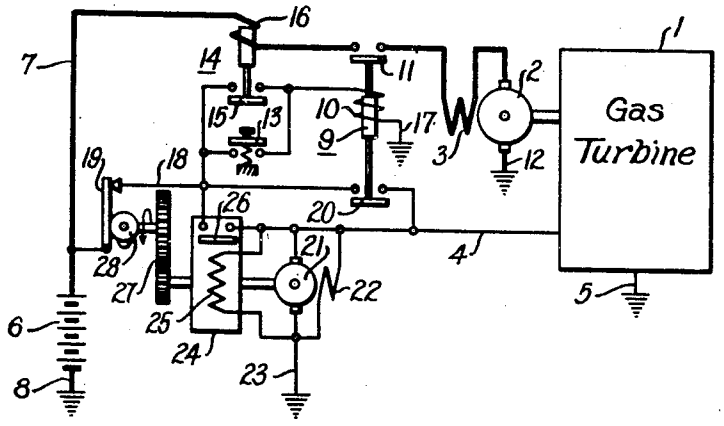
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STARTING MEANS FOR GAS TURBINES

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STARTING MEANS FOR GAS TURBINES

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The present invention relates to starting means for gas turbines, and, more particularly, to control means for the starting motor and the ignition circuit of a gas turbine.

Gas turbines are not self-starting, and they must be started by some external means, usually an electric motor which drives the turbine until it starts to run independently. It is also necessary to ignite the fuel of the gas turbine at the same time the starting motor is started, and this is frequently done by means of an electric ignition circuit, which is energized simultaneously with the starting motor. The energization of the ignition circuit must, of course, be maintained for a long enough time to insure that the fuel is ignited, and that combustion has been well established.

The principal object of the present invention is to provide a simple and reliable starting means for gas turbines.

Another object of the invention is to provide control means for starting a gas turbine, in which the starting motor and the ignition circuit are substantially simultaneously energized, and in which the motor is deenergized when the turbine starts to run, or when it reaches a predetermined speed, while the ignition circuit is deenergized after a predetermined time interval.

A further object of the invention is to provide control means for starting a gas turbine, in which the starting motor and the ignition circuit are energized substantially simultaneously, and in which all parts of the starting system are automatically deenergized at the end of a predetermined time interval, so that the system operates in definite time cycles.

A still further object of the invention is to provide control means for an electric motor and for an associated auxiliary circuit, in which the motor and the auxiliary circuit are energized substantially simultaneously, the motor is deenergized in response to a predetermined load condition, and the auxiliary circuit and motor are both deenergized at the end of a predetermined time interval. This system is especially adapted for use in controlling the starting motor and ignition circuit of a gas turbine, but in its broader aspects, its usefulness is not necessarily restricted to this particular application.

The invention will be more fully understood from the following detailed description, taken in connection with the accompanying drawing, the single figure of which is a schematic diagram showing a preferred embodiment of the invention.

The drawing shows a starting means for a gas

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turbine 1, which has been shown diagrammatically, and which may be of any desired construction. The gas turbine 1 is started by means of an electric motor 2, which is adapted to be mechanically connected to the turbine in any suitable manner to drive it until it has started. The motor 2 is shown as a direct-current series motor, having a field winding 3 connected in series with the armature, although other types of motors might also be used. The gas turbine has an electric ignition circuit 4 for the purpose of igniting the fuel. The ignition circuit 4 may include any suitable type of igniting device in the combustion chamber of the gas turbine 1, and the circuit is completed by a connection to ground at 5.

The starting motor 2 may be supplied from any suitable source of electric energy. The particular embodiment of the invention shown in the drawing is intended for aircraft use, and a battery 6 is utilized as the source of electric energy. One terminal of the battery 6 is connected to supply the motor 2 through a conductor 7, and the other terminal of the battery is grounded at 8. The motor 2 is controlled by means of a contactor 9, which has an operating coil 10 and a main contact 11. The contactor is arranged so that when the coil 10 is energized, the contact 11 of the contactor closes to connect one terminal of the motor 2 to the conductor 7, the other terminal of the motor being grounded at 12.

Operation of the contactor 9 is controlled by means of a normally-open push button 13 and a current-responsive relay 14. The relay 14 has a normally open contact 15 connected in parallel with the push button 13, and an operating coil 16 connected in series with the motor 2 so as to carry the motor current. The relay 14 is designed so that when the coil 16 is energized by the starting current of the motor 2, it will cause the contact 15 to close, and will hold it closed until the motor current decreases to a value corresponding to a predetermined load on the motor, or a predetermined motor speed. When the current has dropped to this value, the relay 14 drops out and opens the contact 15. One end of the operating coil 10 of the contactor 9 is connected to ground at 17, and the other end is connected to a control circuit 18 by means of the push button 13 or the contact 15.

The control circuit 18 is supplied from any suitable source of electric energy, which may be the battery 6, as shown, through a normally closed contact 19. As indicated above, the con-

trol circuit 18 supplies the operating coil 10 of the contactor 9. The control circuit 18 is also utilized to energize the ignition circuit 4 of the gas turbine 1. For this purpose, the contactor 9 has an auxiliary contact 20, which is arranged to close when the main contact 11 closes. The auxiliary contact 20 is connected between the control circuit 18 and the ignition circuit 4, so that the ignition circuit is energized when the contact 20 closes.

There is also provided a timing motor 21, which may be any suitable type of small, substantially constant-speed motor, and which is shown as a direct-current shunt motor, having a field winding 22 connected across the motor terminals. One terminal of the motor 21 is connected to ground at 23, and the other terminal is connected to the contact 20, so that the motor is energized from the control circuit 18 when the contact 20 closes. The timing motor 21 is provided with an electrically operated clutch 24, of any suitable type, which has an operating coil 25 connected in parallel with the motor 21, and which is arranged to be engaged when the coil 25 is energized. An auxiliary contact 26 is provided on the clutch 24, and is arranged to close when the clutch 24 is engaged. The auxiliary contact 26 is connected in parallel with the contact 20. The clutch 24 connects the timing motor 21 to a gear train 27, which drives a cam 28, or other suitable operating device, which actuates the contact 19 to open position after the timing motor 21 has been in operation for a predetermined length of time, determined by the gear train 27, or by adjustment of the cam 28.

In the operation of this system, when it is desired to start the gas turbine 1, the push button 13 is depressed to connect the coil 10 of the contactor 9 to the control circuit 18. Since the contact 19 is normally closed, the coil 10 is energized when the push button 13 is depressed, and the contactor 9 closes its main contact 11 and auxiliary contact 20. Closing of the main contact 11 connects the motor 2 to the battery 6, and the motor starts, driving the gas turbine 1. When the motor starts, the current through the coil 16 of the relay 14 causes it to pick up and close its contact 15, so that energization of the coil 10 is maintained, and the push button 13 can be released as soon as the motor 2 starts.

Simultaneously with the starting of the motor 2, the ignition circuit 4 is energized from the control circuit 18 through the auxiliary contact 20 on the contactor 9. Closing of the contact 20 also connects the timing motor 21 and clutch coil 25 to the control circuit, so that the timing motor 21 starts to run and the clutch 24 is engaged to cause the timing motor 21 to drive the cam 28 through the gear train 27. When the clutch 24 engages, the auxiliary contact 26 closes, paralleling the contact 20, and connecting the timing motor and clutch coil directly to the control circuit 18.

As the starting motor 2 brings the gas turbine 1 up towards its normal speed, the load decreases, and the motor current decreases, and when the current has decreased to a predetermined value, which may correspond to a motor speed at which the gas turbine 1 would normally have started self-sustaining operation, or to any other desired load condition, the relay 14 drops out, opening its contact 15. This deenergizes the coil 10, and the contactor 9 opens its contacts 11 and 20, disconnecting the motor 2 from the battery, so that the motor stops. The contact 26 remains closed,

however, so that the ignition circuit 4 remains energized, and the timing motor 21 continues to run. Thus, energization of the ignition circuit is maintained to insure that combustion of the fuel will be well established.

At the end of a predetermined time interval, the cam 28, which is driven by the timing motor 21, actuates the contact 19 to open it and interrupt the control circuit 18, which deenergizes the ignition circuit 4, the timing motor 21, and the clutch coil 25. This stops the timing motor, and disengages the clutch 24, which causes the contact 26 to open. In case the motor 2 is still running at this time, the coil 10 will also be deenergized, causing the contactor 9 to open the contact 11 and stop the motor. Thus, all parts of the system are automatically deenergized at the end of a definite predetermined time interval. The cam 28, or other actuating device, is arranged so that the contact 19 is opened only momentarily, and then recloses in readiness for another cycle of operation of the system.

If the gas turbine 1 has not yet started when the contact 19 opens, the push button 13 is again depressed and the same cycle is repeated. If desired, the push button 13 can, of course, simply be held down until the turbine starts, the system going through repeated timed cycles of definite duration, as described above.

It will be apparent, therefore, that a starting control for gas turbines has been provided which is simple and reliable, and which effectively performs the functions of energizing the starting motor and ignition circuit substantially simultaneously, of stopping the motor as soon as the gas turbine has started, or has accelerated to a predetermined speed, and of deenergizing the ignition circuit and all other parts of the system automatically at the end of a predetermined time.

A particular embodiment of the invention has been shown and described for the purpose of illustration, but it will be understood that various changes and modifications may be made within the scope of the invention. Thus, the system shown and described is especially adapted for aircraft use, and is, therefore, shown as utilizing a battery, and a ground return circuit, but it will be apparent that any other source of energy might be used, and that a wire return circuit might be utilized. It is to be understood, therefore, that the invention is not restricted to the particular details shown and described, but in its broadest aspects, it includes all equivalent modifications and embodiments which come within the scope of the appended claims.

We claim as our invention:

1. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy, means for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, and means for effecting deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

2. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy, means for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, and timing means, said tim-

ing means being started in operation simultaneously with the energization of the auxiliary circuit and being adapted to effect deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

3. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy and for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, means for maintaining energization of the auxiliary circuit, and timing means for effecting deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

4. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy and for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, contact means for maintaining energization of the auxiliary circuit independently of the motor-energizing means, and timing means for effecting deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

5. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy and for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, contact means for maintaining energization of the auxiliary circuit independently of the motor-energizing means, said contact means being actuated to closed position simultaneously with energization of the auxiliary circuit, and timing means for effecting deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

6. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising means for effecting connection of said motor to a source of electric energy and for substantially simultaneously energizing said auxiliary circuit, means for effecting deenergization of the motor in response to a decrease in the current to the motor, contact means for maintaining energization of the auxiliary circuit independently of the motor-energizing means, and timing means, said contact means being actuated to closed position and said timing means being started in operation substantially simultaneously with energization of the auxiliary circuit, the timing means being adapted to effect deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

7. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising a contactor for connecting said motor to a source of electric energy, manual means for effecting operation of said contactor to closed position, means responsive to the motor current for maintaining the contactor in closed position, said current-responsive means being adapted to cause the contactor to open when the motor current decreases below a predetermined value, means associated with the contactor for energizing the auxiliary circuit substantially simultaneously with the energization of the motor, contact means for maintaining energization of the auxiliary circuit independently of the contactor, and timing means, said contact means being actuated to closed position and said timing means being started in operation simultaneously with energization of the auxiliary circuit, the timing means being adapted to effect deenergization of the motor and of the auxiliary circuit at the end of a predetermined time.

8. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising a contactor for connecting said motor to a source of electric energy, a control circuit, manual means for energizing said contactor from the control circuit to cause the contactor to move to closed position, means responsive to the motor current for maintaining energization of the contactor, said current-responsive means being adapted to effect deenergization of the contactor when the motor current decreases below a predetermined value, means associated with the contactor for connecting said auxiliary circuit to the control circuit to be energized thereby when the contactor closes, contact means for maintaining energization of the auxiliary circuit independently of the contactor, said contact means being actuated to closed position simultaneously with energization of the auxiliary circuit, and timing means for effecting interruption of the control circuit at the end of a predetermined time after the contactor closes.

9. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising a contactor for connecting said motor to a source of electric energy, a control circuit, manual means for energizing said contactor from the control circuit to cause the contactor to move to closed position, means responsive to the motor current for maintaining energization of the contactor, said current-responsive means being adapted to effect deenergization of the contactor when the motor current decreases below a predetermined value, means associated with the contactor for connecting said auxiliary circuit to the control circuit to be energized thereby when the contactor closes, contact means for maintaining energization of the auxiliary circuit independently of the contactor, and timing means, said contact means being actuated to closed position and said timing means being started in operation simultaneously with energization of the auxiliary circuit, the timing means being adapted to effect interruption of the control circuit at the end of a predetermined time.

10. Control means for an electric motor and for an associated auxiliary circuit, said control means comprising a contactor for connecting said motor to a source of electric energy, a control circuit, manual means for energizing said contactor from the control circuit to cause the contactor to move to closed position, means responsive to the motor current for maintaining energization of the contactor, said current-responsive means being adapted to effect deenergization of the contactor when the motor current decreases below a predetermined value, means associated with the contactor for connecting said auxiliary circuit to the control circuit to be energized thereby when the contactor closes, contact means for maintaining energization of the auxiliary circuit independently of the contactor, said contact means being actuated to closed position simultaneously with energization of the auxiliary circuit, and a timing motor, said timing motor being connected to the control circuit simultaneously with ener-

gization of the auxiliary circuit, said contact means being adapted to maintain energization of the timing motor, and the timing motor being adapted to effect interruption of the control circuit at the end of a predetermined time.

11. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, means for effecting connection of said motor to a source of electric energy, means for substantially simultaneously energizing said ignition circuit, means for effecting deenergization of the motor in response to a decrease in the load on the motor, and means for effecting deenergization of the motor and of the ignition circuit at the end of a predetermined time.

12. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, means for effecting connection of said motor to a source of electric energy, means for substantially simultaneously energizing said ignition circuit, means for effecting deenergization of the motor in response to a decrease in the load on the motor, means for maintaining energization of the ignition circuit independently of energization of the motor, and timing means for effecting deenergization of the motor and of the ignition circuit at the end of a predetermined time.

13. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, a contactor for connecting said motor to a source of electric energy, manual means for effecting operation of said contactor to closed position, means responsive to the motor current for maintaining the contactor in closed position, said current-responsive means being adapted to cause operation of the contactor to open position to deenergize the motor when the motor current decreases below a predetermined value, means associated with the contactor for effecting energization of said ignition circuit substantially simultaneously with energization of the motor, and timing means for effecting deenergization of the motor and of the ignition circuit at the end of a predetermined time.

14. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, a contactor for connecting said motor to a source of electric energy, manual means for effecting operation of said contactor to closed position, means responsive to the motor current for maintaining the contactor in closed position, said current-responsive means being adapted to cause operation of the contactor to open position to deenergize the motor when the motor current decreases below a predetermined value, means associated with the contactor for effecting energization of said ignition circuit substantially simultaneously with energization of the motor, and a timing motor energized simultaneously with the ignition circuit, said timing motor being adapted to effect deenergization of the motor and of the ignition circuit at the end of a predetermined time.

15. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, a contactor for connecting said motor to a source of electric energy, a control circuit, manual means for energizing said contactor from said control circuit to cause operation of the contactor to closed position, means responsive to the motor current for maintaining energization of the contactor to hold it in closed position, said current-responsive means being adapted to cause operation of the contactor to open position to deenergize the motor when the motor current decreases below a predetermined value, means associated with the contactor for effecting connection of said ignition circuit to the control circuit to be energized thereby substantially simultaneously with energization of the motor, contact means for maintaining energization of the ignition circuit independently of the contactor, and timing means adapted to effect interruption of the control circuit at the end of a predetermined time.

16. Starting means for a gas turbine which includes an electric ignition circuit, said starting means comprising an electric motor adapted to be connected to the gas turbine for starting it, a contactor for connecting said motor to a source of electric energy, a control circuit including a normally closed contact, manual means for energizing said contactor from said control circuit to cause operation of the contactor to closed position, means responsive to the motor current for maintaining energization of the contactor to hold it in closed position, said current-responsive means being adapted to cause operation of the contactor to open position to deenergize the motor when the motor current decreases below a predetermined value, means associated with the contactor for effecting connection of said ignition circuit to the control circuit to be energized thereby substantially simultaneously with energization of the motor, contact means for maintaining energization of the ignition circuit independently of the contactor, and a timing motor, said timing motor being connected so as to be energized from the control circuit, the timing motor being adapted to effect opening of said normally closed contact in the control circuit at the end of a predetermined time.

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