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(54) Fiber optic flashback detection

(57) An apparatus for detecting flashback occurrences in a premixed combustor system having at least one flame nozzle (12a-12e) includes at least one photodetector (14a-14e) and at least one fiber optic element (24a-24e) coupled between the at least one photodetector and a test region of the combustor system wherein a respective flame of the flame nozzle is not present under normal operating conditions. A signal processor (20) monitors a signal of the photodetector. The fiber optic element can include at least one optical fiber positioned within a protective tube. The fiber optic element can include two fiber optic elements coupled to the test region. The optical fiber and the protective tube can have lengths sufficient to situate the photodetector outside of an engine compartment. A plurality of flame nozzles and a plurality of fiber optic elements can be used with the fiber optic elements being coupled to respective flame nozzles and either to the photodetector or, wherein a plurality of photodetectors are used, to respective ones of the plurality of photodetectors.

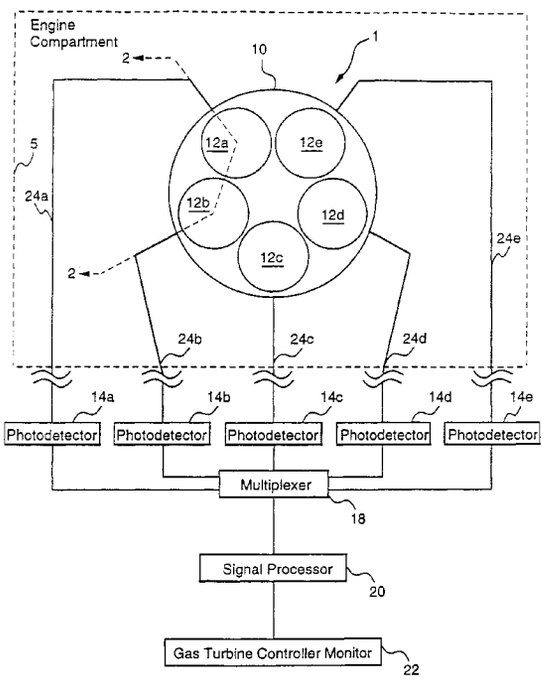


FIG. 1

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Description

This invention relates to an apparatus for monitoring the operation of a gas turbine.

Gas turbines generally include a compressor, one or more combustors, a fuel injection system and a turbine. Typically, the compressor pressurizes inlet air which is then reverse-flowed to the combustors where it is used to provide air for the combustion process and also to cool the combustors. In a multi-combustor system, the combustors are located about the periphery of the gas turbine, and a transition duct connects the outlet end of each combustor with the inlet end of the turbine to deliver the hot products of combustion to the turbine.

Gas turbine combustors are being developed which employ lean premixed combustion to reduce emissions of gases such as NO_x (nitrogen oxides). One such combustor comprises a plurality of burners attached to a single combustion chamber. Each burner includes a flow tube with a centrally disposed fuel nozzle comprising a center hub which supports fuel injectors and swirl vanes. During operation, fuel is injected through the fuel injectors and mixes with the swirling air in the flow tube, and a flame is produced at the exit of the burner. The combustion flame is stabilized by a combination of bluffbody recirculation behind the center hub and swirl-induced recirculation. Because of the lean stoichiometry, lean premixed combustion achieves lower flame temperature and thus produces lower NO_x emissions.

These premixed systems are susceptible to an unpredictable phenomena commonly referred to as "flashback." Flashbacks can be caused by impurities in fuel. Flashbacks can also be caused during mode switching when the flames are in a transient phase. When flashback occurs, a combustor flame moves backward (upstream) and enters zones or cavities of the combustor chamber which may not be designed to contain flames. A flame can also move unexpectedly into combustor cavities used for firing modes other than the combustion mode being exercised at the time of the flashback occurrence. Both types of flashback occurrences result in a loss of combustion control and can additionally cause heating and melting of combustor parts, such as flame nozzles, for example, that are not designed to withstand excessive heating. An operator generally has no method of recognizing the occurrence of a flashback until the combustor sustains damage.

It would be desirable to have a means of quickly detecting the occurrence of a flashback so that a combustor could be shut down before sustaining damage. In the present invention, multiple optical fibers and at least one photodetector are used to sense flashback.

The features of the invention believed to be novel are set forth with particularity in the appended claims. The invention itself, however, both as to organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, where like numerals represent like components, in which:

FIG. 1 is a block diagram of a flashback protection embodiment of the present invention.

FIG. 2 is a sectional view of a portion of the embodiment of FIG. 1.

FIG. 3 is a circuit diagram of a flashback protection embodiment of the present invention.

FIG. 4 is a partial block diagram of another embodiment of the present invention.

FIG. 1 is a block diagram of a flashback protection embodiment of the present invention, and **FIG. 2** is a sectional view of a portion of the embodiment of FIG. 1.

A combustor 1 includes at least one flame nozzle (and preferably a plurality of flame nozzles 12a, 12b, 12c, 12d, and 12e) capable of producing flames 44. Each of the flame nozzles is monitored using a fiber optic element 24a, 24b, 24c, 24d, or 24e comprising at least one respective optical fiber which sends an optical signal to a respective photodetector 14a, 14b, 14c, 14d, or 14e.

If desired, each optical fiber optic element 24a, 24b, 24c, 24d, or 24e may comprise several optical fibers in a bundle as shown by optical fibers 24a', 24a", and 24a"' in FIG. 2.

In one embodiment each fiber optic element includes at least one optical multi-mode fiber pressure-sealed at one end 26 or both ends into a protective tube (shown as tube 25a in FIG. 2) which is capable of withstanding the operating environment. In one embodiment the optical fiber comprises quartz and tube 25a comprises stainless steel. An optical microlens can be used, if desired, for selectively collecting light from the flame which exists during flashback from a portion of the protective tube. The tube can be inserted through holes in a combustor casing 10 (in the air path 46) and a combustor liner 48. The tube can be attached to the combustor casing using a compression fit connection (not shown).

On the other end of the tube, a photodetector can be mounted. In one embodiment, the photodetector comprises a semiconductor photodiode of a material such as silicon, gallium arsenide, silicon carbide, germanium, gallium nitride or gallium phosphide. The photodetectors can be situated outside of an engine compartment 5 which holds the combustor and therefore be protected from the harsh combustion environment. Each photodetector can send an electrical signal to a multiplexer 18 which can then transmit the data to a signal processor 20 before being acted on by a gas turbine controller/monitor 22 (shown in FIG. 1).

Although one fiber optic element and one photodetector per flame nozzle are shown, any of a number of configurations is possible. For example, as shown in **FIG. 4**, one fiber optic element 24a, 24b, 24c, 24d, or 24e can be used for each nozzle with all the fiber optic elements either arranged together in a bundle 54 and served by one photodetector 56 or optically coupled to

a single fiber (not shown) and served by one photodetector. Whenever multiple photodetectors are used, a simple scanning or multiplexing system (shown as multiplexer 18 in FIG. 1) can be used as an interface between the multiple sensing system and the signal processor.

As shown in FIG. 2, in a preferred embodiment the fiber optic element is pointed or aimed at regions (hereinafter referred to as test regions) 13a or 13b of the flame nozzles wherein flames are not present under normal operating conditions. One such test region is at the back portion of the flame nozzle 12a or 12b just forward (downstream) from swirl vanes 52a or 52b and a fuel injector 50a or 50b. At this location, the flame nozzle is not sufficiently hot to emit significant amounts of infrared radiation (IR) that otherwise would saturate a broad spectral responsive semiconductor photodiode with small bandgaps (e.g. silicon, germanium, or gallium arsenide). This simplifies the detection scheme because no IR filters are required.

If desired, for redundancy purposes, a plurality of fiber optic elements 24b' and 24b" in respective tubes 25b' and 25b" can be used to monitor flashback in a flame nozzle.

FIG. 3 is a circuit diagram of an example flashback protection embodiment of the present invention. Fiber optic elements 24a, 24b, and 24c transmit any detected light to respective photodetectors 14a, 14b, and 14c which transmit any resulting electrical signals to multiplexer 18 which includes switches shown as field effect transistors 34a, 34b, and 34c, for example. A shift register 44 can control the timing of switch operation, and an amplifier 38 / resistor 40 pair can be used for signal amplification before signal transmission from the multiplexer to signal processor 20. The diagram of FIG. 3 is for purposes of example only. In another embodiment, for example, an analog-to-digital converter can be used with the switching and amplification then occurring digitally.

If light is detected by a photodetector at a level to indicate that a flame is present in a test region wherein it should not be, the information is transmitted through the signal processor 20 to the controller/monitor 22 (shown in FIG. 1) which can then turn off combustor 1.

Claims

1. An apparatus for detecting flashback occurrences in a premixed combustor system including at least one flame nozzle, the apparatus comprising:

   at least one photodetector;
   at least one fiber optic element coupled between the at least one photodetector and a test region of the combustor system wherein a respective flame of the at least one flame nozzle is not present under normal operating conditions; and
   a signal processor for monitoring a signal of the at least one photodetector.

2. The apparatus of claim 1, wherein the at least one fiber optic element includes at least one optical fiber positioned within a protective tube.

3. The apparatus of claim 2, wherein the at least one fiber optic element includes at least two fiber optic elements coupled to the test region.

4. The apparatus of claim 2, wherein the combustor system is situated in an engine compartment and wherein the at least one optical fiber and the protective tube have lengths sufficient to situate the at least one photodetector outside the engine compartment.

5. The apparatus of claim 1, wherein the at least one flame nozzle comprises a plurality of flame nozzles, the at least one photodetector comprises a plurality of photodetectors, and the at least one fiber optic element comprises a plurality of fiber optic elements, each fiber optic element coupled between a respective one of the plurality of photodetectors and a respective test region of a respective one of the plurality of flame nozzles.

6. The apparatus of claim 1, wherein the at least one flame nozzle comprises a plurality of flame nozzles and the at least one fiber optic element comprises a plurality of fiber optic elements, each fiber optic element coupled between the at least one photodetector and a respective test region of a respective one of the plurality of flame nozzles.

7. An apparatus for detecting flashback occurrences in a premixed combustor system including a plurality of flame nozzles each having a respective test region wherein a respective flame is not present under normal operating conditions, the apparatus comprising:

   at least one photodetector;
   a plurality of fiber optic elements coupled between the at least one photodetector and a respective one of the test regions, each fiber optic element including at least one optical fiber positioned within a protective tube; and
   a signal processor for monitoring a signal of the at least one photodetector.

8. The apparatus of claim 7, wherein the combustor system is situated in an engine compartment and wherein the plurality of optical fibers and the protective tubes have lengths sufficient to situate the at least one photodetector outside the engine com-

partment.

9. The apparatus of claim 7, wherein the at least one photodetector comprises a plurality of photodetectors and each fiber optic element is coupled between a respective one of the plurality of photodetectors and a respective test region.

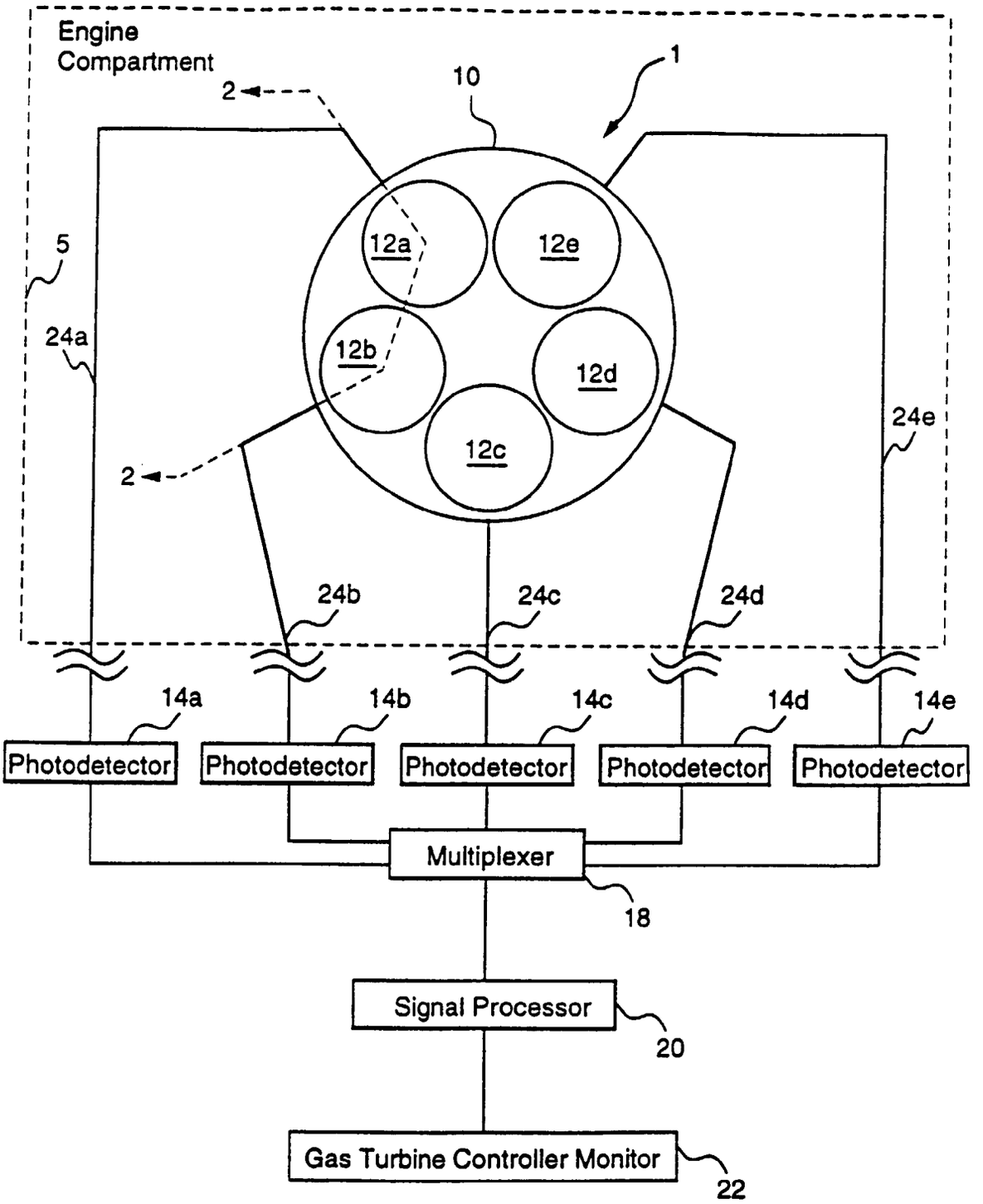

Engine
Compartment
1
2
10
5
12a
12e
24a
12b
12d
24e
12c
2
24b
24c
24d
14a
14b
14c
14d
14e
Photodetector
Photodetector
Photodetector
Photodetector
Photodetector
Multiplexer
18
Signal Processor
20
Gas Turbine Controller Monitor
22

FIG. 1

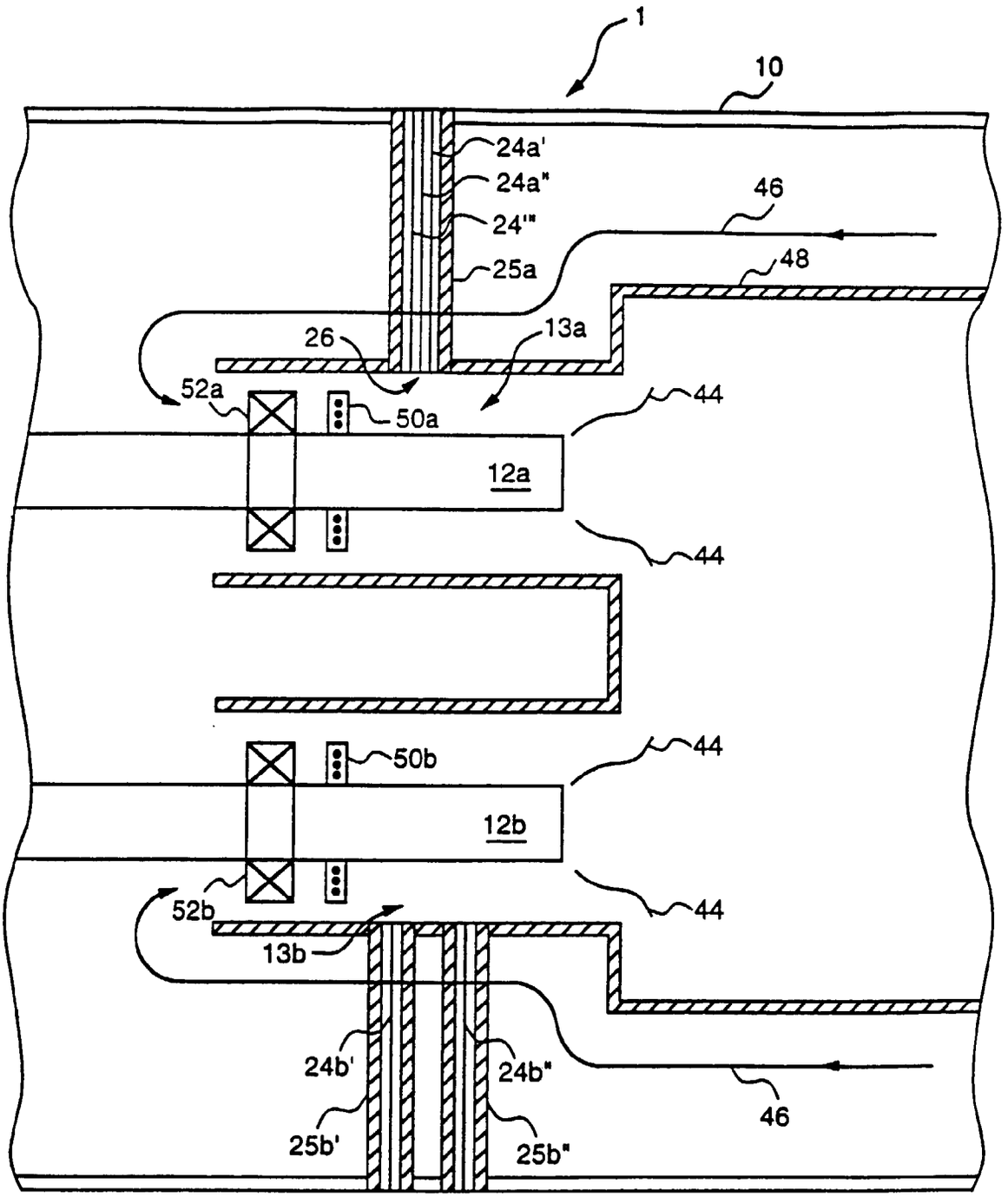

1
10
24a'
24a"
24'"
25a
46
48
26
13a
52a
50a
44
12a
44
50b
44
12b
52b
44
13b
24b'
24b"
46
25b'
25b"

FIG. 2

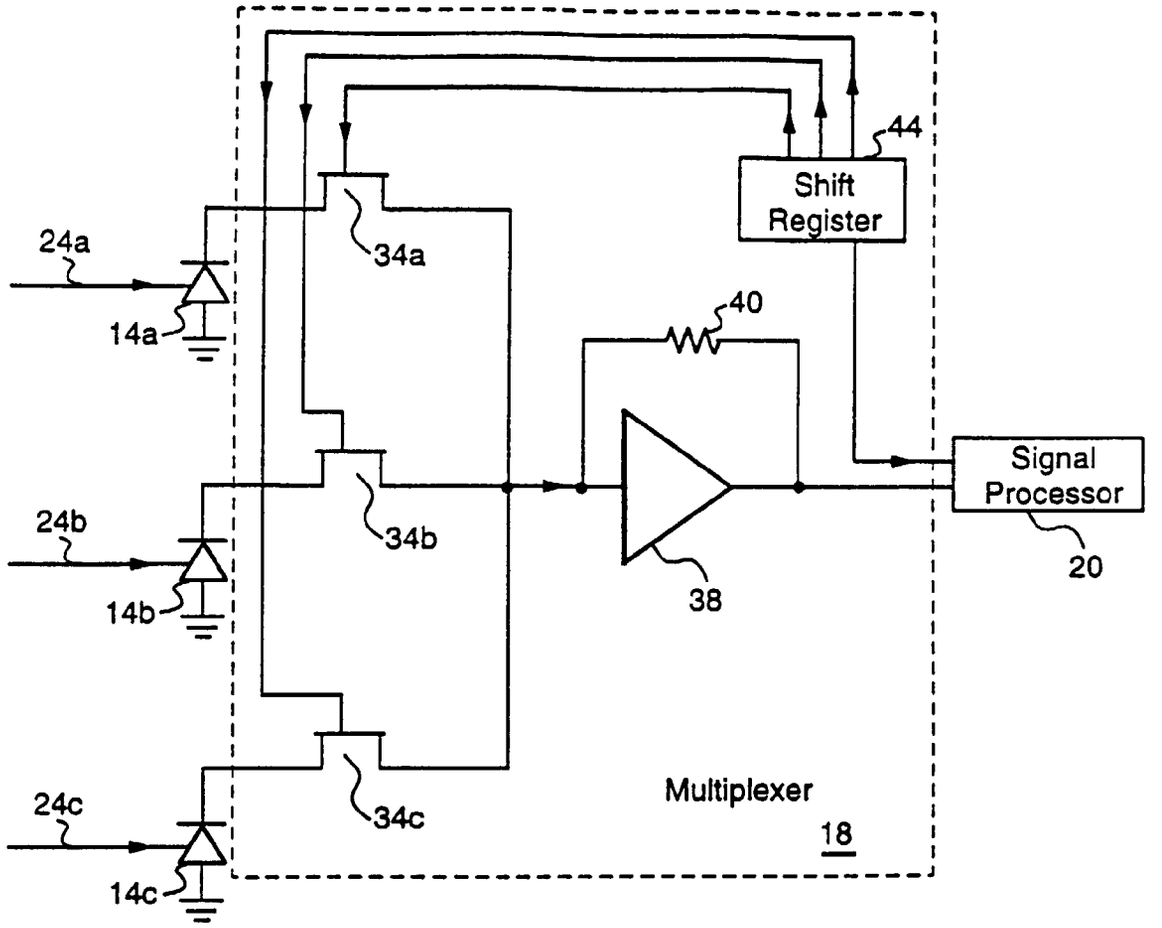

44
Shift Register
24a
34a
40
14a
Signal Processor
24b
34b
38
20
14b
24c
34c
Multiplexer
18
14c

FIG. 3

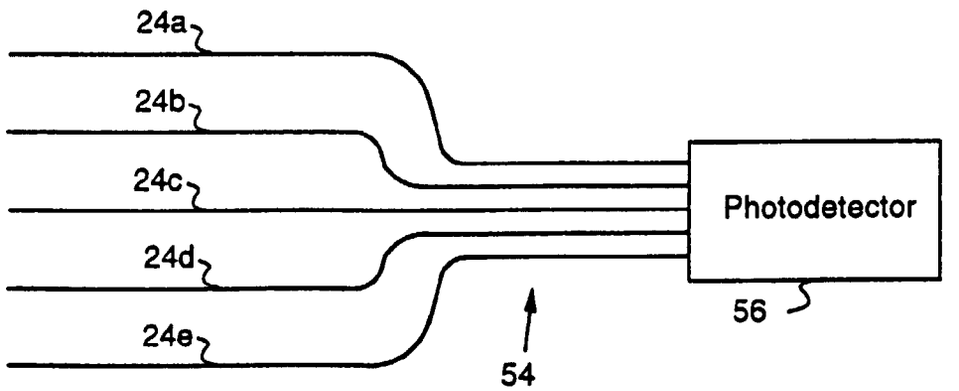

24a
24b
24c
24d
24e
Photodetector
56
54

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 4423

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,P	DE 296 11 439 U (VIESSMANN WERKE) * the whole document * ---	1,7	F23N5/08 F01D21/00 F23D14/72
A	EP 0 638 770 A (SIMMONDS PRECISION ENGINE SYSTEMS) ---	1,7	F23D14/82
A	US 5 148 667 A (MOREY) * abstract; figures * ---	1,7	
A	DE 34 37 103 A (LINDE) * abstract; figures * -----	1,7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F23N
F01D
F23D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 September 1997	Kooijman, F

CATEGORY OF CITED DOCUMENTS

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