MAGNETIC IMPULSE RAPPER

John W. Drenning, Baltimore, Md., assignor to Koppers Company, Inc., a corporation of Delaware

Filed Mar. 28, 1958, Ser. No. 724,674

12 Claims. (Cl. 317—191)

This invention relates to electrostatic precipitators having impulse catchers for the electrodes assemblies of the precipitators, and more particularly to a magnetic rapping for such precipitators.

In electrostatic precipitators electrodes are suspended in a precipitator shell and exposed to a prevailing particle-laden gas stream which flows through the shell under pressure. By means of suitable electrical connections some of these electrodes are positively charged and some are negatively charged so as to create an electrical field which ionizes the gas flowing through the shell. By means of this electrical field charges are imparted to the particles and the charged particles are attached to the electrodes having an opposite charge so that the particles cling thereto with great tenacity. Primarily these particles are attracted to the electrodes which are positively charged but some particles also are attracted to the negatively charged electrodes. The gas, free of particles, then flows out of the precipitator. In time, the particles tend to accumulate on the suspended electrodes to such an extent as to reduce greatly the efficiency of the precipitator and to weigh heavily the electrodes and their supporting structures. Periodically, the electrodes are given a series of sharp blows to jar or vibrate loose the accumulated material and loosen accumulated material falls of its own weight downwardly to a hopper at the bottom of the precipitator shell.

Conventionally mechanical and pneumatic impulse catchers have been used to deliver these blows both to the positively and negatively charged electrodes, but an electromagnetic impulse catcher has been found to be more advantageous for this purpose because the magnitude of the blow imparted to the electrode by the electromagnetic rapping can be so easily adjusted to the proper magnitude for cleaning the electrodes. The heretofore known electromagnetic catchers, however, have been undependable or have required costly and frequent maintenance, such as by the frequent addition of lubrication thereunto or the elimination of dirt therefrom. Also the presence of moisture in the rapping environment as well as the dust particles has caused frequent breakdown in the coils of the electromagnetic units known heretofore.

An object of this invention, therefore, is to provide an electromagnetic rapper which requires infrequent or no lubrication.

A further object is to provide an electromagnetic rapper which is sealed from the environment of dirt and dust.

A still further object is to provide a magnetic impulse rapping having a moisture resistant casing for an electromagnetic coil therein.

A still further object is to provide a magnetic impulse rapping which is operable at elevated temperatures.

This invention contemplates an impulse rapping having a separator and a base adapted to be struck by a hammer to supply vibrations to the electrodes of an electrostatic precipitator, an encapsulated electromagnetic actuator for striking the hammer against the separator, a resilient device for biasing the hammer away from the separator, and a nonmagnetic bearing for guiding the hammer, the hammer including an arrangement for communicating air from one end of the hammer to the other, and a further arrangement for reducing the adverse effects of the electromagnetic actuator on the resilient device.

The above and further objects and novel features of the invention will appear more fully 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 is an elevational and partial cross-sectional view of the novel rapper of this invention.

Fig. 2 is an isometric view of the electromagnetic actuator of Fig. 1.

Fig. 3 is a diagrammatic view of theapper of Fig. 1.

Fig. 4 is a partial cross-section of an electrostatic precipitator with the novel rapping of this invention mounted on a supporting structure for the electrodes.

Electrostatic precipitators are frequently subjected to extremely adverse operating conditions. For example, the outside of the shell of an electrostatic precipitator is subjected to air that contains dirt and moisture and that may have a temperature as high as 200° F. And at these temperatures the lubrication conventionally used in magnetic impulse rappers tends to become very thin or otherwise ineffective.

An electrostatic precipitator is shown in Fig. 4 as having an electrode 11 conventionally in the form of a rod to which are attached wires or plates (not shown), and attached by means of suitable nuts 13 to a plate 15 so as to be suspended in precipitator shell 17. The charged particles from a particle-laden gas stream, which is passed through the shell 17, are deposited on electrode 11. Plate 15 is supported by a conventional insulator 19 which is attached to the outside of the precipitator shell 17 by suitable means well known in the art. To the top of the insulator 19 is attached a plate 21 in a manner such that the electrode 11 is suspended through a hole 23 in plate 21 and a hole 25 in precipitator shell 17 which has a diameter substantially corresponding to the inside diameter of the insulator 19. Interposed between plates 15 and 21 are a plurality of resilient springs 29 which are arranged so that the electrode 11 is resiliently supported and electrically insulated from the shell 17.

Housing 31 provides a closed chamber 33 around the top of the resiliently mounted electrode 11 so that there is no leakage of gas from the inside of shell 17 to the atmosphere. This housing 31 also protects the electrode 11 from weather. Housing 31 is mounted in a conventional fluid-tight manner on the shell 17 around the top of the insulator 19 and the electrode 11. A projection 35 at one side of housing 31 supports a conventional ceramic insulator 37, and a conventional synthetic rubber gasket 39, such as a neoprene boot, is supported at the top of housing 31. Both members 37 and 39 are attached to the housing 31 in a fluid-tight manner by means well known in the art. A conventional electrical connection 41 connected from plate 21 through insulator 37 to a suitable electrical power source (not shown) supplies the necessary electrical potential to the electrode 11.

A suitable insulating rod 43 connected by a conventional metallic coupling 45 to the top of the electrode 11 extends through the gasket 39 in a fluid-tight manner from coupling 45 to rapping 47.

In accordance with this invention, rapping 47 transmits impulses to the electrode 11 through rod 43 and coupling 45. This rapping comprises a hollow base 49 having a raised portion 51 thereon and a separator 53 made of annealed non-magnetic stainless steel mounted on raised portion 51 of base 49, a hollow cap 55 attached to the base 49, a magnetic coil 57 encapsulated in a casing 59.
made of a moldable material such as a polyester resin, a bearing 61 in contact with the bore 63 of casing 59, a floating piston 65 having a first portion 67, a second extended portion 69 and opening 71 for communicating air from one end of said piston to the other, a spring 73 substantially surrounding the portion 69 of the piston 65, and a fixed spacer 75 in bearing 61 and interposed between the spring 73 and the base 49.

Referring more particularly to Fig. 1, base 49 has a substantially hollow portion 77 adapted to receive rod 43. The hollow portion 77 and rod 43 are advantageously secured together by frictional contact but a pin (not shown) may also be used through the base 49 and rod 43. Attached to the base 49 by said means such as by welding is a collar 79. The cap 55 is substantially cylindrical and has a flange 80 advantageously welded to the cap 55 which is attached to surface 81 of collar 79 by suitable bolts 83 and nuts 85. A gasket 87 between the cap 55 and the collar 79 provides a fluid-tight seal. Thus, the inside of cap 55, when the cap 55 is attached to the base 49, is completely closed.

The coil 57 may be conventional. In accordance with this invention coil 57 is encapsulated with a moldable material such as a polyester resin. The electrical windings of the coil are placed in a metal mold (not shown), a metal plug is installed in the bore of the coil, the air is withdrawn from the mold, and liquid polyester resin, advantageously Acme 2001 supplied by the Stone and Barron Company of Baltimore, Maryland, is poured into the mold. The maximum operating temperature of Acme 2001 is about 140°F. But the temperature resistance of this resin may be improved to be as high as 475°F. by using a filler such as asbestos. Other resins and fillers may also be used in accordance with suitable molding processes well known in the art, provided the other resins have the required molding characteristics, high dielectric strength, dimensional stability, high resistance to moisture, and relatively high temperature resistance, and where a lubricant is used in the rapper 47 for the piston 65, the resin and filler should also be resistant to such lubricants. Such other resins include phenolic resins, phenol-formaldehyde casting resins, polyvinylidene chloride and other materials. This type of molded plastic covered coil has the advantage that dimensions on the surface of the coil covering can be held to closer tolerances than was possible with the heretofore known tape covered coils, thereby permitting the resin covered coil to fit easily and snugly into the cap 55 without elaborate hand adjustments. The molded plastic covered coil has the further advantage of maintaining a high dielectric strength for long periods of time despite the presence of moisture which might enter through outlet 89 in the side of cap 55. The molded coil has the still further advantage that the coil 57 and lead wires 91 are resistant to the shock caused by piston 65 hitting the separator 53 during the operation of the rapper 47 and thus the coil windings and the lead wires are not damaged by shock as often happened in the coils used heretofore.

In accordance with this invention, the top of the molded casing or cover 59 has a sill 90 through which lead wires 91 to the coil 57 are attached. Thus when the coil 57 is inserted in the cap 55 the lead wires 91 are prevented from jamming in the cap 55, jamming of the wires often being a problem with the coils known heretofore.

The coil 57 is fitted snugly into the cap 55 so that casing 59 butts against seal 93 at one end and seal 95 at the other end thereby to form a seal between the casing 59 and the corecasing 99. When the coil 57 is inserted into the cap 55, the wires of the coil are prevented from jamming in the cap 55, jamming of the wires often being a problem with the coils known heretofore.

Both seals 93 and 95 advantageously are made of neoprene but other materials such as polytetrafluoroethylene may be used. The bearing 61 is arranged inside the seals 93 and 95 so that the bearing member 61 contacts the bore 63 of casing 59 in a snugly fitting manner and extends from base 49 into recess 97 in cap 55. Thus the seals 93 and 95, as described above, maintain the inside of bearing 61 free of dirt and dust from the atmosphere and the inside of bearing 61 tight from the escape of lubrication, if present therein.

Bearing 61 is advantageously made of a nonmagnetic material in the form of a hollow cylinder having its inside surface coated with a Teflon coating 101. Teflon being the registered trademark of the polytetrafluoroethylene compound made by the E.I. du Pont de Nemours & Company, Inc., of Wilmington, Delaware. Brass is advantageously the nonmagnetic material but other non-magnetic materials such as nonmagnetic stainless steel may be used. This coating 101 substantially reduces friction between the bearing 61 and the piston 65 as the piston reciprocates in the bearing thus eliminating the need for lubrication in the rapper. This Teflon coating is advantageously at least 0.005 of an inch thick. To obtain optimum results with coating 101, the inside surface of the bearing 61 should be cleaned initially of any rust, grease, organic coatings, or dirt, sanded or vapor blasted and washed with a volatile solvent. The polytetrafluoro-

ethene, as a low-viscosity dispersion in a water medium, is applied to the bearing by spraying at room temperature (but it is also possible to dip the bearing repeatedly until the proper coating thickness is achieved) and the coating is dried, preferably at room temperature below approximately 150°F, until the water is evaporated. Thereafter, the polytetrafluoroethylene-coated bearing should be baked at a temperature of at least approximately 675°F. until sintering of the polytetrafluoroethylene occurs. It has been found that rapid cooling of the coating by quenching in cold air or water improves the hardness of the coating and promotes ease of stripping excess material when necessary. It is desirable to use several coatings, it being preferable to use the above described drying and baking steps between the application of the polytetrafluoroethylene layers. Each layer should be limited in thickness in order to avoid "mud cracking" upon drying as well as to permit reasonably rapid vaporization of the dispersing agent during the sintering operation.

The Teflon coating 101 has a maximum operating temperature range of over 400°F. and since the other parts of the rapper including the casing 59, the seals 93 and 95 have very high operating temperatures, this novel rapper can be used in high temperature locations where rappers known heretofore could not operate satisfactorily.

Inside the bore of the bearing 61 is located the floating hammer or piston 65. The first portion 67 of this piston has a diameter corresponding to the inside diameter of the coated bearing 61 and the second portion 69 has a lesser diameter. The piston is held at the end 103 of the cap 55 by the spring 73. Both ends of the piston are chamfered and a hole 71 is drilled through the center of the piston for the communication of air from one side of the piston to the other when the piston reciprocates. Piston 65 is made of magnetic steel.

Piston 65 is biased away from separator 53 by spring 73 made of spring steel which is interposed between a conventional solid or split piston ring 107 made of Teflon located on a shoulder 109 of the piston 65 and a Teflon guide ring 111 located on brass spacer ring 75 which is supported in bearing 61 and in base 49 around the separator 53. The separator 53 is force fitted inside spacer 75 and located on raised portion 51 of base 49. It is important that the separator 53 be made of nonmagnetic material because residual magnetism exists between the piston 65 and the raised portion 51 of base 49. This force of the separator 53 on the piston 65 in a downward position if the piston is allowed to contact the raised portion 51. Separator 53, therefore, being of nonmagnetic material, creates a gap between the piston 65 and the raised portion 51 thus greatly reduces the residual force of attraction and allows the piston to return freely to the top of cap 55. This separator 53 is advantageously made of annealed stainless steel to give it toughness,
otherwise the force of the piston 65 might destroy it. Spacer 75 is advantageously brass but other nonmagnetic materials may be used.

The second extended portion 69 of piston 65 extends downwardly through the coil spring 73 and the spacer 75. It has been found that without such an extension 69 and spacer 75 the spring 73 may be adversely affected to such an extent that it will fail after a limited number of piston cycles. Surprisingly, therefore, it has been found by providing this extended portion 69 and by supporting the spring 73 at one end and on the spacer 75 adverse effects are not experienced and consequently the spring 73 has long life. The reason for this is not completely understood but it is theorized that if the spring 73 is allowed to span the air gap between the retracted piston, i.e., when the piston is at end 103 of cap 55 and the separator 53, the spring being of a magnetic material, will provide a low reluctance path across the air gap for the field produced by the electrical impulse in coil 57.

A still lower reluctance path is formed if adjacent coils of the spring are touching. Since a magnetic field will always take the path of least reluctance, the spring coils are therefore forced to come in contact, each one with its adjacent coil, to form this path. It was found by experiment, for example, that magnetic field alone, in the absence of piston motion, was sufficient to cause coil clash. This coil clash, i.e., the hitting of the coils on each other, flattens the contacting surfaces eventually leading to spring failure. Thus by placing the spring 73 around the piston portion 69, the path of least reluctance is no longer through the spring but rather through the relatively larger mass of magnetic material in the piston portion 69. The magnetic flux is thereby effectively shunted around the spring 73 thus eliminating the forces which cause coil clash. It is theorized that the spacer 75 is effective to reduce the adverse magnetic effects on the spring 73 because the magnetic field is strongest at or near the separator 53 and thus the spacer displaces the spring 73 away from the separator 53 to a position where the magnetic effects on the spring 73 are less adverse.

Coil 57 is energized through lead wires 91 which may be attached to a suitable power source through a timer and off-on switch (not shown). With such timers and switches the coil 57 can be energized for short periods of time, and the energization may be set at any desirable interval. An interval between each energization found to be desirable is about thirty seconds. The energization of coil 57 impels piston 65 against separator 53.

To change the intensity of the rapper impulse under certain conditions present in a precipitator, the voltage may be increased or decreased by a conventional voltage regulator (not shown) thus resulting in an increased or a decreased rapper intensity.

In operation, the piston 65 is normally held at end 103 of the cap 55 by spring 73, this being the condition when coil 57 is de-energized. Upon the energization of coil 57, the piston 65 is impelled downwardly against separator 53 to cause a sharp rapping impulse which is transmitted thereby through base 49 and rod 43 to the electrode 11 of an electrostatic precipitator. This impulse is substantially constant and repetitive in intensity when the voltage to the coil upon each energization is constant. The use of Teflon ring 107 and coating 101 eliminates the need of lubrication in this novel rapper because of the low coefficient of friction of Teflon. Furthermore the wear of the piston and Teflon parts is negligible so that maintenance is substantially eliminated and the impulse intensity remains constant over long periods of time.

If Teflon coating 101 not be used for bearing member 61 lubrication in the form of natural or synthetic grease or oil or other lubricating substances such as graphite or molybdenum disulphide is required. The novel rapper operates satisfactorily however, even if lubrication is used and the rapper be mounted on the precipitator shell 17, as shown in Fig. 3, and requires little or no maintenance because the lubrication is sealed in and dirt sealed out as described above. The maximum operating temperatures under such circumstances are usually limited by the maximum temperature allowable with the lubrication and with Gulf Anti-Friction Grease No. 1, for instance, the temperature range is approximately 200° F. to 150° F. A solid Teflon bearing 61 may also be used to good results although it is more expensive than the last embodiment mentioned.

As shown in Fig. 1 the separator 53 is force fitted into bearing 61 but separator 53 may also be provided which is a part attached by suitable means such as by bolting to the bottom of piston 65.

The ring 107, cut away, may be located between the ends of the first portion 67 of piston 65 in a suitable groove 115 as shown in Fig. 3.

The foregoing has described a novel rapper which provides predetermined rapper impulse intensities, reduced maintenance requirements, infrequent or no lubrication, operation at elevated temperatures, and an interior sealed from the dust and moisture of its environment.

Although the foregoing has illustrated and described the invention in detail it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as will now be understood by those skilled in the art.

What is claimed is:

1. A magnetic impulse rapper particularly adapted for electrostatic precipitators exposed to adverse ambient conditions comprising a hammer, a base, electromagnetic actuating means having a hollow inside for producing a magnetic field for contacting said hammer against said base whereby vibrations of the base are produced, resilient means for biasing said hammer away from said base, a nonmagnetic spacer interposed between said base and said resilient means for reducing adverse magnetic effects on said resilient means whereby said resilient means is operative within said actuating means substantially without being adversely effected by said actuating means, a nonmagnetic bearing interposed between said electromagnetic means and said hammer for guiding said hammer, and means forming a single closed chamber around said hammer action and bearing so as to provide a rapper which is substantially maintenance free.

2. A magnetic impulse rapper particularly adapted for electrostatic precipitators and exposed to adverse ambient conditions comprising a base for transmitting momentary impulses of high vibrating intensity, electromagnetic actuating means having a hollow core, a sleeve member coated with polytetrafluoroethylene in the bore of said electromagnetic actuating means, hammer means reciprocable in said bearing means, said hammer means being actuated in one direction by the energization of said electromagnetic actuating means so as to cause a momentary hammer-like blow of high intensity to said base, spring actuating means for biasing said hammer means in the other direction when said electromagnetic actuating means is de-energized and means enclosing said hammer action in a single chamber so as to separate said chamber from said adverse ambient conditions, whereby said hammer is operative without lubrication.

3. A magnetic impulse rapper exposed to adverse ambient conditions comprising a base having an anvil, a substantially closed housing attached to said base in a fluid tight manner having an outlet therein, a hollow electromagnetic coil in said housing having outlet wires, and producing a magnetic field, a molded casing around said coil which protects said coil and its insulated coil windings, and said casing being located inside the anvil, said housing, said outlet wires being connected to said coil through said outlet in said housing without jamming of the wires, means for sealing the hollow of said coil with said base and said housing so as to protect the hollow of said coil against said ambient conditions, a non-magnetic bearing located in said magnetic coil and
coated with polytetrafluoroethylene resin, a reciprocating piston having an upper and lower portion and being positioned in said bearing, said piston having means for communicating air from one end of said piston to the other end, said piston also having a supporting means thereon extending around its side portion, a polytetrafluoroethylene ring riding on said supporting means, a spacer ring in said bearing in contact with said base, a coil spring interposed between said polytetrafluoroethylene ring and said spacer so as to surround said lower portion of said piston, and to be removed substantially from the strong magnetic field at said base, whereby energization of said magnetic coil impels said piston in one direction against said anvil and upon de-energization of said magnetic coil said spring impells said piston in the opposite direction thereby to provide a rapper operable substantially without maintenance and without adverse effects from said ambient conditions.

4. An electrical precipitator comprising a precipitator shell, an electrode assembly resiliently supported on said shell, a rapper housing connected to said electrode assembly and having a hollow portion closed by a base portion, hammer means in said hollow portion, said hammer means having a first portion of one diameter and a second portion of lesser diameter, a bruss bearing cooperating with said polytetrafluoroethylene for said hammer means having an inside diameter substantially corresponding to the diameter of said first hammer portion, a spacer ring in said bearing, electromagnetic actuating means surrounding said hammer, said electromagnetic actuating means upon energization, actuating said hammer in one direction so as to cause vibrations in said electrode assembly, and a spring actuating means substantially surrounding said second portion of said hammer means and interposed between said first portion of said hammer means and said spacer ring for acting said hammer in the opposite direction.

5. A magnetic impulse rapper exposed to adverse ambient conditions comprising a base having an anvil, a housing attached to said base in a fluid tight manner, a hollow electromagnetic coil enclosed in said housing in a fluid tight manner having electric wires attached thereon, a polyester resin casing around said magnetic coil and interposed between said magnetic coil and said housing in a snugly fitting manner and which protects said coil against said ambient conditions, means forming a slit at one end of said resin casing for connecting wires to said magnetic coil through said housing and said resin casing, bearing means enclosed in said housing in such manner as to support said lower portion of said housing in said bearing means, said hammer means also having internal means for communicating gas from one end of said hammer means to the other, resilient means in operable association with said hammer means, and spacer means interposed between said resilient means and said base, whereby energization of said magnetic coil impells said hammer means in one direction to give a hammer-like blow to said anvil and upon de-energization of said magnetic coil said hammer means is actuated in the other direction so that a rapper is provided which is substantially free from said adverse ambient conditions and substantially free of maintenance.

7. A magnetic impulse rapper exposed to adverse ambient conditions comprising a base having an anvil, a housing attached to said base in a fluid tight manner, a hollow cored electromagnetic coil enclosed in said housing in a fluid tight manner, a casing for said coil interposed between said coil and said housing in a snugly fitting manner and which protects said coil against said ambient conditions, a bearing means enclosed in said casing, a bearing means enclosed in said bearing means so as to be reciprocatable therein, spacer means located in said bearing means in contact with said base, resilient means interposed between said hammer means and said spacer means, means attached to said hammer means and extending into said resilient means responsive to electromagnetic forces caused by said electromagnetic coil whereby energization of said electromagnetic coil impells said hammer means in one direction to give a hammer-like blow to said anvil and upon de-energization of said magnetic coil said hammer means is actuated in the other direction so that a rapper is provided which is operable in said adverse ambient conditions and substantially free of maintenance.

8. An electrical precipitator comprising a precipitator shell, an electrode assembly resiliently supported on said shell, a rapper housing connected to said electrode assembly and having a hollow portion closed by an anvil portion, said housing also having an outlet means, a hollow electromagnetic coil in said hollow portion having outlet wires, a molded polyester resin casing around said coil and so formed that its outside diameter fits snugly in said housing and so that said outlet wires are connected to said coil through said outlet means in said housing without jamming of the wires, means for sealing the hollow bore of said coil with said base and said housing, a bearing located in said magnetic coil, a reciprocatable piston having an upper and lower portion and being positioned in said bearing, said piston having means for communicating air from one end of said piston to the other end, said piston also having a supporting means thereon extending around its mid-portion, a polytetrafluoroethylene piston ring riding on said supporting means, a spacer ring in said bearing in contact with said base, a coil spring interposed between said polytetrafluoroethylene ring and said spacer, whereby energization of said magnetic coil impells said piston in one direction against said anvil of said resin casing, the said electrode assembly and upon de-energization of said magnetic coil said spring impells said piston in the opposite direction.

9. An electrostatic precipitator comprising a precipitator shell, an electrode assembly resiliently supported on said shell, impulse transmitting means connected through said shell to said electrode assembly, sealing means between said shell and said impulse transmitting means, a rapper housing connected to said impulse transmitting means and having a hollow portion closed by an anvil portion, a hollow bore electromagnetic coil in said rapper housing, a molded resin casing around said coil formed so that its outside diameter fits snugly in said housing, means for sealing the hollow bore of said coil with said housing, a nonmagnetic bearing in said magnetic coil and coated with resin having low coefficient of friction, a piston reciprocatable in said bearing with an upper and lower portion, said piston having means thereon extending around its mid-portion, a ring of resin housing a low coefficient of friction riding on said supporting means, a nonmagnetic spacer ring located in said bearing in contact with said anvil portion of said rapper housing, a coil spring interposed between said polytetrafluoroethylene ring and said spacer ring so as to surround said lower
portion of said piston whereby energization of said magnetic coil impels said piston in one direction to cause vibrations in said electrode assembly and upon de-energization of said magnetic coil said spring impels said piston in the opposite direction.

10. An impulseapper not requiring lubrication and particularly adapted for electrical precipitators having adverse ambient conditions comprising a hollow electromagnetic actuator, a piston in said hollow actuator and actuated thereby, a plastic and metal case enclosing said hammer in said actuator and completely separating said hammer from said ambient, said piston having first portion of one diameter and a second portion of lesser diameter, and a nonmagnetic bearing surface between said actuator and said piston, said bearing surface having thereon a coating of polytetrafluoroethylene with a low coefficient of friction.

11. An impulseapper not requiring lubrication and particularly adapted for electrical precipitators comprising a hollow electromagnetic actuator, a piston in said hollow actuator and actuated in one direction thereby, a resilient means for actuating said piston in the opposite direction, means enclosing said hammer and resilient means in said actuator, means for preventing adverse magnetic effects on said resilient means and a nonmagnetic bearing surface between said actuator and said piston, said bearing surface having thereon a coating of polytetrafluoroethylene with a low coefficient of friction.

12. An impulseapper not requiring lubrication and particularly adapted for electrical precipitators comprising a hollow electromagnetic actuator, a piston in said hollow actuator and actuated in one direction thereby, a resilient means for actuating said piston in the opposite direction, means enclosing said hammer and resilient means in said actuator, means for preventing adverse magnetic effects on said resilient means, a nonmagnetic bearing surface between said actuator and said piston, said bearing surface having thereon a coating of polytetrafluoroethylene with a low coefficient of friction, and a means for reducing adverse magnetic effects on said resilient means.

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