

[54] **CONSTANT EFFECTIVE SLOT LENGTH
LIGHT PIPE**

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[51] Int. Cl. **G01n 21/12**

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250/573

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[57]

ABSTRACT

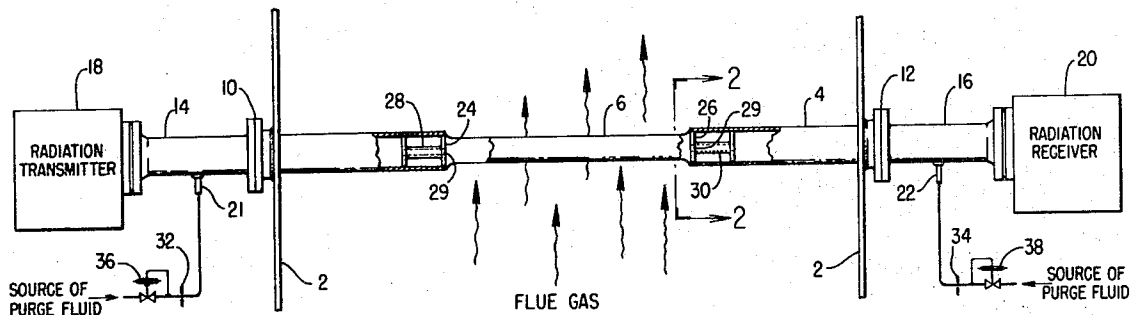
A light pipe producing an in-situ, dimensionally stable, sample of a flowing fluid in which a support pipe is provided with a slot through which the fluid flows. Purge fluid is discharged into the sampled fluid through orifices located at each end of the slot.

[56] **References Cited**

UNITED STATES PATENTS

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7 Claims, 5 Drawing Figures



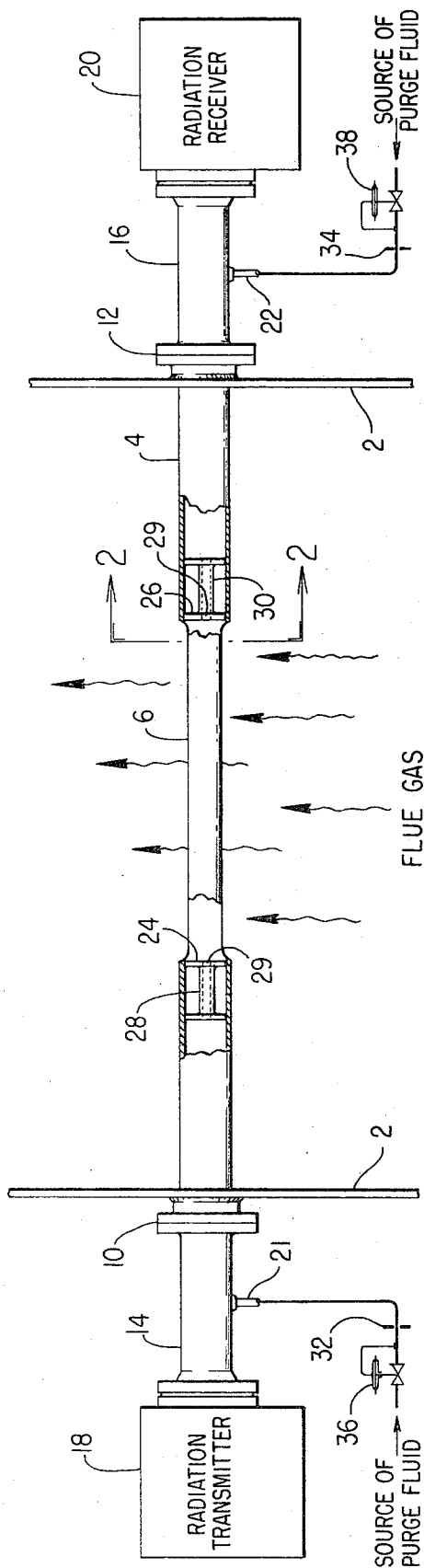


FIG. 1

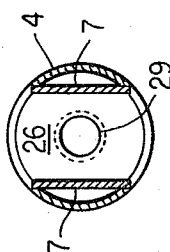


FIG. 2

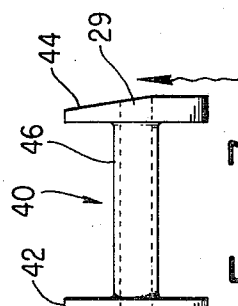


FIG. 3

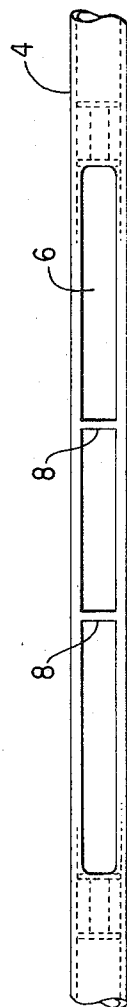


FIG. 4

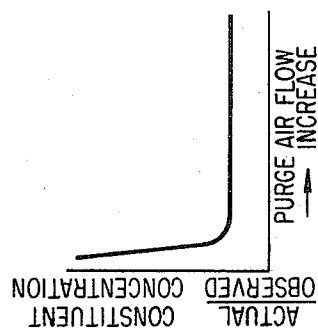


FIG. 5

CONSTANT EFFECTIVE SLOT LENGTH LIGHT PIPE

This invention relates to a device producing an in-situ, dimensionally stable, sample of a flowing fluid essential in making an accurate continual or continuous analysis of the fluid for one or more constituents. The invention is particularly applicable in the analysis of waste gases such as discharged to the atmosphere from industrial processes and fossil fuel-fired furnaces, or produced in industrial processes, for example, such as gases produced in sulphuric acid manufacture, pulp manufacture, and the like. Such analysis may be made by directing a beam of selected electromagnetic or sonic radiation from a transmitter through the sample of flowing fluid to a receiver. The ratio between the radiation transmitted and received is functionally related to a particular constituent or constituents of the flowing fluid.

One common method of forming the sample of flowing fluid is to provide a light pipe having a slot through which a portion of the fluid passes. The radiation transmitter is mounted on one outer end of the pipe and the receiver on the other. Such light pipes have been found to be deficient for accurate analysis in that they do not produce a dimensionally stable sample of the flowing fluid because of the diffusion of the flowing fluid into the light pipe. Furthermore, waste gases, for example, usually carry particulate matter in suspension and it has been found that such particulate matter is transmitted into the light pipe and against the isolating windows or lenses in the transmitter and receiver. Attempts have been made to cure these deficiencies by introducing a purge fluid such as air into the light pipe. It has been found, however, that such an expediency is unsuccessful in the greater majority of applications. Waste gases, for example, are ordinarily discharged through ducts which may vary in width from a foot or two to upwards of 15 feet or more. A light pipe of sufficient rigidity to extend from one side of the duct to the other must be fabricated of a heavy walled pipe having an internal diameter of four inches or more. The introduction of purge fluid into such a pipe does not generate an impervious stable boundary with the flowing fluid at the ends of the slot. Furthermore, it has been found that variations in the rate of flow of purge fluid materially affect the dimensional stability of the flowing sample of the fluid.

In accordance with my invention a heavy walled support pipe is provided having a slot forming the sample of the flowing fluid. Dimensional stability of the sample is obtained by providing an orifice at each end of the slot through which purge fluid is discharged into the slot. I have found that by such a construction of the light pipe a dimensionally stable sample is produced and the deficiencies of the prior art devices are eliminated.

IN THE DRAWINGS

FIG. 1 is a side elevation view partially in cross-section of one embodiment of my invention.

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1 in the direction of the arrows.

FIG. 3 illustrates an alternate arrangement for discharging purge fluid into the flowing sample.

FIG. 4 is a fragmentary top view illustrating a segmented slot.

FIG. 5 is a graph useful in describing certain aspects of my invention.

DETAILED DESCRIPTION

Referring to FIG. 1, I therein show an embodiment of my invention arranged particularly for the sampling of a waste gas, such as, for example, flue gas discharged from a fossil fuel-fired furnace. Such gases are ordinarily discharged through a duct or other type passageway having walls such as shown at 2.

Extending through the duct is a support pipe 4 which may conveniently be made, for example, of 4 inches Schedule 40 pipe. I have found that such a support pipe has sufficient rigidity to assure optical alignment between a radiation receiver and a radiation transmitter for ducts having widths found in most industrial applications. It is apparent, however, that the weight and size of the support pipe may be increased as required to meet the conditions of a particular application. Furthermore such a support pipe usually has sufficient rigidity to eliminate the necessity of supporting the light pipe from within the duct.

The support pipe 4 is provided with a slot 6 through which a portion of the waste gases pass, thus forming a flowing sample. As is apparent, the length of slot can be varied as required to meet the needs of a particular application. Thus for a radiation beam of given intensity, the slot length may be adjusted to allow for the amount of particulate matter in suspension expected and the opaqueness of the gas to the band of radiation being used. For ducts of ordinary width I have found that a continuous slot does not materially affect the rigidity of the support pipe, however, as shown in FIG. 4, for ducts of relatively greater width the slot may be segmented as shown at 8. If required, additional rigidity of the support pipe 4 may be obtained by welding or otherwise securing to the interior wall of the support pipe for the length of the slot side plates such as shown at 7 in FIG. 2.

Conveniently, the support pipe 4 may be located in and supported by the duct walls 2 to which it may be sealed by welding or by other suitable means. The support pipe is provided with flanges 10 and 12 to provide a mounting means for flanged spool pieces 14 and 16 to which a transmitter 18 and a receiver 20 is attached by suitable demountable means (not shown) to provide for the inspection and cleaning, if necessary, of the windows ordinarily provided in typical transmitting and receiving units. Purge fluid, such as air, is introduced into the spool pieces 14 and 16 through suitable connections 21 and 22 respectively. The purge air passes through the support pipe and is discharged into the slot 6.

As heretofore discussed an arrangement such as thus far described does not generate a flowing sample having dimensional stability. This deficiency I overcome by discharging the purge fluid through orifices located at each end of the slot 6. Thus, referring to FIG. 1, I show a disc 24 located in the transmitter end of the slot and a similar disc 26 located at the receiver end of the slot. Each disc is provided with an orifice 29 of relatively small diameter relative to the diameter of the support pipe. As an order of magnitude, with a 4 inches support pipe, the orifices would have a diameter of 2 inches or less. As shown in FIG. 1, purge air to be discharged through the orifices may first pass through tubes 28 and 30, whose length is at least twice the orifice diameter,

to provide a laminar, or at least an orderly flow. I have found that such a construction provides a stable interface between the purge air and sampled fluid, generating a dimensionally stable flowing sample while preventing the suspended particulate matter and sampled gas from entering the light pipe.

In FIG. 5 I show the typical relationship existing between rate of flow of purge air and the ratio between the actual and observed concentration of a measured constituent of the sampled gas. It will be noted that above a minimum flow of purge air the ratio remains constant. Thus the dimensional stability of the sampled fluid is maintained regardless of fluctuations in the rate of flow of purge fluid. As a refinement, however, my invention comprehends maintaining a constant rate of flow of purge fluid in those cases where a compressible gas such as air is used by introducing the purge fluid through orifices 32, 34 and maintaining a pressure on the inlet side above the critical pressure. Constant inlet pressure is maintained by pressure regulators 36, 38.

For 2 inches orifices, I have found that purge flows upwards of 5 scfm per orifice will produce a constant ratio of observed to actual concentration. That is, a value of 7 scfm per orifice may be advantageously chosen so as to provide independence from purge flow or sampled gas flow over wide ranges. For 1½ inches orifices, I have found purge flows of upwards of 3.5 scfm produce a constant ratio. Thus, in general, the minimum purge flow for constant ratio of observed-to-true concentration is about 2.5 scfm per inch of orifice diameter.

In FIG. 3 I show an alternate form of orifice arrangement for introducing the purge fluid into the slot ends. With this arrangement a spool piece 40 having flanges 42 and 44 is provided. After location in the support pipe, flange 44 adjacent the slot may be sealed to the inner wall of the support pipe. As shown, the face of flange 44 facing the slot is tapered. The amount of taper may be as much as 15°. Flanges 42, 44 are separated by a tube 46 of sufficient length, approximately two times the internal diameter of the tube, to establish an orderly flow of purge fluid into the slot. I have found that such a configuration maintains dimensional stability of the flowing sample within approximately the same range of flow of purge fluid and sampled gas as the arrangement shown in FIG. 1.

I claim:

1. In a light pipe for producing an in-situ, dimensionally stable, flowing sample of a fluid, the combination comprising: a support pipe having an elongated slot through which the fluid sample flows, means for admitting purge fluid into said support pipe between each end of said slot and the adjacent outer end of said support pipe, and a disc closing said support pipe at each end of said slot provided with an orifice tube having a length at least twice the diameter of the orifice through which the purge fluid is discharged into the fluid flowing through said slot, thereby producing an orderly flow of purge fluid into said flowing fluid and a dimensionally stable sample of the flowing fluid.

2. A light pipe as set forth in claim 1 further including means for maintaining a constant rate of flow of a compressible gas purge fluid comprising,
a source of purge fluid under pressure,
a conduit for transmitting purge fluid from said source into said support pipe,
an orifice disposed within said conduit, and
means for maintaining a constant pressure on the inlet side of said orifice above the critical pressure.

3. A light pipe as set forth in claim 1 further including a flat reinforcing plate on each longitudinal side of said slot running from substantially end to end of said slot.

4. A light pipe as set forth in claim 1 wherein said slot is divided into a plurality of segments to thereby increase the rigidity of said support pipe.

5. A light pipe as set forth in claim 1 wherein the face of each of said orifice plates adjacent the flowing fluid is tapered relative to the direction of flow of said flowing fluid.

6. A light pipe as set forth in claim 1 further including means controlling the rate of flow of purge fluid through said orifice to maintain a stable interface between the purge fluid introduced into said slot and the flowing fluid passing through said slot.

7. A light pipe as set forth in claim 1 further including means to maintain a purge flow rate through each of said orifices greater than approximately 2.5 scfm per inch of orifice diameter.

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