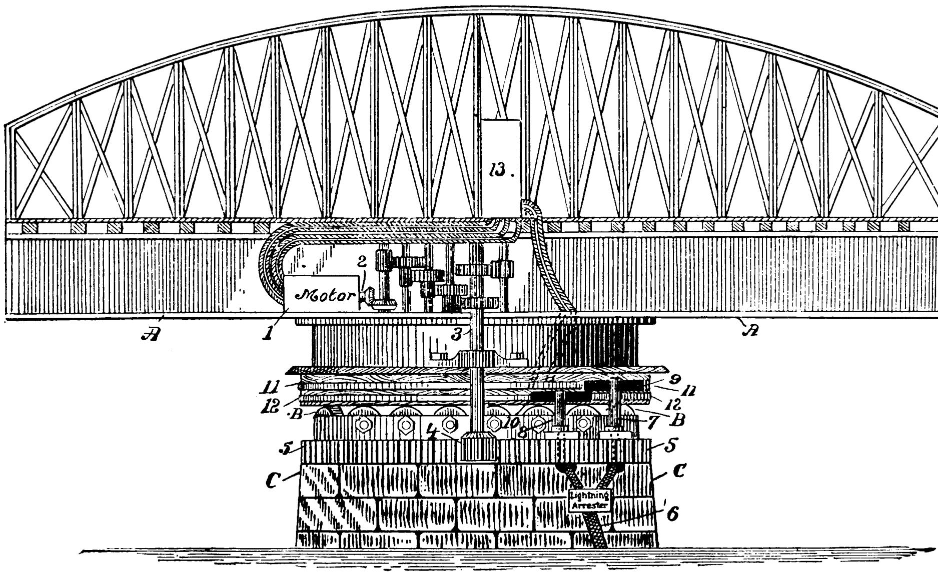
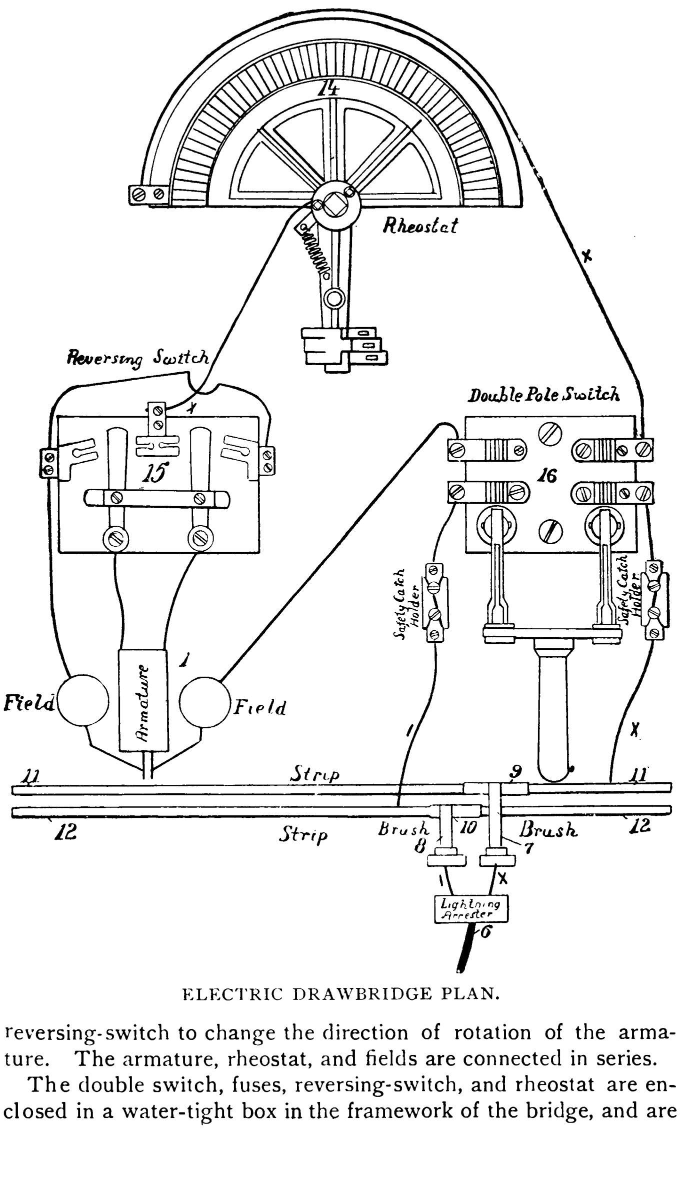
structure, and which carry on their upper ends a pair of brushes which are in contact with two insulated copper bands attached to the circular support of the draw, and moving with it.

A rheostat is used to regulate the speed of the motor, and a reversing-switch to change the direction of rotation of the armature. The armature, rheostat, and fields are connected in series.



ELECTRIC DRAWBRIDGE ELEVATION.



ELECTRIC DRAWBRIDGE PLAN.

The double switch, fuses, reversing-switch, and rheostat are enclosed in a water-tight box in the framework of the bridge, and are easily accessible from the road-bed. The bridge-tender has every thing under complete control, and can easily regulate the speed and the direction of rotation of the drawbridge.

The motive power is furnished by a $7\frac{1}{2}$-horse-power Thomson-Houston motor, securely fastened to the draw by iron braces. One end of the motor-shaft is a pinion, which drives a train of gears, the last of which turns the shaft formerly operated by the men.

This installation is complete in every detail. Its operation is excellent, and reflects much credit upon the Thomson-Houston apparatus. The New England Electric Supply Company has received much praise from mechanical and electrical engineers for the excellent work they have done here, and has applied for patents on the devices used, and is in communication with several cities contemplating installations of the same nature.

A NEW FORM OF SECOHMMETER.

AT a recent conversazione of the Salters Company in London, a new direct-reading secohmmeter of Professors Ayrton and Perry was shown. This has been designed as a cheaper form than the older instrument, and is intended to be used in comparison of the co-efficients of self and mutual induction. The apparatus, with the cover removed, is shown in the accompanying illustration, taken from the *London Electrician*.

In the earlier forms of the secohmmeter, only a make and break were successively made in the battery-circuit, and the circuit of a shunt to the galvanometer; but, by the use of the double commutator in the new form of secohmmeter, the sensibility of the arrangement is increased fourfold: for, if there be any want of balance in the co-efficients of self or mutual induction that are being compared with one another, or with the capacity of a condenser, the galvanometer receives an impulse in the same direction at every reversal of the battery, which impulse is twice as great, and occurs twice as often, as if the galvanometer-needle received an impulse either only at the making or at the breaking of the battery-circuit, as in the earlier forms of secohmmeter. The fly-wheels make 10 revolutions for every revolution of the handle; and although, by the simple alteration of the gearing previously referred to, the commutators can be driven at will, so as to make either two reversals or eight reversals for every revolution of the handle, the ratio of the speed of the fly-wheel to the speed of the driving-handle always remains the same, so that the fly-wheel action remains constant. The driving-handle can be conveniently turned by hand at speeds varying from about 60 to 200 revolutions per minute, producing with one arrangement of the gearing 120 to 400 commutations per minute; so that both the battery and the galvanometer circuits can be conveniently commutated from about 120 to 1,600 times per minute, the lower speeds being used for circuits having a large time-constant, and the higher for circuits with a smaller time-constant. The exact range of commutation, however, is made different in the various secohmmeters intended for different purposes.

When the instrument is intended to be employed for absolute measurements of the co-efficient of induction or the capacity of a condenser in terms of a resistance and a time, a speed-indicator is attached to the spindle seen projecting from the commutator in the figure. But for comparison of the co-efficients of self or mutual induction with one another, or with the capacity of a condenser, no speed-indicator is necessary.

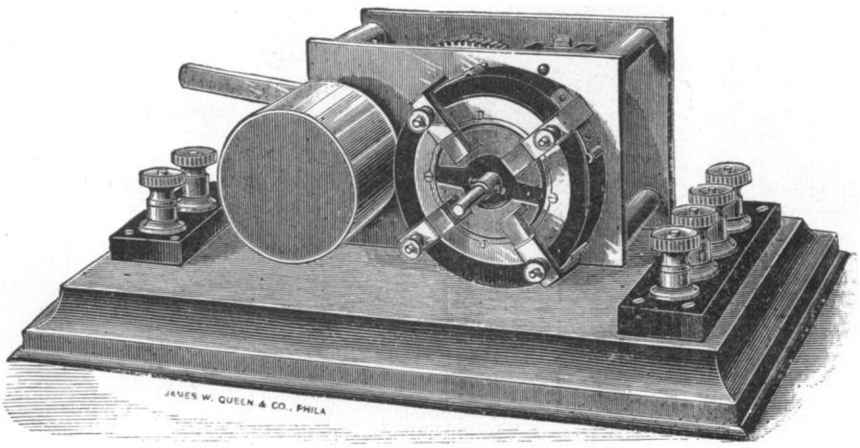


FIG. 1.—AYRTON AND PERRY SECOHMMETER.

Another use to which the secohmmeter can be put is the measurement of the resistance of a liquid which is liable to polarize with direct currents, but which, as is well known, will not polarize with rapidly alternating currents.

This instrument consists of two rotatory commutators, each with four stationary brushes. The commutators are on the same spindle, one at the front, and the other at the back of the secohmmeter, but for convenience they are shown in the accompanying symbolical figures as if they were in the same horizontal plane; in reality, however, the brushes, b_1, b_2, b_3, b_4, are at the top of the instrument. One commutator, *GC*, is for periodically reversing the galvanometer connections; and the other, *BC*, for reversing the battery connections. An adjustment is provided for enabling the relative positions of the two commutators to be varied, so that both reversals can be made to occur simultaneously, or one a little before or after the other, or one reversal midway between two successive reversals of the other.

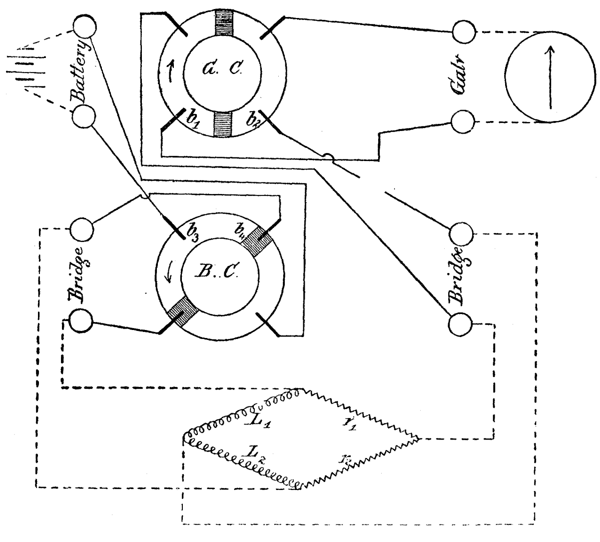


FIG. 2.—COMPARING TWO CO-EFFICIENTS OF SELF-INDUCTION.

The commutators can be driven at one or other of two speeds relatively to that of the driving-handle. With one arrangement there are rather more than 8 reversals of both the galvanometer and of the battery for one revolution of the handle; and with the other, 24 reversals of each for one revolution of the handle. The secohmmeter can be conveniently driven by hand, so as to obtain a steady speed of 300 to 6,000 reversals per minute of both the galvanometer and the battery.

To shift from one speed ratio to the other, press down the end of the locking-lever at the right of the secohmmeter, and slightly push in or pull out the handle, turning it slightly to assist the toothed wheels engaging properly. When engaged, let go the end of the locking-lever.

1. To compare two co-efficients of self-induction, join up the apparatus as in Fig. 2;[1] then, if the resistances r_1 and r_2, of the non-inductive branches of the bridge, be adjusted to give balance with a steady current, balance will also be obtained on rotating the secohmmeter, when

$$\frac{L_1}{L_2} = \frac{r_1}{r_2},$$

L_1, L_2, being the co-efficients of self-induction of the inductive branches. The speed at which the secohmmeter is driven need not be known, but the greater the speed the more sensitive the test; the rate of reversal must not, however, be too great for the currents to reach their steady values between two consecutive reversals.

2. To compare two capacities, join up the apparatus as in Fig. 3; then balance will be obtained on rotating the secohmmeter, when

$$\frac{F_1}{F_2} = \frac{r_2}{r_1},$$

F_1 and F_2 being the capacities of the condensers, and r_1 and r_2 the resistances of the non-inductive branches of the bridge. As before, increasing the speed at which the secohmmeter is driven, merely increases the sensibility of the test without affecting the ratio connecting the capacities with the resistances.

3. In similar ways two co-efficients of mutual induction may be compared with one another, or a co-efficient of mutual induction with a co-efficient of self-induction, or either of these with the capacity of a condenser shunted by a non-inductive resistance.

4. To measure a co-efficient of self-induction absolutely in secohms by the comparative deflection method, attach a speed-indicator to the commutator spindle, which is prolonged for this purpose, and join up the apparatus as in Fig. 4, L being the co-efficient of self-induction to be measured, and r_1, r_2, r_3, values of the three non-inductive resistances that give balance with a steady current. Rotate the secohmmeter handle at some convenient speed, causing the commutator spindle to make n revolutions per second, and observe the steady deflection, d_1, of the galvanometer. Next stop the

[1] The continuous lines represent the permanent connections in the secohmmeter itself; the dotted lines, connections temporarily made outside the instrument.

secohmmeter, and increase or diminish one of the resistances, r_1, for example, by a small amount ρ, obtaining a steady deflection, d_2, of the galvanometer with the battery previously used; then

$$L = \frac{d_1}{d_2} \cdot \frac{r_3}{r_2} \cdot \frac{\rho}{8n} \text{ secohms approximately.}$$

For this test the relative positions of the two commutators is unimportant. They may be as in Figs. 2 and 3, in which case the

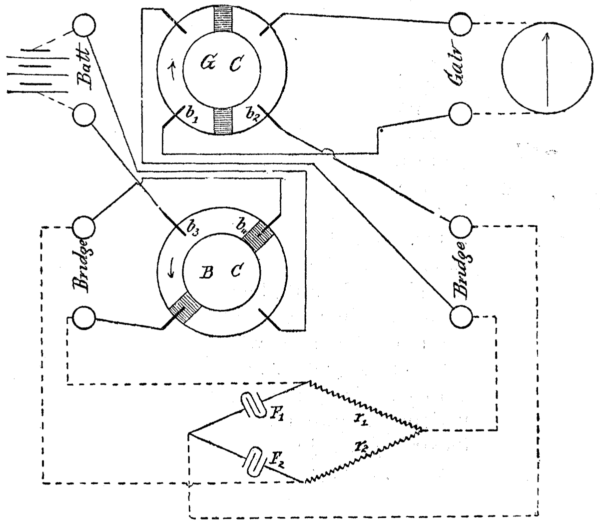


FIG. 3.—COMPARING TWO CAPACITIES.

reversal of the galvanometer occurs midway between two consecutive reversals of the battery; or they may be as in Fig. 4, in which case the reversal of the galvanometer just precedes the reversal of the battery. The greater the value of n, the greater will be the deflection d_1, and the more accurately can it be read; but the speed must not be too great to prevent the currents reaching their steady values between two consecutive reversals of the battery. Whether this condition be fulfilled or not, can be best ascertained

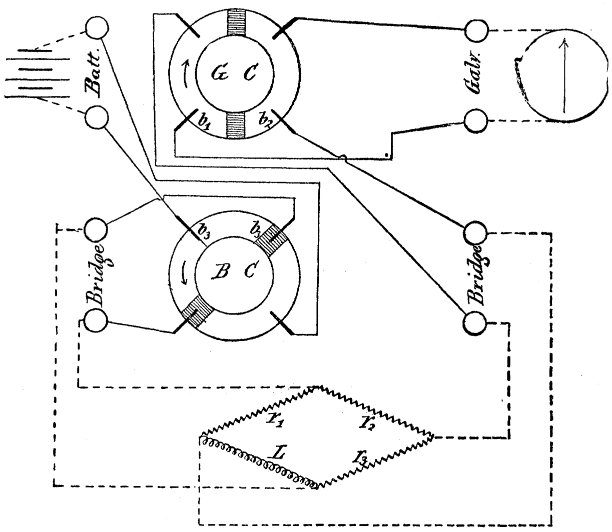


FIG. 4.—CO-EFFICIENT OF SELF-INDUCTION IN SECOHMS.

by seeing whether the same value is obtained for L, for a speed considerably smaller than n.

The sensitive zero method is as follows: Instead of obtaining two deflections, the resistances, r_1, r_2, r_3, are first adjusted to give balance with a steady current, and then one of them, say r_1, is altered by an amount σ ohms, so that there is still no deflection of the galvanometer when the commutator spindle makes, say, n revolutions per second; then

$$L = \frac{r_3}{r_2}\,\sigma\,\frac{k}{n} \text{ secohms approximately,}$$

where k is a constant depending on the relative position of the commutators. The value of the constant k is most accurately ascertained once for all, for a given relative position of the commutators, by experimentally determining the value of $\frac{r_3}{r_2}\sigma$, that produces balance for a known co-efficient of self-induction, when the commutator spindle is driven at some known number of revolutions per second.

For this latter test it is necessary that the commutators be so placed relatively to one another that the galvanometer is not reversed exactly midway between two consecutive reversals of the battery; since, with this latter adjustment, no variation in the resistance of any of the arms of the bridge can counterbalance the effect of the self-induction on rotating the secohmmeter handle: in fact, the more nearly the commutators are placed in the midway adjustment, the smaller will be the value of k, and therefore the larger the value of $\frac{r_3}{r_2}\sigma$, to produce balance for given values of L and n.

5. To measure the resistance of a polarizable electrolyte, replace the coil having self-induction in Fig. 4 by the polarizable electrolyte; adjust the commutators so that the galvanometer is reversed just before the battery; and, using the higher speed ratio for the gearing, rotate the secohmmeter at the highest convenient speed. Then, if x be the true resistance of the electrolyte,

$$x = \frac{r_3}{r_2} r_1$$

THE RATTLESNAKE'S RATTLE.

MR. S. GARMAN of the Museum of Comparative Zoölogy, Cambridge, Mass., has been investigating the rattle of the rattlesnake. The habit of sloughing is common to all serpents. A short time before the removal of the old skin takes place, the new epiderm makes its appearance beneath the old. The mode of growth of the new and the removal of the old is the same in all snakes, with the exception that in those with a rattle that portion of the slough that covers the tip of the tail is retained to form one of the rings of the rattle. The attachment is simply mechanical: the rings are merely the sloughs off the end of the tail. The terminal bone of the tail is formed of vertebræ that have coalesced, and changed in great measure their shape. In the different species the number of vertebræ included in this bone varies considerably, and sometimes it varies in individuals of the same species. With the purpose of indicating the manner of growth of the rattle, and as far as possible determining its origin, Mr. Garman has followed up its appearance in several species, full details of which, with figures, have been lately published. In the very young rattlesnake, while the vertebræ are still separate, there is no rattle; but about a week after birth a well-marked button is seen. With the first slough the first ring is set free, the button being pushed forward, and a third button is gradually perfected. In time the traces of the vertebræ in the terminal bone are almost obliterated. The bone becomes thickened, pushed forward at its edges, and otherwise enlarged. In a full-grown rattlesnake the hinder seven of the rings belong to the period of the snake's most rapid growth,—they form the "tapering rattle" formerly used in classification of the species,—while four of the rings and the button are formed while the gain in size was less rapid, and form the "parallelogrammic rattle" of the old classifiers. Many serpents besides those possessed of a "crepitaculum" are addicted to making a rattling noise by vibrations of the end of their tails. In illustration of the extent to which the tail has been modified in different cases, Mr. Garman figures the tails of several species, among others that of *Ancistrodon contortrix*, Lin., the copperhead of the United States. The tip of its tail is directed downwards as well as a little backwards. Most often the button has one or two swellings in a degree resembling those on a ring of the rattle. A living specimen of this snake, kept for a year or more, would take to rattling on the floor whenever it was irritated. The sound was made by the terminal inch of the tail, this part being swung from side to side in the segment of a circle, so that the tip might strike downward. The result was a tolerable imitation of the sound made by a small rattlesnake.