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METHOD OF AND APPARATUS FOR SAMPLING GASES.

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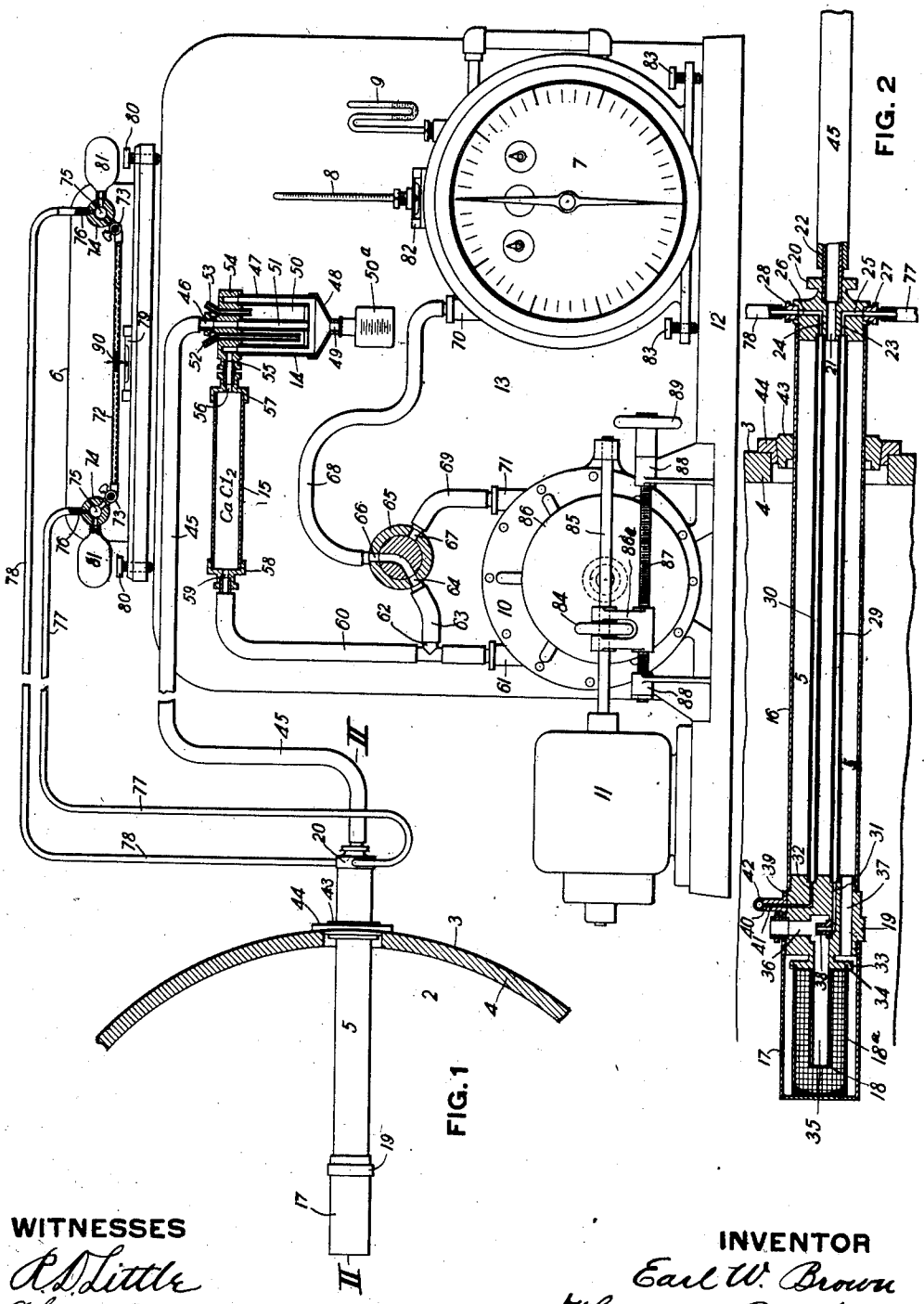


FIG. 1

FIG. 2

WITNESSES

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1,100,171. Specification of Letters Patent. Patented June 16, 1914.

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To all whom it may concern:

Be it known that I, EARL W. BROWN, a citizen of the United States, residing at Elyria, in the county of Lorain and State of Ohio, have invented certain new and useful Improvements in Methods of and Apparatus for Sampling Gases, of which the following is a specification.

My invention relates to the sampling of gases in the determination of constituents and characteristics of gases, and more particularly of blast furnace and similar gases containing moisture and having a considerable amount of finely divided solids in suspension therein, and to a novel construction and arrangement of apparatus adapted for use in making such determinations.

Heretofore, the efforts made by existing methods and with the known apparatus to measure or determine the constituent parts of such gases and gaseous compounds, have been found to be inefficient and inaccurate. Venturi and Pitot meters, which have been employed for this purpose, have proved to be inaccurate on account of the tendency of the openings or passages in such apparatus to clog, and owing to the lack of means for determining the true velocity of the gases containing such widely varying quantities of finely divided solids and other impurities as are found in blast furnaces and similar gases.

Dry meters and meters of the displacement type have been found to be impractical by reason of the large sizes required while with the small sizes the percentage of error is great, even when used in measuring comparatively clean gases.

The electric heating meters which have been experimented with in large sizes have proved only more or less satisfactory under normal conditions with comparatively clean gases and relatively uniform temperatures.

In none of the existing methods or apparatus known to me have means been provided for determining constituents of such gases or gaseous compounds simultaneously with the measurement of the velocity and volume and the temperature and pressure of the gases.

One object of my invention is to provide a new and useful method of sampling gases whereby the temperature, pressure and velocity of the gases is gaged, the volume and moisture content is accurately determined and the quantity of solid matters carried in suspension in the gases is measured.

Another object of the invention is to provide a novel arrangement and combination of parts forming my improved sampling apparatus by the use of which the method of sampling gases forming part of this invention is rapidly and efficiently carried out, and still further objects of my invention will be apparent as the invention is more fully described and claimed hereinafter.

Referring now to the accompanying drawings forming part of this specification, Figure 1 is an elevation showing one embodiment of apparatus constructed and arranged in accordance with my invention and adapted for use in carrying out the steps of the method also forming part of this invention. Fig. 2 is a sectional plan on the line II—II of Fig. 1 showing, on a larger scale, a detail of the construction of the sampling pipe and the manner in which it is applied for use on a gas main or conduit.

In the drawings, the numeral 2 designates a gas main or conduit having a metal shell 3 and a refractory lining 4, through which a constantly flowing stream of gases is conducted from a place of supply, such as a blast furnace, to a place of use, and 5 is a sampling pipe or tube removably secured on the conduit 2 with its end having the casing 17 thereon projecting inwardly within the gas main 2 into the path of the flowing column of gases.

Situated with reference to the gas conduit 2, (which is generally overhead in conducting blast furnace gases), in a suitable location at any convenient distance from the conduit 2 so as to be readily accessible, is a velocity gage 6, a gas meter 7 having a thermometer 8 and a U-tube 9 forming a gas pressure gage thereon, and a rotary pump 10 which is driven by means of an electric motor 11.

The gas meter 7, pump 10 and the pump driving motor 11 are preferably mounted upon the horizontal face of a base 12, and the base 12 has a vertical flange 13 extending upwardly therefrom on which the surface condenser 14 and the receptacle or container 15 for the moisture removing medium are secured. The velocity gage 6 may be conveniently mounted upon the top of the vertical flange 13 forming part of the base 12 in assembling the apparatus.

The sampling pipe, as will best be seen by reference to Fig. 2, is constructed of a tubular metal shell 16 forming a conduit leading to the exterior of the gas main 2. A cap forming a casing 17 inclosing the re-

movable filtering medium 18, (which preferably is a Soxhlet filter shell), is detachably connected by one end to one face of a connecting member 19 by which the shell 16 and casing 17 are connected together, the connecting member 19 having a series of apertures or openings therein for the passage of the gases into and through the sampling pipe 5 from the gas main 2.

The end of the tubular shell 16 on the exterior of the gas main 2 is provided with a head or closure 20 which is screw-threaded into the shell, and this head has a central opening or hole 21 therethrough in which a nipple 22 is secured to project outwardly beyond the outer face of the head. The inwardly extending openings 23 and 24 on the inner face of the head 20 each terminate at their intersection with the radially extending openings 25 and 26 in the head 20, the radial openings 25 and 26 having nipples 27 and 28 screw-threaded thereinto. The small inwardly extending openings 23 and 24 in the head 20 are connected by means of the tubular members 29 and 30 with the small axially extending openings 31 and 32 in one face of the connecting member 19. The other face of the connecting member is provided with a flange 33 having an annular recess or groove 34 in its outer face, and the end of the shell 18^a containing the filtering medium 18 extends within this recess to secure the filtering medium in position within its casing 17 which is removably secured to the connecting member 19 by the internal threads on the end of the casing 17. The connecting member 19 also has an axial opening 35 extending inwardly from the flanged face thereof which terminates at the inner end of the intersecting radial opening 36 located at about the middle of the length of the connecting member. A second opening 37 is provided which extends through the connecting member 19 to connect the interior of the casing 17 for the filtering medium 18 with the interior of the shell 16 forming part of the sampling pipe.

A short tube 38 is inserted within the counterbore at the intersection of the openings 35 and 36 to connect the small longitudinally extending opening 31 with the openings 35 and 36 in the connecting member 19, and the inner end of a radially extending opening 39 intersects the inner end of the lengthwise extending opening 32 which is connected at its outer end to one end of the tubular member 30 within the shell 16.

A hollow plug 40 having a closed outer end is screw-threaded into the radially extending opening, the opening 41 in the plug 40 registering with the opening 39, being connected to the radially extending openings 42 located in the side thereof near the closed end of the plug.

A flange 43 having a tapering or frustoconical periphery is provided at an intermediate point in the length of the shell 16 forming part of the sampling pipe 5 which is inserted within the correspondingly tapered opening in the flange 44, which is located on the side of the gas main 2, when the sampling pipe 5 is in operative position within the gas main 2.

The nipple 22 in the axially central opening 21 in the head 20 on the outer end of the sampling pipe is connected by means of a pipe or tube 45, a rubber hose preferably being employed, with the gas inlet opening 46 on the surface condenser 14. The condenser 14 is formed of an outer shell 47 having a conical bottom 48 with an opening 49 in the bottom leading into a graduated measuring flask 50^a which is removably secured to the bottom of the condenser 14. Depending within the outer shell 47 of the condenser is a water chamber 50, the closed lower end of which extends downwardly within the outer shell, and a conduit or pipe 51 which extends through the center of the water chamber provides a passage through which the gases pass from the tube 45 into the condenser 14. A suitable water inlet 52 and water overflow outlet 53 are provided on the head 54, forming the top of the condenser shell 47 and of the water chamber 50, through which water is caused to flow into and out of the chamber 50 in condensing moisture in the gases passed through the condenser 14.

The condenser 14 is provided with a branch forming a gas outlet 55 on its upper end which is connected to the inlet opening 56 in the head 57 on one end of the receptacle 15 which contains a chemical such as calcium chlorid ($Ca\ Cl_2$) in order to remove any moisture remaining in the gases after passing through the condenser 14. The head 58 on the opposite end of the container or receptacle 15 is provided with an outlet opening 59 which is connected by a pipe or flexible tube 60 to the inlet opening 61 of the pump 10.

A branch outlet 62 on the tube 60 is connected by the tube 63 to one port 64 of a three-way valve 65 and the other two ports 66 and 67 of the valve are connected by tubes 68 and 69 to the inlet opening 70 of the meter 7 and the outlet opening 71 of the pump 10. The three-way valve 65 is connected to the sampling pipe 5, meter 7 and pump 10 so as to enable the gases flowing through the tube 60 to be delivered, through the valve ports 64, 66 directly into the tube 68 without passing through the pump 10, whenever found necessary or desirable. Ordinarily the pump will be operated when sampling the gas although, at times, it may be stopped.

In order to indicate the speed at which

the gases are traveling through the sampling tube 5 and apparatus connected to the discharge outlet thereof, relative to the velocity of the gases in the gas main 2, the velocity gage 6 is provided, which is mounted on the top of the flange 13 forming part of the base 12. This velocity gage is formed of a horizontally extending glass tube 72 having the open ends thereof connected by means of pet cocks 73 to supports 74, 74, by which the tube 72 is secured in place on the base of the gage 6. The supports 74 have openings 75 therethrough connecting the pet-cocks 73 and the nipples 76 located in one of the openings in the supports. The nipples 76 are connected by means of the tubes 77 and 78 with the radial openings 25 and 26 in the head 20 on the outer end of the sampling pipe 5. The velocity gage 6 has a spirit level 79 thereon and is provided with thumbscrews 80 by which it is leveled. A rubber bulb 81 is provided on the supports 74 for the end of the glass tube 72 forming part of the velocity gage 6 to afford means for blowing out the short tube 38 and plug 40, the tubular members 29 and 30, the tubes 77 and 78, and the connecting passages in the connecting member 19 and closure 20 when required, the pet cocks 73 being opened to discharge into the atmosphere for that purpose. The gas meter 7 also is provided with a spirit level 82 and with thumb screws 83 by which it is leveled on the base 12.

The rotary pump 10 is driven by means of the electric motor 11 which is operatively connected thereto by means of a friction drive, a friction driving wheel 84 splined on the motor armature shaft extension 85 engaging with the flat surface of the driven friction wheel 86 on the shaft of the pump 10, the shaft for the pump extending at right angles to the shaft 85. The friction wheel 84 is adjustable lengthwise on the shaft extension 85, across the face of the wheel 86, to vary the speed at which the pump 10 is driven. The wheel 84 is moved lengthwise on the shaft 85 by means of the bifurcated bracket 86[a] which is operatively connected to the screw 87 mounted in bearings 88, 88, on the base 12, and a hand wheel 89 on one end of the screw 87 provides means for adjusting the friction driving wheel 84 on the motor shaft 85 toward and away from the axis of the wheel 86 on the pump shaft.

In carrying out my improved method of sampling the gases in determining constituents and characteristics of gases with the novel arrangement of apparatus shown and described herein, the dry weight of the filtering medium 18 within the cap 17 of the sampling pipe 5, and that of the container 15 connected to the discharge outlet of the surface condenser, are very carefully determined. The filtering medium 18 is then inserted in position within the sampling pipe and the container 15 is connected to the pump 10 and condenser 14 as has been described, and the sampling pipe 5 is inserted in place in the gas main 2. The time is noted, and the rotary pump 10 is then started. The speed of the pump 10 is then regulated in such manner that the oil piston 90 in the horizontal velocity gage 6 is maintained in equilibrium.

The inlet 75 on one end of the velocity gage is connected by the tube 77 and pipe 29 through the sampling pipe 5 with the intersecting apertures 31 and 38 within the connecting member 19 of the sampling pipe, and through the opening 36 in the member 19 through which the gases are led from the gas main 2, to the filtering medium 18, and the inlet 75 on the opposite end of the gage 6 is connected by the pipe 30 and tube 78 to the intersecting apertures 32, 39, in the member 19 and registering axial opening 41 in the plug 40 on the connecting member 19 having side openings 42 therein which communicate directly with the interior of the gas main 2.

The velocity of the gases flowing through the main 2 tends to create suction, or perhaps more accurately, tends to lessen the pressure in the opening 41 and in the velocity gage 6 on the side of the oil piston 90 that is connected therewith, and when the pump 10 is not in operation the pressure of the gases flowing into the opening 38, which leads to the opposite side of the oil piston 90 in the velocity gage 6, acts to increase the unbalancing effect and thereby movement of the oil piston.

When the pump 10 is started in operation, gases will be drawn into the sampling tube 5, through the calibrated opening 36[a], and the suction created by the pump will lessen the pressure in the tubular member 29. When the pressure in this tubular member is reduced to the same extent as that caused in the tubular member 30, the pressure will become balanced, within the velocity gage, and the oil piston 90 will have returned to and will remain stationary in its central position, and indicate when the pressure gage 6 is in equilibrium, that the velocities are equal.

When the oil piston 90 in the tube 72 of the velocity gage 6 remains stationary in its central position, the velocity of the gases passing through aperture 36[a] into and through the sampling pipe into the meter 7 is equal to that of the stream of gases flowing through the gas main 2. The axial center of the opening in the nozzle 36[a] must be absolutely parallel to the direction of flow of the gases in the main 2 and the flow of gases must be directly into the nozzle 36[a]. The location of this nozzle relative to the side walls of the gas main must be

determined experimentally for each particular main, and it is best determined by means of a Pitot tube showing the pressure along a complete diameter. From the average of all these readings a corresponding point in the diameter of the gas main is located and the nozzle 36ª positioned at such point. This has been found by experiment in most cases with mains of circular cross section to be at a point positioned at a distance equal to one-third of the diameter of the main from the side of the main. This balanced condition is then maintained for a definite length of time, which interval is noted, after which the sampling pipe 5 is removed from the gas main 2. The indications of the thermometer 8 and pressure gage 9 on the meter 7, as to temperature and pressure of the gases passing through the meter while the sample pipe is in operative position within the gas main will also be noted. The meter is then read to note the volume of gases passed therethrough, the meter reading multiplied by the ratio of the area of the aperture 36ª in the connecting member 19 of the sampling pipe to the area of the gas main 2, giving the volume of gases passing through the gas main 2 during the elapsed time, the proper corrections as to temperature and pressure having been made to the meter reading. The dry weight of the filtering medium 18 before and after the tests having been determined, the difference in such weights divided by the number of cubic units shown by the meter will give the weight of the solids contained in each cubic unit of the gases of the sample. The sum of the weights of the water caught in the measuring flask 50ª on the bottom of the surface condenser 14, the water in the drying receptacle 15, at the conclusion of the test, will indicate the total amount of water or moisture in the gases of the sample, and the volume of the sample gases being known, the moisture content of the gases flowing through the gas main 2 is readily ascertained. As the container 18ª is always at the same temperature as the gases in the main there will be no deposition of water in this container. The above described operations are then repeated from time to time, as is required in making successive tests.

The advantages of my invention will be apparent to those skilled in the art. By means of my novel method of sampling gases the amount of solids carried in suspension in the gases of the gas main and the moisture content of the gases, are accurately determined. The true velocity of the gases flowing through the gas main is gaged and the pressure and temperature of the gases is measured. The velocity of the gases as they enter the sample pipe is maintained constantly equal to the velocity of the gases in the gas main. This condition insures a correct proportion in the sample pipe of the solids carried in suspension in the gases in the main, as well as a proportionate volume of the gases passing through the main. The area of the gas main and the calibrated aperture or opening of the nozzle 36ª in the sampling pipe being known, the volume of gases flowing through the gas main is quickly and accurately computed. The novel combination of elements forming my improved sampling apparatus provides means for carrying out my method in a rapid manner, and danger of clogging of the apparatus is lessened and prevented and liability of error in the results obtained is avoided and overcome.

The term "gases" as used in the specification and claims is intended to cover blast furnace and all similar combustible gases containing moisture or finely divided solids or both and also to include steam, air and similar gaseous fluids.

Modifications in the construction and arrangement of the parts forming the apparatus may be made without departing from my invention, and apparatus other than that shown and described may be employed in carrying out my improved method of sampling gases forming part of this invention within the scope of the appended claims.

I claim:—

1. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume at the velocity of the gases flowing through the gas main, passing the sample gases through a filtering medium of known dry weight, and then determining the dry weight of the filtering medium and therefrom determining the amount of solids contained in the sample gases.

2. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume at the velocity of the gases flowing through the gas main, passing the sample gases through a filtering medium of known dry weight, condensing the filtered gases to precipitate and collect the moisture therein and determining the dry weight of the filtering medium, and therefrom determining the amount of solids contained in the dry sample gases.

3. The method of sampling gases consisting in removing a sample of gases from a gas main at the velocity of the gases flowing through the gas main, passing the sample gases through a filtering medium of known dry weight, measuring the volume of the sample gases and weighing the filtering medium to therefrom determine the quantity of solids contained in the sample gases.

4. The method of sampling gases consisting in removing a sample of gases from a gas main, passing the sample gases through a filtering medium of known dry

weight, regulating the speed of removal of the sample gases to equal the velocity of the gases flowing in the gas main, measuring the volume of the sample gases and weighing the filtering medium to therefrom determine the amount of solids contained in the sample gases.

5. The method of sampling gases consisting in removing a sample of gases from a gas main, passing the sample gases through a filtering medium of known dry weight, indicating the relative velocity of the gases flowing through the gas main and the sample pipe, equalizing the speed of removal of the sample gases and the gases in the gas main, measuring the volume of sample gases removed at the equalized velocity, and weighing the filtering medium to therefrom determine the amount of solids contained in the sample gases.

6. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, regulating the speed of removal of the sample gases to equal the velocity of the gases flowing in the gas main, passing the sample gases through a filtering medium of known weight, condensing the filtered sample gases to precipitate and collect the moisture therein, measuring the volume, registering the pressure of the sample gases to correct the measured volume and weighing the filtering medium, to determine the amount of solids contained in the dry sample gases.

7. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, passing the measured sample gases through a filtering medium of known dry weight, regulating the speed at which the sample gases are removed to equal the velocity of the gases flowing in the gas main, condensing the filtered gases to precipitate and collect the moisture therein, measuring the volume and registering the pressure and temperature of the sample gases and weighing the filtering medium to determine the amount of solids contained in the sample gases.

8. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, passing the measured sample gases through a filtering medium of known dry weight, regulating the speed at which the sample gases are removed to equal the velocity of the gases flowing in the gas main, condensing the filtered gases to precipitate and collect the moisture therein, and weighing the filtering medium to therefrom determine the amount of solids contained in the sample gases.

9. Apparatus for sampling gases comprising a sampling pipe removably secured within a gas main and having a calibrated aperture therein through which the sample gases pass from the gas main, a filtering medium of known dry weight within the sampling pipe, a condenser connected to the sampling pipe having means for precipitating and measuring the moisture in the sample gases, and means connected to the condenser for measuring the volume of the sample gases.

10. Apparatus for sampling gases comprising a sampling pipe removably secured within a gas main and having a calibrated aperture therein through which the sample gases pass from the gas main, a filtering medium of known dry weight within the sampling pipe, a condenser connected to the sampling pipe having means for precipitating and measuring the moisture in the sample gases, and means connected to the condenser for measuring the volume and indicating the pressure of the sample gases.

11. Apparatus for sampling gases comprising a sampling pipe removably secured within a gas main and having a calibrated aperture therein through which the sample gases pass from the gas main, a filtering medium of known dry weight within the sampling pipe, a condenser connected to the sampling pipe having means for precipitating and measuring the moisture in the sample gases, and means connected to the condenser for measuring the volume and indicating the temperature and pressure of the sample gases.

12. Apparatus for sampling gases comprising a sampling pipe removably secured within a gas main and having a calibrated aperture therein through which the sample gases pass from the gas main, a filtering medium of known dry weight within the sampling pipe, a meter connected to the sampling pipe for measuring the volume of the sample gases, and means for regulating the velocity of the sample gases passing through the sampling pipe.

13. Apparatus for sampling gases comprising a sampling pipe removably secured within a gas main and having a calibrated aperture therein through which the sample gases pass from the gas main, a filtering medium of known dry weight within the sampling pipe, a condenser connected to the sampling pipe having means for precipitating and measuring the moisture in the sample gases, means connected to the condenser for measuring the volume of the sample gases, and means for regulating the velocity of the sample gases passing through the sampling pipe.

14. In apparatus for sampling gases, the combination with a sampling pipe removably positioned in a gas main and having a calibrated opening for the passage of gases therethrough fom the gas main, of condensing means connected to the gas outlet on said sampling pipe for precipitating and collecting moisture in the sample gases, and

means connected to the gas outlet of said condensing means whereby the volume of the sample gases is determined.

15. Apparatus for determining constituents and characteristics of blast furnace gases comprising a sampling pipe removably mounted in a gas main, said sampling pipe having a calibrated aperture therein for the passage of gases through the sampling pipe, means for withdrawing measured samples of gases from the gas main through the sampling pipe, means for comparing the velocity of the gases flowing through the sampling tube with that of the gases in the gas main, and means for equalizing the velocity of gases passing through the sampling pipe with that of the gases in said gas main.

16. Apparatus for determining constituents and characteristics of blast furnace gases comprising a sampling pipe removably mounted in a gas main, said sampling pipe having a calibrated aperture therein for the passage of gases through the sampling pipe, a filtering medium in the sampling pipe to remove and collect the solids in the gases passing through the sampling pipe, and means for withdrawing measured samples of gases from the gas main through the calibrated apertures, and the filtering medium in said sampling pipe, said filtering medium being removably secured in the sampling pipe to permit determination of the dry weights of the filtering medium and the solids removed from the gases of the sample, and therefrom determine the amount of solids contained in the gases flowing through the gas main.

17. Apparatus for sampling gases comprising in combination a sampling tube removably secured within a gas main and having a calibrated aperture therein for the passage of gases, a filtering medium of known weight within the sampling pipe, a condenser connected to the sampling pipe to precipitate and collect moisture in the sample gases, a pump connected to the condenser for withdrawing gases from the main through the sampling pipe, and a meter connected to the pump outlet for measuring the volume of the sample gases drawn thereby from the gas main.

18. Apparatus for sampling gases comprising in combination a sampling tube removably secured within a gas main and having a calibrated aperture therein for the passage of gases, a filtering medium of known weight within the sampling pipe, a condenser connected to the sampling pipe to precipitate and collect moisture in the sample gases, a pump connected to the condenser for withdrawing gases from the main through the sampling pipe, a meter connected to the pump outlet for measuring the volume of the sample gases drawn thereby from the gas main, and a velocity gage connected with the sampling pipe and with the gas main.

19. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume at the velocity of the gases flowing through the gas main, passing the sample gases through a filtering medium of known dry weight, and determining the dry weight of the filtering medium, and therefrom determining the amount of solids contained in the dry sample gases.

20. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, regulating the speed of removal of the sample gases to equal the velocity of the gases flowing in the gas main, passing the sample gases through a filtering medium of known weight, measuring the volume, registering the pressure of the sample gases to correct the measured volume and weighing the filtering medium, to determine the amount of solids contained in the dry sample gases.

21. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, passing the measured sample gases through a filtering medium of known dry weight, regulating the speed at which the sample gases are removed to equal the velocity of the gases flowing in the gas main, condensing the filtered gases to precipitate the moisture therein, measuring the volume and registering the pressure and temperature of the sample gases to correct the measured volume and weighing the filtering medium to determine the amount of solids contained in the sample gases.

22. The method of sampling gases consisting in removing from a gas main a sample of gases of measured volume, passing the measured sample gases through a filtering medium of known dry weight, regulating the speed at which the sample gases are removed to equal the velocity of the gases flowing in the gas main, condensing the filtered gases and collecting the precipitated moisture, measuring the volume and registering the pressure and temperature of the sample gases to correct the measured volume and weighing the filtering medium to therefrom determine the amount of solids contained in the sample gases.

In testimony whereof, I have hereunto set my hand.

EARL W. BROWN.

Witnesses:
CARL EYERICK,
CLAUDE C. HAMEL.