

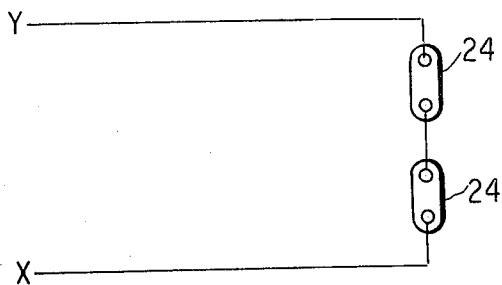
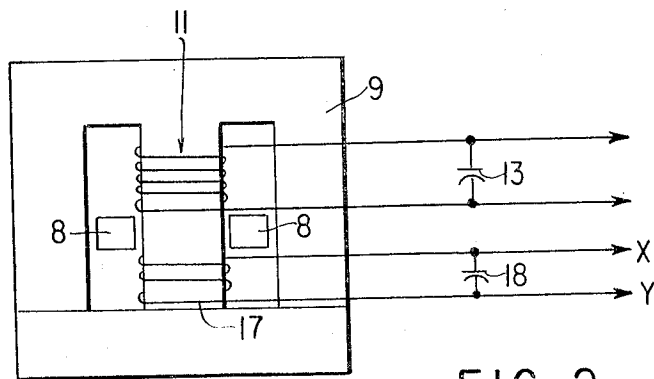
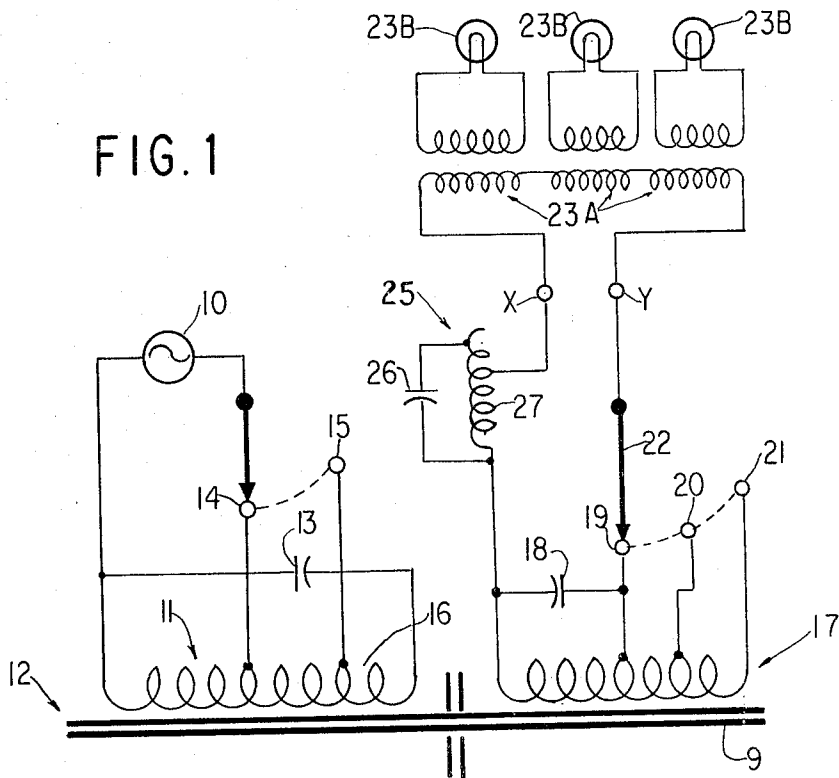
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HIGH LEAKAGE REACTANCE STATIC CONSTANT CURRENT REGULATOR

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**HIGH LEAKAGE REACTANCE STATIC
CONSTANT CURRENT REGULATOR**

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6 Claims. (Cl. 323-6)

This invention relates to electrical systems and more particularly to one having a static constant current regulator. This application is a continuation of application Ser. No. 102,280, filed April 11, 1961, now abandoned.

In some load circuits, it especially is desirable to provide for constant current, such as in airport lighting systems, series street lighting circuits, electrochemical projects, and other similar arrangements. Such constant current regulators, in many instances, have been expensive to build so that one of the problems has been that of reducing cost of the parts needed. The prior devices have frequently included a multiplicity of reactors, capacitors, an output transformer, and moving coils. One of the problems in static constant current regulator systems is that when a non-linear load is introduced in such a system, the non-linear load will produce harmonics in the current with undesirable results.

One of the principal objects of the invention is to provide a static constant current regulator which is economical to build and yet which will provide desired current regulation.

In one aspect of the invention, a high leakage reactance transformer is used, a source of alternating current being connected to the primary thereof, preferably through a tap changing means. A high leakage reactance transformer is one, for example, which has a magnetic shunt between its primary and secondary windings. A capacitor is connected in shunt with the primary for power factor correction purposes. The secondary has a capacitor connected in shunt with a part or all of the secondary winding. A filter network is connected in series with the load and secondary, such being arranged so as to be tuned approximately to the third harmonic of the source so as to offer a high impedance and suppress said harmonic. As a result of the combination, the constant current regulator combines a reactor and transformer in one integral unit, thereby reducing the cost of such a regulator. The secondary may be extended and tapped to make available terminals for the selection of different levels of current regulation.

These and other objects, advantages, and features of the invention will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

FIG. 1 schematically shows one form of circuit which may be used.

FIG. 2 schematically illustrates a high leakage reactance transformer.

FIG. 3 schematically shows a gaseous discharge lamp load which can be connected in place of the load shown in FIG. 1.

The invention will be described in conjunction with a load such as a non-linear gaseous discharge lamp load

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or a load including series connected isolating transformers, but it is to be understood that it can be used with mixed loads and with other types of loads.

Referring now to FIG. 1, alternating current energy is furnished to the static constant current regulator from a source of energy 10, such being connected to primary winding 11 of high-leakage reactance transformer 12. Capacitor 13 is connected in shunt across primary 11, the principal function of capacitor 13 being to correct the power factor of the constant current regulator. Primary 11 may have, but not necessarily, a plurality of taps 14, 15 for use with different values of line voltage. As can be seen, primary 11 is also extended at 16 and the capacitor 13 connected to the ends of the primary so as to operate the capacitor 13 at a higher and more economical voltage than the line voltage. As shown in FIG. 2, the primary and secondary may be mounted on a suitable core means 9. In the form shown, the primary and secondary windings are on the center leg of the core. Magnetic shunts 8 are suitably placed in relation to the core 9 so as to provide leakage flux paths between the primary and secondary windings.

Secondary 17 (FIG. 1) has a capacitor 18 connected in shunt with a portion thereof. Secondary 17 may be extended and provided with taps 19, 20, 21 and a tap-shifting arrangement or switch 22 used for the purpose of adjusting the load current level. Capacitor 18 is an essential part of the constant current circuit as compared with capacitor 13 which merely provides power factor correction.

As mentioned, the output can be connected to a load such as series connected incandescent lamps, series-connected gaseous discharge lamps and other electrical loads requiring constant alternating current to be supplied thereto. The load 23 in FIG. 1 is shown as series connected isolating transformers 23A feeding incandescent lamps 23B. FIG. 3 shows series connected gaseous discharge tube load 24 which may be fed from leads X, Y (FIG. 1) instead of the load of FIG. 1. Filter network means 25 is inserted in series with the load, the network in the form shown having a capacitor 26 and reactor 27 connected in shunt relative to each other. It is to be understood, of course, that the loads may be mixed.

The filter network means is essentially tuned to the vicinity of the third harmonic of the line frequency so as to offer high impedance to the third harmonic. Additional filter elements (not shown) tuned to higher odd harmonics, such as the fifth and the seventh, also could be connected into the circuit.

The function of the filter network means in the static constant current system of this invention is to cooperate therewith to maintain a predetermined constant current level in the face of an abnormal condition such as may occur in series airport lighting circuits wherein the isolating transformers connected between the output circuit and the individual lamps may become open-circuited due to lamp burnout. When such occurs, and there is not a filter network of this invention, the current may saturate the open circuited isolating transformers and the effective or R.M.S. current through the still operating lamps may rise and burn them out. The filter means may also be used with the type of static constant current regulator contemplated herein to enable the regulator to supply gaseous discharge lamps without additional inductive ballasting

and so as to restrict the peak to R.M.S. ratio of the lamp current.

An example of a suitable construction is shown in FIG. 2 wherein a high leakage reactance transformer having core 9, primary winding 11 and secondary winding 17, with magnetic shunts 8, the taps being omitted for clarity. Other types of core arrangement can be used as desired.

The critical parameters of the system are made such that the leakage reactance of the high leakage reactance transformer referred to the secondary winding will be approximately equal to the reactance of capacitor 18 at line frequency. Additionally, the leakage reactance of the transformer multiplied by the secondary current, which it is desired to regulate, should be equal to the open circuit secondary voltage of the transformer with the capacitors disconnected from the winding.

By way of example, a high-leakage reactance transformer used in a system made in accordance with the invention had a capacitor corresponding to 13 of 21.2 microfarads and a capacitor corresponding to 18 of 29.5 microfarads. In the particular transformer concerned, the primary had a total of 247 turns and the secondary had a total of 302 turns. The filter network capacitor 26 used was 10 microfarads, and a reactor was used which had 240 turns with a tap at 140 turns. The reactance of the reactor at 60 cycles per second was adjusted to be approximately 10 ohms from the common terminal of its winding to the 140 turn tap. The capacitor 26 was connected across the beginning of the winding and the 240 turn tap. This will result in the capacitor and inductance being in resonance at 180 cycles per second. A pure resistance load was varied from short circuit to a full load of 4 kw., the line voltage being 240 volts and 60 cycles. It was found that the load current was 6.6 amperes at short circuit and at full load was still 6.6 amperes. With isolating transformers at full load, the current was 6.4 amperes. Then at 100% load and with 30% of the isolating transformers open-circuited, the load current was found to drop only to 6.24 amperes.

It should be apparent that variations can be made in details of construction without departing from the spirit of the invention except as defined in the appended claims.

I claim:

1. In a constant alternating current regulator system for supplying a load, the combination including a source of alternating current energy, a high leakage reactance transformer having a primary for connection to said source and secondary having a terminal for connection to the load, a first capacitor connected in shunt with said primary, a second capacitor connected in shunt with said secondary, said second capacitor having a reactance equal to the leakage reactance of said transformer referred to the secondary at the frequency of said source, and filter means in series with said terminal for connection from said secondary to said load, said filter means being tuned substantially to the third harmonic of the applied alternating current frequency so as to offer high impedance to said harmonic.

2. In a constant current alternating regulator system for supplying a load, the combination including a source of alternating current energy, a high leakage reactance transformer having a primary for connection to said source and secondary, a first capacitor connected in shunt with said primary, a second capacitor connected in shunt with said secondary, said second capacitor having a reactance equal to the leakage reactance of said transformer referred to the secondary at the frequency of said source, connecting means for adjustably connecting said load to said secondary, and filter means in series with said load, said filter means being tuned substantially to the third harmonic of the applied alternating current frequency so as to offer high impedance to said harmonic.

3. In a constant alternating current regulator system for feeding a load, the combination including a source of alternating current energy, a high leakage reactance trans-

former having a primary and secondary, a first capacitor connected in shunt with said primary, means connecting less than the entire primary to said source of alternating energy, a second capacitor connected in shunt with said secondary, said second capacitor having a reactance equal to the leakage reactance of said transformer referred to the secondary at the frequency of said source, connecting means adjustably connecting said load to said secondary, and filter means in series with said connecting means from said secondary to said load, said filter means being tuned substantially to the third harmonic of the applied alternating current frequency so as to offer high impedance to said harmonic.

4. In a constant alternating current regulator system for feeding alternating current of constant current value from an A.C. voltage source to a load, said alternating current to the load being of substantially constant current value in spite of changes in load impedance, a high leakage reactance transformer having a primary and secondary and including magnetic shunt means for providing a leakage flux path to provide a high leakage reactance referred to the secondary, means for adjustably connecting less than the entire primary to said source of alternating current voltage, a capacitor connected in shunt with said secondary, said capacitor having a reactance equal to said high leakage reactance referred to the secondary at the frequency of said A.C. voltage, said leakage reactance multiplied by said alternating current being equal to the open circuit secondary voltage of said transformer with said capacitor disconnected from the secondary, connecting means for adjustably connecting said load to said secondary, and filter means in series with said connecting means from said secondary to said load, said filter means being tuned substantially to the third harmonic of the applied alternating current frequency so as to offer high impedance to said harmonic.

5. A high leakage reactance regulator for supplying alternating current of constant current value to a load in spite of changes in the load impedance comprising transformer core means with a primary winding on said core having primary terminal means for connection to an alternating current voltage source of predetermined frequency, a secondary winding on said core having secondary terminal means for connection to the load, magnetic shunt means in said transformer for providing a leakage flux path between the primary and secondary windings, said transformer having a high leakage reactance referred to the secondary winding, a capacitor connected in shunt relationship with the secondary winding having a capacitance with a reactance equal to said high leakage reactance referred to the secondary winding at the frequency of said A.C. voltage source and filter means in series with said secondary terminal means and being tuned substantially to the third harmonic of the applied alternating current frequency for offering high impedance to said harmonic for supplying alternating current of constant current value to the load connected to the secondary terminal means in spite of changes in load impedance.

6. A high leakage reactance regulator for supplying alternating current of constant current value to a load in spite of changes in the load impedance comprising transformer core means with a primary winding on said core having primary terminal means for connection to an alternating current voltage source of predetermined frequency, a secondary winding on said core having secondary terminal means for connection to a load, magnetic shunt means in said transformer for providing a leakage flux path between the primary and secondary windings, said transformer having a high leakage reactance referred to the secondary winding, a capacitor connected in shunt relationship with the secondary winding having a capacitance with a reactance equal to said high leakage reactance referred to the secondary winding at the frequency of said A.C. voltage source and said

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leakage reactance multiplied by said alternating current being equal to the open circuit voltage of said secondary winding with said capacitor disconnected therefrom, and filter means in series with said secondary terminal means and being tuned substantially to the third harmonic of the applied alternating current frequency for offering high impedance to said harmonic for supplying alternating current of constant current value to a load connected to the secondary terminal means in spite of changes in load impedance.

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