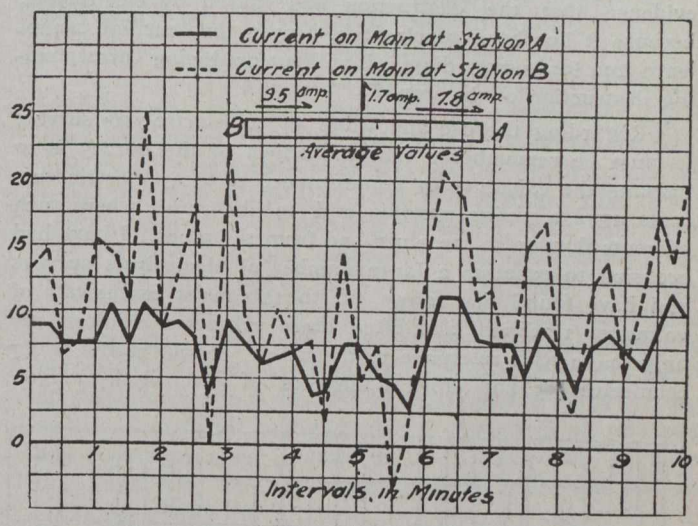

Fig. 8.—Simultaneous Current Measurements Where There is Change in Currents Between Stations.

of electrolytic contact between ground and the zinc sulphate solution eliminates polarization voltages. The polarization voltage between the zinc rod and the zinc sulphate solution, which is a definite known voltage, must be allowed for when using this electrode. It is also essential that, when this electrode is used, the potential measurements be made by means of zero methods, and not with indicating volt-meters, because of the very high contact resistance produced with this electrode.

It is often also desirable to measure directly the flow of current through ground, as between a pipe and rails, or between two pipes. This can be done by means of an earth ammeter, which was also devised by Prof. Haber. This consists of a wooden frame with two copper plates insulated from each other by a plate of mica or glass. Insulated copper wires are brought out from the two copper plates, and these wires are connected to an ammeter. To use the frame, the two copper plates are, first, coated with a paste made of copper sulphate and a 20 per cent. sulphuric acid solution. A wetted piece of parchment paper is then laid over the paste, and the remainder of the frame filled with soil from the excavation where the current flow through ground is to be measured. The frame is then buried in ground normal to the direction of the current flow to be measured, and the ammeter will indicate the current flow which is intercepted by the buried frame. The object of the copper sulphate paste on each plate is to equalize polarization potentials at the surfaces of the copper plates. This earth ammeter is also well suited for measuring current flow between pipe and ground. For this purpose the frame is buried in the ground one or two inches from and parallel to the pipe. Measurement of current flow from a pipe thus made can be used to form an estimate of the probable amount of electrolytic damage to the pipe, and in cases where corrosion has taken place,