it has been shown that a good first approximation is obtained by using formulas for the direct current mutual resistance and mutual inductance. Any network of conductors located on the surface of the earth with which it is conductively connected at any number of points will, for direct currents, have self and mutual inductances which are equal to the Neumann integral, extended over the network alone. In other words, that portion of the complete Neumann integral for closed circuits which involves the return currents through the earth, vanishes. The earth is assumed to be flat, of infinite extent, of unit permeability and of uniform conductivity.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY.

CONTACT ELECTROMOTIVE FORCES DUE TO FILMS ON METALLIC SURFACES.

BY A. E. HENNINGS.

IN preliminary experiments preparatory to an investigation of the temperature coefficient of contact electromotive forces between metallic surfaces certain new phenomena have been observed which indicate that the true effect may be completely masked by the formation of films.

The experimental arrangement was such that one of the surfaces could be changed through a wide temperature range, while the other was not changed in temperature, except in so far as this was brought about by radiation from the first surface. The bottom of a brass cylinder projecting into the vacuum chamber served as the first of these surfaces and the second was that of an insulated brass plate in communication with a quadrant electrometer. By means of an electro-magnetic device this latter plate was brought near or away from the bottom of the cylinder. Thus the Thomson method of measuring the contact electromotive force could be applied.

When liquid air was poured into the cylinder and when the vacuum was such as could be obtained with a Gaede mercury pump, but without charcoal absorption, the contact electromotive force between the brass surfaces changed rapidly from + .02 volt at 20° C., to a higher positive value, which changed quickly to a negative value reaching a maximum of − .78 volt. After the liquid air had evaporated and the bottom of the cylinder began to rise in temperature, the contact electromotive force changed, comparatively slowly at first, to a less negative value, but then very abruptly from − .47 volt to + .32 volt between the times of two observations made as quickly as possible. A maximum of + .43 volt was reached in a short time, which, however, gradually fell, approximating the initial value when the whole apparatus approached the temperature of the room. Other series of observations yielded still greater differences between extremes, the total change in one case being between + .28 and − 1.13 volts.

With an improved vacuum the fluctuations were less pronounced, but nevertheless such that no data, purporting to represent the true temperature coefficient of contact electromotive forces, were obtained.

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