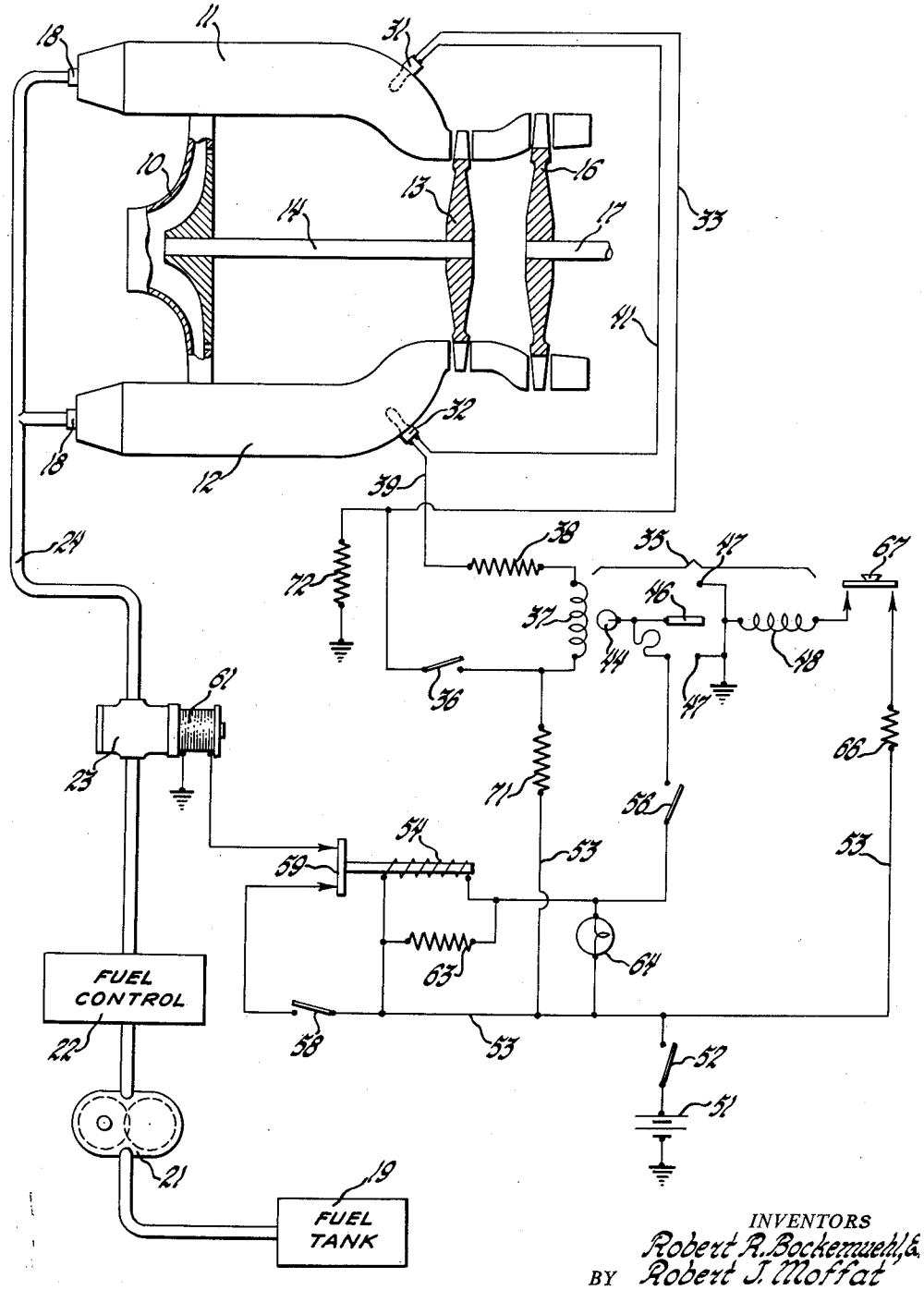
April 17, 1962 R. R. BOCKEMUEHL ET AL 3,030,575

THERMOCOUPLE CIRCUIT

Original Filed Jan. 11, 1954



INVENTORS
Robert R. Bockemuehl, Jr.
Robert J. Moffat
BY Paul Fitzpatrick
ATTORNEY

United States Patent Office 3,030,575 Patented Apr. 17, 1962

3,030,575
THERMOCOUPLE CIRCUIT

Robert R. Bockemuehl, Birmingham, and Robert J. Moffat, Oak Park, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Original application Jan. 11, 1954, Ser. No. 403,398. Divided and this application Sept. 29, 1958, Ser. No. 764,034

3 Claims. (Cl. 324—51)

This application is a division of application S.N. 403,398 filed January 11, 1954 (now abandoned).

Our invention relates to controls for gas turbine engines and other combustion devices or thermal plants. The preferred embodiment of the invention in a safety control for a gas turbine engine with two combustion chambers is described herein.

In brief, the control described herein employs two temperature responsive devices such as thermocouples, one in each combustion chamber, the responsive devices being connected in opposition and operative through suitable relay mechanism to shut off fuel to the engine when significant temperature unbalance occurs.

The invention which is the subject of this application lies particularly in a thermocouple circuit including means for checking the continuity of the circuit to assure that it is in condition to perform its function.

The principles and advantages of the invention will be apparent to those skilled in the art from the succeeding detailed description and the accompanying drawing which is a schematic diagram of a gas turbine fuel system embodying the invention.

The fuel system is illustrated in combination with a gas turbine engine which comprises a compressor **10** supplying combustion chambers **11** and **12**, and a turbine wheel **13** driven by combustion products from the chambers and driving the compressor through a shaft **14**. This part of the engine serves as a gas generator for a power turbine wheel **16** driving a shaft **17**. Fuel nozzles **18** in the combustion chambers are supplied from a fuel tank **19** through pump **21**, fuel control **22**, a normally closed solenoid-opened valve **23**, and line **24**.

Thermocouples **31** and **32**, which may be of a known quick-response high-temperature type, are mounted adjacent the discharge ends of combustion chambers **11** and **12**. These couples are in reverse series connection so that the thermoelectric E.M.F.'s of the two are opposed, and the resultant E.M.F. is substantially zero when the two are at the same temperature. The series circuit may be traced through thermocouple **31**, lead **33**, switch **36**, coil **37** of a sensitive relay **35**, resistor **38**, lead **39**, thermocouple **32**, and lead **41**. Relay **35** is of a known galvanometric type. Coil **37** operates an armature **44** in either direction in response to direction of current in the coil. A contact arm **46** actuated by the armature will engage either of two fixed contacts **47** in response to excitation of coil **37** above a predetermined value. The contact arm is magnetically urged into, and held in, engagement with the contacts until released by energization of a reset coil **48**.

Closure of contacts **46, 47** energizes solenoid valve **23** to close the fuel line by means of the following circuit: A battery **51** is connected to ground, and through switch **52**, line **53**, relay coil **54**, switch **56**, and contacts **47** (when closed) to ground. The battery also is connected through line **53**, switch **58**, back contacts **59** which may be opened by coil **54**, and solenoid **61** of valve **23** to ground. Relay coil **54** is shunted by a resistor **63** and a signal light **64** which is energized when contacts **47** close. The reset coil **48** is energized from the battery through line **53**, resistor **66**, and normally open push button switch **67**.

In normal operation of the electrical system, switches **52, 36**, and **56** are closed. Switch **58** is closed to energize valve solenoid **61** to admit fuel to the engine upon starting. Contacts **47** are normally open and contacts **59** normally closed. If, however, the differential E.M.F. of the thermocouples **31** and **32** exceeds the threshold of relay **35**, contacts **47** close, energizing warning light **64** and relay coil **54**, opening contacts **59** and cutting off the fuel at valve **23**. Because of the inherent thermal lag of thermocouples, the response of the relay is a function of both the magnitude and duration of the temperature difference between the combustion chambers.

Light **64** is energized to indicate that the differential temperature safety circuit has cut out the engine. It remains cut out until switch **67** is closed to reset relay **35**. Switch **56** may be opened to disable the energizing circuit of relay **54**, if desired. Thus, switch **56** may be closed only when starting the engine if the system is desired to be operative only then. Switch **52** is an overall energizing switch for the system.

A test circuit for the thermocouple circuit is provided. Energized line **53** is connected through high resistance **71** to the circuit on one side of switch **36** while the circuit is grounded through high resistance **72** on the other side of switch **36**. With switch **36** closed, the small current bled through resistors **71** and **72** in series passes through this switch and does not affect the relay **35**. To test continuity of the thermocouple circuit, switch **36** is opened, whereupon the battery **51** is connected through resistor **71**, relay coil **37**, the thermocouples, and resistor **72** to ground. If the circuit is complete, relay **35** operates, energizing lamp **64**.

It will be apparent that the invention may be employed in other environments than that described and may be embodied in diverse combinations of apparatus within the scope of the invention.

We claim:

1. In combination, a control circuit comprising at least one thermocouple, a galvanometer, and a normally closed switch in series, and means for testing continuity of the circuit comprising a low-current supply means connected to opposite ends of the switch so that the galvanometer is energized by the said source through the thermocouple when the switch is opened.

2. A control circuit comprising, in combination, thermocouple means, current-responsive means, and a normally closed switch connected in series, and means for testing the continuity of the series circuit comprising a limited current supply means connected to the series circuit at opposite sides of the switch so that the current-responsive means is energized by the source through the thermocouple means when the switch is opened and the series circuit is continuous.

3. A circuit as recited in claim 2 in which the thermocouple means comprises two thermocouples in series opposition.

References Cited in the file of this patent

UNITED STATES PATENTS

2,040,495	Nichols	May 12, 1936
2,163,475	Tomalis	June 20, 1939
2,428,568	Hill	Oct. 7, 1947
2,701,965	Sherman	Feb. 15, 1955
2,774,960	Podell	Dec. 18, 1956