sisted of a piece of platinum foil of several square c. m. area, coated with lead peroxide. Thus the two areas were vastly different; and nearly the whole of the polarization occurred at the point electrode, which was used successively as anode and as kathode.

When used as anode the current-potential curves showed the bend at about 0.4 volt. But used as kathode, the several curves were not in as good mutual agreement, and do not clearly indicate a particular voltage at which action at that electrode begins. The general indications are that the lead appears at a voltage considerably less than that required to separate lead on a platinum kathode, and that the peroxide is reduced. The irregularities that may mask the critical voltage seem to be due to local concentration changes around the electrode.

PbO_2 seemed to form at the anode at the voltage 0.4.

Some Observations with Rayleigh's Alternate Current Phasemeter.

By E. S. Johonnott, Jr.

This instrument in the field of alternate current measurements takes a place similar to that of the galvanometer in direct current measurements; with some advantages, and also with some disadvantages. For example, its indications may represent either current or electromotive force, and the angle of lag and true watts in a circuit may be obtained by a simple calculation. However, its indications, as in all other alternate current meters, vary as the square of the current; hence its range of sensibility is limited.

The principal feature of the instrument is the ease with which it gives the angle of lag of the current in a circuit behind the electromotive force impressed at its terminals. Also when once calibrated it gives all the quantities needed to determine the energy absorbed in a conductor.

Similar to the tangent galvanometer it consists of an iron magnet suspended in the field of the current whose value is required.

Fig. I is a horizontal sectional view of the form used by Lord Rayleigh. *M* represents the current coil, and is connected in series with the conductor on which the measurements are desired to be made. *S* represents the E.M.F. coil and is shunted across the terminals of the conductor.

Between the coils, *M* and *S*, with its center on their common axis, a piece of soft iron wire is suspended at an angle of 45° to the axis of the coils.

In the instrument with which the following observations were made, the coil *M* consisted of 72 turns of No. 22 copper wire wound in two sections having 48 and 24 turns respectively. *S* was similarly wound with No. 28 manganin wire and had a resistance of 668 ohms. Each was made adjustable along their common axis for a distance of 13 centimeters.

The needle was suspended with a fine phosphor-bronze torsion fiber. The deflections were measured with mirror and scale.

If an alternating current is sent through either of the coils, the needle becomes a magnet acted upon by a couple depending upon the instantaneous value of the current. The couple will be in the same direction whatever the direction of the current. In short, it will vary as the sine of twice the angle theta and as the mean of the square of the current values.

Since the couple varies as the sine of twice the angle theta, it will be a maximum for theta = 45°. Here also will be the position for the least sensitiveness to change in the zero.

In order to use the instrument as a phasemeter, readings of the deflection produced by the current in *M*, and the fall of potential in *S* are taken independently. Then, usually, two readings of the deflection produced by the currents in both coils simultaneously are taken—one in which both couples act in the same direction, the other when they act in opposite directions. The values of these two latter readings depend upon the angle of lag, and together with the reading for the currents, independently, give sufficient data for its computation.

The calculation may be made in two ways:

(1) Analytically.

(2) Graphically.

In the first method,

$C_1^2 = A^2 + B^2 + 2AB \cos \phi$

$C_2^2 = A^2 + B^2 - 2AB \cos \phi$ when

A^2 is the deflection with M acting independently.

B^2 is the deflection with S acting independently.

C_1^2 and C_2^2 is the deflection with M and S acting simultaneously.

ϕ may be found from either equation.

In the second method, two triangles are laid off with their sides proportional to the square roots of the readings. The angle of lag, φ, is given in either case as shown in Fig. II.

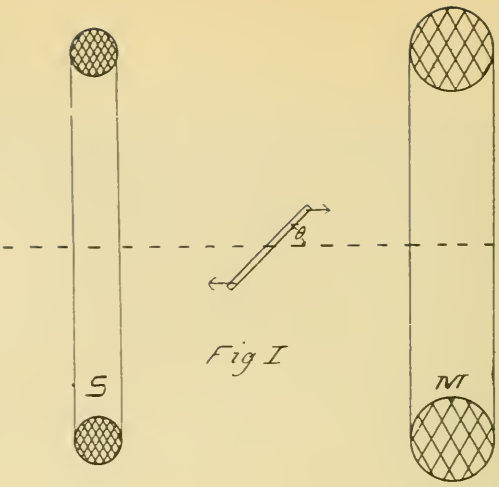

Fig I

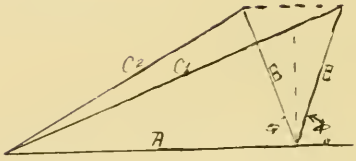

Fig II

$$C_1^2 = A^2 + B^2 + 2AB\cos\phi$$
$$C_2^2 = A^2 + B^2 - 2AB\cos\phi$$

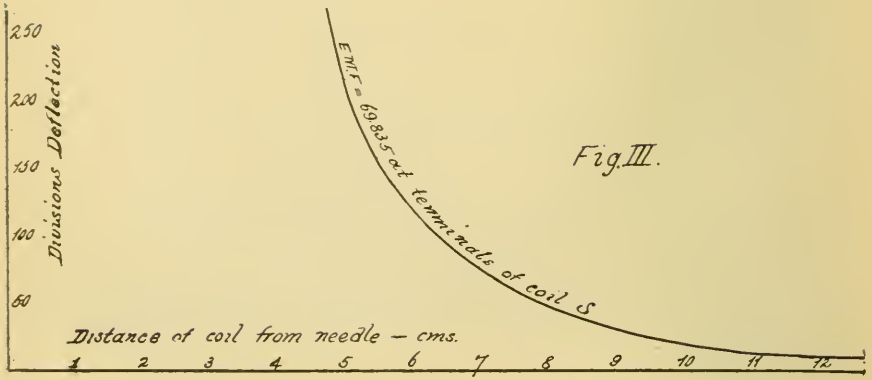

Fig. III.

Considerable range in sensibility for both coils is obtained by adjusting them at different distances from the needle. Some idea of this range may be obtained through inspection of the curve given in Fig. 3.

This was taken with the coil *S*, having a constant E.M.F. of 69.835 volts at its terminals. The abscissae represent the distances of the coil from the needle; the ordinates, the corresponding value of the deflections on the scale.

Both coils were calibrated at different distances from the needle with the Thomson balances. Fig. 4 represents curves taken with the coil, *M*, and shows no appreciable departure from the law of the squares.

In order to facilitate taking the readings, compensating coils, *M'* and *S'*, Fig. 5, were arranged in the circuit for *M* and *S* respectively, so that the conditions within the conductor on which the observations were being made remained the same when either *M* or *S* was cut out. This obviated removing either coil when the reading due to the current in the other was desired.

In Fig. 5 is shown a diagram of the connections used in making an observation for the angle of lag in a circuit which is here shown to be a coil, *X*, on a split anchor ring. *X* and *M* are connected in series in the secondary of a one-to-one transformer, in order to have no appreciable impedance in the circuit, other than *X*. The electrical conditions in this circuit were then controlled by the resistance and choking coil in the intermediate circuit. One commutator was arranged in the shunt circuit to reverse the current in*S*, another to substitute the compensating coil *S'* for *S*.

One of the greatest difficulties encountered in measurements of this character is due to unsteadiness in the source. Particularly is this true when all the readings can not be taken simultaneously. This may, however, in a measure, be overcome by arranging an auxiliary voltmeter similar to the E.M.F. coil, S, with its terminals connected across the terminals of the secondary of the city transformer. The phasemeter readings are then taken when the deflection due to their auxiliary coil is constant.

With respect to accuracy the phasemeter as a current meter is perfectly similar to the galvanometer.

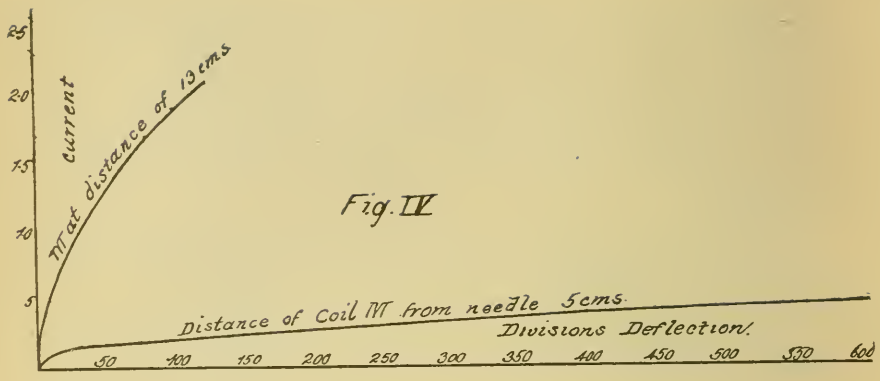
25
20
15
10
5
M at distance of 13 cms
current
Distance of Coil M from needle 5 cms.
Divisions Deflection.
50
100
150
200
250
300
350
400
450
500
550
600

Fig. IV

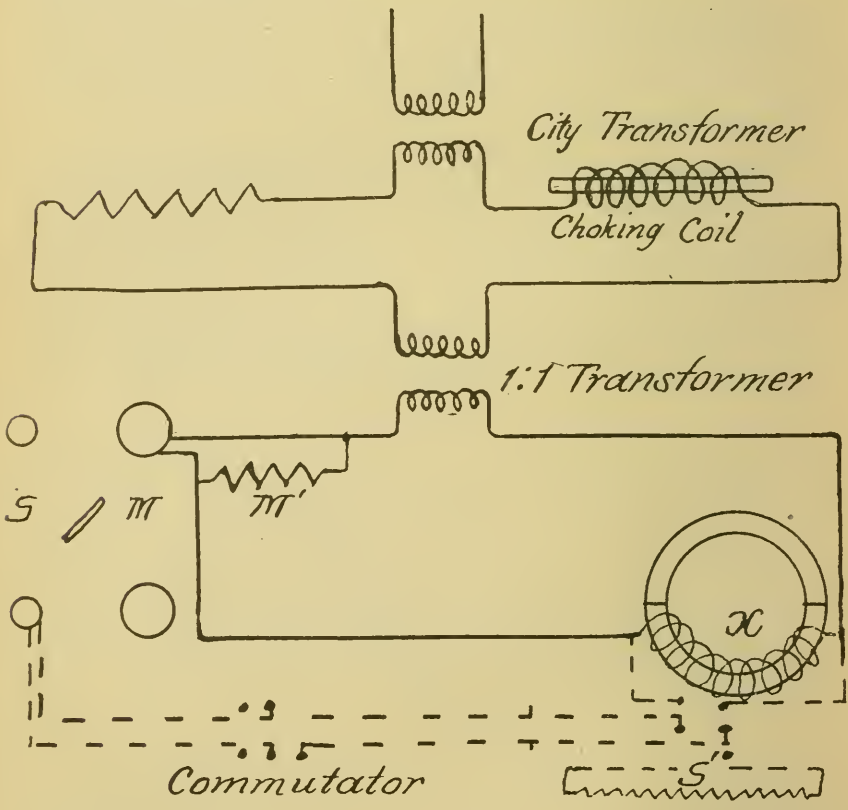
City Transformer
Choking Coil
1:1 Transformer
S
M
M'
X
Commutator
S'

Fig. V.

Some measurements on hysteresis and the effect of iron in the magnetic circuit have been undertaken. It would, however, be too premature to take up their description at this time.

The instrument which has been described was built, largely, by Mr. Edwin Place, formerly connected with the Institute. He made many observations similar to those above recorded.

I should like to take this opportunity to thank Dr. Gray for his many suggestions and for the removal of a number of stumbling blocks.

A Demonstration Apparatus.

By P. N. Evans.

The apparatus is a simple modification of that commonly used to compare, by diffusion, the density of another gas with air. It consists of a porous battery-cell placed horizontally and fitted by a stopper to a glass tube bent downwards at right angles a few inches from the stopper, and then upwards again to its original height. This U-shaped manometer is about two feet long and half filled with a dark-colored liquid; the limbs are close enough together to make a slight difference of level easily seen, against a white background fastened to the tube. To further increase the sensitiveness of the instrument a perforated glass plate or heavy card is secured between two corks on the horizontal part of the tube close to the cell, so that the cylinder or beaker of gas to be examined may be pressed lightly against this, and thus largely prevent loss of the gas before sufficient time has elapsed to show the maximum deviation in the manometer.

While the ordinary apparatus is recommended for demonstration only with gases differing considerably from air in density, this modification has given very satisfactory results with hydrogen sulphide, and even oxygen, with densities of 1.18 and 1.11 respectively, a difference in level of at least an inch being observed in the latter case. A slight effect, clearly visible to the manipulator, though not satisfactory for demonstration purposes, was obtained with nitrogen—density 0.972.