

Dec. 2, 1958

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2,863,071

VARIABLE RESISTANCE STARTING CIRCUIT

Filed Dec. 20, 1957

FIG. 1

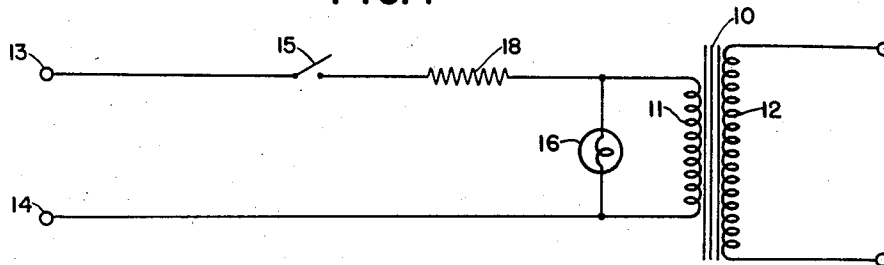


FIG. 2

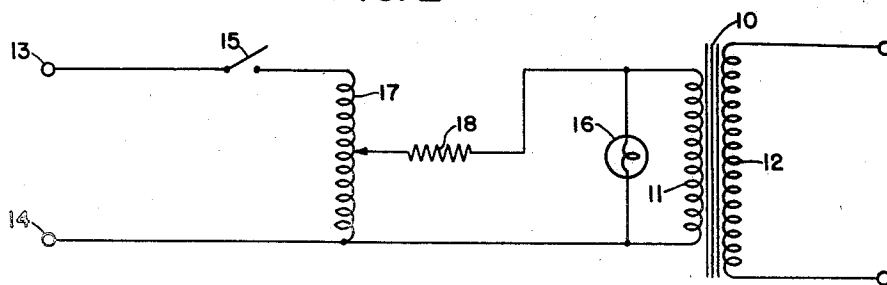
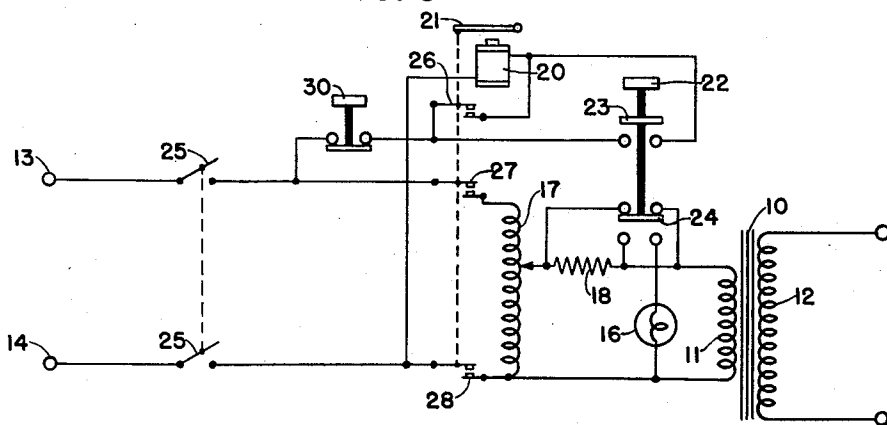


FIG. 3



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VARIABLE RESISTANCE STARTING CIRCUIT

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Application December 20, 1957, Serial No. 704,118

5 Claims. (Cl. 307—93)

This invention relates to a starting circuit for reducing transient voltages when electric power is applied to a circuit containing an inductor. It relates specifically to a non-linear resistance in combination with the primary winding of a high voltage transformer to reduce the transient high voltage pulses which otherwise would appear at the terminals of the transformer secondary winding.

One of the methods for reducing transient currents is to place a variable autotransformer in the circuit preceding the high voltage transformer. The variable transformer must be set to zero before the power supply is switched on, then the variable transformer is turned to increase the voltage until the proper output voltage is obtained. This method is obviously time consuming and there is always the possibility of an operator neglecting to set the variable transformer to a low value before switching on the power. The present invention employs a non-linear resistor connected in parallel with the primary of a high voltage transformer and is not subject to mishandling nor mistakes by an operator.

One of the objects of this invention is to provide an improved starting circuit which always reduces the transient voltages in a starting circuit and avoids one or more of the disadvantages and limitations of prior art circuits.

Another object of the invention is to reduce the transient currents from a starting circuit while at the same time providing maximum steady state currents and voltages in a very short time.

Another object of the invention is to protect the secondary winding of a high voltage transformer and other apparatus connected to its from high voltage transients.

Another object of the invention is to simplify the starting circuit of a high voltage power supply.

Another object of the invention is to provide a simplified switching arrangement for eliminating transient voltages from a high voltage power supply when the power is first applied and then disconnecting a non-linear resistance for the steady state operation.

The invention includes a non-linear resistor connected in parallel with an inductor. Switching means are provided for connecting both the inductor and the resistor to a source of alternating current power. The non-linear resistor has a cold resistance which is substantially less than its resistance when passing steady current from the power source.

One type of circuit designed in conformity with the above provisions includes a tungsten filament lamp connected across the primary winding of a high voltage transformer in series with a resistor.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a schematic diagram of the invention in its simplest form.

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Fig. 2 is an alternate arrangement of the components shown in Fig. 1 but including a variable autotransformer.

Fig. 3 is a schematic diagram of connections showing a switching arrangement in combination with a relay which first connects the non-linear resistor during the starting period and then disconnects it.

Referring now to the figures, a transformer 10 having a primary winding 11 and a secondary winding 12 is connected to input terminals 13, 14, in series with a starting switch 15, and a resistor 18. A non-linear resistor component 16 is permanently connected across the terminals of primary winding 11. The non-linear resistor 16 must have a low resistance when cold and a substantially higher resistance when the switch 15 is closed and current is passed through resistor 16 from the alternating current supply. There are many forms of non-linear resistors which have the above described property, the ordinary tungsten filament lamp being the most convenient and the cheapest to use for this purpose.

The characteristics of a tungsten filament are such that, if a lamp is employed in the circuit having a voltage rating equal to the voltage of the alternating current supply, its cold resistance is about one-tenth its resistance when passing current and heated to incandescence.

Were it not for resistors 16 and 18, when switch 15 is first closed there would be a rush of current through winding 11, because there is no magnetic flux in the core to provide any back-electromotive force at the start. This initial rush of current would produce a high voltage pulse in secondary winding 12 if resistors 16 and 18 were not in the circuit. The presence of resistor 16 with its low resistance draws a large initial current pulse which is limited by resistor 18. The voltage across resistor 16, and therefore winding 11 is quite low, as the division of line voltage is determined by the ratio of resistances 16 to 18. As the current assumes a steady value, the temperature of resistor 16 is raised to incandescence and its resistance is substantially increased, thereby consuming only a small amount of power, and reducing the voltage drop across resistor 18. In most applications the time interval from the closing of switch 15 until a steady state is reached is approximately one-twentieth of a second. During this time interval the voltage across resistor 16, and also winding 11, rises slowly, eliminating all the high voltage transients from secondary winding 12.

The circuit diagram shown in Fig. 2 is similar to that shown in Fig. 1 except that a variable autotransformer 17 has been added to the circuit in order to make it adjustable for a range of output voltages. The operation of this circuit is the same as the operation of the circuit shown in Fig. 1.

Fig. 3 illustrates a switching arrangement which may be applied to the circuit shown in Fig. 2. The purpose of this arrangement is to connect the non-linear resistor 16 across the terminals of winding 11 during the starting interval and then, after the currents have reached a steady state, disconnect resistor 16 and short resistor 18 in order to increase the efficiency of the circuit. This switching arrangement includes a manually operated "Start" switch and a relay having a winding 20 and an armature 21. The Start switch includes a manually operable button 22 and two switch blades 23 and 24. Blade 23 connects the relay winding 20 to the power line while blade 24 connects the non-linear resistor 16 across the primary winding 11. A manually operable main switch 25 is used to connect the input terminals 13, 14, to the circuit.

The relay armature 21 is mechanically connected to three normally open contacts 26, 27, and 28. Contacts 26 are locking or holding contacts and retain the relay in its actuated condition until the power line is broken

by an Off switch 30. Contacts 27 and 28 apply the main source of power to autotransformer 17.

When it is desired to connect the system to the source of power 13, 14, switch 25 is first closed. Then the start button 22 is depressed and blades 23 and 24 actuate the relay and connect resistor 16 in the circuit. As soon as the relay is actuated contacts 27 and 28 are closed and power is applied to the autotransformer 17 and the start circuit as shown in Fig. 2. It should be noted that both resistors 16 and 18 are in the circuit and eliminate voltage transients as explained above.

The start button 22 may be released almost immediately after its depression because the starting action of the circuit is always faster than manual operation. When blade 23 breaks the circuit to the relay winding 20 the relay is retained in its actuated condition because contacts 26 are closed and are connected across the terminals which were closed by blade 23. Blade 24 breaks the circuit to resistor 16 and, in its normal position, shorts out resistor 18, thereby connecting primary winding 11 directly to the autotransformer 17 with no other components in the circuit.

The switching arrangement shown in Fig. 3 is only one of many possible arrangements which may be applied to the circuit shown in Fig. 2 or to many other types of circuits employing the same general idea of connecting a non-linear resistor across the terminals of an inductor.

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

I claim:

1. A variable resistance starting circuit for reducing transient current in an inductor comprising; a non-linear resistor having a cold resistance substantially less than its resistance when passing steady current from a source

of alternating current power which heats said resistor to a temperature above 500 degrees centigrade, switching means which connects the non-linear resistor and the inductor in parallel prior to the application of said source of power, and additional switching means which disconnects said non-linear resistor when a steady current is flowing.

2. A variable resistance starting circuit for reducing transient currents in the primary winding of a high voltage transformer comprising; a metal filament connected in parallel with said primary winding, a first switching means for connecting both the primary winding and the filament to a source of alternating current power in series with a current limiting resistor, said power adapted to heat the filament to a temperature of more than 500 degrees centigrade, said filament having a cold resistance substantially less than its resistance when passing steady current from said power source, and a second switching means which disconnects said filament when a steady current is flowing.

3. A variable resistance starting circuit as set forth in claim 2 wherein said second switching means also shorts said current limiting resistor when a steady current is flowing.

4. A variable resistance starting circuit as set forth in claim 2 wherein said metal filament comprises a tungsten filament lamp.

5. A variable resistance starting circuit as set forth in claim 2 wherein said first and second switching means are operated by a single switching arrangement.

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