

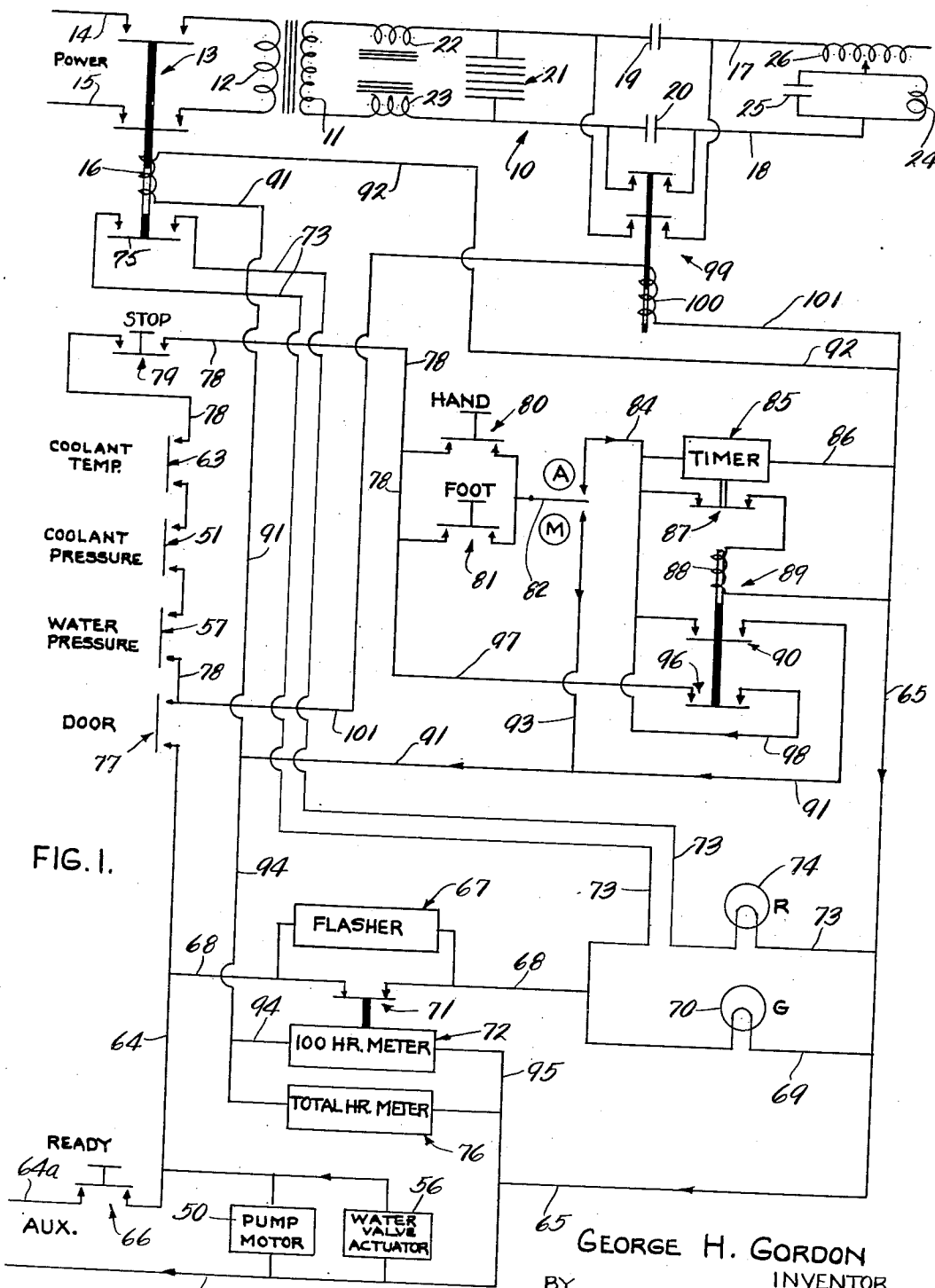
June 7, 1949.

G. H. GORDON
CONTROL SYSTEM

2,472,157

Filed Nov. 1, 1945

2 Sheets-Sheet 1



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INVENTOR
BY *Freeman Albrecht & Williams*
ATTORNEYS

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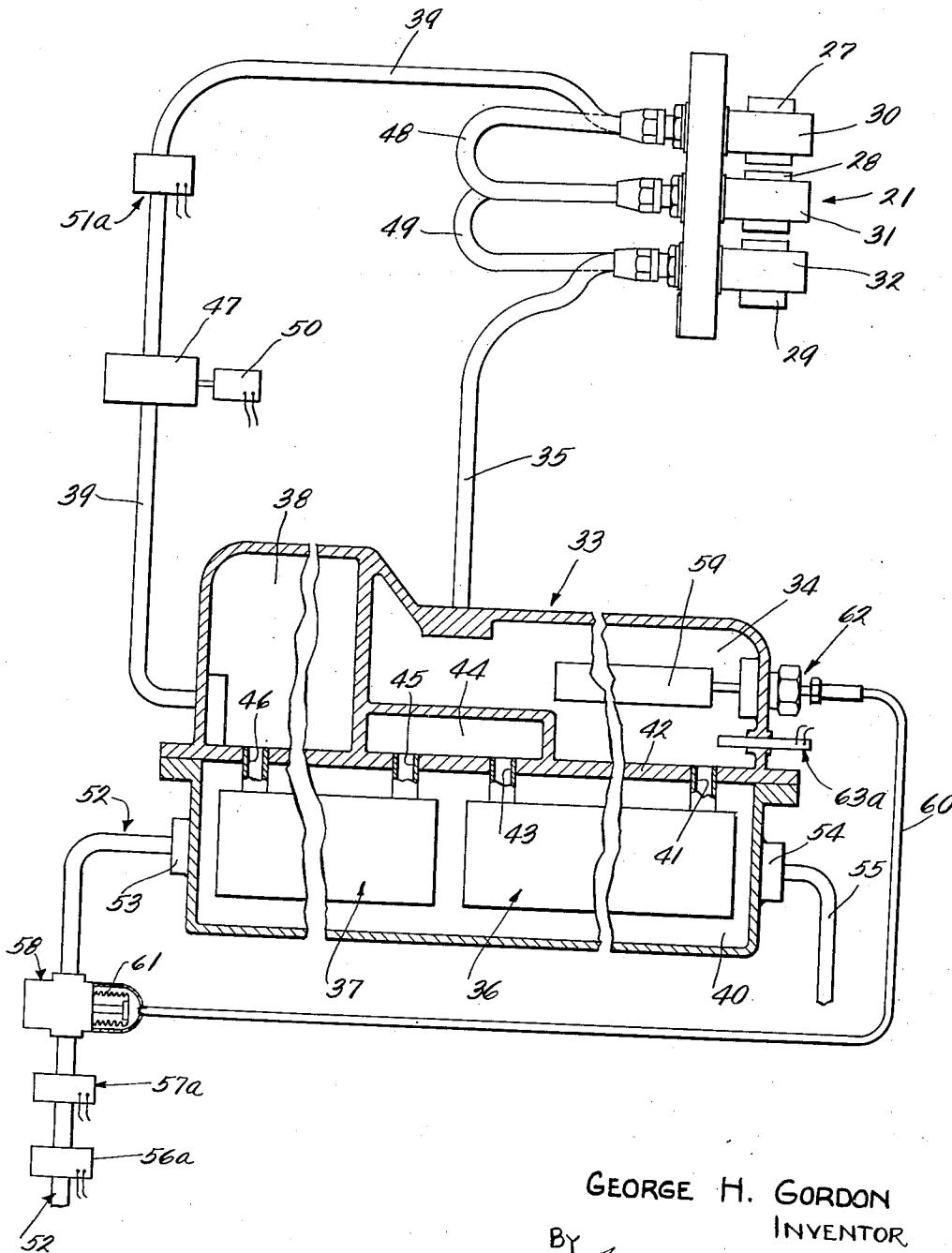
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FIG. 2.



GEORGE H. GORDON
INVENTOR
By *Freeman Albrecht and Williams*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,472,157

CONTROL SYSTEM

George H. Gordon, Bradford Woods, Pa., assignor
to Edwin L. Wiegand Company, Pittsburgh, Pa.,
a corporation of Pennsylvania

Application November 1, 1945, Serial No. 626,147

17 Claims. (Cl. 315—361)

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This invention relates to control systems and more particularly to control systems for high frequency electric apparatus. The invention may be embodied in control systems for high frequency induction heating apparatus. The principal object of the invention is to provide new and improved control systems of these types.

In the drawings accompanying this specification, and forming a part of this application, there is shown, for purposes of illustration, one form the invention may assume, and in these drawings:

Figure 1 is an electrical diagram of a control system embodying the invention, and

Figure 2 is a view, partly diagrammatic, including apparatus controlled by elements of the system of Figure 1, and including apparatus controlling elements of the system of Figure 1.

In the embodiment of Figure 1, the control system is shown as controlling a translating circuit 10, and in the instance illustrated the translating circuit 10 is feedable with alternating current from the secondary 11 of a transformer having a primary 12. The terminals of the primary 12 of the transformer are connectable, by closure of a main switch 13, to electric power conductors 14, 15 leading to a suitable source of alternating current, which may be of the ordinary commercial 60 cycle type.

The switch 13 is operable to closed position by energization of an operating solenoid 16, and is adapted to return to open position when the solenoid is deenergized.

The translating circuit 10 is here shown as comprising the following elements. Conductors 17, 18 are connected to the terminals of the secondary 11, and interposed in the conductors 17, 18 are storage condensers 19, 20. Connected across the conductors 17, 18 is spark gap means 21, in this instance indicated as comprising a plurality of spark gaps in series. Between the spark gap means 21 and the secondary 11, choke coils 22, 23 are interposed in the conductors 17, 18. The choke coils 22, 23 do not interfere with the flow of charging current from the secondary 11 to the condensers 19, 20, but prevent the flow of high frequency current from the spark gap means 21 back through the secondary 11. On the other hand, the storage condensers 19, 20 do not interfere appreciably with the flow of high frequency current to a tank circuit comprising a work coil 24 and a condenser 25. The condenser 25 and work coil 24 are connected in parallel with each other and across the conductors 17, 18 through an inductor 26. The condenser 25 is selected so

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that with the work to be heated, in position in the work coil 24, the tank circuit will be in approximate resonance, final tuning being accomplished by adjustment of the inductance of the variable inductor 26.

It will be understood that the translating circuit 10 hereinbefore described is shown merely by way of illustration, and any other suitable, desired translating circuit may be utilized.

Suitable means is provided for cooling the spark gap means 21. As herein shown (Figure 2) the spark gap means 21 is of the kind disclosed in a copending application of George H. Gordon and Edward C. Hilker, Serial Number 618,860, filed September 27, 1945. In the spark gap means 21 there are three electrodes 27, 28, 29 which are supported and held by clamps 30, 31, 32, each of which is provided with a chamber through which a coolant may flow. Any suitable fluid may be used as the coolant, but it should be of high insulating properties.

The coolant for the spark gap means 21 is here shown as in turn cooled by a heat exchanger 33 which may be of a kind similar to that disclosed in a copending application of Edward C. Hilker, Serial Number 622,981, filed October 18, 1945. As here shown, coolant which has been heated by the spark gap means 21 enters a chamber 34 of the heat exchanger 33 through a pipe 35, and flows from the chamber 34 through one or more cooling elements or heat exchange means 36, 37 into a chamber 38, and thence to a pipe 39. The cooling elements 36, 37 are of any suitable type, and are disposed in a chamber 40 of the heat exchanger 33 through which water or other suitable cooling fluid may flow.

As here shown there are two cooling elements 36, 37, the coolant entering the first one 36 through an aperture 41 in a partition 42 and flowing through the first element 36 through an aperture 43 in the partition 42 into a chamber 44, and from the chamber 44 through an aperture 45 into the second cooling element 37, through the latter and through an aperture 46 into the chamber 38.

In order positively to circulate the coolant, a pump 47 is interposed in the pipe 39, to pump the coolant in the chamber in the uppermost clamp 30 (as viewed in Figure 1). From there the coolant flows through a pipe 48 into the chamber of the intermediate clamp 31, and from thence through a pipe 49 to the chamber in the lowermost clamp 32, and from thence into the pipe 35, so that the coolant flows through the

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chambers in the clamps 30, 31, 32 in series. The pump may be driven by an electric motor 50.

Also connected to the pipe 39 is means 51a responsive to the pressure of the coolant controlling a switch 51 (Figure 1). The means 51a and the switch 51 are so constructed and arranged that when the coolant pressure rises above a predetermined amount the switch is opened.

Water for the chamber 40 is furnished from a supply pipe 52 connected to any suitable source. The pipe 52 is connected, through various intermediate devices, as will appear, to the inlet 53 of the chamber 40. After flowing through the chamber 40 along the cooling elements 36, 37, the water is discharged from an outlet 54 from the chamber 40 into a discharge pipe 55.

Interposed in the pipe 52 is an on-and-off valve 56a operable to open position by energization of a solenoid or any other suitable actuating means 56. When the solenoid or other actuating means 56 is deenergized, the valve 56a returns to its closed position. Downstream of the valve 56a is means 57a responsive to the water pressure in the pipe 52, for operating a switch 57, so constructed and arranged that the switch opens if the water pressure falls below a predetermined minimum; and further downstream is a regulating valve 58, in the pipe 52, the amount of opening of which is responsive to the temperature of the coolant in the chamber 34. As here shown, a thermally responsive means 59 is disposed in the chamber 34, the thermally responsive means containing a gas. The thermally responsive means 59 is connected by a pipe 60 to a metallic bellows 61 or other suitable operating means for the regulating valve 58. The pipe 60 is disposed, fluid-tight, through a wall of the chamber 34, being sealed by suitable gland means 62. The construction and arrangement is such that when the coolant in the chamber 34 is below a predetermined minimum temperature the valve 58 will be closed, and as the temperature of the coolant rises, the gas in the thermally responsive device 59 will expand, resulting in opening of the regulating valve 58, the higher the temperature of the coolant in the chamber 34 the greater being the opening of the regulating valve 58.

Means 63a is provided, responsive to the temperature of the coolant in the chamber 34, for controlling a switch 63, so constructed and arranged that when the temperature of the coolant rises above a predetermined temperature the switch 63 will be opened.

Referring to Figure 1, the control system comprises primary control conductors 64, 65 connectable to any suitable auxiliary source of electric current. A ready switch 66 is here shown as adapted to connect the conductor 64 to a conductor 64a leading to a terminal of the source, the conductor 65 leading to the other terminal of the source. The pump motor 50, and the solenoid or other actuator 56 for the water valve 56a, are connected across the primary control conductors 64, 65, so as to receive current when the ready switch 66 is closed.

Connected across the primary control conductors 64, 65, by conductors 68, 69, is an indicating means, here shown as an incandescent electric lamp 70, which may be green. A switch 71 is interposed in the conductor 68, the switch 71 being normally closed and operable to open position by any suitable hour meter or time measuring device 72, which may be set to actuate the switch 71 to open position after 100 hours, or any other

desired period of time. Shunted around the switch 71 is a flasher 67, so constructed and arranged that when the switch 71 is opened by the hour meter 72, the lamp 70 will alter its indication, that is, in this instance, instead of burning steadily, it will flash periodically.

Connectable in shunt with the lamp 70, by a conductor 73, is another indicating means, here shown as a lamp 74, which may be red. Interposed in the conductor 73 is an auxiliary switch 75 operable by the main switch 13, and so constructed and arranged that when the main switch 13 is closed the auxiliary switch 75 will be closed.

If desired another hour-meter 76 may be connected in shunt with the hour-meter 72, the hour-meter 76 not controlling any switch but serving to register total time of operation of the apparatus as will appear.

A switch 77 is operable to connect the conductor 64 to a conductor 78. The position of the switch 77 is responsive to a door or other closure means for a cabinet or other means for enclosing the translating circuit 10. The construction and arrangement is such that when the door is opened the switch 77 is opened. More than one door and a switch operated by each door may be provided.

Interposed in series in the conductor 78 are the switch 57 responsive to water pressure, the switch 51 responsive to coolant pressure, the switch 63 responsive to coolant temperature, and a stop switch 79.

The conductor 78 is connected to one of the relatively stationary terminals of a hand switch 80 and to one of the relatively stationary terminals of a foot switch 81. The switches 80, 81 are desirably biased to open position. The other relatively stationary terminals of the hand switch and the foot switch are connected to the movable contact 82 of a change-over switch, the movable contact 82 being engageable either with a relatively stationary contact A (indicating automatic control), or a relatively stationary contact M (indicating manual control). The contact A is connected by a conductor 84 to one terminal of a timer 85, the other terminal of the timer being connected by a conductor 85 to the primary control conductor 65. The timer 85 is constructed and arranged to open a normally closed timer switch 87 when a selected predetermined period of time has elapsed after energization of the timer. One of the relatively stationary contacts of the timer switch 87 is connected to the conductor 84 and hence to the contact A, the other relatively stationary contact of the timer switch 87 being connected to a terminal of an operating solenoid 88 of a relay 89. The other terminal of the solenoid 88 is connected to the primary control conductor 65.

The relay 89 comprises a switch 90, one of the relatively stationary contacts of which is connected to the conductor 84 and hence to the contact A, the other relatively stationary contact of the switch 90 being connected by a conductor 91 to one terminal of the operating solenoid 16 of the main switch 13. The other terminal of the solenoid 16 is connected by a conductor 92 to the primary control conductor 65. The contact M of the change-over switch is connected by a conductor 93 to the conductor 91.

One terminal of the time or hour meter 72 is connected by a conductor 94 to the conductor 91, the other terminal of the meter 72 being connected by a conductor 95 to the primary control conductor 65. Likewise, the total time or hour

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meter 76 has its terminals connected respectively to the conductor 91 and to the primary control conductor 65.

The relay 89 further comprises a switch 96 having one of its relatively stationary contacts connected by a conductor 97 to the conductor 78, the other relatively stationary contact of the switch 96 being connected through a conductor 98 to the conductor 84.

The construction and arrangement of the relay 89 is such that when the solenoid 83 is energized the switches 90, 96 are moved to closed position and when the solenoid is deenergized the switches are opened.

A switch 99 has two movable contacts adapted to complete short circuits around the condensers 19, 20 respectively. The switch is operable by a solenoid 100. The solenoid 100 is interposed in a conductor 101, one end of which is connected to the primary control conductor 65, and the other end of which is connected to the conductor 78 between the switch 57 and the switch 77. The construction and arrangement of the switch 99 is such that when the solenoid 100 is energized the short circuits around the condensers 19, 20 will be opened and when the solenoid is deenergized the short circuits will be completed.

The operation of the system is as follows. When it is desired to utilize the translating circuit 10, the ready switch 66 is first closed. This sets the cooling means for the spark gap means 21 into operation, by starting the pump motor 50, and energizing the actuating means 58 opening the water valve 56a. Assuming that the door for operating the door switch 77 is closed and that therefore the switch 77 is closed, the solenoid 100 will be energized, thus opening the short circuits around the condensers 19, 20. Closure of the ready switch 66 also causes lighting of the green lamp 70, indicating that the system is ready for operation. Assuming further that the change-over switch contact 82 is set on the contact A, for automatic operation, and assuming further that all of the switches 57, 51, 63, and 79 are closed, so that the conductor 78 is electrically connected to the primary control conductor 64, closure of the hand switch 80 will energize the timer 85, from the conductor 78, through the hand switch 80 the contacts 82 and A, the timer 85, conductor 86 to the primary control conductor 65. The timer switch 87 being normally closed, the circuit for the relay coil 88 will, at the same time, be completed through the same switches to the conductor 65. Operation of relay 89 causes closure of its contacts 90, 96. Closure of the contact 90 causes energization of the solenoid 16, thus causing closure of the main switch 13. At the same time, the contact 96 electrically by-passes the contacts 82 and A of the change-over switch, and also the hand switch 80 and the foot switch 81, by completing a connection between the conductors 78 and 84. Therefore, under normal conditions, even though the hand switch 80, or foot switch 81, is released to open position, the timer 85 will continue to be energized, the contact 87 will be held closed, and the relay 89 will maintain the solenoid 16 energized.

The time meters 72 and 76 are energized at the same time that the solenoid 16 of the main switch 13 is energized. When the main switch 13 is closed the auxiliary contact 75 is closed, thereby completing the circuit of the red lamp 74, indicating that the translating circuit 10 is energized.

While the timer 85 is energized, the work coil

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24 will, of course, have high frequency current flowing therein and the work will be heated. Heating will continue for a predetermined selected time, as determined by the setting of the timer 85. At the end of the desired heating period the timer opens the switch 87, thereby deenergizing the relay 89 which causes opening of the main switch 13 and discontinues heating.

If at any time after the timer 85 has been started, it is desired to stop heating action of the coil 24, the normally closed stop switch 79 may be opened manually, thereby deenergizing the conductor 78 and hence the relay coil 88. Whereupon the contacts 90, 96 open and the main switch 13 is caused to open.

Assuming that the change-over switch contact 82 is moved to engage the contact M, and the hand switch 80 is closed, a circuit for the solenoid 16 will be completed from the conductor 78 through the hand switch 80, the change-over switch, the conductor 93, the conductor 91, the solenoid 16, through the conductor 92 to the primary control conductor 65. The switch 13 will close and will remain closed as long as the hand switch 80 is held closed. The same result may of course be accomplished by operation of the foot switch 81.

Assuming that the main switch 13 has been caused to close in any of the ways hereinbefore described, the solenoid 16 will be automatically deenergized and the main switch will open if any one of the switches 57, 51, and 63 is caused to open by reason of the occurrence of the conditions to which these switches respectively respond, as hereinbefore described. The main switch 13 will also be opened if a cabinet door is opened, thereby opening the respective switch 77. Since it has been assumed that the main switch 13 was closed when the door switch 77 was opened, the door switch 77 serves the additional purpose of opening the connection from the conductor 64 to the conductor 101, thereby deenergizing the operating coil 100 and causing the switch 99 to short circuit the condensers 19, 20. This at once discharges the condensers and prevents a person who has opened the cabinet door from receiving the condenser discharge in handling some part of the translating circuit 10. The operating solenoid 100 will also be deenergized and the condensers short circuited by the switch 99 if the ready switch 66 is opened. Opening of the ready switch cuts off all current flow to any part of the control system. It is evident that the solenoid 16 cannot be energized to close the switch 13, if any one of the switches 77, 57, 51, 63 or 79 is open.

The time meter 72 being energized whenever the solenoid 16 is energized and hence the main switch 13 is closed, and is deenergized and stops recording whenever the main switch 13 is open, the meter 72 will measure the accumulated time the translating circuit has been in operation. If the meter 72 is set for say 100 hours, then when that accumulated time has elapsed the meter will open the switch 71, thereby causing current to flow to either or both of the lamps 70, 74 through the flasher 67. This causes the lamps 70, 74 to flash on and off, giving an indication that it is time to check the gaps of the spark gap means 21, and adjust them, or replace the electrodes if necessary. When the spark gap means 21 has been checked, the meter 72 is reset, manually, and is ready to start its cycle anew.

Ordinarily, the translating circuit 10 is in such periodic operation, that the spark gap means 21

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will not become too cool, but if there is a long enough interval or a long enough accumulated period of time during which the translating circuit is inactive, the spark gap means may become so cool that moisture from the air will be precipitated on the electrodes. If the translating circuit 10 is then energized, this moisture would ruin satisfactory operation of the spark gap means 21. This condition is obviated by the provision of the regulating valve 58 which reduces the flow of water through the pipe 52 as the temperature of the coolant for the spark gap means 21 decreases. The regulation is such that the temperature of the coolant will not fall so far that the dew point temperature, at the spark gap means, will be reached. It will be apparent, therefore, that even if the ready switch 66 is closed and the pump motor 50 in operation and the water valve 56 open, it is not necessary to have the translating circuit energized to prevent the formation of dew on the spark gap means.

From the foregoing it will be apparent to those skilled in the art that the illustrated embodiment of the invention provides a new and improved control system, and accordingly, accomplishes the principal object of the invention. On the other hand, it also will be obvious to those skilled in the art that the illustrated embodiment of the invention may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those illustrated, without departing from the spirit of the invention, or sacrificing all of the advantages thereof, and that accordingly, the disclosure herein is illustrative only, and the invention is not limited thereto.

I claim:

1. A control system for high frequency electric apparatus, comprising: a translating circuit; main switch means for controlling the supply of electric current to said translating circuit; spark gap means included in said translating circuit; means, including a primary fluid, constructed and arranged to cool said spark gap means; means, including an auxiliary fluid, for cooling said primary fluid; and means responsive to the pressure of said auxiliary fluid, constructed and arranged to prevent closure of said main switch means, and cause opening of said main switch means if closed, if the pressure of said auxiliary fluid is below a predetermined minimum.

2. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; main switch means for controlling the supply of electric current to said translating circuit; actuating means for said main switch means; and circuit means for said actuating means, including auxiliary switch means for completing said circuit means under normal conditions; said auxiliary switch means including a switch controllable by an operator, and switch means for maintaining said circuit means completed during a predetermined time after operation of said operator's switch.

3. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; main switch means for controlling the supply of electric current to said translating circuit; actuating means for said main switch means; circuit means for said actuating means, said circuit means comprising a first part for completing the circuit of said actuating means and a second part for completing the circuit of said actuating means separately from said first part, and comprising a switch con-

trollable by an operator and common to said parts, and comprising a change-over switch so constructed and arranged that said operator's switch may control either said first part or said second part; and said first part including switch means for maintaining said circuit means completed under normal conditions during a predetermined time after operation of said operator's switch, and said second part being so constructed and arranged that the period of time during which said circuit means remains completed under normal conditions depends on the period of time said operator's switch is held closed.

4. A control system for high frequency electric apparatus, comprising: a translating circuit including condenser means; means for enclosing said translating circuit; door means for said enclosing means; and means, responsive to the position of said door means, constructed and arranged to short circuit said condenser means upon opening of said door means.

5. A control system for high frequency electric apparatus, comprising: a translating circuit including condenser means; means for enclosing said translating circuit; a door for said enclosing means; a main switch for controlling the supply of electric current to said translating circuit; and means, responsive to the position of said door, constructed and arranged to prevent closure of said main switch means, and cause opening of said main switch means if closed, if said door is in open position; and means, responsive to the position of said door, constructed and arranged to short circuit said condenser means if said door means is in open position.

6. A control system for high frequency electric apparatus, comprising: a translating circuit; spark gap means included in said translating circuit; means, including a fluid, constructed and arranged to cool said spark gap means; a pump for circulating said fluid; means, including control means, constructed and arranged to cause operation of said pump; and indicating means, responsive to said control means, constructed and arranged to indicate operation of said control means to operating position.

7. A control system for high frequency electric apparatus, comprising: a translating circuit; spark gap means included in said translating circuit; means, including a fluid, constructed and arranged to cool said spark gap means; a pump for circulating said fluid; means, including control means, constructed and arranged to cause operation of said pump; indicating means, responsive to said control means, constructed and arranged to indicate operation of said control means to operating position; switch means for energizing said translating circuit from a supply of electric current; and means for indicating energization of said translating circuit.

8. A control system for high frequency electric apparatus, comprising: a translating circuit; spark gap means included in said translating circuit; switch means for energizing said translating circuit from a supply of electric current; means, including a fluid, constructed and arranged to cool said spark gap means; a pump for circulating said fluid; means, including control means, constructed and arranged to cause operation of said pump; and indicating means, responsive to said control means, constructed and arranged to indicate operation of said control means to operating position; means for measuring the time during which said translating circuit is energized; and means, responsive to said

measuring means, constructed and arranged to cause said indicating means to alter its type of indication when said measuring means has measured a predetermined time.

9. A control system for high frequency electric apparatus, comprising: a translating circuit; switch means for energizing said translating circuit from a supply of electric current; means for indicating energization of said translating circuit; means for measuring the time during which said translating circuit is energized; and means, responsive to said measuring means, constructed and arranged to cause said indicating means to alter its type of indication when said measuring means has measured a predetermined time.

10. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means for cooling said spark gap means; and means for preventing said cooling means from cooling said spark gap means to a temperature below a predetermined minimum.

11. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means including a fluid, constructed and arranged to cool said spark gap means; auxiliary means for cooling said fluid; and means for preventing said auxiliary means from cooling said fluid to a temperature below a predetermined minimum.

12. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means, including a primary fluid, constructed and arranged to cool said spark gap means; means, including a secondary fluid, constructed and arranged to cool said primary fluid; and means, controlling flow of said secondary fluid, constructed and arranged to prevent said auxiliary means from cooling said primary fluid to a temperature below a predetermined minimum.

13. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means, including a primary fluid and a pump for circulating said fluid, constructed and arranged to cool said spark gap means; auxiliary means, including an auxiliary fluid, constructed and arranged to cool said primary fluid; a valve for controlling flow of said auxiliary fluid; and control means for starting said pump and causing opening of said valve.

14. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means constructed and arranged to cool said spark gap means; means constructed and arranged to set said cooling means into operation; main switch means for controlling the supply of electric current to said translating circuit; means for causing closure of

ure of said main switch means, under normal conditions, at selected times for desired periods; and means for preventing said cooling means from cooling said spark gap means to a temperature below a predetermined minimum.

15. A control system for high frequency electric apparatus, comprising: a translating circuit; main switch means for controlling the supply of electric current to said translating circuit; spark gap means included in said translating circuit; cooling means, including a fluid, constructed and arranged to cool said spark gap means; means, responsive to the temperature of said fluid, constructed and arranged to prevent closure of said main switch means, and cause opening of said main switch means if closed, if the temperature of said fluid is above a predetermined maximum; and means for preventing said cooling means from cooling said spark gap means to a temperature below a predetermined minimum.

16. A control system for high frequency electric apparatus, comprising: a translating circuit including spark gap means; means constructed and arranged to cool said spark gap means; means, including a control switch, constructed and arranged to set said cooling means into operation; main switch means for controlling the supply of electric current to said translating circuit; means for causing closure of said main switch means, under normal conditions, at selected times for desired periods, provided said control switch is closed.

17. A control system for high frequency electric apparatus comprising: a translating circuit including spark gap means; means constructed and arranged to cool said spark gap means; means, including a control switch, constructed and arranged to set said cooling means into operation; means for indicating closure of said control switch; main switch means for controlling the supply of electric current to said translating circuit; means for causing closure of said main switch means, under normal conditions, at selected times for desired periods, provided said control switch is closed.

GEORGE H. GORDON.

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