contagium in the milk. This, I am glad to say, is very easily carried out. Heating milk up to 85° C. or 185° F., that is, considerably under the boiling-point, is perfectly sufficient to completely destroy the vitality of the microbe of scarlet fever. In harmony with these experiments on the influence of heat on the microbe of scarlet fever, I can quote, besides the observation given above by Dr. Robertson, also the following observations recorded by Dr. Jacob, Medical Officer of Health of High Ashurst and Headley, and reported in 1878, to this effect. Between June 1 and 7, there were fifteen cases of scarlet fever in three distant houses, the inmates of which had had no communication with infected persons, but had all been supplied with milk from a farm where a certain cowman worked. This cowman had in his family several children ill with scarlet fever. The cowman continued milking the cows during the illness of his children, though he did not himself have the fever, and the milk was not taken into his cottage; but the point which I wish to bring out is this, that other houses besides those in which scarlet fever had broken out had been supplied with the same milk, but no scarlet fever occurred in them, and why? because all these had consumed only the scalded milk.

I should therefore strongly urge that all milk should be boiled, or at any rate heated to at least 85° C. (that is 185° F.) before being consumed. Judging by the large number of cases of scarlet fever recorded in these milk epidemics, one is justified in saying that a considerable percentage of the total number of cases of scarlet fever would have been avoided thereby. Not all, because unfortunately the rules of isolation of patients suffering from scarlet fever are not always rigorously carried out, and therefore infection from person to person will occur. Nor would prevention of scarlatina by milk exclude scarlatina by cream,—cream cannot be easily subjected to heat; and in the epidemic of scarlet fever that occurred in South Kensington in 1875, and that was investigated by Dr. Buchanan, cream was the vehicle of the contagium. But considering the prominent position that milk occupies in every household with children, the possibility of infection with scarlet fever by raw milk deserves careful attention.

THE SECOHMMETER.

A CIRCUIT containing self-induction acts as if it had a larger resistance than its true one when a current is started in it, and a smaller resistance when the current is stopped. Hence, if balance be obtained with a Wheatstone's bridge in the ordinary way, the fact of any of the arms possessing self-induction, or of any one of the arms having a condenser attached to it, will produce no effect on the balance if the battery circuit be rapidly made and broken, provided that the rapidity of make and break be not too great for the currents in the arms of the bridge to reach their steady values each time that the battery circuit is made, and to die away each time that it is broken. If the currents have not time to reach their steady value when the battery circuit is closed, and to die away when it is broken, then self-induction in any one of the arms will produce a disturbance in the balance; but such a method of measuring a coefficient of self-induction would lead to very complicated formulæ, and is not worth developing with the view of obtaining a simple method of measuring self-induction.

It therefore occurred to us to consider whether, without employing such rapid makes and breaks as would prevent the currents reaching their steady values, the self-induction of a circuit might not be made to act as an apparent steady definite increase of the resistance of that circuit which could be measured in the ordinary way with a Wheatstone's bridge or differential galvanometer; and by this means the measurement of a coefficient of self-induction would simply resolve itself into the measurement of a resistance. And this problem we solved in the following way, in the spring of 1886:—

The coil, the coefficient of self-induction of which it is desired to measure, is placed in one of the arms of a Wheatstone's bridge, the three other arms consisting of ordinary doubly-wound resistance coils possessing no appreciable self-induction, and not only is the battery circuit rapidly made and broken, but, in addition, after each closing of the battery circuit the galvanometer circuit of the bridge is either short-circuited or broken, so as to cut out the galvanometer, and after each breaking of the battery circuit the galvanometer circuit is either unshort-circuited or closed again, so that the galvanometer is now operative again. In this way all the successive impulses of the galvanometer needle that are produced on starting the current in the coil with self-induction produce their *cumulative* effects, but the successive impulses of the needle that, under ordinary circumstances, would be produced on the needle in the opposite direction are cut out. Hence the self-induction possessed by one of the arms causes that arm to apparently increase in resistance by a definite amount depending on the coefficient of self-

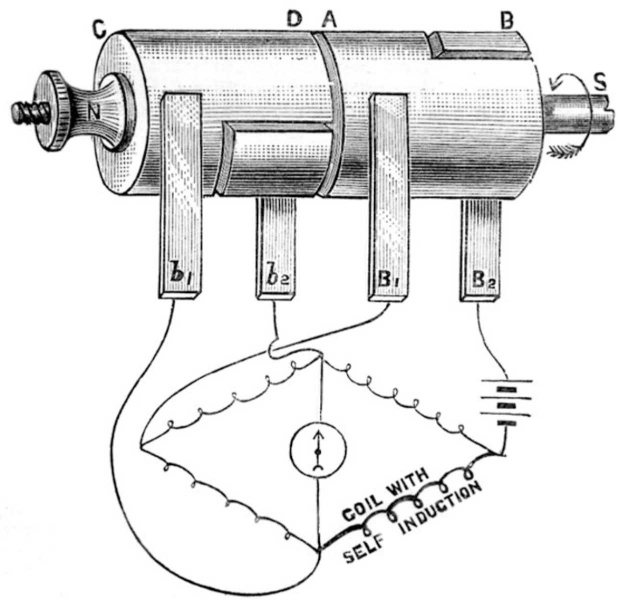

FIG. 1.—Preliminary Apparatus.

induction and the number of operations performed per minute. This apparent increase of resistance produces a deflection of the galvanometer which can be noted, and its value ascertained by comparing it with the deflection produced with steady currents when one or more of the arms of the bridge is altered by a known amount, as in making the Rayleigh test. But since the necessity of having to read the deflection limits the speed of performing the double make and break operation, in order that the spot of light may not be sent off the scale, we soon replaced this comparative deflection *cumulative* method by a much more sensitive *zero cumulative* method; and instead of reading the galvanometer deflection we re-establish the balance, and bring the needle back to zero, by altering one or more of the arms of the bridge, as in making an ordinary resistance test with a Wheatstone's bridge.

The first apparatus for enabling measurements of self-induction to be made in this way was constructed in the spring of 1886, under the superintendence of one of our assistants, Mr. Mather. It consisted of a double commutator, shown in Fig. 1, the spindle, S, to which the commutators were locked by the nut, N, being rotated at any speed by a small electromotor, not shown in the figure, to which was attached a Young's speed indicator, which registered the speed of rotation at any moment. The brushes, B_1, B_2, b_1, b_2, were fixed to the baseboard and joined to the bridge, as indicated in the figure. When the double commutator was rotated by the motor (of which the speed was correctly adjusted by means of a Varley's flexible carbon-resistance), the portion A B caused the battery circuits to be periodically made and broken, while the other portion, C D, periodically short-circuited and unshort-circuited the galvanometer, so that the following cycle of operation, called for simplicity *one operation*, was performed any desired number of times per minute :—

Battery circuit.	Galvanometer short circuit.
Make.	While broken.
While made.	Make.
Break.	While made.
While broken.	Break.
Make.	While broken.

If we call

$$\frac{\text{angle between the slits in the two commutators}}{360^\circ}$$

the lead or l, so that l will be equal, for example, to $\frac{1}{4}$ when each of the cycle of operations given in the table lasts for one-quarter of a revolution, then we have shown that

$$L = \frac{l}{n}\sigma \text{ second-ohms,}$$

where n is the number of revolutions of the commutator per second, and σ the apparent increase of resistance of the coil with self-induction, or

$$L = \frac{60l\sigma}{N} \text{ second-ohms}$$

where N is the number of revolutions per minute.

A number of experiments were made in the summer and autumn of last year, and they showed that this new method was very accurate and furnished an extremely sensitive test for the absolute measurement of a small coefficient of self-induction.

By the simple addition, therefore, of such a commutating arrangement as we have described to an ordinary Wheatstone's bridge, it becomes possible, whenever the resistance of a coil electro-maget, &c., is being measured, to measure also the coefficient of self-induction in absolute measure, by a zero method which is as sensitive for the measurement of self-induction as the ordinary Wheatstone's bridge method is for the measurement of resistance.

The instrument previously described requires an electromotor to drive it, and a speed-indicator to register its speed, hence it would be too cumbersome for every-day work. It therefore became necessary to devise commercial apparatus, and this was done as follows :—

Attached to the commutator of our self-induction apparatus is a box, B (Fig. 2), fitted with weighted elastic sides made of corrugated steel, which fly out more and more, under the action of centrifugal force, as the box is rotated faster and faster. A stout glass tube, G G′, of comparatively small bore, open at both ends, is cemented into a collar in the axis of the box, and rotates with the box. The box is completely filled with mercury, and the tube partially, hence when the volume of the box expands as its sides fly out the length of the column of mercury in the tube diminishes, and the length of the column at any moment is a measure of the speed of rotation of the box. In the neck of the collar, C, in which the tube is cemented, there is a steel tap attached to an axial spindle passing through a tube inside the box, and projected out of this tube at the other end of the box. If this spindle be turned relatively to the box, the tap is opened or closed. At the commencement of the experiment the tap is opened, and the handle, H, is turned with the right hand, faster and faster, until, on depressing the key, K, with the left hand from time to time, the galvanometer needle is seen to be approaching zero, or the spot of light the zero position on the scale. The key may now be kept depressed, and on turning the handle a little faster a speed is at length reached producing exact balance—if the handle be turned faster, the needle or spot of light deflects to one side of the zero, if more slowly to the other—at this moment the trigger, T, is lightly touched with the left hand, and a spring is liberated. This has the effect of producing a resistance to the rotation of the tap-spindle, which previously was rotating freely with the rotating box, and the tap is thus turned off, cutting off the connexion between the mercury in the glass tube and that in the box. Consequently the mercury in the tube remains, even after the instrument is stopped, of exactly the same length that it had when the trigger was touched. The position of the end of thread of mercury in the tube is now read off on the scale attached, and the apparent increase of resistance of the coil, electro-magnet, or whatever it may be, divided by the number on the scale, gives the required coefficient of self-induction in second-ohms without any further calculation.

The instrument is, therefore, direct-reading.

At first, rotating commutators similar to those shown in Fig. 1 were employed with the apparatus shown in Fig. 2; next the brushes were made of a variety of different forms, so as to press *radially* on the rotating commutators to prevent the wear altering the lead, and thus changing the sensibility of the instrument; but this form of commutator has at length been entirely superseded by the two oscillating arms, or brushes, A, A, worked by a cam. Each arm is composed of several pieces of hard copper, contact being made through the ends, as in many of the switches now used for electric-light work. The end of each brush alternately rubs on a flat piece of phosphor bronze, P, P, when it makes contact, and on a *flat* piece of glass or agate, *g*, when it does not. This form of commutator we found superior for our purpose to the double cylindrical one, since, with the two oscillating arms, the lead can be more easily varied for adjustment; and this slight adjustment of the lead, we may here mention, forms the fine adjustment in the construction of this direct-reading instrument. Further, the slow wearing of this form of brush does not alter the lead ; consequently the value of the graduations of the scale remains constant.

The temperature adjustment of the instrument is effected by moving the scale until the zero is opposite the end of the thread of mercury when the instrument is at rest.

Following the precedent of naming an instrument after the name of the unit employed—for example, "ammeter," "voltmeter," "ohmmeter," "wattmeter,"—it seems desirable to call this instrument after the name of the commercial unit of self and mutual induction. The absolute electro-magnetic unit of self and mutual induction is 1 centimetre, a name used by all scientific nations. But the commercial unit of self and mutual induction is $99{,}777 \times 10^4$ centimetres, or the second-ohm, which is about 2·3 in a thousand less than 10^9 centimetres, or one earth's quadrant. Now, in spite of the difference between these two numbers, which, although small, it is a pity to lose sight of, the English word "quadrant" is not used in French, therefore it would not be well to suggest this word as the international name for the unit. Yet it is most important that some name should be universally adopted, since the use of simple familiar names has much to do with making people familiar with the laws of the effect measured by the unit. The unit of electro-static capacity, the farad, has been called after the greatest experimental worker in electricity; it would therefore seem appropriate that the unit of electro-magnetic capacity should be called after Maxwell, the greatest mathematical worker in electricity. We do not, however, like to propose this, as we feel there might be difficulty in obtaining the general acceptance of the name of an Englishman, however great, unless it were sanctioned by an International Electrical Congress, or unless the man's name was intimately associated in men's minds with self and mutual induction. And Maxwell's large contribution to the subject of electro-magnetic induction is surrounded by his equally large contributions to all other branches of

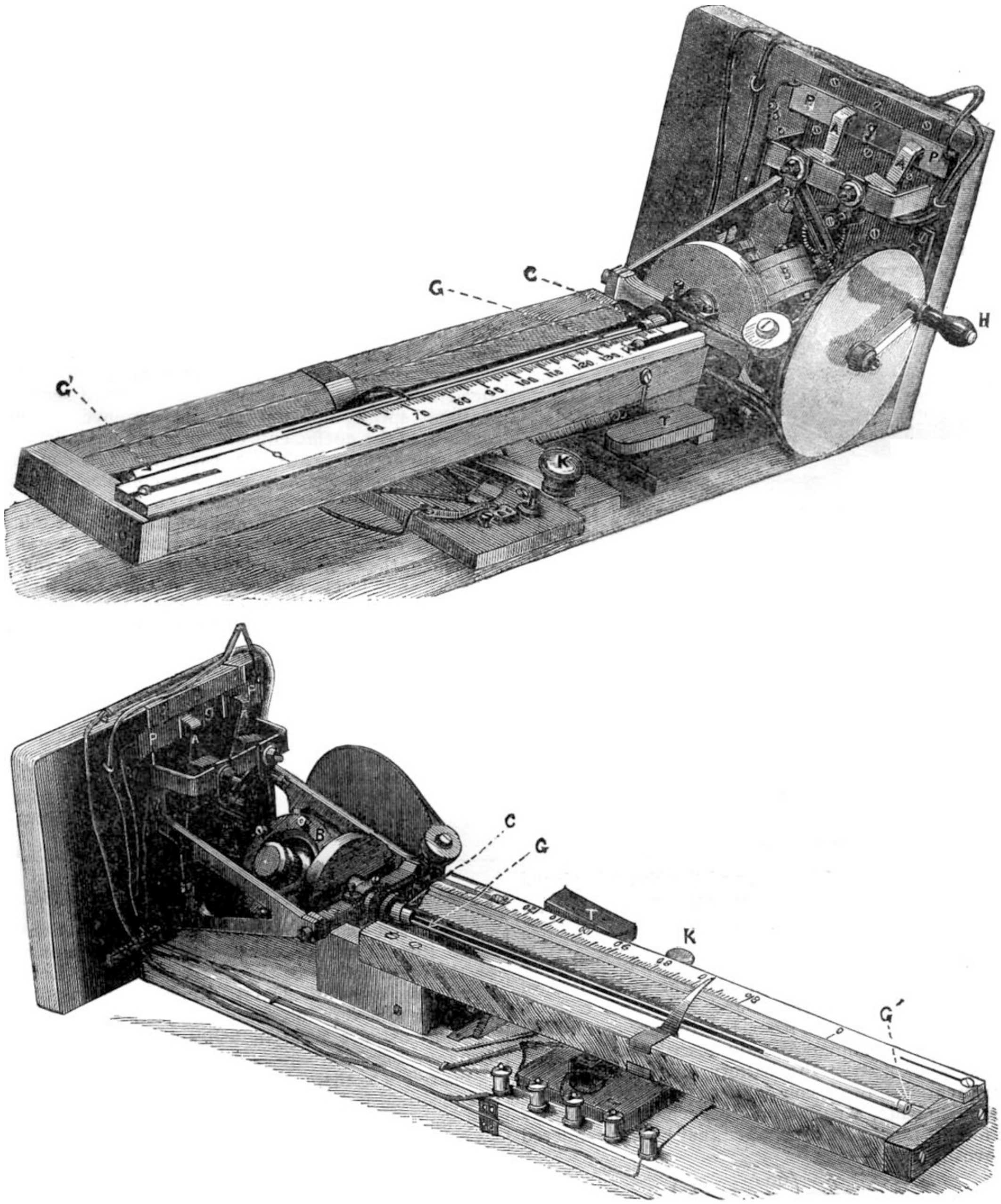

Fig. 2.—Experimental Secohmmeter.

electricity and magnetism—a giant surrounded by giants is not prominent. Coming to the last two years, we are glad that the leader and all those who have followed him in taking part in the widening of our ideas on self-induction are still with us. Hence we are driven to suggesting a temporary name for the unit, and as the first three letters in "second" are common to the name in English, French, German, Italian, &c., and ohm is also common, we venture to suggest "secohm" as a provisional name, and our instrument we will therefore call a "secohmmeter."

Unless the glass tube in the secohmmeter just described be rather long, either the sensibility or the range of the instrument must be limited; but a very long straight tube would make the instrument inconveniently large, and a rapidly rotating *spiral* tube would probably break, from centrifugal force acting on those parts of the tube that were not on the axis of rotation. Hence, in the latest form of secohmmeter, Fig. 3, we have been led to employ a *stationary* spiral glass tube, G, with its end cemented into a stationary hollow steel conical plug fitting mercury-tight in the collar of the rotating metal box, B, with its weighted elastic sides. This arrangement simplifies the tap mechanism, as the tap now is not rotating, also many small improvements have been introduced into this last form: for example, at all the joints there is mercury under pressure, so that there is no tendency for air to be drawn into the apparatus at the joints, a fault which sometimes occurred with the earlier form of the apparatus, and led to irregularities in the readings from a bubble of air in the box acting on an air spring, or from air in the glass tube altering the length of the thread of mercury. The temperature adjustment in this last form of the secohmmeter is made by screwing a screw in or out, which slightly alters the volume of the stationary portion of the mercury vessel. The fly-wheel F has been made to have

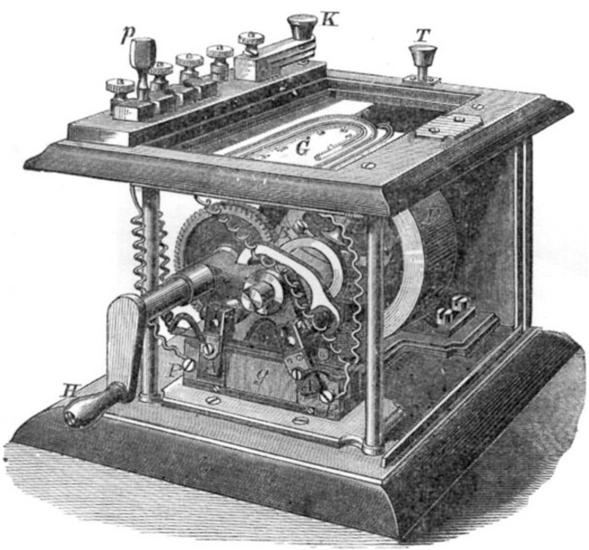

FIG. 3.—Improved Secohmmeter.

a much larger moment of inertia, and the box B is placed inside it, so as to be screened from damage.

Mutual Induction.

If we wish not merely to determine the coefficient of self-induction, L, of a coil, S, but also the coefficient of mutual induction, M, between it and any other coil, we first exclude the other coil from the battery circuit and determine L in the manner already described. We next include the other coil in the battery circuit, and repeat the experiment with the secohmmeter; then, as shown by one of our students, Mr. Sumpner (to whom our thanks are due for the most able assistance that he has rendered in this investigation)—

$$M = \frac{p}{p+r}\left(\frac{60\,l}{N}\,\sigma - L\right),$$

or if N_1 and σ_1 are the speeds and apparent increase of resistance in a first experiment, and N_2 and σ_2 in a second, we have

$$L = 60\,l\,\frac{\sigma_1}{N_1}$$

$$M = \frac{p}{p+r}\,60\,l\left(\frac{\sigma_2}{N_2} - \frac{\sigma_1}{N_1}\right),$$

where p is the resistance of the arm of the bridge opposite the coil S, and r the resistance of the arm joining p and S.

Capacity.

We have also shown that, if, instead of placing a coil with self-induction in one of the arms of the bridge, the arm be shunted with a condenser, there will be an apparent diminution of the resistance of that arm, since such a shunted condenser acts as if it had a negative self-induction. This apparent diminution divided by the product of the square of the actual resistance of the arm into the reading of the scale of the instrument corresponding with the speed at which balance is obtained gives the capacity absolutely in farads. The formula is, therefore, far simpler than that given by Clerk Maxwell for the absolute measurement of the capacity of a condenser, by placing it on one of the arms of the bridge and rapidly reversing the connexions of the condenser with the bridge.

Secohmmeter without Speed Indicator.

Lastly, all known zero galvanometric methods of comparing the coefficients of self or mutual induction with one another, or with the capacity of a condenser, can be increased enormously in sensibility by the use of the secohmmeter, and, since in such cases the speed of rotation need not be known, a very simple form of secohmmeter without speed indicator can be employed. The comparison of the coefficients of self or mutual induction with one another, or with the capacity of a condenser, is usually effected by tests that are completed during the growth or the dying away of a current, since it is only during the variation of a current that self or mutual induction, or the electro-static capacity of a condenser, evidence themselves. The effect of an error in the balance only lasts for a very short time, and therefore is very small if the error be small, that is, the tests are not sensitive. But by the use of the secohmmeter it is now possible not merely to measure the coefficients of self and mutual induction and the capacities of condensers absolutely, but, in addition, to secure the same high degree of sensibility with comparison tests that have hitherto had to be completed during the growth or dying away of a current that it is customary to obtain in the use of the Wheatstone bridge for measuring resistances with steady currents.

W. E. AYRTON.
JOHN PERRY.

THE FOSSIL FISHES OF MOUNT LEBANON.

THE last published part of the Transactions of the Royal Dublin Society (May 1887) contains a memoir on the fossil fishes of the chalk of Mount Lebanon, in Syria, by James W. Davis, which is an important contribution to a very interesting subject.

The existence of fossil fishes in the chalk of Mount Lebanon has been known from remote antiquity; Herodotus refers to them, and various statements about them are recorded in writings scattered over the period between the fourteenth and eighteenth centuries. In our own century, Louis Agassiz, Pictet, Haeckel, Costa, Botta, Fraas, and others, have added greatly to our knowledge of the various species met with, and now this memoir of Mr. Davis, illustrated as it is by twenty-four excellent plates, several of which are folding plates, brings up our knowledge of these remains to the most recent date.

For the chief material on which this memoir is based the author is indebted to the zeal and energy of the Rev. Prof. Lewis, who, during his residence in the American College at Beyrout, availed himself of every opportunity of collecting specimens of these fossils, and succeeded in accumulating a very large series of new forms. Many of these have been acquired for the British Museum Natural