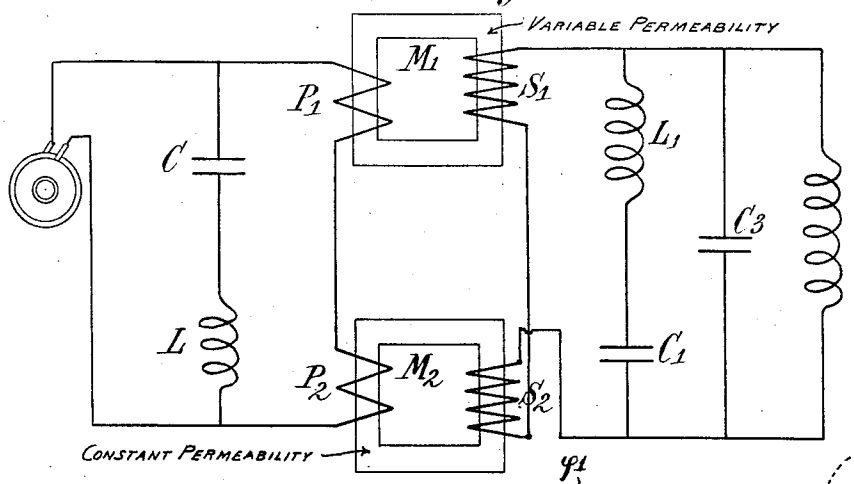
M. JOLY.

STATIC FREQUENCY TRANSFORMER.

APPLICATION FILED MAR. 29, 1911.

1,118,935. Patented Dec. 1, 1914.

Fig. 1.



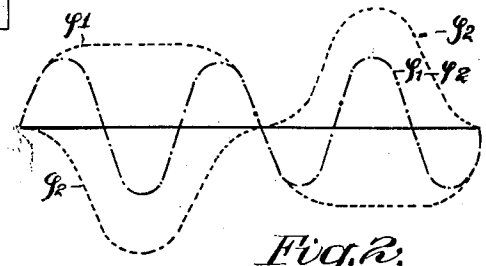


Fig. 2.

WITNESSES:

Fred White

René Beune

INVENTOR:

Maurice Joly,

By Attorneys,

Fraser Hurst Mayer

UNITED STATES PATENT OFFICE.

MAURICE JOLY, OF BOURG LA REINE, FRANCE.

STATIC FREQUENCY-TRANSFORMER.

1,118,935. Specification of Letters Patent. Patented Dec. 1, 1914.

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To all whom it may concern:

Be it known that I, MAURICE JOLY, a citizen of the Republic of France, and residing in Bourg La Reine, Seine, France, have invented certain new and useful Improvements in Static Frequency-Transformers, of which the following is a specification.

The object of the present invention is a method and an apparatus for transforming an alternating current of any frequency into an alternating current whose frequency is a multiple of the former.

The apparatus comprises of two separate transformers; in one at least of which the magnetic circuit is formed of a ferro magnetic metal or alloy. The primaries of these transformers are connected in series, and the secondaries are also in series, but so that the electromotive forces induced by the primary frequencies are opposed.

Figure 1 of the accompanying drawing represents by way of example the system and connections for a static transformer for changing from a given frequency to one three times as high. Fig. 2 is a diagram illustrating the action and relation of the currents in the transformer.

The following description concerns a case where the secondary frequency is an odd multiple of the primary.

Referring to Fig. 1, which illustrates an arrangement for changing from a given frequency to one three times as high, M_1 and M_2 are the two magnetic circuits of which only one contains a magnetic metal, P_1 and P_2 are the primary windings, S_1 and S_2 the secondaries, L_1 and C_1 respectively a self-inductance and a capacity in resonance for the fundamental period, and C_3 a suitable capacity for reinforcing the third harmonic.

At the terminals of the primaries P_1 and P_2 a circuit is shown comprising a self-inductance L and a capacity C provided to prevent any disturbance of the source of primary current.

The two transformers have their primaries connected in series, and their secondaries are connected equally in series in such manner that the induced electro-motive forces of the primary frequency are in opposition.

The primary current should raise the induction in one of the magnetic circuits sufficiently high during a part of the primary period that the permeability is reduced. Of the many different arrangements which may be used for the purpose the following may be mentioned by way of example; in one of the transformers an iron more easily saturated than that used in the other can be employed, or if the same iron is employed at each apparatus the number of primary turns may be different, or the lengths or cross sections of the magnetic circuits may be different, and so on. The other magnetic circuit, contrary to the first, must function with a constant permeability. When the magnetizing current increases, the magnetic circuit is at first very permeable, then it becomes very little so in consequence of the saturation.

The magnetic circuit of the first transformer is very rapidly saturated as soon as the primary current increases by only a very small value, while the magnetic circuit of the second transformer only attains a saturation under increases of current which considerably exceed those of the initial current. From that it follows then that the electromotive forces induced in the second transformer at first overcome those of the secondary coil of the first transformer, whereupon then, however, this overbalancing takes place in the secondary coil of the second transformer, hereafter again in the secondary coil of the first, in which case the primary current goes to nothing, increases and again falls to zero, namely, during a half period. Under these conditions electromotive forces are produced in the combined secondary circuit of the same frequency as the primary, of triple frequency, and of other odd harmonics of the primary frequency, whose intensities rapidly decrease as the number of the harmonic rises. The flux in the first transformer is represented by φ^1 and in the second transformer by φ^2, the forms of which are represented in Fig. 2. Their difference gives the secondary flux, which is, as represented, of triple frequency. Theory and practice show, that short circuiting the secondary causes the secondary electromotive force to vanish without requiring any sensible expenditure of energy in the primary.

More particularly an electromotive force of any given frequency can be eliminated by causing the secondary to supply a circuit which has an impendance as low as possible for this harmonic, by including for example a self-inductance of negligible resistance and a capacity in resonance with the

particular frequency of the electromotive force. Conversely, an electromotive force of given frequency can be reinforced and also the corresponding amount of energy given out, by placing a condenser of suitable capacity in shunt with the terminals of the secondary; this effect is increased according as the condenser is more nearly adjusted, with the secondary circuit of the frequency transformer and the circuits supplied by this secondary, into resonance with the frequency of the reinforced electromotive force. When this secondary is supplying energy, the action taking place reacting on the primary, generates currents whose frequencies are multiples of that of the primary current. Any disturbance of the generating apparatus of the primary current, which may be another frequency transformer, is avoided by inserting, if possible, at the terminals of the primary a circuit with as low an impedance as possible for this harmonic comprising for example in series a self-inductance of negligible resistance and a capacity in resonance with this harmonic.

Having thus described my invention and the best means I know of carrying the same into practical effect, I claim:—

1. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics, one of the transformers having a magnetic circuit in which the induction is such as to reduce the permeability during some part of the primary period.

2. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics, one of the transformers having a magnetic circuit in which the induction is such as to reduce the permeability during some part of the primary period, and a circuit having a negligible impedance for a particular secondary harmonic for eliminating the electromotive force thereof.

3. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics, one of the transformers having a magnetic circuit in which the induction is such as to reduce the permeability during some part of the primary period, and a suitable capacity placed across the terminals of the secondary windings for reinforcing the electro-motive force of any particular harmonic.

4. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics, one of the transformers having a magnetic circuit in which the induction is such as to reduce the permeability during some part of the primary period, a shunt circuit in the primary circuit for preventing a harmonic current flowing in the primary circuit from disturbing the generating source, said shunt circuit having an impedance negligible for such harmonic.

5. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value, comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics.

6. Apparatus for transforming the frequency of an alternating current from a given value to an odd multiple of this value, comprising two transformers whose primaries are connected in series and whose secondaries are opposed, said transformers having different induction characteristics, said first transformer being adapted to become very rapidly saturated when the primary current increases by a small value, and said second transformer being adapted to become saturated under considerably stronger increase of the primary current, in such a manner that the secondary electromotive force has the greater value at the beginning in the secondary coil of the first transformer, then in that of the second, thereupon again in that of the first transformer, while the primary current beginning with zero increases and returns to zero, that is, passes through a half period.

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

MAURICE JOLY.

Witnesses:
H. C. Coxe,
Albert Berg.