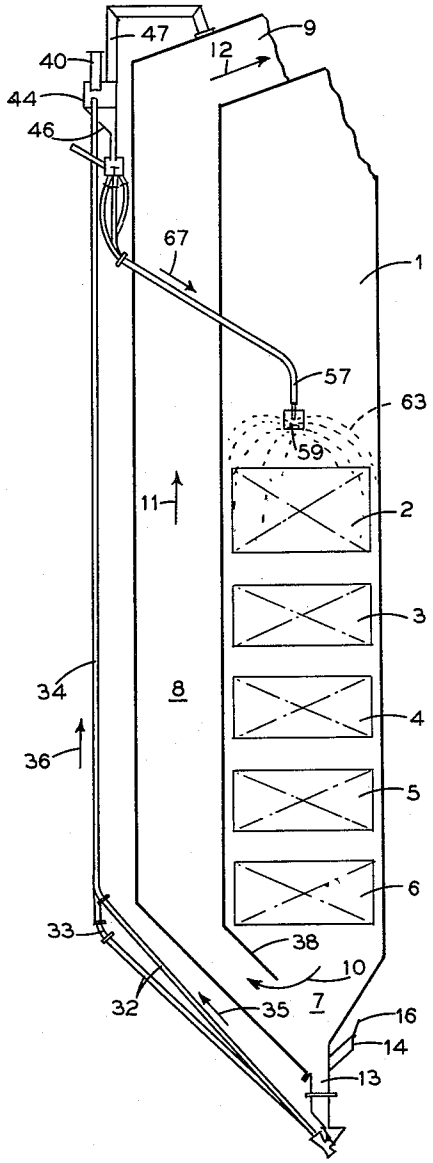
July 25, 1961 W. McCOLL 2,993,681

DENSE FLOW SHOT CLEANING

Filed July 2, 1957 4 Sheets-Sheet 1

FIG. 1



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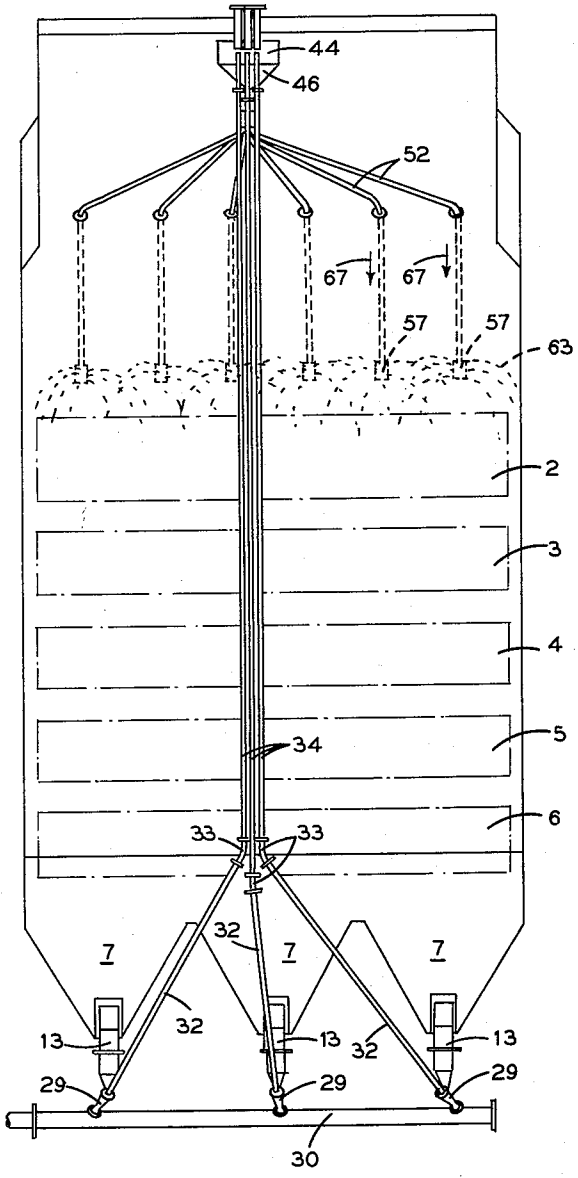
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DENSE FLOW SHOT CLEANING

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FIG. 2



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FIG. 4

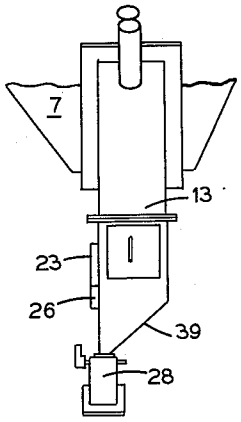
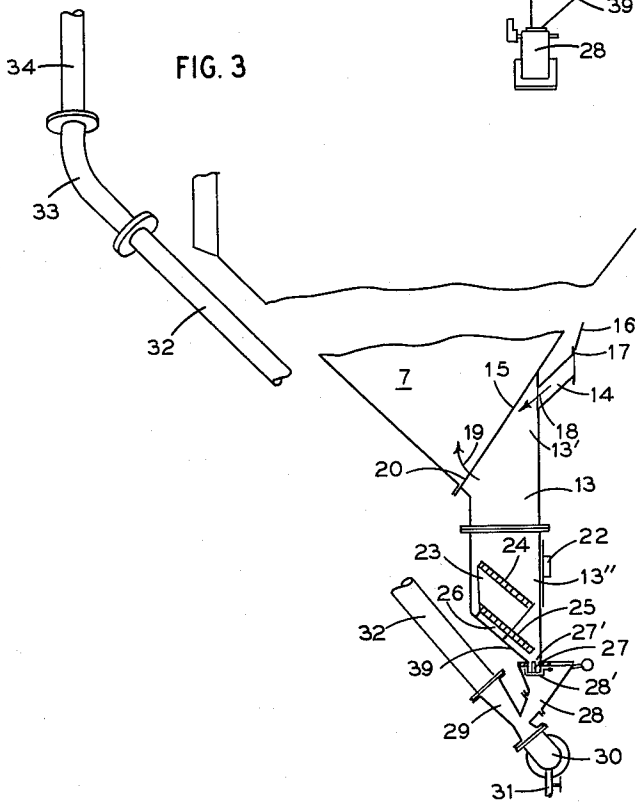


FIG. 3



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FIG. 5

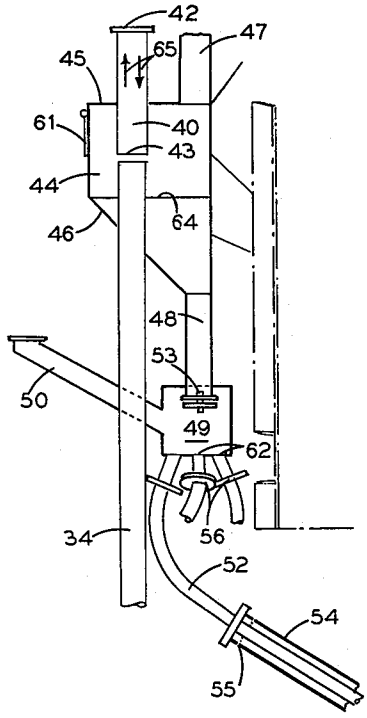
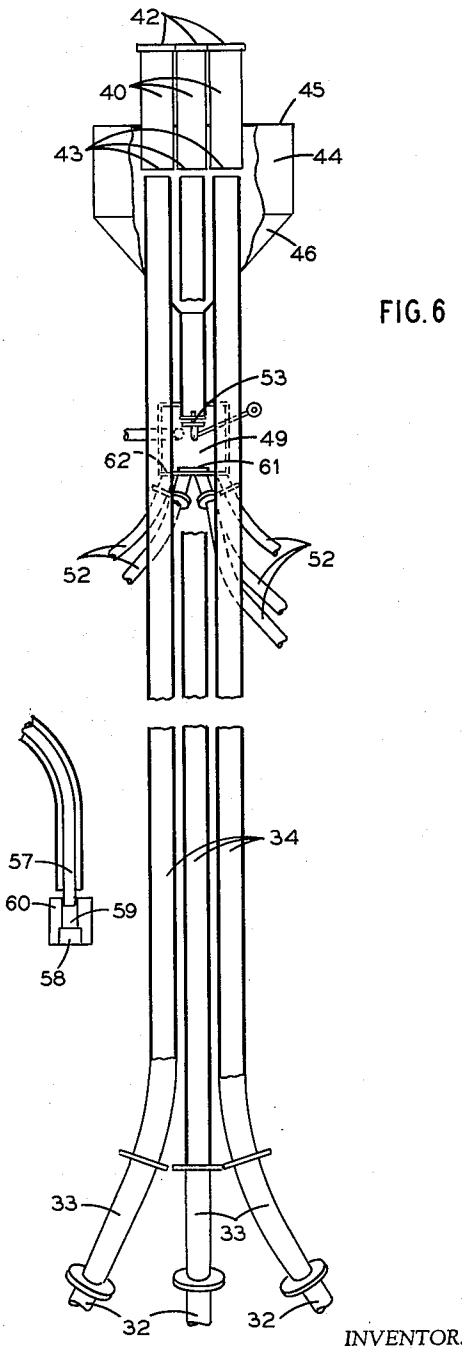


FIG. 6



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United States Patent Office 2,993,681 Patented July 25, 1961

2,993,681

DENSE FLOW SHOT CLEANING

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Claims priority, application Great Britain July 4, 1956
7 Claims. (Cl. 257—1)

This invention relates to a method of and apparatus for cleaning surfaces of heat exchange elements in an upright gas pass. The method to which the invention relates is that in which solid cleaning particles are discharged into a gas pass above the surfaces in the pass to be cleaned. One form of apparatus for carrying out such method is described in British Patent No. 745,556 and includes a plurality of solid cleaning particle scattering means which are spaced from one another and positioned above the heat exchange surfaces in particle distributing relation with respect thereto and each of which includes a deflector and means for directing a stream of particles towards the deflector, collecting means for collecting the particles at a location below the pass and conveying means adapted to convey the particles from the collecting means to an elevation above the scattering means. In the operation of the apparatus the particles during the cleaning period are continuously circulated by pneumatic conveyance from a storage hopper below to a separator and distributor above the pass.

In the practice of the said method various difficulties are liable to arise. For example, when the particles are discharged at the rates normally adopted and dictated by the capacity of the conveying means to circulate the particles or/and by the nature of the scattering means, in the event of the heat exchange surfaces having heavy deposits thereon, then large quantities of particles are liable to be captured by the deposits on the surfaces without effectively cleaning the surfaces, with the result that, as has been found to occur in some installations, the whole charge of particles in the system is liable to disappear and remain in the gas pass. We have discovered that this danger may largely, if not wholly, be avoided by maintaining over a suitable period a much denser discharge of particles than has normally been used.

Another difficulty arises more particularly in connection with gas passes of large cross-sectional area provided below with a plurality of hoppers. When in such a gas pass each hopper has associated therewith conveying means arranged to convey particles to scattering means disposed above the hopper, a drifting of particles from one circulating system to another tends to occur and to give an uneven distribution of particles between the storage means respectively associated with and disposed below the hoppers.

Further difficulties to be feared are wear in certain parts of the conveying means when, as is convenient, pneumatic conveyance of the particles is adopted, and choking of parts of the collecting and conveying means occurs.

The present invention includes the method of cleaning surfaces of heat exchange means in an upright gas pass by discharging solid cleaning particles into the pass above the said surfaces, according to which the particles are elevated by conveying means to storage means to establish a charge of particles in the storage means and particles are discharged from the storage means into the gas pass at a rate much greater than the maximum rate at which the conveying means are able to elevate the particles.

Advantageously, in order to minimize the requisite storage capacity or to enhance the cleaning effect, during the discharge of particles the conveying means are simultaneously operated to elevate particles collected at the bottom of the pass to the storage means.

The invention also includes apparatus for cleaning the surfaces of heat exchange means in an upright gas pass including cleaning particle scattering means positioned above the heat exchange surfaces and adapted to distribute particles in respect thereto, particle collecting means including a plurality of collectors disposed below respective parts of the gas pass and conveying means adapted to convey particles from the collecting means to a common hopper located at an elevation above and arranged to supply particles to the scattering means. With such arrangement the danger of segregation of the available particles in relation to a section or sections of the gas pass is avoided.

The invention furthermore includes apparatus for cleaning the surfaces of heat exchange elements in an upright gas pass including a plurality of solid cleaning particle scattering means which are spaced from one another and positioned above the heat exchange surfaces in particle distributing relation with respect thereto and each of which includes a deflector and means for directing a stream of particles towards the deflector, collecting means for collecting the particles at a location below the pass and conveying means adapted to convey the particles from the collecting means to an elevation above the scattering means, wherein storage hopper means are arranged to receive the particles from the conveying means and to supply under the action of gravity particles with which they are charged to the distributing means and cut-off valve means are provided for permitting or preventing the flow of particles from the hopper means.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

FIGURE 1 is a schematic side view of an arrangement of apparatus for cleaning surfaces of heat exchange means in an upright gas pass;

FIGURE 2 is a schematic end view of the arrangement shown in FIGURE 1;

FIGURE 3 is an enlarged view of part of FIGURE 1 showing cleaning particle collecting and entraining means and part of the conveying means;

FIGURE 4 is an end view of the particle collecting means shown in FIGURE 3;

FIGURE 5 is an enlarged view of part of FIGURE 1 showing a cleaning particle separating means including a storage hopper and leading to particle distributing means; and

FIGURE 6 is an end view of the particle separating means shown in FIGURE 5 with part of the separator casing removed.

In the arrangement of FIGURES 1 and 2 an upright gas pass **1** contains banks **2**, **3**, **4**, **5** and **6** of horizontally extending economizer tubes. The gas pass **1** is of substantial width and is formed at its lower end with three hoppers **7** arranged side by side to provide a bottom to the gas pass. Adjacent the gas pass **1** and extending parallel thereto is a gas outlet pass **8** communicating at its lower end with the economizer pass **1** and leading at its upper end by way of an outlet passage **9** to a stack or draft fan (not shown).

The arrangement is adapted to operate with the flow of hot gases downwardly through the upright pass **1** and over the banks **2** to **6** of economizer tubes, and upwardly through the pass **8** as is shown by the arrows **11** after having turned in a gas turning space above the hoppers **7** as is shown by the arrows **10**. The gases flow from the pass **8** outwardly through the outlet passage **9** as is shown by the arrows **12**.

The wall separating the downflow pass **1** and the upflow pass **8** is provided at its lower end with a downwardly

inclined baffle 38 inwardly extending with respect to the gas pass 1 and helping to prevent the passage of particles with the gases into the pass 8 as is explained hereinafter.

Disposed below the gas pass 1 and cooperating with the lower ends of the hoppers 7 are respective cleaning particle collecting means 13 which are shown more clearly in FIGURES 3 and 4. Thus there are three collector means 13 disposed below respective hoppers of the gas pass 1 which are similarly constructed and arranged. Each collector means 13 comprises a bin including an upper part 13' and a lower part 13", the upper part 13' being closed by a cover plate 15 disposed at such an angle that when the plate 15 is in cooperation with the bottom of the associated hopper 7 the bin of the collector means 13 has an upright position. Each hopper 7 is provided with a restricted particle inlet to the collector means in the form of a slot 20 extending across the width of the associated cover plate 15.

The upper part 13' of each collector means 13 is provided with an associated downwardly inclined inlet passage 14 for the intake of winnowing gas, suitably atmospheric air, under suction. The inlet passage 14 is adjustable by means of a rotatable closure plate 16 pivoted at 17 to control the intake of air therethrough.

The upper part 13' and the lower part 13" of each collecting means 13 are connected by cooperating flanges formed on the respective parts to provide the bin of the collecting means. The lower part 13" has a sloping bottom 39 leading to a cleaning particle outlet at its lower end formed in a corner of the bin. The slope of the bottom 39 is such that in operation cleaning particles flow down the slope to the bottom outlet which is in the form of an outlet spout 27' projecting into the casing of a cut-off valve 28 disposed below the collector means.

Within the bin of the collector means 13 is disposed an inclined screen 25 for the retention of foreign bodies, such as displaced heat exchanger deposits, of relatively large size and the screen is spaced a short distance above the sloping bottom 39 to limit the length of particles or bodies able to pass therethrough. A side by-pass passage 23 leads from an intermediate region of the bin above the screen 25 to an inlet 26 opening to the space between the screen 25 and the bin bottom 39. An auxiliary screen 24 of similar mesh size to the screen 25 is disposed across the inlet to the by-pass passage 23 a short distance from the side thereof in order to limit the length of particles or bodies able to pass therethrough. The lower part 13" of the collector means is provided with an access door 22 covering an access opening sufficiently large to permit removal of the screens 24 and 25.

The cut-off valves 28 respectively disposed below the three collector means 13 are suitably of the nature disclosed in the complete specification of British Patent No. 746,620. Each valve includes a cup-like member 28' mounted on a pivoted arm and having a closed or flow restricting position 28" (shown in broken lines) in which the cup is displaced from the line of discharge of the spout 27' by rotation of the cup 28' about its pivot. The cup 28' is provided with an upstanding poker 27 adapted to enter the spout 27' when the cup is in its closed position.

The casing of each cut-off valve 28 opens at its lower end to associated entraining means comprising a mixing nozzle device 29 for effecting entrainment of cleaning particles in gaseous conveying medium suitably air under pressure supplied to the mixing nozzle 29 through supply conduit 30. The valve casing is formed with a top opening giving access to the valve cup 28' and to the particle inlet to the mixing nozzle device 29. Suitably the top opening is provided in a horizontal cover plate of the valve disposed at a level above the valve cup 28' so that such access enables attention to be given to the valve and affords means for clearing any obstruction at the inlet aperture of the nozzle device 29 even when the particle level in the bin of the collector means 13 is above the level of the screens 24 and 25.

As is shown in FIGURES 2 and 3, there are three mixing nozzles 29 supplied with air under pressure by a conduit 30 suitably provided at lowermost points below the respective mixing nozzle 29 with drain plugs 31 for the removal of stray cleaning particles from the air supply conduit.

Each nozzle device 29 is in the form of a venturi with the inlet from the associated cut-off valve located at the venturi throat. Each nozzle device 29 is upwardly inclined towards its discharge end and arranged to discharge entrained cleaning particles into associated conveying means including a straight length of pipe 32 extending parallel or substantially parallel to a sloping side of the associated hopper 7. The pipes 32 are respectively joined by readily replaceable pipe bends 33 to upright pipe lengths 34 leading upwardly to separating means including a cleaning particle separating chamber 44 providing a common storage hopper, as is shown most clearly in FIGURES 5 and 6. Thus conveying means extend with a single bend from a particle receiving point at the venturi throat adjacent the collecting means 13 to the storage hopper and separating chamber 44. The provision of a single bend in each conveying means restricts most of the wear due to the conveyance of entrained cleaning particles to a single part of the pipe which is readily replaceable.

Separating means including a separating chamber 44 as shown in FIGURES 5 and 6 and described below, form part of the subject matter of a copending application, Serial No. 671,178, filed July 11, 1957, now Patent No. 2,954,843, granted October 4, 1960. Suitably the separating chamber 44 is disposed adjacent a main gallery and includes a storage hopper provided by a hopper bottom 46 to the chamber. The hopper bottom 46 is formed with a downwardly directed particle outlet 48 provided at its lower end with a shut-off valve 53 so that the hopper bottom serves as a storage chamber for cleaning particles which may be discharged downwardly therefrom by opening the valve 53. The separating chamber is provided in a side wall with a hinged door 61 giving access to the separating chamber.

The separating chamber 44 is provided with a roof 45 formed with impact means comprising particle receiving pockets 40 associated with the conveying means from the mixing nozzles 29 and closed at their upper ends by impact plates 42. Thus there are provided three upright pockets 40 extending partly above and partly below the roof 45 and open at their lower or inlet ends 43. The pockets 40 are co-axially arranged with respect to the associated upright ducts 34 of the conveying means, which extend upwardly through the floor 48 of the chamber 44 with their upper ends disposed above the floor and spaced from the associated pocket inlets 43.

Adjacent the pockets 40 in the roof 45 of the separating chamber 44 is formed an opening for the discharge of conveying medium from the chamber. The opening is connected to an outlet duct 47 extending at first upwardly and parallel or substantially parallel to the pockets 40 and communicating at its end remote from the separating chamber 44 with the gas outflow passage 9 from the gas pass 8, shown in FIGURE 1. The outlet duct 47 is arranged to discharge downwardly into the passage 9 immediately above the pass 8.

The single storage hopper provided by the separating chamber 44 is arranged to discharge to a distributor from which respective tubes for the conveyance of cleaning particles under gravity lead to scattering means. Thus below the outlet 48 from the separating chamber 44 is disposed distributing means comprising a distributing chamber 49 in which is located a cut-off valve 53 for controlling the flow of cleaning particles under gravity from the hopper bottom of the separating chamber 44 into the distributing chamber.

Suitably the cut-off valve 53 is of the nature disclosed in British Patent No. 745,620 and is power operated and remotely controlled with its movable valve member be-

ing gravity biased to a closed or flow restricting position. Formed in the bottom of the chamber of the distributing means 49 immediately below the outlet 48 from the separating chamber 44 and its associated cut-off valve 53 is an impact plate 61 providing a horizontal or substantially horizontal impact surface. A downwardly directed duct 50 providing a particle inlet chute closed at its upper end by a hinged closure member 51 extends from a side wall of the distributing chamber 49 and communicates at its lower end therewith.

Symmetrically disposed around the impact plate 61 and opposed to the cleaning particle outlet 41 from the separating chamber are a plurality of outlets for the conveyance of cleaning particles to scattering means. Thus, there are six outlets 62 respectively communicating with downwardly directed discharge tubes 52 by way of flanged connections 56. Below the flanged connections 56 the pipes 52 are bent inwardly towards the gas pass 1 and pass in downwardly inclined manner across the upflow pass 8 into the gas pass 1 where they are directed vertically or substantially vertically downwardly. The lower or discharge ends 57 of the tubes 52 are disposed at intervals across the gas pass 1 as shown in FIGURE 2 and are provided with respective scattering means 59. The scattering means 59 are suitably of the nature disclosed in British Patent No. 745,556 and each includes stationary deflector means 58 supported by and spaced from the outlet end 57 of the associated tube 52 by spacers 60. Thus the ends of the tubes 52 provide upright spouts for directing cleaning particles downwardly onto the associated impact or deflector plates 59 which are adapted to effect scattering of the cleaning particles. Suitably the impact or deflector plates 59 of the scattering means are so designed and spaced that the regions served by adjacent scattering means overlap, and the scattering means are suitably spaced a short distance above the uppermost tube row of the top economizer tube bank 2.

The tubes 52 are provided throughout their lengths, which extend through the gas upflow pass 8 and the downflow pass 1, with protective jackets. Thus each tube 52 is provided with a co-axial jacket or sheath tube 54 of larger internal diameter than the external diameter of the tubes 52. At its outer end the jacket tubes 54 extend outside of the gas pass 8 and are fastened to the associated tubes 52 as is shown most clearly in FIGURE 5. A plurality of circumferentially distributed inlet openings 55 are formed in the outer end of each of the tubes 54 outside the gas pass 8 and communicating with the atmosphere. The inner ends of the jacket tubes 54 are open to the gas pass 1 immediately above the associated scattering means 59 so that in operation owing to the gases flowing in the pass 1 being below atmospheric pressure, suction within the gas pass induces a flow of cooling air through the jackets 54 by way of the associated openings 55 and sufficient flow of air is maintained to protect the tubes 52 from overheating.

In service, when a cleaning operation is to be initiated, the storage hopper of the separating means 44 will normally be fully charged with the level 64 of cleaning particles just below the upper or outlet ends of the upright conveying pipe lengths 34. After a fan for supplying conveying air through the conduit 30 to the mixing nozzles 29 has been started, the cut-off valves 28 at the outlets 27' from the collector means 13 are opened so that any dust or cleaning particles collected in the collector means 13 since the last cleaning operation are conveyed to the separating chamber 44 where the cleaning particles are retained and the air and dust are discharged through the outlet duct 47 into the outlet passage 9. At this stage the power operated remotely controlled cut-off valve 53 is opened and the charge of cleaning particles in the storage hopper 44 begins to flow under the action of gravity and in substantially unimpeded manner by way of the distributing means to the six scattering means 59 disposed above the economizer tube banks 2 to 6.

Within the distributing chamber 49 the falling cleaning particles impinge upon the impact plate 61 where they are scattered sidewardly and pass under the action of gravity downwardly through the outlets 62 to the conveying tubes 52 as shown in FIGURES 1 and 2 by the arrows 67. The cleaning particles fall through the tubes 52 and are discharged through the upright discharge spouts which form the ends of these tubes onto the deflector 58 of the scattering means 59 where they are scattered substantially uniformly across the gas pass 1 as shown by the broken lines 63. Deposits on the tubes of the economizer banks 2 to 6 are dislodged by the cleaning particles and fall with the cleaning particles to the hoppers 7 forming the bottom of the gas pass 1. Cleaning particles falling in the pass 1 adjacent the pass 8 are directed towards the hoppers 7 by the inwardly inclined baffle 38. The baffle 38 also deflects the flow of gases towards the hoppers 7 before the gases can pass to the gas pass 8 and consequently the turning of the gases around the lower edge of the baffle 38 effects the separation of cleaning particles from the gas stream.

The cleaning particles pass through the restricted particle outlets 20 at the bottoms of the respective hoppers 7 and downwardly through the collector means 13. Owing to the pressure of the gases in the gas pass 1 being below atmospheric, air is drawn upwardly through the restricted particle outlet in opposition to the downward cleaning particle flow as is shown in FIGURE 1 by the arrows 19 by way of the adjustable air intake 14 as shown by the arrow 18 and exerts a winnowing effect on the cleaning particles tending to prevent the entry of dust and small particles of deposit into the collector means 13. In the collector means 13 the cleaning particles continue downwardly through the main screens 25 or auxiliary screens 24 where large bodies or fragments of deposit too long to enter the mixing nozzles 29 are retained, to the bottom outlet 27. From the bottom outlets 27 the cleaning particles pass through the casings of the associated cut-off valve 28 to the corresponding mixing means 29 for entrainment in the gaseous conveying medium.

With the arrangement of collector means 13 and cut-off valve 28 disclosed, in the event of the main screen 25 becoming choked, cleaning particles will pass by way of the by-pass 23 and auxiliary screen 24 to the bottom outlet 27'. In the event of the outlet 27' becoming choked, it may be cleared by means of the poker 27 through oscillation of the pivoted arm supporting the cup-like member 28.

After being entrained in gaseous carrier medium the cleaning particles are conveyed upwardly through the tubes 32 and 34 as shown in FIGURES 1 and 2 by the arrows 35 and 36 and are discharged from the upper ends of the tubes 34 into the separating chamber 44. The cleaning particles are directed from the tubes 34 into the associated pockets 40 towards the impact plates 42 where some of the cleaning particles rebound into the oncoming stream. As is shown by the arrows 65, the particle flow is reversed and the cleaning particles fall to the sloping floor 46 of the separating chamber 44 where they are stored, building up to the level 64 just below the uppermost parts of the tubes 34 within the separating chamber.

The conveying air undergoes a double flow reversal within the separating chamber 44 and is discharged upwardly so that cleaning particles do not tend to be carried away in the gas stream through the passage 47. The conveying medium is discharged downwardly from the passage 47 into the gas pass 8 so that any particles retained in the gas stream tend to fall through the pass 8 and are retained in the system.

During the cleaning operation, the conveying means are maintained in operation so that the length of the cleaning operation may, if desired, be prolonged by the

return of cleaning particles accumulating at the collector means **13** to the separating chamber **44**. Termination of the cleaning operation is effected by closure of the power operating cut-off valve **53** and the operation of the conveying means is continued until the storage hopper of the separating chamber has been recharged when the supply of conveying medium to the mixing nozzles **27** is ceased and the cut-off valves **28** are closed.

The rate of discharge of the scattering means **59** is independent of the rate at which the conveying means are capable of returning particles collected at the bottom of the pass and the rate of discharge is very much greater than would be practicable in a system depending upon continuous circulation of the particles. Consequently the much denser discharge reduces the tendency for cleaning particles to be lost by adherence to the deposits on the tubes and effective dislodgement of deposits is more easily obtained. By way of example, the storage hopper may contain a charge of two tons of particles, suitably in the form of steel shot or pellets, which are discharged at a flow rate of approximately 45,000 pounds per hour and distributed to six scattering means each adapted to distribute the particles over a circle at the top tube row of the uppermost tube bank having a diameter of 10 feet.

Furthermore, the arrangement disclosed permits the replenishment of cleaning particles to the system at a single location, suitably at the distributing means **53** by way of the chute **50**. The use of a single hopper feeding distributor means permits the maintenance of a uniform rate of discharge of cleaning particles from the various scattering means and the drifting of particles within the gas pass from one recirculation system to another is avoided. A uniform distribution of cleaning particles across the gas pass occurs and consequently a uniform cleaning effect is obtained.

It has been found that with such method of operation, the cleaning effect is highly effective and the risk of loss of particles is avoided. It is thought that the action may depend partly upon the cleaning action of material dislodged from the tubes, dislodgment being ensured by the denseness of the particle discharge and also partly by the increased flow rate and turbulence within the tube bank created by the flow, not only of the gases but also of the particles and the dislodged material. However this may be, an efficient and reliable cleaning action is ensured.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. Apparatus for cleaning the surfaces of heat exchange elements in an upright gas-pass including a plurality of solid cleaning particle scattering means spaced from one another and positioned above the heat exchange elements in particle distributing relation with respect thereto, a plurality of collecting means for collecting the particles at a position below said gas pass, separate fluid lift means for conveying said particles from each of the collecting means to an elevation above said scattering means, a common storage hopper means arranged to receive the particles from the conveying means, separating means in the upper portion of said hopper means for separating the particles from the conveying fluid and discharging the separated particles into the lower portion of said hopper, a conduit connecting said hopper means and each of said scattering means for gravitational movement of particles therethrough, and means for controlling flow of particles from said hopper means.

2. Apparatus as claimed in claim 1 wherein the hopper means comprise a single hopper arranged to discharge to a distributor from which respective tubes for the conveyance of particles lead to the scattering means.

3. Apparatus as claimed in claim 2, wherein the distributor includes a chamber in which is located a cut-off valve for regulating the flow of particles from the hopper into the chamber.

4. Apparatus as claimed in claim 1, wherein the separating means for separating particles from the gaseous conveying medium discharge through each fluid lift means are disposed within the storage hopper means.

5. Apparatus as claimed in claim 4, wherein a duct for the discharge of separated gaseous conveying medium from the separating means in said hopper discharges downwardly into a space from which particles may fall to said collecting means and which is in communication with an induced draft.

6. Apparatus as claimed in claim 1, wherein each of said fluid lift means includes an upwardly inclined venturi section having a conveying fluid inlet, and means for introducing cleaning particles into said venturi section.

7. Apparatus as claimed in claim 1, wherein each of said collecting means has a bottom outlet for cleaning particles; a spout opening from said outlet and projecting into the casing of a cut-off valve, said cut-off valve including a cup-like member mounted on a pivoted arm to engage the end of said spout in closing relationship therewith.

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