Dec. 26, 1950 G. J. LEXA 2,535,499

CONTROL SYSTEM FOR IGNITRON TUBES

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Fig. 1

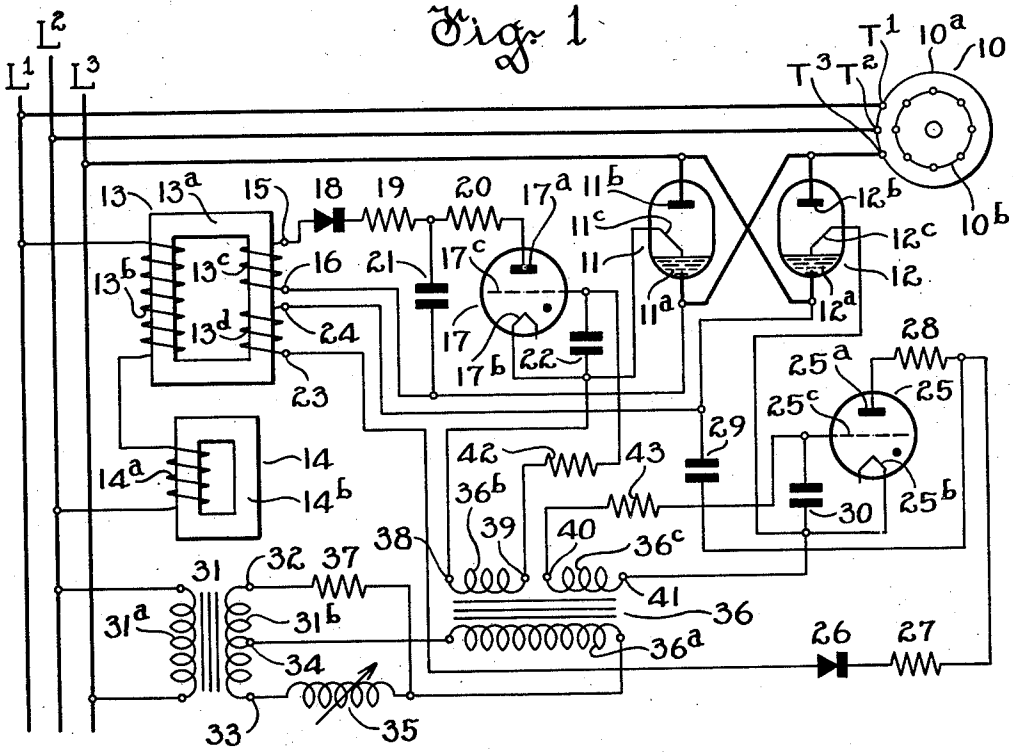


Fig. 2

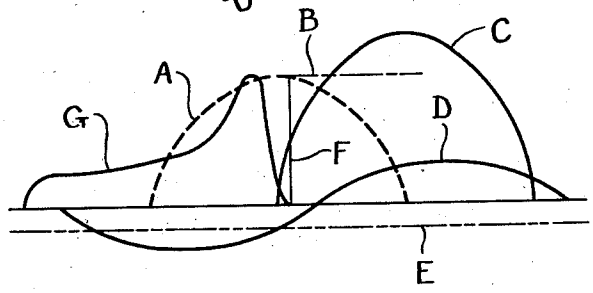
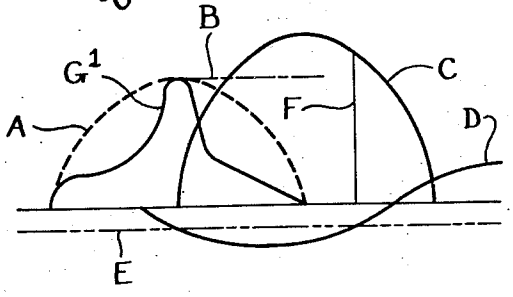


Fig. 3



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CONTROL SYSTEM FOR IGNITRON TUBES

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5 Claims. (Cl. 315—272)

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This invention relates to a control system for ignitron tubes.

In certain control systems for ignitron tubes, the ignition voltage for energizing the ignition electrode thereof is supplied by energy stored in a capacitor. The capacitor is charged with alternating voltage through a rectifier from a source of alternating current and the energy stored therein is discharged through the ignition electrode and cathode of the ignitron to initiate its conduction. Charging of the capacitor is usually effected during non-conducting periods of the ignitrons and discharged during the conducting periods thereof. In certain applications of ignitrons the moment of initiation of conduction thereof will vary widely. Under certain load conditions it is necessary to initiate conduction of the ignitrons just prior to the end of the conducting half cycles of voltage impressed on said ignitron, whereas under extreme load conditions, the ignitron is made conducting at, or just after the beginning, of the conducting half cycles of voltage impressed theeron. Regardless of the condition of loading the capacitor supplying the ignition energy is charged to a potential such that it will discharge during substantially the entire conducting half cycle of voltage impressed on said ignitron. Thus under the extreme conditions of loading aforementioned, while the capacitor in discharging decreases in potential, the charging voltage impressed thereon is such as to recharge it during the periods of its discharge. This causes the flow of unnecessary high current through the ignition electrode and cathode of the ignitron, such current exceeding considerably in amount that required for initiating conduction of the ignitron. Excess current not required for initiating conduction of the ignitron, causes greater wear of the ignition electrode and reduces the tube life.

The present control system obviates such disadvantage by providing a charging circuit for the capacitor which supplies it with a high peak voltage which drops rapidly to zero after its maximum value has been reached, so as a consequence thereof the energy discharged through the ignition electrode and cathode of the ignitron is substantially only that stored in said capacitor prior to the moment the ignitron is rendered conducting.

An object of the present invention is to provide an energizing system for ignitron tubes restricting to a minimum the required ignition energy, and

Another object is to provide a system of the

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aforementioned type which affords a substantially constant amount of ignition energy regardless of the loading on the ignitron tube.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawing illustrates one embodiment of the invention which will now be described, it being understood that the embodiment shown is susceptible of modification in respect of its details without departing from the scope of the appended claims.

In the drawing:

Figure 1 illustrates, partly diagrammatically and partly schematically, a control system for a polyphase alternating current motor.

Fig. 2 illustrates the relationship of voltages existing between certain components of the control system of Fig. 1 under one operating condition, and

Fig. 3 is similar to Fig. 2 but illustrates the relationship of voltages under another operating condition.

Referring to Fig. 1, it shows a three phase alternating current induction motor 10 having a primary winding 10^a and a secondary winding 10^b. Winding 10^a is provided with three terminals T^1, T^2 and T^3. Terminals T^1 and T^2 are directly connected to the bus bars L^1 and L^2 of a three phase alternating supply circuit. A pair of ignitron tubes 11 and 12 are connected between bus bar L^3 of the current supply circuit and terminal T^3 of the motor primary in an inverse parallel relation. More particularly cathode 11^a of tube 11 and anode 12^b of tube 12 are connected to terminal T^3 while anode 11^b of tube 11 and cathode 12^a of tube 12 are connected to bus bar L^3. Ignitron tubes 11 and 12 are provided with ignitor electrodes 11^c and 12^c respectively, which when suitably energized initiate conduction of the respective tubes.

The circuit arrangement of the main electrodes of tubes 11 and 12 in the power supply to the motor 10 is like that shown and described in the Elliot Patent 2,448,256, issued August 31, 1948. The purpose of the tubes 11 and 12 when the conduction thereof is suitably controlled by the control system to be described hereinafter in detail, is that described in the aforementioned patent. Although in the aforementioned patent the motor corresponding to motor 10 is shown as having secondary resistance which is controlled, such is dispensed with in the present application as it forms no part of the present invention. It will be apparent to those skilled in the art that the secondary resistance and the control

disclosed in the aforementioned patent may be incorporated with the secondary winding 19b of the motor 18 if desired.

A preferred system for controlling the conduction of ignitrons 11 and 12 will now be described.

A transformer 13, schematically depicted in Fig. 1, is provided with a laminated core 13a and a primary winding 13b having one end terminal connected to bus bar L^1 and its other end terminal connected to bus bar L^2 through a winding 14a which is wound on a laminated core 14b of an inductive reactor 14, which is also schematically depicted in Fig. 1. Transformer 13 has a secondary winding 13c having end terminals 15 and 16. End terminal 15 of winding 13c is connected to an anode 17a of a thyratron tube 17 through a half-wave rectifier 18 and resistors 19 and 20. The end terminal 16 of winding 13c is connected to the cathode 11a of ignitron 11. A capacitor 21 is connected at one of its terminals to a common point between the resistors 19 and 20 and its other terminal is connected to a point common to terminal 16 of winding 13c and cathode 11a of ignitron 11. Cathode 17b of thyratron 17 is connected to the ignitron electrode 11c of ignitron 11. Thyratron 17 is also provided with a control electrode 17c which is connected to the cathode 17b through a smoothing capacitor 22.

Transformer 13 is also provided with another secondary winding 13d having end terminals 23 and 24. End terminal 23 of winding 13d is connected to anode 25a of a thyratron tube 25 through a half-wave rectifier 26 and resistors 27 and 28. End terminal 24 of winding 13d is connected to the cathode 12a of ignitron 12. A capacitor 29 is connected at one terminal to a point common to the resistors 27 and 28 and is connected at its other terminal to a point common to end terminal 24 of winding 13d and cathode 12a of ignitron 12. Cathode 25b of thyratron 25 is connected to the ignitor electrode 12c of ignitron 12. Thyratron 25 is also provided with a control electrode 25c which is connected to the cathode 25b thereof through a smoothing capacitor 30.

A transformer 31 is provided with a primary winding 31a having one of its terminals connected to bus bar L^2 and its other end terminal connected to bus bar L^3. Transformer 31 also has a secondary winding 31b having end terminals 32 and 33 and a mid-point terminal 34. End terminal 33 is connected to the terminal 34 through a variable inductance 35 and a primary winding 36a of a transformer 36. End terminal 32 is connected to a point common to the inductance 35 and the winding 36a of transformer 36 through a resistor 37. Transformer 36 is also provided with a secondary winding 36b having end terminals 38 and 39 and another secondary winding 36c having end terminals 40 and 41. The terminal 39 of winding 36b is connected to control electrode 17c of thyratron 17 through a resistor 42 and the terminal 38 of said winding is connected to a point common to the cathode 17b of thyratron 17 and the capacitor 22. The terminal 40 of winding 36c is connected to control electrode 25c of thyratron 25 through a resistor 43 and the terminal 41 of said winding is connected to a point common to the cathode 25b of thyratron 25 and the capacitor 30.

As will be understood by those skilled in the art, transformer 31, variable inductance 35, and resistor 37 constitutes a phase shift network of a well known type. The output of such network is impressed on the control electrodes 17c and 25c of thyratron 17 and 25 respectively, through the medium of the secondary windings 36b and 36c of transformer 36. Any other suitable adjustable phase shift network may be used in the place of the one herein shown and described. In the aforementioned patent there is shown a phase shift network which is particularly suitable when it is desired to automatically afford adjustments thereof according to variations in operating conditions of the motor.

It has been found in connection with the present control system that for best operation when the phase shift network is adjusted for maximum phase shift, the voltage impressed on the control electrode 17c should lag the voltage impressed on the anode 11b of ignitron 11 not less than 30° and similarly the same relation should exist between the voltages impressed on the control electrode 25c of thyratron 25 and on the anode 12b of ignitron 11.

It has also been found that for best operation of the present control system, under no load conditions, the voltages induced in the secondary winding 13c should lead the voltage impressed on the anode 11b of ignitron 11 by 90° and similarly that the same relation should exist between the voltages induced in secondary winding 13d of transformer 13 and that impressed on the anode 12b of ignitron 12.

To best understand the advantages of the present control system, its operation will be first considered as if the reactor 14 were not included in the power connections to the primary winding 13a of transformer 13 and then its operation will be considered with such reactor included as hereinbefore shown and described.

In the first case the voltage induced in the secondary winding 13c will have the usual sinusoidal wave form as depicted by the dotted line curve A in Fig. 2. When the polarity of the voltage at the terminal 15 is positive with respect to that at the terminal 16 in winding 13c, current will flow through the rectifier 18, resistor 19, capacitor 21 to terminal 16 thereby charging capacitor 21 to the potential depicted by the straight line B in Fig. 2. At the moment the charge on capacitor 21 has reached the potential B, the voltage impressed on the anode 11b of ignitron 11 becomes positive; the voltage impressed on the anode 11b being depicted by the curve C in Fig. 2. Assuming that the aforedescribed phase shift network is adjusted for maximum phase shift, then the voltage impressed on the control electrode 17c of thyratron 17 may be that depicted by the curve D in Fig. 2. When the voltage impressed on control electrode 17c exceeds the critical potential of thyratron 17, which is represented by the straight line E in Fig. 2, thyratron 17 will conduct. As a result of thyratron 17 becoming conducting, capacitor 21 discharges through a path including resistor 20, thyratron 17, the ignitor 11c and cathode 11a of ignitron 11, thereby initiating conduction of the latter which remains conducting for the remainder of the half cycle of anode voltage depicted by the curve C; the moment of initiation of conduction of ignitron 11 being depicted by the vertical line F in Fig. 2.

Although capacitor 21 may be such that when charged to the potential B and discharged as aforedescribed to initiate conduction of ignitron 11, current in excess of that supplied from the capacitor will also flow through the discharge path aforementioned. At the moment thyratron 17 is rendered conducting the polarity of the

voltage at terminal 15 of winding 13c is still positive with respect to terminal 16 and of such magnitude that current flows through rectifier 18, resistor 19 supplementing the current flowing through the discharge path from capacitor 21. Such excess current is proportional to the area under the curve A to the right of vertical line F. As such excess current is not needed for initiating conduction of ignitron 11, its only effect is to shorten the life of ignitor electrode 11c. As the phase shift network is adjusted more toward a condition of minimum phase shift, such as depicted by the relationship of voltages shown in Fig. 3, the amount of such excess current decreases, and at the condition of phase shift depicted, no excess current will flow through the discharge path of capacitor 21. It has been found that the average current supplied to the ignitor of ignitron tube 11 under a condition of maximum phase shift is 5 to 6 times that supplied under a condition of minimum phase shift.

Now considering the present control system as it actually exists with the reactor 14 connected in the power connections to the primary winding 13b of transformer 13, the relationship of the instantaneous voltages induced in the winding 13c, when terminal 15 thereof is positive with respect to its terminal 16, is not of sinusoidal wave form but is of the high peaked forms depicted by curves G and G1 in Figs. 2 and 3 respectively. Although under no load condition the circuit connections of transformer 13 are such that the voltage induced in winding 13c leads the anode voltage of ignitron 11 by 90°, it has been found that under load conditions and under a condition of maximum phase shift it leads somewhat more. Referring to curve G in Fig. 2, it will be seen that after the voltage induced in winding 13c has reached maximum value it drops to zero rapidly and attains a zero value before the anode voltage of ignitron 11 is of sufficient magnitude to render the latter conducting. Therefore the only current supplied through the aforementioned discharge path of capicitor 21 is that stored in the latter, there being no excess current supplied from the winding 13c. When the phase shift network is adjusted to provide a condition near minimum phase shift net, depicted by Fig. 3, the wave form of the voltage induced in winding 13b changes somewhat to that depicted by curve G1 and leads the anode voltage of ignitron 11 by substantially 90°. It has been found that when the voltage induced in winding 13c has the wave forms depicted by curves G and G1 under the conditions of phase shift depicted by Figs. 2 and 3, the average ignitor current is the same for both conditions, and is the same for other conditions of phase shift therebetween. Thus with the present control system the ignitor 11c is supplied with only that amount of energy as is necessary to initiate conduction of ignitron 11 and the life of the latter is thereby materially enhanced.

The wave form of the voltages induced in winding 13d will also be like that depicted by curves G and G1 of Figs. 2 and 3 respectively. Thus ignitron 12, which is controlled in exactly the same manner as ignitron 11 during positive half cycles of the voltage impressed on its anode 12b, will likewise be supplied with only that amount of energy needed to initiate its conduction.

It has been found by experiment that by using an inductive reactor having a core formed of electrical sheet steel laminations describing a closed magnetic path and with its inductance winding connected in the power connections to the primary winding as hereinbefore described, voltages will be induced in the secondary windings of the transformer having wave forms generally similar to those depicted by curves G and G1 in Figs. 2 and 3 respectively. In one particular embodiment of the present control system, wave forms of the voltages induced in the secondary windings of the transformer 13 were obtained which were substantially like that depicted by curves G and G1 using the following combination of a transformer and inductive reactor connected as aforedescribed to a 215 volt alternating supply source:

Transformer:

- Rating—335 volt amperes
- Primary winding—240 turns of #19DC wire
- Secondary winding—316 turns (each) of #24DC wire
- Core—formed of electrical sheet steel laminations describing closed magnetic path

Inductive reactor:

- Inductance winding—430 turns of #H17E wire
- Core—formed of electrical sheet steel laminations describing a closed magnetic path—suitable for a 140 volt-ampere transformer

As will be understood by those skilled in the art, the combinations of transformers and reactors that will provide induced voltages having wave forms substantially like the wave forms depicted by curves G and G1, depends upon a number of variables. Generally considered, when the primary winding of the transformer and the inductance winding are connected in circuit as hereinbefore described and the secondary windings of the transformer are open circuited, the measured voltage drops across the primary winding of the transformer and across the inductance winding of the reactor should be substantially equal.

I claim:

1. In combination, an alternating current supply source, an ignitron tube which through its main electrodes conducts energy from said source and which has an ignitor electrode. means, including a capacitor, supplying energy stored in said capacitor to said ignition electrode in timed relation to the voltage cycles of said source, transforming and rectifying means in energy supplying relation to the first mentioned means including said capacitor, and a primary circuit for said transforming means supplied from said source and having reactance affording peaking of the voltage pulses in the secondary of said transforming means restricting transfer of energy to said ignitor electrode from said source substantially to only the energy stored in said capacitor.

2. In combination, an alternating current supply source, an ignitron tube which through its main electrodes conducts energy from said source and which has an ignitor electrode, means, including a capacitor, supplying energy stored in said capacitor to said ignition electrode in timed relation to the voltage cycles of said source, an inductive reactor, a rectifier, a transformer having its primary winding connected to said source through the winding of said reactor and having its secondary winding connected to said capacitor through said rectifier, said transformer and said reactor in association affording peaking of the voltage pulses in the secondary winding of said

transformer for restricting transfer of energy to said ignitor electrode from said source substantially to only the energy stored in said capacitor.

3. In combination, an alternating current supply source, an ignitron tube which through its main electrodes conducts energy from said source and which has an ignitor electrode, means, including a capacitor, supplying energy stored in said capacitor to said ignition electrode in timed relation to the voltage cycles of said source, an inductive reactor having a core formed of a low reluctance material and describing a closed magnetic path upon which its winding is wound, a rectifier, a transformer having its primary winding connected to said source through the winding of said reactor and having its primary winding connected across said capacitor through said rectifier, said transformer and said reactor in association affording peaking of the voltage pulses in said transformer secondary winding for restricting transfer of energy to said ignitor electrode from said source substantially to only the energy stored in said capacitor.

4. In combination, a polyphase alternating current supply source, a translating device connected to said source for deriving energy therefrom, an ignitron tube having its main electrode connected in a power connection to said device and having an ignitor electrode, means, including a capacitor, supplying energy stored in said capacitor to said ignitor electrode, means limiting the supply of energy to said ignitor electrode in a timed relation to conducting half cycles of voltage of said ignitron tube, an inductive reactor having a core formed of a low reluctance material and describing a closed magnetic path upon which its winding is wound, a rectifier, and a transformer having its primary winding connected across one phase of said source through the winding of said reactor and having its secondary winding connected across said capacitor through said rectifier, said transformer and said reactor in association affording peaking of the voltage pulses in the transformer secondary winding for restricting transfer of energy to said

ignitor electrode from said source substantially to only the energy stored in said capacitor.

5. In combination, a polyphase alternating current supply source, a translating device connected to said source for deriving energy therefrom, an ignitron tube having its main electrodes connected in a power connection to said device and having an ignitor electrode, a capacitor, a normally non-conducting second electron tube having its main electrodes connected across said capacitor through said ignitor electrode and the cathode of said ignitron tube and having a control electrode, an inductive reactor having a core formed of a low reluctance material and forming a closed magnetic path upon which its winding is wound, a rectifier, a transformer having its primary winding connected across one phase of said source through the winding of said reactor and having its secondary winding connected across said capacitor through said rectifier for charging said capacitor during the non-conducting periods of said ignitron tube, and means deriving energy from said source of supply to said control electrode and limiting to the conducting half cycles of voltage of said ignitron tube the supply of energy to initiate discharge of said capacitor through said second tube for energizing said ignitor electrode, said transformer and said reactor in association affording peaking of the voltage pulses in said transformer secondary winding for restricting the transfer of energy to said ignitor electrode from said source to substantially only the energy stored in said capacitor.

GEORGE J. LEXA.

REFERENCES CITED

The following references are of record in the file of this patent:

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