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CLEANING CONTROL FOR ELECTROSTATIC PRECIPITATOR

Filed July 17, 1969

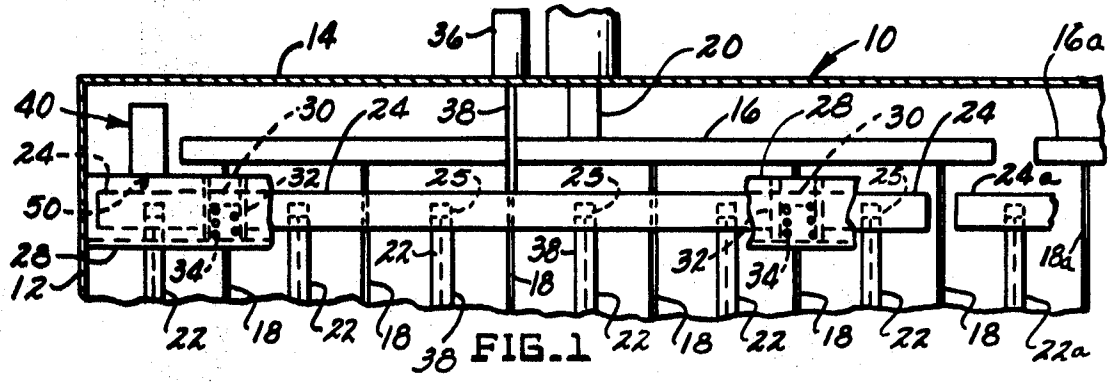


FIG_1

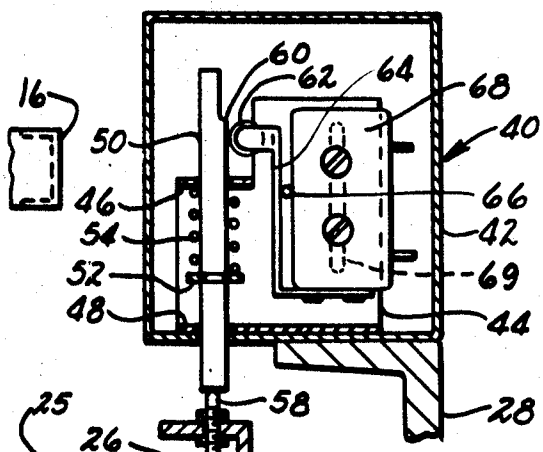


FIG_2

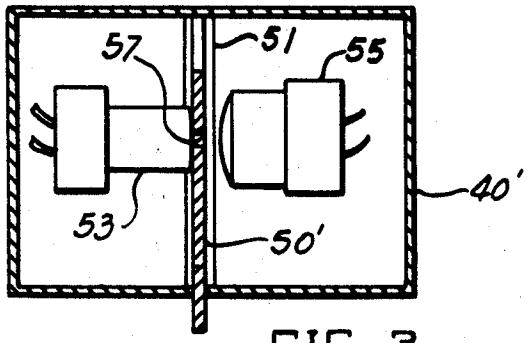
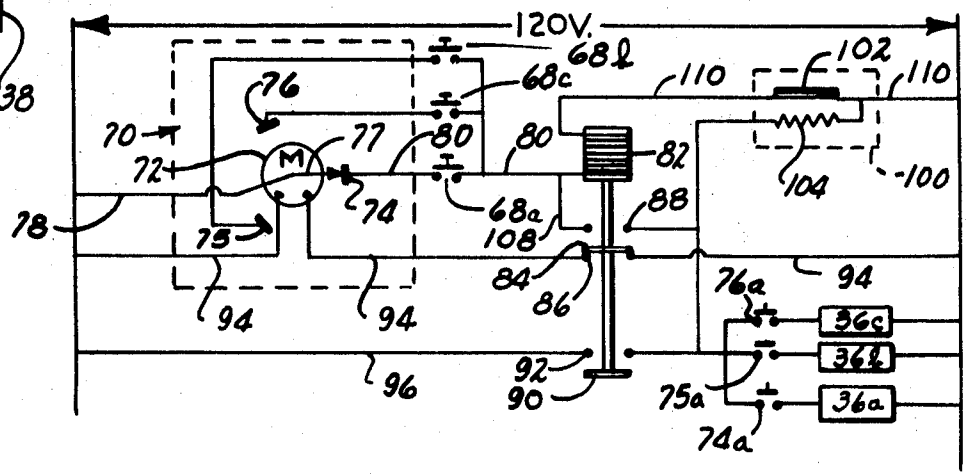


FIG_3

FIG_4



INVENTOR.

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CLEANING CONTROL FOR ELECTROSTATIC PRECIPITATOR

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ABSTRACT OF THE DISCLOSURE

An industrial electrostatic precipitator having a rapper control which initiates a rapper cycle in response to dust weight accumulations on the collector plates. The plates are deflected downwardly by the weight of the dust; after predetermined weight increase the deflection is sufficient to actuate a trigger for the rapper control.

THE DRAWINGS

FIG. 1 is a schematic representation of the upper portion of an electrostatic precipitator which can be equipped with a rapper control of the present invention.

FIG. 2 is a sectional view taken through the sensor-trigger portion of a rapper control of the present invention.

FIG. 3 shows another form which the sensor-trigger mechanism can take in practicing the invention.

FIG. 4 is an electric circuit diagram of a rapper control using the invention.

THE DRAWINGS IN DETAIL

FIG. 1 illustrates the upper portion of an industrial electrostatic precipitator used to remove dust particles from furnaces and other equipment in such environments as power plants, kilns, steel mills, dryers, sintering and calcinating plants, etc. As shown, the precipitator comprises a housing **10** having a sidewall **12** and a roof **14**.

PARTICLE IONIZATION

Disposed within the housing is a horizontal rectangular frame **16**, from which are suspended suitable ionizer wires **18**, each frame and its wires forming one ionizer section. In practice the precipitator may comprise many sections arranged behind and alongside one another.

The high voltage power supply for the illustrated ionizer wires may take the form of two insulated hanger rods **20**, positioned one behind the other, each rod being connected at its lower end to frame **16** to supply electric power to the frame and to the depending ionizer wires **18**. In practice the wires may be arranged in rows, spaced apart about eight inches, the wires in each row being spaced from one another about seven inches; each row may contain for example twelve wires. The dusty gas is fed into the housing **10** in a direction normal to the plane of the paper so that the gas flows past the various wires **18** in each of the six illustrated rows. As is conventional, the wires may be held substantially taut by means of weights fastened to the lower ends of the wires (not shown).

COLLECTOR PLATES

The rows of various taut wires are arranged between grounded collector plates **22** suitably suspended from an overhead frame **24**. As seen in FIG. 1, the collector plates present their frontal edges to the entering dusty gas. In a direction normal to the paper the plates may be five feet wide and thirty feet high. Along its upper edge each plate may be reinforced with a tubular section **25**; as shown in FIG. 2 pipes or the like **26** may extend into the extremities of each tubular section to suspend the individual plates from frame **24**.

Frame **24** may be suitably suspended within housing **10** by various structural arrangements. As shown in FIG. 1, the suspension mechanism includes a stationary channel member **28** extending across the inlet face of the housing in the space forwardly of the front edges of the collector plates **22**; a similar stationary channel member (not shown) would extend across the corresponding space beyond the rear edges of the collector plates. Frame **24** may be provided with blocks or the like **30**, each of said blocks being slidably arranged within a guide channel **32** secured to the rear face of channel member **28**. A heavy compression spring **34** may be disposed in each channel member beneath the respective slide block, each spring thereby yieldably supporting part of the weight of frame **24** and the collector elements **22** carried thereby. In a typical arrangement the frame **24** would be equipped with four block-spring assemblies, two of them being located at the front of the frame as shown in FIG. 1, and two of them being located at the rear of the frame adjacent the non-illustrated support channel. Each spring would thus bear approximately one-fourth of the total frame-collector weight, which might be on the order of 4500 pounds.

DUST REMOVAL

During operation the dust particles in the gas stream are ionized by the wires **18**, and the ionized particles are attracted to the adjacent grounded collector plates **22**. As the dust accumulates on the plates a resistive dust layer builds up on the plate surfaces, thus somewhat impairing the ability of the plates to attract additional dust particles. Therefore it is necessary to remove the dust accumulations from the plates. Under conventional practice such removal operations are sometimes accomplished by vibrating the plates, at frequencies of 50 cycles per second or thereabouts. More commonly the removal operations are accomplished by impulse rapping the plates at periodic intervals, as for example one or two raps every minute or thereabouts. The present invention concerns a control for either type operation, i.e. impulse rapping or vibration. For convenience the term dislodger mechanism will be used herein to apply to either type of apparatus.

RAPPING OPERATION

Rappers can take various forms, as for example giant solenoids wherein the armature acts as an anvil, or pneumatic hammers in which air is rapidly applied to or exhausted from a piston type anvil, or motor-elevated hammers operating by gravity against the collector plates. In most cases the rapper-dislodger force is applied vertically against the plate suspension frame. As shown in FIG. 1, the rapper takes the form of a giant solenoid or linear motor **36** suitably mounted on roof **14**; another solenoid would be located directly behind the illustrated solenoid, so that rapping force is transmitted simultaneously to the front most area of frame **24** and the rearmost area of the frame.

The armature **38** for each rapper motor is secured to frame **24** so that energization of the motor produces a rapid up and down motion of the frame **24** which is effective to shake dust particles from the collector plates **18**. The space beneath the collector plates is commonly occupied by one or more hoppers which receive the separated dust particles and which are periodically opened at the bottom thereof to permit discharge of the hopper dust.

MULTIPLE COLLECTOR SECTIONS

During the rapping operation the gas usually continues to pass through the spaces between wires **18** and collector plates **22** so that some of the dust particles which are shaken from the collector plates during the rapping cycle become reentrained in the gas stream. Therefore it is common practice to provide additional

collector sections downstream from the principal dust collector section. The downstream collector sections are usually carbon copies of the principal collector section as above described. However they do not collect as much dust as the principal collector section because they collect only the reentrained dust and any other stray dust particles which may escape the principal collector section. Commonly the collector is equipped with three collector sections arranged in series flow relation, the first one collecting and retaining something on the order of 65% of the dust, the next one collecting and retaining perhaps 25% of the dust, and the last one collecting and retaining perhaps 10% of the dust.

Commonly the collector plates are formed with full length vertical baffles protruding from their side surfaces at their front and rear edges, and also at points therebetween; in FIGS. 1 and 2 representative baffles are identified by numeral **38**. These baffles form vertical pockets which channel the dust downwardly as it is rapped off of the collector plate surfaces. In spite of these baffles some of the dust in the principal collector section becomes reentrained in the main gas stream, but usually at a lower point such that it is subsequently collected at a lower point in the first set of collector plates or in the next set of collector plates. This action of the dust makes it undesirable for each of the three collector sections to be rapped at the same time or moment. Thus, when the principal collector plate section is being rapped it is desirable that the next two sections be operational for collecting any reentrained dust particles as well as any particles originally in the gas stream then flowing through the collector plates; this eliminates what is sometimes referred to as "puffing," means puffs of dust particles flowing through the stack as a result of coincidental rapping in each of the three sections.

RAPPING CYCLE

Conventionally the rapping cycles for the various collector sections are controlled on a time basis, the principal collector section having rapped most frequently and the last collector sections being rapped least frequently. The time basis for rapping control has some disadvantage in that it does not take into account any variations in dust loading or possibility of coincidental rapping of all collector sections. As a result, one or more of the sections is usually rapped more frequently or less frequently than the desired optimum. In many instances continued surveillance of the equipment by technical experts is required.

The present invention proposes that each collector section be rapped after said section has accumulated a predetermined weight of dust thereon. The invention also proposes a scanner system of automatic surveillance for preventing coincidental rapping of the various collector sections.

As shown in FIG. 1, the precipitator is equipped with a combination sensor-trigger mechanism **40**, said mechanism being disposed in a suitable fixed location registering with the collector plate assembly. As shown in FIG. 2, the mechanism includes a box or enclosure **42** adjustably or otherwise fixed atop the channel **28**, said housing having a bracket **44** therein which is equipped with two laterally turned ears **46** and **48**. Vertically aligned openings in these ears form guide surfaces for a plunger type sensor member **50** having an E-ring **52** thereon for engagement with a compression spring **54**. Spring **54** is effective to maintain plunger **50** in contact with an adjustable set screw **58** carried by the collector frame **24**.

As the various collector plates **22** accumulate dust on their surfaces the added weight of the dust causes the frame **24** to be deflected downwardly, since it is yieldably supported by the springs **34**; the plunger **50** follows this downward movement of the collector assembly until its cam surface **60** reaches the roller **62** carried by the spring arm **64**. At that point arm **64** moves leftwardly to permit the spring-biased plunger **66** to close the contacts in the snap switch **68**. The snap switch thus acts trigger to initiate the rapping sequence.

FIG. 4 CONTROL CIRCUIT

FIG. 4 shows one form of control circuit which can utilize switch **68**. The circuit there shown includes three similar switches, **68***a*, **68***b*, and **68***c* all similar to the FIG. 2 switch, and each having a sensor similar to the plunger type sensor **50** shown in FIG. 2. Switch **68***a* would be utilized with the first collector section, switch **68***b* would be utilized with the second collector section, and switch **68***c* would be utilized with the third collector section.

Cooperating with the three switches is a scanner means **70** which may take the form of a small synchronous electric motor **72** and a set of three contacts **74**, **75** and **76**. The shaft of the motor carries an electrical switch arm or rotor **77** which slowly traverses the three contacts **74**, thereby to periodically complete a circuit between electric power line **78** and the particular contact then engaged with arm **77**; one complete rotation of rotor **77** might require forty-five seconds as an example. In its illustrated position arm **77** connects with a circuit line **80** which energizes a relay coil **82** when the trigger switch **68***a* is closed due to dust weight accumulations on its collector plate surfaces. At initial energization of coil **82** the controlled switch arm **84** is caused to open the contacts **86** and to close the contacts **88**; at the same time the controlled switch arm **90** closes the normally open contacts **92**, thereby energizing the rapper type dislodger **36***a* through contacts **74***a*. Contacts **74***a* are physically oriented to be opened and closed in synchronism with contacts **74**. Thus, switch arm **77** simultaneously closes contacts **74** and **74***a*. In similar fashion, the switch arm simultaneously closes contacts **75***a* when it closes contacts **75** and contacts **76***a* when it closes contact **76**.

Relay contacts **86** are disposed in a circuit line **94** which normally energizes scanner motor **72**. Therefore as contacts **86** open, the motor **72** is deenergized so that switch arm **77** remains in its illustrated position connecting the two circuit lines **78** and **80**. Contacts **86** serve to start and stop the scanner motor action.

On some occasions one rap on the collector plates will be sufficient to substantially clean said plates of collected dust. On other occasions, or with stickier dusts, it may be necessary to repeat the rapping a number of times. To continue the rapping cycle beyond the first rapper energization the circuit is equipped with a time delay mechanism **100** illustratively shown as a bimetal switch **102** and electric resistance heater **104**. At the start of the rapping cycle the bimetal switch is in the illustrated position completing a circuit through line **78**, arm **77**, line **80**, relay coil **82** and line **110**. As the cycle proceeds the heater **104** warps the bimetal **102** away from the fixed contact to open the circuit across line **110**. If switch **68***a* is not opened when the bimetal **102** opens, then the rapping may continue until switch **68***a* is opened. Normally the time constant for mechanism **100** is chosen so that substantially all dust is dislodged from the plates before bimetal **102** opens; a few seconds is all that is usually required.

It will be appreciated that the time delay mechanism **100** can take various forms, and that any commercially available time delay mechanism can be employed in practicing the invention. In operation of the time delay mechanism, the opening of switch **102** deenergizes coil **82** and returns switches **84** and **90** to their illustrated positions; motor **72** is thus energized to advance rotor **77** toward the next contact **74**, **75** or **76**.

FIG. 4 shows a relay **82**, a rapper **36**, and a time delay mechanism **100** used to produce a controlled rapping of three collector sections **36***a*, **36***b*, and **36**. Only one of the sections can be rapped at any one moment because

only one of the switches **74***a*, **75***a* or **76***a* is closed at any one moment.

FREQUENCY OF CLEANING THE PLATES

As previously noted, it is sometimes desirable to rap the first collector section at more frequent time intervals than the next two collector sections. In the FIG. 4 circuit, should the scanner switch arrive at a particular contact **74**, **75** or **76**, and should the dust build up on the collector plates for that contact be so slight as not require cleaning, the respective switch **68***a*, **68***b* or **68***c* will be in the open condition, and motor **72** will remain energized so that scanner switch **76** will proceed on to the next contact **74**, **75** or **76**. The actual rapping of plates will therefore only take place when cleaning is necessary, as determined by the weight of dust accumulations. Also, the rapping cannot by coincidence occur simultaneously in two collector sections because the switch **77** can at any one moment only close one of the switches **74***a*, **75***a*, or **76***a*.

It will be appreciated that the rapper responds to specific predetermined dust weight accumulations. However, the dust actuation weight for each collector section need not be the same. For example, an accumulation of two thousand pounds of dust may be used as the control weight for the principal collector section, while a weight of only five hundred pounds may be used as the control weight for the last collector section. The last section might advantageously be kept fairly clean at all times because any reentrained dust will escape to the stack; the first or principal collector section could be permitted to accumulate larger quantities of dust because reentrained dust can be caught in the next sections.

The dust weight accumulation needed to actuate each switch **68** may be determined or varied by adjusting the travel of sensor **50**, as by vertical adjustment of the switch **68** position via slots **69** in bracket **44**, or by adjustment of set screw **58**. Sensor **50** could of course be formed as an integral part of frame **24** or any one of the collector plates. However in that event there might be some calibration difficulties, some mechanical alignment difficulties, and also some sealing problems. Preferably the sensor operates in a sealed enclosure **40** protected against ingress of dust particles.

FIG. 3 TRIGGER

The sensor-trigger means can take various structural forms other than the form shown in FIG. 2. Thus, as shown in FIG. 3 the sensor can consist of a shutter plate **50'** slidably disposed within a housing **40'** and guided for vertical movement by channel grooves or guides **51** disposed on the opposite sidewalls of the housing. The space to the left of shutter **50'** may be occupied by a small continuously energized glow lamp **53**, and the space to the right of shutter **50'** may be occupied by a cadmium sulfide photoelectric cell **55**. The shutter plate **50'** is intended to follow the movement of the collector plate assembly in the same manner as previously described plunger **50**; **50'** is therefore preferably biased downwardly, as by a spring (not shown) or by its own weight. At a suitable point the plate is provided with an aperture **57**. When the plate has moved down a sufficient distance the aperture transmits a sufficient percent of the light from bulb **53** to energize the cadmium sulfide cell **55**. The current flow through the cell can be applied to a conventional amplifier located in the energizer circuit for relay **82**. Thus the FIG. 3 mechanism can serve the same function as the FIG. 2 mechanism in the FIG. 4 control circuit.

For most purposes it is believed that electric control of the rapper is most feasible. However it is possible to use pneumatic controller switching, especially when the rapper is itself a pneumatic device. Thus, the large forces generated by the deflection of the heavy collector plate assembly, numbering several hundred pounds, will enable a pneumatic valve to be used in lieu of mechanism **40**.

In such event the actuator for the valve could be the sensor responsive to downward deflection of the collector assembly, and the fluid flow through the valve could be applied directly to the pneumatic rapper or to a fluid switch arranged in a pneumatic control circuit.

The principal feature of interest relates to the concept of using dust weight accumulations on the collector plates to initiate the rapper control cycle. Preferably the triggers for the various collector sections are arranged so that only one set of collectors are rapped at any one moment.

The drawings show a collector of the single stage type, i.e. ionization of the particles and collection thereof take place in the same section or stage. The invention may be practiced in a two stage collector wherein ionization occurs upstream from the point of collection.

I claim:

1. An electrostatic precipitator comprising a housing adapted to have dusty gas pass therethrough; ionizer means arranged within the housing for charging dust particles in the gas stream; collector elements arranged within the housing to remove the charged dust particles from the gas stream; means yieldably supporting the collector elements so that dust accumulations on the collector elements cause said elements to be deflected downwardly in proportion to the weight of the dust accumulations thereon; means for dislodging the dust accumulations on the collector elements; and automatic control means for energizing the dislodging means; said control means including sensor-trigger means responsive to predetermined downward deflections of the collector elements, whereby the dislodging means is actuated only after the elements have become loaded with predetermined dust accumulations thereon.

2. The precipitator of claim **1** wherein the collector elements comprise at least two sets of collector plates arranged in series flow relation; said dislodging means comprising a separate dislodger mechanism for each set of collector plates; said control means comprising a separate sensor-trigger means for each dislodger mechanism, and a scanner means arranged to operably connect each trigger and dislodger mechanism in a predetermined time sequence so that only one dislodger mechanism is capable of operation at any one moment.

3. The precipitator of claim **2** wherein the sensor for the downstream collector plates actuates its trigger after a lesser dust weight accumulation than the sensor for the upstream collector plates.

4. The precipitator of claim **2** wherein the control means comprises a time delay means operable at initiation of each dislodging cycle to continue the dislodging operation for a predetermined time period irrespective of the condition of the sensor.

5. The precipitator of claim **1** wherein the sensor means comprises a cam movable vertically in response to downward deflections of the collector elements, and the trigger means comprises a snap action switch operably connected with the cam for snap-action movement when the cam reaches a predetermined position.

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