Jan. 13, 1942. C. W. KRONMILLER 2,269,978

ELECTRICAL APPARATUS

Filed Feb. 29, 1940

Fig. 1.

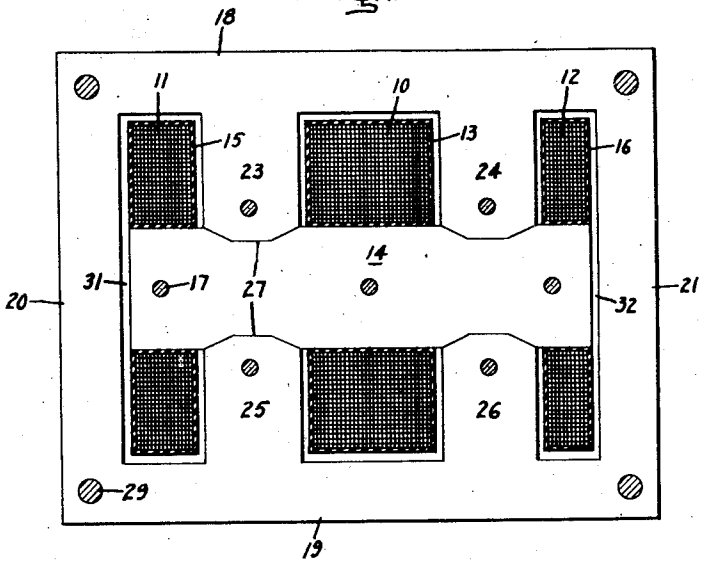
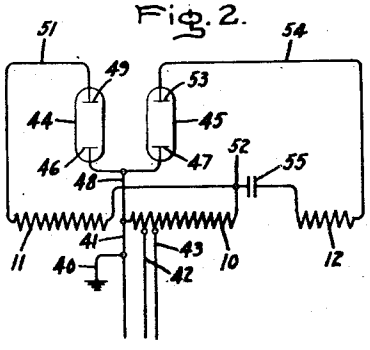


Fig. 2.



Inventor:
Charles W. Kronmiller,
by Harry E. Dunham
His Attorney.

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ELECTRICAL APPARATUS

Charles W. Kronmiller, Fort Wayne, Ind., assignor to General Electric Company, a corporation of New York

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12 Claims. (Cl. 171—119)

My invention relates to electrical apparatus for use with loads having negative resistance characteristics such as gaseous conduction lamps or arc lamps.

Gaseous electric or vapor tube lamps generally require a relatively high ignition potential due to the initial high impedance of the device but after the discharge of the lamp is started, the resistance of the tube drops to a relatively low value so that in order to limit the current of the circuit an inductive reactor is usually incorporated in the energizing circuit. The necessary reactance is usually provided by a choke coil, or, if the tube is energized through a transformer, the transformer possesses a high reactance which acts as an inductive ballast in the circuit. The power factor of such a system, however, is relatively low, usually of the order of 50 per cent, and with steadily increasing loads of this type the low power factor of such apparatus is becoming increasingly objectionable. The power factor of such a lamp circuit may be improved materially by a specially designed transformer with a capacitor which means, however, has heretofore been so expensive that in many instances its use has not been justified.

It is an object of the present invention to provide a new and improved transformer apparatus for use with gaseous electric discharge lamps and the like loads having substantially unity power factor operation characteristics and which is also otherwise efficient, simple in design, and low in manufacturing costs.

Furthermore, in most instances the illumination circuits are energized from a single phase source of current and for which reason the light output of the individual lamps varies directly as the current flowing therethrough. The result is a flickering characteristic of the lamp, that is, during each half cycle the light output varies approximately 63 per cent from a mean value. Such a variation represents a noticeable change in the light intensity and produces a stroboscopic flicker which is very objectionable, especially where persons are working with revolving machinery under the light so produced.

It is, therefore, a further object of this invention to provide a new and improved transformer apparatus for supplying electrically displaced currents for operating a pair of illuminating lamps in phase opposition so that no stroboscopic flicker is produced, which transformer apparatus is compact in design, light in weight, and efficient in operation.

In accordance with the illustrated embodiment of my invention, a transformer device is provided having a pair of reactors built into the unitary structure, each reactor being so designed to provide the necessary inductive ballast for an associated lamp. The core structure includes a central longitudinal winding leg having reactance windings on the opposite ends thereof and a transformer winding arranged in a spaced relationship therebetween. The outer shell of the core structure has two pairs of legs extending inwardly between the various windings and abutting against the central leg in such a manner as to lock it securely in position. Air gaps are provided between the opposite ends of the central winding leg and the adjacent portion of the outer shell so that the desired linear reactance characteristics are provided for the reactors.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto taken in connection with the accompanying drawing.

In the drawing Fig. 1 is a cross-sectional view in elevation of the transformer device constructed in accordance with one form of my invention and Fig. 2 is a schematic wiring diagram including the transformer shown in Fig. 1 in a circuit for supplying energy to a pair of similar arc discharge lamps.

Referring now to Fig. 1 of the drawing, the auxiliary device shown therein comprises a combined transformer and a pair of reactors particularly applicable for supplying electrically displaced currents to a pair of similar load devices having negative resistance characteristics such as arc discharge lamps. The transformer winding 10 is arranged within a central window of the unitary core structure, and reactance windings 11 and 12 are arranged within cooperating windows provided in the core structure on opposite sides of the transformer winding. The transformer winding 10 is preferably of the autotransformer type having a plurality of taps brought out for connection to a suitable source of supply though it is obvious of course that the winding 10 may be divided into two portions, a primary or low voltage winding and a secondary or high voltage winding. The transformer winding is suitably taped with insulation as indicated at 13 and is arranged upon the central winding leg 14 of the core structure. The reactor windings 11 and 12 are also suitably taped with insulation as indicated at 15 and 16, respectively, and are mounted upon the opposite ends of the central winding leg in a spaced relation with re-

spect to the intermediate transformer winding 10. The winding leg 14 is built up of punched laminations which are secured together by suitably spaced rivets 17. The outer shell of the core structure cooperating with the central winding leg to provide magnetic circuits for the various windings is similarly built up of unitary punched laminations comprising side portions 18 and 19, end portions 20 and 21, and spaced leg portions 23, 24, and 25, 26 extending inwardly from the side portions 18 and 19, respectively. The extremities of the leg portions are shaped so as to fit cooperatively into suitable notches 27 provided on opposite sides of the winding leg 14 between the transformer winding 10 and the reactance windings 11 and 12. The stack of outer laminations may be suitably secured together by means of rivets 29.

The winding leg 14 is of a length somewhat less than the distance between the inner surfaces of the end portions 20 and 21 of the outer shell so that when assembled, non-magnetic gaps or air gaps 31 and 32 are provided between the ends of the winding leg 14 and the adjacent portion of the outer shell so as to increase the reluctance of the magnetic circuit or provide a relatively high reluctance magnetic circuit for the windings 11 and 12, respectively. It is of course obvious that the exact spacings may be varied in accordance with the operating characteristics desired for the device.

The space between the extremities of the aligned legs 23, 25 and 24, 26 is preferably somewhat less than the thickness of the winding leg at the notches 27. In assembling the device, the windings 10, 11 and 12 are first mounted in their proper relative positions upon the winding leg 14. The space between the legs 23, 25 and 24, 26 is slightly widened by pulling apart the side portions 18 and 19 of the outer shell structure whereupon the winding leg 14 with the various windings mounted thereupon may be readily inserted in position. The side portions 18 and 19 of the outer shell structure are thereupon released, and the legs 23, 25 and 24, 26 will spring somewhat together to engage tightly with the winding leg at the notched portions. It is obvious of course that the winding leg can be forced into the gap opening between the extremities of the outer shell legs simply by the application of sufficient force thereto at the exposed portions thereof between the windings. As a natural consequence of such procedure, however, shearing or bending over of the engaging edges of the laminations takes place establishing short circuits between the adjacent laminations. Such short circuits, however, result in increased eddy currents and core losses and hence a material drop in the efficiency of the device. By the preferred method of assembly described, the insulation between adjacent laminations is not affected and a more efficient core structure is produced.

The extremities of the legs extending inwardly from the outer shell and fitting tightly into or squarely against the cooperating notches 27 of the central winding leg accurately position the central winding leg with respect to the opposite end portions 20 and 21 of the outer shell so that the air gaps 31 and 32 will be definitely and accurately fixed. Vibrations or rough handling of the transformer cannot cause a shifting movement of the central winding leg with respect to the outer shell to vary the original gap spacings.

Referring now to the schematic diagram of Fig. 2, the device of Fig. 1 is shown connected for supplying energy to a pair of gaseous electric lamps such as the mercury arc type. A suitable source of alternating current is connected between one terminal 41 of the transformer winding 10, which may be grounded as indicated at 40, and either of a plurality of tap connections 42 or 43 depending upon the ratio of voltage transformation desired. The gaseous electric discharge lamps 44 and 45 are connected in parallel across the transformer winding 10, the electrodes 46 and 47 of the respective lamps being connected through a common lead 48 to the transformer terminal 41. The other electrode 49 of the lamp 44 is connected by lead 51 to one terminal of the reactance winding 11, the other terminal of which winding is in turn connected to the high voltage terminal 52 of the transformer winding. The other electrode 53 of the lamp 45 is connected by lead 54 to one terminal of the reactance winding 12, the other terminal of which winding is in turn connected through the capacitor 55 to the transformer terminal 52. The self-inductance of the winding 11 is such that after the initiation of the discharge in the lamp 44 the current flowing through this circuit will be suitably limited to the normal operating value. The reactor is preferably so designed that the power factor of this circuit will be approximately 60 per cent lagging as regards the impressed voltage. The self-inductance of the reactance winding 12 is relatively smaller than the self-inductance of the reactance 11, being merely sufficient to stabilize the lamp 53 so that the circuit is predominantly capacitive due to the capacitor 55. The latter circuit including the reactor 12 and the capacitor 55 is so designed that the power factor thereof will be approximately 60 per cent leading as regards the impressed voltage. The resultant power factor of the entire load on the line will therefore be substantially unity.

It will be noted that the flux produced by the transformer winding does not link either of the reactor windings. Due to the high reluctance created by the air gaps 31 and 32 at the opposite ends of the central winding leg 14, the magnetic circuit for the transformer is restricted to the central portion of the winding leg 14 and the yoke of the outer shell including legs 23, 24 and 25, 26, and the portions of the side members 18 and 19 between the legs 23, 24 and 25, 26, respectively. The magnetic circuit for the reactor winding 11 includes the left end of the central winding leg 14, the legs 23 and 25, and the left end of the outer shell connecting the legs 23 and 25. Similarly the magnetic circuit for the reactor winding 12 includes the right end of the central winding leg 14, the legs 24, 26 and the right end of the outer shell connecting these legs. The air gaps 31 and 32 are so designed as to give the proper linear reactance characteristics to the two reactors for varying load currents. It is obvious that the legs 23 and 25 are in a magnetic circuit common to the transformer winding 10 and to the reactor winding 11, while the legs 24 and 26 are common to the magnetic circuit of the transformer winding 10 and the reactor winding 12. Since the flux produced by the reactor windings is in quadrature with the flux produced by the transformer winding, the resultant flux at any one instant in either pair of legs is materially less than the arithmetic sum which would be the case if the flux produced by all windings were in an in-phase relation so that the common legs are substantially non-saturating. By reason of this fact the cross-section of the legs 23, 24,

25, and 26 need be very little larger than would be required for the proper operation of the transformer portion alone.

By combining the transformer and the two reactors into a single auxiliary unit, as described, a compact and efficient arrangement is produced. A considerable saving in material, approximately 40 per cent, is effected over that which would be required to construct separate units for each individual lamp circuit. The transformer winding providing current for two lamps with this unitary structure requires approximately 50 per cent less copper than would be required by two individual transformers because of the fact that the two secondary currents being out of phase from each other add vectorially so that the resultant current is considerably less than the arithmetic sum of the secondary currents of separate transformers. Thus the total starting current for operating two lamps in a circuit as shown in Fig. 2 and embodying the transformer of my invention is approximately but 20 per cent of that heretofore required with transformers of conventional design. With the present auxiliary device, the starting current is even considerably less than the normal running current, hence the high switching capacity and heavy duty auxiliary wiring apparatus which are required with transformers of conventional design may be replaced by correspondingly lighter and less expensive equipment in the case of the present device.

By so proportioning the circuit inductance for the lamp 44 and the circuit capacitance for the lamp 45 that the light output of the two lamps varies in direct phase opposition, no stroboscopic effect can be observed in the resultant illumination. Even at frequencies of the power supply as low as 25 cycles per second, a satisfactory light output is obtainable.

Having described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the specific arrangement shown is merely illustrative and that the invention may be carried out in other ways than those specifically shown and described herein.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus for supplying electrically displaced operating currents to a pair of gaseous electric discharge lamps comprising a transformer winding, a relatively low reactance winding, a relatively high reactance winding, a magnetic structure for said windings comprising a longitudinal winding leg extending axially through said windings, said transformer winding being centrally arranged upon said winding leg, said reactance windings being arranged upon the opposite ends of said winding leg and spaced from said transformer winding, said magnetic structure also including an outer shell surrounding said windings and having legs extending inwardly between said windings and engaging with said winding leg so as to provide a substantially closed, low reluctance magnetic circuit for said transformer winding, and non-magnetic gaps provided between the ends of said central winding leg and the adjacent portion of said outer shell.

2. An apparatus for supplying electrically displaced operating currents to a pair of gaseous discharge lamps comprising a transformer winding and a pair of reactance windings, a magnetic structure for said windings comprising a central winding leg and an outer shell, said transformer winding being centrally arranged upon said central leg, said reactance windings being arranged upon the opposite ends of said winding leg and spaced from said transformer winding, said winding leg having notches on opposite sides thereof between said windings, said outer shell having integral legs extending inwardly between said windings and engaging with said central winding leg at said notches and with such force as rigidly to hold said central winding leg in a fixed position as regards said outer shell, and air gaps provided between the opposite ends of said winding leg and the adjacent portions of said outer shell.

3. An apparatus for supplying electrically displaced operating currents to a pair of gaseous discharge lamps comprising a transformer winding, a magnetic core structure including a central longitudinal winding leg extending through said transformer winding, a reactance winding arranged on each of the opposite ends of said central winding leg and spaced from said transformer winding, said magnetic structure also including an outer shell for cooperating with said central winding leg, said outer shell having integral legs extending between said windings and abutting against said central winding leg so as to provide a substantially closed low reluctance magnetic circuit for said transformer winding, said integral legs supporting said central winding leg so as to provide an air gap between the opposite ends of said winding leg and the adjacent outer shell portions whereby a relatively high reluctance magnetic circuit is provided for each of said reactance windings.

4. An apparatus for supplying electrically displaced operating currents to a pair of gaseous electric discharge lamps comprising a transformer winding, a first and a second reactance windings, a magnetic core structure for said transformer and said reactance windings, said core structure including a first substantially non-saturating leg common to said transformer winding and said first reactance winding and a second substantially non-saturating leg common to said transformer winding and said second reactance winding.

5. An apparatus for supplying electrically displaced operating currents to gaseous discharge lamps comprising a transformer winding, reactance windings arranged on opposite sides of said transformer winding, a magnetic structure for said windings comprising a winding leg extending axially through said windings, an outer shell having aligned legs extending inwardly between said windings, said aligned legs having portions at their ends abutting squarely against said winding leg providing a substantially closed low reluctance magnetic circuit for said transformer winding and non-magnetic gaps between the ends of said winding leg and the adjacent shell portions providing a relatively high redluctance magnetic circuit for each of said reactance windings.

6. An apparatus for supplying electrically displaced operating currents to gaseous discharge lamps comprising a magnetic core structure including a winding leg and an outer leg, a transformer winding arranged on said winding leg, a pair of reactance windings provided on said winding leg on the opposite sides of said transformer winding, said core structure including additional legs integral with one of said first mentioned legs and extending between said wind-

ings and abutting against the other of said first mentioned legs, fixed non-magnetic gaps provided between the opposite ends of said winding leg and adjacent portions of said outer leg providing a relatively high reluctance magnetic circuit for each of said reactance windings.

7. Apparatus for supplying electrically displaced operating currents to a pair of loads having negative resistance characteristics, said apparatus comprising a transformer winding, a pair of inductance windings, a unitary core structure for said windings providing a low reluctance magnetic circuit for said transformer winding and individual magnetic circuits for said inductance windings and fixed non-magnetic gaps in the individual magnetic circuits for said inductance windings to provide substantially linear reactance characteristics therefor.

8. In electrical voltage transformation apparatus for supplying electrically displaced currents, a transformer winding, a pair of inductance windings, a low reluctance core structure for said transformer winding, means providing individual magnetic circuits for each of said inductance windings including different portions of said transformer winding core structure, and fixed non-magnetic gaps in each of said individual magnetic circuits providing a predetermined substantially linear reactance characteristic for each of said inductance windings.

9. A transformer apparatus for supplying electrically displaced currents to a pair of substantially similar loads having negative resistance characteristics, said apparatus including a transformer winding and a pair of inductance windings, a unitary magnetic core structure for said windings, means for connecting said inductance windings in parallel load circuits across said transformer winding, a capacitor connected in one of said load circuits whereby the capacitive reactance of said one circuit is greater than the inductive reactance therein by an amount substantially equal to the inductive reactance in the other of said load circuits, and means including non-magnetic gaps in portions of the core structure associated with said inductance windings whereby the reactance characteristics thereof are made substantially linear for varying load currents.

10. Apparatus for supplying electrically displaced currents to a pair of substantially similar loads of negative resistance characteristics, said apparatus comprising a transformer winding, a core structure for said transformer winding, a pair of parallel circuits for connecting said winding to said loads, a first inductance winding connected in a first of said circuits, a magnetic circuit for said first inductance winding including one portion of said core structure, a second inductance winding having an inductive reactance less than that of said first inductance winding connected in the second of said circuits, a magnetic circuit for said second inductance winding including a second portion of said core structure, a capacitor connected in said second circuit of such value that the net reactance of said second circuit is capacitive and substantially balances the inductive reactance of said first circuit.

11. A transformer apparatus for supplying electrically displaced currents to a pair of loads having negative resistance characteristics, said apparatus comprising a transformer winding and a pair of inductance windings, a unitary magnetic core structure for said windings, means for connecting said transformer winding to an alternating current source of supply, means for supplying one alternating current from said transformer winding through one of said inductance windings to a first one of said loads, means including a condenser for supplying a second alternating current electrically displaced from said one alternating current from said transformer winding through the second of said inductance windings to a second load, and means including non-magnetic gaps in the magnetic circuits for said inductances to provide substantially linear reactance characteristics therefor.

12. An electrical inductance device comprising a magnetic core structure including a central portion and an outer portion, a first winding centrally arranged on said central core portion, a second and third windings arranged on said central core portion spaced from the opposite sides of said first winding, legs extending between said windings and between said central and outer core portions, said legs each being integral at one end with one of said core portions and abutting firmly at its other end with the adjacent core portion, and non-magnetic gaps between the opposite ends of said central core portion and the adjacent outer core portion, said central core portion being held in position by compression of said legs.

CHARLES W. KRONMILLER.