

Feb. 9, 1960

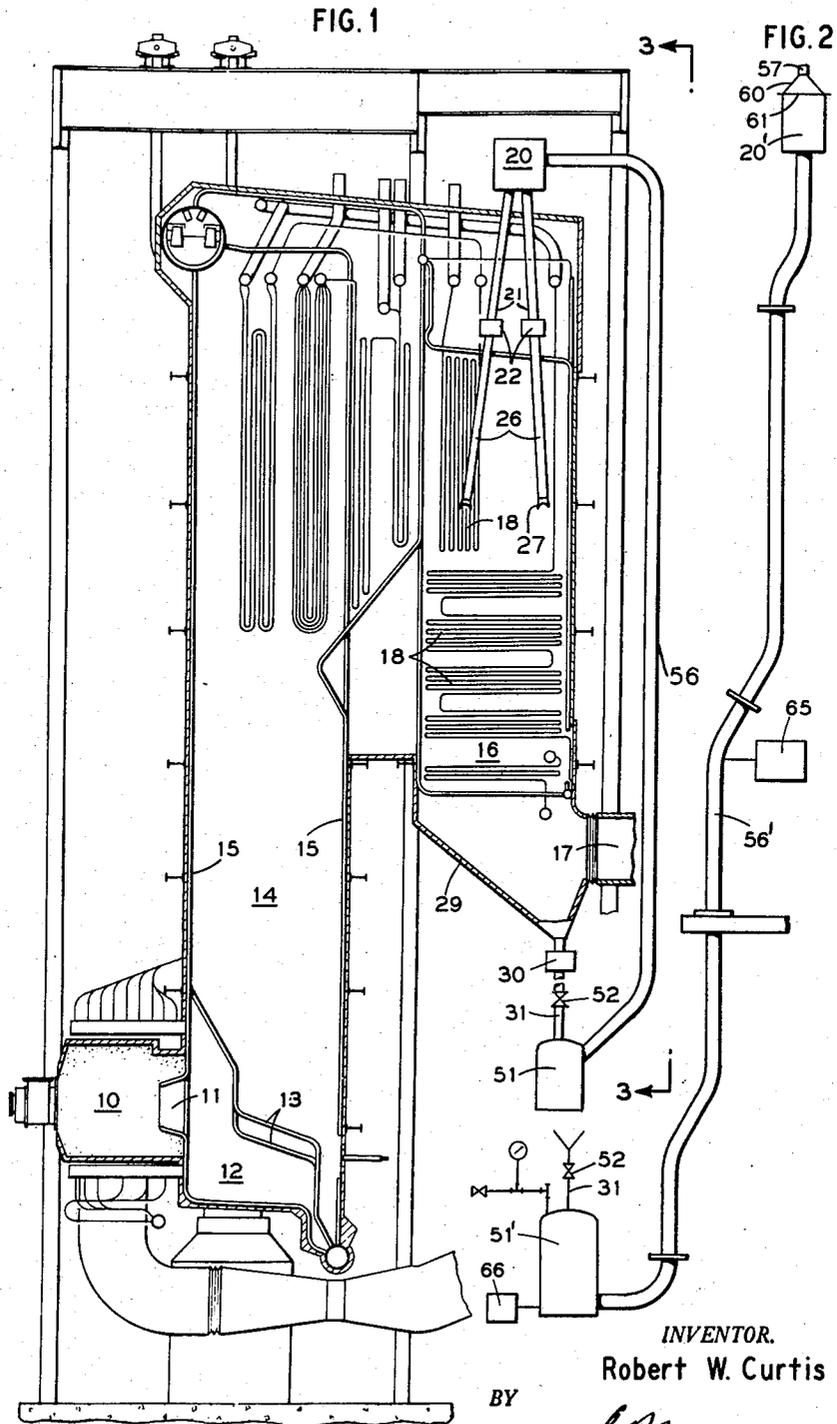
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2,924,435

APPARATUS FOR CLEANING GAS-SWEPT HEATING SURFACES

Filed Feb. 15, 1956

4 Sheets-Sheet 1



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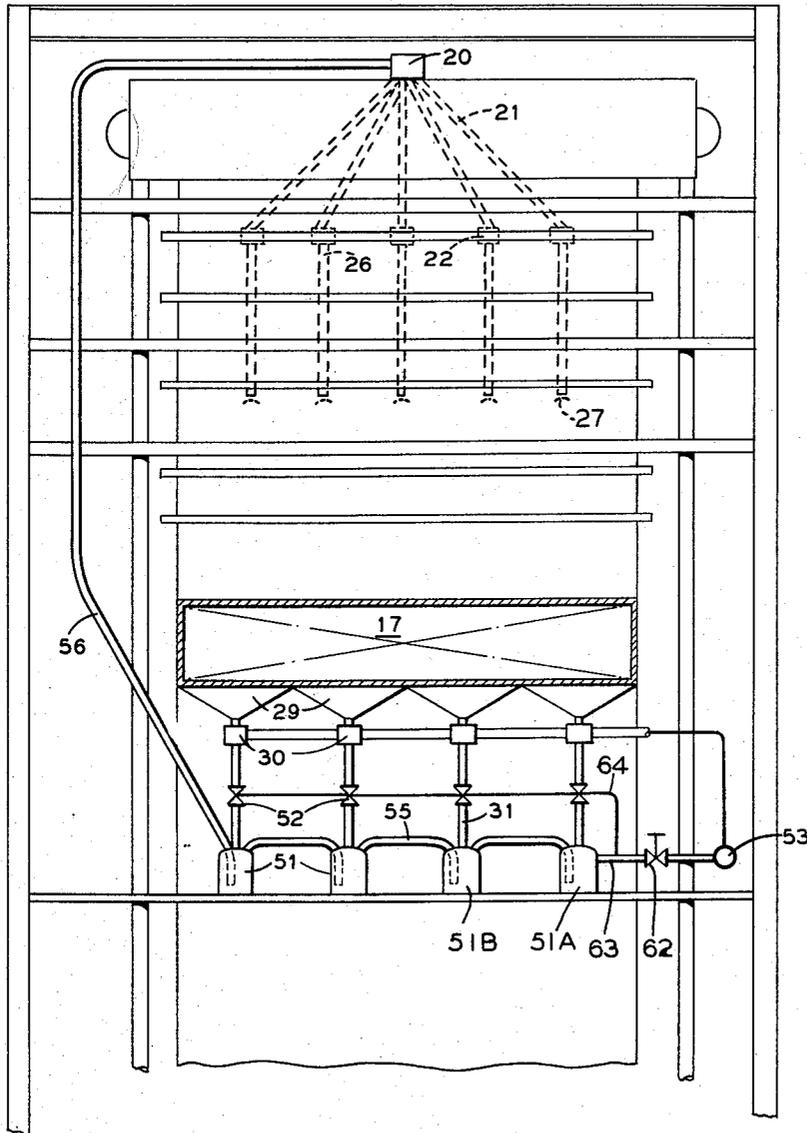
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FIG. 3



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FIG. 4

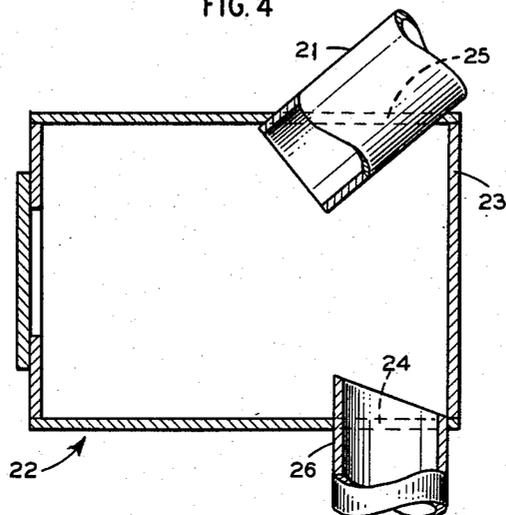
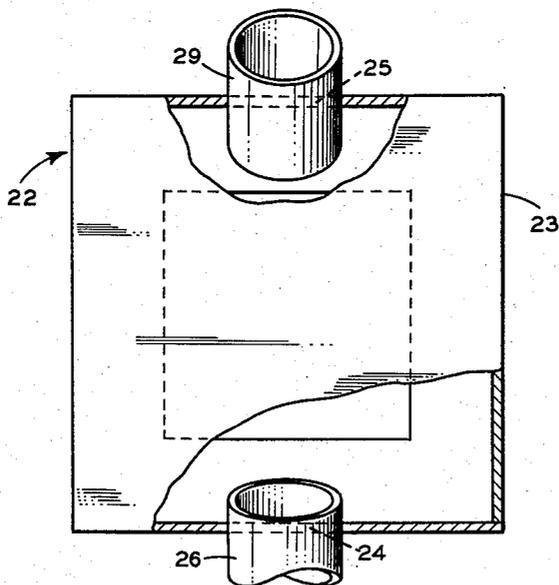


FIG. 5



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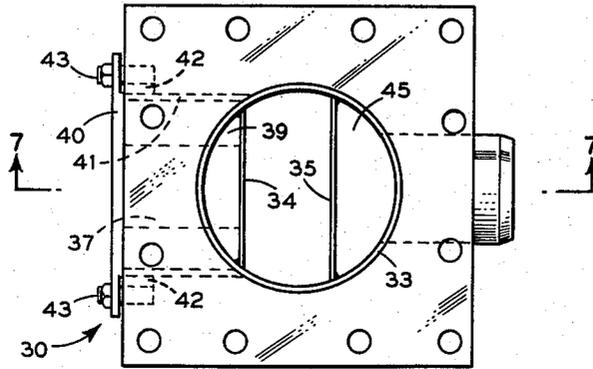


FIG. 6

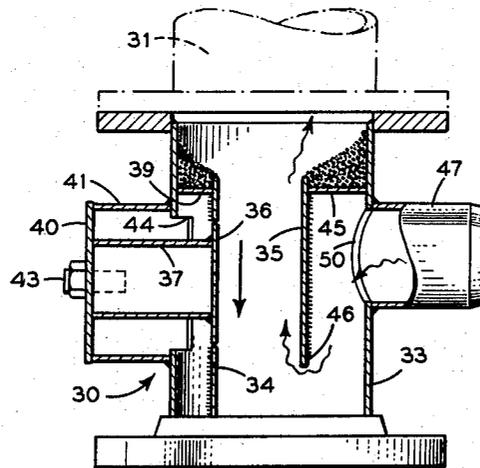


FIG. 7

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APPARATUS FOR CLEANING GAS-SWEPT HEATING SURFACES

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Application February 15, 1956, Serial No. 565,576

4 Claims. (Cl. 257—1)

The present invention relates to the cleaning of heat exchange surfaces, and more particularly to apparatus for cleaning gas-swept heat exchange surfaces by cascading solid materials downwardly over the surfaces, while the unit is in operation.

In heat exchange apparatus such as, for example, vapor generating units fired by ash containing fuel, it has been customary to utilize high pressure blowers to remove the dust accumulations from the gas-swept surfaces of the heat exchange elements. In recent years, cleaning of the surface has been accomplished by the use of shot, or other solid particle form materials, which is cascaded downwardly over the heat exchange surfaces with the impingement of the shot on the surfaces removing the dust accumulations. In shot cleaning systems, the shot is recycled and periodically introduced into the upper portion of the housing enclosing the heat exchange elements so that the shot is distributed over the entire cross-sectional area of the heating gas pass. Customarily, the gravitational movement of the shot is concurrent with the movement of the heating gases over the heat exchange elements of the unit, although countercurrent or transverse gas flow may be used. Since shot may have an erosive effect on the heat exchange elements if the impact velocity of the shot is excessive, it is desirable to provide means for maintaining the initial velocity of the shot to a minimum value in initially contacting the heat exchange elements. It is also desirable to separate the dislodged dust and ash from the shot before the shot is returned to the heat exchange elements for cleaning purposes.

In accordance with my present invention, I provide one or more shot arresters which are located upwardly adjacent the uppermost row of heat exchange elements in the unit to be cleaned. The shot arrester reduces the velocity of the shot contacting the elements of the heat exchanger and avoids erosion thereof. After the shot has passed through the heat exchange elements of the unit, and has dislodged dust or deposits accumulated on those surfaces, the foreign matter is separated from the shot by the use of high velocity gaseous flows so that the dust and ash will be entrained in the gases leaving the heat exchange unit. The shot thereafter passes downwardly to a group of collecting tanks positioned below the heat exchanger. In returning the shot to the upper portion of the heat exchange unit, I utilize a carrier medium, such as air for example, which is passed through the shot collecting tanks in series with the shot from all of the tanks passed upwardly through a single conduit or pipe to a storage reservoir positioned above the unit. The carrier medium is delivered at high pressure and in relatively low volume so that the movement of shot upwardly through the conduit is relatively slow with the erosion of the conduit and of the shot particles established and maintained at a minimum. After delivery to the reservoir, the shot and carrier medium is separated with the shot stored in the reservoir and the carrier medium discharged to the atmosphere, or alternately discharged into the heat exchange unit.

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The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:

Fig. 1 is a side elevation, in section, of a steam generating and superheating installation incorporating the present invention;

Fig. 2 is an outline elevation of an alternate arrangement of conveying apparatus;

Fig. 3 is an elevation of the apparatus taken on the line 3—3 of Fig. 1;

Fig. 4 is an enlarged end elevation, in section, of a portion of the apparatus shown in Fig. 3;

Fig. 5 is a side elevation of the apparatus shown in Fig. 4;

Fig. 6 is an enlarged plan of another portion of the apparatus shown in Fig. 1; and

Fig. 7 is an elevation, partly in section, taken on the line 7—7 of Fig. 6.

In the embodiment of the invention shown in the drawings, a shot cleaning installation constructed and arranged according to the invention is applied to a vapor generating and superheating unit of the general type disclosed in U.S. Patent 2,687,708. As shown in Fig. 1, the vapor generating unit is supplied with heating gases resulting from the combustion of granular solid fuel. The solid fuel is burned in a cyclone type furnace 10 with the gases discharging from the throat 11 of the cyclone into a primary furnace 12. Combustion of the fuel is substantially completed within the cyclone furnace 10 and the hot gases are partially cooled by the water cooled surfaces in the boundary walls of the primary furnace 12. The partially cooled hot gases of combustion pass upwardly through a bank of spaced tubes 13 into an upwardly elongated secondary furnace 14 where the gases are further cooled by heat exchange with fluid cooled tubes 15 in the walls of the secondary furnace.

Thereafter, the gases of combustion leave the upper end portion of the upwardly elongated furnace 14 to reverse their direction of flow and to move downwardly across convection heat exchange surfaces positioned in a vertically elongated convection gas pass 16. Leaving the lower portion of the convection gas pass 16 the hot combustion products are discharged through a gas outlet 17 to a tubular air heater or the like and thence discharge to the atmosphere through a stack (not shown).

While the hot products of combustion leaving the cyclone furnace 10 are largely free of entrained non-combustible materials, the entrained solids in the gases may be in a sticky state and are apt to be deposited on any cooling surfaces they may encounter. The bank of tubes 13 positioned across the lower portion of the furnace 14 and the tubes 15 in the furnace generally cools the combustion gases below the temperature at which the non-combustible solids therein are molten, or in a sticky form. Thus, the gases turning into the convection gas-pass 16 will contain a relatively minor amount of generally dry suspended solid materials. However, the suspended solids will have a tendency to deposit on the convection heating surfaces in the convection gas-pass, such as on the banks of superheating and economizer tubes indicated generally at 18 and it is desirable to maintain these surfaces as clean as possible for high heat transfer rates between the heating gases and the fluid within the tubes, as well as to maintain draft losses at a low value.

As illustrated in the drawings, a shot cleaning system

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is installed in the convection gas-pass 16 of the vapor generating and superheating unit. The shot may consist of substantially any solid granular material of regular or irregular shape capable of withstanding the temperature shock and erosive conditions encountered in the service indicated. Steel particles in the form of spheres or cylinders of $\frac{1}{8}$ to $\frac{1}{4}$ inch dimensions has proven satisfactory in actual service. As shown the system consists of an upper storage reservoir 20 from which the shot gravitates through a plurality of downwardly extending tubes 21. The lower ends of the distributing tubes 21 are provided with shot arresters 22 which reduce the downward component of motion of the shot, at the level of the arresters. As shown particularly in Figs. 4 and 5, each arrester comprises a container 23 which may be of cylindrical or polygonal horizontal section having a lower shot discharge outlet 24 and an upper shot inlet 25. The inlet 25 and outlet 24 are positioned in the top and bottom, respectively, of the container and are so related that the shot discharging through the distributing pipe 21 will substantially come to rest within the container 23, before discharging through the shot outlet 24.

Leaving the arrester body, the shot overflows through the outlet 24 and moves by gravity through a generally vertical section of pipe 26 to encounter a distribution head 27 at the lower end of the pipe. The distributor head may be of hemispherical configuration, for example, with the shot falling thereon discharged outwardly to cascade downwardly over and against the tubular surfaces of the convection heating banks 18 of the unit. The number, surface configuration and position of the distributor heads is determined by the cross-sectional dimensions of the convection gas pass 16 and the distributor heads are constructed and arranged in their assembled position so as to distribute the shot substantially throughout the cross-sectional area of the gas pass.

The cascading action of the shot impacting the heat exchange surfaces 18 in the convection gas pass 16 removes the ash deposited on the surfaces, with the shot and dislodged ash falling downwardly to the lower portion thereof. A row of spaced hoppers 29 are positioned across the bottom of the gas pass 16, downwardly adjacent the gas outlet 17 through which the gases and entrained ash passes toward the atmosphere. The change in the direction of flow of the combustion gases in moving through the gas outlet 17 from the gas pass 16 separates the shot from the gases, so that the shot continues downwardly into the hoppers. The smaller particles of the dislodged ash will generally follow the movement of the gases while the larger particles of dislodged ash will fall to the hoppers 29 with the shot.

As hereinafter described, the shot is conveyed to the top of the unit for reuse as a heat exchanger cleaning medium. According to the invention the shot conveying is accomplished by a fluent lift mechanism of the "dense phase" type wherein a low volume of the fluent conveying medium, at a relatively high pressure, moves the shot through a pipe as a substantially solid mass having substantially the same density as an equal volume of the shot without the conveying medium. In such a lift system, it has been found desirable to remove the dust and ash particles from the mass of shot before the shot is subjected to the action of the conveying fluid.

The separation of foreign particle material, such as ash, from the shot is accomplished in a elutriator 30 such as shown in Figs. 6 and 7. The finer particles of dust dislodged from the banks of the economizer are entrained with the gases of combustion leaving the unit through the outlet 17 while the larger particles, which are of a high density, will be separated from the gases of combustion and tend to follow the shot into the hoppers 29 at the bottom of the unit. The elutriator

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shown in Figs. 6 and 7 is constructed from a short length of pipe 33 of the same diameter as the pipe 31 leading from the hoppers 29 to the tanks 32 positioned immediately below the hoppers. The pipe length 33 is provided with a pair of horizontally spaced upright plate members 34 and 35 which form therebetween a shot flow path having a considerably reduced cross-sectional area when compared with the cross-section area of the pipe 31. The plate wall 34 extends substantially the full length of the pipe section 33 and is provided with a horizontally disposed upper plate 39 which is welded between the interior wall of the pipe 33 and the plate 34 to form an upper closure on the exterior side of the plate 34. The sides of the plate 34 are longitudinally welded to the side wall of the pipe 33. A portion 36 of the plate 34 is cut out and welded to a horizontally extending pipe 37. The outer end of the horizontally disposed pipe 37 is provided with an overhanging plate 40 which lies in a plane normal to the axis of the pipe 37 and engages a horizontally arranged pipe 41 of increased diameter which is welded to the exterior side of the pipe length 33. The outer end portion of the pipe 41 is provided with shoulders 42 to which the plate 40 is attached by bolts 43. Necessarily, a section of the pipe 33 is removed, as at 44, so that when the bolted connection to the shoulders 42 is disengaged, the plate 36 may be removed for access to the interior of the elutriator 30.

The opposite plate 35 is likewise provided with a horizontally disposed upper plate 45 which is welded to the surface of the pipe 33 and to the outer side of the plate 35. The lower end 46 of the plate 35 is spaced above the lower end of the pipe length 33, as shown in Fig. 7. A pipe nipple 47 is welded to the pipe 33 to enclose an opening 50 and form an inlet for elutriating air which is positioned immediately below the lower edge of the horizontally disposed plate 45.

In operation, the elutriator is provided with a flow of compressed air or other pressure fluid so that the velocity of the air passing up between the spaced plates 35 and 36 is sufficient to entrain relatively large particles of dust dislodged from the heat exchange elements 18 without entraining the shot. Thus, the shot discharging downwardly from the elutriator 30 will be substantially clean, and when delivered to the conveying mechanism will not interfere with the transportation thereof.

The shot receiving tanks 51 are each equipped with a check valve 52 positioned in the discharge pipe 31 which are actuated to a closed position by the delivery of high pressure air to the tank from a high pressure air source, such as a conduit 53. As soon as compressed air, or other pressure fluid, is delivered to the tank 51 by opening the valve 62 in the connecting pipe 63 some of the air passes to a power piston associated with each of the check valves 52 through a connecting pipe 64. All of the check valves 52 are closed so that the high pressure air entering the tanks 51 does not discharge upwardly through the conduits 31 but is effective in transporting the shot from the tanks. The check valves 52 are disclosed and claimed in a copending application of Lloyd W. Yoder, Serial Number 568,613, filed February 29, 1956.

With the check valves 52 closed the compressed air enters the tank 51A and moves the shot in the tank through the connecting pipe 55 to the tank 51B from which the accumulated shot passes through the connecting pipe to the next tank in series flow. The inlet end of each connecting pipe 55 opens into its respective tank at a position adjacent the bottom of the tank, while the discharge end of the pipes 55 open to the upper end portion of the adjacent tank 51. The tank 51 furtherest removed from the air inlet connection is provided with a lift pipe 56, the lower end of which opens to the tank adjacent the bottom thereof while the upper end opens

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to the reservoir 20. The pipe 56 may have a number of bends therein such as shown at 56' in Fig. 2, depending upon the layout of the steam generating and super-heating unit. The pipe 56 discharges into the reservoir 20 where the conveying fluid is separated from the shot and the fluid thereafter vented to the atmosphere through a vent pipe 57 as shown in Fig. 2; or, as shown in Fig. 1, the carrier air from the conveying system may be vented through the pipes 21 to the gas pass 16.

The reservoir 20 illustrated in the drawings consists of a cylindrical or polygonal vessel of considerably greater cross-sectional area than the diameter of the pipe 56 or 56' connected thereto. The pipe 56 or 56' may terminate at the bottom of the reservoir 20 or may extend upwardly into the reservoir. The type of construction will determine whether or not the discharge end of the pipe is submerged in shot. Either form of construction is satisfactory for the purposes of the shot conveying system illustrated. The reservoir 20 may have sufficient volume to store all of the shot such as indicated at 20' in Fig. 2, or the shot may be stored in the tanks 51 and delivered to the reservoir 20 substantially as needed for cleaning purposes, as indicated at 20 in Figs. 1 and 3.

As shown in Fig. 2, the upper end portion of the shot reservoir 20 may be provided with a frusto-conical cone section 60 which is supplied with a screen 61 extending across the entire cross-section of the reservoir. The upper end of the cone 60 is provided with a carrier fluid outlet opening for the discharge of the separated carrier fluid through the vent 57. The screen is used to prevent discharge of shot through the carrier medium outlet during periods when a surge occurs in the transport line.

In the arrangements illustrated, the shot cleaning equipment is intended for periodic operation. For example, the shot may be discharged across the heat exchange surfaces of the unit for a period of, for example, 5 or 10 minutes during each hour. The frequency of operation of shot cleaning equipment is dependent upon the operating characteristics of the particular unit in which the cleaning system is installed. For example, when handling an extremely dirty fuel it may be necessary to operate the shot cleaning apparatus as frequently as 3 or 4 times during each hour. With an intermittent type of operation, a charge of shot may be delivered to the reservoir 20 or 20' at the top of the unit and the entire charge cascaded over the heat exchange surface. The shot gravitates downwardly until all of it has accumulated in the shot receiving tanks 51 at the bottom of the installation. The shot may then return to the reservoir 20' until the next cycle of shot cleaning is desired.

As an illustration of the operation of the shot cleaning apparatus, let it be assumed that a complete charge of shot for each cleaning cycle amounts to one ton. After cascading through the gas pass, the shot will accumulate in the shot receiving tanks 51. Compressed air, at a pressure of from 75 to 150 pounds per square inch and in a volume of from 100 to 300 cubic feet per minute is delivered to the shot receiving tanks. The admission of compressed air to the tanks 51 will close the check valves 52, and the shot will move in series through each of the tanks and the transport pipe 56 to the reservoir 20. With a 3" diameter shot transport pipe, the shot will be transported from the tanks 51 to the reservoir 20 in a matter of 1 or 2 minutes. During transportation of the shot, the shot conveying pipe 56 will be filled with the shot which has a transport density substantially equal to the static density of the shot without the addition of the transporting air. In this type of shot transportation equipment the mass of shot moves upwardly substantially as a solid mass and at a slow rate with minimum wear on the walls of the confining transport line, and on the shot.

It has been found that the pressure of the conveying fluid delivered to the transport system through the con-

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duit 63 can be substantially reduced by the use of vibrators attached to the tanks 51 and/or to the conveying pipe 56 or 56'. The vibrators may be of the electric or mechanically actuated type, and are illustrated at 65 and 66 in Fig. 2. Since the conveyance of the particle material through the pipe 56 or 56' occurs by the movement of particles in contact with adjoining particles, as caused by high pressure fluid flow through the pipe, the use of mechanical vibrations overcomes some of the particle inertia and reduces the fluid pressure required to cause the particle movement through the pipe.

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 gas swept heat exchange surfaces comprising walls defining an enclosure having gas inlet and outlet means in the walls thereof, heat exchange means disposed within said enclosure, a storage reservoir for shot positioned above said enclosure, means for introducing shot into the upper portion of said enclosure including a stationary distributor directly above said heat exchange surfaces for gravitational movement of the shot downwardly in impinging relationship with said heat exchange surfaces, including a reservoir, an arrestor and a distributor interconnected by lengths of pipe for gravitational movement of solid particle material therethrough, the pipe length between said arrestor and said distributor being selected for a predetermined striking velocity of said materials upon said distributor the movement of said shot through said enclosure dislodging materials deposited upon said heat exchange surfaces with the finer portions of said removed materials passing with the gases through said gas outlet means, means for separating the larger particles of said dislodged materials from said shot in the lower portion of said enclosure, means for collecting said shot in a plurality of containers positioned below said enclosure, and means for moving said shot from said containers to said storage reservoir including pipes connecting said containers in series, a pipe connecting one of said containers with said storage reservoir, a check valve in the shot inlet end of each of said containers, a source of high pressure fluid, and a valved pipe connecting said fluid source with one of said containers whereby the shot is moved by said fluid serially through said containers and pipes to said reservoir.

2. Apparatus for cleaning gas swept heat exchange surfaces comprising walls defining an enclosure having gas inlet and outlet means in the walls thereof, heat exchange means disposed within said enclosure, a storage reservoir for shot positioned above said enclosure, means for introducing shot into the upper portion of said enclosure including a stationary distributor directly above said heat exchange surfaces for gravitational movement of the shot downwardly in impinging relationship with said heat exchange surfaces, including a reservoir, an arrestor and a distributor interconnected by lengths of pipe for gravitational movement of solid particle material therethrough, the pipe length between said arrestor and said distributor being selected for a predetermined striking velocity of said materials upon said distributor the movement of said shot through said enclosure dislodging materials deposited upon said heat exchange surfaces with the finer portions of said removed materials passing with the gases through said gas outlet means, means for separating the larger particles of said dislodged materials from said shot in the lower portion of said enclosure including an unobstructed elutriator having a reduced cross-section area,

gaseous fluid inlet means opening to said elutriator for high velocity flow therethrough to entrain said larger particles and to discharge same into the gas stream passing through said enclosure gas outlet, means for collecting said shot in a plurality of containers positioned below said enclosure, and means for moving said shot from said containers to said storage reservoir including pipe means connecting said containers in series, a pipe connecting one of said containers with said reservoir, a check valve in the shot inlet end of each of said containers, a source of high pressure fluid, and a valved pipe connecting said fluid source with one of said containers whereby the shot is moved by said fluid serially through said containers and pipes to said reservoir.

3. Apparatus for cleaning gas swept heat exchange surfaces comprising walls defining an enclosure having gas inlet and outlet means in the walls thereof, heat exchange means disposed within said enclosure, a storage reservoir for shot positioned above said enclosure, means for introducing shot into the upper portion of said enclosure including a stationary distributor directly above said heat exchange surfaces for gravitational movement of the shot downwardly in impinging relationship with said heat exchange surfaces, including a reservoir, an arrestor and a distributor interconnected by lengths of pipe for gravitational movement of solid particle material therethrough, the pipe length between said arrestor and said distributor being selected for a predetermined striking velocity of said materials upon said distributor the movement of said shot through said enclosure dislodging materials deposited upon said heat exchange surfaces with the finer portions of said removed materials passing with the gases through said gas outlet means, means for separating the larger particles of said dislodged materials from said shot in the lower portion of said enclosure including an unobstructed elutriator having a reduced cross-section area, gaseous fluid inlet means opening to said elutriator for high velocity flow therethrough to entrain said larger particles and to discharge same into the gas stream

passing through said enclosure gas outlet, means for collecting said shot in a plurality of containers positioned below said enclosure, and means for moving said shot from said containers to said storage reservoir including pipe means connecting said containers in series, a pipe connecting one of said containers with said reservoir, means for vibrating said pipe, a check valve in the shot inlet end of each of said containers, a source of high pressure fluid, and a valved pipe connecting said fluid source with one of said containers whereby the shot is moved by said fluid serially through said containers and pipes to said reservoir.

4. Apparatus for transporting recirculated solid particle materials comprising at least one tank container, a conduit opening to said container for the gravitational movement of said solid particle material to said container, check valve means in said conduit, a reservoir spaced at a level above said container, a pipe connecting said reservoir with said container, external means for vibrating said pipe, a source of super atmospheric pressure fluid, a valved pipe connecting said fluid source with said container for series flow of fluid and solid particle materials through said container and upwardly as a substantially solid mass through said pipe to said reservoir and means for random gravitational movement of said solid particle materials to said container from said reservoir.

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