No. 671,730. Patented Apr. 9, 1901.

R. D. MERSHON.

FREQUENCY OR SPEED INDICATOR.

(Application filed July 12, 1899.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.

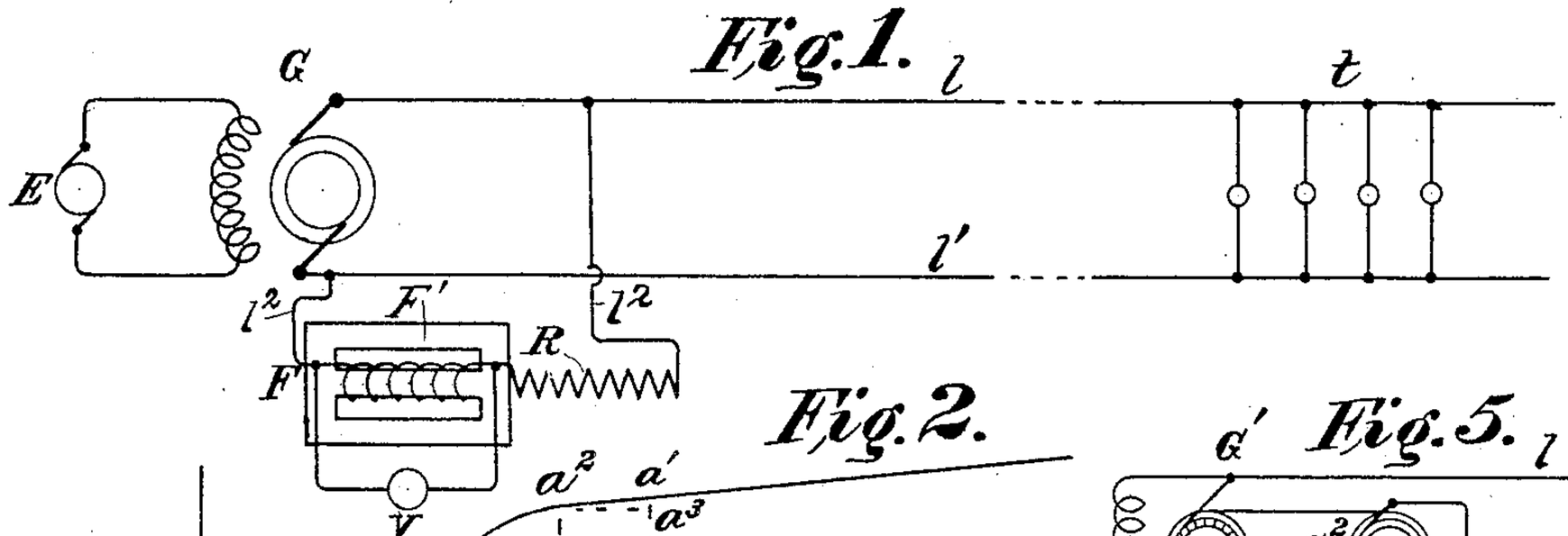


Fig. 2.

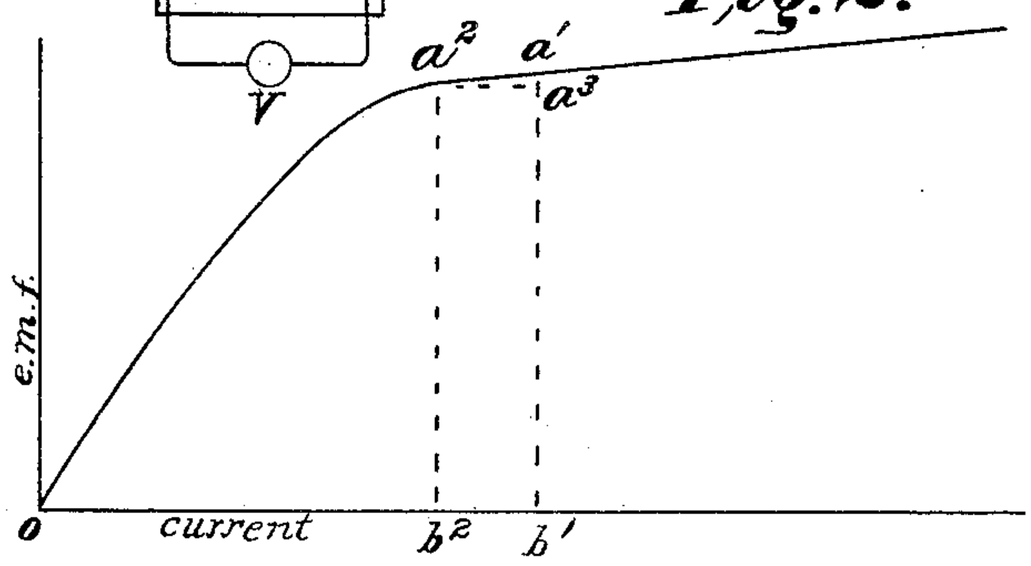


Fig. 5.

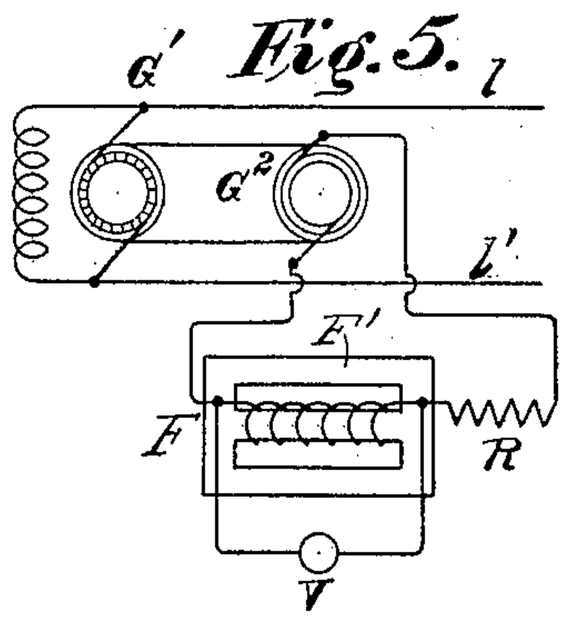


Fig. 3.

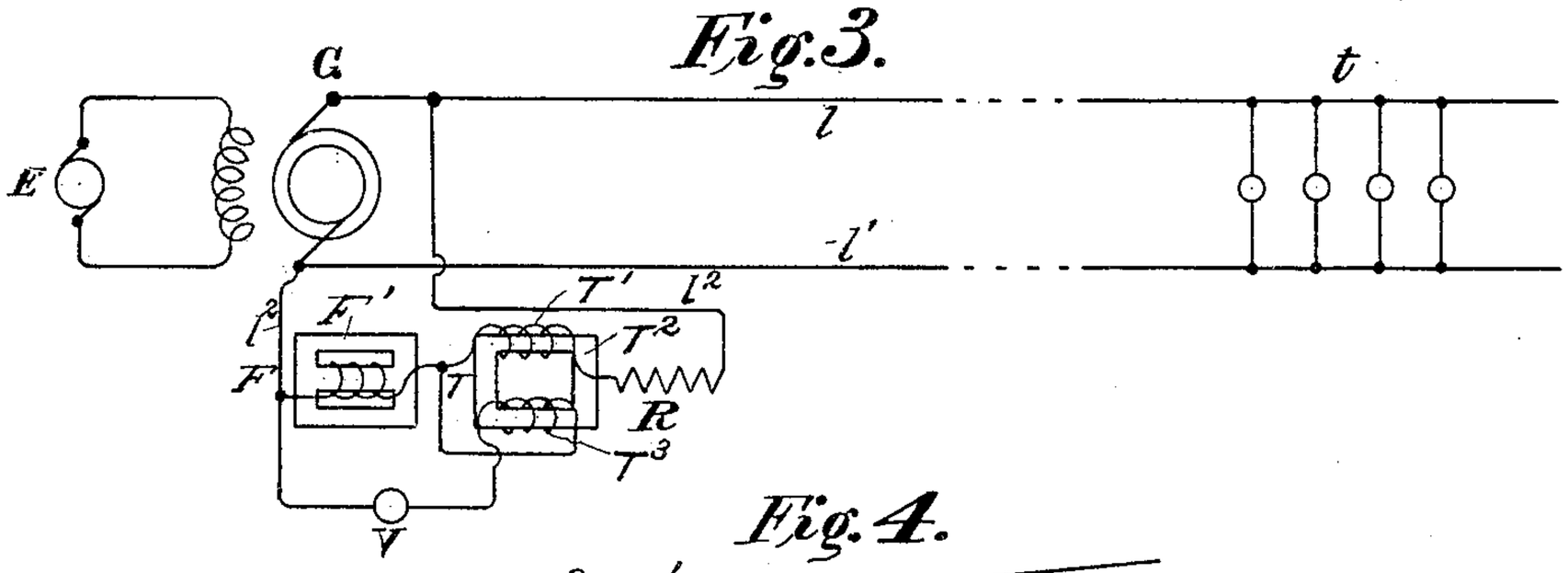
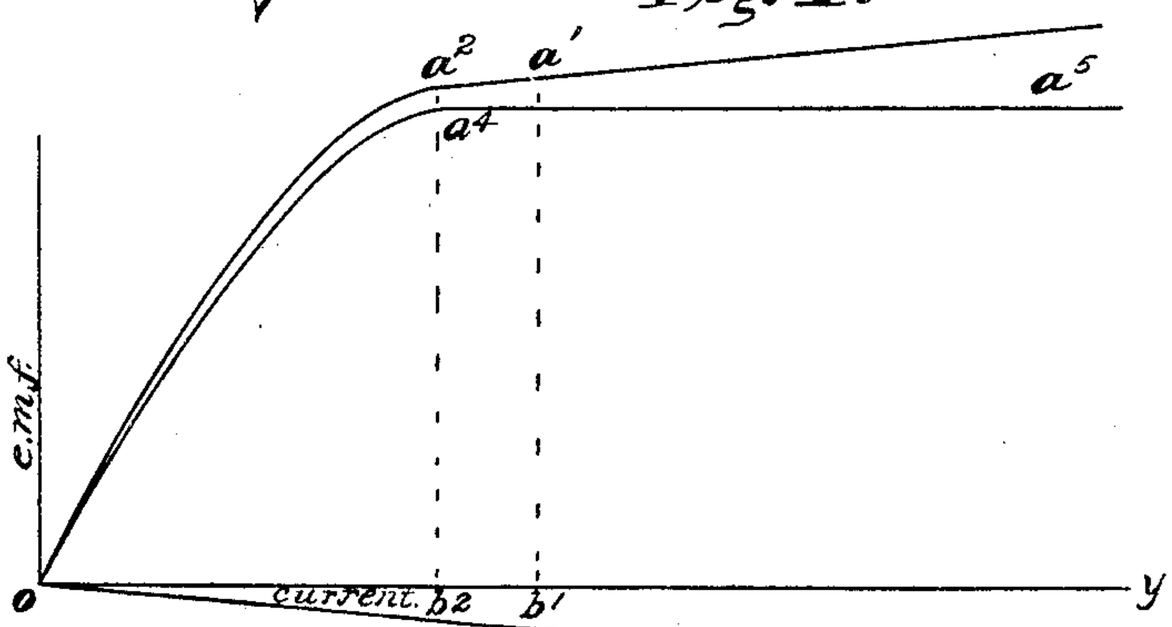


Fig. 4.



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No. 671,730. Patented Apr. 9, 1901.

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FREQUENCY OR SPEED INDICATOR.

(Application filed July 12, 1899.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 6.

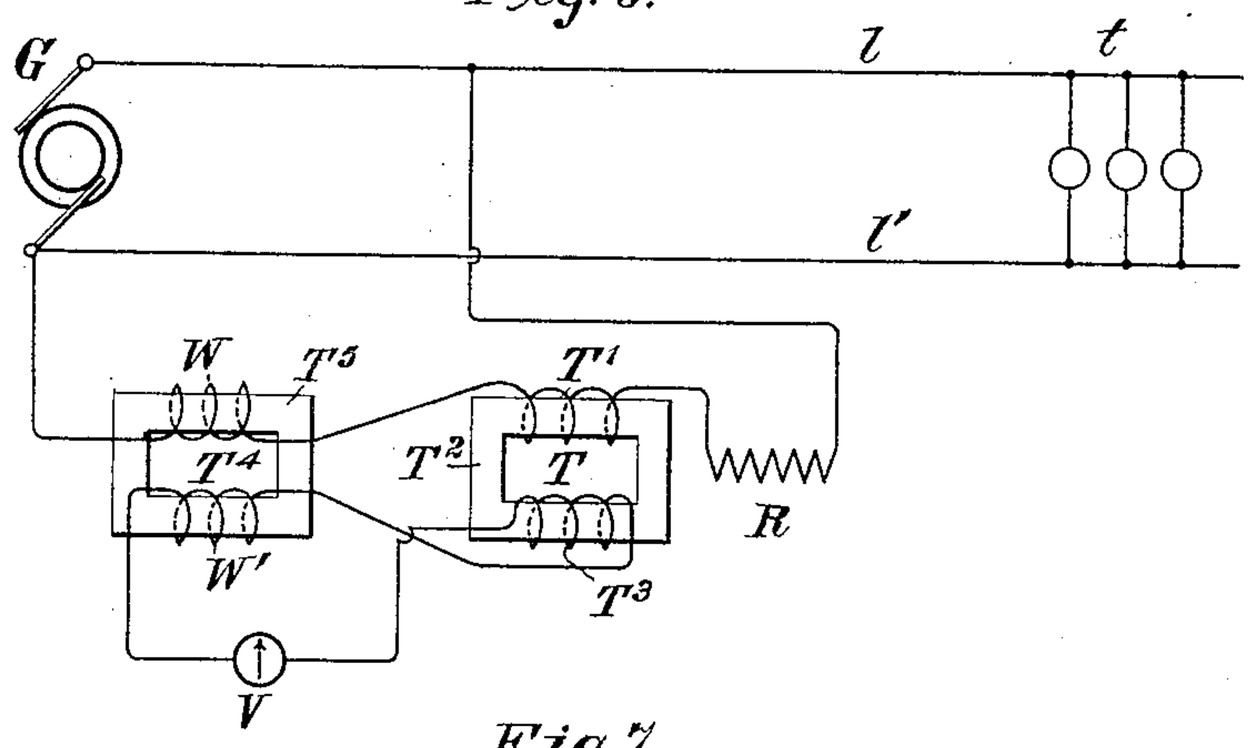


Fig. 7.

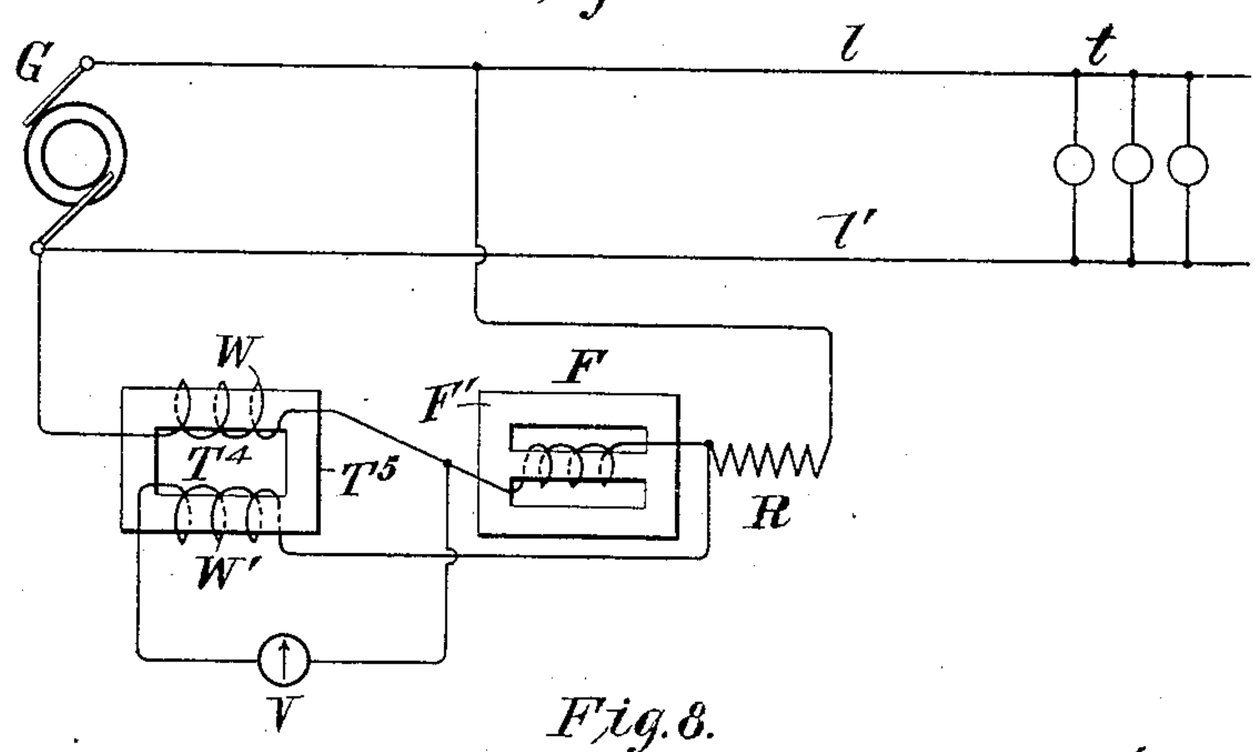
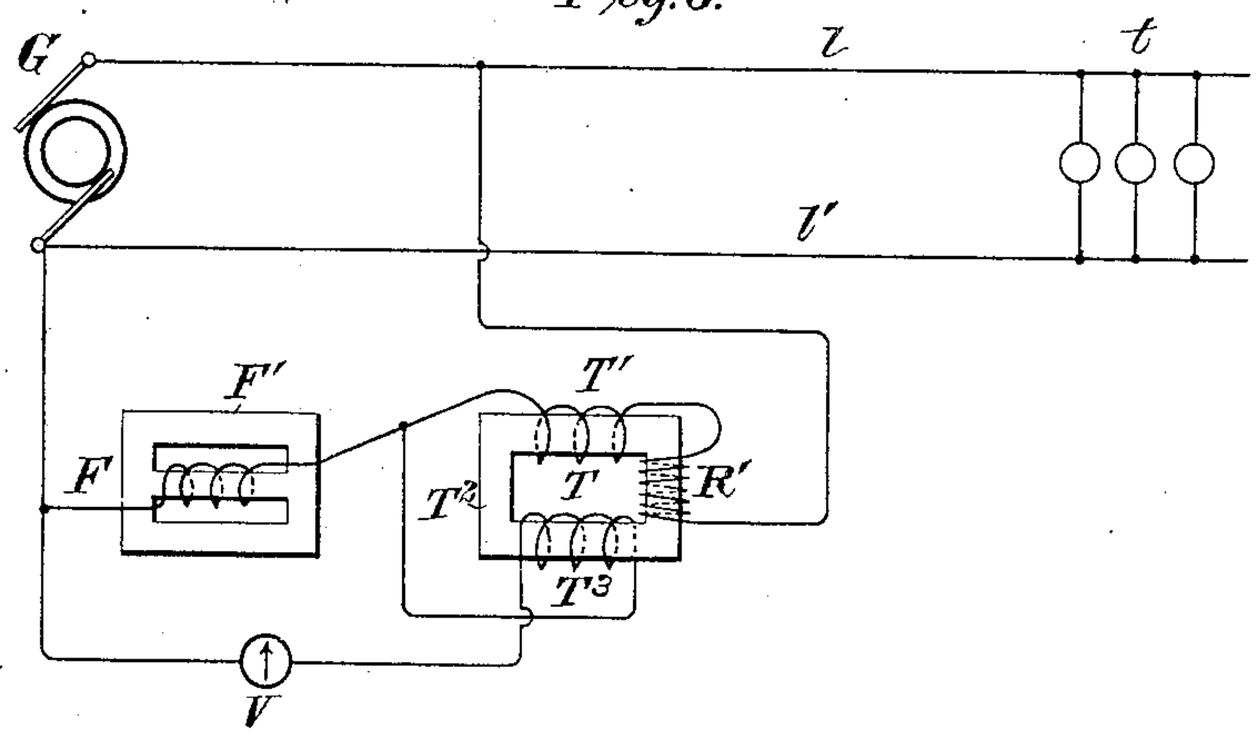


Fig. 8.



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FREQUENCY OR SPEED INDICATOR.

SPECIFICATION forming part of Letters Patent No. 671,730, dated April 9, 1901.

Application filed July 12, 1899. Serial No. 723,567. (No model.)

To all whom it may concern:

Be it known that I, RALPH D. MERSHON, a citizen of the United States, residing at New York, in the county and State of New York, have invented a new and useful Improvement in Means for Indicating Electric Generator Speed or Current Frequency, (Case No. 842,) of which the following is a specification.

My invention relates to means for indicating the speed of a dynamo-electric generator or the frequency of a current generated by it; and it has for its object to provide a simple electrical apparatus for this purpose which shall be effective and reliable in operation.

In the accompanying drawings, Figure 1 is a diagram of a system of distribution embodying an alternating-current generator and my improved means for indicating speed or frequency. Fig. 2 is a diagram of a magnetization curve and its coördinates, illustrating the operation of my invention. Fig. 3 is a diagram similar to Fig. 1, illustrating a modification. Fig. 4 is a diagram similar to Fig. 2, but illustrating the conditions which obtain in the operation of the apparatus shown in Fig. 3. Fig. 5 is a diagram similar to Fig. 1, but embodying two generators. Figs. 6, 7, and 8 are diagrammatic views similar to Figs. 1 and 3, but embodying modified forms of my invention.

Referring now particularly to Figs. 1 and 2, the alternating-current generator G, the field-magnet of which is excited by a direct-current exciter E, supplies energy through the transmission-conductors l and l' to suitable translating devices t. The terminals of a local circuit l^2 are respectively connected to the brushes of the generator G or to the conductors leading therefrom, and in this local circuit is located an inductive resistance or choke coil F, having an iron core F', and in series therewith a non-inductive or ohmic resistance R.

A voltmeter V or other indicating instrument of similar character has its terminals connected to the terminals of the inductive resistance or choke coil F, as indicated. The character and amount of iron embodied in the core of the choke-coil are such that the iron will be worked at some point above saturation, and the ohmic resistance R is of such proportions that the drop between its terminals relative to that between the terminals of the inductive resistance is so great that the former substantially governs or controls the amount of current which flows from the generator G through the local circuit l^2.

The operation is as follows: Assuming that the voltage of the generator G remains constant and that its speed varies, the amount of current flowing through the inductive and ohmic resistances will be substantially constant and the voltage across the terminals of the inductive resistance will vary approximately as the frequency of the current passing through it varies and therefore approximately as the speed of the generator. Such being the case, the indicating instrument V will indicate approximately the frequency or speed. If desired, this instrument V may be calibrated in either alternations per minute or revolutions per minute or in any other way in which it is desired to indicate either frequency or speed instead of being calibrated to indicate volts. The indications of the voltmeter would be absolutely correct if the ratio between the ohmic and inductive resistances were infinity—that is to say, if the ohmic resistance were of such proportions as to absolutely determine or control the amount of current passing through the local circuit. In practice this condition may be so nearly approximated that any error resulting from the fact that a change in frequency tends to effect a change in current will be so small as to be within the limits of negligible error in ordinary measurements. Such an adjustment is aided by reason of the fact that the voltages across the two resistances F and R instead of being in step with each other have a substantially ninety-degree phase difference. The phase difference between them would be absolutely ninety degrees if the ohmic resistance were absolutely non-inductive and the inductive resistance were entirely free from losses. Even if such an adjustment is not made the voltmeter indications will be correct provided the instrument is calibrated with the rest of the apparatus by varying the rate of alternations of the circuit instead of calibrating the instrument as a voltmeter.

The statements above made apply to cases where there is a constant voltage at the terminals of the generator and remains true whether the iron of the choke-coil be satu-

rated or unsaturated; but it is evident that a variation in the voltage of the generator, whether the frequency remains constant or not, will produce a variation in the reading of the voltmeter which when the latter is set as a frequency-indicator would constitute an error. It is for this reason and in order to make the indications of the voltmeter less dependent upon changes in the voltage of the generator, so that when the frequency is constant the reading of the voltmeter will not change appreciably with changes in generator-voltage, that the iron of the inductive-resistance core is worked above saturation. The reason for this may be understood by reference to Fig. 2, which represents a magnetization curve for the iron of the core of the inductive resistance in which the coördinates, as indicated, are respectively the current traversing the local circuit and the electromotive force across the terminals of the inductive resistance. The line a' and b' marks the point in the magnetization curve at which the iron core of the inductive resistance is normally worked. The length of the line a' b' represents at that point the voltage across the terminals of inductive resistance, and the line o b' represents the corresponding current passing through the inductive-resistance coil. Assuming that the voltage of the generator varies to such an extent that the current traversing the local circuit decreases to an amount represented by line o b^2, the corresponding change of voltage across the terminals of inductive resistance will be from a' b' to a^2 b^2, the amount of the change being represented by the line a' a^3. It will be readily seen that under these conditions the variation of voltage between the terminals of the inductive resistance will be a very much smaller percentage of the total voltage than the percentage of current through such resistance, so that by selecting for the core of this resistance-coil a quality of iron the magnetization curve of which has an abrupt bend or knee it is possible to secure indications by means of the voltmeter which are not to any great extent influenced by normal variations of the voltage of the generator, but will be mainly influenced by variations in the frequency of the current supplied by the generator, or, what amounts to the same thing in this connection, by the speed at which the generator is run. A similar analysis is possible and applicable in cases where the voltage of the generator G increases instead of decreases. Of course if the voltage of the generator is allowed to vary to such an extent that the iron of the core of the inductive resistance is worked at a point near to or below the knee of its magnetization curve the indications afforded by the voltmeter will be inaccurate so far as they purport to represent the frequency of alternations.

In case it is desired to secure a more accurate indication than is possible under all circumstances with the apparatus already described I may use the apparatus shown in Fig. 3, in which the inductive resistance F and the ohmic resistance R are or may be substantially the same as in the apparatus shown in Fig. 1; but in addition thereto I include in series with these resistances in the local circuit l^2 the primary winding T′ of a transformer T. This transformer T is shown as provided with an iron core T^2; but such a core is not essential in all cases. Where it is employed, the iron instead of being worked above or near saturation must be on that part of the magnetization curve below the knee, which is approximately a straight line. The secondary coil T^3 of this transformer is so connected with one terminal of the inductive resistance F and with one terminal of the voltmeter V as to oppose the voltage which the voltmeter receives from the inductive resistance. The result secured by such combination and arrangement of apparatus is indicated in Fig. 4, where the voltage of the secondary T^3 of the transformer T, which is subtracted from the voltage obtained from the inductive resistance F, is measured from the line o x. This transformer voltage serves, therefore, to change the voltage at the terminals of the voltmeter from the value represented by line o a^2 a' to that represented by the line o a^4 a^5, the portion a^4 a^5 of which approximates very closely to a straight line, which is substantially parallel to the coördinate o y. It follows that any variation in the voltage of the generator G, provided its speed remains constant, will produce substantially no effect upon the voltmeter. By carefully proportioning the several parts of the apparatus the indication may be made to have any desired degree of accuracy. It will be noted that the voltage obtained from the secondary of the transformer T is small as compared with that obtained from the inductive resistance F.

Referring now to Fig. 6, the apparatus is the same as that illustrated in Fig. 3, except that a transformer T^4, having a saturated core T^5, a primary winding W, and a secondary winding W′, is substituted for the choke-coil F. In this arrangement the two secondaries T^3 and W and the voltmeter V are connected in series, as indicated.

In the modification illustrated in Fig. 7 the transformer T^4 of Fig. 6 is employed and the choke-coil F of Fig. 3 is employed in place of the transformer T. It must be borne in mind, however, that the device, which is in shunt to the voltmeter, whether it be a choke-coil or a transformer, must be so constructed that its core is worked above saturation and that the core of the other device, where two are employed, as indicated in Fig. 3, must be unsaturated, whether such device be a choke-coil or a transformer.

It will be noted that my invention embodies a means whereby a constant electromotive force may be obtained from a source the voltage of which is variable within certain given limits, but the frequency of which is constant.

I desire it to be also understood that the calibration of the voltmeter as a speed-indicator need not necessarily be made by varying the speed of the generator G; but when, as has already been indicated, the ohmic resistance is large as compared with the inductive resistance of the choke-coil or that of the choke-coil and the transformer the voltmeter may be calibrated by varying the voltage at its terminals, since the speed then indicated by it will be directly proportional to the scale of calibration and it will be merely necessary to determine the speed or frequency corresponding with one point upon this scale.

If it is desired, the voltage across the terminals of the inductive resistance may be made to increase as the voltage of the generator decreases by increasing the angle between the line $o\ x$ and the line $o\ y$. This will cause the line $a^4\ a^5$ to drop instead of remaining horizontal.

I have thus far described my invention as adapted for indicating the speed of an alternating-current generator or the rate of alternations of the current generated by it. I desire it to be understood, however, that the speed of either an alternating or a direct current generator may be indicated by the means described, if a small alternating-current generator be belted or otherwise coupled or geared to the main generator and the local circuit containing the resistances and indicating instrument be supplied with current from such small alternating-current generator. In Fig. 5 I have illustrated such a combination, in which the main generator G′, which is here shown as a direct-current machine, but which might obviously be an alternating-current generator, is belted to a small alternating-current generator G^2, the local circuit l^2, containing the speed-indicating apparatus, being connected to the brushes of such small generator.

In Fig. 8 I have illustrated a modification that differs from the modification shown in Fig. 3 only in having the ohmic resistance R′ wound upon the core T^2 of transformer T. It is within the scope of this modification to place the ohmic resistance upon either the saturated or the unsaturated core, but in either case the core on which the ohmic-resistance coil is wound must have separate primary and secondary inductive windings, the former of which will be so proportioned as to size, number of turns, and resistance as to produce the proper inductive effect in the core.

Other variations from what is specifically shown and described may obviously be made without departing from the spirit and scope of my invention.

I claim as my invention—

1. A speed or frequency indicator for dynamo-electric machines comprising a local circuit supplied with alternating currents, directly or indirectly, from the main generator of the system, one or more inductive windings and an ohmic resistance in said local circuit, said ohmic resistance being of such proportions as to practically control the amount of current flowing in the local circuit and an indicating instrument connected in shunt to all or a portion of the inductive winding or windings.

2. In a system of electrical distribution, the combination with an alternating-current dynamo-electric machine, of means for indicating its speed or the rate of alternations of the generated current comprising a local circuit containing an inductive resistance the core of which is worked above the knee of the magnetization curve, and an ohmic resistance connected in series with the inductive winding and of such proportions as to practically control the amount of current in the local circuit, and an indicating instrument connected in shunt to the inductive resistance.

3. In a system of alternating-current electrical distribution, the combination with a main generator, of means for indicating its speed or the rate of alternations of the generated current comprising a local circuit supplied with current, directly or indirectly, from said generator and containing two inductive windings respectively provided with a saturated and an unsaturated core, an ohmic resistance in series with said windings, a secondary for at least one of said windings having its terminals reversely connected to the respective ends of the other winding and an indicating instrument in series with said secondary.

4. A speed or frequency indicator for dynamo-electric machines comprising a local circuit supplied with alternating currents, directly or indirectly, from the main generator of the system and containing an inductive winding having a core worked above saturation, an ohmic resistance of such proportions as to practically control the amount of current flowing in said local circuit and an indicating instrument connected in shunt to said inductive winding.

5. In a system of alternating-current electrical distribution, the combination with a main generator, of means for indicating its speed or the rate of alternations of the generated current comprising a local circuit supplied, directly or indirectly, from said generator and containing two inductive windings respectively provided with a saturated and an unsaturated core and having their terminals reversely connected together, an ohmic resistance for controlling the amount of current flowing in the local circuit and an instrument for giving the desired indications of speed or rate of alternations.

In testimony whereof I have hereunto subscribed my name this 8th day of July, 1899.

RALPH D. MERSHON.

Witnesses:
W. K. ARCHBOLD,
F. L. TOWNSEND.