Feb. 24, 1959 P. J. WALSH 2,875,378

ALTERNATING CURRENT CONTROL DEVICE

Filed May 21, 1954 2 Sheets-Sheet 1

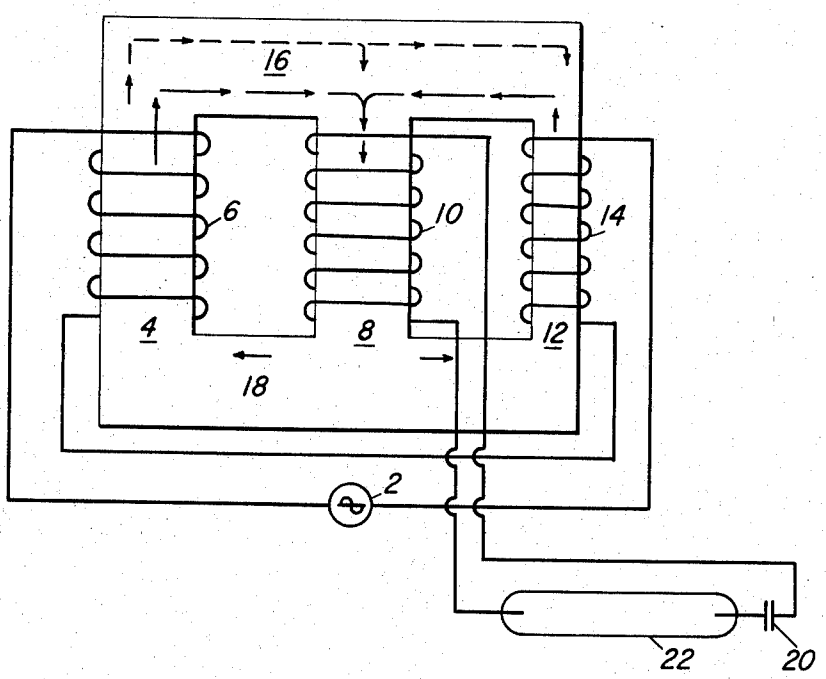


Fig 1

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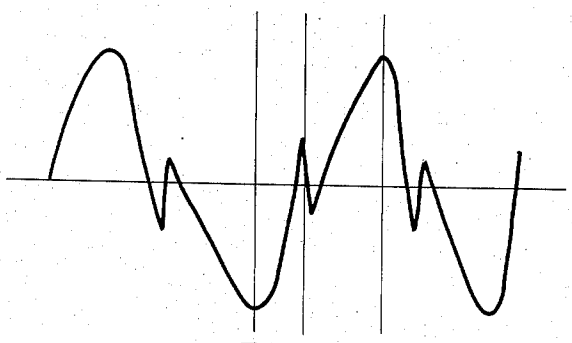


Fig 2

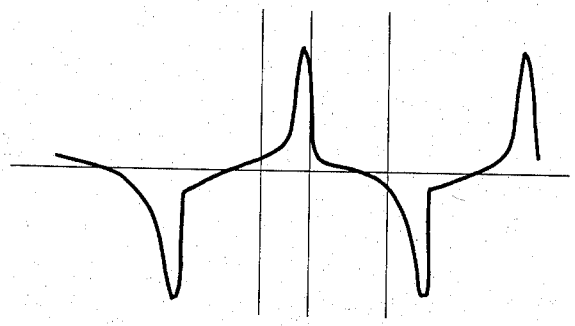


Fig 3

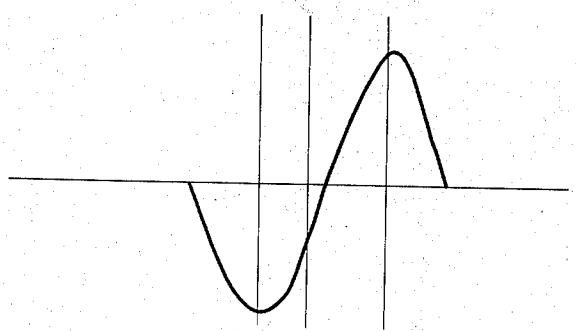


Fig 4

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2,875,378

ALTERNATING CURRENT CONTROL DEVICE

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5 Claims. (Cl. 315—100)

This invention relates to the control of current through a load having a negative resistance, or run-away, characteristic.

The fluorescent lamp is such a load and requires auxiliary equipment to develop a voltage across the lamp that is high enough to start the arc in the lamp and to control the current flow through the lamp, since the resistance of the lamp decreases as current flows.

Heretofore, this has been accomplished by employing an auto transformer to raise the line voltage high enough to start the arc and controlling the current flow by means of a very large iron core choke coil in series with the lamp.

Special high reactance transformers are used to supply the high voltage and current control function through long lengths of luminous tubing. The open circuit output voltage of these transformers can be of the order of 15,000 volts and when the proper luminous tube load is connected across the output, this voltage value falls to less than 7,000 volts after the arc starts in the tube. With this type of transformer this high voltage loss is necessary in order to control the current through the tube. The power factor of such a transformer is lagging and is of the order of 50%. The light output of tubing connected to such a transformer varies with variations in line voltage.

It is one of the objects of my invention to obviate these disadvantages and to provide a low cost, light weight and efficient control device that operates a given length of luminous tubing at less than half the required output voltage of the conventional transformer.

It is another object of my invention to provide a control device for electric discharge tubes having a high power factor.

It is still another object of my invention to provide a control device that produces a constant light output from the lamp regardless of large line voltage variations.

My invention possesses many other advantages and has other objects which may be made more easily apparent from a consideration of one embodiment of my invention. For this purpose, I have shown a form in the drawing accompanying and forming part of the present specification. I shall now proceed to describe this form in detail, which illustrates the general principles of my invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of my invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a system diagram depicting one form of my invention;

Figures 2, 3, and 4 are drawings for facilitating explanation of the invention.

In Fig. 1 I show a fluorescent-tube lighting circuit employing a preferred embodiment of my invention. As is illustrated in this schematic diagram, a generator 2, which can be the ordinary commercial power supply, is connected to a three-legged transformer having the customary laminated steel core. The core comprises an

outer leg 4, carrying a primary winding 6, a center leg 8, on which is wound a secondary winding 10, and another outer leg 12 carrying a second primary winding 14. Windings 6 and 14 are connected in series with the source 2, the connections being such that the magnetomotive forces set up by current through the winding develop fluxes in the legs and in yokes 16 and 18 respectively, joining the three legs, in the directions indicated by the solid arrows. The secondary winding 10 connects in series with the load, a series condenser 20 preferably, but not necessarily, being interposed in the circuit in series with the fluorescent lamp 22.

The parts are so proportioned that when the load is disconnected the voltage drop across the winding 14 is less than that across the winding 6. This can be accomplished in either of two ways; the cross-section of the leg 12 may be smaller than that of legs 4 and 8, the number of turns in coil 14 may be less than the turns of coil 6, or the two expedients may be combined. As a result of this arrangement, at instants when higher values of current are being drawn by the load and, as a result, relatively high counter-magnetomotive forces are set up by the coil 10 in the core, the flux distribution through the core will be as indicated by the dotted arrows.

In a test of my invention satisfactory operation was obtained when the number of turns in the coil 6 was greater than the number of turns in coil 14. That is, in the test referred to, coil 6 contained 800 turns and coil 14 contained 600 turns.

Several models embodying the principles of my invention were constructed and tested. As shown in the drawing, the core is arranged so that the leg 12 is of one half the cross-sectional area of the legs 4 and 8 and the yokes 16 and 18. This is the most economical form, however, other core forms can be employed provided the turns in the coils are properly proportioned to produce the necessary operating magnetic flux characteristics.

The core can be made of low cost silicon steel laminations, preferably the sheets marketed as Transformer No. 52, by several steel companies. The laminations are tightly stacked and lapped at the joints in order to avoid air-gaps. The yokes 16 and 18 are short, so that the coils are as close together as possible.

When the flux linking the winding 10 is changing, an electromotive force equal to the time rate of change of the flux linkage is generated in this winding and tends to send current through winding 10 in a direction to oppose the change in flux. The luminous tube load 22 connected across the terminals of coil 10 acts as a switching load with a negative resistance characteristic. That is, during each half cycle, the arc starts in the tube when the voltage across the tube reaches a definite value and stops when the voltage value is too low to maintain the current flow through the tube. This action develops a sort of rhythm between the load 22 and the flux in the leg 8. The flux in the leg 12 reaches saturation value before the current flowing in coil 14 reaches its maximum value. When this point in the current cycle is reached, only the coil 6 continues to produce a flux change in the leg 8 as the current builds up to its maximum value.

The control of the current is due to several factors which combine to produce a constant current effect. The load current flowing in coil 10 develops an opposing magnetomotive force in leg 8 thus forcing some of the flux from leg 4 over to leg 12. This flux develops a bucking voltage in coil 14 at one instant and in coil 6 at another instant which acts to maintain the value of the current substantially constant regardless of very large line voltage variations. Figure 2 is an oscillogram of the voltage wave across the terminals of coil 6 and Figure 3 is an oscillogram of the voltage wave across the terminals of coil 14, which shows this effect. These oscillograms were obtained

by connecting an oscilloscope directly across the coils and indicate that the peak voltage across coil **6** equals that across coil **14** and has a value of 140 peak volts when the applied voltage of source **2** has an effective value of 110 volts. Figure 4 is an oscillogram of the voltage across the terminals of the source **2**. It is seen that when this voltage reaches its maximum value, the voltage across coil **6**, as shown in Figure 2, is passing through its maximum value and Figure 3 shows that the voltage across the coil **14**, is very near zero value at this instant.

In one comparative test of my invention, the load **22** comprised a fourteen foot length of twelve millimeter tubing. According to the standard chart published by the manufacturers of luminous tube transformers, this length of tubing requires a conventional transformer having an open circuit output voltage of 5,000 volts. The open circuit voltage developed across the coil **10** during this test was 2,200 volts. The light output of the tube, as measured by a foot-candle meter, was equal to that developed by the tube when connected to the conventional transformer. The condenser **20** had a value of one tenth microfarad and raised the power factor from 79%, without the condenser connected in the circuit, to 92% with the condenser connected as shown.

In another test of my invention the load **22** comprised an 8 foot cold cathode lamp having a diameter of one inch and operating current of 120 milliamperes. Condenser **20** had a value of six tenths microfarad. The light output from the tube was substantially constant while the line voltage was varied and the power factor was 95%.

I claim:

1. A transformer for supplying gas-discharge tubes comprising a closed magnetic core having two end legs and a center leg connected by yokes, a pair of primary windings disposed on the two end legs of said core and connected in series so as to develop magnetomotive forces acting in the same direction through the center leg of said core, said series-connected windings being adapted for connection to a relatively low-voltage source of alternating current power and a relatively high-voltage secondary winding disposed on said center leg, the product of the number of primary turns on one of said end legs times the cross-sectional area of the leg whereon it is disposed being materially greater than the product of the number of turns of the other of said end legs times the cross-sectional area of the leg whereon it is disposed.

2. A transformer for supplying gas-discharge lighting tubes comprising a closed magnetic core having three legs connected by yokes, said legs including a first end leg and a center leg of substantially equal cross-section and a second end leg of materially smaller cross-section, a section of primary winding disposed on said second end leg, a second primary winding section having a number of turns

at least equal in number to those of said first primary winding section disposed on said first end leg and so connected in series with said first primary winding section as to develop magnetomotive forces in the same direction through said center leg, said primary winding sections being adapted for connection to a relatively low voltage source of alternating current power, and a relatively high voltage secondary winding disposed on said center leg.

3. A transformer as defined in claim 2 wherein the number of turns of said second primary winding-sections is materially greater than the number of turns of said first primary winding sections.

4. A transformer for supplying gas-discharge tubes comprising a closed magnetic core having two end legs and a center leg connected by yokes, primary winding-sections adapted for connection to a relatively low voltage source of alternating current power disposed on said end legs and so connected in series as to develop magnetomotive forces acting in the same direction across said center leg, one of said primary winding sections having a materially less number of turns than the other, and a relatively high voltage secondary winding disposed on said center leg.

5. In a gas-discharge tube lighting circuit, a transformer comprising a closed magnetic core having three legs connected by yokes and including two end legs and a center leg, a primary circuit adapted for connection to a power source and comprising two winding sections connected in series and disposed on said two end legs respectively, the product of the number of turns of one of said winding sections times the cross-sectional area of the core on which it is disposed being materially greater than the product of the number of turns of the other of said sections times the cross-sectional area of the core-leg whereon it is disposed and a secondary circuit consisting essentially of a secondary winding disposed on the center leg of said core, gas discharge apparatus having a negative impedance characteristic and a condenser connected in series.

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