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Bosch

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[54] **SYSTEM FOR DETERMINING THE DUST CONTENT OF GASES**

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[51] **Int. Cl.** **G01n 31/00**

[58] **Field of Search** .... 73/28, 432 PS, 421.5 R, 73/421.5 A; 55/270, 261, 274, 283, DIG. 30, DIG. 41

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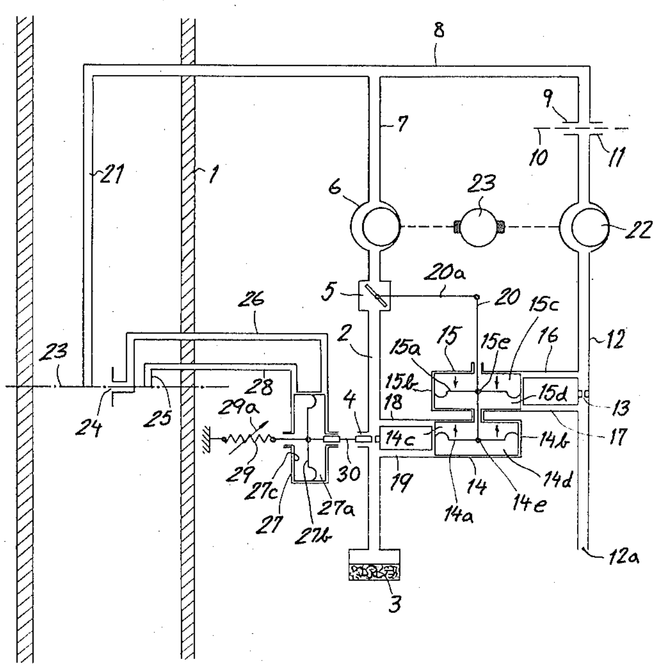
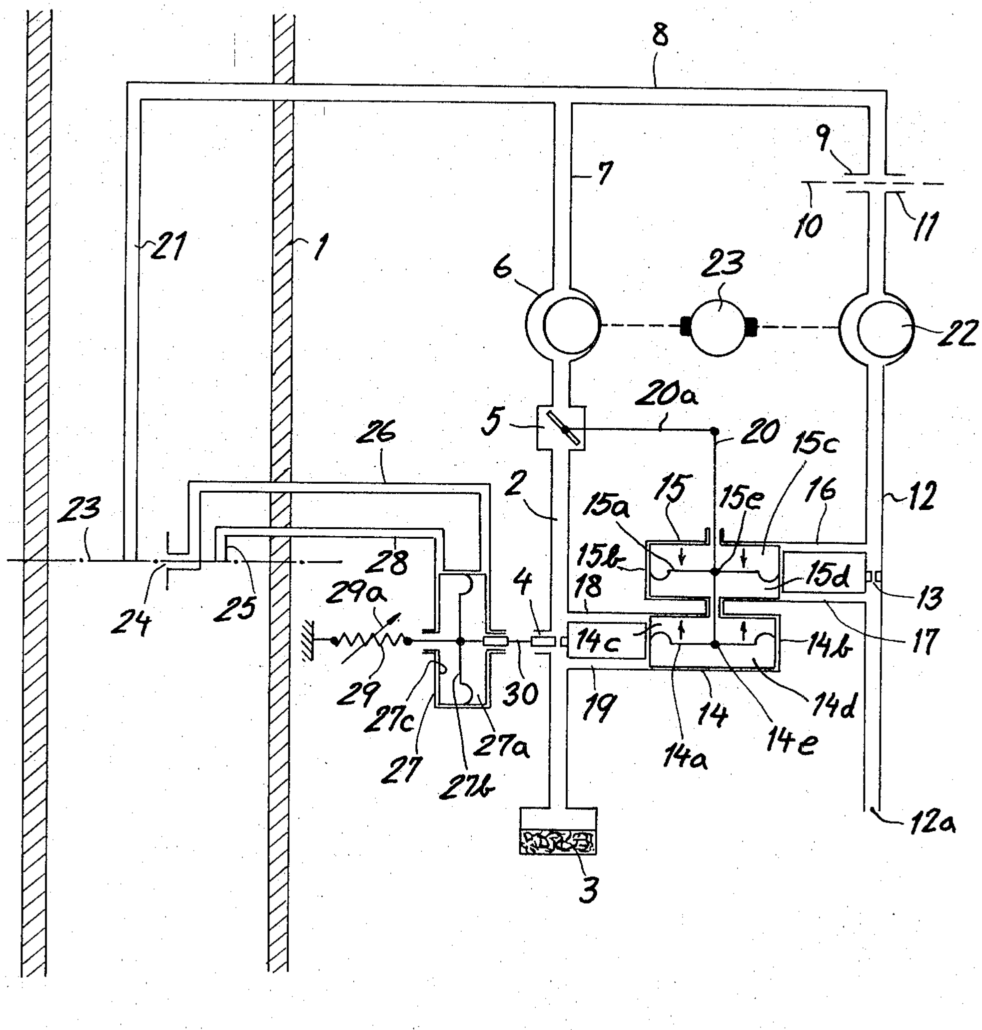
[57] **ABSTRACT**

A system for measuring the dust content of gases traversing a stack or other duct, e.g., a chimney stack, before release of the gases into the atmosphere, comprises a conduit arrangement with pumps establishing a circulation of air from and to the atmosphere which is unbalanced between the intake and discharge branches to permit induction of the sampled stream of gas from the stack between these branches and upstream of a dust detector. A device for generating an output representing a pressure differential receives one input representing the static pressure of the stack and another input representing the total flow pressure (static pressure + dynamic pressure) therein controls a throttle which, in turn, is followed by an adjustable flow-control means for producing the imbalance in accordance with the dynamic pressure of the gases in the stack.

3 Claims, 1 Drawing Figure

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SYSTEM FOR DETERMINING THE DUST CONTENT OF GASES

FIELD OF THE INVENTION

The present invention relates to a system for the measurement of dust emissions from ducts through which particle-containing gases are displaced, especially smoke stacks, industrial stacks and other arrangements discharging a dust-laden gas into the atmosphere.

BACKGROUND OF THE INVENTION

Numerous systems have been proposed heretofore for the determination of the particulate content of gas streams conveyed along a duct and, possibly, discharged into the atmosphere. These systems include direct-reading arrangements in which a sensor is provided directly in the stack and monitors the particular compound by combustion or change of any other measurable parameter therein. An analogous system is one which provides a filter across the stack at certain intervals to collect substantially all of the particulates whereupon the film is evaluated, e.g., by weighing or by some more detailed analysis.

More recently, it has been desired to provide continuous or intermittent monitoring systems in which a portion of the dust-laden gas is diverted for analysis and accurately represents the remainder of the gas traversing the stack. For this purpose a sampling tube may be provided with a regulator such that the quantity of gas diverted from the stack for analysis (i.e., for determination of the quantity of particulates in the gas of the sample stream) is controllable.

The result obtained with this system is a percentage by weight of the total dust content per unit volume of exhaust gas and, for relatively constant flow velocities over the measurement period, these results are adequate. Difficulties have been encountered when the velocity of gas in the duct varies frequently and sharply within wide ranges. In this case the results obtained are only approximate and the system is disadvantageous from the point of view of environmental pollution. To compensate for the fluctuation by conventional means is expensive and difficult, even where it is possible.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved system for the monitoring, measurement or detection and sampling of the dust in dust-laden gas streams traversing a stack or other duct.

It is another object of the invention to provide a system or device of the character described which is less likely to produce inaccurate results due to fluctuations in the volume rate of flow through the duct to be monitored than earlier systems.

SUMMARY OF THE INVENTION

These objects are attained, in accordance with the present invention, by the use of a two-branch conduit system provided with throttles in the branches so as to establish a flow volume differential between them and thereby induce the sampled portion of the gas to flow into the conduit path, ahead of a particle detector, as a function of the pressure relationships within the stack or duct.

More particularly, the system of the present invention comprises an intake branch having a pump and at least one throttle ahead of this pump (a first throttle), a second branch having a pump and a throttle downstream thereof (a second throttle) for throttling the discharge of the conduit system to the atmosphere by the latter pump, and a particle detector in the conduit network between these pumps, a sampling tube being connected between the stack or duct to be monitored and the conduit means ahead of the particle detector.

According to the invention, a pressure detector (capable of generating an output representing pressure differential) has one side provided with an input for the stack which represents the static pressure therein at the level at which the sampling tube opens into the stack. The other side of the pressure detector receives an input which represents the total flow pressure (static pressure plus dynamic pressure) of the stack so that the pressure detector develops a pressure differential which represents the dynamic pressure in the stack, this pressure being used to control one of these throttles.

Controllers responsive to the flow rates through the two branches are provided and they, consequently, react to the adjustment of the first throttle or the second throttle by the pressure-detecting device to operate an adjustable throttle or other flow-control means in one of the branches in a sense such that the flow rate differential between the branches is minimized or brought to zero as the dynamic pressure in the stack is reduced or brought to zero and vice versa.

While the adjustable first or second throttle may be provided in each branch, I prefer to provide it in the intake branch between its pump and a filter through which the intake branch receives fresh air from the atmosphere. Similarly, while the adjustable throttle may be provided in either branch as will be apparent hereinafter, I prefer to provide it in the intake branch between the variable-cross-section first throttle and the pump of the intake branch.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages will become more readily apparent from the following description, reference being made to the sole FIGURE of the accompanying drawing which is a diagram illustrating the system of the present invention.

SPECIFIC DESCRIPTION

In the drawing, I show a system for determining the particulate contents of a gas stream traversing a duct and, more specifically, the dust emission from such ducts as chimneys, smokestacks and industrial gas discharge facilities.

The system, for the smokestack **1**, comprises an intake suction tube (intake branch) **2** provided with a filter **3** and an adjustable throttle (first throttle) **4**. The setting positioning throttle or flow-control means **5** is provided downstream of the throttle **4** in the form of a flap of the butterfly type while a suction pump **6** is connected downstream of the butterfly throttle **5** to induce gas through the filter.

At the output side of the pump **6**, a duct **7** is provided in communication with a duct **8** to the input **9** of a dust-measuring device or dust detector **9, 10, 11** which, for the sake of simplicity, has been shown as a filter band **10**. The dust in the gases traversing this filter band is collected on the latter and is measured, e.g., by weighing or some other means such as the blocking of a light beam, and converted into a weight or volume or particle-number measure per unit of time. A device of this type has been shown at 1 and described in German Pat. No. 2,032,172 (see also the English language reprint RECORDING COUNTER FOR THE CONTINUOUS DETERMINATION OF THE CONCENTRATION OF PULVERULENT AIR POLLUTANTS, STAUB REINHALTUNG DER LUFT, Vol. 27 (1967) No. 10, p.p. 21–24).

At the outlet **11** of the dust-measuring device, there is provided a duct (outlet branch) **12** having a throttle (second throttle) **13** of fixed cross-section which is spanned by tubes **16** and **17** connected to opposite chambers of a pneumatic bellows **15**. The pneumatic bellows is coupled with a pneumatic bellows **14** whose inlets **18** and **19** are bridged to opposite sides of the throttle **4**. The pneumatic bellows **15** may comprise a membrane **15***a* in a housing **15***b* subdivided into a compartment **15***c* receiving the higher pressure from line **16** and a compartment **15***d* receiving the lower pressure from the downstream side of the throttle **13** via tube **14**.

The membrane is connected at **15***e* with a rod **20** pivotally connected at **20***a* with the butterfly valve **5**.

The bellows **14** is provided with a membrane **14***a* connected at **14***e* to the rod **20** and received withing a housing **14***b* subdivided into the low-pressure compartment **14***c* and the high-pressure compartment **14***d* by the membrane. Compartment **14***c* is connected by tube **18** to the line **2** downstream of the throttle **4** while compartment **14***d* is connected by line **19** to this conduit upstream of the throttle **4**.

The pressure differential at the throttles **4** and **13** thus serves to operate the bellows **14, 15**, together forming a unit whose output is the rod **20** connected to the positioning throttle **5** as previously described.

A sampling tube **21** (running at least initially parallel to the stack axes) is connected to the duct system previously described between the output of pump **6** and the input **9** of the dust-measuring device **9, 10, 11**, and extends into the chimney or stack **1** to terminate in a plane **23** perpendicular to the axis of the stack and at which the mouth of tube **21** opens in a direction opposite that of gas flow through the stack.

A pump **22** is provided between the output side **11** of the dust-measuring device and the throttle **13** and drives air through the latter toward an outlet **12***a* communicating with the atmosphere. The pumps **6** and **22** are driven by a common motor **23**.

At the level of the horizontal measuring plane of stack **1**, there are provided further intake openings **24** and **25**. The intake opening **24** serves to sense the static pressure in the stack **1** while opening **25** responds to the total pressure (dynamic or flow pressure plus static pressure) in the stack. Opening **24** of the stack-pressure sensing means is connected by a duct **26** with one compartment **27***a* of a pressure-sensing capsule **27** having a membrane **27***b* subdividing the capsule **27** into the compartment **27***a* and a further compartment **27***c*. The latter communicates via line **28** with the opening **25** of the differential-pressure sensing means.

As described for the bellows **14** and **15**, the capsule **27** contains the membrane which provides an output in the form of a linear displacement which is proportional to the pressure differential across the membrane. The membrane **27***b* is connected to a tension spring **29**. The membranes of the pressure-detecting capsules **27**, and the bellows **14** and **15** and the throttle **5** have a median position which has been shown in the drawing. A rod **30** connects the membrane **27***b* of the pressure-detecting devise **27** with the throttle **4** in such manner as to control the effective cross-section of the constriction formed thereby. In its open position, the throttle **4** has substantially the same cross-section as the throttle **13**.

When the gas flow velocity through the stack **1** of smoke or other particulate-containing gases is zero the spring **29** draws the membrane of the pressure-detecting device **27** into its extreme left-hand position and imposes the larges cross-section of throttle **4** in the conduit **2**. The membranes in the bellows **14** and **15** assume such positions that the throttle **5** is opened and the pump **6** draws fresh air through filter **3** from the atmosphere, as mentioned, via duct **2** while air is returned to the atmosphere by pump **22** and outlet conduit **12**. The system is pneumatically balanced so that substantially no partial stream of gas is withdrawn from the stack **1** by the sampling tube **21**.

When the stack gases traversing the chimney **1** have some speed, the pressure detector **27** responds to proportionally reduce the cross-section of throttle **4**. More particularly, the total pressure detected at **25** applied to one side of the membrane is greater than the static pressure detected at **24** and applied to the other side of the membrane, the pressure differential displacing the membrane **27***b* against the force of the tension spring **29**.

The pressure differential is a measurement of the dynamic pressure in stack **1**, and rod **30** thereby proportionally reduces the cross-section of the throttle and hence the velocity with which the fresh air traverses intake conduit **2**. The pressure differential across the throttle thereby increases and is converted into a pressure differential at bellows **14** which shifts the rod **20** upwardly and effectively reduces the cross-section of throttle **5** until the pressure differential at the throttle **4** again reaches its original velocity. A large quantity of fresh air is thus drawn in through duct **2** by comparison with the quantity of gas-laden air displaced by the pump **22** and discharged through duct **12**. This flow-quantity differential requires replacement by induction of gas through the sampling tube **21** from the stack. Consequently, as the flow velocity in stack **1** increases, the dynamic pressure and the quantity of sampling gas increases.

The spring **29** is of adjustable tension as represented by the arrow **29***a* so that its force can be set with respect to the characteristics of throttle **4**, bellows **14**, bellows **15** and throttle **5** such that the withdrawal velocity of the gas in sampling tube **21** corresponds to the gas flow velocity in the remaining cross-section of the stack **1**. In this manner an equivelocity of isokinetic withdrawal of the sampled gas is ensured. The spring **29** allows, moreover, temperature compensation in a simple way since the equivelocity arrangement ensures that the same proportion of the sampled gas will be withdrawn with high stack temperatures as with low stack temperatures.

Of course, the adjustable throttles **4** and **5** need not be provided in the intake line **2** only but one or more of these throttles can also be disposed in the discharge line **12**. Thus the throttle **4** controlled by the pressure-detecting device can be provided in the intake line **2** while the throttle 5 controlled by the regulator 14 and 15 can be provided in line 12 although, whereas the system illustrated in the drawing requires a decreased cross-section for throttle 5, the alternative system will provide an increased cross-section. Furthermore, instead of the throttle 4 the throttle 13 may be made adjustable by the pressure-detecting device 27 and in this case the throttle 13 must be its smallest cross-section when the flow velocity in the intake is zero. Finally, it is possible to provide an arrangement whereby throttle 5 remains in the intake line 2 and throttle 4 has a fixed cross-section while throttle 13 is adjustable by the device 27.

I claim:

1. A system for measuring the dust content of a gas stream traversing a duct, said system comprising:
 a pair of motor-driven pumps, each having an inlet and an outlet, the inlet of one of said pumps and the outlet of the other pump forming respective branches communicating with the atmosphere;
 a dust detector having an input side connected to the outlet of said one of said pumps and an output side connected to the inlet of said other pump;
 a sampling tube open into said duct and communicating with said input side of said dust detector downstream of said one of said pumps;
 a first hrottle located at said inlet branch downstream of its communication with the atmosphere and a second throttle located at said outlet branch upstream of its communication with the atmosphere;
 means for varying the effective flow cross section of one of said throttles;
 operating means responsive to the flow velocity of said gas stream in said duct and operatively connected to said means for varying said cross section for adjusting said cross section of said one of said throttles to generate a flow-rate differential between said inlet branch and said outlet branch in dependence upon said flow velocity; and
 an automatic differential controller including:
  an adjustable-cross section further throttle in one of said branches,
  a control member shiftable in response to a pressure differential across said branches, and
  means operatively connecting said control member to said first throttle for increasing the flow-rate differential across said branches in conjunction with said operating means upon an increase in said flow velocity and vice versa.

2. The system defined in claim 1 wherein said operating means includes:
 a pressure-sensing capsule responsive to pressures applied to opposite sides thereof for producing an output representing the differential of the latter pressures;
 means for applying the static pressure in said duct to one side of said pressure-sensing capsule; and
 means for applying the total velocity pressure in said duct to the other side of said pressure-sensing capsule.

3. The system defined in claim 2 wherein said automatic differential controller further comprises respective pneumatic bellows having tubes bridged on opposite sides of said first and second throttles in said inlet and outlet branches.

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