is shown to be more than sufficient to pay all annual charges on the proposed installation and leave a net profit of about \$1600 per year. A further advantage of the proposed plan is the provision of 800 kilowatts additional reserve substation capacity and improved operating conditions.

A system of potential wires extending from some central point to the point of lowest potential on the track and to the points of highest potential within the city on each line is recommended.

SPECIAL STUDIES IN ELECTROLYSIS MITIGATION.

3. A REPORT ON CONDITIONS IN SPRINGFIELD, OHIO, WITH INSULATED FEEDER SYSTEM INSTALLED.

By Burton McCollum and G. H. Ahlborn.

THIS report concerning electrolysis conditions in Springfield, Ohio, deals with the electrolysis situation with the completed mitigation systems in operation and the track return much improved.

Before presenting the data taken in the survey the general condition of city and the public utilities which might affect electrolysis are discussed. The insulated return feeder system is described in detail, the description including data on cables and resistance taps and a map of the systems. The permanent pressure wire system installed to obtain overall potential measurements is described in detail.

The cost of railway operation as it is affected by the mitigation system is shown to be slightly greater than it was before any system was installed. This is due to the investment in copper, the power losses being about the same. The cost is less than with the first mitigation system in operation, chiefly because the power losses have been reduced. The annual charges on the feeders are shown in detail.

The methods employed in obtaining the data are discussed and the correction and reduction factors that must be applied to the various sets of readings are given, the data being reduced to average values for the 24-hour and maximum hour periods.

The data were obtained in July and August, 1914, and are discussed under the heads, Potential Differences, Potential Gradients, Overall Potentials, and Stray Currents in Underground Structures. The potential differences between pipes and rails

show that all values are well below one volt for the all-day average, and at only two points do the values for the maximum hour reach one volt. The potential differences between gas and water mains are practically zero, and the lead sheaths are everywhere negative to the other structures and ground. The potential gradients are low on all sections of track, and on all repaired sections not substantially insulated from ground the overall potentials are less than 3 volts for the all-day average values. There were still two or three sections not completely bonded or practically insulated from earth where the drop was over 3 volts. The stray current in the underground structures is practically negligible at all points, that in the gas mains being especially low. There are a few points where tracks lie near each other where local potential differences should be further reduced by cross-ties between such tracks. The potential differences existing in such places are shown and the amount of copper necessary for the cross-ties is stated. In reviewing the above data it is pointed out that the structures are comparatively safe and the results obtained satisfactory.

The data obtained during the summer of 1914 are compared with similar data taken in the survey of the previous winter to determine any effect of frost and lower temperatures. The loads on the interurban lines are about the same during both seasons, but decidedly heavier on the Springfield Railway during the winter. Taking this into consideration, as well as the increased conductivity of the rails in cold weather, it is evident that the potential differences are greater because of the frost, but that the stray currents are reduced.

Recommendations are made concerning improvement in track bonding, precautions that should be taken in the laying of new pipes and repairing old ones, and supervision and inspection by the city officials in order to maintain good electrolysis conditions. It is recommended that the insulated return feeder system be continued in operation and annually inspected, that the sections of track mentioned in the report as in bad condition be repaired, that certain interconnections between tracks be made, and that the pressure wire system now installed be maintained. It is also recommended that no pipe drainage and only limited lead sheath drainage be permitted, that pipe-owning companies install new mains and services so as to pick up as little stray current as

possible, and insert insulating joints in new mains and services where these are in close proximity to railway lines.

The city is urged to adopt 3 volts average for the 24-hour period as the overall voltage limit, except on two lines, where 4 volts may be permitted; to require rebonding of rail joints where their resistance exceeds that of ten feet of rail; to require annual tests and reports of bonding conditions, and to appoint a city expert to determine overall potentials and pass on the above tests and reports.

A METHOD FOR MEASURING EARTH RESISTIVITY.

By Frank Wenner.

[ABSTRACT.]

A KNOWLEDGE of earth resistivity may be of value in determining something of its composition, such, for example, as moisture content, whether or not it contains oil or ore of high conductivity, etc., or in the calculation of damages to pipe systems by the return current of street railway systems. For some of these or other reasons we may wish to determine the resistivity of limited portions of the earth.

For those cases in which we desire the resistivity of a fairly large portion of earth, extending to a considerable depth, or where there are reasons why the measurement should be made without disturbing the portion to be measured, the following method is suggested:

Four holes are made in the earth approximately uniformly spaced in a straight line. The diameter of the holes is not more than 10 per cent. of the distance between them and all extend to approximately the same depth, which is usually that at which we are most concerned with the resistivity. In each hole is placed an electrode which makes electrical contact with the earth only near the bottom. Two of these electrodes serve as current terminals and two as potential terminals in the measurement of the resistance.

Knowing the resistance, the depth of the holes, and the distance between them, we have data from which the effective resistivity in the vicinity can be calculated.

In case a is the distance between the holes, b is the depth of