



XIII. On new instruments for the direct measurement of the frequency of alternating or pulsating electric currents

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and (2) becomes

$$R_t = R\alpha_c^t.$$

But 1° F. may be expressed as $\left(\frac{5}{9}\right)^\circ \text{ C.}$, so that

$$R_{\left(\frac{5}{9}\right)} = R\alpha_c^{\left(\frac{5}{9}\right)}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and $R_{\left(\frac{5}{9}\right)}$ will be the resistance at 1° F.

$$\text{Hence} \quad R_{\left(\frac{5}{9}\right)} = R\alpha_f. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Thus, from (4) and (5),

$$\alpha_f = \alpha_c^{\left(\frac{5}{9}\right)},$$

$$\text{or,} \quad \log \alpha_f = \left(\frac{5}{9}\right) \log \alpha_c.$$

XIII. *On New Instruments for the Direct Measurement of the Frequency of Alternating or Pulsating Electric Currents.*
By ALBERT CAMPBELL, B.A.*

IN many experiments with alternating currents it is a very great convenience to be able to draw the supply from an ordinary lighting circuit, but the value of such a source of current is often lessened by the fact that the frequency of alternation is usually variable, the limits of variation being in some cases very wide indeed. It was for the purpose of getting rid of this uncertainty that, about a year ago, I devised the two instruments described below.

Most methods of measuring frequency depend either on Impedance measurements or on the production of Resonance (or Synchronism). The former I avoided, for unfortunately the wave-form as well as the frequency affects impedance, and I aimed at an instrument which would give trustworthy readings for any kind of pulsating current whatever.

Of the Resonance (or Synchronism) methods two are familiar. The first consists in running a small synchronous motor and measuring its speed by a speed-counter or indicator. This is a rather laborious way, and not very accurate if only a tachometer is used. In the second method† a stretched wire carrying the alternating current is placed in a constant magnetic field; by varying the stretching-weight the wire is

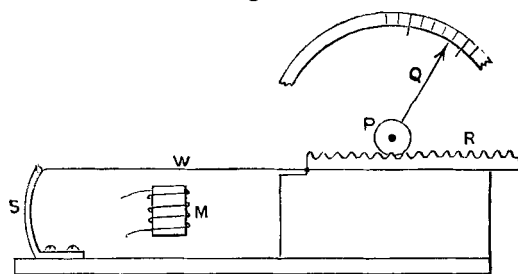
* Communicated by the Physical Society: read May 22, 1896.

† Due to Professors Ayrton and Perry.

tuned until it is set into strong vibration, and then the frequency is calculated from the tension, length, and mass of the wire. The original arrangement has been simplified, I believe, by Mr. Alexander Russell, of Faraday House, who uses a steel wire thrown into vibration by an iron-cored choking-coil placed near it. In both arrangements some uncertainty is introduced by the wire passing over a bridge or pulley.

In my first type of instrument I developed the last-mentioned arrangement. The working parts of the instrument are shown in fig. 1:—

Fig. 1.



A steel wire, *W*, is fastened at one end to a spring, *S*, and at the other to a rack, *R*, sliding in guides. Near the wire is fixed an electromagnet *M* with a laminated core; this magnet is excited by the given alternating current. By turning the pinion *P* the wire can be tightened until it is thrown into vigorous vibration by the magnet. The pointer *Q* attached to the pinion then shows directly the frequency on a suitably graduated scale. Many varieties of this arrangement may be used; for example, the pointer may be fastened to *S*, or other kinds of magnifying-gear may replace the rack-and-pinion.

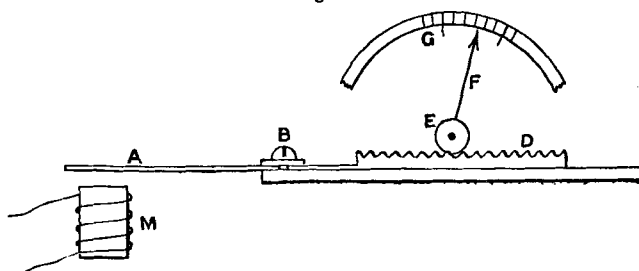
With careful use I believe that this type is accurate to within less than 0.2 per cent., but it is not so convenient as the second type, which I now proceed to describe. This more practical instrument is shown diagrammatically in fig. 2.

Here *M* is a choking-coil fixed near a steel strip *A**, which can be moved back and forward through the clamp *B* by a rack-and-pinion, not shown. *A*'s change of length is

* I find, since writing the above, that in 1889 Professors Ayrton and Perry suggested the use of a variable magnetic tongue near an alternating electromagnet. Their idea, however, was never embodied in a direct-reading practical instrument.

magnified by the rack-and-pinion D and E and the pointer F. The protruded length of A is altered until the alternating

Fig. 2.



field due to M causes the maximum resonance, and the frequency is read off on the scale G.

By proper choice of the dimensions of the vibrator and the rack-and-pinion a very extended scale may be obtained. I have constructed one instrument in which the pointer goes more than twice round the circumference from 40 periods per sec. to 150 periods per sec., and at the middle part of the scale the accuracy of reading is within 0.3 per cent.

The electromagnet M is usually of fine wire, and has a non-inductive resistance in circuit with it, so that the current taken is very small.

The reading is usually taken at the point of maximum resonance. This is observed by means of the sound given out or by watching the variation in amplitude either directly or by mirror, light-spot, and scale. Sometimes I fix near the vibrator an adjustable piece, against which it rattles or jars when the resonance is sufficient. This jarring piece may be made part of an electric circuit, including a lamp or an indicating instrument, in such a way that the circuit becomes broken when the greatest resonance occurs.

The instrument can be used as a speed-indicator for machinery by attaching to the rotating shaft a suitable commutator to make and break an electric circuit carried to the instrument, which may thus be at any distance.

If we keep to simple English we might call such an instrument a "Wave-teller," but to make the meaning clearer I propose to name it a "Frequency-teller."

In conclusion I may mention that since there is very little inertia in the moving parts the readings can be taken rapidly, and thus the instrument can be made to follow fairly quick changes in frequency.