Jan. 15, 1924. 1,480,723

R. E. HELLMUND

ABSORPTION OF CURRENTS OF UNDESIRABLE FREQUENCIES

Filed Dec. 14, 1918 4 Sheets-Sheet 1

Fig. 1.

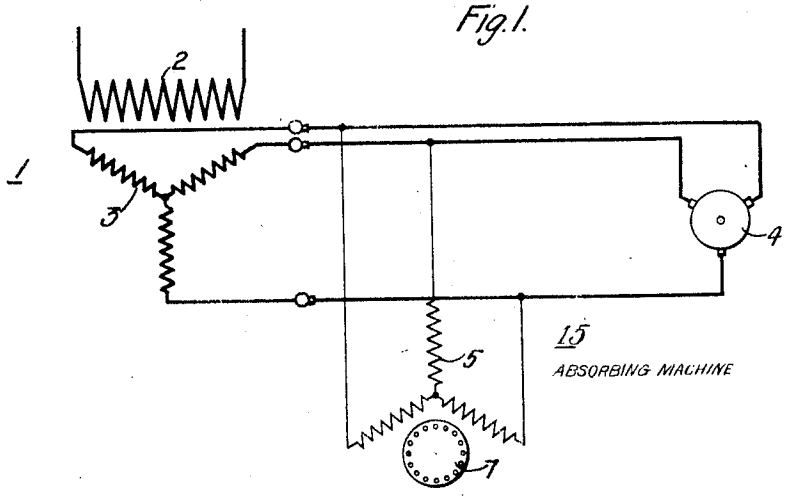
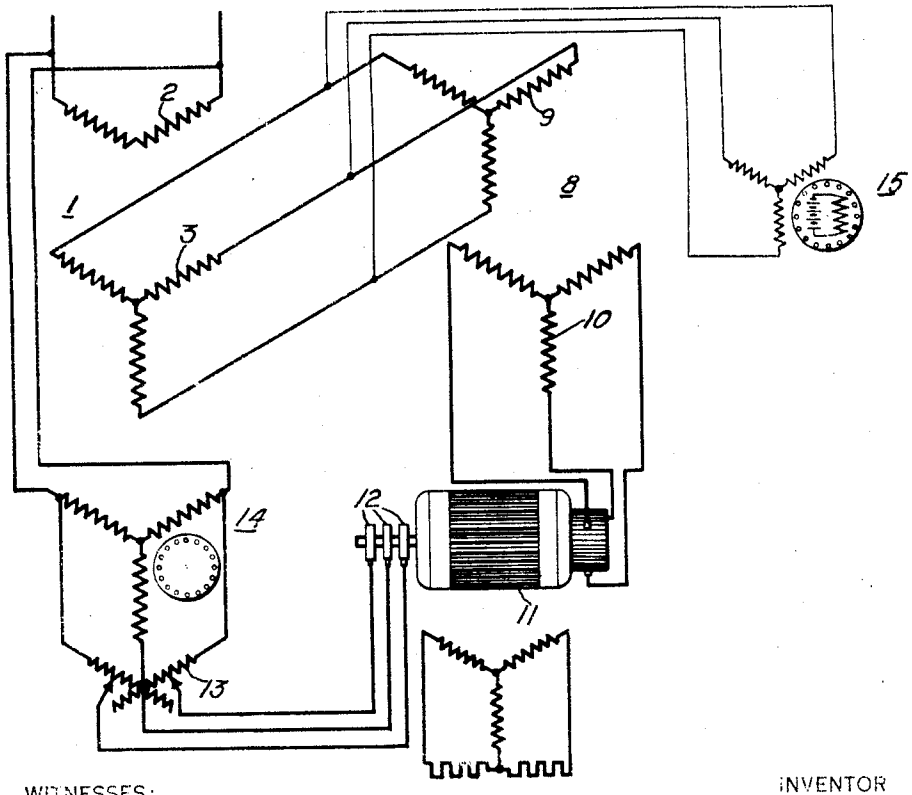


Fig. 2.



WITNESSES:
J. A. Helsel.
A. A. Board

INVENTOR
Rudolf E. Hellmund
BY
Cheney & Sloan
ATTORNEY

Jan. 15, 1924. 1,480,723

R. E. HELLMUND

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Filed Dec. 14, 1918 4 Sheets-Sheet 2

Fig. 3.

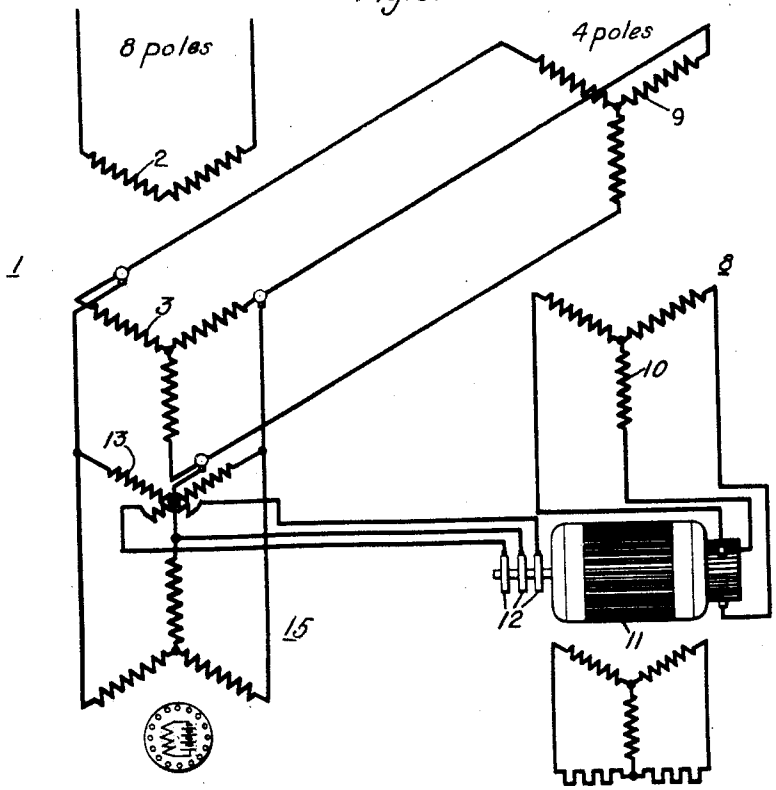
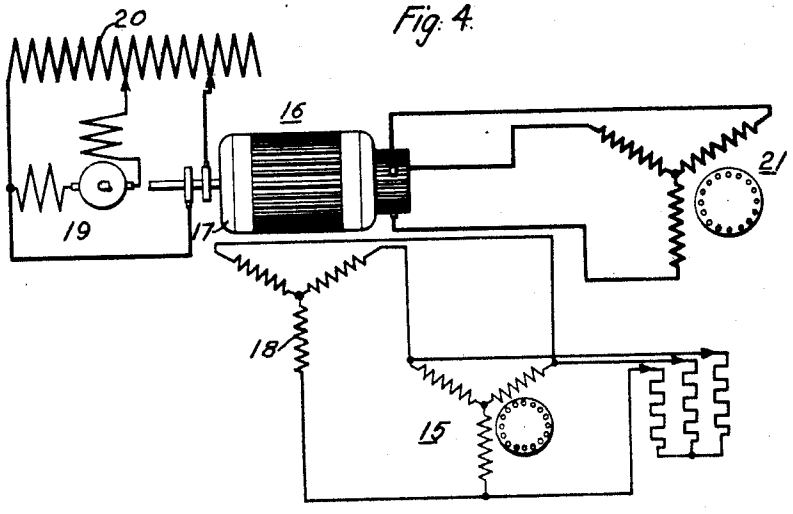


Fig. 4.



WITNESSES:
J. A. Helsel.
A. A. Brand

INVENTOR
Rudolf E. Hellmund.
BY
Wesley G. Carr
ATTORNEY

Jan. 15, 1924. 1,480,723

R. E. HELLMUND

ABSORPTION OF CURRENTS OF UNDESIRABLE FREQUENCIES

Filed Dec. 14, 1918 4 Sheets-Sheet 3

Fig. 5.

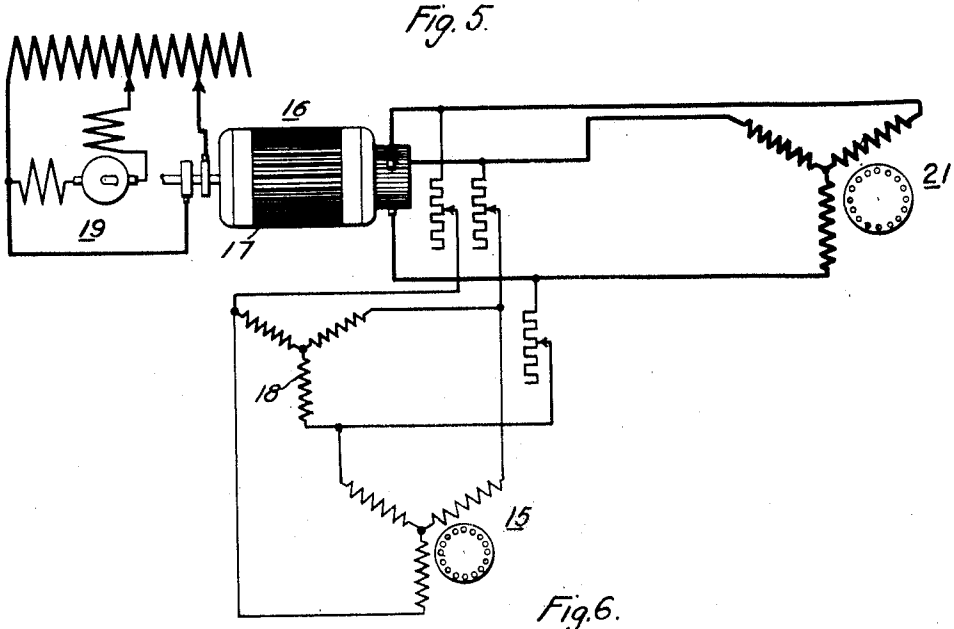
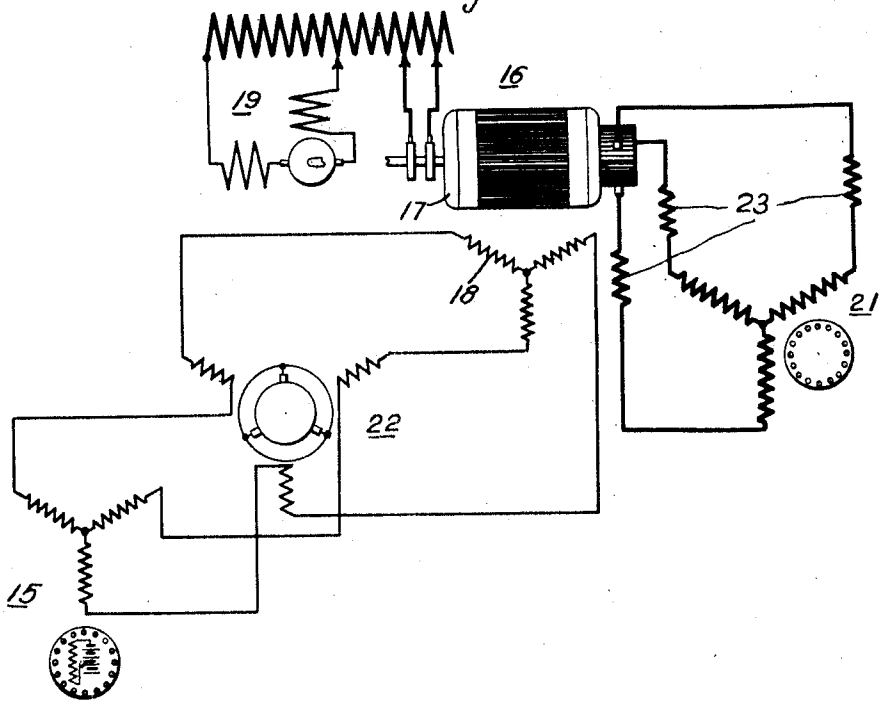


Fig. 6.



WITNESSES:
J. A. Helsel.
A. A. Brand

INVENTOR
Rudolf E. Hellmund.
BY
Overley & Sloan
ATTORNEY

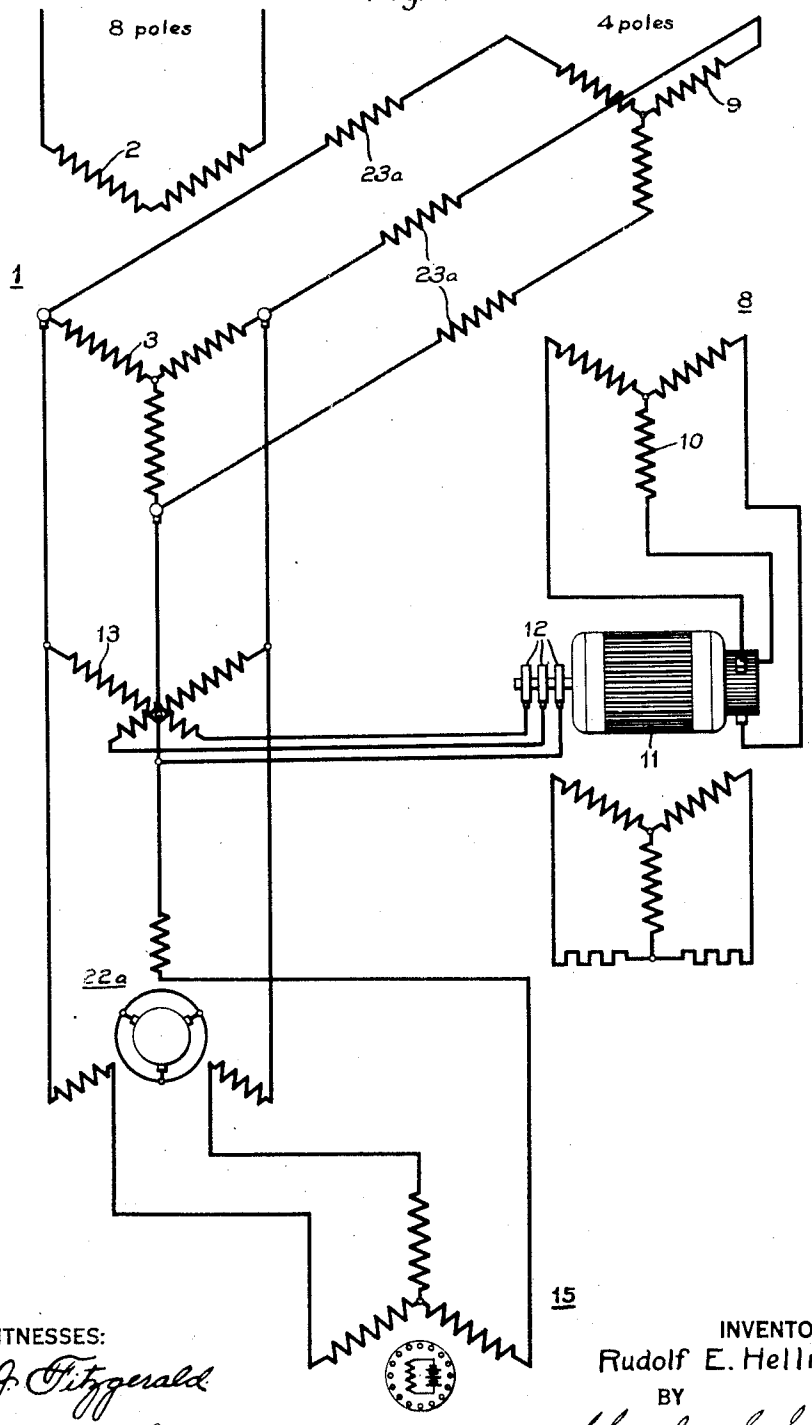
Jan. 15, 1924. 1,480,723

R. E. HELLMUND

ABSORPTION OF CURRENTS OF UNDESIRABLE FREQUENCIES

Filed Dec. 14, 1918 4 Sheets-Sheet 4

Fig. 7.



WITNESSES:

R. J. Fitzgerald

O. B. Buchanan

INVENTOR

Rudolf E. Hellmund.

BY

Merle G. Carr

ATTORNEY

Patented Jan. 15, 1924. 1,480,723

UNITED STATES PATENT OFFICE.

RUDOLF E. HELLMUND, OF SWISSVALE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

ABSORPTION OF CURRENTS OF UNDESIRABLE FREQUENCIES.

Application filed December 14, 1918. Serial No. 266,750.

To all whom it may concern:

Be it known that I, RUDOLF E. HELLMUND, a citizen of the German Empire, and a resident of Swissvale, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Absorption of Currents of Undesirable Frequencies, of which the following is a specification.

My invention relates to means for absorbing currents of undesirable frequencies which may exist in the circuits of various types of electrical apparatus, and more particularly in the secondary circuits thereof.

Commutator machines of various types are frequently used in the secondary circuits of polyphase induction motors for a number of different purposes such, for instance, as phase-advancement, speed-regulation, etc. Such machines can be worked quite satisfactorily because the frequencies which must be handled by the commutator machine in this instance are usually relatively low.

However, when application of the same principle is attempted in the case of single-phase or unbalanced polyphase induction motors, numerous commutating difficulties are encountered. These difficulties are principally due to the fact that single-phase induction motors carry higher harmonic currents, in addition to the load currents of slip frequencies. These currents are usually nearly twice the line frequency (double frequency minus slip) and, in addition, have marked higher harmonics superimposed thereupon. These higher frequency currents are necessary for the satisfactory operation of single-phase motors and yet have a very harmful effect upon the commutation of any commutator machines which may be inserted in the secondary circuit of a single-phase induction motor for purposes, as above described. It is necessary, therefore, to allow such high harmonic currents to flow in the secondary circuit of the induction machine and, at the same time, to provide means for their elimination from other portions of the electrical circuit.

I propose, therefore, to associate with the secondary circuits of those electrical machines in which higher frequency currents are induced, apparatus which will allow their presence in the required portion of the circuit but, at the same time, will promote the elimination thereof from the circuits of such apparatus as are likely to be harmfully effected thereby.

For a better understanding of my invention reference may be had to the accompanying drawings in which Fig. 1 shows a simple case of a single-phase induction machine in which the undesirable high frequency currents are induced, together with means for eliminating the same; Fig. 2 represents two induction machines cascaded and the attendant apparatus for the elimination of the high frequency currents; Fig. 3 is a modification of the system shown in Fig. 2; Fig. 4 illustrates the manner in which the high-frequency current eliminating devices are used with machines such as frequency changers; Fig. 5 is a modification of the system shown in Fig. 4 and Figs. 6 and 7 are further modifications in which a negative impedance is introduced into the eradicator circuit.

Referring now more particularly to Fig. 1, a single-phase induction motor 1, having a single-phase primary winding 2 and a polyphase secondary winding 3, is shown as having a regulating commutator machine 4 in its secondary circuit. Connected between the secondary winding 3 and the commutator machine 4 is the primary member 5 of an induction machine 15 having a squirrel-cage wound rotor member 7.

In Fig. 2, two induction motors 1 and 8 are shown connected in concatenation. The secondary member 3 of the motor 1 is connected to the primary member 9 of the motor 8 and a secondary member 10 of the motor 8 is connected to the commutator end of a frequency-changer 11, the slip rings 12 of which are connected through a transformer 13 and a phase-converter 14 of the single-phase source of supply, as shown.

A small induction machine 15, adapted to have a direct current excitation applied to the secondary member thereof, is connected intermediate the members 3 and 9 and thereby assists in eliminating any high frequency currents which, while they may be necessary for the satisfactory operation of the motor 1, are preferably eliminated from the primary circuit of the motor 8.

Fig. 3 shows a modification of the system described in connection with Fig. 2, wherein

the slip rings 12 of the frequency changer 11 are connected through the transformer 13 directly to the secondary member 3 of the motor 1. In this figure, it will be understood that the motor 8 is of a lower pole number than the motor 1.

In Fig. 4, a frequency-changer 16, having a rotor 17 and a wound stator member 18, is shown as driven by a small commutator machine 19 from any suitable source of power such, for example, as the secondary member 20 of a supply transformer. The frequency-changer 16 is used to furnish reduced frequency to an induction machine 21, this machine here being shown as connected to the commutator end of the frequency-changer 16. The regulating induction machine 15 is, under these circumstances, connected to the stator winding 18 and, by its operation in connection therewith, serves to eliminate the undesirable high frequency currents.

In Fig. 5, the system of Fig. 4 is modified in so far as the field winding 18 is here excited from the commutator end of the frequency-changer. The regulating machine 15 is, therefore, so connected that the currents flowing from the commutator end of the frequency changer may be adjusted before they pass into the stator winding 18.

In Fig. 6 the harmonic eradicator 15 is shown as connected to the phase wound member 18 of the frequency changer. By reason of this particular connection, the field of the frequency changer is freed from such currents as are liable to give rise to undesirable harmonics in the rotor of the regulating machine.

As a further eradicating means I have shown in the present case, a negative impedance device 22 inserted between the hereinbefore described eradicating machine 15 and the phase-wound stator member 18. The negative impedance machine 22 is shown somewhat diagrammatically as comprising a rotor having short circuited brushes and having its field windings connected in series with the stator circuit of the eradicator machine. The insertion of such an additional impedance device is instrumental in cutting down to a minimum amount the undesirable current which tends to flow.

Having described several modifications of my proposed system for the elimination of undesirable high frequency currents from the machine operating in conjunction with secondaries of electrical machines, the operation thereof is as follows:

Referring to Fig. 1, it is apparent that in order to eliminate from the circuit of the commutator machine 4 those high frequency currents which are induced in the winding 3, it will be necessary to provide a shunt circuit through which such high frequency currents may flow without undue obstruction. This means is provided by running the machine 15 at a speed corresponding to the synchronous speed of the slip frequency of the motor 1. Under these circumstances, the winding 5 will constitute a very high impedance for currents of the slip frequency since, while running at the synchronous speed of these currents, it will take only magnetizing current.

For currents of frequencies higher than the slip frequency, however, this winding constitutes practically a short-circuit and the undesirable high-frequency currents will be shunted out of the machine in question.

In Fig. 2, the hereinbefore described system of connecting the regulating machine 15 intermediate the secondary member of one motor and the primary member of the other motor results in the member 3 being provided with the necessary high frequency currents for satisfactory operation and, at the same time, serves to eliminate from the primary winding 9 such undesirable frequency currents.

In Fig. 3, the method of connecting the slip rings of the frequency-changer directly to the intermediate circuit serves to furnish the excess power derived from this frequency changer to the intermediate circuit. This connection is particularly advantageous when two motors of different current capacity or pole numbers are cascaded. If, for example, we consider the motor 8 to have four poles while the motor 1 has eight poles, which, of course, means larger current capacity for the four-pole connection when the motors are of equal size, a greater total output may be obtained if the primary member 9 of the motor 8 is furnished with the additional power derived from the frequency changer, as shown in the connections of this figure. Moreover, it is quite possible to obtain satisfactory operation and elimination of undesirable currents under these circumstances without the use of the absorbing machine 15.

In Fig. 4, the output voltages of the frequency-changer 16 usually contain higher harmonics on account of the fact that the field of the machine is not a rotating field of uniform strength. This field may, however, be smoothed out and the desired characteristics imparted thereto by running the machine 15 at such speed that the undesirable frequencies will be eliminated from the field winding 18. By providing the resistor, as shown, the frequency-changer 16 may be made self-propelling so that the starting machine 19 need be used only for starting operation.

The system above described is modified in Fig. 5 in so far as the stator winding 18 of the frequency-changer and the harmonic eradicator are connected in parallel to the commutator of the frequency-changer. The

impedance devices shown are preferably inserted to obtain satisfactory regulation.

The operation of the system shown in Fig. 6 is analogous to that described in connection with the system shown in Figs. 4 and 5 with the exception that the additional impedance device gives slightly more satisfactory results under some conditions of operation. When used as described in connection with the above system the eradicator may be furnished with a direct-current excited field and is, therefore, able to furnish an out-of-phase component of electromotive force to the system which operates to greatly improve the power factor of the line. In all cases of this kind, the relative effect of the eradicator is better if its resistance and leakage reactance is small, compared to the resistance and leakage reactance of the motor controlled by the regulating frequency changer. The proper relation can, of course, be obtained by the proper design of the two machines, but can be improved, or even secured altogether, by means of external devices such as the negative impedance booster 22 in series with the absorbing machine 15, or the impedance or reactance devices 23 in series with the load machine 21.

In all of the above described systems, it should be borne in mind that the eradicator machine should follow in general the design indicated in connection with Fig. 6, that is, it should have low resistance as well as low leakage reactance. Thus, in Fig. 7 is shown a combination similar to that shown in Fig. 3, but with the addition of a polyphase commutator-type booster 22^a in series with the machine 15, and a plurality of impedance devices 23^a in series with the windings 9. Moreover, it is, of course, entirely possible to supply any of the eradicator machines shown in the above system with direct current excited fields, thereby obtaining a greater degree of harmonic eradication under some circumstances.

While I have shown several systems for the elimination of undesirable high frequency currents in connection with electrical machines of the class described, it is entirely possible that many modifications thereof may occur to those skilled in the art, and I desire, therefore, that only such limitations be placed on my invention as are imposed by the scope of the prior art or specifically set forth in the appended claims.

I claim as my invention:

1. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of an electrical energy-translating device connected to said secondary circuit and requiring currents of only one of said frequencies, and a shunting means connected to said secondary circuit to absorb substantially all of the currents of the other frequencies while drawing substantially no current of said required frequency.

2. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of means connected to said secondary circuit and furnishing a negligibly small conductance to currents of one of said frequencies but being substantially a short circuit for currents of the other frequencies.

3. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of an electrical energy-translating device connected to said secondary circuits and requiring currents of only one of said frequencies, and a freely running dynamo-electric machine connected in shunt with said device and adapted to absorb currents of the other frequencies.

4. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuits carrying currents of a plurality of frequencies, of an electrical energy-translating device connected to said secondary circuit and requiring currents of only one of said frequencies and a freely running induction machine having a primary winding connected in shunt with said device and having a good damper winding whereby said induction machine is adapted to absorb currents of the other frequencies.

5. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of an electrical energy-translating device connected to said secondary circuit and requiring currents of only one of said frequencies and an induction machine having its primary connected to said secondary circuit, said induction machine offering a negligibly small conductance to currents of said frequency, but constituting a shunt path of negligibly low impedance for currents of the other frequencies.

6. The combination with two cascaded induction motors adapted to be supplied from a single-phase source, of a frequency changer having one end connected to the secondary member of the second motor and having its other end connected to the intermediate circiut between said motors, and dynamo-electric means connected across said intermediate circuit to selectively absorb currents of frequencies other than those required to operate said second motor.

7. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of an

induction machine having its primary connected to said secondary circuit, said induction machine offering a negligibly small conductance to currents of one of said frequencies but constituting a path of substantially low impedance for currents of the other frequencies.

8. The combination as set forth in claim 7, in combination with a dynamo-electric machine operating as a booster to reduce the impedance of the induction machine circuit to currents flowing therein.

9. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying currents of a plurality of frequencies, of a second dynamo-electric machine connected to said secondary circuit and requiring currents of only one of said frequencies, and an auxiliary induction machine having its primary connected to said secondary circuit, said auxiliary machine offering a negligibly small conductance to currents of said frequency, but constituting a shunt path of substantially low impedance for currents of the other frequencies.

10. The combination as specified in claim 9, characterized by the fact that the reactance due to the resistance and leakage of the auxiliary machine is small compared with the corresponding reactance of the second dynamo-electric machine.

11. The combination as specified in claim 9, in combination with means external of said machines for, in effect, increasing the relative leakage flux of said second dynamo-electric machine as compared with the auxiliary induction machine.

12. The combination as specified in claim 11, said external means comprising a series, commutator, polyphase booster in series circuit relationship with said auxiliary induction machine.

13. The combination with a dynamo-electric machine having primary and secondary circuits, said secondary circuit carrying fundamental and harmonic currents, of an electrical energy-translating device connected to said secondary current and requiring said fundamental currents only, and an induction machine having its primary connected to said secondary circuit, said induction machine offering a negligibly small conductance to said fundamental currents but constituting a shunt path of substantially low impedance for said harmonic currents.

14. The combination as specified in claim 13, in combination with means external of said electrical device and said induction machine for increasing the relative value of the admittance of said induction machine to said harmonic currents as compared with the admittance of said electrical device to said harmonic currents.

In testimony whereof, I have hereunto subscribed my name this 4th day of Dec., 1918.

RUDOLF E. HELLMUND.