Dec. 16, 1969 B. F. QUINTILIAN ET AL 3,483,670

DISCHARGE ELECTRODE ASSEMBLY FOR ELECTROSTATIC PRECIPITATORS

Filed Dec. 15, 1967 2 Sheets-Sheet 1

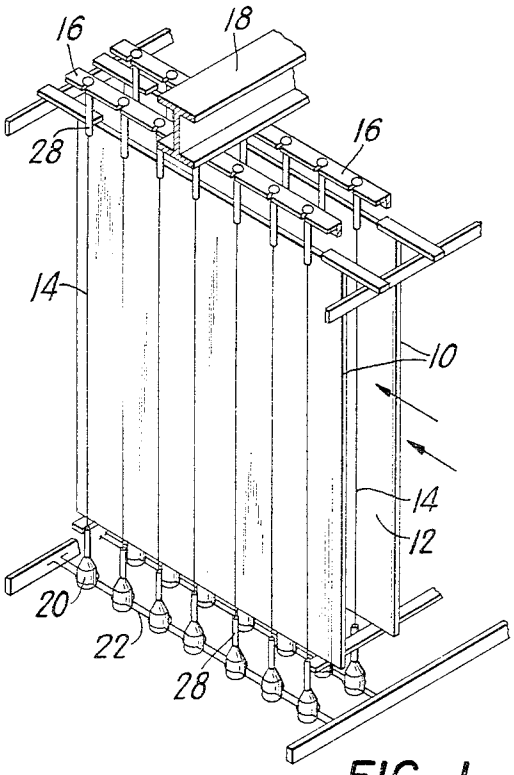

FIG. 1

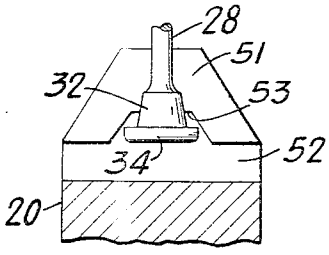

FIG. 4

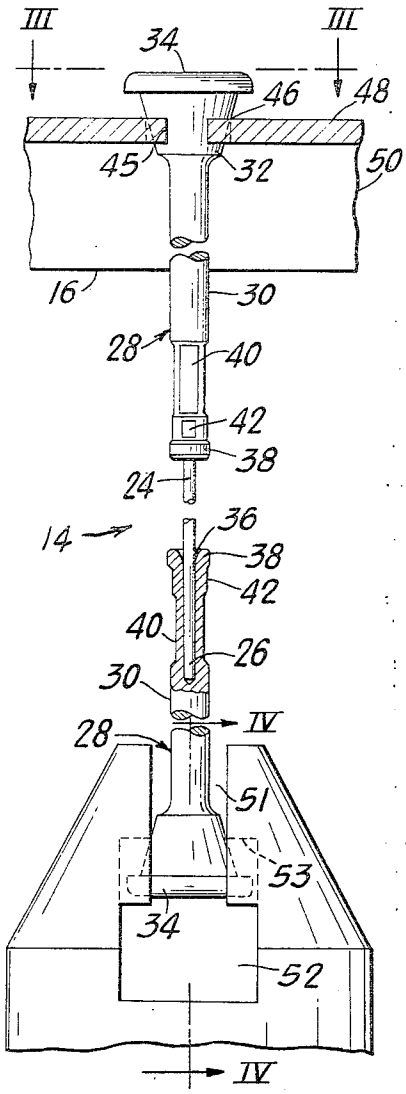

FIG. 2

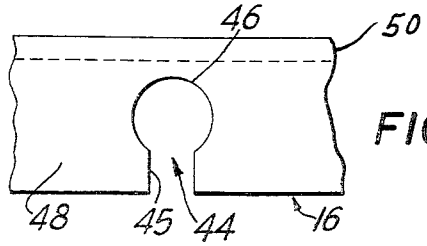

FIG. 3

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DISCHARGE ELECTRODE ASSEMBLY FOR ELECTROSTATIC PRECIPITATORS

Filed Dec. 15, 1967 2 Sheets-Sheet 2

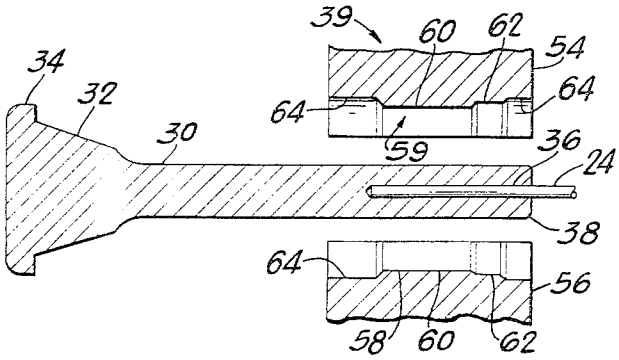

FIG. 6

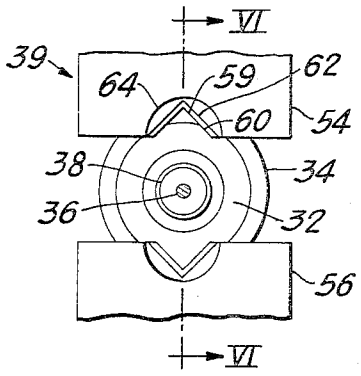

FIG. 5

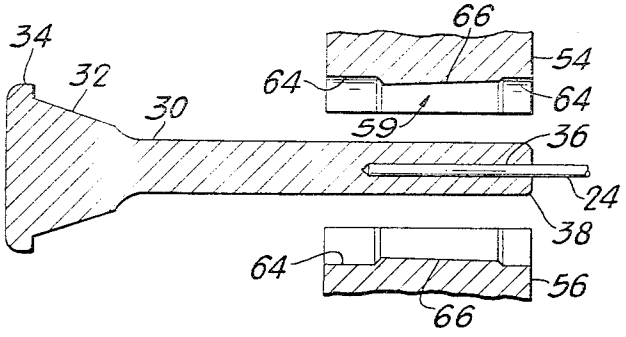

FIG. 8

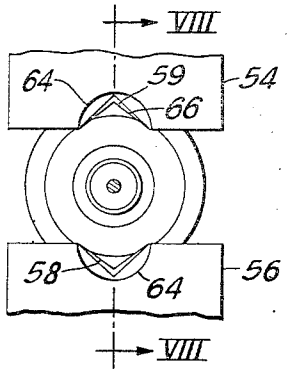

FIG. 7

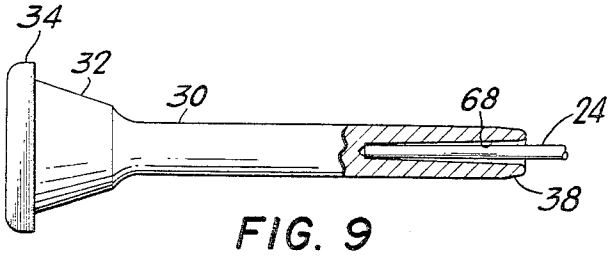

FIG. 9

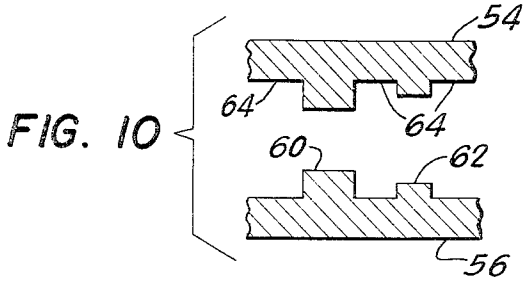

FIG. 10

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DISCHARGE ELECTRODE ASSEMBLY FOR ELECTROSTATIC PRECIPITATORS

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Int. Cl. B03c 3/76
U.S. Cl. 55—112 2 Claims

ABSTRACT OF THE DISCLOSURE

A discharge electrode assembly for electrostatic precipitators adapted for vertical suspension from a high voltage support frame; the discharge electrode assembly comprising an elongated electrode wire having its opposite ends terminating axially within two identical shrouds; each of the shrouds shaped as an elongated rod terminating in a combined frusto-cone and enlarged button head. The electrode wire and shrouds are secured together by means of a non-linear multi-sided crimp which provides stepped or tapering forces on the electrode wire from light at the rod end of the shroud to heavy at the end of the wire. In assembly, one of the two shrouds seats on the edges of an open keyhole slot located in the support frame with the remainder of the electrode assembly suspended vertically beneath. The other shroud seats on the edges of a transverse slot located in a cylindrical weight adapted to receive the shroud, the weight confining the shroud in a central position to provide tensioning and aligning means for the electrode assembly.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to gas separation devices such as electrostatic precipitators and more particularly to an improved electrical discharge electrode assembly having retaining and tensioning means.

Description of the prior art

Conventional electrostatic precipitators, such as described in Cummings et al. Patent No. 3,109,720, are used to remove foreign particles from a gas stream. Briefly, they are made up of a plurality of grounded collecting electrodes and high voltage discharge electrodes in spaced relationship to each other and which are suspended from supporting structure in a precipitator shell.

A uni-directional high potential field is set up between the collecting and discharge electrodes and at a critical voltage a corona discharge takes place resulting in an ion discharge. The bulk of the foreign particles in the gas stream passing between the electrodes become negatively charged as a result of the ion discharge and consequently are attracted to the grounded collecting electrodes and accumulate thereon although a few of the particles may be attracted to the discharge electrodes.

Rappers or vibrators, such as described and illustrated in Pennington Patent No. 3,030,753, are attached to the collecting and discharge electrode support structure to remove the particles collected thereon by producing vibrations on the electrodes and causing the accumulated particles to jar or vibrate loose and fall downwardly of their own weight into suitable collecting means well known in the art.

The collecting electrodes are usually constructed of flat metal plates suitably connected together, whereas the discharge electrodes have taken the form of elongated wires, ribbons or rods connected to the support structure in any one of several ways, such as bolting, welding, or clamping the electrode to the supporting structure.

It is well known, however, that the discharge electrodes are more sensitive to rapping or vibrating than the collecting electrodes and therefore have required the most attention as to the method of suspension because of fatigue and subsequent mechanical failure. It is also well known that rapping of the discharge electrodes imparts a relatively large deflection to the electrodes resulting in severe localized stresses occurring at the upper and lower points of suspension of the electrodes. It is at these points that breakage and failure of the electrodes have for the most part been concentrated. Conventional connecting or suspensory means generally have made little or no provision to reduce or obviate these highly stressed conditions. Consequently, when a discharge electrode fails, it is often necessary to interrupt the operation of the precipitator to repair or replace the broken electrode, otherwise, a hazardous and undesirable arc-over is likely to occur between the broken electrode and the grounded collecting electrode. Such interruptions are not only costly, but in addition, repairing or replacing the broken electrode is usually difficult.

Present methods of connecting the discharge electrodes to the support structure or weight means create difficulties of their own. Welded or bolted electrodes provide good electrical conductivity, but the electrode has to be plumbed manually. Replacing welded or bolted connections is time consuming and often proves destructive to the support structure when attempts are made to remove or dislodge rusted bolts or to burn off welded connections. Spool type connections provide good self alignment but only marginal electrical conductivity and under some conditions will arc and burn through the connection.

Conventional means of tensioning electrode wires by the use of weights are accomplished with connections that have surfaces in substantial contact between the wire and weight means, such as with welding, clamps, spools and the like. Consequently, these connections frequently result in dirt accumulation between the weight and electrode wire resulting in arcing and subsequent erosion of the connection. Furthermore, as little or no provision has been made for self-alignment of the wire and weight, a bent wire could join the weight in its weight guide or heavy dirt accumulation could result in a cocked weight. Cocking or jamming of the weight may result in bending or bowing of the electrode wire or slackening of tension permitting the electrode wire to move out of vertical alignment and thereby approach the collecting electrode surfaces resulting in arc-over at a lower voltage and reducing the maximum power available for particle collection. Further, if the weight and wire are unable to assume an aligned position with respect to each other, a heavy stress concentration may occur on the wire resulting in mechanical failure of the electrode.

One known method of joining electrode wires to the supporting structure is by crimping the wire within a shroud which is joined to the support. This method has advantages in that it is simple and economical to manufacture. Unfortunately, the conventional crimping usually results in severe localized stresses at the juncture of the wire and the crimp since the crimp is applied equally or linearly along the wire. That is, the crimped portion of the shroud exerts pressure against the wire equally along the length of the crimp. Thus, this type of connection is also subject to fatigue and mechanical failure.

SUMMARY OF THE INVENTION

The present invention provides a novel discharge electrode assembly having identical and interchangeable sleeves or connections, hereinafter referred to as shrouds, secured to the opposite ends of an elongated discharge electrode wire. The shrouds are secured to the electrode

wire by crimping the shrouds to the wire in a manner to provide a substantially circumferential or multi-sided mechanical connection which grips the electrode with graduated or tapering forces along the length of the crimp. In this manner, the graduated forces reduce the severe localized stresses at the point of connection common to present crimped connections and spreads or distributes the stress through a much larger area to prevent breakage and provide a longer service life for the electrode.

The shrouds are also provided with a frusto-conical portion adapted for seating within an open keyhole slot in the supporting structure. This connection facilitates installation and replacement of electrodes and provides a positive electrical connection. The shrouds are preferably identical on both ends of the wire so that they may be secured to either the supporting structure or a weight used to tension the wire.

Another advantage of this invention is that it provides a discharge electrode assembly which is self-aligning in operation and produces positive electrical conductivity between it and the support structure.

A still further advantage of the discharge electrode assembly is that it is of simple construction, economical to manufacture and is well adapted for rapid installation or replacement to the high voltage support frame through the use of the open keyhole slot located in the electrode support frame. 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.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like parts are marked alike:

FIGURE 1 is an isometric view of a section of complementary discharge and collecting electrode structures of an electrostatic precipitator embodying the discharge electrode assembly of the present invention;

FIGURE 2 is an enlarged front elevation, partly in cross-section, of one of the discharge electrode assemblies of FIGURE 1;

FIGURE 3 is a top view of a part of the discharge electrode support frame taken along the line III—III of FIGURE 2;

FIGURE 4 is a side view in cross-section of the electrode weight taken along line IV—IV of FIGURE 2;

FIGURE 5 is an axial view of the shroud taken from its rod end and its complementary crimping die in the open position;

FIGURE 6 is a side view in cross-section taken along the line VI—VI of FIGURE 5;

FIGURE 7 is an axial view of the shroud taken from its rod end illustrating another construction of the crimping die used to crimp the shroud;

FIGURE 8 is a side view in cross-section taken along the line VIII—VIII of FIGURE 7;

FIGURE 9 is a side view, partly in cross-section, illustrating still another construction of the shroud used in the discharge electrode assembly; and

FIGURE 10 is a side view of a die portion of a configuration to provide axially spaced apart crimps of stepped force.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGURE 1 of the drawings, there is illustrated a plurality of grounded collecting electrodes **10** supported in the conventional manner in spaced parallel relationship to each other to form gas passages **12** through which the gas to be cleaned is passed, as indicated by the arrow.

Spaced along the centerline of passages **12** are discharge electrode assemblies denoted generally as **14**, supported from high voltage support frames **16** and main support member **18** located above the collecting electrodes **10**. Cylindrical weights **20** are attached to the bottom ends of discharge electrode assemblies **14** to provide tension and aid in vertical alignment. A typical alignment or steadying frame **22** partially surrounds weights **20** to prevent the weights from swaying and thereby contacting the grounded collecting electrodes **10**.

Collecting electrodes **10** and discharge electrode assemblies **14** are rapped or vibrated by means well known in the art to remove any dust collected thereon and to cause the dust to fall downwardly into conventional dust receiving means located beneath the electrodes (not shown).

According to this invention, FIGURE 2 illustrates a discharge electrode assembly **14** comprising an elongated electrode wire **24** having its opposite ends **26** terminating within identical shrouds **28**. Each shroud **28** is shaped as a rod **30** having one of its ends taper outwardly in a frusto-conical portion **32** which portion terminates in, or is capped by, an enlarged button head **34**. The ends **26** of electrode wire **24** are inserted into a central axial opening **36** provided in rod portion **30** of shroud **28**.

In the preferred construction, illustrated in FIGURES 5 and 6, rod portion **30** is crimped non-linearly to the electrode wire **24** by means of a non-linear multi-sided crimping tool **39**. That is, rod portion **30** is crimped in at least two places to deform the rod causing a pressure to be exerted against wire **24** to hold it within shroud **28**. One crimp deforms rod **30** a small amount to exert a first or light pressure against wire **24**; a second crimp deforms rod **30** a larger amount to exert a second or heavy pressure against wire **24** which is greater than the pressure exerted by the first crimp. That is, the pressures exerted against wire **24** by the crimped deformations are unequal and are hereinafter referred to as constituting a non-linear crimped connection. Crimping tool **39** provides an area of light crimp **42** on the rod portion **30** (see FIGURE 2) substantially near the rod end **38** and an area of heavy crimp **40** immediately adjacent thereto and extending along rod **30** toward the frusto-conical portion **32** and terminating substantially over the electrode wire end **26** within shroud **28**.

The crimped areas, **40** and **42**, provide a multi-sided non-linear grip on the electrode wire **24**, preferably on four sides, providing graduated forces on the wire **24** from light at the rod end **38** to heavy at the end **26** of wire **24**. Crimping tool **39** applies heavy force to area **40** and light force to area **42** on wire **24**. Consequently, the grip on the wire is stepped or tapered from heavy at the end **26** of the wire **24** to light at the rod end **38** of the shroud **28**. In this manner, low stress is induced in the electrode wire **24** at the point where the wire **24** enters the area of light crimp **42** and where the maximum stress is most likely to occur.

The crimping tool **39** illustrated in FIGURES 5 and 6 comprises two metal die halves **54** and **56**, having matching crimping profiles. The crimping profile, as viewed from the end, FIGURE 5, comprises a substantially V-shaped groove **59** formed in two steps **60** and **62**; step **62** being slightly deeper than step **60**. At opposite ends of the groove **59** are annular recesses or reliefs **64** larger than the diameter of rod portion **30**.

To crimp wire **24** in shroud **28**, the rod portion **30** is first placed between the dies **54** and **56** of crimping tool **39** as illustrated in FIGURES 5 and 6. The dies are then closed loosely against the shroud. Wire **24** is inserted in opening **36** until it bottoms therein. Pressure, e.g. by a hydraulic ram (not shown), is then applied to the two dies **54** and **56** to force them together into compressive engagement with rod portion **30**. The stepped portions **60** and **62** of grooves **59** of both dies thus imparts, on four sides, an area of light crimp **42** and an area of heavy crimp **40**, FIGURE 2, on the rod portion **30**. Step **60**, being less deep than step **62**, imparts the greatest compressive force on the shroud **28**. The crimping tool

39 deforms rod portion 30 so that the periphery of the rod is compressed radially into wire 24. Wire 24 is preferably deformed so that a mechanical lock results between the wire 24 and the rod portion 30 instead of just a compressive friction lock.

In operation, the electrode assembly 14 is vertically suspended from a horizontal support frame 16, FIGURES 2 and 3, by inserting one of the shrouds 28 of assembly 14 into an open keyhole slot 44 located in the support frame and seating the shroud 28 in the hole portion 46 so that the frusto-conical portion 32 is supported thereon. The weight of the assembly 14 draws or pulls the frusto-conical portion 32 into the hole portion 46 thereby causing the assembly to align itself vertically and establish positive electrical contact with the support frame 16. The enlarged button head portion 34 of shroud 28 also prevents the shroud 28 from falling from the frame 16 under extreme operating conditions or under conditions of extreme wear where the slot 44 becomes enlarged.

Electrode weight 20 is provided for tensioning the electrode assembly 14. By using a free-hanging weight, any variations in the length of the electrode because of manufacturing tolerances or thermal expansion in operation are automatically compensated for.

Weight 20 is provided with a first transverse slot 51 at the top of the weight as illustrated in FIGURES 2 and 4. Its width is sufficient to permit rod portion 30 of shroud 28 to pass freely therethrough. A second transverse slot 52 is provided beneath slot 51 and is wide enough to permit the button head portion 34 of shroud 28 to be inserted therein. Slot 52 has a central portion which tapers upwardly into slot 51 and terminates in a flat portion 53. Conical portion 32 seats against the juncture formed by slot 51 and flat portion 53 to retain weight 20 and to provide a positive electrical connection. In this manner, a simple and easily assembled electrode-weight connection is provided. It also permits shrouds 28 to be identical on both ends of wire 24; the frustoconical portion 32 supporting the electrode in the keyhole slot 44 and the identical portion 32 of the other shroud supporting weight 20.

Support frame 16 is preferably of structural angle construction having a first leg portion 48 extending horizontally and secured in the known manner to support member 18, FIGURE 1, and a second leg portion 50 extending perpendicularly downward therefrom.

An open keyhole slot 44 is provided in leg 48 for supporting electrode assembly 14. Slot 44 comprises a hole portion 46 of a diameter to support the frusto-conical portion 32 of shroud 28 at about mid-point as shown in FIGURE 2. The sharp intersection between hole portion 46 and cone portion 32 provides a positive electrical connection even though dust particles may collect in the area of the connection.

A slot 45 extending from the edge of leg 48 to hole portion 46 provides a path for insertion of shroud 28 in keyhole 44 so that the shroud need not be threaded into hole portion 46. The width of slot 45 is made to allow crimped portion 40 of rod portion 30 of the shroud to pass easily therethrough. Thus, it is not necessary to pass wire 24 through slot 45 with the chance of damaging it on the sharp edges of the slot.

DESCRIPTION OF THE OTHER CONSTRUCTIONS

FIGURES 7 and 8 illustrate another construction of the die halves 54 and 56. In this construction, steps 60 and 62 of the crimping profile are replaced by a single tapering step 66 which, when rod portion 30 of shroud 28 is inserted between the dies and pressure applied as previously described, will impart non-linear crimping pressure on the shroud 28 and wire 24. The crimping or compressive pressure will thus taper in a straight line rather than in steps from light at the rod end 38 of shroud 28 to heavy at the end 26 of wire 24.

While FIGURE 6 illustrates a pair of axially-adjacent stepped crimps, any number of steps may be used. As the number becomes infinite, then the stepped pressure forces approaches a straight line as just described for FIGURES 7 and 8.

FIGURE 9 illustrates still another construction of shroud 28. In this construction, the central axial opening 36 in rod portion 30 is replaced by a tapered opening 68, tapering inwardly from the rod end 38 of shroud 28. With this construction, the step portions 60 and 62 or tapered step 66 of dies 54 and 56 are preferably replaced by a straight crimping portion (not shown) extending parallel to the axis of rod portion 30. Since opening 68 is tapered, deformation of rod portion 30 by crimping pressure will cause less contact pressure against wire 24 at the largest part of opening 68. Thus a tapered crimping force is obtained similar to that described for the construction of FIGURES 7 and 8. If desired, a combination of a tapered opening 68 with either a stepped or tapering crimping profile can be used.

FIGURE 10 in highly exaggerated fashion illustrates a die for providing stepped force that are axially displaced from each other.

Although the electrode wire 24 described herein is round, the shroud openings 36 or 68 can be modified to receive any number of discharge electrode wire shapes such as square, barbed and the like and a non-linear crimping force applied thereto as previously described.

From the foregoing description, it can be readily seen that to install the electrode assembly 14, all that is necessary is to first insert one of the shrouds 28 of assembly 14 into the open keyhole slot 44 in the support frame so that the assembly is suspended vertically from and beneath the support frame. Weight 20 is then secured to the lowermost shroud 28 by inserting the shroud into the transverse slot 51 and 52 contained therein and seating the frusto-conical portion 32 on the juncture formed by slot 51 and flat portion 53 of weight 20. Should the electrode assembly 14 be accidentally pushed out of line, the assembly will automatically reassume its original aligned position when the electrode support frame is rapped or vibrated.

Any one of the foregoing electrode constructions provides longer service life than conventional crimped electrode constructions due to the non-linear crimped connection. A further advantage of this electrode assembly is that it permits rapid installation or replacement during overhaul and reconditioning periods with resultant savings in time and expense. Their use is particularly advantageous where problems of frequent discharge electrode wire breakage are encountered.

Having thus described the invention in its best embodiment and mode of operation, that which is desired to be claimed by Letters Patent is:

1. In electrostatic precipitator apparatus including collector electrodes defining a plurality of gas passages therebetween and a main support member supporting a high-voltage support frame adjacent the top of said collector electrodes from which a plurality of discharge electrodes are suspended beneath said frame in said gas passages between said collector electrodes with tensioning means secured to the lower end of said discharge electrodes for tensioning the same and a steadying frame associated with said tensioning means for maintaining said discharge electrodes in substantial vertical alignment and further having rapping means in operative engagement with said collector and discharge electrodes for vibrating the same to remove collected dust therefrom, the improvement wherein:

said discharge electrodes each includes an electrode wire with substantially identical shrouds secured to the opposite ends thereof, each of said shrouds having a rod portion with a central opening in its one end for receiving an end of said wire therein and having its other end terminating in an outwardly tapering frusto-conical portion, said shrouds secured to said wire by a substantially flat first crimped de-

formation in the end of said shroud adjacent said wire for exerting a first pressure against said wire and a substantially flat second crimped deformation in the end of said shroud adjacent said frusto-conical portion for exerting a second pressure against said wire greater than said first pressure;

said high-voltage support frame includes at least one substantially horizontal surface above each gas passage extending generally parallel with said collector electrodes, said horizontal surfaces having open key-hole slots for receiving upper ones of said shrouds therein, said slots having sides extending substantially perpendicular to said horizontal surfaces thereby providing sharp upper edges for engaging the frusto-conical portion of each of said shrouds in substantial line contact to provide positive electrical contact between the shrouds and said support frame and to support said discharge electrodes vertically beneath the support frame; and

said tensioning means includes a weight attached to lower ones of said shrouds for maintaining tension in said wire, said weight having an inverted T-slot therein forming sharp and substantially horizontal edges at the juncture of the legs of the T for engaging the frusto-conical portions of the shroud in substantial line contact to provide positive electrical contact between the shroud and the weight.

2. An improved discharge electrode for electrostatic precipitators, comprising:

an electrode wire having substantially identical shrouds secured to the opposite ends thereof, each of said shrouds having a rod portion with a central opening in its one end for receiving an end of said wire therein and having its other end terminating in an outwardly tapering frusto-conical portion, said shrouds secured to said wire by a first crimped deformation in the end of said shroud adjacent said wire for exerting a first pressure against said wire and a second crimped deformation in the end of said shroud adjacent said frusto-conical portion for exerting a second pressure against said wire greater than said first pressure,

each of said shrouds adapted for substantially vertical hanging engagement with either:

(a) a discharge electrode support frame having a shroud-receiving opening therein with sharp edges for substantially line contact engagement with the frusto-conical portions of said shrouds, or

(b) a wire tensioning weight having a shroud-receiving opening therein with sharp edges for substantially line contact engagement with the frusto-conical portions of said shrouds,

for providing positive electrical contact between said discharge electrode and said support frame and between said discharge electrode and said weight.

References Cited

UNITED STATES PATENTS

1,501,138	7/1924	Rounds	24—126
2,272,244	2/1942	Klein	29—517
2,327,650	8/1943	Klein	287—109
2,708,980	5/1955	Hull	55—147 X
2,711,224	6/1955	Herber	55—147
2,867,287	1/1959	Armstrong	287—23 X
2,870,861	1/1959	Valvo et al.	55—147 X
2,910,983	11/1959	Everett	128—339
3,354,617	11/1967	Hoisington et al.	55—112 X

FOREIGN PATENTS

980,435	12/1950	France.
503,495	7/1930	Germany.
517,262	2/1931	Germany.
558,171	12/1943	Great Britain.
971,804	10/1964	Great Britain.
1,016,905	1/1966	Great Britain.
163,531	11/1933	Switzerland.

OTHER REFERENCES

German printed application, No. 1,019,797, Nov. 21, 1957, S. J. Everett.

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U.S. Cl. X.R.

24—126; 29—517; 55—147, 148, 151; 248—58, 314; 287—109