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STATIC FREQUENCY MULTIPLYING SYSTEM

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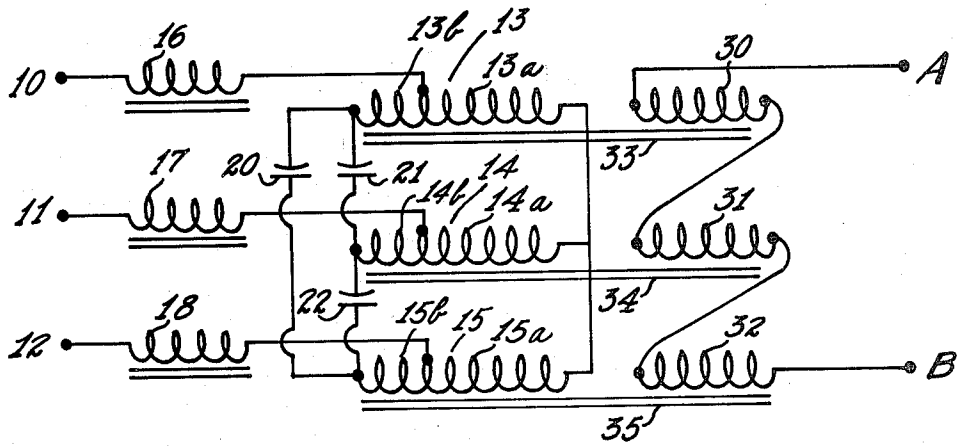


FIG. 1

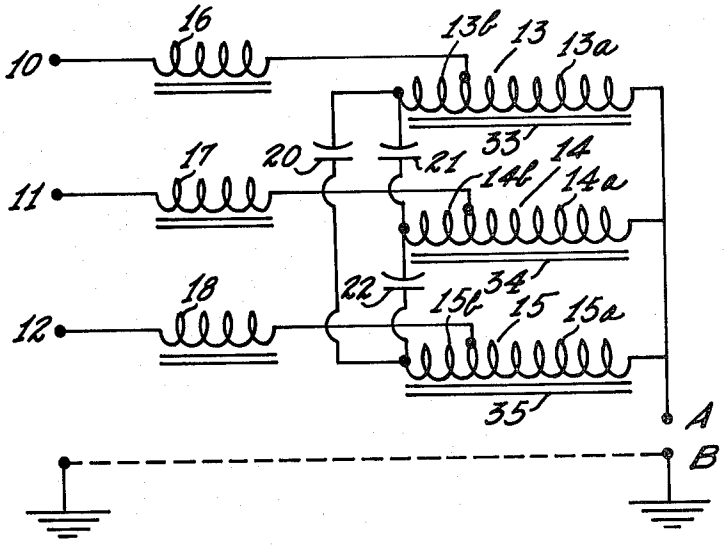


FIG. 2

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STATIC FREQUENCY MULTIPLYING SYSTEM

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My invention relates to a static frequency multiplying system and relates more particularly to improvements in a symmetrical frequency multiplying system wherein means are employed for stabilizing the system consisting of reactors having a current-voltage relationship which is linear throughout the operating range of the system, as set forth in co-pending applications for U.S. Letters Patent, Serial Nos. 713,343 and 725,004, filed February 7, 1958, and March 31, 1958, which issued into United States Letters Patent No. 3,040,230 and No. 3,040,231 dated June 19, 1962, respectively.

In such systems a multiphase source, such as a three-phase source of alternating current, energizes current dependent inductances, i.e. primaries normally connected in star relation to a star connection point, the said current dependent inductances or primaries are separated from the source terminal by said reactors, condensers are effectively connected to the primaries either in Y or delta form and said condensers are supplied with non-sinusoidal voltage developed phase to phase between the reactors and the non-linear primaries.

The present improvement consists in providing means for selecting desired values for the non-sinusoidal voltages supplied to the condensers.

It is an object of my invention to provide improved means associated with the non-linear inductances or primaries of the system referred to, which are simple in construction and readily incorporated in said primaries and which, without altering the essential non-linear characteristics of such primaries, produce an auto-transformer effect in the system so that the value of the non-sinusoidal voltages supplied to the condensers may be different from values of the non-sinusoidal voltage appearing across the junctures between the so-called linear reactances and said current depending inductances, viz. primaries.

It is a further object of my invention to provide by the utilization of much improved means in connection with the non-linear primary structures a more economical construction of condensers without loss in operating efficiency.

A further advantage resides in the fact that when the improved means of my invention are used to increase the voltages as applied to the condensers, it is possible to reduce the cross-section at once of the conductors used in the windings in the non-linear inductances, thereby achieving a relative reduction in eddy current losses in said conductors and a resulting improvement in the overall efficiency.

Other objects of the invention and the invention itself will be more readily appreciated by reference to the appended description and drawings, in which drawings:

FIG. 1 is an electrical schematic view of a preferred power system for connecting a multiphase power source to single phase high frequency power output for induction heating service;

FIG. 2 is an electrical schematic view of another embodiment of my invention.

The system of the invention as shown in the drawings submitted herewith discloses a multiphase source, such as a three-phase source of alternating voltage delivered from terminals **10**, **11**, and **12** energizing current dependent inductances, i.e. primary structures **13**, **14**, and **15** connected in star arrangement, the primaries being separated from the terminals by reactances **16**, **17**, and **18** for the current which reactances may be furnished

in the form of chokes having an air gap (not shown).

The primary structures shown consist of windings **13***a* and **13***b*, **14***a* and **14***b*, **15***a* and **15***b* of different leakage reactance. Each said reactance serves to connect the respective primaries to their respective source and serves also to isolate the source from harmonic currents reflected by the primaries. The reactances **16**, **17**, and **18** have, in the form shown, a current-voltage relationship which is linear, developing non-sinusoidal voltages across the junctures between the reactors and the primary structures and provide a high impedance path for harmonic components of said frequency reflected by the primary structures.

Condensers **20**, **21**, and **22** are effectively connected to the primaries either in Y, in which case the star point should not be grounded, or delta, the delta connection being shown. It is to be noted that the connection of the condensers to the primaries are at a point on the primary windings where the leakage reactances of the windings are different from the point at which the linear reactances are connected to said windings. Said condensers provide a low impedance path for harmonic currents passing non-sinusoidal current to the primaries. Each of the linear reactances **16**, **17**, and **18** are connected to a selected point on the said primary windings so that each respective linear reactance is interposed between each said primary and its terminal source.

By properly selecting the turn of the respective primary winding, as by a tap connection, etc., to each of which a linear reactance and condenser are connected, the value of non-sinusoidal voltages delivered to the condensers can be controlled to any desired value. The importance of this control of the value of the voltage delivered to the condensers lies in the fact that it enables a more economical design of the condensers than would be possible with the connections shown in the prior applications to which reference has been made.

When the selected connection is made as described above, and the condensers are connected at a point equivalent to an extension of the primary winding, a reduction of the cross-sectional area of the conductors used in the primary windings may be and is preferably made whereby the relative eddy current losses are reduced with an improvement in the overall efficiency. The connection illustrated, which is made as above discussed, enables the values of the non-sinusoidal voltages delivered to the condensers to be adjusted to a different value from that present across the junctures of the linear reactances and the primaries, without, however, affecting the non-linear characteristics of the primaries and without affecting the symmetry of the system adversely in any way.

In the form of my invention shown in FIG. 1, I have shown secondaries **30**, **31**, and **32** connected in series and magnetically coupled to the primary windings **13**, **14**, and **15** by cores **33**, **34**, and **35** which in turn are connected to the load indicated at A–B. It will be understood that secondary windings such as **30**, **31**, and **32** are not essential to the operation of the system and it will be apparent to those skilled in the art that arrangements such as shown in FIG. 2 could be utilized to deliver the desired harmonic frequency output.

In either form, the voltage across the terminals A–B will be a harmonic of the source and the power delivered will be single phase distributed symmetrically across the primaries and a substantial unity power factor is achieved at the source.

While I have described my invention in connection with several preferred embodiments thereof, I am aware that departures may be made therefrom, such as providing separate conductors of different cross-sectional area for the portions **13***a* and **13***b*, **14***a* and **14***b*, **15***a* and **15***b*, respectively, with a resultant reduction in eddy losses in

the section of lesser cross-sectional area in the portions 13*b*, 14*b*, and 15*b*, but without, however, departing from the spirit of my invention or the scope of the appended claims.

What I claim is:

1. A power supply system comprising a multiphase source of alternating voltage of sinusoidal form and predetermined frequency and adapted to deliver single phase power of the harmonic frequency of the source symmetrically distributed with respect to said source, a primary structure for each phase of said source energizable by the latter having a current voltage relationship which is non-linear for each phase of said source and consisting of windings of different leakage reactance; a reactance having a current voltage relationship which is linear disposed between said primary structure and said source; said linear reactances developing non-sinusoidal voltages across the junctures of said linear reactances and said primary structures; condensers interposed between said primary structures; means associated with each of said primary structures whereby the value of voltages supplied to said condensers is caused to differ from those values of voltages appearing across the junctures of said linear reactances and said primary structures while preserving the non-linear characteristics of said primary structures.

2. A power supply system comprising a multiphase source of alternating voltage of sinusoidal form and predetermined frequency and adapted to deliver single phase power of the harmonic frequency of the source symmetrically distributed with respect to said source, a primary structure for each phase of said source energizable by the latter having a current voltage relationship which is non-linear for each phase of said source; a reactance having a current voltage relationship which is linear disposed between said primary structure and said source; said linear reactances developing non-sinusoidal voltages across the junctures of said linear reactances and said primary structures; condensers interposed between said primary structures passing non-sinusoidal current to said primary structures; selecting means associated with each of said primary structures whereby the value of voltages supplied to said condensers is caused to differ from those values of voltages appearing across the junctures of said linear reactances and said primary structures while preserving the non-linear characteristics of said primary structures, means to obtain harmonic frequency power symmetrically distributed with respect to said source.

3. A power supply system comprising a multiphase source of alternating voltage of sinusoidal form and predetermined frequency and adapted to deliver single phase power of the harmonic frequency of the source symmetrically distributed with respect to said source, a primary structure for each phase of said source energizable by the latter having a current voltage relationship which is non-linear for each phase of said source; a reactance having a current voltage relationship which is linear disposed between said primary structure and said source; said linear reactances developing non-sinusoidal voltages across the junctures of said linear reactances and said primary structures; condensers interposed between said primary structures passing non-sinusoidal current to said primary structures; means associated with each of said primary structures whereby the value of voltages supplied to said condensers is caused to differ from those values of voltages appearing across the junctures of said linear reactances and said primary structures while preserving the non-linear characteristics of said primary structures; secondary windings for each primary structure magnetically coupled to the latter; and means connecting said secondary windings electrically in series thereby to obtain a single phase harmonic frequency power symmetrically distributed with respect to said source, the relationship between the reactances and condensers being such that a substantial unity power factor is achieved at the source.

4. A power supply system comprising a multiphase source of alternating voltage of sinusoidal form and predetermined frequency and adapted to deliver single phase power of the harmonic frequency of the source symmetrically distributed with respect to said source, a primary structure for each phase of said source energizable by the latter having a current voltage relationship which is non-linear for each phase of said source and consisting of windings of different leakage reactance; a reactance having a current voltage relationship which is linear disposed between said primary structure and said source; said linear reactances developing non-sinusoidal voltages across the junctures of said linear reactances and said primary structures; condensers interposed between said primary structures; said condensers being connected through a winding of said primary structures of different leakage reactance than the remainder of the primary connected to the juncture of said linear reactance and said primary whereby the value of voltages supplied to said condensers is caused to differ from those values of voltages appearing across the junctures of said linear reactances and said primary structures while preserving the non-linear characteristics of said primary structures.

5. In a system as claimed in claim 2, characterized by each of said primary windings consisting of a pair of windings, each set of said windings being of different cross-sectional area, the said selecting means increasing the value of the voltages supplied to said condensers to a predetermined value above the values of the voltages appearing across the junctures whereby eddy current losses corresponding to the harmonic distribution of currents in said windings approaches a minimum.

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