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APPARATUS AND METHOD FOR CONTINUOUSLY SAMPLING GAS

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Fig. 1

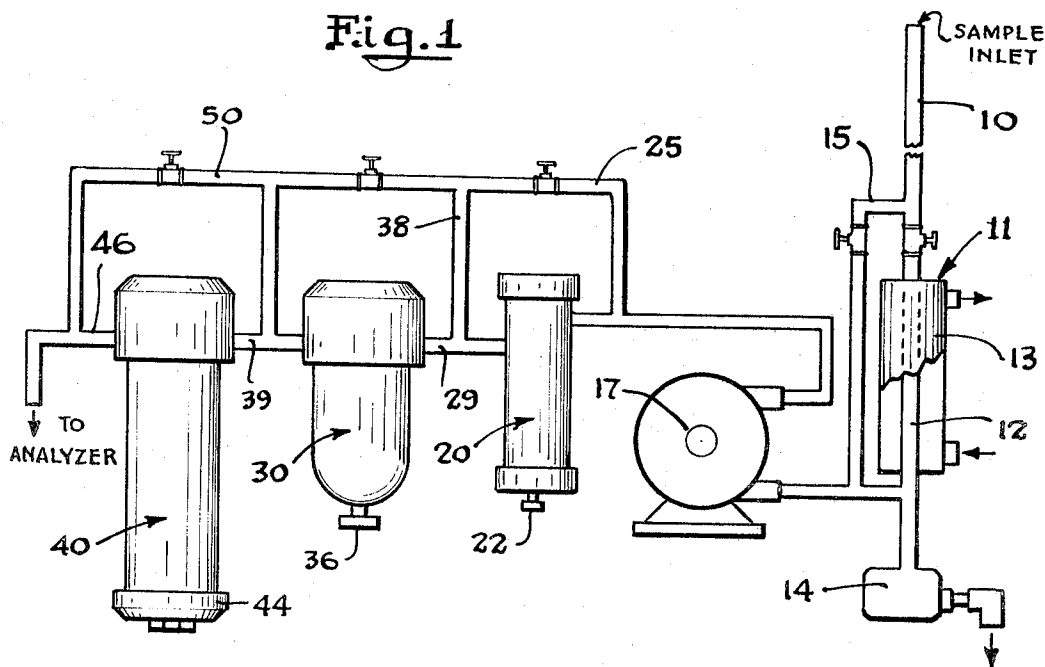
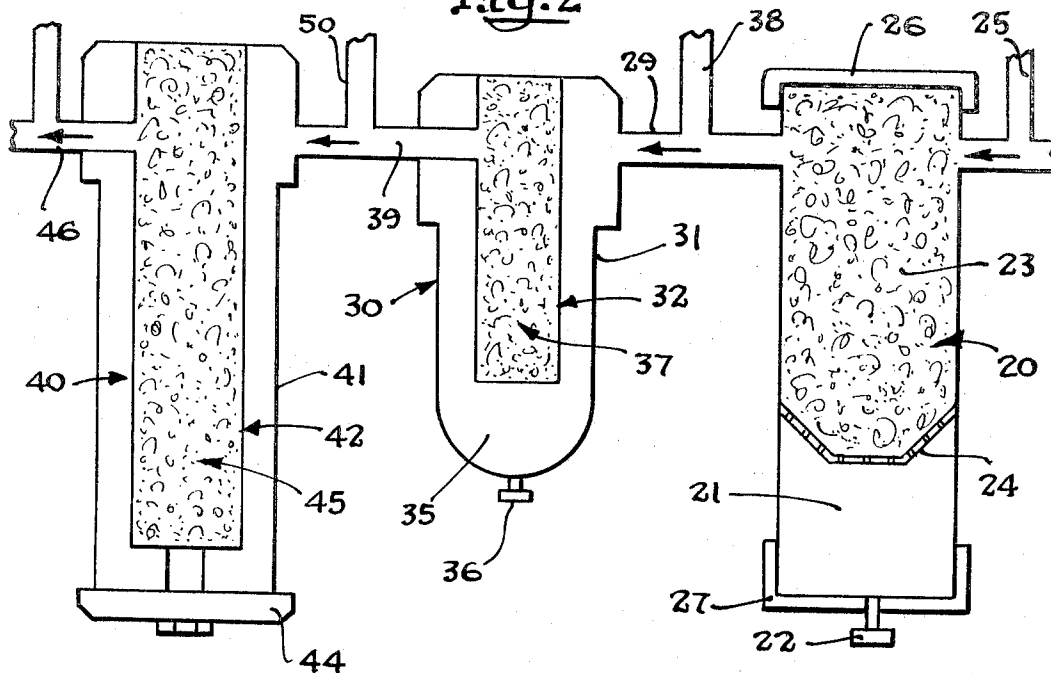


Fig. 2



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APPARATUS AND METHOD FOR CONTINUOUSLY SAMPLING GAS

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The present invention relates generally to providing a representative gas sample to a gas analyzer from a stream of gas and more particularly to apparatus for continuously obtaining a representative multi-component gas sample from a stream of furnace gas which is heavily laden with dust, such as gases from an open hearth furnace or a blast furnace.

Many types of apparatus have been devised for providing a gas sample to a gas analyzer, but none of the commercially available types are capable of continuously supplying a truly representative sample of a multi-component high temperature furnace gas of the above type which contains a high proportion of solids and generally substantial amounts of moisture, carbon dioxide or carbon monoxide. Since modern multi-component gas analyzers are very sensitive instruments, it is necessary to remove substantially all of the dust contained in the original gas sample without, however, removing any of the gaseous components which are to be analyzed. Gas sampling systems which remove solids from a heavily dust-laden, moisture-containing gas sample by washing with water or condensing with steam also remove a significant amount of carbon dioxide which is often an important component of a furnace gas to be analyzed. Many other gas sampling systems are objectionable because of their inability to handle heavily dust-laden gas samples without becoming clogged with dust and requiring frequent attention for maintenance and repair.

It is therefore an object of the present invention to provide an improved apparatus and method of continuously providing a representative gas sample of a heavily dust-laden, multi-component gas containing moisture and other components which are readily absorbed by water.

It is a further object of the present invention to provide an improved apparatus and method of continuously removing dust from a heavily dust-laden sample of a furnace gas which avoids removal from the sample of gaseous components to be analyzed and eliminates frequent interruptions in the gas sample flow due to clogging of filters.

Other objects of the invention will be evident to those skilled in the art from the detailed description and claims to follow when read in conjunction with the accompanying drawing, wherein:

FIG. 1 is a schematic side elevational view partially in vertical section of the gas sampling apparatus of the present invention, and

FIG. 2 is an enlarged vertical sectional view of a portion of the apparatus of FIG. 1.

The furnace gas sampling apparatus of the present invention employs in combination means for effecting first a demisting treatment on the gas sample prior to specific treatment for removing dust particles and means for effecting a series of dry filter treatments of the sample to remove substantially all solids having a particle size in excess of about 1 micron. To carry out the foregoing treatments continuously, a sample of a furnace gas atmosphere having a temperature between about 1000° F. and 3000° F., an average concentration of solid particulate matter of about 25 grains per standard cubic foot, and a moisture concentration as high as 50% is continuously withdrawn from the back uptakes of a furnace, such as an open hearth furnace, by means of a water-cooled gas-sampling probe 10 which is preferably mount-

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ed on the end bulk-head so as to reach about the center of the uptake duct. The gas sample is conducted continuously through the probe 10 directly into a suitable heat exchanger 11 which preferably consists of a water-cooled pipe or coil 12 surrounded by an enclosure 13 through which cooling water flows continuously to effect the desired cooling and condensation of moisture in the gas. The exit temperature of the gas sample leaving the heat exchanger 11 is approximately 65° F. when water is used as the cooling fluid. The exit temperature of the gas sample from the heat exchanger is, of course, dependent upon the temperature and flow of the cooling medium. If desired, one may use different cooling mediums to obtain predetermined gas temperature as the gas sample leaves the heat exchanger 11.

The heat exchanger 11 serves essentially to condense moisture from the gas sample. The percentage of moisture removed by the heat exchanger 11 through the moisture trap 14 can vary from 60 to 85 percent, depending upon whether or not the gas sample is supersaturated with moisture at the heat exchanger inlet. When a high percentage of moisture is present in the furnace gas, the gas sample is supersaturated with moisture at the heat exchanger inlet and an increased amount of moisture is removed from the gas stream in the heat exchanger 11. Under normal conditions when the furnace or other process gas sample is simply saturated with moisture, the amount of moisture removal is approximately 65 percent when the gas sample leaving the heat exchanger 11 has a temperature of about 65° F. The amount of moisture removed can, of course, be increased by lowering the temperature of the cooling medium of the heat exchanger.

If the dew point of the sample is so low that no condensation forms in the heat exchanger 11 with a particular cooling fluid, the heat exchanger 11 then simply cools the gas sample as the sample passes therethrough from a high temperature zone of the furnace. Also, if there is only a relatively small amount of moisture in the gas sample and no cooling of the sample is required, the gas sample can be conducted around the heat exchanger 11 through the by-pass piping 15.

In order to insure a continuous uniform flow of sample gas to the gas analyzer (not shown), a gas pump 17 is preferably used to control the flow of the gas sample through the probe 10 and heat exchanger 11, and through the remaining mechanical filter units and gas analysis apparatus. The gas pump 17 can be of any conventional design, including a flexible tubing type pump, with suitable drive means which can be used to regulate the speed thereof to control the rate of flow of gas sample. Additional moisture can be removed from the gas sample during the latter steps, if desired. In circumstances where conditions preclude the use of an electric motor drive, an air motor has been used and provides excellent results. It should also be noted that a pump is not needed if the pressure of the atmosphere to be sampled is sufficiently high to provide a positive continuous flow of gas through the gas sampling apparatus and the gas analyzer. The need for and type of pump used will depend on considerations such as the gas sample pressure mentioned above, the distance from the sampling system to the analyzer, the pressure drop enroute to the analyzer, and the pressure and flow requirements of the gas analyzer. Since the pump flow and pressure of the present apparatus are adjustable, the gas sampling system is able to meet a wide variety of gas analyzer requirements.

Upon leaving the pump 17, the relatively dry gas sample is passed into a coarse mechanical filter unit 20 in which most of the large solid particles having a particle size larger than about 100 microns in the gas are removed, along with additional moisture which condenses and collects in the sump portion 21 at the bottom of the

filter 20 and which has a drain valve 22 for removing condensed moisture. The amount of moisture removed by the coarse filter can be up to about 25 percent. Part of the moisture removal in the coarse filter, of course, is due to a drop in temperature that occurs after the sample gas has been discharged from the pump. In the event there is no coarse solid particulate material larger than about 100 microns in size suspended in the gas sample or when the filter unit 20 must be shut down for repair, a by-pass tubing 25 is provided to convey the gas sample around the filter 20 directly from the pump 17 to a succeeding filter unit. The filter material 23 which is supported within the filter unit 20 by a pervious member 24 spaced from the lower end of the filter unit 20 can be glass wool or any other inexpensive filter medium desired. For ease of maintenance, the filter unit 20 is provided with removable top and bottom closures 26, 27, respectively.

The gas sample flows from the coarse filter unit 20 through conduit 29 into the fine filter unit 30 which removes dust particles having a particle size down to about 75 microns. The body section 31 of the filter unit 30 encloses and removably supports thereon a filter cartridge 32 in spaced relationship with the wall of the body section 31. The filter material 37 in the cartridge 32 can be formed of glass wool or other filter material compressed therein to provide for the removal of predetermined particle size material. If desired, the fine filter element can consist of a Monel screen with a transparent bottom section, such as a Norgren filter. The lower sump end 35 of the filter body section 31, which is provided with a pet cock or drain valve 36 for removing any condensed moisture which collects therein, is removable to facilitate replacement of the cartridge 32, when required. It has been found that the fine filter removes up to 5% moisture from the gas sample. A by-pass conduit 38 is also provided to convey the gas sample around the fine filter unit 30 directly to the ultra fine filter unit 40, when required.

The gas sample is conveyed directly from the filter cartridge 32 of filter unit 30 through conduit 39 into the ultra fine filter unit 40 wherein particles having a particle size larger than about 1 micron are removed from the gas sample. The body section 41 of the filter unit 40 encloses and removably supports therein in spaced relationship with the sides of the body section 41 a filter element 42. The filtering material of the filter element 42 can comprise packed glass wool 45, if desired, but preferably is a commercial filter unit with a replaceable filter cartridge constructed to remove particles having a size larger than about 1 micron. The glass wool or cartridge can be removed for replacement by removing the detachable end cap 44 at the lower end of the filter unit 40. The substantially dry, dust free gas sample after passing through the ultra fine filter element 42 is carried by conduit 46 to the gas analysis apparatus (not shown) which forms no part of the present invention and can be of any desired type suitable for analyzing a multi-component gas. The ultra fine filter unit 40 can be by-passed by conduit 50, if necessary.

Since the furnace gas sample is treated to remove therefrom a substantial proportion of the moisture before the gas sample enters the series of dry mechanical filters, there is substantially less tendency for the filters to become clogged than when the gas sample having a high concentration of both dust and moisture is initially subjected to a filtering treatment to remove dust and the like solids.

While the gas sampling apparatus has been described as applied to sampling the gas from an open hearth furnace, it should be understood that other metallurgical furnace gases and process gases other than open hearth

furnace gases, such as gases from a coke plant, can be continuously sampled by the apparatus of the present invention to provide a representative gas sample of a gaseous process stream to a continuous gas analyzer.

Others may practice the invention in any of the numerous ways which are suggested to one skilled in the art by this disclosure, and all such practice of invention are considered to be a part hereof which fall within the scope of the appended claims.

I claim:

1. A gas sampling apparatus for collecting a representative gas sample from an atmosphere of 1000-3000° F. furnace gas having a concentration of up to about 50% by weight moisture and an average concentration of solid particulate matter of about 25 grains per standard cubic foot which comprises in combination; a fluid cooled heat exchanger which is adapted to remove a major proportion of the moisture from said gas sample with said heat exchanger disposed in direct communication with a gas sampling tube adapted to continuously withdraw said gas sample from said atmosphere, a coarse mechanical filter adapted to remove suspended particles larger than about 100 microns and additional moisture from said gas sample, a fine mechanical filter adapted to remove suspended particles larger than about 75 microns and residual moisture, and an ultra fine mechanical filter adapted to remove suspended particles larger than about 1 micron, each of said filters having associated therewith by-pass means enabling said gas sample to be conducted around any said filters, and a gas pump disposed in series with said heat exchanger and said filters for regulating the flow of said gas sample through said heat exchanger and filters.

2. In a process of continuously sampling an atmosphere of 1000-3000° F. furnace gas having a maximum moisture concentration of about 50% by weight and containing an average concentration of solid particulate matter of about 25 grains per standard cubic foot, and passing said sample to a gas analyzing apparatus, the improvement comprising;

- (A) continuously introducing a sample of said gas into a fluid cooled heat exchanger to cool and condense from said gas a major proportion of the moisture contained therein;
- (B) continuously passing said gas sample from which a substantial proportion of the moisture has been removed through a coarse mechanical filter to remove suspended particulate matter larger than 100 microns and additional moisture remaining in said sample;
- (C) continuously conducting said sample from said coarse mechanical filter to a fine mechanical filter wherein suspended particles larger than about 75 microns are removed along with a substantial amount of the residual moisture in said sample removed; and
- (D) continuously passing said sample directed from said fine filter to an ultra fine mechanical filter wherein suspended particles larger than about 1 micron are removed to provide a substantially dry gas sample substantially free of suspended solid particles and having the original gaseous components present in their original proportions.

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