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A. LOFT

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PHOTOELECTRIC FLAME DETECTOR

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2 Sheets-Sheet 2

Fig. 2.

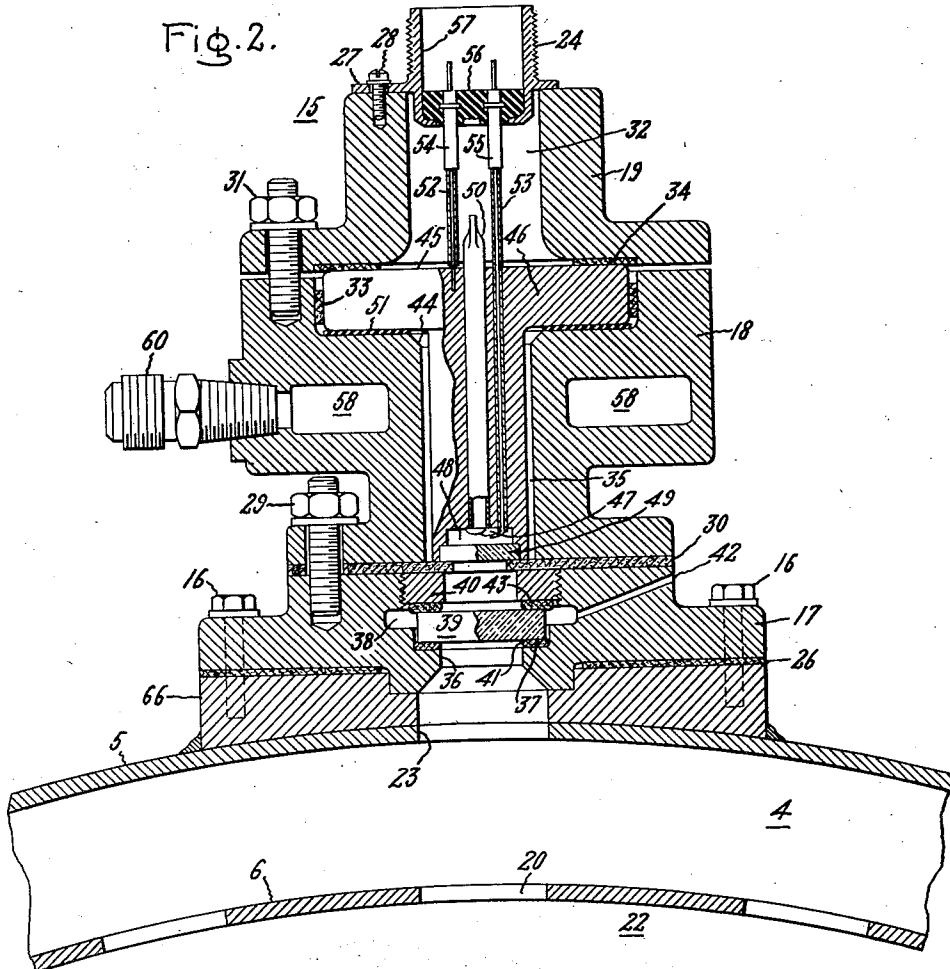
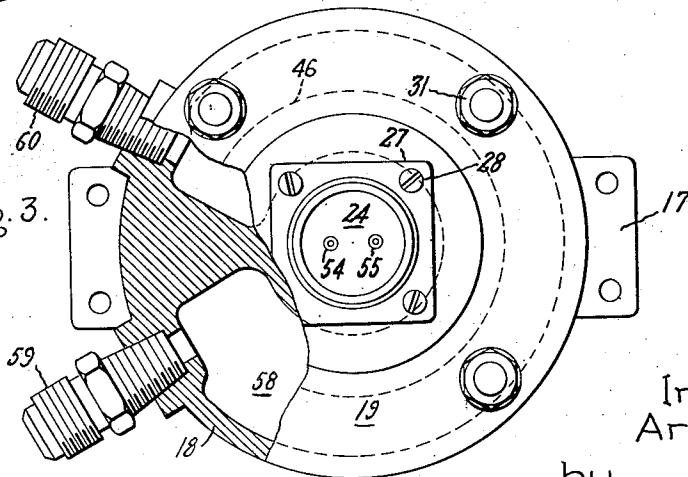


Fig. 3.



Inventor:
Arne Loft
by *Kiess*
His Attorney.

1

2,797,336

PHOTOELECTRIC FLAME DETECTOR

Arne Loft, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

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5 Claims. (Cl. 250—239)

This invention relates to flame detection devices for use in combustion apparatus, particularly to a detector of the photoelectric type for signaling the presence or absence of flame in the combustor of a gas turbine power plant.

Many different arrangements have been considered for indicating the presence of flame in combustion apparatus, including certain photoelectric devices. Difficulty has been experienced with the previously known devices due to the fact that the light sensitive element used in the prior art devices was not sufficiently accurate and reliable to permit widespread use in combustion apparatus.

Accordingly, an object of the present invention is to provide an improved flame detector of the photoelectric type which will act rapidly and accurately in response to the presence or absence of flame in the combustor of a gas turbine power plant.

Another object is to provide an improved flame detector which is simple in construction and low in manufacturing cost.

A further object is to provide a flame detector device which can be quickly and easily installed on a gas turbine.

Other objects and advantages will be apparent from the following description taken in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic representation of a portion of a gas turbine power plant showing the arrangement of a flame detector in accordance with the invention; Fig. 2 is a sectional view of the flame detector mounted in proper relation to the gas turbine combustor taken on the plane 2—2 in Fig. 1; Fig. 3 is an end view in elevation, partially cut away, of the flame detector; and Fig. 4 is a schematic diagram of the circuit embodying the photoelectric flame detector.

Generally stated, the invention comprises an improved photoelectric flame detector for a gas turbine. The flame detector contains a light sensitive element that changes its resistance in accordance with light intensity and is made of a multipart construction that permits it to be readily removed, inspected, and replaced without shutting down the turbine.

Referring now more particularly to Fig. 1, a flame detector incorporating the invention is shown mounted in proper position in the combustion system of a gas turbine power plant, in which a compressor of any suitable type, indicated generally at 1, supplies air at a suitable pressure, for instance 150 pounds per square inch, gauge, through diffusing passages 2 and transition passages 3 to the combustor indicated generally at 4. The combustor includes an outer housing 5 surrounding and spaced from an inner liner assembly 6, which latter defines the combustion space 22. The liner may be supported from the outer housing by any suitable means, for instance suitable radially extending brackets 7. Substantially closing one end of the liner is an end dome 8 which is spaced from the inner surface of the liner 6 to form an annular nozzle for discharging a high velocity jet of cooling air

2

along the inner surface of liner wall 6, as indicated by the arrow 9.

For introducing liquid fuel in a finely atomized spray into the end dome 8, a nozzle 10 is provided. This may be of any suitable type, but is preferably as shown in Patent No. 2,595,759 issued May 6, 1952, in the names of B. O. Buckland and D. C. Berkey, and assigned to the same assignee as the present application. The nozzle 10 is secured to a mounting boss 21 formed on the exterior surface of the outer casing 5, and is adapted to inject a conical spray of atomized fuel particles into the end dome 8, as indicated by the dotted lines 11. For igniting the fuel air mixture, an electric spark plug 12 is secured to the outer housing wall 5 and projects through the inner liner 6 and end dome 8 so that the electrodes provide a spark gap located approximately in the fuel spray pattern 11. Fuel is supplied to the nozzle 10 through a supply 10a containing a solenoid operated shut-off valve 13. If the nozzle 10 is of the air atomizing type disclosed in the above mentioned Buckland and Berkey patent, atomizing air at a suitable pressure is supplied to conduit 10b. Of course, with gaseous fuels a different style of nozzle, not provided with atomizing air, would be employed.

The exact details of the compressor, combustor, fuel nozzle, and other components are not essential to an understanding of the present invention; however, it may be noted that the combustor illustrated is of the general type disclosed in the Patent No. 2,601,000 issued June 17, 1952, to Mr. A. J. Nerad. An important characteristic of this type of combustor is that the combustion supporting air is injected through circumferential rows of opening 6a at such pressure and velocity as to form strong discrete jets which persist all the way to the center of the liner, diametrically opposed jets meeting at the axis of the liner to produce a resultant velocity back towards the dome 8, this reverse circulation being represented by the axial air flow arrows 14.

The flame detector itself, to which the present invention particularly relates, is shown generally at 15. It will be apparent that the detector is secured to the outer housing 5 by any suitable means, for instance two or more mounting bolts 16.

Referring now to Fig. 2, the flame detector comprises a three-piece assembly 17, 18 and 19 with the extreme end portion 17 of the flame detector located adjacent the circular opening 23 formed in the wall 5 of the combustor 4. The opening 23 is located directly opposite opening 20 in the liner 6 surrounding the combustion space 22 so that the flame detector is directly exposed to radiation from the flame in the combustion space, as may be seen more clearly in Fig. 2. The outer end portion 19 of the flame detector comprises an electrical coupling member 24 adapted to receive a suitable electrical connector plug (not shown) for coupling the flame detector to a suitable sensitive relay panel indicated generally at 25 in Fig. 4. The specific type of relay panel employed is not material to the present invention.

The relay panel takes the signal received from the flame detector and modifies the operation of the power plant accordingly. This may, for instance, take the form of a solenoid operated valve 13, which is arranged to close and shut off the supply of fuel to the nozzle 10 whenever the flame in the combustor becomes extinguished. It will, of course, be obvious to those skilled in the art that a signaling, controlling, or indicating device or other arrangements for modifying in a desired manner the operation of the power plant, may be actuated by the flame detector.

The internal structure of the flame detector 15 is shown more particularly in Fig. 2. It will be seen that the mounting bolts 16 pass through the flange member 17 and

are threadedly received in the mounting boss 66 with a suitable gasket 26 between boss 66 and flange 17. The gasket is for the purpose of preventing leakage of the high pressure air outwardly around the flame detector and also acts as a heat barrier between the photoelectric device and the combustor. Attached to the flange member 17 by bolts 29 is the main casing 18 which contains the light sensitive assembly. Leakage is prevented between casing 18 and flange member 17 by gasket 30. Closing the outer end of the casing 18 is a cover 19 or cap member bolted to the casing 18 by threaded fastenings 31. To prevent leakage into chambers 32 and 35 within casing 18 and cover 19 respectively are gaskets 33, 34 and 51. These gaskets also act as electrical insulators. Located in the top of cover 19 and closing off chamber 32 is the electrical coupling member 24. The coupling member is exteriorly threaded to receive an internally threaded member of the electrical connector. Electrical coupling member 24 is also provided with a radially extending flange 27 through which pass four machine screws 28 for securing flange 27 to cover 19.

The flange member 17 defines a circular hole 36 extending therethrough, which hole is in alignment with openings 20 and 23 in the inner and outer liner respectively of combustor 4. The central portion of flange member 17 defines an annular shoulder 37 and chamber 38 surrounding the bore 36. Located within the flange member 17 and abutting annular shoulder 37 is a glass or quartz window 39 maintained in place in member 17 by a threaded washer 40 inserted in the outer end of member 17. To prevent the leakage of gas between the glass plate 39 and the shoulder 37, a gasket 41 is inserted therebetween. In the event gas manages to leak into chamber 38, passages 42 are provided for venting the gas to the outside atmosphere. The glass plate 39 acts as a shield restricting the transmission of heat by radiation between the hot gases in the combustor and the photoelectric device. Gasket 43 is further provided to prevent leakage between glass plate 39 and the washer 40. The gasket 43 also distributes the thrust load on glass plate 39 by washer 40.

The casing 18 defines a T-shaped opening 44, the centerline of which is in alignment with the centerline of hole 36 in flange member 17. Adapted to be disposed within the opening 44 is the light sensitive assembly 45.

The light sensitive assembly 45 comprises a T-shaped copper block 46, having the same configuration but slightly smaller than opening 44 in casing 18. The copper block 46 is T-shaped to get good radiation cooling transfer surface between the block and the water cooled casing 18. Copper is used due to its excellent heat conducting properties. However, for electrical insulation purposes the copper block is coated with an insulating enamel. The copper block 46 is also electrically insulated from the casing 18 by spacers 33, 34 and 51. Within the copper block there is located the light sensitive element 47, which in this case is a cadmium sulfide crystal. The cadmium sulfide cell is located in a cavity 48 in the lower end of the copper block. The cadmium sulfide cell is soldered to the copper block 46 at the upper end of cavity 48. This cavity 48 is in alignment with the circular hole 36 in member 17 and the openings 20 and 23 in the inner and outer liner respectively of combustor 4. Thus it can be seen that the light sensitive element is directly exposed to the light conditions in the combustion space 22 in the combustor 4. To further decrease the radiation of heat through the opening in washer 40 to the light sensitive assembly 45, and also to prevent impurities from coming in contact with the cadmium sulfide cell, the cavity is sealed off with a heat resistant glass 49 that is maintained in place by applying solder to the copper block adjacent the outer surface of the glass plate. The solder hermetically seals the cavity 48. The cavity 48 is then evacuated and filled with helium through a tube 50, which is then pinched off and soldered closed, so that

the cadmium sulfide will operate in a more stable and accurate manner.

Cadmium sulfide is used because of its high resistance change versus incident light intensity. This high resistance change is measured through the two insulated electrical lead wires 52, 53 one of which is fused to the copper block 46 and the other is fused to the lower end of the cadmium sulfide cell. These lead wires are suitably connected to the prongs 54, 55 in the electrical coupling member 24. The prongs 54, 55 are secured in an insulating body 56 which is pressed, molded, or otherwise secured in the internal bore 57 of the electrical coupling member 24. The insulating bushing 56 may be of any suitable type, but is preferably of a high temperature resistant molded plastic material, such as the polystyrene plastic known to the trade as "Amphenol." Obviously other plastic or ceramic insulating materials, such as those well known in the spark plug art may also be employed. It will be seen from Fig. 2 that the contact prongs 54, 55 project at both ends from the insulating body 56, the upper end being a reduced diameter prong adapted to engage a suitable electrical connector plug received in the bore 57.

Fig. 3 is an end view in elevation showing more clearly the shape of the mounting flanges 19, 27 and 17 and the arrangement of the respective threaded fastenings 28, 31 and the electrical contact prongs 54, 55. In order to prevent overheating of the light sensitive assembly, it is cooled. This is done by providing the casing 18 with an annular chamber 58, surrounding the light sensitive assembly. The chamber 58 is supplied with a coolant through inlet fitting 59 and it leaves through outlet fitting 60. The casing 18 may be made of brass or other copper, or perhaps an aluminum alloy because of their excellent heat conducting properties.

The operation of the flame detector will be seen from the following: In starting the power plant, the compressor 1 is caused to rotate by an external starting motor (not shown) until the air supplied to the combustor is of a volume flow and pressure adequate to produce a good air-fuel mixture when fuel is injected through the nozzle 10. The opening of the shut-off valve 13 and the operation of the flame detector can be best described by referring to the schematic diagram of the circuit embodying the photoelectric flame detector illustrated in Fig. 4. A voltage is impressed across parallel circuits 61, 62. It makes no difference whether A. C. or D. C. is used. The fuel valve 13 is opened to allow fuel to enter the combustor by energizing the solenoid 64. This is done by closing the circuit 61 by the manual push button means 63. This push button has a timer attached (not shown) which reopens the circuit after a predetermined interval (i. e. 15 seconds). During this time interval, the fuel is ignited by a suitable ignition system (not shown). The light given off by the flame reduces the resistance of the light responsive cadmium sulfide element in the flame detector in circuit 62. This decrease in resistance in the flame detector allows sufficient current to flow through circuit 62 to energize the flame detector relay in panel 25 to move switch 65 to a closed position to complete the portion of circuit 61 which bypasses push button 63. The current flowing in circuit 61 through switch 65 to the solenoid 64 will continually energize the solenoid, and valve 13 will remain open. However, if the flame were to go out in the combustor 4, the flow of current through the flame detector would be sufficiently decreased due to the increased resistance of the light responsive element that the relay would not be able to maintain switch 65 in closed position. When switch 65 opens, the current to solenoid 64 is cut off, thereby allowing valve 13 to close, which in turn stops the flow of fuel to the combustor.

Thus it will be seen that the invention provides an improved flame detector which acts rapidly to control the flow of fuel to a gas turbine in response to the condition of the flame in the combustor. This flame detector due

to its mechanical construction can be quickly and easily installed and removed from the turbine whenever desired. The three-part construction also permits disassembly and inspection without requiring the gas turbine to be shut down. The additional features of venting to atmosphere whatever gas might leak into the flame detector and the continuous cooling of the light sensitive assembly enables the device to continue in operation for a long period of time without replacement becoming necessary. A sample device made in accordance with the invention appears to have almost indefinite life. Specifically, one unit has run for 500 hours without any sign of failure or deterioration.

While only one specific embodiment of the invention has been described in detail, it will be apparent to those skilled in the art that changes and substitutions of equivalents might be made. For example, the light sensitive element could be lead sulphide or some other known equivalent element which substantially changes its resistance in response to light intensity.

It is, of course, desired to cover by the appended claims all such modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A photoelectric flame detector for a combustion chamber having walls forming a combustion space and an air supply passage, the photoelectric flame detector comprising a flange member adapted to be secured to the outer wall of the combustion chamber, the flange member having a first axial bore which is adapted to be in alignment with openings in the walls of the combustion chamber, the flange member having an annular chamber surrounding said first axial bore, a glass plate disposed in said first axial bore and adapted to abut the bottom surface of said annular chamber, a washer threadedly disposed in the outer end of the flange member and adapted to abut against the glass plate to maintain it in place, sealing washers located between the glass plate and the flange member and threaded washer respectively to prevent leakage around the glass plate, and a vent passage formed by the flange member leading from the annular chamber to the atmosphere which is adapted to vent any hot gas which may leak into the annular chamber from the combustion chamber, a housing secured to the flange member and having a second axial bore which is in alignment with said first axial bore, a light responsive assembly disposed in said second axial bore which is adapted to be responsive to the light of the flame in the combustion chamber, the light responsive assembly consisting of a metal block defining a cavity at its end adjacent the flange member, a light responsive element disposed in said cavity with one end fused to the block, the light responsive element being of the type which changes its electrical resistance in response to the light intensity, a pair of lead wires fused to the light responsive assembly, one of said lead wires being connected to the metal block and the other connected to the outer end surface of the light responsive element, a glass plate secured to the block to close off the outer end of the cavity, a cap member adapted to maintain the light responsive assembly in said housing, means securing cap member to the housing member, the cap member forming an axial bore closed at its outer end by an electrical coupling member containing an insulating member having two contact prongs disposed therein and which at their inner ends are connected to the lead wires of the light responsive element and are adapted at their outer ends to receive a suitable electrical connector plug.

2. A photoelectric flame detector for a combustion chamber having walls forming a combustion space and an air supply passage, the photoelectric flame detector comprising a flange member adapted to be secured to the outer wall of the combustion chamber, the flange member having a first axial bore which is adapted to be in alignment

with openings in the walls of the combustion chamber, a housing secured to the flange member and having a second axial bore which is in alignment with said first axial bore, a light responsive assembly disposed in said second axial bore which is adapted to be responsive to the light of the flame in the combustion space of the combustion chamber, the light responsive assembly consisting of a metal block defining a cavity at its end adjacent the flange member, a light responsive element disposed in said cavity with one end fused to the block and being of the type which changes its electrical resistance in response to the light intensity, a pair of lead wires fused to the light responsive assembly, one of said lead wires being connected to the metal block and the other connected to the outer end surface of the light responsive element, a glass plate secured to the block to close off the outer end of the cavity, a cap member secured to the housing member and having an axial bore closed at its outer end by an electrical coupling member containing an insulating member having two contact prongs disposed therein and which at their inner ends are connected to the lead wires of the light responsive element and are adapted at their outer ends to receive a suitable electrical connector plug.

3. A photoelectric flame detector for a combustion chamber having walls forming a combustion space and an air supply passage, the photoelectric flame detector comprising a flange member adapted to be secured to the outer wall of the combustion chamber, the flange member having a first axial bore which is adapted to be in alignment with openings in the walls of the combustion chamber, a housing secured to the flange member and having a T-shaped axial bore which is in alignment with said first axial bore, a light responsive assembly disposed in said second axial bore which is adapted to be responsive to the light of the flame in the combustion space, the housing member also forming a chamber surrounding the light responsive assembly having an inlet and outlet and which is adapted to be supplied with a cooling medium to cool the light responsive assembly, the light responsive assembly consisting of a T-shaped metal block of substantially the same configuration as said T-shaped axial bore whereby a large radiation heat transfer surface exists between the cooled casing and the light responsive assembly, the metal block having a cavity at its end adjacent the flange member, a light responsive element disposed in said cavity with one end fused to the block and being of the type which changes its electrical resistance in response to the light intensity, a pair of lead wires fused to the light responsive assembly, one of said lead wires being connected to the metal block and the other connected to the outer end surface of the light responsive element, a glass plate secured to the block to close off the outer end of the cavity, a cap member secured to the housing member and having an axial bore closed at its outer end by an electrical coupling member containing an insulating member having two contact prongs disposed therein and which at their inner ends are connected to the lead wires of the light responsive element and are adapted at their outer ends to receive a suitable electrical connector plug.

4. A photoelectric flame detector for a combustion device having walls forming a combustion space and an air supply passage, the photoelectric flame detector comprising, a flange member adapted to be secured to the outer wall of the combustion device, the flange member having a first axial bore which is adapted to be in alignment with openings in the walls of the combustion device, a housing connected to the flange member and having a second axial bore which is in alignment with the first axial bore, a light responsive assembly disposed in said second axial bore which is adapted to be responsive to the light of the flame in the combustion space of the combustion device, the light responsive assembly containing a light sensitive element which changes its resistance in response to light intensity, a cap member secured to the housing and having an axial bore closed at its outer end by an electrical

7

coupling member containing an insulating member having two contact prongs disposed therein and connected at their inner ends to opposite end surfaces of the light responsive element for detecting changes in the resistance of the light responsive element, said contact prongs being adapted at their outer ends to receive electrical connector means.

5. A photoelectric flame detector in accordance with claim 4 in which the flange member forms an annular chamber surrounding said first axial bore, a glass plate disposed in the flange member and adapted to abut the bottom surface of said chamber, a washer threadedly disposed in the outer end of the flange member and adapted to abut against the glass plate to maintain it in place, sealing washers located between the glass plate and the flange

5

15

8

member and threaded washer respectively to prevent leakage around the glass plate, and a vent passage formed by the flange member leading from the annular chamber to the atmosphere which is adapted to vent any hot gas which may leak into the annular chamber from the combustion device.

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