

[54] FLAME DETECTOR

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431/78; 73/35, 116, 346, DIG. 4; 340/227, 228 F;
179/100.41 B

[56]

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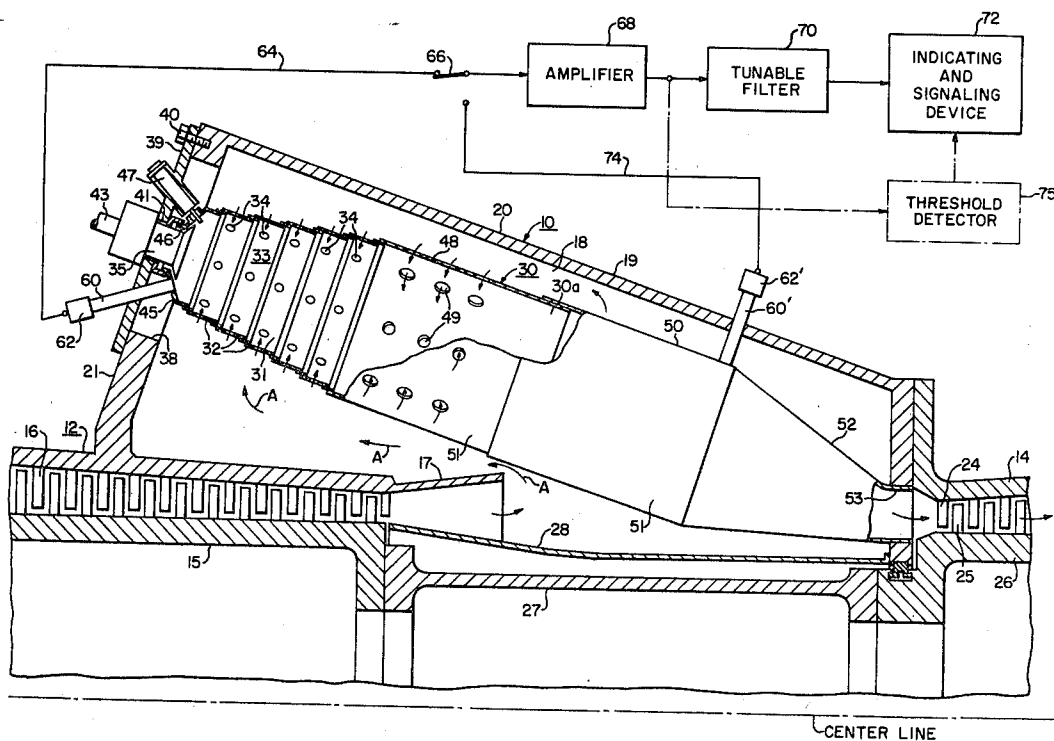
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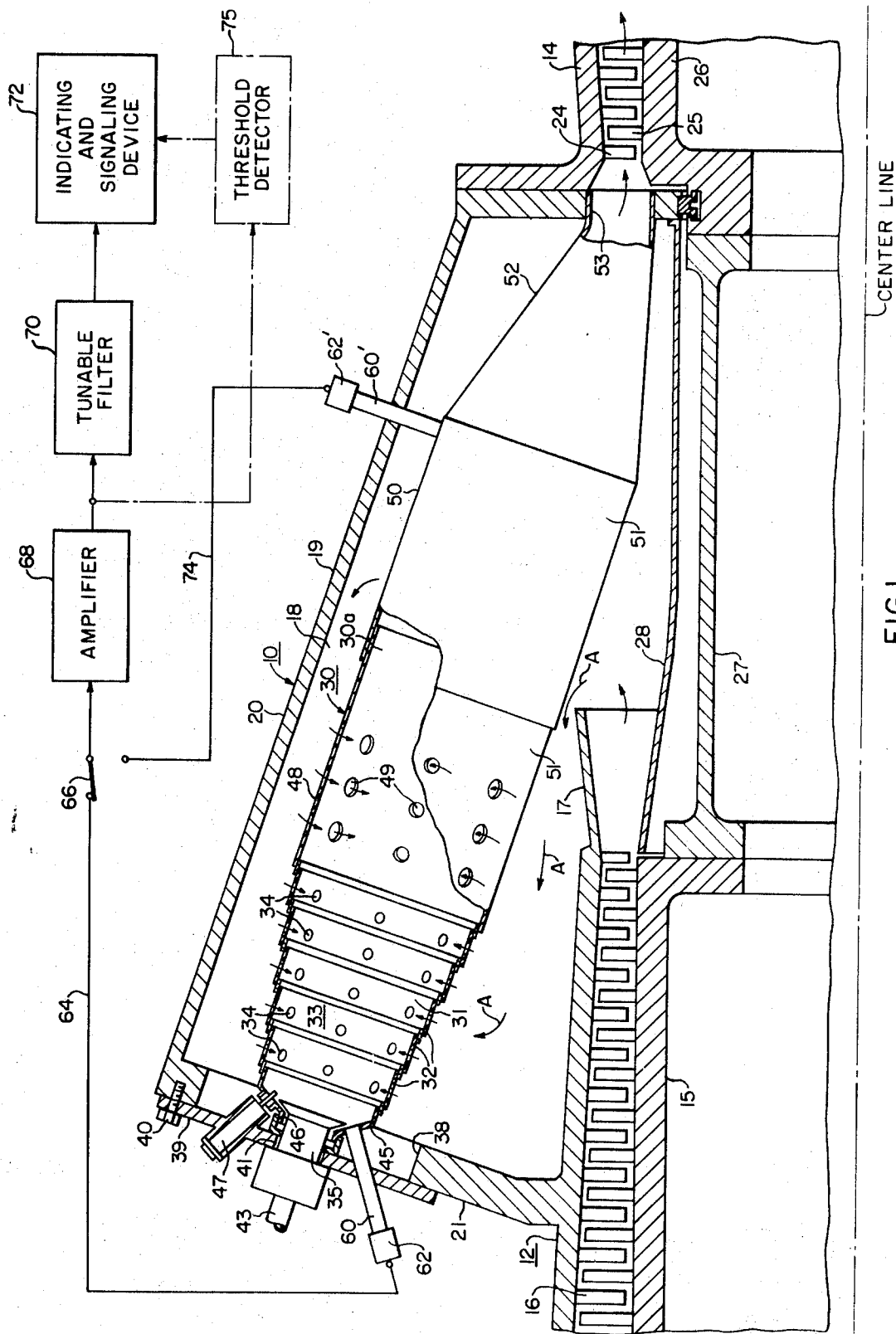
ABSTRACT

Apparatus for detecting the existence of a flame in a combustion chamber by means including an electroacoustic device for converting audible sounds which occur only when the flame is present into an electrical signal having a frequency component corresponding to the frequency of the audible sound. If necessary, a filter may be incorporated into the converting means for eliminating frequencies which occur due to the introduction of fuel and/or a gas containing oxygen into the combustion chamber without the existence of a flame.

Alternatively, a threshold detector can be incorporated into the system for detecting audible sounds above a predetermined sound level only, which sounds are those due to the existence of a flame.

4 Claims, 3 Drawing Figures





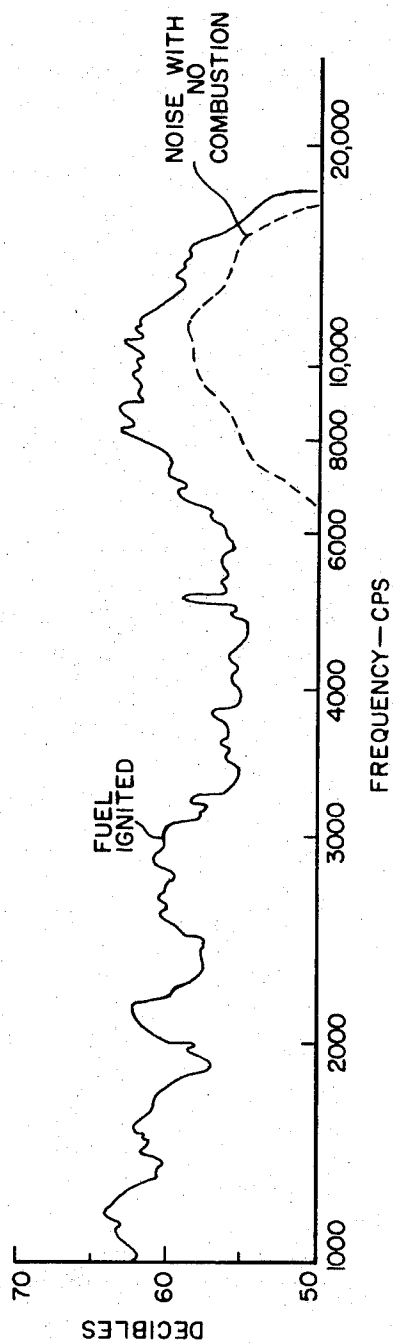


FIG. 2.

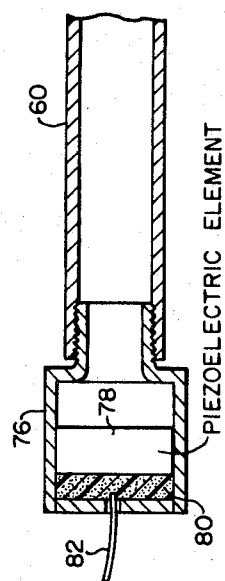


FIG. 3.

FLAME DETECTOR

BACKGROUND OF THE INVENTION

While not limited thereto, the present invention is particularly adapted for use in detecting the existence of a flame in a combustion basket employed in gas turbine combustion apparatus. In the past, flame detection within a combustion basket of this type has usually been by means of devices reacting to the light energy from the flame or by thermocouples in the gas stream. In particular, devices reacting to ultraviolet radiation as viewed through a viewing tube are widely used. These devices have the drawback that extremely thin oil films or dirt will block the ultraviolet radiation from the sensing device, thereby rendering the device inoperative. Usually, an attempt is made to prevent the formation of such an oil film from the combustor fuel by providing sweep air in the viewing tube; however this is only partially effective.

SUMMARY OF THE INVENTION

In accordance with the present invention, the existence of a flame is detected by the noise or audible sound associated with the flame. Whenever a flame exists within a combustion chamber, there is a flame noise. This can be observed, for example, with a conventional domestic furnace or water heater. When the flame ignites, a characteristic sound emanates from the combustion chamber due to pressure pulsations which are associated with the presence of a flame condition.

Preferably, the flame noise is detected by means of an electroacoustic device at one end of a passageway having another end opening into the combustion chamber. This electroacoustic device may comprise a conventional microphone, a piezoelectric element or any other type of sound pickup. Indicating circuit means is connected to the electroacoustic device for indicating the existence of sound waves in the combustion chamber which occur when a flame exists.

As will be appreciated, noise or sound waves, other than those due to a flame, may be detected by the electroacoustic device. For example, even though a flame does not exist in a combustion chamber, the noise will exist within the chamber, particularly if it is pressurized; and there may be fuel jet noise with no combustion. Additionally, and assuming that the device is associated with a turbine or other similar device, noise may exist due to vibration of the various machine components. Accordingly, a tunable filter is included between the pickup device and an indicating or signaling device whereby only those sound frequencies due to a flame will pass to the indicating and signaling device. In this manner, false indications due to spurious or stray signals are eliminated.

The sound level due to a flame will ordinarily be higher than that due to other factors such as a fuel jet noise, air passing through apertures in the combustion chamber and the like. Accordingly, a threshold detector may be incorporated between the pickup and the indicating device such that only those sounds of higher level due to a flame will pass to the indicating device; while lower level sounds will be eliminated in the threshold detector.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIG. 1 is an axial sectional view of the upper half of a gas turbine provided with combustion apparatus incorporating the flame detection apparatus of the invention;

FIG. 2 is a plot of sound level versus frequency for sounds occurring in a combustion chamber of the type shown in FIG. 1; and

FIG. 3 is a cross-sectional view of a typical sound pickup device usable with the invention.

With reference now to the drawings, and particularly to FIG. 1, there is shown combustion apparatus generally designated by the reference numeral 10 and associated with a gas turbine power plant of the axial flow type. Since the combustion apparatus 10 may be employed with any suitable type

of gas turbine power plant, only a portion of the powerplant sufficient for comprehension of the invention has been shown. However, it will be understood that the powerplant includes an axial flow air compressor 12 for directing pressurized air to the combustion apparatus 10 and a gas turbine 14 connectable to the combustion apparatus 10 and receiving hot products of combustion therefrom for motivating the powerplant.

Only the upper half of the powerplant and combustion apparatus has been illustrated, since the lower half may be substantially identical and symmetrical about the centerline or axis of rotation of the powerplant.

The air compressor 12 includes, as is well known in the art, a multistage bladed rotor structure 15 cooperatively associated with a stator structure having an equal number of multistage stationary blades 16 for compressing the air directed therethrough to a suitable pressure value for combustion in combustion apparatus 10. The outlet of the compressor 12 is directed through an annular diffusion member 17 forming an intake for a plenum chamber 18 defined by a housing structure 19. The housing structure 19 includes a tubular shell member 20 of frustoconical shape extending at an acute angle with the centerline of the powerplant, a forward annular wall member 21 connected to the external casing of the compressor 12, and a rearward annular wall member 22 connected to the outer casing of the turbine 14. The turbine 14, as mentioned above, is of the axial flow type and includes a plurality of expansion stages formed by a plurality of rows of nozzle blades 24 cooperatively associated with an equal plurality of rotating blades 25 mounted on the turbine rotor 26. The turbine rotor 26 is drivingly connected to the compressor rotor 15 by a tubular connecting shaft 27; and a tubular liner or fairing member 28 is suitably supported in encompassing stationary relation with respect to the connecting shaft portion 27 to provide a smooth airflow surface for the air entering the plenum chamber 18 from the compressor diffuser 17.

It will be noted that the housing 19 is disposed in partially overlapping relation with the compressor 12 in order to shorten the axial length of the powerplant, as is well known in the art. Hence, the diffuser 17 provides an air intake for the housing disposed intermediate the end walls 21, 22.

Within the housing 19 there is provided a plurality of tubular combustion baskets 30 of the cellular or canister type disposed in an annular, mutually spaced array and inclined with the centerline of the powerplant. As will be understood, only one of the combustion baskets 30 is shown in FIG. 1, the remaining combustion baskets being circumferentially spaced around the fairing member 28.

Each combustion basket 30 includes an upstream end portion 31 which may be formed of a plurality of cylindrical liner members 32 of graduated size disposed in slightly overlapping relation with each other and forming a primary combustion zone 33. Each of the liner members 32 has an annular array of apertures 34 for admitting primary air into the combustion zone 33 to support the combustion of fuel injected therein by a suitable fuel injector 35.

The forward wall 21 of the combustion apparatus is provided with a circular opening 38 of sufficiently large diameter to clear the combustion basket 30 for service purposes and is enclosed by a circular combustion cover plate 39 attached to the wall member 21 in any suitable manner, as by means of bolts 40. The cover plate 39 is further provided with a central opening 41 through which the fuel injector 35 extends. The fuel injector 35 is supplied with fuel by a suitable conduit 43 connected to any suitable fuel supply, not shown, and may be of the well-known atomizing type formed in a manner to provide a substantially conical spray of fluid within the primary combustion zone 33.

A frustoconical dome member 45 serves to close the extreme forward end of the combustion basket 30 and is provided with a central opening 46 accommodating the fuel injection nozzle 35 and cooperatively associated therewith in such a manner that substantially no airflow is emitted therethrough into the combustion zone 33. Also, a suitable electrical ignitor

47 is provided for igniting the fuel and air mixture in the combustion zone 33.

The combustion basket further includes an elongated intermediate cylindrical portion 48 provided with a plurality of annular rows of apertures 49 for admitting secondary air into the combustion chamber during operation, and a downstream end portion or transition member 50 having a forward portion 51 of cylindrical shape disposed in encompassing and slightly overlapping relation with the intermediate portion 48 and a rearward tubular portion 52 that progressively changes in contour from circular cross section at the jointure with the cylindrical portion 51 to arcuate cross section at its outlet end portion 53. The arcuate extent of the outlet 53 is such that, jointly with the outlets of the other combustion baskets, a complete annulus is provided for admitting the hot products of combustion from the combustion baskets 30 to the blades 24 and 25 of the turbine 14. In operation, pressurized air from the compressor 12 is directed into the plenum chamber 18 through the diffuser member 17 to fill the chamber with air at substantial pressure which then flows into the combustion basket 30 through apertures 34 and 49 to provide hot motive gases for motivating the turbine 14. The direction of flow of the pressurized air is indicated by the arrows A. When the combination of air and fuel within the combustion basket 30 is ignited and a flame exists, a characteristic sound or noise will be emitted. Of course, some noise will be emitted due to injection of fuel into the combustion chamber without the existence of a flame; and noise will also occur due to the passage of pressurized air through the openings 34 and 49. However, the sounds which occur without the flame will be of a characteristic frequency different than the frequencies existing when the flame is ignited and ordinarily of a lower sound level. This is shown in FIG. 2 which is a plot of frequency versus sound level of the noise occurring in a typical combustion chamber. When the fuel is ignited and a flame exists, the frequency of the sound varies over a wide spectrum, from about 1,000 cycles per second to almost 20,000 cycles per second. However, when no flame exists, the noise associated with the fuel injection and airflow varies only between about 6,000 and 16,000 cycles per second. Thus, it can be concluded that there is a characteristic sound frequency associated with the existence of a flame. Note also that the sound level due to the flame is higher than that due to airflow and fuel injection at any corresponding frequency.

Returning again to FIG. 1, the apparatus of the present invention for detecting the existence of a flame includes a tube 60 which passes through the cover plate 39 and has an open end passing through the dome member 45 closely adjacent the nozzle 35. At the other end of the tube 60 is an electroacoustic device 62 such as a microphone or piezoelectric crystal which is connected through lead 64 and switch 66 to an amplifier 68. The output of the amplifier 68, in turn, is passed through a tunable filter 70 to an indicating and signaling device 72.

In the operation of the invention, the tunable filter 70 will be tuned to filter out frequencies which occur when no flame is present. In the example given in FIG. 2, for example, these frequencies will be in the range of about 6,000 to 16,000 cycles per second. In this respect, the tunable filter 70 may be of the conventional band rejection type. Consequently, no frequencies in the range of 6,000 to 16,000 cycles per second will pass to the indicating and signaling device 72 and the device will not respond to noise occurring when no flame exists. However, the filter 70 will pass frequencies outside its rejection band. Again, in the example given in FIG. 2, it will pass frequencies in the range of 1,000 to 5,500 cycles per second, these frequencies being due to the existence of a flame only. Consequently, if an output from the filter is applied to the indicating and signaling device 72, it is known that a flame exists. Otherwise, the flame is extinguished.

As will be understood, in most cases the sound energy will simply be converted by the pickup device 62 into an electrical signal having a frequency corresponding to that of the sound. However, it is also possible, within the purview of the inven-

tion, to utilize conventional modulation techniques wherein the sound frequency is impressed upon a carrier frequency and then demodulated.

Instead of mounting the pickup device at the forward end of the combustion basket 30, it is also possible to provide a tube 60' extending through housing 19 and having an open end projecting into the transition member 50. At the other end of the tube 60' is a sound pickup device 62' which may be connected through lead 74 and the switch 66 to amplifier 68. Of course, it is also possible to have both pickup devices 62 and 62' connected to the amplifier 68 at the same time.

Instead of using the filter 70, it is also possible to pass the output of amplifier 68 through a threshold detector 75 before it is applied to the indicating and signaling device 72. The detector 75 will pass only those signals above a predetermined sound level. Since, as shown in FIG. 2, the noise level of the flame is higher than that of other effects, the threshold level of the detector 75 will be just above the noise level of effects other than the flame. If desired or necessary, both the tunable filter 70 and detector 75 could be used in series leading into the indicating and signaling device 72.

In FIG. 3, a typical piezoelectric pickup is shown and includes an outer housing 76 having a reduced diameter portion threaded into the end of the tube 60, for example. Within the housing 76 is a piezoelectric element 78 connected through a conducting epoxy 80 to an electrical lead 82 which, in turn, can be connected to the amplifier 68, for example. As explained above, however, a conventional microphone or other and different types of sound pickup devices can be used equally as well.

In a complete turbine plant having a plurality of circumferentially spaced combustion baskets such as that shown in FIG. 1, a sound pickup can be used on each basket. Alternatively, where crossfiring techniques are used and it is known that all flames are ignited if a flame exists in the last basket of the crossfired series, then a pickup need be provided only for said last-fired basket.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. An apparatus for detecting the existence of a flame in a combustion chamber for a gas turbine power plant of the type having a combustion chamber connected through a transition member to an outlet which directs the products of combustion against the blades of said turbine, the combination of an electroacoustic device for converting sound energy into an electrical signal having a frequency component equal to the frequency of the sound converted, said frequency of sound being between 1,000 cycles per second and 20,000 cycles per second, a passageway having one end opening into said combustion chamber and another end in sound-transmitting relationship with said electroacoustic device, indicating circuit means connected to said electroacoustic device for indicating the existence of sound waves in said combustion chamber which occur when a flame exists in the combustion chamber, rejection filter means interposed between said electroacoustic device and said indicating circuit means for filtering out the frequencies of noises due to effects other than the existence of a flame, said rejection filter means operable between the frequencies of 6,000 cycles per second and 16,000 cycles per second.
2. The apparatus of claim 1 and further including a threshold detector interposed between said electroacoustic device and said indicating circuit means for eliminating signals other than those above a predetermined noise level.
3. The apparatus of claim 1 wherein said electroacoustic device comprises a piezoelectric crystal.
4. The apparatus of claim 1 wherein said electroacoustic device comprises a microphone.

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