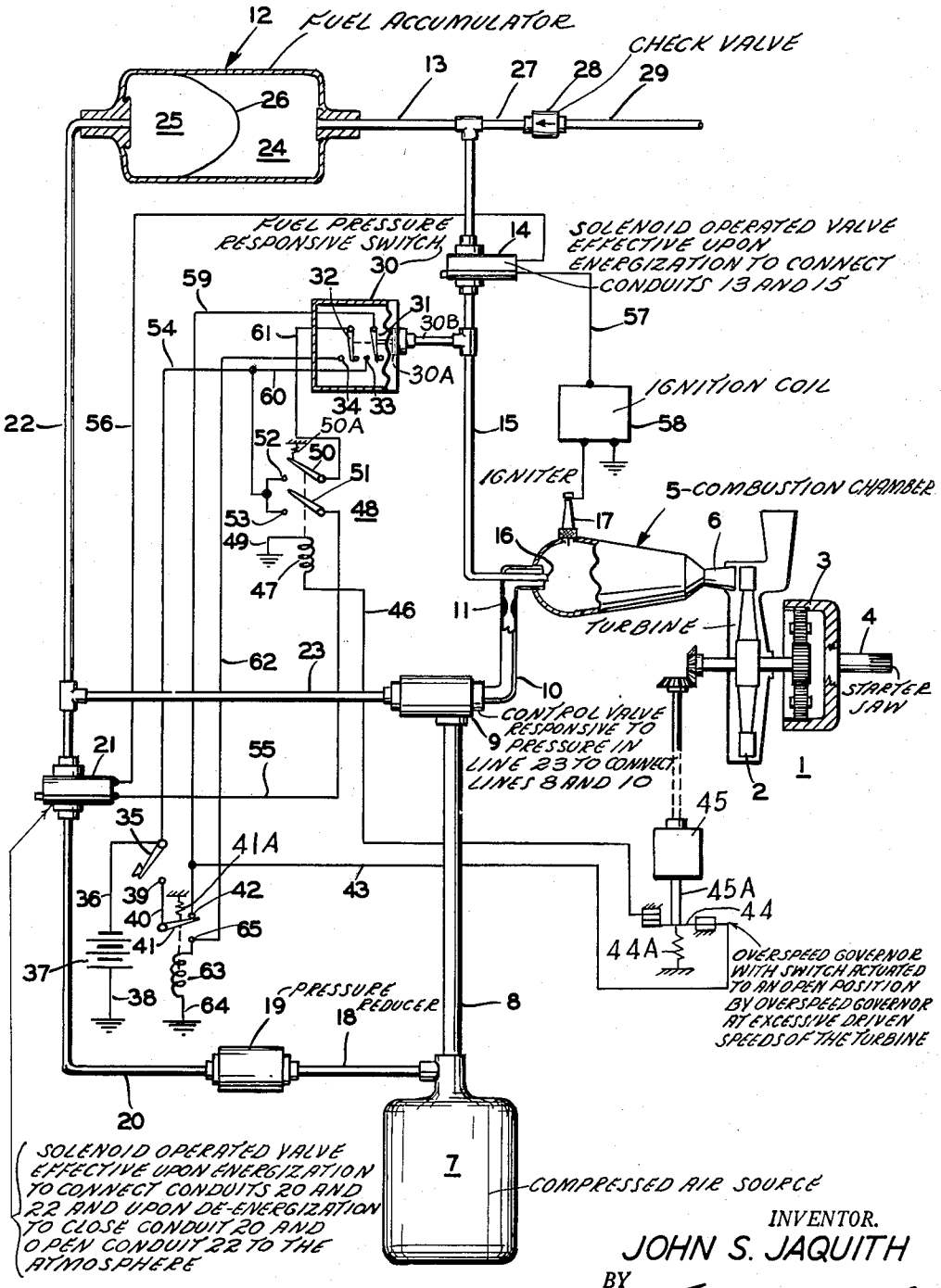
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STARTER CONTROL SYSTEM

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STARTER CONTROL SYSTEM

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The present invention relates to engine starters and more particularly to a liquid-fuel turbine type starter.

The advent of the gas turbine or jet engine introduces new problems in the design of starters. Such engines differ from the conventional piston type internal combustion engines in that they must be brought up to a self-sustaining speed in order to be started whereas the piston type engine would start upon being cranked at a very low speed.

The severe cranking requirements of the gas turbine type of engine together with the compact design of the aircraft for which such engines are used render the conventional electric starters unpractical. A turbine type starter utilizing a small turbine running at a high speed appears to be adapted to the requirements.

Chemical means and solid propellants such as a slow burning powder have been suggested for generating gases for the operation of the turbine. The aforenoted means, however, are objectional in view of the extensive safety precautions necessary to harness and control the generated gases. Further, the storage of the chemicals or powder creates a hazardous condition.

It has been found that burning a mixture of fuel and air provides a means for generating gases which overcomes the aforenoted objections. The fuel used is the same as that normally used for the gas turbine or jet. In a system utilizing a mixture of fuel and air it is necessary to prevent the burning period from becoming extended with resultant damage to the turbine. Also it is desirable to conserve the compressed air in order that the size of the air tanks may be held to a minimum.

Heretofore the combustion period has been controlled by an electronic timer which shuts off the flow of air and fuel after a predetermined period of time. This method has the disadvantage in that once the timer is started it is necessary that it run its complete cycle whether ignition has taken place in the combustion chamber or not.

The present invention provides means for de-energizing the system after a predetermined quantity of fuel has been burned and is responsive to a decrease in pressure in the fuel line to de-energize the system after the fuel has been delivered.

It is an object of the present invention to provide a novel starting system.

Another object of the invention is to provide an improved control system for a starter.

Another object of the invention is to provide an improved starter for a gas turbine.

Another object of the invention is to provide an improved starter system for a gas turbine in which a predetermined amount of the fuel for the gas turbine is used to power the starting system.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one embodiment of the invention is illustrated by way of example.

In the drawing:

The single figure is a schematic diagram of a starter system embodying the invention.

Referring to the drawing, a starter is indicated generally by the numeral 1 and comprises a turbine 2 connected through reduction gearing 3 to starter jaw 4. The starter jaw 4 is adapted to be connected to the engine to be started (not shown) in a conventional manner. Details of the turbine 2, reduction gearing 3 and starter jaw 4 have been omitted as the structure thereof forms no part of the present invention.

A combustion chamber 5 is connected to the turbine 2 by nozzles 6. A source of compressed air 7 is connected by conduit 8, pressure responsive valve 9, conduit 10, and air nozzle 11 to the chamber 5. A source of fuel or fuel accumulator 12 is connected by conduit 13, solenoid operated valve 14, conduit 15 and fuel nozzle 16 to the chamber 5. A spark plug or ignitor 17 is provided in the chamber 5 to ignite the mixture of fuel and air.

The compressed air source 7 is also connected by conduit 18, pressure reducer 19, conduit 20, solenoid operated valve 21 and conduit 22 to the fuel accumulator 12. Also the pressure responsive valve 9 is connected by a conduit 23 to the conduit 22.

The accumulator 12 has a fuel section 24 and an air section 25. The sections 24 and 25 are separated by a leakproof elastic diaphragm 26. Air enters the air section 25 from the conduit 22. The fuel section 24 is connected to the aircraft fuel system (not shown) by conduits 13, 27, check valve 28 and conduit 29.

A pressure responsive switch 30 is provided of conventional type including, for example, a switch operating bellows 30A connected by conduit 30B to the fuel conduit 15 and has switch members 31 and 32 normally biased in an open position as by the spring tension of bellows 30A. The switch members 31 and 32 when actuated to a closed position as by fuel pressure applied to the bellows 30A through conduit 30B are adapted to engage contacts 33 and 34 respectively.

A switch member 35 has one side thereof connected by conductor 36 to a source of electrical energy such, for example, as a battery 37. The other side of the battery 37 is connected to ground by a conductor 38. The switch member 35 is adapted to engage contact member 39 which is connected by conductor 40 to switch member 41 which is normally biased as by a spring 41A in a closed position into engagement with contact member 42.

The contact member 42 is connected by a conductor 43 to one side of a switch 44 biased as by a spring 44A to a normally closed position. The switch 44 is operated by a centrifugal overspeed governor 45 of conventional type connected by gearing to the turbine 2. Upon the turbine 2 exceeding a predetermined speed the switch 44 will be actuated by a rod 45A of the overspeed governor 45 to an open position.

The other side of the switch 44 is connected by conductor 46 to control winding 47 of relay 48. The other end of the control winding 47 is connected by conductor 49 to ground. The relay 48 has a pair of normally open switch members 50 and 51 biased to the open position by a spring 50A. The switch members 50 and 51 are adapted when actuated to a closed position upon energization of control winding 47 to engage contact members 52 and 53 respectively. The contact members 52 and 53 are connected together and connected by conductor 54 to the battery 37.

The switch member 51 is connected by conductor 55 to one side of the solenoid operated valve 21. The other side of the solenoid operated valve 21 is connected by conductor 56 to one side of the solenoid operated valve 14. The other side of the solenoid operated valve 14 is connected by conductor 57 to spark coil 58 which is con-

nected to the spark plug 17. While the valves 21 and 14 and the spark coil are illustrated as connected in series, it is understood that they could be connected in parallel without departing from the scope of the invention.

The switch member 31 of the pressure responsive switch 30 is connected by conductor 59 to the conductor 43 and contact member 33 is connected by conductor 60 to the conductor 54. The switch member 32 is connected by conductor 61 to the switch member 50 of the relay 48. Contact member 34 is connected by conductor 62 to one end of a control winding 63. The other end of the control winding 63 is connected by a conductor 64 to ground. The winding 63 is adapted when energized to actuate the switch member 41 out of engagement with contact 42 and into engagement with a contact 65.

The solenoid operated valves 14 and 21 during de-energization are normally closed and the valve 21 when in the closed position vents the conduit 22 to atmosphere in a conventional manner while closing conduit 20 to conduit 22.

In operation, the starting switch 35 is manually closed and control winding 47 of the relay 48, which is connected in series with the centrifugal switch 44, is energized. The winding 47, when energized, actuates switch members 50 and 51 into engagement with the respective contacts 52 and 53. This energizes the solenoid operated valves 21 and 14 and the spark coil 58. Upon being energized, the valve 21 is opened and air flows to pressurize the accumulator 12 and also actuates the pressure responsive valve 9 to permit air to flow from the air bottle 7 to the combustion chamber 5. The valve 14 is also actuated to an open position thus permitting fuel to flow from the accumulator 12 to the combustion chamber where the mixture of fuel and air is ignited to provide means for actuating the turbine 2.

The pressure in the conduit 15 actuates the pressure responsive switch 30 causing the switch members 31 and 32 to engage the respective contacts 33 and 34 thereby to bypass the switch 35 and to energize the winding 63 which actuates the switch member 41 so as to open contact 42 and into engagement with a contact 65 thus rendering the starting switch 35 ineffective. The switch 44 is in series with the control winding 47 of the relay 48 and upon the turbine exceeding a predetermined speed the overspeed governor 45 through rod 45A will open the switch 44 thereby de-energizing the system.

Upon the fuel in the accumulator being expended, the pressure in the conduit 15 will decrease and the switch 30 will return to its open position. This de-energizes the relay 48 which opens the circuits to the solenoid operated valves 14 and 21, thus permitting them to return to a closed position thereby shutting off the air supply. The valve 21 is of a conventional type so arranged that upon the valve 21 being in a closed position it vents the conduit 22 to atmosphere. A resulting reduction in the pressure of the air in the conduit 23 permits the pressure responsive valve 9 to return to a closed position shutting off the air from conduit 8 to conduit 10.

Upon the pressure being removed from the accumulator 12 it will be refilled with fuel from the craft's fuel system through the conduit 29 and check valve 28.

Thus when the charge of fuel stored in the accumulator has been discharged therefrom the system is automatically shut off thus conserving the air supply and protecting the system against an extended burning period, the length of the burning period being determined by the amount of fuel in the accumulator.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention.

What is claimed is:

1. A control system for a turbine type engine starter powered by burning a mixture of fuel and air in a combustion chamber, comprising a source of fuel, a source of pressurized air, a starting switch, first relay means, a pressure responsive switch, second relay means, means connecting said source of pressurized air to said combustion chamber and to said source of fuel for pressurization thereof, said air connecting means including a first solenoid operated valve for controlling the supply of air from the source of pressurized air to said combustion chamber and for connecting said fuel source for pressurization by said air supply, means connecting said source of fuel to said combustion chamber, said fuel connecting means including a second solenoid operated valve for controlling the supply of fuel from the fuel source to the combustion chamber, ignition means for the fuel and air mixture in the combustion chamber, control means responsive to actuation of said starter switch to actuate said first relay means, first circuit means responsive to actuation of said first relay means to energize said first and second solenoid operated valves and said ignition means, energization of said solenoid operated valves causing fuel to be supplied the combustion chamber under pressure of the pressurized air, means operatively connecting said fuel connecting means to said pressure responsive switch, said pressure responsive switch being actuated to a closed position upon said fuel pressure exceeding a predetermined value, second circuit means effective upon actuation of said pressure responsive switch to said closed position to bypass said starter switch and energize said second relay to render said starter switch ineffective, said pressure responsive switch being responsive to said fuel pressure falling below said predetermined value to de-energize said system.

2. The combination as set forth in claim 1 and including means responsive to the speed of the turbine, a switch serially connected in the second circuit means and operated by said speed responsive means upon the speed of said turbine exceeding a predetermined value to de-energize said system.

3. A control system for a turbine type engine starter powered by burning a mixture of fuel and air in a combustion chamber, comprising air control means to effect upon energization a flow of air to the combustion chamber, fuel control means to effect upon energization a flow of fuel to the combustion chamber, ignition means to effect ignition of the fuel-air mixture in the combustion chamber, means for initially energizing said air control means, said fuel control means and said ignition means, and other means for controlling energization of the air-fuel control means and the ignition means including pressure responsive means responsive to fuel pressure to shunt said initial energizing means upon the pressure of the fuel supplied said chamber exceeding a predetermined value and to de-energize said system upon a drop in said fuel pressure below said predetermined value.

4. A control system for an engine starter powered by burning a mixture of fuel and air under pressure in a combustion chamber, comprising a starting switch, relay means connected for energization upon actuation of said starting switch, a solenoid operated air control valve, a solenoid operated fuel control valve, ignition means, circuit means responsive to energization of said relay means to energize said solenoid operated valves and said ignition means, switch means responsive to fuel pressure to energize said solenoid operated valves, said relay and said ignition means independent of said starting switch upon said fuel pressure exceeding a predetermined value, and control means operated by said fuel pressure responsive switch means to render said starting switch ineffective upon the fuel pressure exceeding said predetermined value.

5. The combination as set forth in claim 4 and including turbine speed responsive means, switch means in series with said relay means and operated by said speed responsive means to de-energize said relay means

upon the speed of the turbine exceeding a predetermined maximum value.

6. For use in an engine starter adapted to be powered by burning a mixture of air and fuel in a combustion chamber, a control system comprising air control means, fuel control means, means for initially actuating said air and fuel control means to an open position to supply air and fuel to said combustion chamber for burning, means responsive to a rise in a fluid pressure caused by the supply of fuel to said combustion chamber to take over the control of said fuel and air control means and to actuate said air and fuel control means to a closed position upon said fluid pressure dropping below a predetermined value.

7. An engine starter system comprising a combustion chamber, a turbine, nozzle means connecting said combustion chamber to said nozzle, a starter jaw member, reduction gearing interconnecting said turbine and said jaw, a source of compressed air, means including a solenoid operated valve for connecting said air source to said combustion chamber, a source of fuel, means including a second solenoid operated valve for connecting said source of fuel to said combustion chamber, said first solenoid operated valve connecting said fuel source for

pressurization by said air supply, ignition means for said combustion chamber, a source of electrical energy, a main relay, means including a starting switch to initially energize said main relay, circuit means responsive to actuation of said main relay to energize said solenoid operated valves and said ignition means, circuit means including a pressure responsive switch effective upon the pressure of the fuel supplied said chamber exceeding a predetermined value to cause energization of said solenoid operated valves and said ignition means independent of said starting switch, and an auxiliary relay means controlled by said pressure responsive switch to disable said starting switch.

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