April 24, 1962 J. W. PENNINGTON 3,030,753

RAPPER

Filed April 10, 1958

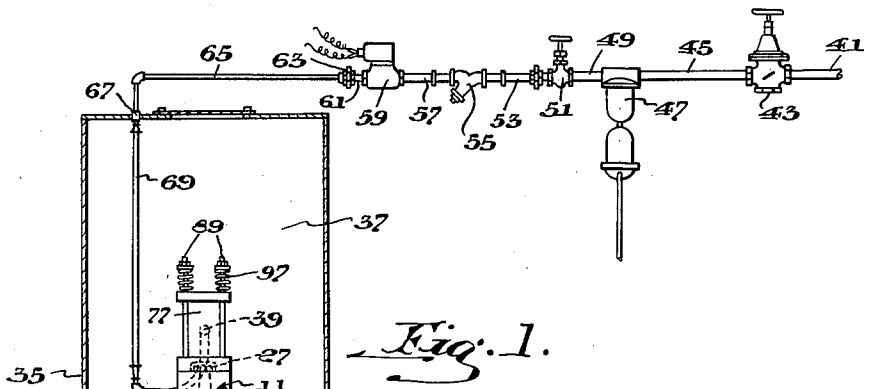


Fig. 1.

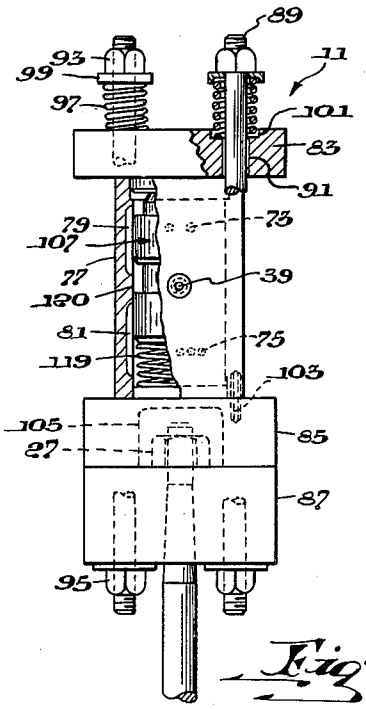


Fig. 2.

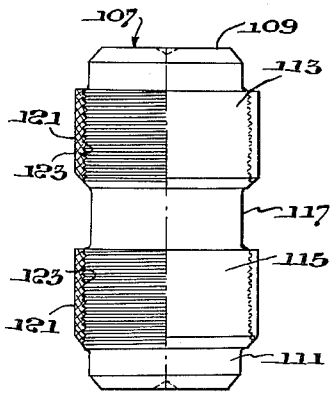


Fig. 3.

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RAPPER

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This invention relates to an electrostatic precipitator and particularly to a pneumatic rapper for electrode structures of electrostatic precipitators.

Conventionally, impulse rappers of the mechanical, pneumatic or electromagnetic types have been used to effect transient vibrations of high intensity in electrodes suspended in the prevailing particle-laden gas flow in electrostatic precipitators. These vibrations cause the material deposited on the electrodes to fall into a hopper at the bottom of the precipitator. The rappers as known heretofore, however, often supplied the electrode with vibrations that were too intense, thus causing the material deposited on the electrodes to break up into very fine particles. Accordingly, much of the material which vibrated loose from the electrodes was re-entrained in the prevailing gas stream in the precipitator and carried out of the precipitator.

It has been discovered, according to this invention, that rappers which cause vibrations of more continuous duration and lower intensity are advantageous for vibrating the electrodes because such rappers effectively remove deposited material from the electrodes and greatly reduce re-entrainment of the loosened material in the gas.

An object of the invention, therefore, is to provide the electrodes of an electrostatic precipitator with a rapper having a novel rapping motion and provision for keeping dislodged material from re-entering the gas stream.

Another object is to provide such a rapper which requires no lubrication.

This invention contemplates a novel rapper that is pneumatically actuated for rapidly reciprocating a hammer in a rapper housing to effect vibrations of low intensity and high frequency to the suspended electrodes of an electrostatic precipitator and has a provision for lowering the friction between the hammer and the housing so that lubrication is not required. In another aspect, this invention contemplates applying, with the aid of an epoxy resin, a low friction material to the hammer of the rapper so as to form a firmly bonded veneer which requires no lubrication.

The above and further objects and novel features of the invention will appear more fully from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are not intended as a definition of the invention but are for the purpose of illustration only.

FIG. 1 shows a partial cross-section of an embodiment of the novel rapper of this invention connected to a resiliently mounted electrode of an electrostatic precipitator.

FIG. 2 is a partial cross-section showing details of the novel rapper of FIG. 1.

FIG. 3 shows a partial cross-section of the hammer of FIG. 2.

Referring to FIG. 1, the novel rapper **11** or vibrator, as it is sometimes called, is connected to an electrode **13**. Conventionally, electrode **13** has wires or plates (not shown) suspended therefrom in the path of a prevailing particle-laden gas stream passing through a precipitator shell **15** under pressure. Electrode **13** is supported by a nut **17** that is locked to electrode **13**, as by a nut **19**, and rests on a resilient spring **21** interposed between a plate **23** and the nut **17**. Plate **23** is attached to the top of an insulator **25** which, by suitable means well known in the art, is mounted on the outside of the shell **15**.

Rapper **11** is rigidly connected to the collecting electrode **13** by means of a suitable nut **27** threaded on the top of the electrode **13**. The electrode **13** extends into the precipitator shell **15** through a suitable hole **29** in plate **23** and a hole **31** in the precipitator shell **15**. The diameter of hole **31** substantially corresponds to the inside diameter of the insulator **25**. A conventional tubular sparking shield **33** is suspended from the inside of shell **15** around electrode **13**. The electrode **13** and the rapper **11** are thus electrically insulated from the shell **15** as well as being resiliently supported so that vibrations are transmitted from the rapper **11** to the electrode **13** without undue damping effects in the electrode supporting structure as would be present with conventional rigid supports for the electrode.

Housing **35** surrounds the rapper **11** and insulator **25** with a chamber **37** and prevents the leakage of gas from the inside of the precipitator shell **15** to the atmosphere. The housing **35** may also have a conventional insulator (not shown) attached through the side thereof in a fluid-tight manner and a conventional electrical connection may be held in this insulator in a conventional fluid-tight manner so that this electrical connection may be attached from the electrode **13** to a suitable electrical source (not shown) to give the electrode **13** an electrical potential as required.

Air is supplied to the rapper **11** through a hole **39** in the side of the rapper **11** from a suitable source (not shown) through pipe **41**, regulator valve **43**, pipe **45**, filter **47**, pipe **49**, hand valve **51**, pipe **53**, trap **55**, pipe **57**, solenoid operated valve **59**, pipe **61**, union **63**, pipe **65**, connection **67**, tube **69** and hose **71** which has conventional fittings which are threaded into hole **39** and the end of tube **69**. Suitable pressure gauges (not shown) and drain lines for excess moisture may be supplied in a conventional manner. With the valves mentioned and conventional actuating means therefor air pressure to the rapper **11** may be regulated to obtain desired vibration frequencies and intensities from the rapper. Suitable control means such as a conventional timer may also be provided together with solenoid valve **59** to start and stop the rapping of rapper **11**. This may be done so that the rapper is on and off at suitable intervals.

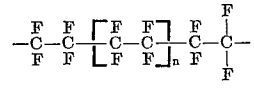
Advantageously air supply tube **69** is suspended from connection **67** to a point in a plane near the bottom of the rapper **11** and the connection **67** is attached to the top of the housing **35** in a fluid-tight manner. The hose **71** is advantageously arranged away from air exhaust ports **73** and **75** (FIG. 2) of the rapper **11**. A rubber hose may extend from connection **67** to hole **39** in the rapper **11**, but in this event, any bend in the hose must not be less than eight inches in diameter to prevent undue restriction in the hose and wear at the fittings for the hose such as would be caused by sharper bends.

Referring now to FIG. 2, rapper **11** comprises a rapper housing **77** hereinafter called a cylinder **77** with external ports **73** and **75** and internal communicating vents **79** and **81**. Cylinder **77** at one end is closed by a plate **83** and the other end is closed by a plate **85** that is in frictional contact with a base **87**. Cylinder **77** is advantageously held within end plates **83** and **85** and base **87** by four rods **89** disposed in four straight-through holes **91**, four top nuts **93**, four bottom nuts **95** and four springs **97** interposed between the nuts **93** and plate **83**. Springs **97** surround rods **89** and abut washers **99** at one end and indentations **101** in plate **83** at the other end. A suitable pin **103** is inserted in both cylinder **77** and plate **85** to prevent their relative movement. One end of the electrode **13** is partially conical in cross-section and this end of electrode **13** extends through a conical opening in base **87** and is secured thereto by nut **27** in a hollow **105** in plate **85**.

A hammer **107** reciprocates within the cylinder **77**. This hammer **107** (FIG. 3) has raised end portions **109** and **111**, bearing lands **113** and **115** and a groove **117** between the lands. Hammer **107** is advantageously made of SA 1030 steel which has been carburized for eight to ten hours at 1700° F., oil quenched at 1600° F., and then stress relieved at 350° F. for three hours. This gives the hammer the required toughness and a Rockwell scale "C" hardness of between 52–58. Other materials, however, may also be used provided they have the necessary toughness and hardness.

A conventional steel coil spring **119** having one end of smaller diameter than the other end contacts the hammer **107** and the plate **85**. The spring end of smaller diameter fits over the bottom raised portion **111** of hammer **107** and the end of larger diameter contacts the inside of plate **85** so that raised portion **111** may strike plate **85**. Thus, spring **119** can exert an upward force on the hammer **107**.

In accordance with this invention, to reduce the friction between the hammer **107** and the inside bearing surface **120** of cylinder **77**, it has been found advantageous to bond glass-filled polytetrafluoroethylene to the lands **113** and **115** and it has been found advantageous to use polytetrafluoroethylene in the form of a suitably treated tape, such as the glass-filled polytetrafluoroethylene tape purchased from the Ethylene Chemical Corp. of Summit, New Jersey. Polytetrafluoroethylene has the chemical structure as follows:



In its polymerized form, polytetrafluoroethylene has the advantageous properties of low coefficient of friction, toughness and flexibility over a wide range of temperatures. The granular polymer is supplied in a powdered form which can be extruded or molded easily in a conventional manner. To give added strength to the polytetrafluoroethylene chopped glass fibers, free of sizing in the amount of about 23% to 25% by weight, are advantageously mixed with powdered polytetrafluoroethylene and this mixture of chopped glass and powdered polytetrafluoroethylene is extruded into a suitable solid shape. This extrusion is skived into a coiled tape whose inside coil is not less than twelve inches in diameter. This coiled tape is then stress relieved by heating to 425° F. for three hours in a conventional oven and thereafter cooled to room temperature in the oven. This glass-filled polytetrafluoroethylene tape is advantageously approximately ¼ to 3/32 of an inch thick as commercially available. If this tape is thinner than 3/32 of an inch it may not wear satisfactorily and if it be thicker than ¼ of an inch the leading edge may flow or stretch in operation. This tape is then formed by cutting into substantially circular rings **121** of ½ to 1 inch widths and of inside diameters corresponding to the outside diameter of the bearing lands **113** and **115**.

To provide optimum results in bonding these glass-filled polytetrafluoroethylene rings **121** to the hammer **107**, the surface of the bearing lands **113** and **115** are threaded with threads **123**. The hammer **107** is then cleaned of any rust, grease, organic coatings or dirt by blasting, as with liquid and fine sand, and dipping the hammer in a volatile solvent such as carbon tetrachloride.

The rings **121** are bonded to the threaded bearing lands **113** and **115** and the ends of the rings **121** are joined with an epoxy resin. For this purpose it is advantageous to use Palmer Products' epoxy resin No. 6035 which is thinned with Palmer Products' thinner No. BS–1022, both being supplied by Palmer Products of Worchester, Pa. The thinned resin is applied to the surface of the bearing lands **113** and **115**, and the rings **121** are held firmly to the bearing lands **113** and **115**, having the epoxy resin thereon, by a conventional sheet metal sleeve and two

hose clamps (not shown). The assembly is placed in a conventional oven for curing at room temperature and brought to 175° F. and maintained at this temperature for five hours. Thereafter, the temperature is raised to 250° F. and maintained at 250° F. for one additional hour. The assembly is then cooled to room temperature, for example, either in the oven or in still air. The cured resin is extremely hard, and advantageously the excessive cured resin, if present, is removed and the glass-filled polytetrafluoroethylene tape, now in the form of a veneer, is finished to size by machining. It has been found that, in bonding the glass-filled polytetrafluoroethylene rings **121** to the hammer **107** in the manner described, no growth in the dimensions of the tape occurs to cause seizing of hammer **107** in cylinder **77**. Rates of wear of the glass-filled polyetetrafluoroethylene rings **121** tend to be constant, uniform and slow so that substantially constant rapper vibration intensities are maintained over long periods of time.

In operation, rings **121** around bearing lands **113** and **115** are in frictional sealing contact with the inside bearing surface **120** of cylinder **77**. When there is no air under pressure being supplied to the rapper **11** through hole **39** the hammer portion **109** is held in contact with the inside of plate **83** by spring **119**. When the hammer **107** is in contact with the plate **83** ring **121** around bearing land **113** covers ports **73** so as to close the upper inside half of cylinder **77** from the atmosphere and air may flow from hole **39** through groove **117** and vent **79** to the upper inside half of cylinder **77**. Also, when hammer portion **109** is in contact with plate **83**, ring **121** around bearing land **115** closes vent **81**, so that air cannot communicate to the lower inside half of cylinder **77** from hole **39** through groove **117** and vent **81**, and ring **121** around bearing land **115** does not cover ports **75** so that the lower inside half of cylinder **77** is vented to the atmosphere through ports **75**. Thus, when the hammer **107** is in contact with plate **83** and air under pressure is supplied through hole **39**, air is supplied through vent **79** to the upper inside half of cylinder **77**, air pressure on the top of hammer **107** increases and air pressure on the lower half of the hammer is vented to the atmosphere. This pressure differential on the hammer overcomes the resistance of spring **119** and the hammer is impelled downwardly so that portion **111** strikes the inside of plate **85**. As the hammer **107** moves downwardly the ring **121** around bearing land **113** uncovers ports **73** so as to communicate the upper inside half of cylinder **77** with the atmosphere and this ring **121** around bearing land **113** also closes the vent **79** so that no air can communicate from hole **39** through groove **117** and vent **79** to the upper inside half of cylinder **77**. Also, as the hammer **107** moves downwardly, the ring **121** around bearing land **115** covers the ports **75** so as to close the lower inside half of cylinder **77** from the atmosphere and opens vent **81** so that air can communicate from hole **39** to the lower inside half of cylinder **77** through groove **117** and vent **81**. Thus when the hammer **107** is in contact with plate **85** and air under pressure is supplied through hole **39** air is supplied through vent **81** to the lower inside half of cylinder **77**, pressure on the bottom of hammer **107** increases and pressure on the upper half of the hammmer is vented to the atmosphere. This pressure differential on the hammer **107** together with the force of spring **119** impels the hammer upwardly so that portion **109** strikes the inside of plate **83**. As long as air under pressure is supplied through hole **39** the hammer will reciprocate rapidly and continuously in the manner described above. Advantageously this reciprocation is repeated at approximately sixty cycles per second. This rate of reciprocation, however, can be varied by increasing or decreasing the air pressure and flow through hole **39** by means of regulator valve **43** and hand valve **51**. This rapid reciprocation of hammer **107** transmits vibrations from the rapper **11** to the electrode **13**. For example, every time the hammer **107** strikes one

of the end plates 83 or 85 the terminal energy of the hammer, which is determined by the mass and final velocity of the hammer is imparted to the electrode 13 via the base 87 so that vibrations are imparted to the electrode 13. Advantageously the intensity of the vibrations thus imparted to the electrode 13 is great enough to remove the deposited material from the electrode 13 but not great enough to cause the removed material to be broken up into fine particles so as to cause re-entrainment. These vibrations can be increased or decreased to the desired intensity by increasing or decreasing the air pressure and flow rate through the hole 39 by means of regulator valve 43 and the hand valve 51.

Tests on hammers having glass-filled polytetrafluoroethylene veneer applied in the above described manner to a hammer which reciprocates, as described, indicate that such a veneer can be used over greatly extended periods of time under normal operating conditions without detrimental effects on the bonded veneer or the cylinder bearing surface. These tests indicate that such pistons give vibrations of substantially uniform intensities at elevated temperatures for long periods of time without any lubrication whatsoever.

What is claimed is:

1. In an electrostatic precipitator for removing particles from a gas stream having elevated ambient temperatures, a casing and a plurality of electrodes suspended within said casing; the improvement comprising means for vibrating said electrodes, said means being a resiliently-mounted vibrator including a cylinder having end-plate closures, a hammer mounted for reciprocation within said cylinder between said end-plate closures and having two spaced raised bearing lands formed thereon, said lands having threadlike grooves formed in the outer surface thereof, each of said bearing lands having a single layer of fiber-filled polytetrafluoroethylene tape bonded to said threaded outer surface for forming a lubricant-free bearing surface, said layer having a thickness between about $\frac{3}{32}$ and about $\frac{1}{4}$ of an inch and means for causing said hammer to reciprocate, said hammer striking said end-plate closures with substantially equal impact.

2. In an electrostatic precipitator for removing particles from a gas stream having elevated ambient temperatures, a casing and a plurality of electrodes suspended within said casing; the improvement comprising means for vibrating said electrodes, said means being a resiliently-mounted vibrator including a cylinder having end-plate closures, a hammer mounted for reciprocation within said cylinder striking said end-plate closures and having two spaced bearing lands formed thereon, said lands having threadlike grooves formed in the outer surface thereof, each of said bearing lands having a single layer of fiber-filled polytetrafluoroethylene tape of approximately $\frac{1}{4}$ to $\frac{3}{32}$ of an inch thickness bonded to said threaded outer surface for forming a lubricant-free bearing surface, means for causing said hammer to reciprocate, said hammer striking said end-plate closures with substantially equal impact and means for controlling the intensity of vibration of said hammer.

References Cited in the file of this patent

UNITED STATES PATENTS

2,030,936	Pickop	Feb. 18, 1936
2,702,090	Brown	Feb. 15, 1955
2,777,535	Hull	Jan. 15, 1957
2,809,130	Rappaport	Oct. 8, 1957
2,817,562	Fleming	Dec. 24, 1957
2,828,236	West	Mar. 25, 1958
2,847,391	Wheeler	Aug. 12, 1958