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AUTOTRANSFORMER VOLTAGE REGULATOR

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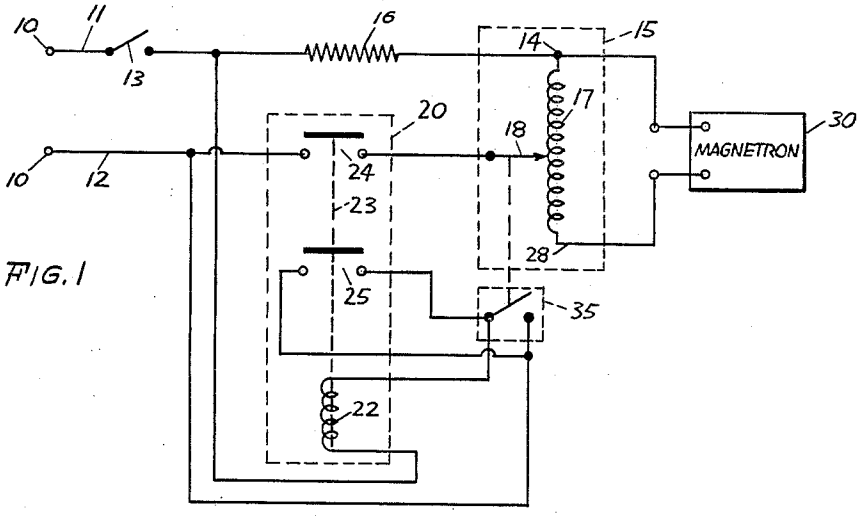


FIG. 1

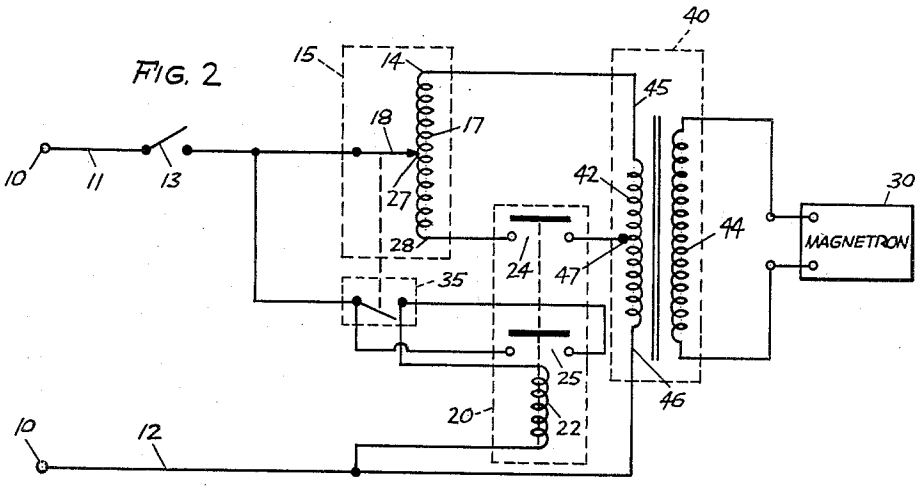


FIG. 2

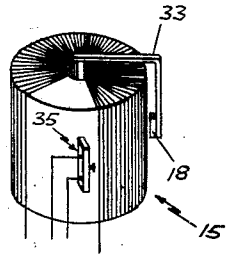


FIG. 3

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AUTOTRANSFORMER VOLTAGE REGULATOR

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This invention relates to a control circuit for a variable voltage power supply and, more particularly, relates to a system for permitting application of energy of variable voltage to an output utilization device only when said voltage is a minimum.

In certain types of equipment, particularly systems for supplying energy to a magnetron, undesirable voltage and current surges in the power supply and in the magnetron occur when full operating voltage is suddenly applied. These surges not only cause sputtering of the cathode with an attendant decrease in life of the magnetron but may cause the magnetron to operate in an undesirable mode. In addition, these surges cause short time overloads in the power supply, thereby affecting the life of the tubes used therein.

It is desirable, therefore, to provide means for preventing a high voltage supply from being energized above a predetermined amount unless or until the voltage varying means is set to a position corresponding to minimum voltage. Furthermore, if a power failure occurs or any element of the control circuit opens, it is essential that the voltage varying means be reset to the position corresponding to minimum voltage before full power can be reapplied.

One system for varying the high voltage supplied to a magnetron or other utilization means includes a variable autotransformer having a winding whose terminals are connected either directly to the utilization means or in parallel with a portion of the primary of a high voltage transformer which is, in turn, connected to said utilization means. The autotransformer, which is energized by an input source of relatively low voltage, is provided with a movable contact or arm which is adapted to move along the winding of the autotransformer between certain limits, which may be the terminals of the winding, in order to vary the transformation ratio of the autotransformer. When the movable arm is at one of the aforesaid limits, the voltage across the output of the autotransformer, and consequently the high voltage output is a minimum while the output, voltage obtained at the other limit is a maximum.

In accordance with one embodiment of this invention, the variable autotransformer is so designed that, when set to the minimum position, that is, the position corresponding to minimum voltage, the movable arm closes a starting point control switch. This switch is in series with a relay coil which is energized by a suitable source whenever the switch is closed. This relay has a normally open main contact in series with the input circuit of the autotransformer. When the aforesaid switch is closed and the relay is actuated, the contact closes, thereby producing an output voltage across the terminals of the auto-

transformer winding less than the aforementioned predetermined amount. Whenever, upon starting, the control switch is open, however, that is, whenever the autotransformer arm is not at the minimum position, when the system is started, the output voltage is zero because the input circuit is interrupted, provided that the relay is initially deenergized. It is necessary, therefore, when the autotransformer is set initially at other than the minimum position or when the output voltage has been cut off in some manner during operation to reset the movable arm to the minimum position before a high voltage output above the predetermined amount can be obtained. Once this minimum position is obtained, a holding contact on the relay maintains the latter energized after the movable arm is moved away from the minimum position.

Although the system just described often provides satisfactory operation, particularly at lower voltages, it sometimes happens in certain applications that when the relay main contact is in series with either side of the input line, considerable arcing of the contact will occur when such contact closes because of high transient starting currents. This current surge causes pitting of the contact and the life of the relay may be reduced to a relatively few operations.

In accordance with a second embodiment of this invention, the output terminals of the autotransformer are connected across a portion of the primary of a high voltage transformer and the main relay contact is positioned in the line between one of the autotransformer terminals and a tap on the high voltage transformer primary. With this arrangement, the current flowing through the relay contact becomes quite small and injury to the contact is prevented or substantially reduced. In this manner the contact used may have low current points since the contact is never made under a heavy load condition. This arrangement is particularly suitable for providing high voltage excitation for a magnetron which tends to sputter or to oscillate in an undesired mode when suddenly subjected to a voltage in excess of some predetermined amount.

Although this arrangement permits the application of input voltage to the high voltage output transformer, even when the relay is deenergized, this input voltage is applied across a portion of the autotransformer winding and all of the high voltage transformer primary winding in series. Since the voltage applied to the primary winding of the high voltage transformer is less than the line or input voltage, the output voltage derived from the secondary of this high voltage transformer is insufficient to cause the magnetron to oscillate.

When the moving arm has reached the minimum position and the switch has closed, the relay is energized and its main contact is closed. At this time the input or line voltage is across the entire primary winding of the high voltage transformer and the voltage across its secondary is still insufficient to permit the magnetron to oscillate.

Once the autotransformer arm has been returned to the minimum position, the holding contact of the relay is closed, and the relay remains energized. The arm can now be moved away from the minimum position and the input voltage is applied across a portion only of the high voltage transformer primary and a variable portion of the autotransformer winding in series. The primary voltage and, consequently, the output voltage may now be increased as the arm is moved further away from the minimum position until the output voltage across high

voltage transformer secondary is sufficiently great to permit the magnetron to oscillate. The magnitude of the output voltage is dependent upon the position of the movable arm along the autotransformer winding.

In the drawings:

Fig. 1 is a schematic diagram of a first embodiment of the subject invention;

Fig. 2 is a schematic diagram of a second embodiment of the subject invention; and

Fig. 3 is a view showing certain details of the autotransformer and control switch of Figs. 1 and 2.

In the drawing, like reference numerals refer to corresponding elements. In Fig. 1, an alternating current input voltage from any appropriate source, such as conventional 110 volt-60 cycle A. C. power mains, is available at input terminals **10** to which a pair of input lines **11** and **12** are connected. One of these input lines **11** is connected through a switch **13** and a current limiting resistor **16** to one terminal **14** of the single winding **17** of a variable autotransformer **15** which includes a movable sliding contact member or arm **18** which may be either manually or mechanically driven in electrical contact with the turns of the winding. Winding **17** may be toroidal, in which case the arm **18** is adapted to rotate about the periphery of the winding over bared portions of insulated winding turns, as shown in Fig. 3. Although a single pole switch is shown in line **11** of Fig. 1, it is possible to use a double pole switch connected in both lines **11** and **12**. Furthermore, one of the two lines may be grounded. The other input line **12** is connected to the arm **18** of autotransformer **15** through the medium of a relay **20**, comprising an actuating winding **22** connected across the input terminals **10**, an armature **23**, a normally open main contact **24** and a normally open holding contact **25**.

Output terminals **14** and **28** of autotransformer winding **17** are connected to an output utilization device shown, by way of example, as a magnetron oscillator **30**.

A starting point control switch **35** is connected across the holding contact **25** of relay **20** and is adapted to close whenever arm **18** reaches terminal **28** of winding **17**. Control switch **35** may be mechanically linked to the control arm or may be a micro switch mounted on the autotransformer assembly **15** and actuated by the rotary element **33** of the autotransformer to which arm **18** is attached, as shown in Fig. 3.

As previously stated, whenever, for any reason, it is desired to supply high voltage to a deeenrgized output means of the magnetron type, it is essential that the latter be energized at a voltage below a certain predetermined amount. A glance at Fig. 1 will indicate that the minimum voltage will be derived across output terminals **14**, **28** of the autotransformer when the arm **18** is in contact with terminal **28** of the winding since the input voltage is then applied across the entire winding and the transformation ratio of autotransformer **15** is unity. As the arm is moved away from terminal **28** and toward terminal **14**, the transformation ratio is increased.

When the magnetron is initially deenergized, either because of line switch **13** being opened or because of some fault in the system, or if the arm **18** is not in the minimum position, relay coil **22** cannot be energized because control switch **35** is open and the series path, including the relay coil and the control switch, is open. Since line **12** is open, it is impossible to reapply an input voltage across a portion only of the autotransformer winding.

If the arm **18** is reset to terminal **28**, however, control switch **35** is closed, relay coil **22** becomes energized and both the main contact **24** and the holding contact **25** of relay **20** close. Since the circuit between the input or line terminal **10** and the autotransformer is now completed, a voltage is derived across the output terminals **14**, **28** of the autotransformer. This voltage is equal to the input voltage, neglecting transient effects owing to winding inductance, since the transformation ratio of the autotransformer is unity. The voltage initially applied to the magnetron at the instant switch **35** closes is not sufficient to initiate oscillations in the magnetron. Once the relay coil is energized and the relay armature actuated, the holding circuit including contact **25** shunting control switch **35**, maintains the relay actuated even though arm **18** is backed off from terminal **28** and control switch **35** opened. It is then possible to adjust arm **18** until the proper voltage is obtained at the output terminals of autotransformer **15** to cause the magnetron **30** to oscillate. The holding circuit remains active until, for some reason, input power is removed from the autotransformer.

In Fig. 2, a modification of the system of Fig. 1 is shown which, in addition to the elements shown in Fig. 1, includes a high voltage transformer **40** having a primary winding **42** and a secondary winding **44** connected to a magnetron **30** or other output utilization device. The terminals **14**, **28** of autotransformer winding **17** are connected, respectively, to one terminal **45** of the primary winding **42** of the high voltage transformer and to a tap **47** along the primary **42** by way of the main contact **24** of relay **20**. The position of tap **47** will depend upon the output voltage desired; as shown in Fig. 2, the tap may be positioned at the midpoint of the primary winding. One input line **11** is connected to movable arm **18** of autotransformer **15** and the other input line **12** is connected directly to terminal **46** of primary winding **42**.

If the autotransformer arm **18** is in contact with terminal **14**, when switch **13** is closed, control switch **35** is closed and the relay **20** is energized as soon as power is applied. Contact **24** thus closes immediately. In this condition, the input voltage to the primary of the high voltage transformer is produced across its terminals **45**, **46** and the voltage difference between the opposite points of the contact **24** is very small. Since the total primary voltage for the transformer **40** is then equal to the line voltage, the output voltage, that is, the voltage across the secondary **44** of transformer **40**, will be insufficient to cause the magnetron to oscillate with substantial power output.

If the autotransformer arm **18** is not at point **14** when switch **13** is closed, but at some position such as **27**, shown in Fig. 2, the control switch **35** will be open, relay coil **22** will not be energized, main contact **24** will be open, and the circuit between points **28** and **47** will not be closed. Now the applied input voltage will be across a portion **14—27** of the autotransformer winding **17** and the primary **42** of transformer **40** in series. In this condition, the transformer primary voltage is less than the input voltage and the secondary or output voltage will still be insufficient to cause the magnetron to oscillate.

In order to apply a voltage of sufficient magnitude to enable the magnetron to commence oscillating, it is thus necessary to return arm **18** of autotransformer **15** in contact with terminal **14** which causes the relay contact **24** in line **11** to close under conditions of minimum load in said line. Once closed, the holding circuit becomes effective and the arm **18** may be gradually moved from the starting point **14** toward terminal **28** until the output voltage applied to the magnetron becomes sufficient to permit the latter to oscillate with the desired power output.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. For example, this invention is not limited to control systems incorporating magnetrons but may be used with any device which, because of its large inductance, or for other reasons, must not be energized suddenly at high voltage levels. It is, accordingly, desired that the appended claims be given a broad interpre-

tation commensurate with the scope of the invention within the art.

What is claimed is:

1. In combination, input terminals responsive to electrical input energy, an autotransformer including a single winding and having an adjustable sliding member connected to one of said input terminals and contacting said single winding between certain limits, an output transformer having primary and secondary windings, a portion of said primary winding being connected to the other of said input terminals, an electromechanical device energized by said input energy and energized only in response to attainment of one only of said limits for connecting said autotransformer winding in parallel with a fixed portion of said primary winding, and output terminals connected to the ends of said secondary winding.

2. In combination, input terminals responsive to electrical input energy, an autotransformer including a single winding and having an adjustable sliding member connected to one of said input terminals and contacting said single winding between certain limits, an output transformer having primary and secondary windings, a portion of said primary winding being connected to the other of said input terminals and another portion of said primary winding being connected to said autotransformer winding, an electromechanical device energized by said input energy and energized only in response to attainment of one only of said limits for connecting said autotransformer winding in parallel with a fixed portion of said primary winding, and output terminals connected to the ends of said secondary winding, said electromechanical device further including means responsive to energization thereof for maintaining said device energized upon subsequent movement of said member away from said one limit.

3. In combination, input terminals receptive of an input voltage, an output transformer having primary and secondary windings, an autotransformer including a single winding and having a variable sliding member connected to one of said input terminals and contacting said autotransformer winding between certain limits, a portion of said primary winding being connected to the other of said input terminals and another portion of said primary winding being connected to said autotransformer winding, an electromechanical device, means responsive only to attainment of one only of said limits by said member for initially energizing said electromechanical device, said single winding having one end connected directly to said primary winding and the other end connected to a portion of said electromechanical device during energization thereof, said input voltage being applied across the terminals of said primary winding during the attainment of said one limit, said electromechanical device further including means responsive to said energization thereof for maintaining said device energized upon subsequent movement of said member away from said one limit and for deriving an output voltage across the secondary winding of said output transformer whose magnitude is dependent upon the position of said sliding member.

4. In combination, input terminals receptive of an input voltage, an output transformer having primary and secondary windings, output terminal means connected to the ends of said secondary winding, an autotransformer including a single winding and a variable sliding member connected to one of said input terminals and contacting said autotransformer winding between certain limits, a portion of said primary winding being connected to the other of said input terminals and another portion of said primary winding being connected to said autotransformer winding, an electromechanical device, means responsive only to attainment of one only of said limits by said member for initially energizing said electromechanical device, said single winding having one end connected directly to said primary winding and the other end connected to a portion of said electromechanical device during energization thereof, said input voltage being applied across the terminals of said primary winding during the attainment of said one limit, said electromechanical device further including means responsive to said energization thereof for maintaining said device energized upon subsequent movement of said member away from said one limit and for supplying an output voltage across said output terminals whose magnitude is dependent upon the position of said sliding member.

5. In combination, input terminals receptive of electrical energy, a voltage controlling device including a single winding for connection to output terminals and a variable sliding member contacting said winding between certain limits, said voltage controlling device having a portion thereof connected to one of said input terminals, a switching device including a single actuating coil and a main contactor element for insertion between the other of said input terminals and said variable sliding member, said switching device further including a control contactor in series with said actuating coil and connected mechanically to said sliding member for initially energizing said coil of said switching device and for supplying energy available at said input terminals to a portion of said single winding only when said sliding member is at one only of said limits, said switching device further including a holding contactor element in shunt with said control contactor for maintaining said switching device actuated upon subsequent movement of said sliding member away from said one limit and while said input terminals are receptive of input energy.

6. In combination, input terminals receptive of electrical energy, a voltage controlling device including a single winding having a variable sliding member connected to one of said input terminals and contacting said single winding between certain limits, an output transformer having primary and secondary windings, a portion of said primary winding being connected to the other of said input terminals and another portion of said primary winding being connected to said single winding, a switching device connected in energy-supplying relationship between said input terminals and said voltage controlling device, said switching device having a main contactor inserted in an auxiliary line between one end of said single winding and a fixed point on said output transformer, said switching device including a control switch for initially closing said main contactor only when said sliding member is at one of said limits, and means responsive to closure of said main contacts for energizing said output transformer.

7. In combination, input terminals receptive of electrical energy, a voltage controlling device including a single winding having a variable sliding member connected to one of said input terminals and contacting said winding between said limits, a portion of said primary winding being connected to the other of said input terminals and another portion of said primary winding being connected to said single winding, an output transformer, a switching device connected in energy-supplying relationship between said input terminals and said voltage controlling device, said switching device having a main contactor inserted in an auxiliary line between one end of said single winding and a fixed point on said output transformer, said switching device including a control switch for initially closing said main contactor only when said sliding member is at one of said limits, and means responsive to closure of said main contactor for energizing said output transformer, said switching device further including holding means having a contactor in shunt with said control switch for maintaining said switching device actuated upon subsequent movement of said sliding member away from said one limit and only so long as said source is supplying energy, said holding means further including means for de-actuating said switching

device whenever input energy is interrupted while said sliding member is at other than said one limit.

8. In combination, input terminals receptive of electrical energy, a voltage controlling device including a single winding for connection to output terminals and having a portion thereof connected to one of said input terminals and a variable sliding member contacting said winding between certain limits, a switching device including a single actuating coil and a main contactor element for insertion between the other of said input terminals and said variable sliding member, said switching device

further including a control contactor in series with said actuating coil and connected mechanically to said sliding member for initially energizing said coil of said switching device and for supplying energy available at said input terminals to a portion of said single winding only when said sliding member is at one only of said limits.

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