April 28, 1964 W. McCOLL 3,130,778

SHOT CLEANING SYSTEMS FOR HEAT EXCHANGERS

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FIG. 1

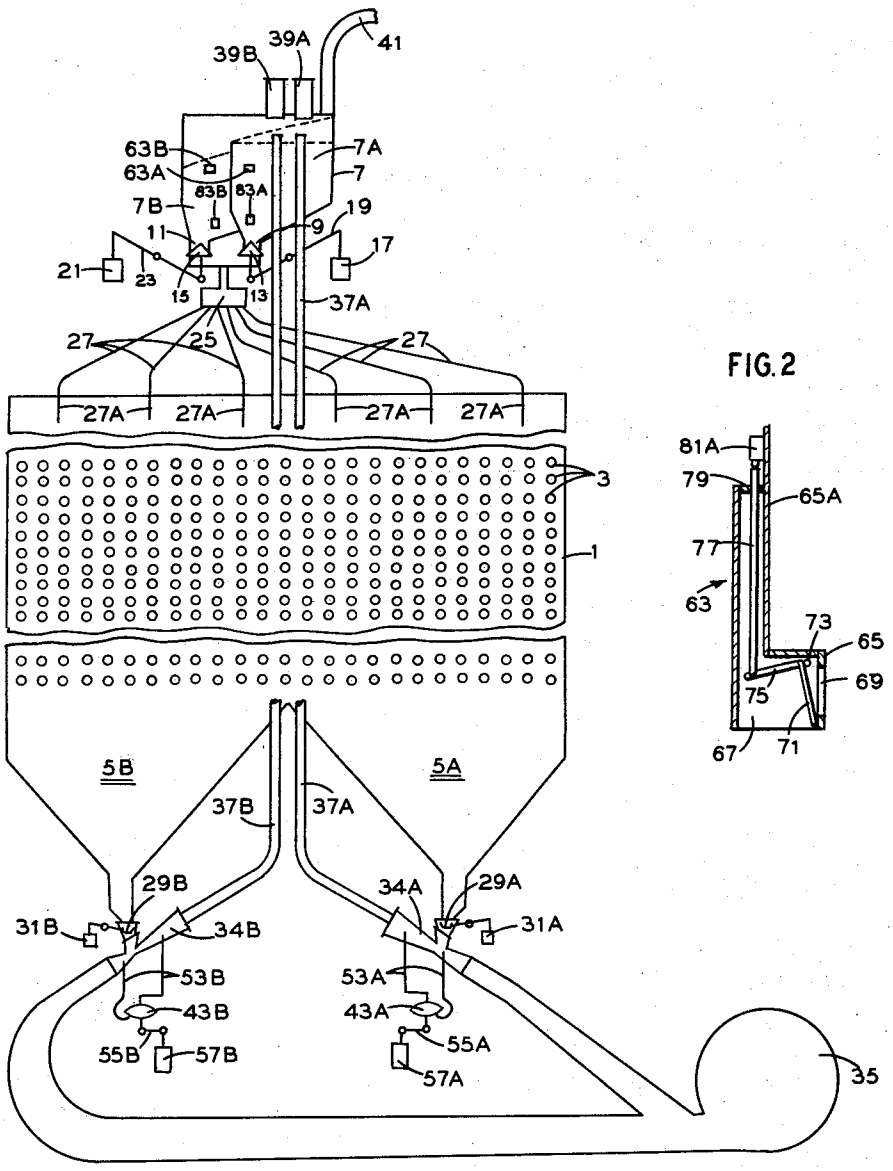


FIG. 2

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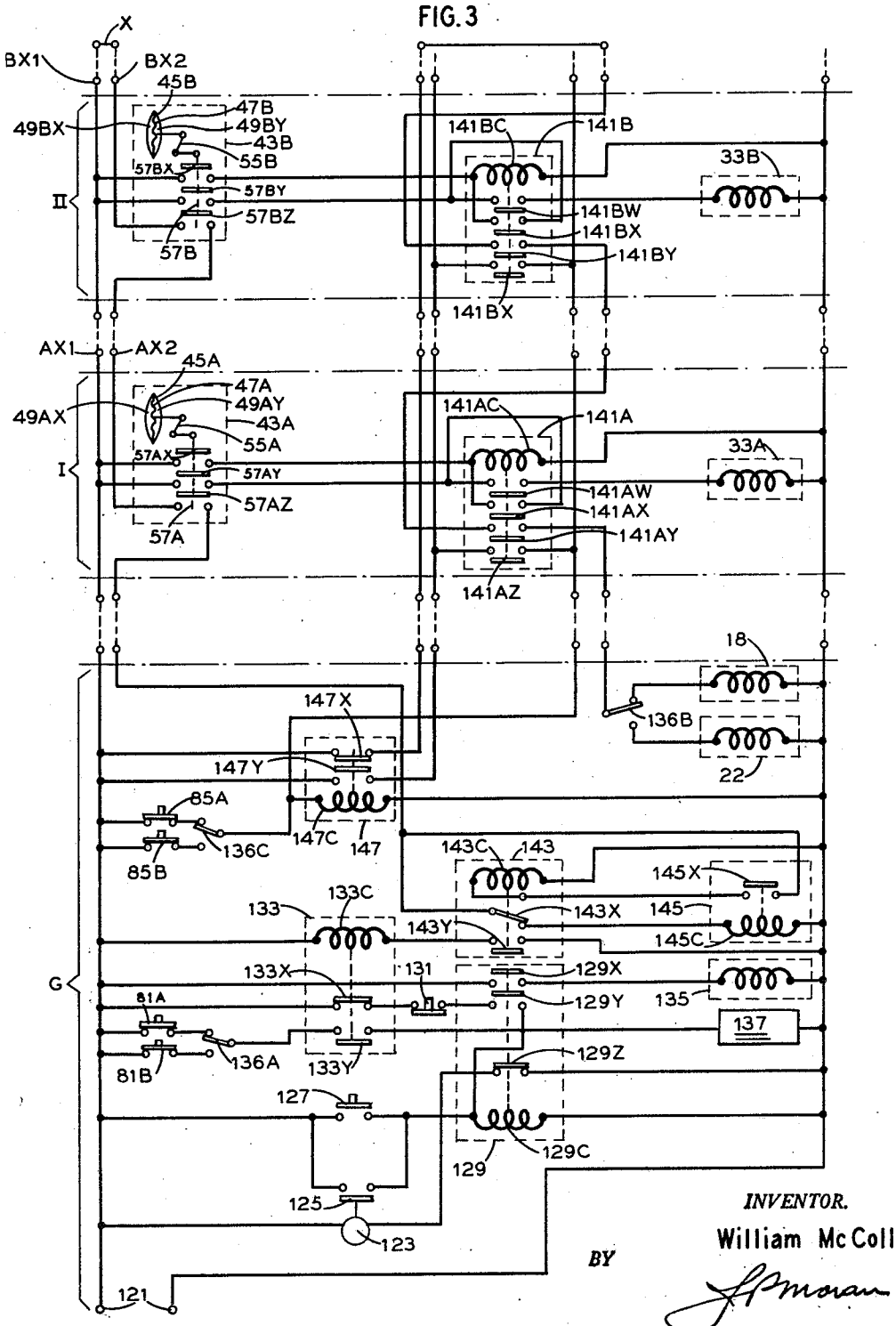
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FIG. 3



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SHOT CLEANING SYSTEMS FOR HEAT EXCHANGERS

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11 Claims. (Cl. 165—11)

This invention relates to shot cleaning systems for heat exchangers of the kind in which shot, commonly in the form of cleaning particles of steel, is discharged from a recovery hopper above the heat exchanger surfaces to be cleaned and the shot, having passed downwardly over the surfaces, is collected for return to the recovery hopper.

Conveniently, pneumatic handling means can be provided for carrying the collected shot to the recovery hopper, in which case it is desirable that the cleaning cycle should be initiated only when the handling means are in a condition to handle the shot and the discharge of shot should immediately be discontinued in the event of the handling means becoming ineffective. Moreover, when the collected shot has been delivered to the recovery hopper, the handling means should be shut down.

In such a system, if the surfaces to be cleaned are allowed to become unduly foul, the shot tends to become trapped during its downward passage through the gas pass containing the heat exchanger and indeed it is possible for the whole of a normal charge of shot to be lost in this way, in which case the gas pass holds not only the deposits which should have been removed from the heat exchanger surfaces but also the charge which should have removed the deposits. Furthermore, the medium for removing the deposits is no longer available for use. It is important to guard against this eventuality. It is also important in order to maintain the effectiveness of the heat exchange surfaces to operate the shot cleaning system at sufficiently short intervals of time.

The invention includes a shot cleaning system for a heat exchanger having recovery hopper means above the surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned and handling means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to a condition in the handling means and arranged when the shot collected in the collecting hopper means has been returned by the handling means to the recovery hopper means, to effect operation of control means automatically to stop the operation of the handling means, means sensitive to the presence of shot at a selected high level in the recovery hopper means, and precautionary means arranged automatically to exert a signal should the operation of the handling means be discontinued when shot is not present at the selected high level.

The invention also includes a shot cleaning system for a heat exchanger having recovery hopper means above the surfaces to be cleaned, a first automatically controlled valve for controlling the discharge of shot from the hopper means onto the surfaces to be cleaned, collecting hopper means below the surfaces to be cleaned, pneumatic handling means for returning shot collected in the collecting hopper means to the recovery hopper means, a second automatically controlled valve for controlling the discharge of shot from the collecting hopper means to the pneumatic handling means and pressure sensitive means responsive to pressure conditions in the pneumatic handling means and adapted to distinguish between the condition when the handling means are free from shot, the

condition when the handling means are conveying shot and the condition when the handling means are overloaded with shot and to exert control such that opening of the first valve will occur only when the handling means are free or substantially free of shot and closure of the second valve will automatically occur if during conveyance of shot the handling means become overloaded.

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

FIG. 1 is a sectional elevation, partly broken away and not to scale, through an upright gas pass containing a tubulous heat exchanger, and parts of a shot cleaning system associated with that heat exchanger;

FIG. 2 is a sectional side elevation through a level sensitive switch device shown in FIG. 1; and

FIG. 3 is an electrical circuit diagram of control means for the shot cleaning system indicated in FIG. 1.

An upright gas downpass **1**, of considerable vertical extent, contains a bank of heat exchange tube lengths **3** which extend horizontally across the gas pass and are connected in known manner at their ends to form sinuous tubes of an economizer of a steam generator. The uppermost horizontal row of tube lengths is spaced from the top of the gas pass and the lowermost horizontal row of tube lengths is spaced a short distance from a lower part of the gas pass, which is so formed as to provide two collecting hoppers **5A** and **5B**.

Above the gas pass **1** is arranged a recovery hopper system **7** comprising a main shot hopper **7A** and a reserve shot hopper **7B**. The hoppers are provided at their lower ends wtih outlets **9** and **11** respectively and these outlets are provided with conical valves **13** and **15** respectively. Valve **13** is movable between open and closed positions by a pneumatic cylinder **17** controlled by a solenoid valve operator **18** (see FIGURE 3) arranged to effect opening and closure of the valves associated with the pneumatic cylinder, and the cylinder is coupled to the valve **13** through a linkage **19**. Valve **15** is similarly movable by a pneumatic cylinder **21** associated with a solenoid valve operator **22** and is coupled to the valve through a linkage **23**. Both outlets **9** and **11** communicate with a distributor **25** from which extend six discharge ducts **27** having their outlet ends **27A** suitably distributed over the whole cross-sectional area of the upper part of the gas pass **1**.

The two collecting hoppers **5A**, **5B** are provided with automatically controlled valves **29A**, **29B** respectively, for controlling the discharge of shot from the hopper. Valves **29A**, **29B** are cup valves actuated by pneumatic cylinders **31A**, **31B** controlled respectively by solenoid valve operators **33A**, **33B** (see FIGURE 3) arranged to effect opening and closure of valves associated with the pneumatic cylinders.

Disposed immediately below the valve **29A** is a Venturi nozzle type pneumatic handling device **34A** having its inlet end connected to a fan **35** driven by an electric motor (not shown), the outlet from the collecting hopper **5A** discharging into the narrow part of the Venturi nozzle, and the outlet end of the nozzle is connected by an uptake duct **37A** to a separator **39A** arranged to separate entraining air from the shot and to return the shot to the hopper **7A**. The separator **39A** is in the form of a short upright tube with a closed upper end. Air and entrained shot enter the separator from the duct **37A**, their upward movement is arrested by the closed upper end and they are discharged downwardly. The shot enters the hopper **7A** and the air escapes laterally. In a similar manner a pneumatic handling device **34B** is disposed immediately below the valve **29B**, and has its inlet end connected to the fan **35** and its outlet end connected by an uptake duct **37B** to a separator **39B** arranged to return separated

shot to the hopper 7A. The hoppers 7A and 7B are so arranged that the returned shot first fills the hopper 7A and then spills over into the other hopper 7B. An outlet duct 41 is connected to the enclosed upper ends of the hoppers 7A and 7B and communicates with a gas flue leading from the lower end of the pass 3.

Associated with the pneumatic handling device 34A is a pressure sensitive device 43A of the type having a casing 45A (see FIGURE 3) divided by a flexible diaphragm 47A into two chambers 49AX and 49AY which are connected respectively by pipes 53A to the Venturi nozzle on opposite sides of the throat. The center of the diaphragm is coupled by a suitable mechanical linkage 55A to a switch device 57A having three electrical switches 57AX, 57AY and 57AZ. The mechanical linkage 55A is arranged to close all three switches 57AX, 57AY and 57AZ upon the occurrence of the pressure drop in excess of a predetermined value across the narrow part of the Venturi nozzle, but to permit the switches 57AX and 57AZ to open upon the pressure drop falling to a second, lower predetermined value. At still lower pressure drops including zero pressure drop all three switches are open.

Associated with the pneumatic handling device 34B is a similar pressure sensitive device 43B having a casing 45B divided by a diaphragm 47B into two chambers 49BX and 49BY connected respectively by pipes 53B to the Venturi nozzle. A linkage 55B couples the diaphragm to a switch device 57B having three electrical switches 57BX, 57BY and 57BZ. These switches are actuated in a manner similar to the switches 57AX, 57BY and 57BZ respectively.

Associated with the hopper 7A is a high level responsive device 63A including (see FIGURE 2) a sheet metal casing 65 forming an open-bottomed chamber 67, one side of the casing being formed with an aperture 69. Inside the chamber 67 is located a flap 71 mounted on a pivot 73 and provided with a lever arm 75 extending across the chamber and coupled to an upright rod 77. The rod 77 extends upwardly through a tubular extension 65A of the casing 65 and is guided in a cross-member 79 mounted at the upper end of the extension. The combined weight of the rod 77 and the lever arm 75 is sufficient to tilt the flap from the vertical to the position shown in FIGURE 2, in which its lower edge butts against the casing 65 adjacent the aperture 69. When the flap is in this position, the upper end of the rod 77 is positioned a short distance below the plunger of an electric switch 81A the contacts on which are spring biased to the closed position. The casing 65 is disposed in the hopper 7 with the aperture at a level at which the presence of shot is to be detected. When shot is heaped up over the lower part of the casing 65, some of it enters the aperture 69 and, by pressing upon the flap 71, turns that flap on its pivot 73 to raise the rod 77 and so open the switch 81A. When shot subsequently falls away from the level of the casing, any shot inside the chamber 67 also falls away and the flap 71 is free to return to the position shown in FIGURE 2, so that the switch 81A recloses.

A similar high level responsive device 63B is provided in the hopper 7B and includes a switch 81B, and similar low level responsive devices 83A and 83B are provided at low levels in these two hoppers 7A and 7B respectively and are provided with switches 85A and 85B respectively.

In the arrangement shown in FIGURE 1, two collecting hoppers 5A and 5B are provided, and in any installation the number of collecting hoppers to be provided at the bottom of the gas pass is determined by the width of the gas pass and by the height available for the provision of the hoppers and the subjacent pneumatic handling device or devices. The number of collecting hoppers will normally be one, two or three.

Referring now to the circuit diagram of FIGURE 3, the parts of this have been arranged in such a manner that, although it is drawn for an installation utilizing two collecting hoppers, it will be clear how the circuit shown may be modified for use with one hopper or with three or more hoppers. Thus, the lower part of the diagram, marked G, includes the parts of the control system relating to the fan 35 and the recovery hoppers 7A and 7B, while the two upper parts I and II include respectively the two parts of the circuit peculiar to the two collecting hoppers 5A and 5B.

A single phase alternating current supply is connected between the terminals 121. A timing device 123 is arranged to close, at a preset time after it is energized, a time switch 125, this period suitably being between two and four hours. A manually operable pushbutton Start switch 127, spring biased to its open position, is connected in parallel with the switch 125. Connected in series between the terminals 121 with the parallel combination of switches 125 and 127 is the operating coil 129C of a Start relay 129 having two normally open switches 129X and 129Y and a normally closed switch 129Z. The switch 129Z is connected in series with the timing device 123 between the terminals 121. Thus, closure of the contacts of the time switch 125 or of the switch 127 will energize the Start relay and so open switch 129Z and close both the switches 129X and 129Y. The switch 129Y is in series between the terminals 121 with a manually operated Stop switch 131, which is spring biased to the closed position, and a Stop switch 133X of a Stop relay 133. The switch 133X is normally closed, but it is opened upon energization of an operating coil 133C of the Stop relay. If the relay 133 is not energized, then, unless the Stop switch 131 is manually opened, when the coil 129C of the Start relay 129 is energized, the closure of its switch 129Y will complete a hold circuit by which that coil will continue to be energized even when both the switches 125 and 127 are open. The second switch 129X of the Start relay 129 is in series between the terminals 121 with a motor starter control 135 which when energized by closure of the switch 129X starts up the motor driving the fan 35 and runs the motor and thus, fan 35 up to speed.

A second normally open switch 133Y of the Stop relay 133 is connected in series between the terminals 121 with one movable arm 136A of a two-position, multi-pole switch, a selected one of the two high level switches 81A, 81B of the high level responsive devices associated with the two hoppers 7A and 7B, and with an audible and visible alarm device 137. It will be seen that the alarm device 137 is energized so as to give an alarm only if the Stop relay 133 has operated to stop the fan 33 and at the same time the level of the shot in the selected hoppers 7A or 7B is lower than it should be.

In the circuit part I, the switch 57AX of the pressure sensitive device 43A is connected in series between the terminals 121 with the operating coil 141AC of a relay 141A associated with that device. Similarly, in the circuit part II, the switch 57BX of the pressure sensitive device 43B is connected in series between the terminals 121 with the operating coil 141BC of a relay 141B associated with that device.

The switch 57AZ and the switch 57BZ of the devices 43A and 43B respectively are connected in series between the terminals 121 with one another and with a normally closed switch 143X of a relay 143 and the operating coil 145C of a time delay relay 145. It will be seen that this circuit is completed by a link X applied between terminals BX1 and BX2 on circuit part II. If only one collecting hopper 5A had been provided, the circuit part II would have been omitted and the link X applied to the terminals AX1, and AX2 of the circuit part I. On the other hand, if three collecting hoppers had been provided, a third circuit part II similar to circuit parts I and II would have been added to the top of FIGURE 3, and the link X removed from the position shown and inserted in the corresponding place in the circuit III. By the application of the link in the manner indicated to the uppermost circuit part in use, the circuit shown can readily be modified to

accommodate a number of collecting hopper circuits other than two.

The relay **145** includes a switch **145X** connected in series circuit with the operating coil **143C** of relay **143**, the series combination being connected in parallel with the series combination of switch **143X** and the coil **145C**. When relay coil **145C** is energized, switch **145X** closes and relay coil **143C** is energized. When relay coil **143C** is energized, switch **143X** opens the circuit through coil **145C** but remakes a new circuit in which it by-passes switch **145X** to provide a hold-circuit for its own operating coil **143C**.

Should both of the pressure sensitive devices **43A** and **43B** be subjected to the first, higher predetermined pressure drop, which will happen if both shot returning circuits are free from shot and the fan **35** is operating properly, then switches **57AX** and **57BX** are both closed and initially the coil **145C** of the relay **145** is energized; after a designed delay period coil **145C** effects closure of the switch **145X** (unless during that period it becomes de-energized), so energizing the coil **143C** of relay **143**. This in turn effects closure of a second switch **143Y** of relay **143**, opening by switch **143X** of the circuit through coil **145C**, and the establishment of a hold circuit by switch **143X** for relay coil **143C**. Closure of switch **143Y** completes a series circuit between terminals **121** which includes operating coil **133C** of relay **133** and the switch **143Y**. The stop relay **133** thus operates and switch **133X** opens. This de-energizes the operating coil **129C** of relay **129**, opening the switch **129X** and by de-energization of the motor starter control **135** stopping the motor driving the fan **35**. This stopping of the fan is prevented upon the commencement of operation by opening of one or both of switches **57AZ**, **57BZ**, as described below.

In the circuit part I, the relay **141A** includes four switches **141AW**, **141AX**, **141AY**, and **141AZ** all normally open but closing upon energization of the coil **141AC** by closure of switch **57AX**. Switch **57AY** of the pressure sensitive device **43A** is in a series circuit between the terminals **121** with switch **141AW** and the solenoid valve operator **33A** which controls the valve **29A** associated with the collecting hopper **5A**. It follows that the valve **29A** is open when switch **57AY** is closed, that is to say when the pressure drop across the throat of the Venturi nozzle of device **34A** is at the second, lower predetermined value corresponding to an operating condition in which there is shot passing through the uptake duct **37A**. Switch **141AX** is in series circuit between the terminals **121** with the switch **57AY** and the relay coil **141AC**, so that one relay **141A** is energized, then as long as either of the switches **57AX** and **57AY**, is closed, the relay coil **141AC** will continue to be energized.

Switch **141AY** is in series circuit between the terminals **121** with a normally closed switch **147X** of a relay **147**, a similar switch **141BY** in a similar relay **141B** in circuit part II, a second movable arm **136B** of the two position switch referred to above, and either the solenoid valve operator **18** controlling the valve **13** at the outlet from the recovery hopper **7A**, or the solenoid valve operator **22** controlling the valve **15** at the outlet of the recovery hopper **7B**, depending upon the setting of the two position switch incorporating movable arms **136A**, **136B** and a further movable arm **136C**. The three arms **136A**, **136B** and **136C** move in unison so that they make either three circuits associated with hopper **7A** or three circuits associated with hopper **7B**. Relay **147** includes an operating coil **147C** connected in series circuit between the terminals **121** with the movable switch arm **136C** and with a selected one of the two low level switches **85A**, **85B** of the low level responsive devices associated with the two hoppers **7A** and **7B**. As long as the selected hopper **7A** or **7B** is filled above the effective level of the low level device, the associated switch **85A** or **85B** is open, the relay coil **147C** is de-energized, and the switch **147X** is closed. When the discharge of shot from the hopper **7A** or **7B** (selected by the setting of the two position switch) causes the associated low level responsive device to be uncovered, its switch **85A** or **85B** closes, coil **147C** is energized, switch **147X** opens, and the discharge of shot from that hopper is stopped by closure of the associated valve as the associated solenoid valve operator **18** or **22** is de-energized. The relay **147** also includes a normally open switch **147Y** connected in series between the terminals **121** with switch **141AZ** and the relay coil **147C** to provide a hold circuit for the relay **147** so that it is impossible for selected solenoid valve operator **18** or **22** to become effective, even if the selected hoppers **7A** or **7B** becomes filled above the level of its low level responsive device until the relay **147** is caused to open upon the pressure drop across the Venturi throat falling to a very low value upon stoppage of the fan **35** or overloading of both handling devices **34A**, **34B**.

The circuit part II is similar to the circuit part I, including the relay **141B** corresponding to the relay **141A** and having an operating coil **141BC** and switches **141BW**, **141BX**, **141BY** and **141BZ**. The switch **141BW** is in series with the solenoid valve operator **33B** which controls the valve **29B** associated with the collecting hopper **5B**. Switch **141BX** controls a hold circuit for the coil **141BC**. Switch **141BY** is in series with the switch **141AY**. Switch **141BZ** is in parallel with the switch **141AZ**.

The shot cleaning system described above will normally operate automatically at predetermined intervals at the instigation of the timer **123**, which closes the switch **125**, but the cleaning operation may be commenced by closure of the manually operated push button Start switch **127**.

At the commencement of a cleaning operation, valves **13**, **15**, **29A** and **29B** will be closed, the fan will be quiescent and both recovery hoppers **7A** and **7B** will be filled to the levels indicated in FIGURE 1 with shot. Upon closure of either switch **125** or switch **127**, the relay **129** is energized and causes energization of the motor starter control **135** through closure of the switch **129X**. Initially, the pressure drop across each Venturi nozzle is zero and the switches of the pressure sensitive devices **43A** and **43B** are all open. As the rate of air flow from the fan **35** increases, the pressure sensitive devices will act to close the switches **57AY** and **57BY**. This will have no effect, since the series switches **141AW** and **141BW** are both open. As the pressure drops across the two Venturis increase further, the pair of switches **57AX**, **57AZ** and **57BX**, **57BZ** also close by the action of the pressure sensitive devices **43A** and **43B**. Thus, when a sufficient flow of air is taking place through the pneumatic handling device **34A**, a circuit is established through switch **57AX** to operate relay **141A** and thus establish a further circuit through switch **141AW** and solenoid valve operator **33A** to open collecting hopper valve **29A**. In a similar manner, upon a sufficient flow of air through the pneumatic handling device **34B**, solenoid valve operator **33B** effects opening of collecting hopper valve **29B**. Closure of both of the switches **57AX**, **57BX** also energizes through the series connected switches **141AY** and **141BY** the selected solenoid valve operator **18** which causes opening of valve **13** of the main shot recovery hopper **7A**. Shot released from the hopper **7A** falls down into the distributor **25** and thence through the six discharge ducts **27** for discharge from the outlet ends **27A** of those ducts to fall onto and to pass between the heat exchange tube lengths **3**. In their fall the shot dislodges particles of dirt from the tubes, and these pass downwardly with the shot to the lower part of the gas pass **1**. This cleaning operation is carried out with the induced draught fans of the steam generator in operation, so that there is a considerable flow of air or gases through the downpass. The dirt is for the most part entrained by the air gases and swept out from the gas outlet (not shown) at the foot of the down-

pass, to be separated from the air or gases in the gas cleaning plant associated with the chimney of the steam generator.

The shot so discharged into the gas pass 1 collects in the two collecting hoppers 5A and 5B and from each hopper a steady stream of shot falls into the associated pneumatic handling device 34A or 34B. It is entrained in the stream of air from the fan 35 and swept up the associated uptake duct 37A or 37B to the associated separator 39A or 39B. The separated shot falls into the main hopper 7A and the separated air passes through to duct 41 to the gas cleaning plant referred to above.

As each pneumatic handling device 34A, 34B commences to handle shot from its associated collecting hopper, the associated pressure sensitive device 43A, 43B will open its switches 57AX, 57AZ or 57BX, 57BY.

While the cleaning operation is in progress, some of the shot will be in circulation in the gas pass, in the collecting hoppers 5A and 5B, and in the uptake ducts. Since the rate of return of shot is less than the rate of discharge from the recovery hopper 7A, after a time the high level responsive device becomes uncovered and switch 81A closes. This has no effect on the control system since the series switch 133Y is still open. After a further time interval, the low level responsive device becomes uncovered and switch 85A closes. This energizes the relay 147, which is then held by the hold circuit through switch 147Y and either or both of the switches 141AZ, 141BZ. Opening of switch 147X de-energizes the solenoid 18 to cause closure of the valve 13 controlling the discharge of shot from the recovery hopper 7A. However, shot already in the system continues to reach the two pneumatic handling devices 34A and 34B and is returned to the hopper 7A.

It may happen that one of the pneumatic handling devices, say the device 34A, becomes overloaded with shot. This will cause an excessively low pressure differential across the throat of the Venturi, the pressure sensitive device 43A will open all the contacts 57AX, 57AY and 57AZ, relay 141A will be de-energized, so de-energizing the solenoid valve operator 33A and causing closure of the valve 29A associated with the collecting hopper 5A. This permits the pneumatic handling device 34A to dispose of the surplus of shot, and when it has done so the pressure differential across the throat of the Venturi rises and through the pressure sensitive device 43A first closes the switch 57AY, which has no effect, and then as the pressure differential rises still further closes the switches 57AX and 57AZ. Closure of switch 57AX energizes the relay 141A and causes energization of the solenoid valve operator 33A, so effecting opening of the valve 29A associated with the collecting hopper 5A, so that the device 34A is again effective to return shot from that hopper to hopper 7A. Should pneumatic handling device 34B become overloaded, the pressure sensitive device 43B in a similar manner first causes closure, and then opening, of the valve 29B associated with the collecting hopper 5B.

If either of the pneumatic handling devices 34A and 34B should become overloaded, then the associated switches 141AY or 141BY will be opened and solenoid 18, if then energized, will be de-energized, closing valve 13 associated with the recovery hopper 7A. When both of the switches 141AY and 141BY are closed, then if the shot level in hopper 7A is above the Empty level (so that the switch 147X is closed) solenoid 18 is energized and opens the valve 13. In these circumstances, even although the relay 147 has previously operated to terminate the release of shot from hopper 7A, its hold circuit through switch 141AZ, 141BZ having been broken a repetition of the part of the cleaning cycle leading up to de-energization of solenoid 18 is inevitable.

Eventually the collecting hoppers 5A and 5B, the pneumatic handling devices 34A and 34B, and the shot uptake ducts 37A, 37B will all be free from shot. As each pneumatic handling device 34A or 34B reaches this state, its associated pressure sensitive means 43A or 43B effects closure of its switches 57AX and 57AZ or 57BX and 57BZ. When both switches 57AZ and 57BZ are closed, the time delay relay 145 is energized and, unless it is meanwhile de-energized by the falling down of retained shot from the gas pass 1 into one of the handling devices 34A, 34B to open one of the switches 57AZ or 57BZ, after the designed delay time the relay 145 closes switch 145X and so energizes relay 143. By closure of the switch 143Y this energizes the Stop relay 133 to de-energize the relay 129 thus the motor starter control 135, so stopping the motor driving the fan 35. At the same time, switch 129Z is closed to start the timing device 123. As the fan slows down, the pressure drops across the two pneumatic handling devices 34A and 34B fall to zero and the switches 57AX, 57AY, 57AZ, 58BX, 57BY and 57BZ all open. Relays 141A and 141B both become de-energized, solenoid valve operators 33A and 33B become de-energized, and the collecting hopper valves 29A and 29B both close.

If both hoppers 7A and 7B are then filled with shot above the level of the high level responsive devices, both of the switches 81A and 85A will be open and relay 147 will be de-energized by opening of its hold circuit through the switches 141AZ and 141BZ. Since switch 81A is open, the alarm device 137 will remain quiescent.

If the level in hopper 7A is below that of the high level responsive device of that hopper, switch 81A will be closed and the device 137 will give the alarm to the operator, who must decide what action to take, although it would be a simple matter to arrange the alarm device 137 to initiate a further cleaning cycle. In normal operation, the low level responsive device will be covered and the switch 81A open, and the operator will change over the two position switch to render the solenoid valve operator 22 effective, and initiate a further cleaning cycle utilizing hopper 7B, by closure of the manual Start switch 127.

In this further cleaning cycle, the shot will be discharged from the hopper 7B, and the returned shot will fill the hopper 7A and then spill over into hopper 7B.

In the system described above, the success of a cleaning operation is indicated by the stoppage of the fan 35 without the giving of an alarm by an alarm device 137, since if the system were badly fouled, part of the shot would be retained in the glass pass 1 and the appropriate high level responsive device would cause the alarm device to operate. The danger of omission to clean the heat exchange surfaces at proper times is avoided since the cleaning cycle is automatically started by a time switch. Upon completion of the cleaning cycle the fan 35 is shut down and, in the event of either of the pneumatic handling devices 34A and 34B becoming overloaded, the discharge of shot from the recovery hoppers 7A and 7B is immediately stopped.

In the event of an appreciable amount of shot being trapped in the gas pass a warning is given, and this is of advantage because should the tubes of the economizer or other heating surface become fouled, warning of inadequate cleaning is given long before gas temperature or draught loss would become sufficiently changed to indicate fouling.

The pressure sensitive means responsive to the pressure conditions in pneumatic handling devices 34A and 34B operate by measuring the difference between the two pressures at opposite sides of the throats of the Venturi nozzles. Although that arrangement is to be preferred, it is possible to operate the switch device 57A by means of a diaphragm device similar to that shown but having one chamber in communication with the uptake side of the Venturi throat and the other chamber in communication with the atmosphere. It will be appreciated that, if the outlet pressure of the fan 35 is constant, the pressure on the downstream side of the Venturi nozzle will be relatively high at low rates of air flow, and relatively low at high rates of air flow, since this pressure is the difference

between the outlet pressure of the fan and the pressure drop across the Venturi nozzle.

What is claimed is:

1. A shot cleaning system including heat exchanger surfaces, recovery hopper means positioned above heat exchange surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the recovery hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned, handling means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to the presence of shot at a selected high level in the recovery hopper means, means sensitive to a condition in said handling means to regulate operation of said handling means, said last named means operable to stop said handling means when the shot collected in said collecting hopper means has been returned by said handling means to the recovery hopper means, and alarm means operable by said high level sensitive means should the operation of said handling means be discontinued when shot is not present at said selected high level in said recovery hopper means.

2. A shot cleaning system including heat exchanger surfaces having recovery hopper means positioned above heat exchange surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the recovery hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned, pneumatic conveying means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to the presence of shot at a selected high level in the recovery hopper means, means sensitive to a pneumatic pressure condition in said pneumatic means, said pressure sensitive means operable to distinguish between a condition when shot is being conveyed and when the conveying means is free of shot, said pressure sensitive means being operable to regulate the operations of said pneumatic conveying means, and alarm means operable by said high level sensitive means should the operation of said pneumatic conveying means be discontinued when shot is not present at said selected high level in said recovery hopper means.

3. A shot cleaning system as claimed in claim 2, wherein the pressure sensitive means exert a control such that opening of the first valve means will occur only when the pneumatic conveying means are substantially free from shot.

4. A shot cleaning system including heat exchanger surfaces having recovery hopper means positioned above heat exchange surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the recovery hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned, pneumatic conveying means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to the presence of shot at a selected high level in the recovery hopper means, pressure sensitive means in said pneumatic conveying means to regulate operation of said conveying means, said last named means operable to stop said pneumatic conveying means when the shot collected in said collecting hopper means has been returned by said conveying means to the recovery hopper means, alarm means operable by said high level sensitive means should the operation of said conveying means be discontinued when shot is not present at said selected high level in said recovery hopper means, and second automatically controlled valve means operable to regulate flow of shot from said collecting hopper means to said pneumatic conveying means, means connecting said pressure sensitive means with said second valve means to close the latter when said pneumatic conveying means becomes overloaded.

5. A shot cleaning system including heat exchanger surfaces, recovery hopper means positioned above the heat exchange surfaces to be cleaned, a first automatically controlled valve for controlling the discharge of shot from the hopper means onto the surfaces to be cleaned, collecting hopper means below the surfaces to be cleaned, pneumatic handling means for returning shot collected in the collecting hopper means to the recovery hopper means, a second automatically controlled valve for controlling the discharge of shot from the collecting hopper means to the pneumatic handling means; and pressure sensitive means responsive to pressure conditions in the pneumatic handling means and adapted to distinguish between the condition when the handling means are free from shot, the condition when the handling means are overloaded with shot, and operable with opening of the first valve occurring only when the handling means are substantially free of shot, and closure of the second valve will automatically occur if during conveyance of shot the handling means become overloaded.

6. A shot cleaning system as claimed in claim 5, wherein the pressure sensitive means are adapted when the condition indicating that the handling means are free from shot has persisted for a predetermined time to terminate operation of the handling means.

7. A shot cleaning system as claimed in claim 5, wherein the pressure sensitive means are responsive to differential pressure across a throat which is arranged to carry the pneumatic conveying medium and an entry for the shot from the collecting hopper is provided downstream therefrom.

8. A shot cleaning system including heat exchanger surfaces, a plurality of recovery hopper means positioned above the surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from each of said recovery hopper means onto the surfaces to be cleaned, a plurality of collecting hopper means disposed below the surfaces to be cleaned, pneumatic conveying means for returning shot collected in each of the collecting hopper means to the recovery hopper means, second valve means for controlling discharge of shot from each of said collecting hoppers to a corresponding conveying means, pressure sensitive means in each of said pneumatic conveying means to regulate operation of each of said conveying means, said pressure sensitive means operable to open one of said first valve means when one of said conveying means is free of shot and to close one of said second named valve means when the corresponding conveying means is overloaded.

9. A shot cleaning system including heat exchanger surfaces, recovery hopper means positioned above the heat exchange surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the recovery hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned, handling means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to the presence of shot at a selected high level in the recovery hopper means, means sensitive to the presence of shot below a selected low level, means sensitive to a condition in said handling means to regulate operation of said handling means, said last named means operable to stop said handling means when the shot collected in said collecting hopper means is present at said selected high level in said recovery hopper means, and means responsive to said low level sensing means operable to close said first valve.

10. A shot cleaning system including heat exchanger surfaces, recovery hopper means positioned above the heat exchange surfaces to be cleaned, first automatically controlled valve means for controlling the discharge of shot from the recovery hopper means onto the surfaces to be cleaned, collecting hopper means disposed below the surfaces to be cleaned, handling means for returning shot collected in the collecting hopper means to the recovery hopper means, means sensitive to the presence of shot at

a selected high level in the recovery hopper means, means sensitive to the presence of shot below a selected low level in the recovery hopper means, means sensitive to a condition in said handling means to regulate operation of said handling means, said last named means operable to stop said handling means when the shot has been removed from said collecting hopper means, and means operable to actuate an alarm when said handling means is stopped as an indication that the shot has been removed from said collecting hopper means and the shot level in said recovery hopper does not actuate said high level means, said alarm actuating means being indicative of shot loss in said heat exchanger.

11. A shot cleaning system as claimed in claim 8, wherein said plurality of recovery hopper means includes one

hopper means arranged to receive shot only as overflow from another recovery hopper means.

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