

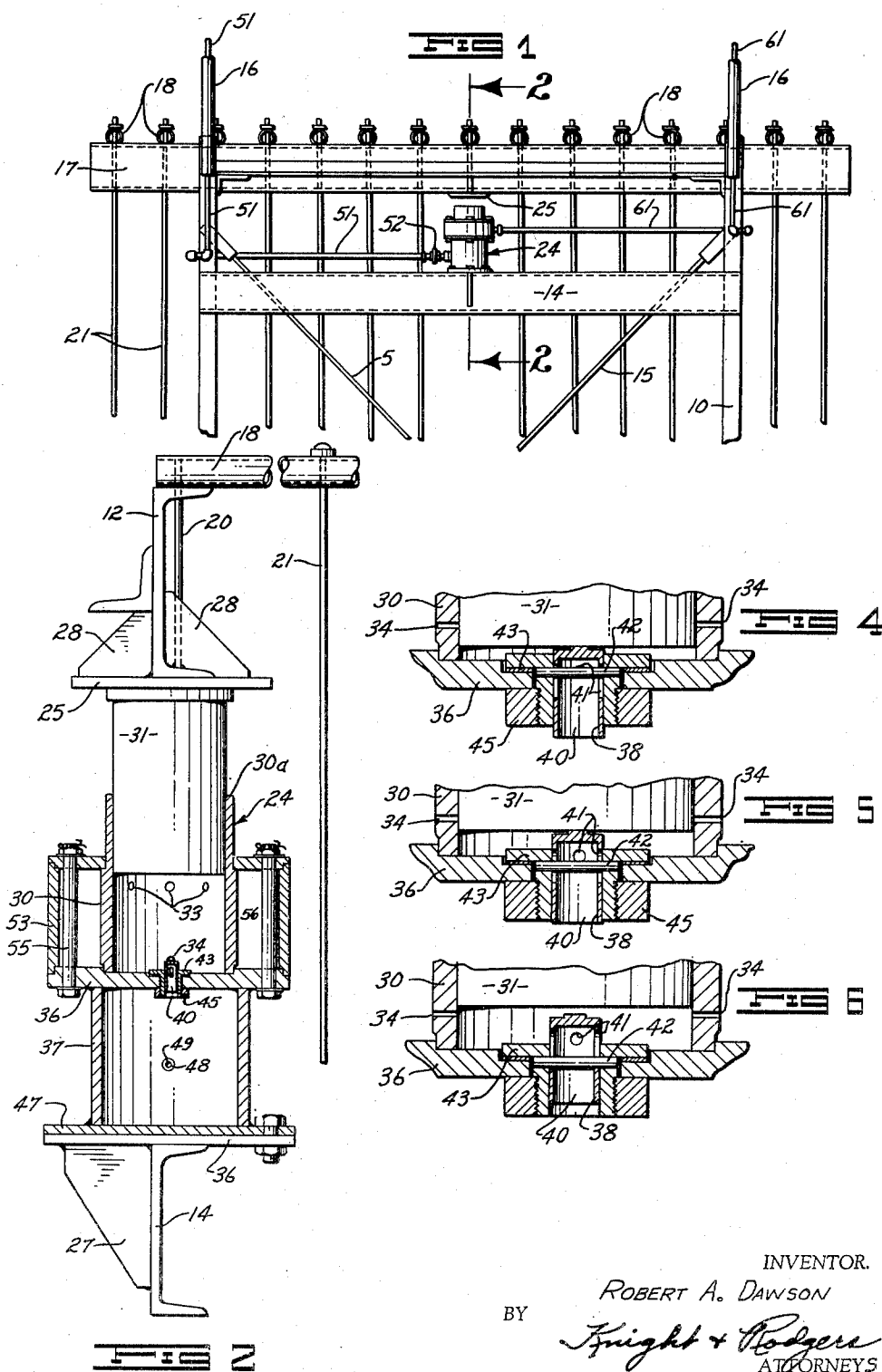
May 15, 1951

R. A. DAWSON
APPARATUS FOR RAPPING ELECTRODES IN
ELECTRICAL PRECIPITATORS

2,552,771

Filed Oct. 26, 1948

2 Sheets-Sheet 1



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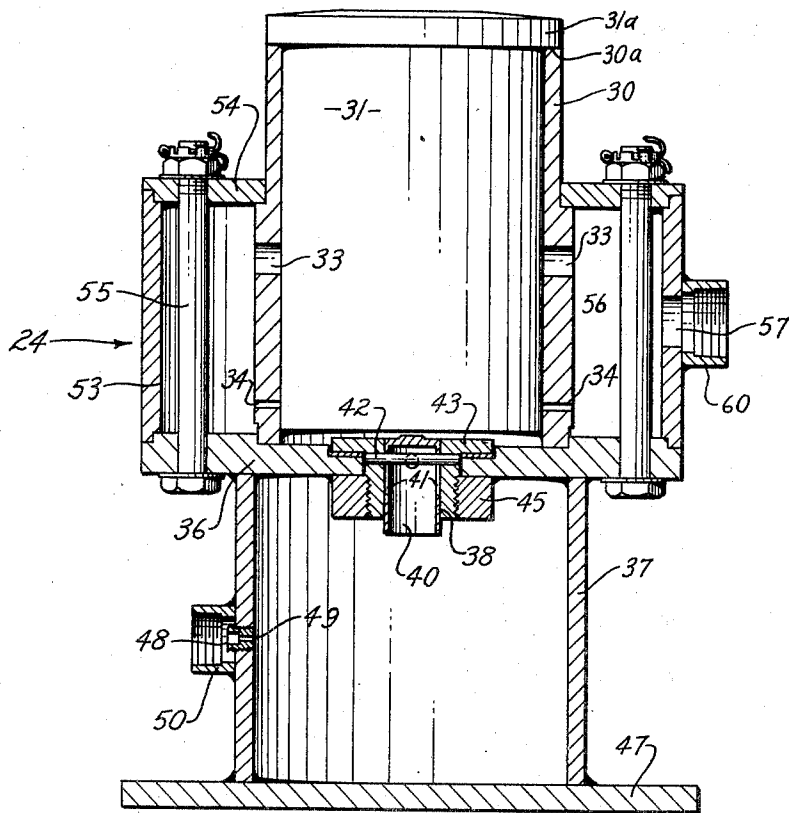
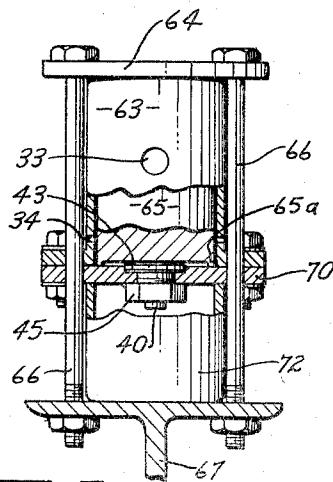


FIG. 1



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UNITED STATES PATENT OFFICE

2,552,771

APPARATUS FOR RAPPING ELECTRODES IN
ELECTRICAL PRECIPITATORS

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Application October 26, 1948, Serial No. 56,654

9 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 improvements in pneumatic rapping devices for cleaning electrodes in the precipitator of accumulations of dust.

In electrical precipitators of this type, a 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 then 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 beneath the electrode and is usually collected in the bottom of the shell or housing of the precipitator which is formed as a hopper for this purpose.

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 a type having a plurality of electric fields. A conventional and formerly widely used method of rapping an electrode is to deliver blows to the electrode assembly by a manually operated mechanism. This method has very distinct disadvantages which have resulted in the development of automatically operated mechanisms for rappers which are adapted to actuate the rapping mechanism at fixed intervals of time. Some of these automatic mechanisms have involved complicated timing valves or other timing devices which are expensive to construct and to maintain, and in some cases are not sufficiently reliable in operation to be entirely satisfactory.

These considerations have led to the development of a self-timing pneumatic rapper which is entirely self-contained and dispenses with external timing valves. Rappers of this type are disclosed in the co-pending applications of Floyd H. Viets, Ser. No. 715,020, filed December 9, 1946, for "Pneumatic Method and Apparatus for Rapping Electrodes in Electric Precipitators" (now Patent 2,525,325, dated October 10, 1950), and Ser. No. 782,076, filed October 25, 1947, for "Ap-

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paratus for Introducing Air to an Insulated Electrode Structure in an Electrical Precipitator" (now Patent 2,526,715, dated October 24, 1950). Reference may be made to these co-pending applications for additional details relative to installation, construction, and operation of self-timing pneumatic rappers of the type herein disclosed. Certain features and the method of operation disclosed herein are claimed in these earlier applications.

A pneumatic rapping mechanism of this character comprises generally a cylinder attached to the electrode assembly with a freely movable piston therein, the cylinder being provided with an inlet for fluid under pressure from a fluid reservoir or other suitable source. When the pressure within the reservoir reaches a predetermined value, the piston is raised thereby and fluid under pressure is admitted to the cylinder to drive the piston toward the end of the cylinder. Satisfactory and continued operation of this device depends upon proper control of air passing from the reservoir into the cylinder.

In the co-pending applications referred to above, the passage of air into the cylinder is stopped by the piston resting on the cylinder end wall, cooperating valve faces being placed on these two parts. Some difficulty has been encountered in obtaining air-tight engagement of these surfaces, and especially to maintain it after extensive operation because wear on the valve faces permits air to leak past them into the cylinder. In this type of rapper the hammer falls under gravity after the upward rapping blow is struck; and wear of the sealing surfaces takes place at the end of the return stroke. Experience has indicated that the pressure-tight engagement of the surfaces can be greatly extended in life if these surfaces are not subjected to impact from the falling hammer; and as a consequence operation of the hammer is improved and maintenance greatly decreased.

Hence it becomes a general object of my invention to insure regular and uniform operation of self-timing rappers for electrodes of electrical precipitators.

It is another object of my invention to provide means for controlling the flow of fluid under pressure into the cylinder which is simple in construction, yet effective for the intended purpose and able to operate over an extended period of time without maintenance or replacement. Simplicity of construction has the added advantages that the device is simple and easy to maintain and repair.

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These and other objects of my invention are attained in a rapping device of the character described above by providing a sliding-type valve means to control fluid movement through the inlet to the cylinder. The inlet port is closed by the sliding valve means, which can be moved to open position by a predetermined fluid pressure in the reservoir. The valve means is capable of limited movement in response to such pressure without opening the port. When the upward force applied to the valve by gas pressure within the reservoir exceeds the weight of the piston, the valve moves to the open position, following which gas pressure is applied to the full area of the underside of the piston and the piston lifts rapidly, delivering a solid rapping blow of a type peculiarly effective in removing adhering dust deposits on the electrode. After the piston has lifted to a point where the exhaust ports are uncovered, the pressure within the cylinder drops rapidly, allowing the piston to return to a rest position. The hammer is designed so that the force of the falling piston is not delivered to the valve assembly, but the energy is dissipated by engaging the cylinder. When in its rest position, the piston is supported independently of the valve member by cooperating means on the cylinder and piston, but engages the valve member and holds it closed against the force exerted by the fluid pressure from the reservoir until the pressure within the reservoir again builds up to a predetermined value sufficient to raise the piston and open the valve.

When at rest, the piston may be supported at either end by cooperating means on the piston and cylinder. In a preferred form of my invention, the piston has a flange at its upper end which is adapted to seat upon the upper end of the open cylinder. In this form, the piston does not engage the bottom of the cylinder but is sufficiently long to hold the valve closed when the peripheral flange is seated on the cylinder wall. In a modified form of my invention, the lower end of the piston is recessed so that the piston is supported at points around its periphery on the bottom wall of the cylinder and at a position centrally of the piston engages the valve to hold it closed when the piston is in the rest position.

The fluid reservoir has an inlet of relatively small diameter so that an appreciable length of time, say several seconds, is required to completely fill the reservoir and bring its pressure up to the pressure of the fluid supply line. Ordinarily the predetermined pressure at which the valve into the cylinder opens is somewhat lower than this maximum pressure, but it still takes several seconds for the pressure within the reservoir to build up to this predetermined operating value. Control of this interval of time or of the rate at which the reservoir fills determines the frequency of blows delivered by the piston for any given installation.

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 elevation of the upper end of a collecting electrode assembly showing a self-timing pneumatic rapper mounted on the assembly;

Fig. 2 is an enlarged vertical section on line 2—2 of Fig. 1;

Fig. 3 is a further enlarged vertical section of a rapper viewed at 90° to the plane of Fig. 2 show-

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ing the pneumatic rapper only, and with the piston in the rest position;

Figs. 4, 5, and 6 are fragmentary sections similar to Fig. 3, showing successive positions of the valve and piston; and

Fig. 7 is a combined elevation and partial section through a modified form of pneumatic rapper showing the cylinder with a closed end.

In order to fully illustrate my invention, there is shown in Fig. 1 a portion of the discharge electrode assembly of an electrical precipitator which is typical of industrial precipitators for collecting dry solids suspended in a stream of gas. As the construction and arrangement of the various parts of electrical precipitators are well known to persons skilled in the art, it is believed that a description of the details of the precipitator itself is unnecessary here except for a typical illustration of how the pneumatic rapping device is attached to an electrode assembly. Therefore, it will be understood that my invention is in no way limited to the particular electrode construction shown herein, but may be applied equally well to collecting or discharge electrodes of other constructions than shown herein. Various modifications of the location and attachment of the rapper are within the scope of persons skilled in the art.

Fig. 1 illustrates the upper portion of a high-tension electrode assembly viewed from one end of a precipitator, so that the direction of gas flow is perpendicular to the plane of the drawing. The assembly comprises a pair of upright angles 10 which are interconnected at their upper ends by horizontal channels 12 and 14. The lower ends of angles 10 are likewise connected by a horizontal member similar to channel 12 but not shown in the drawings. Diagonal bracing 15 is added to give desired rigidity to the assembly. These structural members compose a framework which extends transversely of the gas stream and is suspended by hangers 16 from suitable insulated supports, not shown. Hangers 16 may be any type of structural member, but are preferably hollow tubes in order that at least one of the hangers may be used as a means for introducing the compressed air line. The details of this construction are illustrated and claimed in co-pending application Ser. No. 782,076 (now Patent 2,526,715) referred to above.

Horizontal channel 12 supports one end of a plurality of pipes 18 in a manner shown best in Fig. 2. Channel 12 has a plurality of pins 20 which extend a short distance above the top edge of the channel and serve as individual supports for horizontally extending pipes 18. The pipes are drilled on one side only near the end in order that a pin 20 can pass through the wall of the pipe and rest against the inside face of the upper wall of the pipe, as shown in Fig. 2. Each pipe 18 supports a plurality of individual high-tension electrodes 21 which are spaced at intervals along the pipe. Electrodes 21 are wires or twisted members of relatively small diameter suspended from a pipe 18, as shown in Fig. 2.

Horizontal channel 14 is located directly below the upper channel 12 the proper distance so that the rapping device, indicated generally at 24, can be mounted upon the lower channel and yet strike against an anvil plate 25 mounted on the under side of channel 12. Although the rapper 24 can be fastened directly to channel 14, it is preferred that it be rigidly mounted, as by bolts or other fastening means, to plate 26 which is fastened to the top of the channel by welding and reinforced by bracket 27. Anvil plate 25

is similarly fastened to the under side of channel 12 and reinforced by brackets 28.

Rapper 24 comprises cylinder 30 within which piston 31 is freely movable relative to the cylinder. Cylinder 30 is open at its upper end, and the top end of the cylinder provides a continuous annular seat 39a upon which peripheral flange 31a of piston 31 is adapted to seat when the piston is lowered in the cylinder to the rest position shown in Fig. 3. Flange 31a is located at the upper end of the piston and is larger than the internal diameter of cylinder 30 so that engagement of the flange with the cylinder wall limits downward movement of the piston relative to the cylinder. Thus the piston is supported on the cylinder when in the normal or rest position.

Cylinder 30 is ordinarily located with its longitudinal axis extending upwardly, as shown in the drawings. This is done so that the piston is returned by gravity from the raised position at the end of the stroke, as shown in Fig. 2, to the rest position of Fig. 3. For other reasons which are discussed later, the cylinder and piston are substantially the same length so that the cylinder surrounds substantially all of the piston; but this general proportion of parts is also desirable in order to obtain a maximum amount of guiding action by the cylinder and also permit a reasonable length of stroke. Otherwise special guide means must be provided in order to insure the proper return of the piston into the cylinder. Hammer piston 31 is a loose sliding fit within the cylinder. The normal clearance between the piston and the cylinder wall is preferably approximately $\frac{1}{100}$ of an inch, but it may be changed keeping in mind that the operation of the hammer is modified appreciably if this clearance is rendered excessively large.

The side walls of cylinder 30 are provided with fluid exhaust or outlet ports 33 located just below the piston at the upper range of its travel. Ports 33 are here shown as being six in number; and their aggregate area is sufficiently large to insure rapid exhaust of fluid under pressure from the cylinder at the end of the piston stroke. Near the bottom of the cylinder walls are one or more bleeder ports 34 which are considerably smaller in diameter so that their aggregate area is not great enough to detract substantially from the force delivered to the piston by the fluid under pressure.

The lower end of cylinder 30 is closed by plate 36 which separates the interior of cylinder 30 from the interior of reservoir 37, but has a bore 38 connecting the interior of cylinder 30 with reservoir 37, through which bore fluid leaves the reservoir and enters the cylinder. Inlet port 38 is closed by valve means of the sliding type, here shown as being cylindrical sleeve 40 which is adapted to slide longitudinally within bore 38.

Valve member 40 is a hollow member closed at its upper end and open at its lower end. The side walls of the valve are pierced by a plurality of openings 41. Two oppositely disposed openings 41 are elongated and through them passes pin 42 which is held in valve guide 43. Valve 40 is free to slide up and down within passage 38 and its movement is limited by pin 42, the range of movement being determined by the length of the elongated slots 41. Valve 40 is a close sliding fit within inlet 38, sufficiently so that air under pressure does not leak out of reservoir 37 into the upper cylinder when the valve is lowered within the inlet.

The valve assembly is held in place by threaded

engagement of valve guide 43 with stationary nut 45 which is welded or otherwise attached to the under side of plate 36. A metallic washer 46 is preferably used to insure an air-tight fit between the guide 43 and plate 36.

Beneath cylinder 30 and plate 36 is located fluid pressure reservoir 37, which is conveniently made circular in cross section. The lower side of reservoir 37 is closed by plate 47 which forms a base by which rapper 24 is mounted on plate 26, as shown in Fig. 2. At a convenient point in a side wall, reservoir 37 is provided with a threaded plug 48 which has a small diameter bore 49 drilled longitudinally of it. Bore 49 provides an inlet orifice for fluid under pressure entering reservoir 37, and is only a few hundredths of an inch in diameter in order to meter the flow of fluid into the reservoir. By providing the inlet orifice in a threaded plug as shown, plug 48 can be quickly replaced with another one in order to change the size of the orifice as desired.

On the exterior of reservoir 37 and surrounding plug 48, is located a pipe union or coupling 50 to which the fluid supply line 51 (shown in Fig. 1) is attached in order to supply compressed air or other suitable fluid under pressure to the rapping device. It is within the scope of my invention to provide a filter 52 in the air supply line at some suitable point ahead of orifice 49 in order to strain out solid particles which might clog the orifice. This filter can be of fiberglass or any other suitable material conventionally used in filters.

When the rapper is on a high tension electrode assembly as in Fig. 1, it is preferable to have the supply line 51 pass through a hanger 16, as described in greater detail in the co-pending applications referred to above.

Although it is possible to vent exhaust ports 33 and bleeder ports 34 directly to the interior of the precipitator, it is ordinarily preferred not to do this because of the fact that dust carried by the gas stream and corrosive gases, if present, can enter the ports during periods of idleness and cause corrosion or increased wear of the parts. The reduction of useful life of the hammer from this cause is quite appreciable under many circumstances. To overcome this difficulty, it is desired to provide a shell or housing around the cylinder into which the ports 33 and 34 exhaust.

This housing may take other forms than the one shown herein, but in Fig. 3 it typically comprises a cylindrical member 53 which rests at its lower edge on plate 36 and is in engagement at its upper edge with plate 54, which latter plate also seats on a shoulder on the exterior surface of cylinder 30, as shown. The entire assembly is held rigidly in place by a plurality of bolts 55 which draw plates 54 and 36 together and force the bottom end of cylinder 30 into fluid-tight engagement with its seat in plate 36. The annular space 56 between shell 53 and cylinder 30 is an exhaust chamber into which the cylinder exhausts spent fluid. This fluid leaves exhaust chamber 56 through an outlet port 57.

The enclosed exhaust chamber may provide adequate protection for the cylinder under some circumstances; but where it is desired to provide additional protection, as is especially the case where the precipitator is treating corrosive gases, a pipe union or coupling 60 is fastened to the outside of housing 53 over outlet port 57. An exhaust line 61 is then attached to coupling 60, as shown in Fig. 1. Exhaust line 60 passes up-

wardly through an electrode assembly hanger 15 and opens to the atmosphere outside the precipitator shell. In this way, gas from the stream within the precipitator is entirely excluded from the interior of rapper 24 and the working parts come into contact only with clean filtered air introduced through supply line 51.

Having described the construction of a preferred form of my invention, I shall now describe its operation. The air supply line 51 is connected to a suitable source of compressed air, or any other fluid adapted to this same purpose, such as the reservoir of a conventional compressor unit. Flow of fluid through supply line 51 is continual during any rapping period during which hammer 24 is in operation; but since it is ordinarily sufficient in rapping to strike the electrode assembly with several blows and then wait for an interval of several minutes before repeating this rapping, there may be provided in supply line 51 suitable valve means, not shown, for periodically shutting off the continuous flow of air through the supply line. For additional details of this apparatus, reference may be made to Viets application, Ser. No. 715,020 referred to above.

Compressed air from supply line 51 passes through metering orifice 49 into reservoir 37 from which it cannot escape when sleeve valve 40 is lowered and closes passage 38. Assuming the initial pressure within reservoir 37 to be substantially atmospheric, as it is after the end of each operating stroke of the hammer piston, air pressure within the reservoir builds up as air enters through port 49. Because the area of port 49 is so very small, pressure within the reservoir builds up slowly; and, if no air were removed from the reservoir, it would require several seconds to completely fill the reservoir, that is to bring the pressure within the reservoir up to the pressure of supply line 51. The length of time required can obviously be controlled by controlling the size of metering orifice 49.

However, the hammer is designed to operate at some predetermined pressure within reservoir 37 which is lower than the pressure within supply line 51. By way of typical example, if the supply line pressure is in the neighborhood of 75 to 80 pounds per square inch, the hammer is designed to operate at a reservoir pressure in the neighborhood of 40 to 50 pounds per square inch. Metering orifice 49 is sufficiently small that it requires several seconds to fill up reservoir 37 to this predetermined operating pressure from substantially atmospheric.

When the air pressure is the same on both sides of the valve 40, it seats fully by gravity as shown in Fig. 3 and is supported in place by engagement with pin 42. As the first effect of increased pressure within reservoir 37, valve 40 rises slightly because of the increased pressure on its under side until it comes into engagement with hammer 31, as shown in Fig. 4. The valve can rise no further now because the weight of the hammer is sufficient to hold down the valve which is still in the closed position in which valve 40 prevents the flow of fluid from the reservoir through inlet 38 into the cylinder. When the predetermined operating pressure is reached in the reservoir, the pressure on the under side of valve 40 is sufficient to raise piston 31; and the piston moves upwardly relatively slowly until the valve reaches the position of Fig. 5 in which it has lifted sufficiently that the upper end of openings 41 are at the top edge of valve guide 43. After the valve moves beyond this position so that openings 41

open into cylinder 30 above guide 43, air can flow from the reservoir through the hollow interior of the valve and outwardly through ports 41 into the lower end of the cylinder and fill the space inside the cylinder beneath piston 31. The piston is now exposed to air pressure over its entire lower end surface and moves upwardly as in Fig. 6 in which valve 40 is shown as fully open.

The unit pressure against the end surface of the piston is but slightly less than the predetermined pressure within the reservoir at which valve 40 opens because the additional space into which the compressed air has expanded is relatively small. Consequently the piston is driven upwardly with a relatively great force and strikes a sharp, vigorous blow against anvil 25, reaching at the end of its upward stroke the position shown in Fig. 2.

Exhaust ports 33 are located in the walls of cylinder 30 slightly below the lower end of the piston when it has reached the extreme upward range of travel shown in Fig. 2. In this way the ports are covered during most of the forward or upward travel of the piston, but are fully uncovered to allow the escape of air from the cylinder when the piston reaches the end of its stroke. When ports 33 are uncovered, the air within the cylinder rapidly exhausts through them into chamber 56, sufficiently reducing the pressure within the cylinder that piston 31 is able to return, under the influence of gravity, to the rest position of Fig. 3.

Bleeder ports 34 are located near the bottom of the cylinder, but sufficiently far up on the walls that they remain fully covered by the piston until valve 40 is fully opened (Fig. 6). Of course these ports cause some diminution in pressure during the upward travel of the hammer, but they are sufficiently small that this decrease in pressure is not substantial as compared with what the pressure would be if ports 34 were not present. The primary function of ports 34 is to permit escape into chamber 56 of air trapped within the lower part of the cylinder on the downward stroke of the piston after it seals off exhaust ports 33. For this purpose, the size of ports 34 is large enough that a slight cushioning effect is produced on the falling piston but at the same time the piston is permitted to drop at once to a fully seated position with its peripheral flange 31a in engagement with the seat 30a provided by the upper open end of the cylinder. It is possible to omit ports 34, but in this case it is necessary to provide somewhat greater clearance between the piston and the cylinder walls in order that the air trapped beneath the piston can flow by and escape either at the principal exhaust ports or at the upper end of the cylinder. This increased clearance is not preferred because it permits air to leak around the piston during the power stroke and also causes the cylinder walls to wear more rapidly.

When at the end of the power stroke air pressure is equalized between the cylinder and air reservoir 37, valve 40 returns to the closed position under the influence of gravity. If for any reason the valve does not previously close, the falling piston engages the raised valve and pushes it downwardly to a closed position, the weight of the piston being sufficient to accomplish this even though the air pressure is higher in the reservoir than in the cylinder. Thus the piston operates not only to hold the valve closed but also, if necessary, to close the valve. In order to control the valve, the piston is sufficiently long

axially that it engages the valve and holds it in a closed position even when seated at 30a on the cylinder. It can also engage the valve when above the closed position and move it to that position.

In practice it has been found desirable that the hammer be operated at the rate of from twelve to twenty-four blows per minute, that is, the interval between power strokes of the piston is about three to five seconds. This frequency of blows is established by the relationship of various weights and areas and can be changed by any one of several factors, but it may be summarized as being determined by the rate at which air flows through orifice 49 to fill the reservoir and the force required to lift the valve and piston to open valve 40. The frequency of operation being inherent in the design, it is maintained within narrow limits once the design has been established; and for this reason the rapping device has been termed "self-timing." Ordinarily, it is unnecessary that rapping of the electrode assembly be continued over any extensive period of time, as it is only necessary to strike a sufficient number of blows to loosen accumulated deposits on the electrodes and then to cease rapping until deposits have accumulated again to an extent to impair efficiency of the electrodes, at which time rapping should again be instituted.

There is shown in Fig. 7 a modified form of my invention which is designed according to the same general principles and operates in the same fashion as described above, with the exceptions specifically pointed out below. In this form cylinder 63 is closed at both ends, the upper end of the cylinder being closed by plate 64 which also serves as an anvil against which piston 65 strikes when it is driven upwardly. The shock delivered to anvil plate 64 is transmitted through bolts 66 to I-beam 67 upon which the rapper is mounted. This particular type of construction is especially adapted to mounting on collecting electrodes, not shown in the drawing but ordinarily suspended from I-beam 67. In order to transmit the shock of the blow with relatively high efficiency, bolts 66 are tightened up to place them under tension.

Piston 65 is made of uniform diameter throughout its length so that it is necessary to provide other means for supporting the weight of the piston independently of valve 40. In order to accomplish this support of the piston, the central portion of the piston is recessed, as shown in Fig. 7. This results in an annular surface or flange 65a, adjacent the periphery of the piston, which engages plate 70 that closes the lower end of cylinder 63. The annular flange 65a need not be continuous, although it is preferable that it be continuous in order to provide the maximum amount of surface engaging end plate 70.

The depth of the recess is such that when the piston is in the rest position of Fig. 7 with flange 65a engaging plate 70 to support the weight of the piston, none of the piston weight rests directly upon valve 40. However, in this position when valve 40 is raised by pressure in reservoir 72 the valve engages the piston before it reaches an open position permitting air to enter the cylinder from the reservoir. In this way the piston acts as previously described to hold the valve in a closed position to prevent flow of pressure fluid into the cylinder at less than a predetermined pressure in the reservoir at which the piston is raised and the valve opened.

The modification shown in Fig. 7 further

illustrates a form of my invention in which exhaust chamber 56 and housing 53 have been omitted. This may be done when the rapper is located outside the stream of dust-laden gas, as is often the case with rappers on collecting electrodes.

It will be obvious from the foregoing that plate 70 could be centrally recessed to lower the valve from its present position sufficiently that the piston can have a flat lower end and still engage plate 70 only over an annular area, as in Fig. 7. This is simply a transfer of the piston recess, or flange 65a, to the end plate of the cylinder.

Having described certain embodiments of my invention, it will be apparent that various changes in construction and arrangement of the parts may be made by persons 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 considered as illustrative of, rather than limitative upon, the appended claims.

I claim:

1. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder with its longitudinal axis extending upwardly, the cylinder having an outlet port in a side wall and an inlet port in the bottom wall communicating with a fluid pressure chamber; sliding valve means at the inlet port adapted to open the inlet port when in raised position and to close the inlet port when in lowered position; and a fluid-pressure actuated piston freely movable vertically relative to the cylinder and when in rest position adapted to close the outlet port and to hold the valve means in closed position to prevent inflow of fluid at less than a predetermined pressure of fluid in said chamber.
2. A pneumatic rapping device for an electrode assembly, comprising: a cylinder mounted on the electrode assembly with its longitudinal axis extending upwardly, the cylinder having an outlet port in a side wall and an inlet port in the bottom wall; a fluid pressure reservoir beneath and communicating with the cylinder through the inlet port; a vertically movable valve member regulating fluid flow through the inlet port and movable between an upper position in which the inlet port is open and a lower position in which the inlet port is closed and capable of limited vertical movement without opening the inlet port; and a fluid-pressure actuated piston freely movable vertically relative to the cylinder and when in rest position adapted to close the outlet port and to hold the valve member in closed position to prevent inflow of fluid at less than a predetermined pressure of fluid in said reservoir.
3. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder with its longitudinal axis extending upwardly, the cylinder having an outlet port and an inlet port communicating with a fluid pressure chamber; a sleeve valve slidably mounted at the lower end of the cylinder to open and close the inlet port and movable upwardly to open position in response to fluid pressure in said chamber; and a fluid-pressure actuated piston freely movable vertically relative to the cylinder and when in lowered rest position adapted to hold the valve means in lowered closed position to prevent inflow of fluid at less than a predetermined pressure of fluid in said chamber, the piston having an area exposed to fluid pressure in the cylinder that is several times the area of

the sleeve valve exposed to fluid under pressure tending to open the valve.

4. A rapping device as in claim 2 in which the reservoir has a fluid inlet of such small size that several seconds are required to raise fluid pressure therein to said predetermined value after each release of fluid from the reservoir.

5. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder open at the upper end and having an inlet port at the other end; valve means at the lower end of the cylinder adapted to open and close the inlet port, said valve means comprising a vertically movable valve member movable to a raised position in response to fluid pressure outside the cylinder in which the valve member opens the port and projects into the cylinder and movable to a lowered position in which the valve member closes the port and is substantially all below the end of the cylinder; a fluid-pressure actuated piston freely movable relative to the cylinder and provided with a flange at the upper end having a diameter larger than the internal diameter of the cylinder, the flange when seated on the upper end of the cylinder supporting the piston in its rest position; the piston being of sufficient length axially to engage and hold the valve means in a lowered closed position when the piston is in said rest position; and a fluid reservoir communicating with the cylinder through the inlet port and having a fluid inlet of relatively small diameter so that when fluid under pressure is supplied continuously thereto several seconds are required to fill the reservoir.

6. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder with its longitudinal axis extending upwardly and having an inlet port formed by a bore located in the end wall of the cylinder and communicating with a fluid pressure chamber; a sliding valve member in the port having a fluid passage opening at one end to a surface of the valve member that slidably engages the end wall, the bore wall covering the fluid passage to close the port when the valve member is lowered and uncovering the passage to open the port when the valve member is raised in response to pressure in said chamber, the valve member being capable of limited movement while keeping the port closed; and a fluid-pressure actuated piston freely movable relative to the cylinder, said cylinder and piston having cooperating means other than the valve member to support the weight of the piston in a rest position in which the piston engages the valve to hold it in a lowered closed position, the valve member being capable of downward movement to a position out of engagement with the piston in said rest position.

7. In an electrical precipitator, a rapping device for an electrode assembly, comprising: a cylinder mounted on the electrode assembly with its longitudinal axis extending upwardly, the cylinder having a pair of outlet ports and an inlet port communicating with a fluid pressure chamber; a valve member slidably mounted to open and close the inlet port, and capable of limited sliding movement without opening the inlet port; and a fluid-pressure actuated piston

freely movable relative to the cylinder and when in rest position adapted to close said outlet ports and to hold the valve member closed to prevent inflow of fluid at less than a predetermined pressure of fluid in said chamber; one of said outlet ports being of relatively large diameter to exhaust fluid rapidly from the cylinder and located near the upper end of the cylinder to be uncovered by the piston near the end of its upward stroke, and the other of said outlet ports being of relatively small diameter and located near the bottom of the cylinder to be uncovered after relatively short movement of the piston above the rest position.

8. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder mounted with its longitudinal axis extending upwardly, the cylinder having an outlet port in a side wall and an inlet port in the bottom wall communicating with a fluid pressure chamber; a fixed valve guide in the bottom wall of the cylinder having a bore; a valve member slidable in the guide bore with an exterior surface in sealing engagement with the guide bore wall and provided with a fluid passage communicating with said pressure chamber and opening at one end to said exterior surface of the valve member to communicate with the cylinder when the valve member is raised relative to the valve guide, the fluid passage being closed to the cylinder by the bore wall when the valve member is lowered in the valve guide; and a fluid-pressure actuated piston freely movable vertically relative to the cylinder and when in lowered position in the cylinder adapted to hold the valve member in lowered position to prevent inflow of fluid at less than a predetermined pressure of fluid in the pressure chamber.

9. In a pneumatic rapping device for an electrical precipitator, the combination comprising: a cylinder mounted with its longitudinal axis extending upwardly, the cylinder having an outlet port in a side wall and an inlet port formed by a bore in the bottom wall communicating with a fluid pressure chamber; sliding-type valve means comprising a valve member in said bore, the valve member having a fluid passage in communication at one end with the fluid pressure chamber and being slidable in the bore between a raised open position in which the other end of the fluid passage communicates with the cylinder and a lowered closed position in which the bore wall closes said other end of the fluid passage; and a fluid-pressure actuated piston freely movable vertically relative to the cylinder and when in lowered position in the cylinder adapted to hold the valve member in lowered position to prevent inflow of fluid at less than a predetermined pressure of fluid in the pressure chamber.

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