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[73] Assignee **National Steel Corporation**

[54] **FLUID-HANDLING, GAS-SCRUBBING, AND BLAST FURNACE TOP PRESSURE CONTROL**
15 Claims, 3 Drawing Figs.

[52] U.S. Cl. **261/36,**
261/118, 137/81.5, 137/13
[51] Int. Cl. **B01f 3/04**
[50] Field of Search **261/DIG**
54, 118, 36.1; 137/13, 81.5

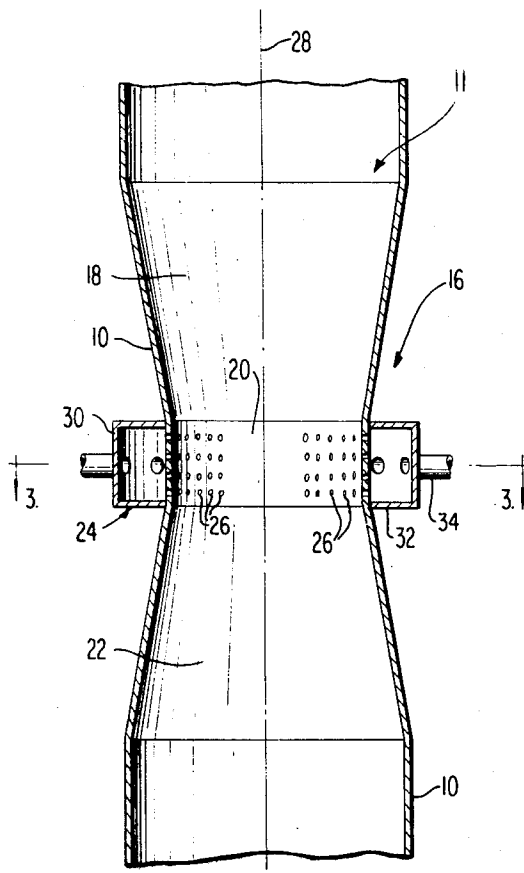
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Primary Examiner—Tim R. Miles
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ABSTRACT: Venturi-scrubbing system for blast furnace effluent gases, embodies a fluid handling system in which pressure of fluid (including the effluent gases) flowing in a passageway in open communication with the blast furnace top, is controlled by injecting control fluid into the passageway to increase and decrease the effective transverse cross-sectional area of the passageway at the location of control fluid injection. The control fluid is injected at the throat of the venturi in response to sensed pressure in the passageway, to adjust the effective cross-sectional area of the throat to maintain a predetermined pressure drop across the venturi, or a predetermined pressure upstream or downstream of the venturi. By controlling pressure in the passageway, the blast furnace top pressure is controlled.



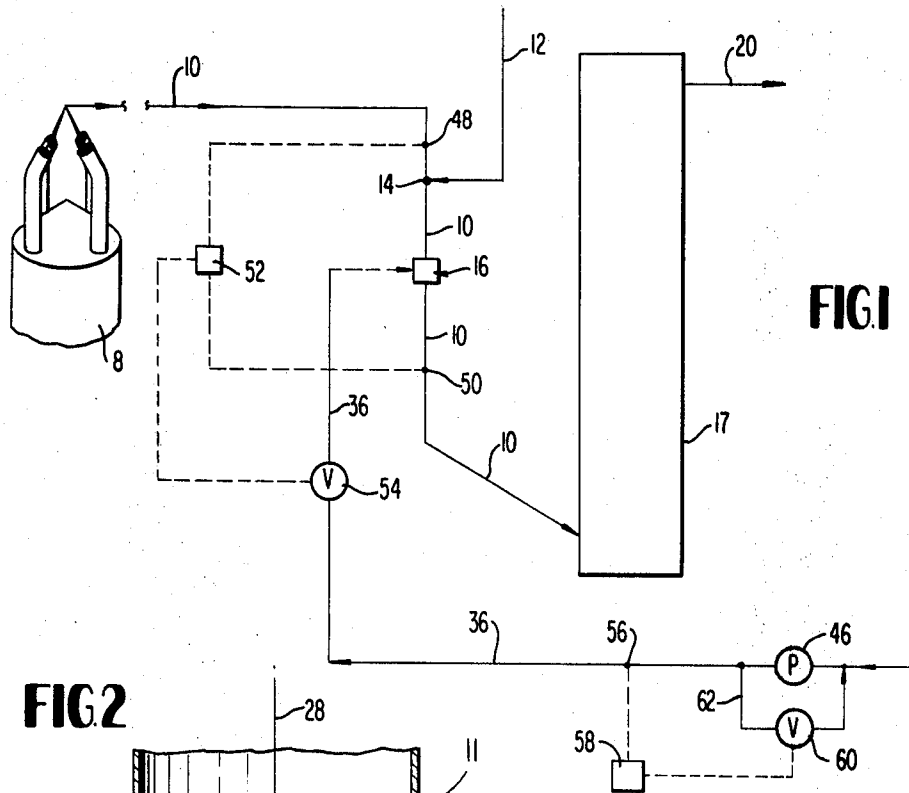


FIG. 1

FIG. 2

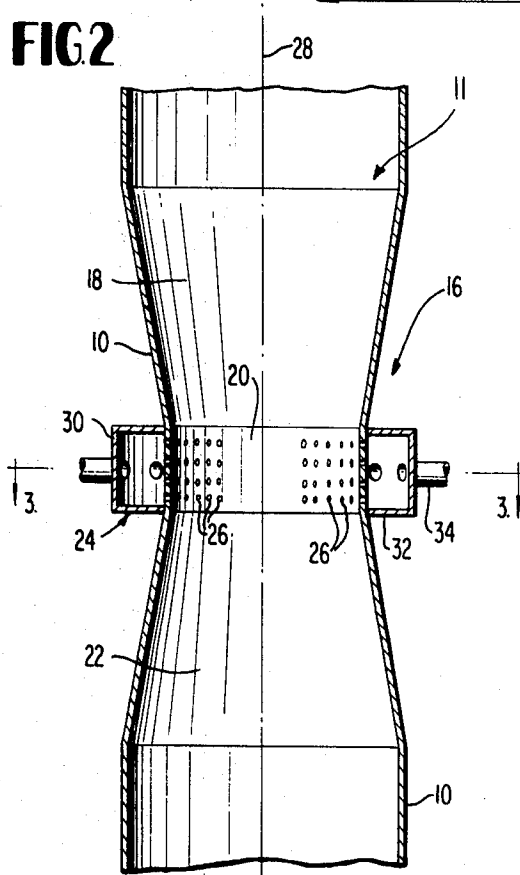
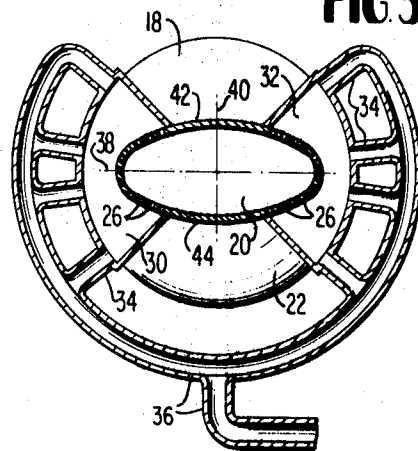


FIG. 3



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FLUID-HANDLING, GAS-SCRUBBING, AND BLAST FURNACE TOP PRESSURE CONTROL

BACKGROUND OF THE INVENTION

This invention relates to fluid-handling systems. In its more particular aspects, the invention pertains to systems for scrubbing gases to remove entrained dust particles.

In operation of venturi scrubbers for dust-laden blast furnace off-gases, the pressure of gases in the scrubbing system is controlled as an expeditious technique for controlling the pressure in the top of the furnace from which the off-gases are withdrawn. For smooth furnace operation, it is desirable to maintain a generally constant top pressure for a given set of operating conditions. Without control, the top pressure fluctuates as a result of changes in burden density and other factors.

To control the pressure of gases in a venturi-scrubbing system, it has been proposed to provide the venturi with walls which are movable to alter the cross-sectional area of the venturi. Adjustment of the venturi area controls pressure in the system, but movable-wall constructions of the prior art are disadvantageous in that moving parts are necessarily exposed to the highly erosive action of the dust-laden blast furnace gases. As a result of erosion, prior art adjustable-area orifices provide constant maintenance problems and have unacceptably short service lives.

Main objects of the invention are to provide improved and simplified fluid-handling, gas-scrubbing and blast furnace top pressure control systems, in which pressure can be effectively controlled and the effective cross-sectional area of a venturi can be adjusted without subjecting moving parts to erosive action of fluids in the system.

Other objects of the invention will appear from the following detailed description which, together with the accompanying drawings, discloses a preferred embodiment of the invention for purposes of illustration.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, similar reference characters denote similar elements throughout the several views, and:

FIG. 1 schematically illustrates a venturi-scrubbing system embodying principles of the invention;

FIG. 2 is a cross-sectional view of the venturi of the system of FIG. 1; and

FIG. 3 is a cross-sectional view on line 3-3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, hot, dust-laden blast furnace effluent gases are withdrawn from the top of an iron blast furnace 8, passed through a conventional dust catcher (not shown) for removal of many of the entrained dust particles, and then passed via conduit 10 through a venturi-scrubbing system constructed and operated in accordance with the invention. Water or other scrubbing liquid is sprayed from pipe 12 into conduit 10 at location 14, in a conventional manner. The blast furnace gases, with entrained scrubbing liquid, are accelerated in a venturi (generally indicated at 16) downstream from the locus of injection of washing liquid. Acceleration of fluid in venturi 16 intimately contacts the dust-laden gases with the scrubbing liquid by atomizing into fine particles the relatively coarse spray particles of scrubbing liquid, so that the gases are effectively cleaned of contaminants. The scrubbed gases then pass into a conventional cooling tower 17 and upwardly through the tower in countercurrent flow with cooling water to emerge clean and cool through conduit 20.

As will be appreciated from FIGS. 2 and 3, the walls of conduit 10 define a fluid passageway 11 which is constricted at venturi 16. The venturi includes a contraction section 18, a throat section 20, and an expansion section 22, as is conventional.

A control fluid injector, generally indicated at 24, is located at throat section 20. Injector 24 includes a plurality of injection apertures 26 formed in the walls of throat 20. As discussed in detail hereinafter, control fluid is injected into

throat 20 to control the pressure of fluid flowing in the passageway by adjusting the effective transverse cross-sectional area of the throat. Apertures 26 direct the control fluid into throat 20 in a transversely inward direction relative to the passageway. Stated differently, the control fluid is directed into the passageway from the walls in the general direction of i.e., toward, longitudinal axis 28 of the passageway.

Control fluid under pressure is supplied to apertures 26 from headers 30, 32 which are located on opposite sides of throat 20. Headers 30, 32 are supplied with control fluid through a plurality of branches 34 of a control fluid supply conduit 36.

Throat 20 has a generally elliptical cross-sectional configuration (FIG. 3), although other than elliptical configurations can be employed. Since the walls of the conduit are fixed in position, throat 20 has a fixed open cross-sectional area. Being elliptical, throat 20 has major and minor axes 38, 40 respectively. Control fluid injection apertures 26 are grouped around those opposed end portions of the throat which lie at the ends of major axis 38. Imperforate wall portions 42, 44 separate the groups of injection apertures. For example, each of the opposed imperforate wall portions 42, 44 can comprise about 20 percent of the throat circumference.

At any given location along its length, the passageway defined by the walls of conduit 10 has an effective cross-sectional area, herein defined as that portion of the transverse cross-sectional area of the passageway through which fluid can flow. The maximum value for the effective cross-sectional area at any given location is the open cross-sectional area of the conduit. The effective cross-sectional area of the passageway is generally constant all along the length of the passageway, except at venturi 16 where the walls of the conduit converge and diverge. At all locations along the passageway the effective cross-sectional area is fixed at the maximum value defined by the open cross-sectional area of the conduit, except in throat 20. In the throat, the cross-sectional area available for fluid flow can be adjusted as desired by adjusting the pressure under which control fluid is injected through apertures 26. The effective cross-sectional area of the throat, before any control fluid is injected, is that of the open cross-sectional area defined by the walls of the throat. However, after injection is initiated, the effective cross-sectional area of the throat is decreased because of resistance to flow provided by the injected control fluid. The extent to which the effective cross-sectional area of the throat is decreased is proportional to the pressure of injection of control fluid. With increasing control jet pressure, throat 20 is progressively choked down, approaching a generally circular configuration because of the location of apertures 26 at the major axis end portions of the throat. The process is reversible, with reduction in control jet pressure increasing the effective orifice cross-sectional area so that the orifice progressively approaches the size and shape of the area defined by the fixed walls of the throat.

Control fluid supplied to injector 24 through conduit 36 is pressurized by pump 46 (FIG. 1). Injector 24, conduit 36 and pump 46 are thus parts of a system by which control fluid is injected into conduit 10 to decrease and increase the effective cross-sectional area of the gas passageway at venturi 16. Control fluid pressure is increased and decreased to decrease and increase the effective cross-sectional area of the passageway at the venturi to maintain a predetermined pressure condition of fluid flowing in the passageway, by an automatic control system. The control system includes pressure sensors 48, 50, which can be of any suitable type of conventional design. For example, a Pneumatic Differential Pressure Transmitter, Series 292, manufactured by Honeywell, Inc. (Industrial Division), Fort Washington, Pa. (hereafter termed "Honeywell"), can be employed. The pressure sensors sense pressure of gases and other fluid in the passageway at locations upstream and downstream, respectively, of venturi 16. The pressure sensors transmit pressures in conduit 10 upstream and downstream of venturi 16 to controller 52, which can be of any suitable type of conventional design. For example, a Honeywell Class 70

Pneumatic Controller can be used. Controller 52 is operatively connected in a conventional manner to a pressure regulating valve 54 and opens and closes the valve to increase and decrease control fluid pressure in conduit 36 downstream of the valve in response to the sensed pressures. Valve 54 can be of any suitable, conventional type, and as an example, can be a Honeywell Cage Type Flow Control Valve.

With pressure sensors 48, 50 transmitting pressures upstream and downstream of venturi 16 to controller 52, the pressure differential across the venturi is constantly monitored and can be maintained at any desired predetermined value set on the controller. For example, if it is desired to maintain a pressure condition in the conduit in which there is a pressure drop of about 30 inches of water across the venturi, this value is set on controller 52. When, because of variation in pressure of the input gases or for any other reason, the pressure drop increases above the desired value, controller 52 responds to the increase as sensed by sensors 48, 50 by progressively closing valve 54 to progressively decrease the control jet pressure, thereby progressively increasing the effective cross-sectional area of throat and progressively decreasing the pressure drop across the venturi back toward the predetermined level. When the predetermined level is attained the controller holds valve 54 in the position then occupied, to maintain the present level.

Conversely, if the pressure drop across the venturi decreases below that desired, controller 52 responds by opening valve 54 to increase the control jet pressure, thereby choking down the effective cross-sectional area of throat 20 and increasing the pressure differential across the venturi back to the predetermined value.

By controlling the pressure differential across venturi 16, the back pressure (i.e., the pressure upstream of the venturi) and thus the furnace top pressure is controlled, because conduit 10 is in open fluid communication with the top region of the furnace. The greater the pressure differential across the venturi, the higher the furnace top pressure. Stated another way, the furnace top pressure is proportional to the pressure drop across the venturi, the exact proportion being determined for any given system by conduit losses and other factors operative between the furnace and the scrubber. Since the walls of throat 20 are fixed, no moving parts are exposed to the erosive action of the dust-laden gases, and effective furnace top pressure control can be exercised by orifice-area control without the disadvantages of prior art variable-area orifices.

By eliminating or otherwise deactivating downstream sensor 50, setting controller 52 to respond only to upstream pressure sensor 48, control fluid pressure can be adjusted to maintain a pressure condition in which the pressure upstream of venturi 16 is held at any desired, predetermined value by adjustment of the effective cross section of throat 20.

For example, if it is desired to maintain a gas pressure of about 90 inches of water in conduit 10 upstream of venturi 16, this value is set on controller 52 and downstream sensor 50 is deactivated (as by venting to atmosphere, in the case of a pneumatic sensor). When upstream sensor 48 detects an increase in pressure above that desired, controller 52 responds by closing valve 54, thereby decreasing control jet pressure and increasing the effective cross-sectional area of throat 20 so that gas pressure in conduit 10 upstream of the venturi decreases toward the desired level. If the upstream pressure decreases below that desired, controller 52 responds to correct the condition by opening valve 54, thereby increasing control jet pressure and decreasing the effective cross-sectional area of the throat so that back pressure upstream of the venturi increases toward the preset value. In this mode of operation, as in the mode employing pressure-drop control, the blast furnace top pressure is controlled by controlling pressure in conduit 10, by virtue of the conduit being in open fluid communication with the blast furnace top region and the top pressure being proportional to the passageway pressure upstream of the venturi.

By deactivating upstream pressure sensor 48 so that controller 52 responds only to the downstream sensor 50, control fluid pressure can be adjusted to maintain a gas pressure condition in which pressure downstream of venturi 16 is held at a predetermined value.

For example, if it is desired to maintain a fluid pressure of about 50 inches of water in conduit 10 downstream of the venturi, this pressure is set on controller 52 and upstream sensor 48 is deactivated. When sensor 50 detects an increase in pressure above the desired value, controller 52 responds by opening valve 54, thereby increasing control jet pressure, decreasing the effective cross-sectional area of the throat 20, and decreasing the downstream pressure towards the preset level. Conversely, if the downstream pressure decreases below the level set on controller 52, the controller responds to the decrease as detected by sensor 50 by closing valve 54, thereby decreasing control jet pressure, increasing the effective cross section of throat 20, and increasing the pressure downstream of the venturi back to the preset level. Since the furnace top region is in open fluid communication with conduit 10 and the furnace top pressure is proportional to the pressure downstream of the venturi, this mode of operation also controls the furnace top pressure.

The volume fluid can be water, clean gas, or any other suitable material. The output of pump 46 is controlled to assure that supply conduit 36 always contains sufficient control fluid volume and pressure upstream of pressure regulating valve 54 to accommodate any demand that may be required on opening valve 54, but without developing an unduly high pressure head against the pump. This is effected through a conventional pressure sensor 56 which detects the pressure in supply conduit 36 upstream of valve 54 and downstream of pump 46. This pressure is transmitted to controller 58, which can be of any suitable type of conventional design, and is operatively connected to position valve 60. When back pressure in conduit 36 exceeds a value necessary for proper operation of injector 24, valve 60 is opened by controller 58 to bleed a portion of the pump output from conduit 36 for recycle through conduit 62. Thus, pressure in conduit 36 upstream of regulating valve 54 is maintained at desired levels by recirculating as much or as little of the pump output as is necessary to maintain the necessary pressure in conduit 36 upstream of valve 54.

Fluid-handling systems embodying principles of the invention are highly advantageous. With such systems, the effective cross-sectional area of fluid passageways can be adjusted for operation at maximum efficiency irrespective of input pressure by a simple system employing no moving parts exposed to the fluid stream. A predetermined pressure drop can be maintained across a constricted orifice, or pressure above or below the orifice can be established at a predetermined value. Control can be exercised over blast furnace top pressure by pressure control in a venturi scrubber without maintenance problems associated with prior art movable-wall, adjustable-area orifices.

Although the invention has been described with reference to a preferred embodiment, modifications of that embodiment can be made without departure from the principles of the invention. Such modifications are within the scope of the invention as defined by the appended claims.

I claim:

1. Fluid handling apparatus, comprising means including walls defining a passageway having an effective cross-sectional area for flow of first fluid, the walls of the passageway being immovable relative to one another, sensing means for sensing pressure of first fluid flowing in the passageway, means including an injector located along the passageway for injecting second fluid into the passageway to decrease and increase the effective cross-sectional area of the passageway at the location of second fluid injection,

the injector including directing means for directing second fluid into the passageway in a direction transverse to the passageway, and
 control means responsive to the sensing means for increasing and decreasing pressure of second fluid to decrease and increase the effective cross-sectional area of the passageway, to maintain a predetermined pressure condition of first fluid flowing in the passageway,
 the passageway including a venturi portion having a contraction section, a throat section, and an expansion section defined by portions of the passageway walls,
 the injector being located at the venturi portion of the passageway,
 the directing means including means defining a plurality of injector apertures in the walls of the passageway in the throat section of the venturi portion,
 the throat section having a fixed cross-sectional area defining a maximum value for the effective cross-sectional area of the passageway in the throat section,
 the fixed cross-sectional area of the throat section having a major axis and a generally elliptical configuration,
 the injector apertures being positioned around opposed major axis end portions of the throat section,
 the walls of the passageway including opposed, imperforate portions between the major axis end portions of the throat section.
 2. Gas-scrubbing apparatus, comprising
 means including walls defining a passageway having a venturi portion and having an effective cross-sectional area for flow of first fluid including gas,
 means for injecting scrubbing liquid into the passageway at a location upstream of the venturi portion,
 the passageway walls at the venturi portion including means for accelerating the first fluid to disperse injected scrubbing liquid into fine particles,
 the venturi portion being characterized by absence of movable walls,
 sensing means for sensing the pressure of the first fluid flowing in the passageway,
 means including an injector located at the venturi portion for injecting second fluid into the passageway to decrease and increase the effective cross-sectional area of the passageway at the venturi portion,
 the injector including directing means for directing the second fluid into the passageway in a direction transverse to the passageway to form a flow-retarding barrier, and
 control means responsive to the sensing means for increasing and decreasing the pressure of the second fluid to decrease and increase the effective cross-sectional area of the passageway to maintain a predetermined pressure condition of the first fluid flowing in the passageway,
 the flow-retarding barrier advancing away from and withdrawing toward the walls of the passageway with the increasing and decreasing pressure of the second fluid.
 3. The apparatus of claim 2,
 the means for injecting second fluid into the passageway to decrease and increase the effective cross-sectional area of the passageway including
 a supply conduit in fluid communication with the injector,
 the control means including
 a pressure regulator in the supply conduit, and
 controller means responsive to the sensing means for operating the pressure regulator to increase and decrease pressure in the supply conduit downstream of the pressure regulator.
 4. The apparatus of claim 2,
 the venturi portion having a contraction section, a throat section, and an expansion section,
 the injector being located at the throat section of the venturi portion.
 5. The apparatus of claim 4,
 the sensing means including a first pressure sensor located upstream of the throat section of the venturi portion and

a second pressure sensor located downstream of the throat section of the venturi portion,
 the control means increasing and decreasing the pressure of second fluid to maintain a predetermined pressure differential in the passageway across the venturi portion.
 6. The apparatus of claim 4,
 the sensing means including a pressure sensor located upstream of the throat section of the venturi portion,
 the control means increasing and decreasing the pressure of second fluid to maintain a predetermined pressure in the passageway upstream of the venturi portion.
 7. The apparatus of claim 4,
 the sensing means including a pressure sensor located downstream of the throat section of the venturi portion,
 the control means increasing and decreasing the pressure of second fluid to maintain a predetermined pressure in the passageway downstream of the venturi portion.
 8. The apparatus of claim 4,
 the directing means including means defining a plurality of injection apertures in the walls of the passageway in the throat section of the venturi portion.
 9. The apparatus of claim 8,
 the throat section having a central axis,
 the injection apertures directing second fluid toward the central axis of the throat section.
 10. Gas-scrubbing process, comprising
 passing first fluid including gas through a passageway having walls and having an effective cross-sectional area for flow of the first fluid,
 the passageway having a venturi portion characterized by absence of movable walls,
 injecting scrubbing liquid into the passageway at a location upstream of the venturi portion,
 accelerating the first fluid in the venturi portion, thereby dispersing injected scrubbing liquid into fine particles,
 sensing the pressure of the first fluid flowing in the passageway,
 injecting second fluid into the passageway at the venturi portion in a direction transverse to the passageway, thereby forming a flow-retarding barrier, and
 automatically increasing and decreasing the pressure of the second fluid in response to the sensed first fluid pressure to advance the barrier away from and withdraw the barrier toward the walls of the passageway, thereby decreasing and increasing the effective cross-sectional area of the passageway to maintain a predetermined pressure condition of the first fluid flowing in the passageway.
 11. The process of claim 10,
 the venturi portion having a contraction section, a throat section and an expansion section,
 the second fluid being injected into the throat section of the venturi portion.
 12. The process of claim 11,
 the pressure of first fluid being sensed at a location upstream of the throat section of the venturi portion and at a location downstream of the throat section of the venturi portion,
 the pressure of second fluid being increased and decreased to maintain a predetermined pressure differential in the passageway across the venturi portion.
 13. The process of claim 11,
 the pressure of first fluid being sensed at a location upstream of the throat section of the venturi portion,
 the pressure of second fluid being increased and decreased to maintain a predetermined pressure in the passageway upstream of the venturi portion.
 14. The process of claim 11,
 the pressure of first fluid being sensed at a location downstream of the throat section of the venturi portion,
 the pressure of second fluid being increased and decreased to maintain a predetermined pressure in the passageway downstream of the venturi portion.
 15. Blast furnace top pressure control and gas-scrubbing process, comprising

withdrawing first fluid including gas from a blast furnace top region,
passing the withdrawn first fluid through a passageway in open fluid communication with the blast furnace top region,
the passageway having walls and having an effective cross-sectional area for flow of the first fluid,
the passageway having a venturi portion characterized by absence of movable walls,
injecting scrubbing liquid into the passageway at a location upstream of the venturi portion,
accelerating the first fluid in the venturi portion, thereby dispersing injected scrubbing liquid into fine particles,
sensing the pressure of the first fluid flowing in the

passageway,
injecting second fluid into the passageway at the venturi portion in a direction transverse to the passageway, thereby forming a flow-retarding barrier, and
automatically increasing and decreasing the pressure of the second fluid in response to the sensed first fluid pressure to advance the barrier away from and withdraw the barrier toward the walls of the passageway, thereby decreasing and increasing the effective cross-sectional area of the passageway to maintain a predetermined pressure condition of the first fluid flowing in the passageway,
thereby maintaining a predetermined pressure in the blast furnace top region.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,582,050

Dated June 1, 1971

Inventor(s) Hiram C. Kozak

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title, delete the hyphens (-) between "Fluid" and "Handling" and between "Gas" and "Scrubbing"

In the first line of the Abstract, omit the hyphen (-) between "Venturi" and "scrubbing"

Column 1, line 1, delete the hyphens (-) between "Fluid" and "Handling" and between "Gas" and "Scrubbing"

Column 1, line 4, delete the hyphen (-) between "fluid" and "handling"

Column 1, line 16, delete the hyphen (-) between "venturi" and "scrubbing"

Column 1, line 27, delete the hyphens (-) between "fluid" and "handling" and between "gas" and "scrubbing"

Column 1, line 41, delete the hyphen (-) between "venturi" and "scrubbing"

Column 1, line 52, delete the hyphen (-) between "venturi" and "scrubbing"

Column 3, line 46, change "disadvantages" to --disadvantage--

Column 4, line 12, delete "the" after "of" and before "throat"

Column 4, line 25, change "volume" to --control--

Column 4, line 46, delete the hyphen (-) between "fluid" and "handling"

Column 5, line 15, change "injector" to --injection--

Column 5, line 22, change "injector" to --injection--

Column 5, line 28, delete the hyphen (-) between "gas" and "scrubbing"

Column 6, line 26, delete the hyphen (-) between "gas" and "scrubbing"

Column 6, line 74, delete the hyphen (-) between "gas" and "scrubbing"

Signed and sealed this 22nd day of February 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents