Feb. 6, 1968 F. S. TOBEY 3,368,140

VARIABLE AUTOTRANSFORMER

Filed Nov. 12, 1964

Fig. 1

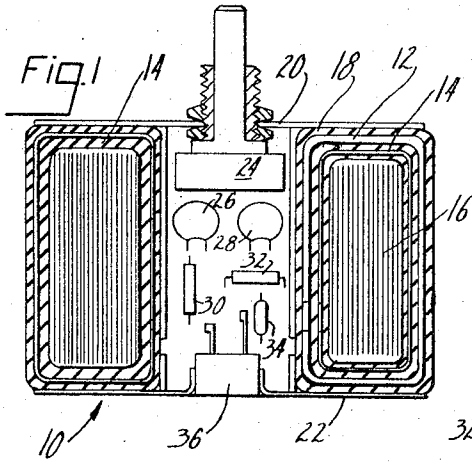
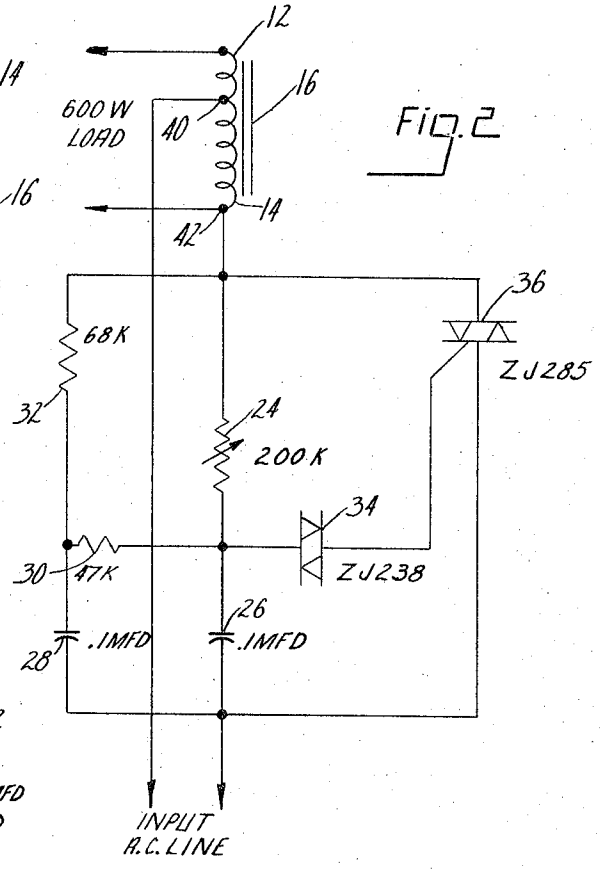


Fig. 2



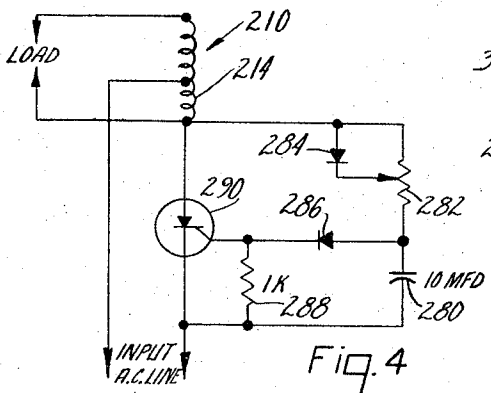
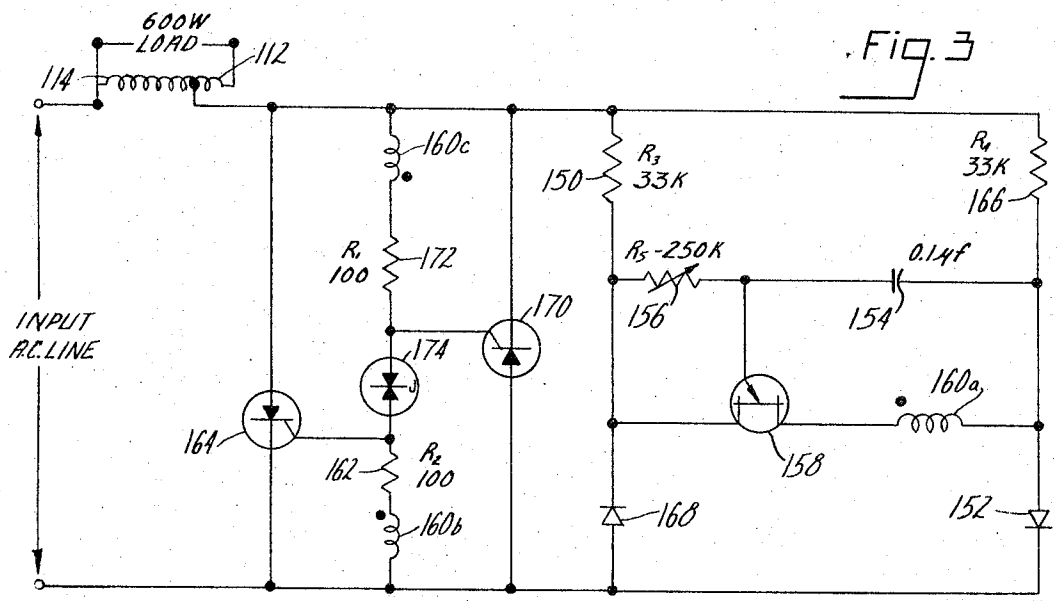


Fig. 4

Fig. 3



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VARIABLE AUTOTRANSFORMER

Frederic S. Tobey, Walpole, Mass., assignor to W. H. Brady Co., Milwaukee, Wis., a corporation of Wisconsin

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ABSTRACT OF THE DISCLOSURE

A variable autotransformer system with semiconductor switch elements to control the point in each half cycle at which current may flow through the input winding.

This invention relates to variable autotransformers.

A primary object of the invention is to provide a variable autotransformer capable of handling many times the wattage of a prior art autotransformer of the same size. Further objects are to provide such a device free of any movable contact shortcircuiting adjacent turns, in which wire of greater diameter may be used outside the transformer input contacts than inside them, in which wire may be distributed in the transformer in the most efficient way, including winding in more than a single layer, in which higher operating temperatures can be tolerated and at the same time because of winding efficiencies permitted the same wattage produces lower temperatures than in prior art devices, in which winding need be less precise inasmuch as a smooth outer surface is not required, and which makes possible obtaining higher power ratings at less manufacturing expense.

Generally speaking, my invention in its basic aspect contemplates providing an autotransformer in a circuit which provides for selectively varying the fraction of available system energy supplied to a load. In preferred embodiments, wire diameter is less (permitting smaller autotransformer sizes) inside the transformer input contacts than outside them, the transformer is wound in a plurality of layers, and particular circuitry is used.

Other objects, features, and advantages will appear from the following description of preferred embodiments of the invention, taken in conjunction with the attached drawings, in which:

FIG. 1 is a view, somewhat diagrammatic, of the preferred autotransformer, showing it cut generally centrally by a vertical plane;

FIG. 2 is a circuit diagram of the said embodiment;

FIG. 3 is a circuit diagram of a first modification; and

FIG. 4 is a circuit diagram of a second modification.

Referring now more particularly to the drawings, there is shown in FIG. 1 a generally toroidal autotransformer 10 in which turns of heavy wire 12 lie outside the input contacts and turns of light wire 14 lie within the said contacts, in one portion of the transformer as shown the heavy wire 12 overlying the light wire 14. All the turns are wound on laminated iron core 16, and each winding is in contact on both its sides with insulating layers, including outside the outermost windings insulating layer 18, against which rest heat sinks 20 and 22.

Inside the autotransformer windings is ample room for variable resistance 24, capacitors 26 and 28, resistors 30 and 32, diffused silicon bi-directional trigger diode (Diac) 34, and three-electrode AC semiconductor switch (Triac) 36. The circuit diagram of this embodiment is FIG. 2. Transformer input contacts 40 and 42 are in series with variable resistor (up to 200 kiloohms) 24 and capacitor 26 (0.1 microfarad). In series with capacitor 26 and parallel with variable resistor 24 is Diac 34 (supplied by the General Electric Company under the designation ZJ 238), which acts as a trigger for Triac 36 (supplied

by the General Electric Company under designation ZJ 285), which is connected in parallel with both variable resistor 24 and capacitor 26.

Capacitor 28, resistor 30, and resistor 32 may be omitted if desired, although in this event variable resistor 24 must be adjusted after operation begins in order to achieve the lowest operating energy levels. Inclusion of these elements in the circuit permits an initial setting that will permit such levels, eliminating the asymmetry otherwise present.

In operation, as voltage begins to rise in a new A.C. cycle, capacitor 26 begins to charge through variable resistor 24. When the capacitor 26 is charged to a voltage corresponding to the breakover voltage of Diac 34, the latter triggers Triac 36 whereupon the latter becomes conducting, and full current flows through the coil wound from wire 14. The point in the sine wave of each cycle at which current starts flowing through the autotransformer coil can be varied as desired by the setting given the variable resistance 24, the energy obtained from the transformer being of course the area under the sine curve (voltage versus time). Not only may energy output be thus selectively varied, but peak voltage may similarly be varied, by initiating current flow through the coil at selective times later than 90° in each half cycle. In any event, as voltage drops to zero at the end of each half cycle, Triac 36 becomes once more non-conducting, and the process is repeated.

Although the circuitry of my preferred embodiment of autotransformer provides selective chopping of input energy, my invention contemplates chopping of the autotransformer output instead, although this has the disadvantage of requiring that higher voltages be dealt with. In this preferred embodiment, as in typical prior art constructions, maximum R.M.S. output voltage, from a 117 volt source, is 132 volts, but safe output wattage is 600, not 200.

In the embodiment shown and described, I have provided an autotransformer that, while no larger than typical commercial autotransformers capable of handling without overheating an output of only 200 watts, is capable of handling without difficulty a 600 watt output. Not only does elimination of the sliding contact permit less concern for oxidation and higher operating temperatures, but protection of the surfaces is practical, and winding arrangements resulting in less heat generation at given wattages are practical.

Modified circuitry for use between the power source and the coil is shown in FIG. 3. Here circuitry used with primary 114 of the autotransformer includes resistance 150 (33 kiloohms) and diode 152 (which may suitably be that designated by the General Electric Company as 6RS5GD1BAD1). In each new half cycle in which current polarity causes passage of current through diode 152, capacitor 154 is charged through variable resistance 156 and resistance 150. When a sufficient charge is built up in capacitor 154, unijunction transistor 158 (which may suitably be one sold by the General Electric Company under the designation 2N2646) discharges capacitor 154 through primary 160*a* of a transformer having two secondaries 160*b* and 160*c*. Discharge through primary 160*a* produces in secondary 160*b* a pulse which, applied through resistor 162 (100 ohms) fires silicon controlled rectifier 164, whereupon current flows through primary 114 of the autotransformer for the remainder of that cycle. As the next half cycle is begun, the same process is repeated, except through resistance 166 (corresponding to resistance 150) and diode 168 (corresponding to diode 152), and except that now a pulse in secondary 160*c* fires silicon controlled rectifier 170 (corresponding to SCR 164) through resistance 172 (corresponding to resistance 162). Thyrector 174 (which may suitably be that designated 6RS5SP5B5 by the General Electric Com-

pany) prevents excessive gate back voltage. Variable resistance 156 is adjustable to selectively regulate the rate at which capacitor 154 charges, and thus the time in each half cycle at which current begins flowing freely through the autotransformer primary. Maximum R.M.S. output voltage is again 132.

In the modified circuitry of FIG. 4, only alternate half cycles energize the autotransformer primary 214, and the autotransformer 210 is designed to give a 382 volt peak output from a 120 volt R.M.S. supply. (This takes into account the differences between peak and R.M.S. voltages and provides a wattage with the same load, equivalent to that provided by the 132 volt output of FIG. 3.) When polarity is proper, capacitor 280 is charged through variable resistance 282 and diode 284. The charge on capacitor 280 acts through diode 286 and resistance 288 on silicon controlled rectifier 290, which fires to permit full autotransformer action for the remainder of the half cycle.

I have thus discovered a variable autotransformer that not only gives selective voltages up to a figure predeterminedly higher than line, but in addition at low expense and without undue bulk will handle wattages many times that of prior art devices of the same size. Other embodiments within the claims that follow will occur to those skilled in the art.

I claim:

1. A variable autotransformer comprising a core, a coil of wire including a primary portion and a secondary portion encompassing more turns than said primary portion, and circuitry connected with said coil to restrict flow of current through said primary portion to a small amount during a fraction of a power half cycle and permit flow therethrough of a much greater amount during a different fraction of a power cycle.

2. A variable autotransformer comprising a coil of wire having a secondary portion encompassing more turns than a primary portion, and circuitry connected with said autotransformer to provide full current flow therethrough during a selectively predetermined fraction of a current half cycle.

3. The autotransformer of claim 2 in which said circuitry includes a capacitor, a variable resistance selectively variable to vary the rate of charge of said capacitor, and a switching arrangement responsive to a predetermined charge in said capacitor to initiate full current flow through one of said primary portion and said secondary portion during said half cycle.

4. The autotransformer of claim 3 in which said switching arrangement comprises a diffused silicon bidirectional trigger diode responsive to the charge on said capacitor and a three-electrode AC semiconductor switch adapted to be triggered thereby to permit full current therethrough and through one of said primary portion and said secondary portion.

5. The autotransformer of claim 3 in which said switching arrangement comprises a pair of oppositely oriented diodes, each with cooperating resistance, for charging said capacitor through said variable resistance during alternate half cycles of current, a unijunction transistor responsive to said predetermined charge to pulse the primary of a second transformer having a pair of secondary windings, and a pair of oppositely oriented silicon controlled rectifiers connected to be fired through a pair of resistances by resultant pulses in said secondary windings during alternate half cycles of current to permit full current flow thereafter in a respective half cycle through the respective silicon controlled rectifier and one of said primary portion and said secondary portion.

6. The autotransformer of claim 3 in which said switching arrangement comprises a diode charging said capacitor through said variable resistance on alternate half cycles only, and in turn triggers on reaching a predetermined charge a silicon controlled rectifier connected to thereafter in said half cycle permit full current through one of said primary portion and said secondary portion.

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JOHN F. COUCH, *Primary Examiner.*

W. E. RAY, *Assistant Examiner.*