

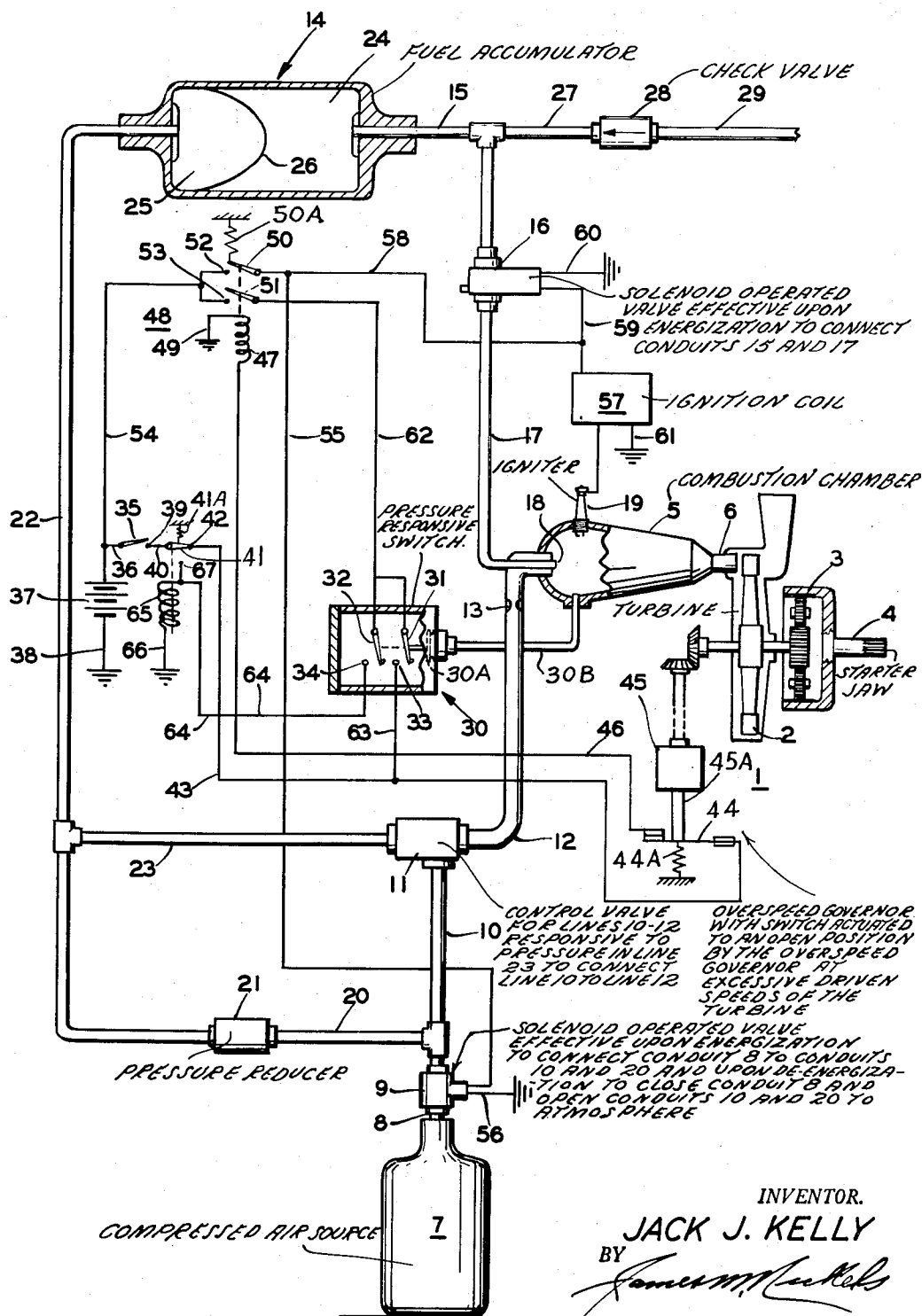
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STARTER CONTROL SYSTEM

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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 impractical. 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 aforementioned 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 create a hazardous condition.

It has been found that burning a mixture of fuel and air provides a means for generating gases which overcomes the aforementioned 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 combustion chamber 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.

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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, solenoid operated valve 9, conduit 10, pressure responsive valve 11, conduit 12 and air nozzle 13 to the chamber 5. A source of fuel or fuel accumulator 14 is connected by conduit 15, solenoid operated valve 16, conduit 17 and fuel nozzle 18 to the chamber 5. A spark plug or ignitor 19 is provided in the chamber 5 to ignite the mixture of fuel and air.

The compressed air source 7 is also connected by conduit 8, the solenoid operated valve 9, conduit 20, pressure reducer 21 and conduit 22 to the fuel accumulator 14. Also the pressure responsive valve 11 is of conventional type and connected by a conduit 23 to the conduit 22 so that upon the air pressure in conduit 22 exceeding a predetermined value, the pressure responsive valve 11 is actuated to an open position so as to effectively connect the conduit 10 to the conduit 12 in a conventional manner.

The accumulator 14 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 15, 27, check valve 28 and conduit 29.

A pressure responsive switch 30 is provided of a conventional type including, for example, a switch operating bellows 30A connected to the combustion chamber by a pressure conduit 30B so as to be actuated by the pressure in the combustion chamber 5. The switch members 31 and 32 may be normally biased in an open position by the spring tension of bellows 30A. The switch members 31 and 32 when actuated to a closed position by the combustion pressure applied to bellows 30A 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 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 is of a conventional type and has a pair of normally open switch members 50 and 51 biased to an open position, as by a spring 50A. The switch members 50 and 51 are biased to a closed position by the electromagnetic control winding 47 upon energization thereof. The members 50 and 51 are adapted when actuated to a closed position 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 50 is connected by conductor 55 to one side of the solenoid operating the valve 9. The other side of the solenoid operating the valve 9 is connected by conductor 56 to ground. Also one side of the solenoid operating the valve 16 and a spark or ignition coil 57 are connected by conductors 58 and 59 to the switch member 50. The solenoid operating the valve 16 is connected by a conductor 60 to ground and the spark coil 57 by a conductor 61 to ground. While the control solenoids for valves 9 and 16 and the spark coil 57 are illustrated as connected in parallel, it is understood that they could be connected in series without departing from the scope of the invention.

The switch members 31 and 32 of the pressure switch 30 are connected by conductor 62 to the switch member 51 of the relay 48. The contact member 33 is connected by conductor 63 to the conductor 43. Contact member 34 is connected by conductor 64 to one end of a control winding 65. The other end of the control winding 65 is connected by a conductor 66 to ground. The winding 65 is adapted when energized to actuate the switch member 41 so as to open contact 42 and into engagement with a contact 67.

The solenoid operated valves 9 and 16 are normally closed during deenergization of the respective solenoids operating the same and the valve 9 when in the closed position vents the conduits 20, 22, 23 and 10 to atmosphere in a conventional manner.

In operation, the starting switch 35 is manually closed and control winding 47 of the relay 48, which is connected in series with the 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 solenoids controlling the valves 9 and 16 and also the spark coil 57. Upon being so energized, the solenoid operated valve 9 is opened and air flows to pressurize the accumulator 14 and the air pressure applied to lines 22—23 also actuates the pressure responsive valve 11 so as to cause the same to open and thereupon permit air to flow from the air bottle 7 to the combustion chamber 5. The valve 16 upon energization of its control solenoid is also actuated to an open position thus permitting fuel to flow from the accumulator 14 to the combustion chamber 5 where the mixture of fuel and air is ignited to provide means for actuating the turbine 2.

The pressure in the combustion chamber, upon the mixture of fuel and air being ignited, 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 65 which actuates the switch member 41 into engagement with the contact 67 and opening contact 42, thus rendering the starting switch 35 ineffective to control energization of the relay 48. The switch 44 is in series with the relay 48 and upon the turbine exceeding a predetermined speed will open thereby deenergizing the control winding 47 of relay 48 and in turn deenergize the starting system.

In the event the driven speed of the turbine 2 does not exceed the predetermined value at which the governor 45 opens the switch 44 so as to in turn deenergize the starting system, a cut off of the starting system may be effected by the pressure switch 30. Thus, in the event the switch 44 remains closed and does not cut off the starting system, it will be seen that upon the fuel in the accumulator 14 being expended, the pressure in the combustion chamber 5 will decrease and the switch 30 will return to its open position. This deenergizes the relay 48 which opens the circuits to the respective solenoids operating valves 9 and 16, thus permitting these valves to return to a closed position thereby shutting off

the air supply. Upon the valve 9 being in a closed position it vents the conduits 22, 23, 20 and 10 to atmosphere in a conventional manner. Shutting off the air in the conduit 23 permits the pressure responsive valve 11 to return to a closed position in which conduit 10 is closed to conduit 11.

Upon the pressure being removed from the accumulator 14 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, said system comprising a starter switch, first relay means, a pressure responsive switch, second relay means, an air supply, a fuel supply of a predetermined quantity, a first solenoid operated valve for controlling the air supply, a second solenoid operated valve for controlling the fuel supply, ignition means, control means responsive to actuation of said starter switch to actuate said first relay means, circuit means for energizing said first and second solenoid operated valves and said ignition means upon actuation of said first relay means, energization of said solenoid operated valves causing air and fuel to flow to said starter for ignition by said ignition means, means connecting said pressure responsive switch for response to the products of combustion of said fuel and air to actuate said pressure responsive switch to a closed position upon said combustion creating a pressure above a predetermined value, circuit means responsive to actuation of said pressure responsive switch 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 being expended causing a drop in combustion pressure below said predetermined value to de-energize said system.

2. The combination as set forth in claim 1 and including switch means electrically connected to the control means and responsive to a predetermined speed of said turbine to de-energize the control means so as to cause operation of the first relay means in a sense 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, said system comprising air control means, fuel control means, ignition means, means including a control circuit and auxiliary circuit means for initially energizing said air control means, said fuel control means and said ignition means, and pressure responsive means responsive to pressure in said combustion chamber and including circuit means to shunt the control circuit of said initially energizing means upon the pressure in said combustion chamber exceeding a predetermined value and to open said shunt circuit means to deenergize said control system upon a drop in said pressure below said predetermined value.

4. A control system for an engine starter powered by burning a predetermined amount of fuel mixed with air under pressure in a combustion chamber, said system 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, pres-

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sure responsive switch means responsive to pressure in said combustion chamber to energize said relay means independently of said starting switch upon said pressure exceeding a predetermined value and other means responsive to operation of said switch means to render said starting switch ineffective to control the aforesaid relay means.

5. The combination as set forth in claim 4 and including means responsive to the speed of said starter, control means in series with said relay means, and said control means operated by said speed responsive means to deenergize said relay means upon the speed of said starter exceeding a predetermined value.

6. For use in an engine starter adapted to be powered by burning a mixture of fuel and air in a combustion chamber, a control system comprising air control means, fuel control means, means for initially actuating said fuel and air control means to an open position to admit fuel and air to said combustion chamber for burning, means responsive to the pressure in said combustion chamber to take over the control of said initially opened fuel and air control means upon said pressure exceeding a predetermined value and to cause said fuel and air control means to close upon said combustion chamber pressure dropping below said 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 mechanism, reduction gearing interconnecting said turbine and said jaw mechanism, a source of compressed air, means including an electrically operable valve for connecting said air source to said combustion chamber, a source of fuel having a predetermined amount of fuel, means including a second electrically operable valve for connecting said source of fuel to said combustion chamber, means to pressurize said fuel source by said air supply through said first electrically operable valve, 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 ener-

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gization of said main relay to energize said electrically operable valves and said ignition means, a pressure responsive switch responsive to pressure in said combustion chamber exceeding a predetermined value to control energization of said main relay and thereby said electrically operable valves and said ignition means independent of said starting switch, and auxiliary relay means energized by said pressure responsive switch to disable said starting switch.

8. The combination set forth in claim 7 and including means responsive to the speed of said turbine, another switch in series with said starting switch and said pressure responsive switch to control energization of said main relay, said other switch operable by said speed responsive means to de-energize said main relay upon the speed of said turbine exceeding a predetermined maximum value.

9. In an engine starter adapted to be powered by combustion gases generated in a combustion chamber; a control system comprising first valve means for controlling supply of a combustion supporting fluid medium to said combustion chamber, second valve means for controlling supply of a combustible fluid fuel to said chamber, means for initially actuating said first and second valve means to an open position to admit the fuel and combustion supporting medium to said combustion chamber for effecting combustion, means responsive to the pressure of the combustion gases in said chamber to take over the control of said initially opened first and second valve means upon the pressure of the combustion gases exceeding a predetermined value and to cause said first and second valve means to close upon the pressure of the combustion gases in said chamber decreasing below said predetermined value.

References Cited in the file of this patent

UNITED STATES PATENTS

2,559,006	Clapham	July 3, 1951
2,611,239	Briggs	Sept. 23, 1952
2,643,511	Briggs	June 30, 1953