

[54] GAS TURBINE STARTING CIRCUIT

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[56] References Cited

UNITED STATES PATENTS

2,886,015	5/1959	Steinke	123/32 EA
2,962,597	11/1960	Evans	60/39.14
3,310,937	3/1967	Smith	60/39.28 R
3,440,433	4/1969	Comen	60/39.14
3,443,112	5/1969	Huntzinger	60/39.14
3,691,759	9/1972	Scheerer	60/39.14

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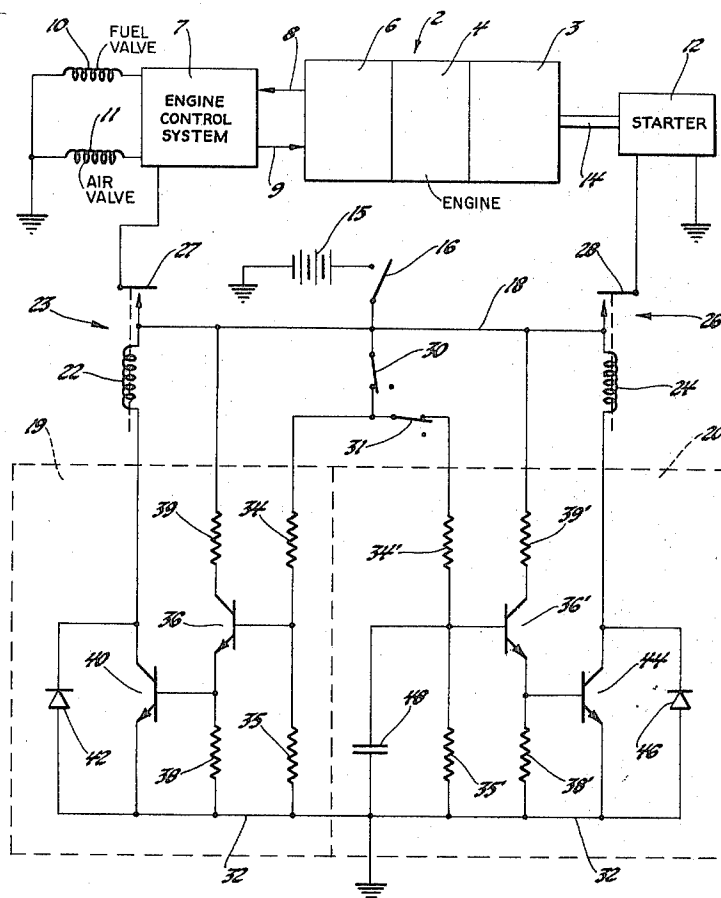
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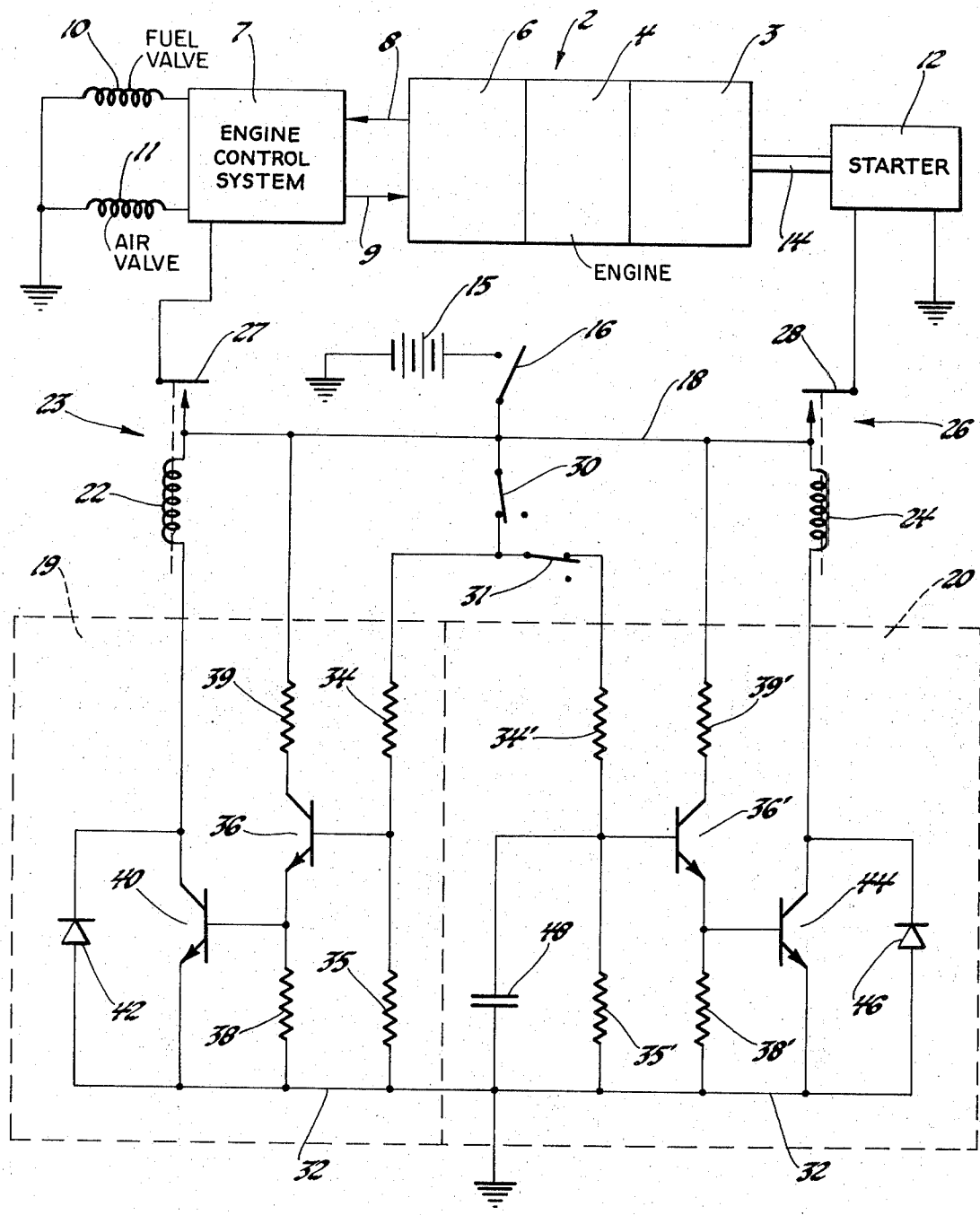
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[57] ABSTRACT

A gas turbine power plant includes an electric starter for cranking the engine and an electrical control system, both energized from a storage battery. The control system regulates the operation of the engine and includes a fuel valve solenoid and an atomizing air valve solenoid which are electrically energized. When the engine is started, these devices are energized along with the starter. Because of the heavy current required to operate the starter, the other electromagnetic devices are energized slightly before the starter to allow them to pull in while battery voltage is still at a normal level. The control system is energized by a first relay and amplifier or driver circuit and the starter by a second relay and amplifier or driver circuit. The starter amplifier circuit includes a capacitor which delays its operation for approximately 1/20 second after that of the other amplifier.

2 Claims, 1 Drawing Figure





GAS TURBINE STARTING CIRCUIT

Our invention is directed to a control system for a gas turbine engine and particularly to a combination of a starting system and other control systems for the engine in which energization of the starter is slightly delayed upon initiation of engine operation so as to allow for pull-in of electromagnetic devices included in the engine fuel supply system.

In its preferred embodiment, the system includes electromagnetic devices which are energized in order to enable operation of the engine and a starter which cranks the engine. These are concurrently energized from a common power source, but the energizing circuit of the starter includes delay means so that the other electromagnetic devices may pull in prior to the imposition of heavy current drain on the power source by the starter.

The principal objects of our invention are to improve the operation of gas turbine engines, to improve the starting characteristics and reliability of such engines, and to provide a simple starting circuit energizable through a single switch which delays energization of a starter until other electromagnetic devices have had time to pull in.

The nature of our invention and its advantages will be clear to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawing thereof.

The FIGURE is a schematic diagram of a starting and control system for a gas turbine engine.

Referring to the drawing, a conventionally represented gas turbine engine 2 may include a compressor 3, combustion apparatus 4, and a turbine or turbines 6. Turbine 6 may drive a load such as a motor vehicle, for example. The turbine or part of the turbine also drives compressor 3, which supplies air to the combustion apparatus to provide motive fluid for the turbine. The engine is operated under control of an engine control system 7, the details of which are immaterial to the present invention except as may be explained subsequently. Such control systems receive input of engine operating conditions and control operation of the engine through regulation of fuel or other conditions such as variable turbine nozzles and power transfer clutches, for example. Interconnections between the engine and control are represented by the arrows 8 and 9.

In the present example, the control system is at least partly electrical or electronic and includes electromagnetic devices which must be energized to effect operation of the engine. Such devices energized through the control system 7 may include a solenoid 10 which opens a valve in the fuel line to the engine and a fuel atomizing air valve solenoid 11. The operation of such solenoids, particularly the pull-in of such solenoids, is sensitive to the available voltage, but once the solenoid is pulled in, thus opening the valve, they are relatively insensitive to the drop in battery output voltage caused by the heavy drain for operating the engine starter.

The electric starter 12 is indicated as connected to the engine through a suitable shaft 14. The starter is energized only to crank the engine to self-sustaining speed, after which it is deenergized and effectively disconnected from the engine. The source of power for the entire system is the vehicle storage battery 15 which is connected through a switch 16 to a positive bus 18, the other terminal of the battery being grounded. Switch 16 may correspond to the ordinary

ignition and start switch of a vehicle and is opened to stop the engine and closed to cause the engine to run. When the switch is closed and bus 18 is energized, it provides a source of power for a run relay driver or amplifier 19 and a starter relay driver or amplifier 20. These energize, respectively, the coils 22 of a run relay 23 and the coil 24 of a starter relay 26. When the run relay 23 is energized, it closes contact 27 to deliver power to the engine control system 7 including solenoids 10 and 11. When the starter relay coil 24 is energized, it closes contact 28 to deliver power from the battery 15 to the starter motor 12.

Both the run relay amplifier 19 and starter relay amplifier 20 are energized, when switch 16 is closed, through a normally closed Run-Stop switch 30. This switch is opened to stop the engine. It may be manually actuated and may also respond to engine overspeed, overtemperature, or other unsatisfactory operating conditions of the engine sensed by the control system 7, as is well known. The starter amplifier is also energized through a Starter Cutout switch 31 which is closed initially and remains closed until the engine has been started, at which time this switch is opened by the control system 7 to terminate operation of the starter and remains open until the engine is stopped and a new starting cycle is initiated, as is generally understood.

We may now consider the Run and Starter relay amplifiers 19 and 20. In connection with this discussion, the values of components and identification of components are presented in the interest of complete disclosure. It will be understood, however, that the values may be varied to suit individual preferences or in response to developments in the electronic arts.

The amplifiers 19 and 20 are connected between the bus 18, energized at a nominal 12 volts from battery 15 when switch 16 is closed, and a ground or return bus 32. Considering first the run relay amplifier 19; when switch 16 is closed a circuit is completed from bus 18 through normally closed Run-Stop switch 30 and a voltage divider comprising series resistors 34 and 35 (both of 10 kilohms) to ground. The junction of these resistors is connected to the base of an NPN transistor 36 (Delco Service No. 67). The emitter of transistor 36 is connected to ground bus 32 through one kilohm resistor 38 and its collector is connected to bus 18 through a 470 ohm one watt resistor 39. The emitter of transistor 36 is connected to the base of an NPN transistor 40 (type 2N5183). This transistor has its emitter connected to ground bus 32 and its collector through relay coil 22 to bus 18. When switch 16 is closed, the base of transistor 36 is raised to approximately 1.5 volts which turns it on, and the resulting drop through resistor 38 turns on transistor 40, the base current of which flows through transistor 36. Relay 23, thus energized, closes contact 27 to supply 12 volts of power to the engine control system 7.

The emitter-collector circuit of transistor 40 is shunted by a diode 42 (Delco Service Type 31). When the engine is stopped by opening Run-Stop switch 30 and transistor 40 becomes non-conducting, there will be a reverse voltage surge from the inductive load of relay coil 22, which is shunted through diode 42 to protect transistor 40.

The starter amplifier 20 is identical to amplifier 19 except for the provision for time delay and for heavier duty components in the output circuit to handle the heavier current demand of the starter relay 26. Specifi-

cally, elements 34', 35', 36', 38' and 39' duplicate the corresponding elements of amplifier 19. The power transistor 44 is Delco Service type 513 and the diode 46 is Delco Service type 79. It can be seen that the circuit connections for these are the same as the other amplifier. The additional element of amplifier 20 is a 50 mfd delay capacitor 48 connected in parallel with resistor 35'. With this circuit, when switch 16 is closed and current flows through switches 30 and 31 and resistor 34', the potential rise across resistor 35' follows an exponential curve as capacitor 48 charges. The charging time of the capacitor is such that the base of transistor 36' reaches its turn-on voltage after a delay of approximately 1/20 second. Otherwise, amplifier 20 operates the same as amplifier 19.

It will be seen that the system and circuit as described provides a very simple and effective arrangement for allowing the valve solenoids 10 and 11 to pull in for operation of the engine prior to energization of the starter and the imposition of the corresponding heavy drain on the battery.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

We claim:

1. In a motor vehicle, the combination of a gas turbine engine, an electrically-energized starter for cranking the engine, a control system for the engine includ-

ing electromagnetic devices energized during starting and operation of the engine, and a storage battery for energizing the control system and starter with first relay means connected to energize the said control means from the battery, second relay means connected to energize the starter from the battery, and common energizing means for simultaneously energizing the said relay means, in which the second relay means includes time delay means to allow energization and pull-in of the said electromagnetic devices prior to energization of the starter and the accompanying drop in battery output voltage.

2. In a motor vehicle, the combination of a gas turbine engine, an electrically-energized starter for cranking the engine, a control system for the engine including electromagnetic devices energized during starting and operation of the engine, and a storage battery for energizing the control system and starter with first relay means connected to energize the said control means from the battery including a first amplifier, second relay means connected to energize the starter from the battery including a second amplifier, and common energizing means for simultaneously energizing the said amplifiers, in which the second amplifier includes time delay capacitor means to delay operation of the second amplifier and thus allow energization and pull-in of the said electromagnetic devices prior to energization of the starter and the accompanying drop in battery output voltage.

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