May 3, 1949. H. M. HUGE 2,468,878

FREQUENCY REDUCER

Filed July 19, 1945 2 Sheets-Sheet 1

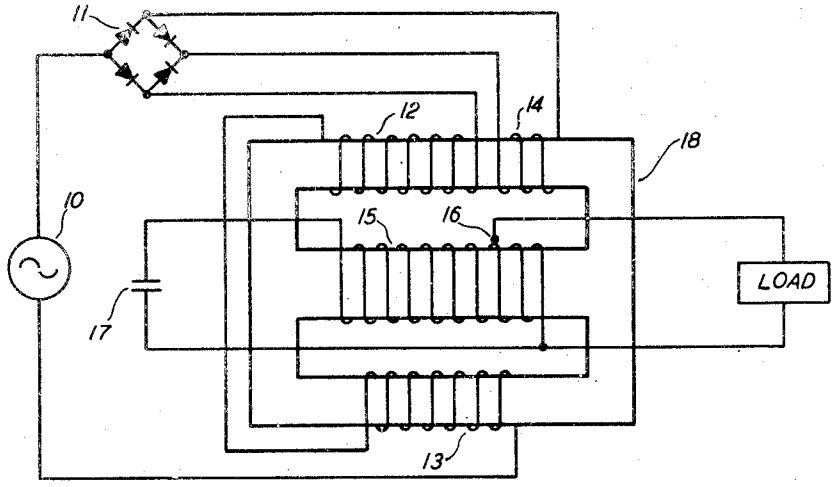



FIG. 1

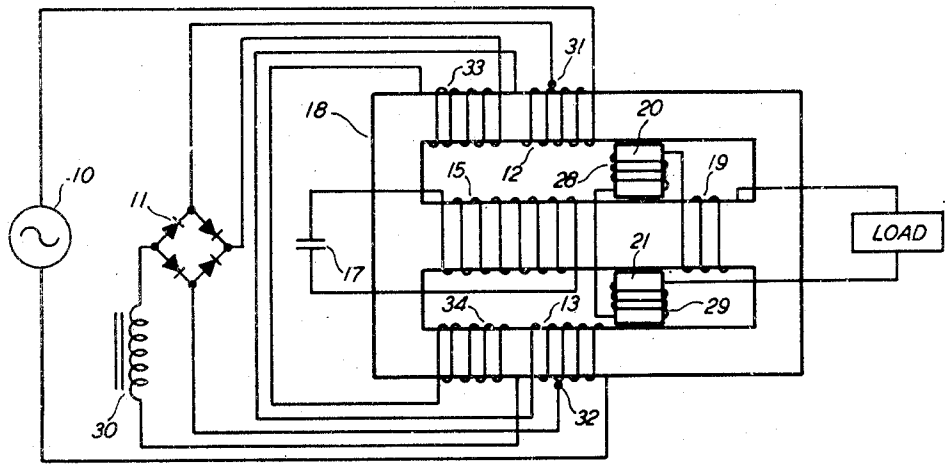



FIG. 2

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Filed July 19, 1945 2 Sheets-Sheet 2

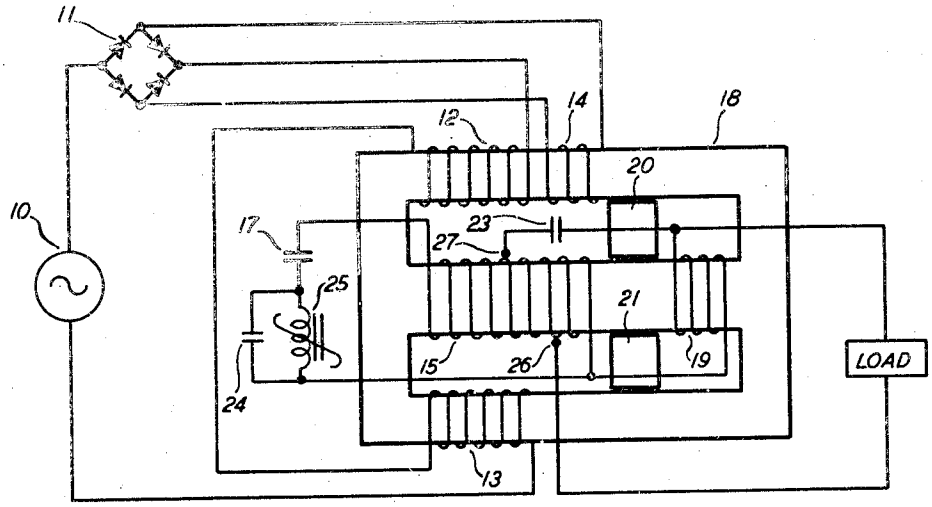



FIG. 3

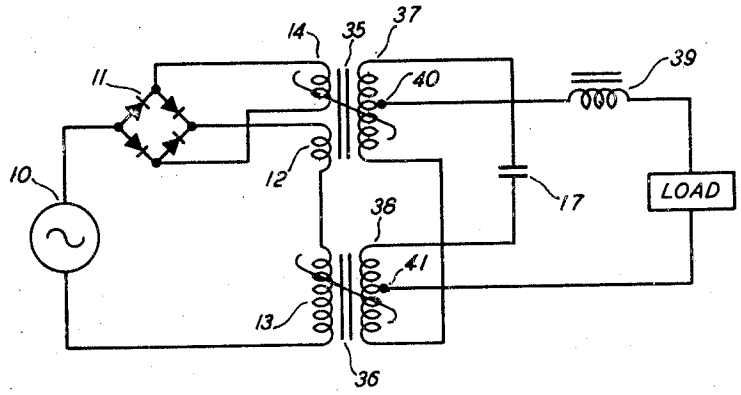



FIG. 4

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Patented May 3, 1949

2,468,878

# UNITED STATES PATENT OFFICE

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## FREQUENCY REDUCER

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Application July 19, 1945, Serial No. 605,969

15 Claims. (Cl. 172—281)

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This invention deals with magnetic frequency reducers, and particularly with a self-starting arrangement for generating an even subharmonic of the energizing frequency through the use of biased saturable magnetic core means.

The invention constitutes an improvement over the subject matter of my U. S. patent application, Serial No. 485,832, filed May 6, 1943, now Patent 2,418,640, issued April 8, 1947. The present application describes a frequency reducer having in one form a leakage-reactance structure for protection against overloads, and utilizing an improved biasing arrangement.

It is an object of this invention to generate an even subharmonic of the frequency of an alternating current source by utilizing a biased saturable magnetic core structure.

Another object of this invention is to produce a self-starting subharmonic generator in which the self-starting of the oscillations is assured in spite of widely varying operating conditions.

Another object of my invention is to use rectifiers to supply biasing current for the saturable magnetic core of a subharmonic generator and to control the biasing current in response to biasing requirements.

Still another object of my invention is to protect a subharmonic generator against overloads through the use of a leakage reactance core structure together with an improved winding arrangement.

An additional object is to increase the audible components in the output voltage of a subharmonic generator, and to maintain the audible level with variations in load.

Other objects and a better understanding of my invention may be obtained by referring to the following specification and claims together with the accompanying drawings in which

Figure 1 is the schematic diagram of one embodiment of my invention with my improved biasing arrangement applied to a common-core subharmonic generator.

Figure 2 is the schematic diagram of a modified subharmonic generator, with a common core structure provided with a leakage reactance arrangement for overload protection and utilizing a biasing circuit differing from that shown in Figure 1,

Figure 3 shows a common-core subharmonic generator having overload protection and having a harmonic generating circuit for introducing audible components in the output voltage, and

Figure 4 shows an embodiment of my invention utilizing two separate saturable inductances to replace the three-legged core construction of the other figures.

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The frequency reducers made according to my invention make use of biased saturable magnetic core means and a winding arrangement having primary and secondary terminals. The winding arrangement is approximately balanced, so that when an alternating voltage is applied to the primary terminals, relatively little voltage of the applied frequency appears across the secondary terminals. Conversely, when the voltage is applied to the secondary terminals, relatively little voltage of the applied frequency appears across the primary terminals. This relationship is known in the art as a conjugate relationship between primary and secondary terminals, and may be achieved by combining opposing magnetizing forces in a three-legged core as in Figures 1, 2 and 3, or by combining opposing voltages in serially connected windings as is done in Figure 4.

In operation, the magnetic bias of the saturable core means is applied in such a manner that the impedance looking into the secondary terminals is substantially symmetrical, while the impedance looking into the primary terminals is unsymmetrical.

The primary impedance becomes unsymmetrical because on one half of a cycle, the alternating current aids the unidirectional biasing flux and highly saturates the core, while on the other half cycle it opposes the biasing flux; hence, when a symmetrical voltage wave is applied, an unsymmetrical current wave is produced.

In the secondary circuit, the impedance remains substantially symmetrical because each half cycle of secondary alternating current aids the biasing flux in one portion of the core and opposes it in the other portion. When the bias is provided by direct current, the direct current is applied at the primary terminals to produce this result.

In operation a suitable capacitor is connected to the secondary terminals and an alternating voltage is applied to the primary terminals. With appropriate circuit constants, I have found that when alternating voltage is applied as shown in Figure 1 the capacitor very readily excites subharmonic oscillations of one-half the source frequency. The subharmonic oscillations thus produced require no starting transient or shock of any kind, and therefore are termed "self-starting." The unidirectional biasing flux impressed on the saturable core, conditions the

frequency changer for the self-starting production of even subharmonics and particularly of an output frequency equal to one-half the energizing frequency. The conversion of power from the fundamental frequency to the subharmonic frequency is accomplished by the superposition of the fundamental and subharmonic fluxes in the biased saturable magnetic core members as in the device described in my U. S. patent application Serial No. 485,832, filed May 6, 1943 now Patent Number 2,418,640, of April 8, 1947.

With more particular reference to Figure 1, there is shown a three-legged saturable magnetic core structure 18, having primary windings 12 and 13 on its outer core members and secondary winding 15 on its central core member. Capacitor 17 is connected across winding 15 and the load is supplied from a portion of winding 15 terminated at tap 16, which is located to supply the desired voltage to the load.

Primary windings 12 and 13 are connected in series with each other and energized from the alternating current source 10. The rectifier bridge 11 is connected in series with windings 12 and 13 to supply them with direct current to bias the saturable magnetic core 18. The rectifier bridge 11 is supplied with alternating current from winding 14 which is wound on the same core member as primary winding 12.

The primary windings 12 and 13 are polarized to magnetize the outer members of the core 18 and to produce opposing magnetizing forces in the central core member This arrangement produces a conjugated relationship between the primary circuit comprising windings 12 and 13 and the secondary circuit comprising winding 15.

In operation the subharmonic flux circulates through the central core member and through both outer core members, while the flux of the energizing frequency circulates chiefly through the two outer core members. Because of the conjugate arrangement, it is possible to interchange the primary and secondary circuits without changing the method of circuit operation. Thus, the capacitor 17 could be connected to the windings 12 and 13, and the source 10 and rectifier 11 connected to the winding 15 without changing the essential properties of the arrangement. It is not necessary to change the location of the rectifier energizing winding 14 when the primary and secondary circuits are thus interchanged because it is coupled to both the primary and secondary circuits in both arrangements.

The method of energizing rectifier 11 which is shown in Figure 1 is highly effective in producing consistent circuit operation under widely varying load conditions and wide variations of the voltage of source 10. As previously mentioned, the outer core members carry flux both of the energizing frequency and of the subharmonic frequency, so the voltage induced in winding 14 has components of both frequencies.

The rectifier 11 might be supplied with voltage only from source 10 and still supply biasing current to satisfactorily operate the subharmonic generator under many operating conditions. With such an arrangement, however, I have found that when the voltage of source 10 is abnormally high, the biasing current becomes excessive and the subharmonic oscillations may not always be self-starting, particularly if they are stopped by an overload condition. When the voltage of source 10 is abnormally low, there may be insufficient biasing current and the application of heavy loads on the output circuit may cause the oscillations to cease or become intermittent.



According to my invention, both of these difficulties are overcome, and the correct biasing current is maintained over widely varying conditions of load and input voltage. This is accomplished by energizing the rectifiers 11 with subharmonic voltage in addition to voltage from source 10. A suitable arrangement for energizing the rectifiers with both voltages is shown in Figure 1, in which the winding 14 is wound on one of the outer core members in which subharmonic and fundamental frequency flux are both circulating.

Because of the saturation of the core, the subharmonic voltage tends to remain relatively constant in spite of variations of the voltage of source 10, and therefore acts to minimize variations of biasing current which are produced by source voltage variations. Furthermore, in case the oscillations are stopped by an overload, there is a reduced voltage applied to the rectifier 11 and the self-starting of the oscillations upon removal of the overload is assured.

This improved biasing arrangement has a further action in that it tends to unbalance the circuit slightly, so that some voltage of the source frequency is applied to capacitor 17, helping to initiate oscillations in the secondary circuit. The unbalanced condition may be adjusted to its optimum value by varying the relative number of turns in windings 12 and 13, but I have found that highly satisfactory results can be obtained by making winding 12 with the same number of turns as winding 13.

In the circuit of Figure 1, the alternating current from source 10 flows through the rectifier 11. I prefer to provide sufficient biasing current so the current through the rectifier will not be forced to reverse. If the voltage supplied by winding 14 is too small, the rectifier bridge 11 may have impressed on it a high reverse voltage from source 10 and be damaged. In such a case, a capacitor could be provided to by-pass the alternating current. Such a capacitor would be connected across the direct current terminals of the rectifier bridge 11.

In the preferred biasing arrangement shown in Figure 1, a by-pass condenser is not needed, and in fact not desirable. There is a tendency for the rectifier bridge 11 to act as a half-wave rectifier of the current of source 10, and when the application of load on the secondary circuit increases the primary current, it also tends to increase the biasing current. An increase of biasing current under these conditions is desirable since it increases the ability of the subharmonic generator to carry load without stopping the subharmonic oscillations.

The benefits obtainable with my improved biasing arrangement are not limited to the biasing circuit shown. To those skilled in the art, other methods of connecting the rectifier bridge 11 in the primary circuit will be apparent. Some of these methods are described in my U. S. patent application, Serial Number 485,832. Specifically, it is not necessary for the direct current to flow through the source 10, but the circuit shown provides a simple and economical assembly and is preferred whenever the flow of direct current through the alternating current source does not produce difficulties.

One biasing circuit which does not pass direct current through the alternating current source 10 is shown in Figure 2. This figure also shows

a leakage reactance core structure for protecting the generator against overloads.

The biasing arrangement shown in Figure 2 makes use of a separate pair of windings, 33 and 34 on the outer members of core 18. These windings are connected in series in the same polarity as the primary windings 12 and 13 and therefore constitute a primary circuit of the frequency changer. Windings 33 and 34 are supplied with direct current for biasing the core 18. They are energized from the rectifier 11 through the blocking inductance 30, which limits the flow of alternating current through the biasing circuit. Because of the balanced character of the circuit, there is relatively little subharmonic voltage in the primary circuits, and the inductance 30 may be relatively small and still satisfactorily block the higher frequencies in the circuit.

The rectifier 11 is supplied with alternating current from a pair of taps 31 and 32 located on the primary windings 12 and 13 respectively. The relative amounts of windings 12 and 13 included between these taps determine the relative amounts of source voltage and subharmonic voltage which are applied to the rectifiers 11. For example, if equal amounts of windings 12 and 13 are included, the voltage applied to the rectifier 11 will be of the frequency of source 10. Differences in the turn numbers introduce subharmonic voltage in the rectifier supply.

The overload protection system shown in Figure 2 is an improvement over the leakage-reactance arrangement shown in U. S. Patent No. 2,179,386, issued November 7, 1939, to C. P. Stocker. In Figure 2, the magnetic shunt members 20 and 21 provide a leakage reactance between the secondary winding 15 and the output winding 19. The shunt members 20 and 21 are preferably constructed to provide small air gaps in their magnetic circuits, so that under light loads on output winding 19 relatively little of the subharmonic flux is diverted away from winding 19. As the load increases, the magnetizing force of the load current causes more of the subharmonic flux to flow through the leakage flux path presented by members 20 and 21.

Windings 28 and 29 on the shunt members 20 and 21 are connected in series with output winding 19, and when energized by the load current serve to aid in the diversion of flux away from the output winding. In addition, the voltage induced in windings 28 and 29 subtracts from the output voltage so that the diversion of a relatively small amount of flux away from the output winding results in a larger drop in output voltage and hence a larger drop in the loading of the converter. This action is highly effective in protecting the converter against overloads because it permits an appreciable portion of the subharmonic flux to flow through the winding 19 under all load conditions, even when the output is short circuited. By permitting subharmonic flux to flow through the closed saturable flux path of the core structure 18 instead of forcing it all through the leakage flux paths, the normal operation of the converter is maintained under overload conditions, and the overload protection circuit acts to maintain the subharmonic oscillations at a reduced level, utilizing the saturable properties of the entire magnetic core structure 18.

The voltage of the source frequency which is induced in windings 28 and 29 is in opposite polarity in the two windings and therefore need not appear in the load voltage. Alternatively, windings 28 and 29 may be connected in parallel,



effectively preventing the flow of fundamental flux through the leakage members 20 and 21, while permitting the subharmonic flux to circulate as previously described.

Figure 3 shows a modification of the arrangement of Figure 2 with several circuit elements added for the purpose of introducing audible components in the output voltage. The biasing arrangement of Figure 3 is similar to that of Figure 1, with rectifier 11 receiving its alternating current supply from winding 14 and supplying direct current to the primary windings 12 and 13.

The overload protection arrangement of Figure 3 is, in effect, similar to that of Figure 2, although the windings 28 and 29 on the leakage flux members are omitted in Figure 3. They are replaced by a portion of secondary winding 15 terminated at tap 26. The load is supplied from output winding 19 through the portion of winding 15, with the voltage from winding 15 opposing that from the output winding. In operation, this combination produces an effect similar to that described in connection with Figure 2, so that on a short circuit some subharmonic flux can still circulate through the closed flux path surrounded by winding 19.

Under some conditions, it may be preferable to provide less protection against overloads in order to maintain a more nearly constant output voltage under normal load conditions. When this is true, the reluctance of the leakage flux paths through shunts 20 and 21 may be increased to a point where heavy overloads will cause the subharmonic oscillations to cease. Even under these conditions, my improved overload protection arrangement provides advantages in maintaining stabilized converter operation under heavy loads and in assuring self-starting of the oscillations after they are stopped by overloads. As previously mentioned the ability of the converter to self-start its oscillations is greatly improved by the biasing arrangement shown, in which both subharmonic voltage and fundamental frequency voltage are rectified to supply biasing current for the magnetic core.

Saturable inductance 25 is connected in series with capacitor 17 in Figure 3. The subharmonic current flowing through the capacitor 17 sharply saturates the inductance 25 and in so doing generates high order harmonics of the output frequency. The capacitor 24 in parallel with inductance 25 provides a local resonant circuit for the desired harmonics and increases their generation.

When the frequency changer is used to supply ringing current for telephone exchanges, the high order harmonics are often needed to supply ringing tone to signal the calling subscriber that ringing current is being supplied to the number he is calling. When relatively little audible tone is needed, the capacitor 24 may be omitted.

The harmonics generated by inductance 25 appear initially across secondary winding 15, and to some extent across output winding 19. When load is applied, however, the flux produced by the harmonics tends to flow through the shunt members 20 and 21 and the harmonic voltage across output winding 19 would rapidly diminish if it were not maintained by capacitor 23. I have found that by connecting capacitor 23 to one end of winding 19 and to a suitably located tap 27 on winding 15 it is possible to maintain a relatively constant audible tone level across the load. The windings are preferably polarized so that

the action of capacitor 23 aids the normal harmonic voltages appearing across winding 19.

If the saturable inductance 25 has too high an impedance it may prevent the self-starting of the subharmonic oscillations. The unbalancing action of the biasing supply winding 14 tends to reduce this difficulty, but in some cases it may be desirable to further adjust the unbalance of the structure by altering the number of turns on winding 12 or winding 13.

Although mention is here made of an unbalanced condition, it is to be understood that the structure of the frequency changer is substantially balanced, and relatively little unbalance is required to produce the effects described. The fact that the primary and secondary circuits provide a substantially balanced or conjugate combination is best demonstrated by noting that relatively little current or voltage of the source frequency appears in the secondary circuit, that is, the circuit of capacitor 17.

The circuit of Figure 4 is that of an embodiment of my invention utilizing two saturable cores 35 and 36 to replace the three-legged core structure 18 shown in Figures 1, 2, and 3.

The operation of the circuit of Figure 4 is, for practical purposes, the same as that of Figure 1, except that inductance 39 in series with the load in Figure 4 provides overload protection not provided in Figure 1. The primary windings 12 and 13 in Figure 4 are wound on the saturable magnetic cores 35 and 36 respectively. These primary windings are connected in series to the source 10 through the D. C. terminals of rectifier 11.

Rectifier 11 is supplied with alternating current from winding 14, wound on core 35 with primary winding 12. The winding 14 is coupled to both the primary and secondary circuits, as in Figure 1 and it supplies both subharmonic voltage and fundamental voltage to the rectifier 11.

The secondary circuit of Figure 4 comprises windings 37 and 38 on cores 35 and 36 respectively. The secondary windings are polarized oppositely to the primary windings so that the entire arrangement is a substantially balanced combination, with voltage of the primary frequency being substantially balanced out of the secondary circuit.

Capacitor 17 is connected in a closed circuit with the secondary windings 37 and 38, and excites the subharmonic oscillations in the secondary circuit. In operation, both the cores 35 and 36 are magnetized with both fundamental and subharmonic flux, and, as previously mentioned, winding 14 is excited by both frequencies.

The load is supplied from a portion of the secondary circuit, including portions of both windings 37 and 38. The taps 40 and 41 are located to supply the desired output voltage of the subharmonic frequency. By including equal portions of windings 37 and 38, an output voltage of substantially the same wave shape as the voltage across capacitor 17 is provided.

My invention has been described herein as being applied to specific types of balanced or conjugate circuits comprising saturable magnetic core means, but other similar arrangements may also be used. For example, the biasing arrangement described herein may be substituted in the circuits shown in my U. S. patent application Serial No. 485,832, for the biasing arrangements shown therein.

Although I have described my invention with a certain degree of particularity, it is to be understood that the present disclosure has been made only by way of example, and that numerous modifications in the details of construction and the arrangement of the parts may be made without departing from the scope of the invention as hereinafter claimed.



I claim as my invention:

1. A frequency changer adapted to be energized by a source of alternating current and to generate a frequency which is an even subharmonic of the frequency of said source, said generator comprising a three-legged magnetic core structure, first and second winding means on the first and second legs of the core structure, said first and second winding means being connected in series with each other and adapted to be energized by said source to produce opposing magnetizing forces in the third leg of the core structure, a rectifier connected in series with the first and second winding means to supply direct current thereto, a rectifier energizing winding on the first leg of the core connected to said rectifier, third winding means on the third core leg, and a capacitor connected to the third winding means.

2. In combination, a magnetic core structure having a plurality of members, a plurality of windings on the core structure, comprising primary and secondary circuit means, the primary and secondary circuit means being in a substantially balanced relationship to each other, a capacitor connected in a closed circuit with the secondary circuit means, biasing means for producing a unidirectional flux in the core structure to modify the impedance of said primary circuit means so that said impedance offers a greater opposition to one half of an alternating current cycle than to the other half of the cycle, output winding means on the core structure inductively related to the secondary circuit means, leakage reactance means providing leakage reactance between the output winding means and the secondary circuit means, and load circuit means including the output winding means and at least a portion of the secondary circuit means, said load circuit means being adapted to supply a load with subharmonic voltage from the output winding means and an opposing subharmonic voltage from the secondary circuit means.

3. In combination, a magnetic core structure having first, second and third members, first and second windings on the first and second members, said first and second windings being connected in series and polarized to produce opposing magnetizing forces in the third member, means for energizing said first and second windings from a source of alternating current, biasing means for producing unidirectional flux in the first and second members, a third winding on the said third member, a capacitor connected in a closed circuit with the third winding, a fourth winding on the said third member, leakage flux means providing leakage reactance between the third and fourth windings, and an output circuit including the fourth winding and at least a portion of the third winding.

4. In combination, a magnetic core structure having first, second and third members, first and second windings on the first and second members, said first and second windings being connected in series and polarized to produce opposing magnetizing forces in the third member, means for energizing said first and second windings from a source of alternating current, biasing means for producing unidirectional flux in the first and second members, a third winding on the third

member, a capacitor connected in a closed circuit with the third winding, a fourth winding on the third member, leakage flux means providing leakage reactance between the third and fourth windings, winding means on the leakage flux means, and an output circuit including said winding means and said fourth winding.

5. A frequency reducer adapted to be energized by an alternating current source and to supply an output voltage of a frequency which is an even subharmonic of the source frequency, comprising in combination, a magnetic core structure having a plurality of members, a plurality of windings on the core structure, comprising primary and secondary circuit means, the primary and secondary circuit means being in a substantially conjugate relationship to each other, a capacitor connected in a closed circuit with the secondary circuit means, a rectifier connected to the primary circuit means to supply direct current thereto, output winding means inductively related to the secondary circuit means, and leakage reactance means providing leakage reactance between the output winding means and the secondary circuit means.

6. In combination with a frequency reducer having primary and secondary winding means arranged on a magnetic core structure having a plurality of saturable members, with a capacitor connected to the secondary winding means, with output winding means on the core structure and with leakage reactance means providing leakage reactance between the output winding means and the secondary winding means, tone circuit means for supplying harmonic voltage to the output winding means, said tone circuit means comprising saturable inductance means connected in series with said capacitor, and capacitive coupling means coupling the output winding means to the secondary winding means.

7. In combination with a frequency reducer having primary and secondary winding means arranged on a magnetic core structure having a plurality of saturable members, with a first capacitor connected to the secondary winding means, with output winding means on the core structure and with leakage reactance means providing leakage reactance between the output winding means and the secondary winding means, tone circuit means for supplying harmonic voltage to the output winding means, said tone circuit means comprising a saturable inductance connected in series with the first capacitor, a second capacitor connected substantially in parallel with the saturable inductance, and capacitive coupling means coupling the output winding means to the secondary winding means.

8. In combination with a magnetic frequency reducer having primary and secondary winding means arranged on a magnetic core structure having a plurality of members, an overload protective arrangement comprising in combination, output winding means on the core structure inductively related to the secondary winding means, leakage reactance means providing leakage reactance between the output winding means and the secondary winding means, and a load circuit including the output winding means and at least a portion of the secondary winding means, and adapted to supply an output voltage of a reduced frequency from the output winding means and an opposing voltage of the reduced frequency from the secondary winding means.

9. In combination with a magnetic frequency reducer having primary and secondary winding means arranged on a magnetic core structure having a plurality of members, an overload protective arrangement comprising in combination, first output winding means on the core structure inductively related to the secondary winding means, magnetic shunt means providing leakage reactance between the first output winding means and the secondary winding means, and second output winding means on the magnetic shunt means connected in series with the first output winding means and polarized to supply an output voltage opposed to the voltage supplied by the first output winding means.

10. A magnetic frequency changer comprising magnetic core means having a plurality of members, primary and secondary winding means on the core means, means for energizing said primary winding means from an alternating current source, at least one of said winding means comprising a plurality of portions on different members of the plurality of magnetic core members, polarized to produce substantially cancelling voltages in the other of said winding means, a rectifier adapted to supply direct current to at least a portion of the primary winding means, a rectifier energizing circuit connected to the rectifier and coupled to both the primary and secondary winding means, and a capacitor connected in a closed circuit with the secondary winding means.

11. A magnetic frequency changer adapted to be energized by a source of alternating current and to supply an output voltage of a frequency which is a subharmonic of the source frequency, said frequency changer comprising magnetic core means having a plurality of core members, primary and secondary winding means on the core means, means for energizing said primary winding means from an alternating current source, at least one of said winding means comprising a plurality of portions on different members of the plurality of magnetic core members, said portions being polarized to produce substantially cancelling voltages in the other of said winding means, a rectifier connected in series with the primary winding means to supply direct current thereto, a rectifier supply circuit adapted to supply the rectifier with subharmonic voltage and with voltage of the source frequency, a capacitor connected in a closed circuit with the secondary winding means and means for supplying a subharmonic output voltage from said secondary winding means.

12. In combination with a self-starting frequency reducer adapted to supply an output frequency which is an even subharmonic of its energizing frequency, and comprising magnetic core means having a plurality of core members with primary and secondary winding means thereon forming a substantially balanced conjugate combination, unbalancing means for assuring the self-starting of subharmonic oscillations in the secondary winding means, said unbalancing means producing a residual unbalanced condition in the substantially balanced conjugate combination for introducing primary voltage in the secondary winding means.

13. A self-starting frequency changer adapted to be energized by a source of alternating current and to supply an output frequency which is one-half of the source frequency, said frequency changer comprising a magnetic core structure having first, second, and third members, first and second windings on the first and second members,

connected in series, adapted to be energized by said source, and polarized to supply opposing fluxes to the third member, a rectifier connected in series with the first and second windings to supply direct current thereto, a third winding on the third member, a capacitor connected in a closed circuit with the third winding, a saturable inductance connected in series with the capacitor for introducing harmonics in the voltage across the third winding, and a fourth winding on the first member connected to the rectifier to supply rectifier with alternating current, said capacitor being supplied with a relatively small voltage of the source frequency to aid in initiating self-starting oscillations of one-half the source frequency through said capacitor.

14. A magnetic frequency changer comprising a magnetic core structure having a plurality of members, a plurality of windings on the members, comprising primary and secondary winding means in substantially conjugate relationship to each other, a rectifier adapted to supply direct current to at least a portion of the primary winding means, a capacitor connected in a closed circuit with the secondary winding means, output winding means inductively related to the secondary winding means, magnetic shunt means providing leakage reactance between the secondary and output winding means, and a rectifier supply circuit connected to the rectifier and adapted to be energized from both the primary and secondary winding means, said primary winding means being adapted to be energized by a source of alternating current.



15. A subharmonic generator adapted to be energized by a source of alternating current and to generate a frequency which is an even subharmonic of the frequency of said source, said generator comprising magnetic core means, a primary circuit and a second circuit, said primary and said secondary circuits comprising at least three windings on said core means, said primary circuit being adapted to be energized by said source for magnetizing said core means, said primary and secondary circuits being disposed to provide a substantially conjugate relationship therebetween, biasing means adapted to supply unidirectional current to said primary circuit, said primary circuit and said biasing means exciting at least a portion of said magnetic core means to a saturated condition, said biasing means comprising a rectifier and circuit means for energizing said rectifier with voltage of the source frequency and with subharmonic voltage, and a capacitor connected to the secondary circuit, said capacitor in cooperation with said primary and secondary circuits and said magnetic core means exciting subharmonic oscillations in the secondary circuit when the said at least a portion of said core means is saturated by the combined effect of said biasing means and said primary circuit.

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No references cited.