Oct. 10, 1950 F. H. VIETS 2,525,325

PNEUMATIC APPARATUS FOR RAPPING ELECTRODES IN ELECTRICAL PRECIPITATORS

Filed Dec. 9, 1946 2 Sheets-Sheet 1

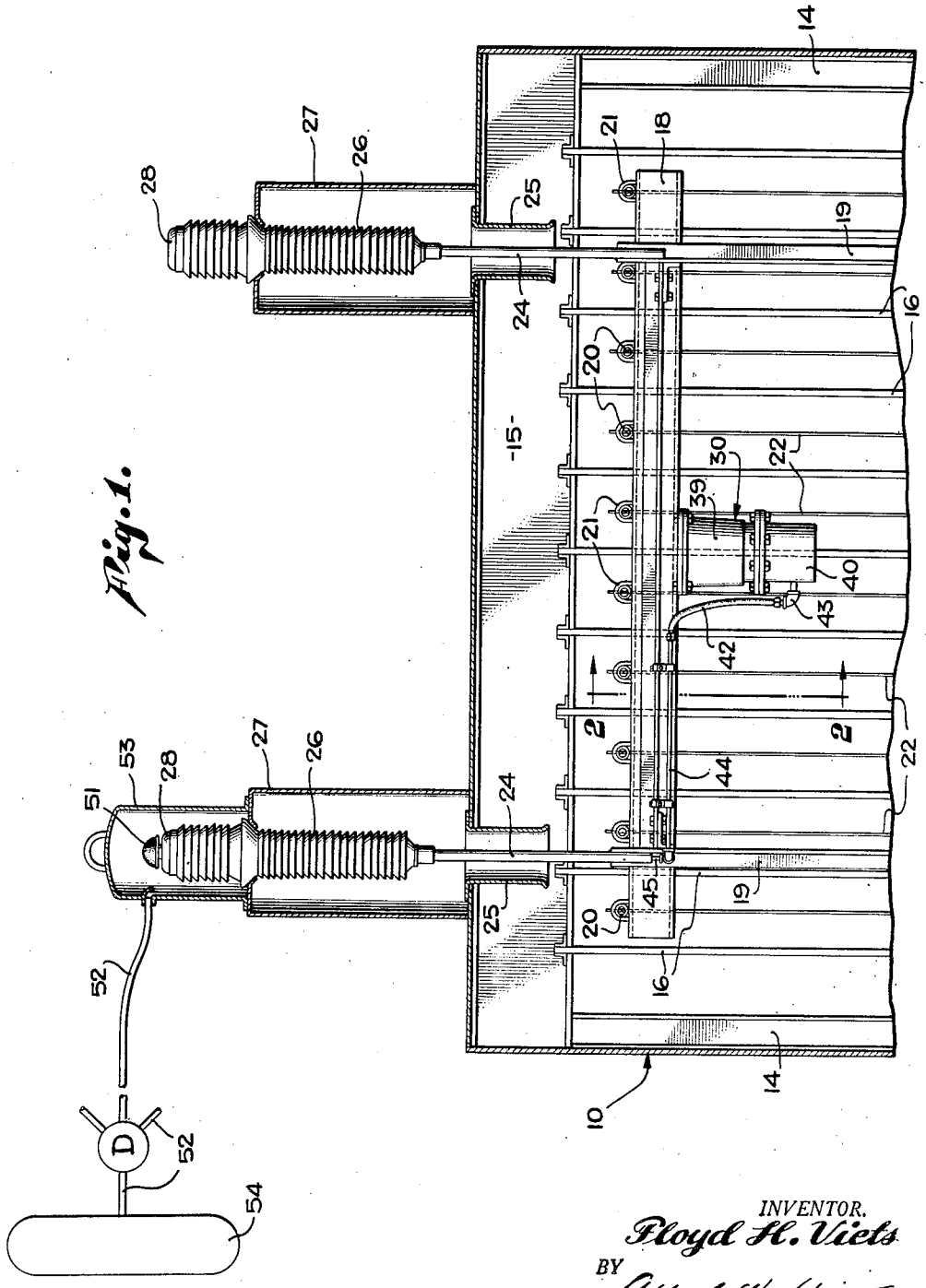


Fig. 1.

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Fig. 2.

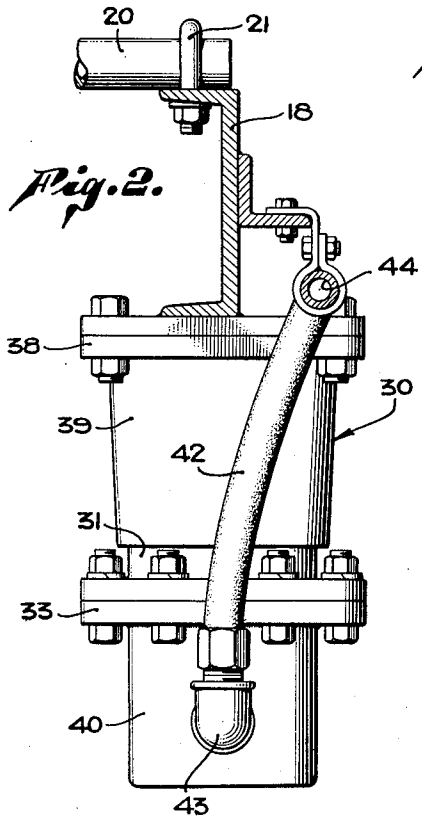


Fig. 5.

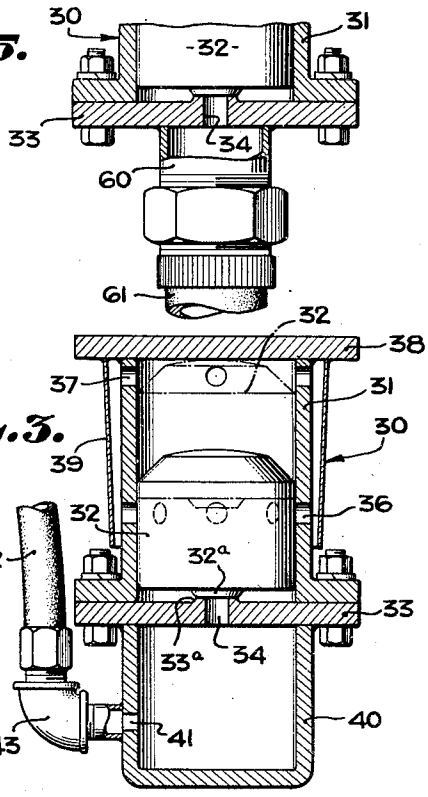


Fig. 4.

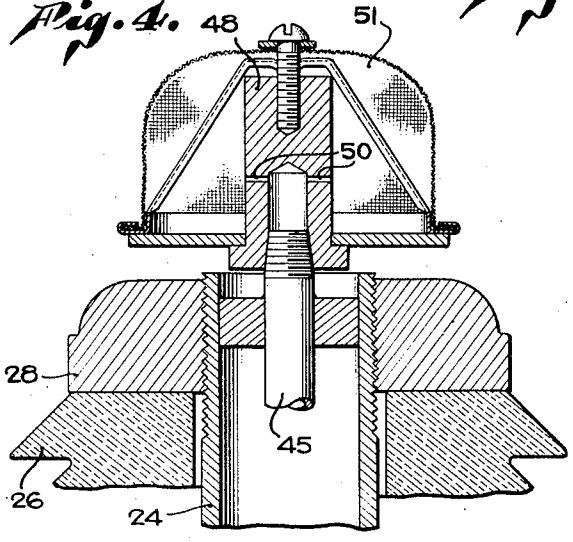
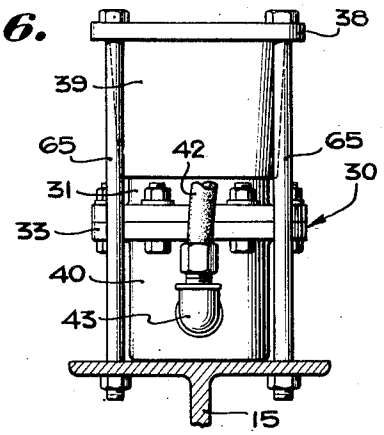


Fig. 6.



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PNEUMATIC APPARATUS FOR RAPPING ELECTRODES IN ELECTRICAL PRECIPITATORS

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Application December 9, 1946, Serial No. 715,020

8 Claims. (Cl. 183—7)

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The present invention relates generally to electrical precipitators for removing suspended particles from a stream of gas, and more particularly to rapping devices for cleaning the electrodes in the precipitator of accumulations of dust.

In electrical precipitators of this type, the stream of gas carrying particles in suspension passes through one or more electrostatic fields in which the suspended particles receive a charge and are then moved, under the influence of an electric field, toward a collecting electrode. When the collected material is a dry solid, it ordinarily accumulates upon the surface of the collecting electrode, and it becomes necessary to clean the electrode periodically in order to maintain the efficiency of the precipitator. Under these circumstances, cleaning an electrode can be accomplished by delivering a series of sharp blows to the electrode to jar or shake loose accumulated material which then, of its own weight, falls downwardly to some point beneath the electrode.

Although the bulk of the suspended material ordinarily accumulates upon the collecting electrode, it is common that a certain proportion of the material accumulates upon the high tension electrode; and this condition is particularly true when the precipitator is of the type having a plurality of electric fields.

A conventional method of rapping the electrode is to deliver the blows to the electrode by a manually operated mechanism. Although this method of operating the rapping mechanism has the advantages of simplicity of apparatus and control by the operator, it has the very prominent disadvantages of being expensive, since a workman cannot efficiently do other work at the same time, and is subject to a high percentage of failure due to forgetfulness or other causes.

These factors have resulted in the development of automatic operating mechanisms for rappers which are adapted to actuate the rapping mechanism at fixed intervals of time. To be satisfactory, the operating mechanism must be such that the time interval between successive operations can be varied over a fairly wide range in order to be adapted to actual operating conditions, and it must be able to maintain operations at an established interval with reasonable accuracy. As a result, automatic rapping mechanisms have involved complicated timing valves or mechanisms which are expensive to construct and maintain and are not entirely satisfactory in operation.

In the case of rapping mechanisms for high

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tension electrodes, an additional problem in construction and operation is adequately insulating the rapping mechanism itself, which is attached to the high tension electrode, from as much as possible of the control and actuating mechanism.

Hence, it becomes a general object of my invention to provide a system for insuring the regular, uniform, and automatic rapping of the electrodes of electrical precipitators.

It is another object of my invention to provide a rapping mechanism and control means therefor that is simple in construction and operation, that is of the fluid-pressure actuated type, and which permits desired variation in the frequency and duration of rapper operation.

A further object of the invention is to provide an efficient and effective rapping device, adapted to cleaning low or high tension electrodes, whether discharging or non-discharging.

The above, as well as other, objects are attained in a system constructed according to my invention by providing a rapping device comprising a fluid-pressure actuated piston which is freely movable within a cylinder, and means for supplying a fluid-pressure medium, such as compressed air, to the cylinder to bring about repeated movement of the piston against one end of the cylinder which acts as an anvil to receive the blows of the piston. The cylinder is ordinarily attached to a member of an electrode assembly with the axis of the cylinder extending vertically, in which case the compressed air is introduced into the cylinder beneath the piston, and the compressed fluid medium periodically drives the piston against the upper end of the cylinder.

Means for supplying fluid under pressure to the cylinder includes an inlet port in the cylinder of substantially smaller diameter than the diameter of the piston, so that the minimum area of the piston exposed to fluid pressure through the port is but a small fraction of the total diameter of the piston. When the piston is at rest, it is adapted to close this inlet port until the fluid pressure at the inlet port exceeds a predetermined value. When this predetermined pressure is exceeded, the piston is moved from its rest position, at which time one entire side is subjected to the pressure of the incoming fluid, and the expansion of this fluid in the cylinder drives the piston to deliver a sharp blow against the end of the cylinder.

When the rapper is attached to a member of the high tension electrode assembly, the fluid supply means includes a fluid-tight housing en-

closing the upper end of one of the insulators which suspends the high tension electrode assembly. Fluid under pressure is conducted to the interior of this housing which is in communication with a fluid passage extending through the electrode suspension member to a conduit attached to the rapper. The fluid-tight housing is grounded to the shell of the precipitator. There is no direct electrical connection between the conduit which discharges fluid from the housing and the housing itself, so that the housing interior becomes, in effect, an electrically insulating space in the fluid path.

How the above objects and advantages of my invention, as well as others not particularly mentioned, are attained will be more readily understood by reference to the following description and to the annexed drawings, in which:

Fig. 1 is a fragmentary vertical section through a typical electrical precipitator looking in the direction of gas flow; showing the high tension and collecting electrode assemblies, with a rapping device attached to the high tension assembly and means supplying fluid under pressure to the the rapper;

Fig. 2 is a fragmentary side elevation of the rapper taken on line 2—2 of Fig. 1;

Fig. 3 is a vertical median section through the rapper of Fig. 2;

Fig. 4 is an enlarged vertical section through the top end of an insulator showing the filter mounted in the upper end of the insulator;

Fig. 5 is a fragmentary section similar to Fig. 3 showing a modified form of construction; and

Fig. 6 is a side elevation similar to Fig. 2 showing the rapping mechanism attached to a member of the collecting electrode assembly.

In order to illustrate and disclose my invention, there is shown in Fig. 1 a portion of an electrical precipitator which is typical of industrial precipitators for collecting dry solids suspended in a stream of gas. Since the construction and arrangement of the various portions of an electrical precipitator are well known to those skilled in the art, it is considered that description of such details is unnecessary here beyond showing how my invention may be applied or adapted to a typical precipitator construction. Therefore, it will be understood that my invention is in no way limited to the precipitator construction shown herein, but may be applied equally well to other types of electrode assemblies. Necessary modifications in location and attachment of the rapper and fluid supply means are within the skill of persons skilled in the art.

The electrical precipitator in Fig. 1 is contained within a housing or shell 10 which not only encloses the electrode assemblies but also provides a duct through which the dust-laden gas stream flows. The direction of gas flow is perpendicular to the plane of the drawing. The structural framework of the precipitator includes posts 14 within shell 10 which support at their upper ends transverse beam 15 at the top of the gas duct. From two such beams 15, spaced in the direction of gas flow, are suspended a plurality of plates 16 which extend parallel to the direction of gas flow. Plates 16 constitute individual collecting electrodes. The collecting electrode assembly, including plates 16 and beams 15, are all connected together and connected to the framework and shell 10, and all of these parts are grounded electrically.

The high tension electrode assembly comprises a pair of transverse members, of which only the upper member 18 is shown. The lower member is similar to the one illustrated. The upper and lower transverse members are connected by a pair of vertically extending members 19, thus forming a generally rectangular end frame. Two such end frames spaced in the direction of gas flow support between them a plurality of pipes 20, or similar longitudinally extending members. As may be seen best in Fig. 2, pipes 20 are attached to transverse beams 18 by U-bolts 21, or similar means. Pipes 20 extend parallel to and midway between two collecting electrodes 16. Suspended from each pipe 20 is a plurality of wire or rod elements 22 which are the discharge electrodes.

Each of the rectangular end frames of the high tension electrode assembly just described, is suspended by two rods or tubes 24 which are attached at their lower ends to upright members 19 and extend upwardly through sleeves 25 into and through insulators 26. At least certain ones of members 24 are hollow in order to provide a fluid supply passage, as will be explained in greater detail. Each member 24 is secured at its upper end to a metal cap 23 which rests upon the top of an insulator 26, as shown in Fig. 4. Each insulator 26 has an enlarged portion which rests upon a flange provided by housing 27 to support the insulator. The joint between insulator 26 and the flange of housing 27 is made fluid-tight. This fluid-tight connection not only keeps the gases being treated from escaping from housing 27, in the case of the right hand insulator in Fig. 1, but also prevents the compressed air from entering the gas duct, in the case of the left hand insulator in Fig. 1, as is more fully described later.

The device for rapping the electrode assembly is indicated generally at 30, and is shown in greater detail in Figs. 2 and 3. Rapping device 30 is rigidly attached to the underside of top transverse member 18, as it has been found by experience to be a particularly effective point at which to deliver the rapping blows. However, the rapping device may be attached to any other member of the electrode assembly, and in such numbers, as may be desirable. The rapping device comprises cylinder 31 within which piston 32 is freely movable. The axis of cylinder 31 is preferably vertical in order that piston 32 may return after each rapping stroke, under the influence of gravity, to the rest position, shown in Fig. 3, at the bottom of the cylinder. The lower end of cylinder 31 is closed by plate 33 in which is located fluid inlet port 34 which is surrounded at its upper end by a raised rim 33*a*. A valve face is ground upon rim 33*a* which engages and cooperates with a similar valve face on the lower end of boss 32*a* on piston 32. When piston 32 is at the rest position, as shown in full lines in Fig. 3, the piston covers the inlet port, and the cooperating valve faces on the piston and plate 33 at inlet port 34 form a fluid-tight seal which prevents entry of fluid into the cylinder until the pressure of the fluid at the inlet port exceeds a predetermined value.

The side walls of cylinder 31 are provided with fluid exhaust or outlet ports 36 located just below the position of the piston at its extreme upper range of travel. A second set of ports 37 is located near the upper end of the piston in order to allow air freely to enter or leave the space between piston 32 and anvil plate 38 which closes the upper end of cylinder 31. A sheet metal guard 39 is placed around the outside of

cylinder 31 and over ports 36 and 37 in order to prevent entry into the cylinder through these ports of any foreign particles which would interfere with the operation of piston 32 and the proper seating of the piston on valve rim 33a to close inlet port 34.

Located below plate 33 is a second cylinder 40, the interior of which forms a reservoir communicating with inlet port 33 and to which fluid under pressure is supplied through port 41. Fluid under pressure is brought to port 41 by a conduit which includes a length of flexible hose 42 attached to a fitting on reservoir 40 by elbow 43, and pipe 44 which is connected to the lower end of pipe 45. Pipe 45 is within, and extends the full length of, hollow tube 24.

It is desirable to place in the line supplying fluid to the rapping device, a small orifice for restricting or metering the flow of fluid. While the location of this orifice is not critical, it is preferred to place it at the upper end of pipe 45 and on top of insulator 26 since in this location the orifice is reasonably close to the rapping device and is also accessible for cleaning or changing. This construction is illustrated in detail in Fig. 4, which shows cap 48 screwed onto the upper end of pipe 45 and provided with two small passages 50 through which fluid under pressure enters the cap and flows into tube 45. It is desirable to surround orifices 50 with a suitable filter, such as wire cloth screen 51, in order to remove from the fluid any solid particles which might lodge in passages 50. It will be noted that all other cross-sectional areas of the fluid supply means between passages 50 and port 34 are many times larger than the total area of these passages, so that these passages effectively determine the rate of supply of pressure fluid to the reservoir.

The fluid supply means also includes air line 52 and bell housing 53 which covers or encloses the upper end of insulator 26 and is secured to the top of housing 27 to effect a fluid-tight joint therewith. Bell housing 53 being connected to housing 27, the former is electrically grounded by its connection through the metal framework of the precipitator to shell 10. However, pipe 45, cap 48, and filter 51 are connected electrically to the high tension electrode assembly through tube 24 and are consequently maintained at a relatively high potential. For this reason, housing 53 must be of sufficiently large diameter that no spark-over can occur between the housing and filter 51 or other nearby high tension parts.

Having described the construction and arrangement of a preferred form of my invention, I shall now describe its operation. Air line 52 is connected to a suitable source of compressed air, or any other fluid adapted to this same purpose, such as supply tank 54 of a compressor unit. The fluid under pressure is conducted by line 52 from the source into the precipitator shell and into housing 53 which is a part of the conduit means containing fluid under pressure.

From the space within housing 53, the fluid passes through filter 51 and passages 50 into the upper end of pipe 45. The fluid then flows through pipe 45 to pipe 44, connected to the lower end of pipe 45, and through flexible hose 42 into reservoir 40. From reservoir 40, fluid enters cylinder 31 through port 34, and exhausts to the interior of the precipitator from the cylinder through ports 36. Fluid flow through passage 50 is continuous while there is direct communications with a source of fluid under pressure;

and the rate of flow is substantially constant, though it fluctuates somewhat with changing pressures in reservoir 40.

Piston 32 closes inlet 34 when the piston is at rest, and during the time that the port is closed fluid at less than a predetermined pressure cannot enter the cylinder but accumulates in reservoir 40, building up pressure therein. Piston 32 is at all times subjected on its under side to pressure from the incoming fluid. When at rest, the only area on the piston exposed to fluid pressure is that area on boss 32a which is bounded by the perimeter of port 34, and is equal in area to the inlet area. The diameter of port 34 is but a small fraction of the diameter of the piston; and consequently the area on the piston exposed to fluid pressure when the piston is at rest, is but a small fraction of the entire piston area. The diameter of the piston is several times the diameter of the inlet port; preferably in excess of three times, at least, and is here shown as about seven times the diameter of port 34.

The area of port 34 and the weight of piston 32 determine the fluid pressure at which the piston is lifted off the valve seat at the inlet port. When the fluid pressure in reservoir 40 reaches or exceeds this predetermined pressure, piston 32 is raised upwardly, and fluid at this predetermined pressure flows from the reservoir into the cylinder. It will be obvious that now the entire area of piston 32 is exposed to fluid pressure, and consequently the upward force acting upon the piston is suddenly much greater than the upward force acting upon the piston when it is in the rest position. This larger force now drives the piston upwardly in the cylinder, causing the piston to strike a sharp blow against anvil plate 38. Pressure within cylinder 31 does not reach a maximum value equal to the initial pressure at which fluid commences to flow into the cylinder, because the fluid cannot flow into reservoir, and hence into the cylinder, fast enough to maintain this pressure. Pressure in both reservoir 40 and cylinder 31 drops sharply as piston 32 rises, but because of the greatly increased area over which the fluid acts upon the piston, the expanding fluid continues to drive the piston upward.

At the end of its upward stroke, the piston strikes anvil 38 and reaches the position shown by the dot-dash lines in Fig. 3. The piston has now uncovered exhaust ports 36 which are considerably larger in total area than inlet port 34 so that the pressure below the piston rapidly falls to a relatively low value which permits the piston to return to the bottom of the cylinder under the influence of gravity. The cooperating valve faces on the piston and plate 33 again seal inlet port 34 and fluid accumulates once more in reservoir 40 until it again builds up to this predetermined pressure, when the cycle is repeated.

With the proportions shown in the drawings, piston 32 is lifted when the pressure in reservoir 40 reaches or exceeds 50 pounds per square inch. For this actuating pressure, it is desirable that air line 52 be connected to a supply source which is maintained at a pressure of about eighty pounds per square inch. At these pressures, and with the metering passages 50 having a diameter of 3/64 inch, piston 32 is actuated by the fluid pressure at intervals of about three to four seconds, striking anvil plate 38 at the rate of fifteen to twenty blows per minute. This frequency of blows is inherent in the design and proportion of the

rapping device, and is independent of any valve mechanism.

It is of course unnecessary that this rate of rapping be continued over any great length of time, it being generally sufficient to strike three to six blows to loosen accumulated dirt from the electrode assembly. For this reason, it is sufficient that the rapping mechanism be actuated for short lengths of time, say eight to ten seconds, at intervals of from five to fifteen minutes or longer, depending upon the rate of accumulation of dust upon the electrodes. In order to bring about this intermittent operation of the rapping mechanism, it is desirable to place in line 52, between the fluid source 54 and the precipitator, a suitable type of intermittently operated valve which closes line 52 except for those short intervals of time when it is desired to operate the rapping mechanism. This timing valve arrangement may be of any suitable character and need not be described in detail here.

It may be desirable to provide the timing valve in the form of a distribution valve D which is adapted to connect each one of a series of air lines 52, in succession, to a single source of compressed air. Valve D may be intermittently operated by an automatic timing device, not shown. This arrangement enables the successive operation of a number of rappers within a single precipitator. Since such valves are known in the art, it is unnecessary that they be described in detail here; but reference may be made to Patent 2,392,088 issued January 1, 1946, to J. H. Hamilton and H. J. White for a description of a typical distribution valve.

Fig. 5 illustrates a modified construction in which reservoir 40 has been eliminated and replaced by a relatively large diameter fitting 60 attached directly to the bottom of plate 33 so that the interior of fitting 60 communicates with inlet port 34. Flexible hose 62 has been replaced by hose 61 of larger diameter. The internal diameter of these parts is typically in the neighborhood of two inches.

Piston 32 being pressure actuated, the energy available for driving the piston upwardly against anvil plate 38 is determined by the amount of fluid which passes through inlet port 34 into the cylinder and expands within the cylinder below the piston. The purpose of reservoir 40 is not so much to store any particularly large volume of fluid, as simply to provide an adequate volume of fluid under pressure in a space adjoining inlet 34 so that enough fluid will pass through the inlet and expand within the cylinder to drive the piston upwardly with the desired force. If the supply of fluid immediately outside the cylinder is inadequate, the stroke delivered by the piston is too feeble. The supply cannot be increased merely by enlarging port 34 beyond the proportions shown. To do so permits fluid to enter the cylinder at too high a rate with the result that the frequency of strokes is increased and a relatively high pressure is maintained in the cylinder during the latter end of the piston stroke, thus preventing a sufficiently sharp reduction in pressure to permit the piston to return fully to the rest position.

These delivery functions of reservoir 40 can be performed by the enlargement, near inlet 34, of the conduit delivering fluid and without providing any special space which sharply defines a reservoir. By enlarging hose 61 and fitting 60 as shown in Fig. 5, the fluid supply lines have sufficient volume of fluid in them in the space adjoining inlet 34 to cause the piston to function as described above. In essence, it will be seen that reservoir 40 is merely a sharply defined enlargement of the conduit supplying fluid to the cylinder and located adjoining the cylinder inlet port 34. However, another space of somewhat larger volume may be successfully substituted by enlarging the supply lines, thus removing any sharp definition of the reservoir volume itself.

The rapping device described above has been illustrated as attached to a discharge electrode assembly; however, it will be understood that there is no reason to so limit my invention for it may be used in connection with non-discharging high tension electrode assemblies or with collecting electrode assemblies equally well.

Fig. 6 shows the preferred location and means for attaching the rapping device 30 to a collecting electrode assembly. Since it is desirable to maintain the rapping device in its same relative position described with the axis of the cylinder extending vertically and plate 38 at the top of the device, it is mounted in this same position on the top of beam 15 to which collecting electrodes 16 are fastened. In this construction anvil plate 38 is connected to the flanges of I-beam 15 by means of tension bolts 65 which are drawn up tightly to fasten rigidly the rapper to the support member of the electrode assembly. Blows delivered to anvil plate 38 by the piston are transmitted through bolts 65 to the flanges of beam 15, and the vibrations caused thereby are transmitted through the beam to the individual collecting electrodes 16. It will be appreciated that under these circumstances a sharp, heavy blow is necessary in order to vibrate the collecting electrodes sufficiently to jar loose the accumulated dust.

Except for the differences in the means of attaching the rapping device to the member of the electrode assembly, the operation of the rapping device is the same as described above regardless of whether the device is attached to the collecting electrode or to a high tension electrode, with the possible exception that the interval between successive periods of rapping may be somewhat greater in the case of high tension electrodes. The increase in interval is caused by the greater rate of accumulation on the collecting electrodes; but this is somewhat counteracted by the fact that any accumulation of dust on discharge electrodes cause a greater interference with efficiency of collection.

Having described a preferred form of my invention, and certain modifications thereof, it will be apparent that various changes in construction and arrangement of parts will occur to those skilled in the art without departing from the spirit and scope of my invention; and consequently I wish it understood that the foregoing description is to be construed as illustrative of, rather than limitative upon, the appended claims.

I claim:

1. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port in the lower end of the cylinder communicating with a source of fluid under pressure and an outlet port in the side wall of the cylinder; and a fluid-pressure actuated piston freely movable within the cylinder to a blow-delivering position in which the outlet port is uncovered and when at rest position adapted to close the inlet port to prevent

inflow of fluid at less than a predetermined pressure.

2. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port in the lower end of the cylinder communicating with a source of fluid under pressure and an outlet port in the side wall of the cylinder; and a fluid-pressure actuated piston freely movable within the cylinder to a blow-delivering position in which the outlet port is uncovered and when at rest position adapted to close the inlet port to prevent inflow of fluid at less than a predetermined pressure, the diameter of the piston being several times the diameter of the inlet port.

3. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port communicating with a source of fluid under pressure and an outlet port positioned to release fluid pressure in the cylinder after the piston has moved a predetermined distance from the inlet port; a fluid-pressure actuated piston freely movable within the cylinder and when at rest position adapted to close the inlet port to prevent inflow of fluid at less than a predetermined pressure; and a fluid pressure reservoir discharging into the cylinder through said inlet port.

4. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically; a fluid-pressure actuated piston freely movable within the cylinder; means for supplying fluid under pressure to the cylinder beneath the piston to raise the piston; and means to release fluid from the cylinder when the piston is a predetermined distance above the lower end of the cylinder; said piston when above the rest position having an area exposed to the fluid under pressure which is several times the area of the piston exposed to the fluid when the piston is in the rest position.

5. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically; a fluid-pressure actuated piston freely movable within the cylinder; means including a fluid reservoir adjoining the cylinder for supplying fluid under pressure to the cylinder beneath the piston to raise the piston; and means to release fluid from the cylinder when the piston is a predetermined distance above the lower end of the

cylinder; said piston when above the rest position having an area exposed to the fluid under pressure which is several times the area of the piston exposed to the fluid when the piston is in the rest position.

6. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port communicating with a source of fluid under pressure and an outlet port; a fluid-pressure actuated piston freely movable within the cylinder; and cooperating valve faces on the piston and around the inlet port adapted to engage when the piston is at rest to prevent inflow of fluid at less than a predetermined pressure.

7. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port communicating with a source of fluid under pressure and an outlet port; a fluid-pressure actuated piston freely movable within the cylinder; cooperating valve faces on the piston and around the inlet port adapted to engage when the piston is at rest to prevent inflow of fluid at less than a predetermined pressure; and a fluid reservoir discharging into the cylinder through said inlet port.

8. In an electrical precipitator, the combination comprising: a cylinder rigidly mounted on a member of the electrode assembly with the axis of the cylinder extending vertically, the cylinder having an inlet port in the lower end and an outlet port in a side wall; a fluid-pressure actuated piston freely movable within the cylinder and when at rest position adapted to close the inlet port to prevent inflow of fluid at less than a predetermined pressure and also to cover the outlet port, the outlet port being uncovered to release fluid pressure as the piston nears the end of its stroke; a fluid pressure reservoir discharging into the cylinder through said inlet port; and supply means for supplying fluid under pressure to the reservoir including a flow-restricting orifice having a diameter which is but a small fraction of the diameter of said cylinder inlet port.

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Number	Name	Date
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