Oct. 6, 1953 H. A. WINTERMUTE 2,654,438

ELECTRICAL PRECIPITATOR

Filed Sept. 8, 1952 4 Sheets-Sheet 1

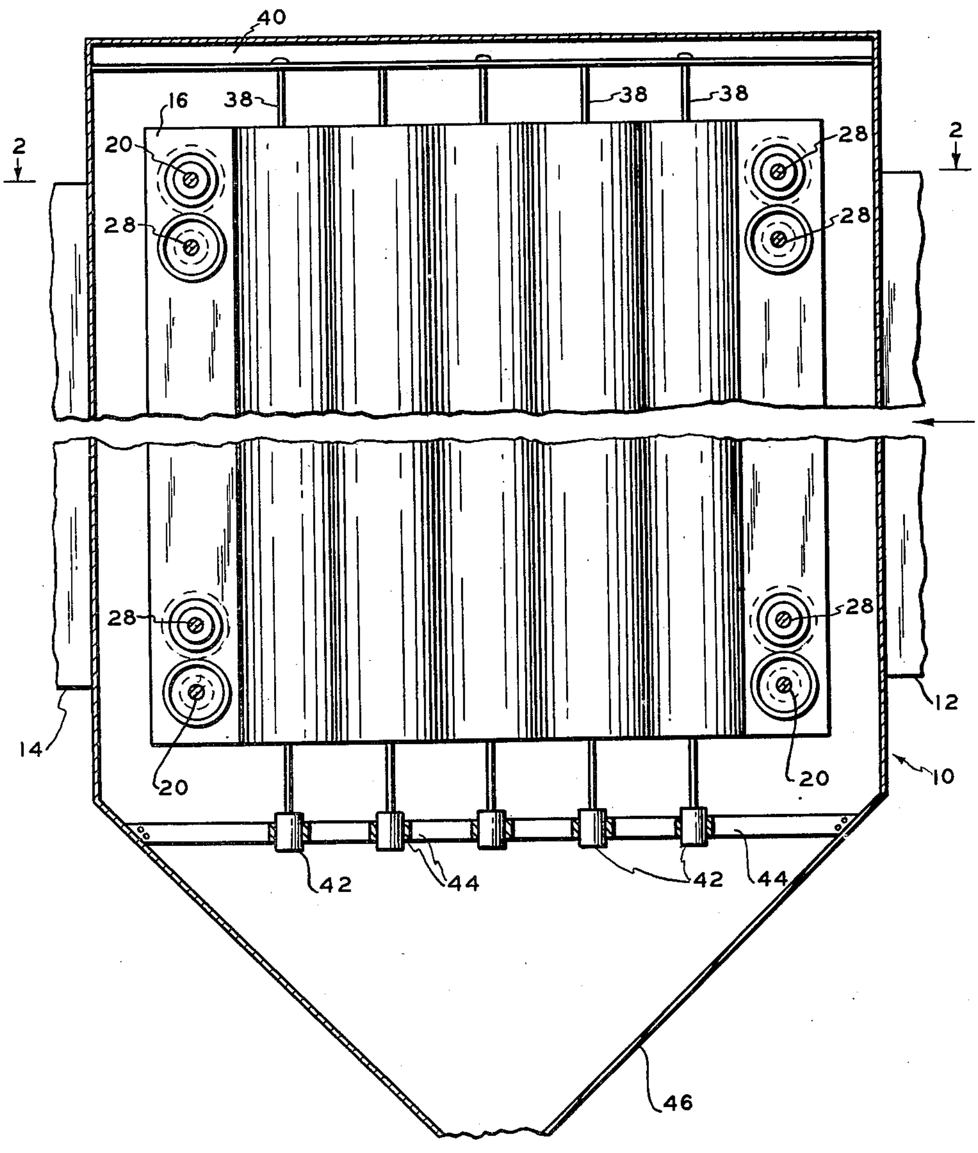

Fig. 1

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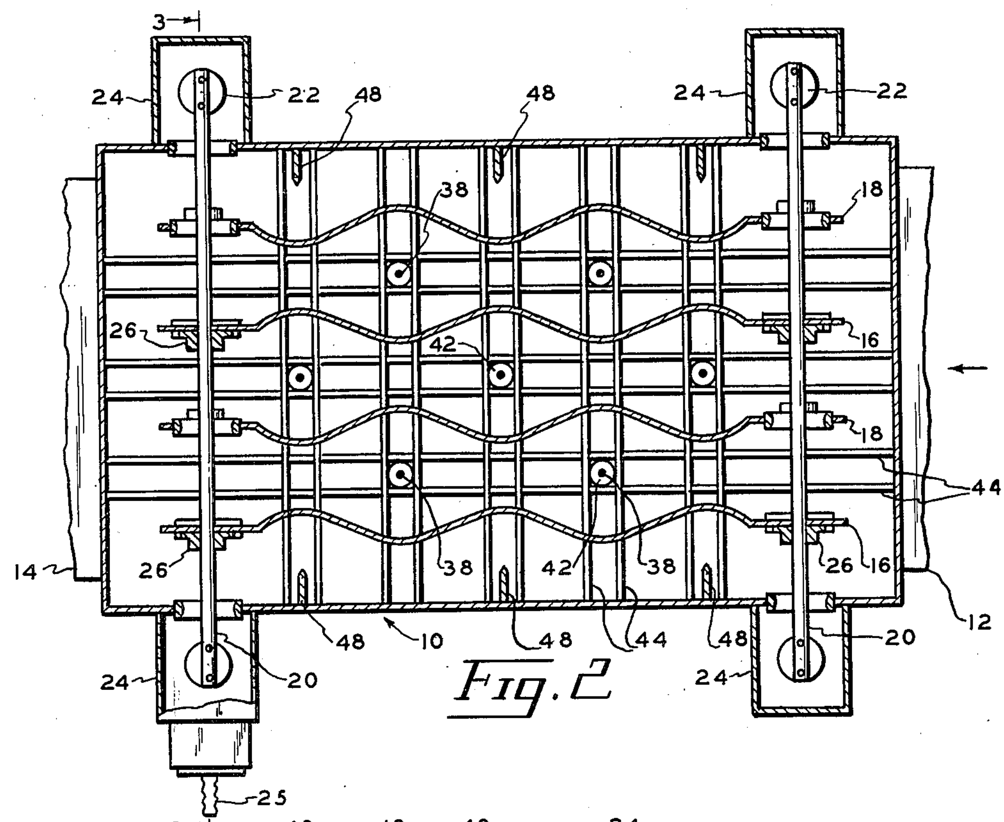

Fig. 2

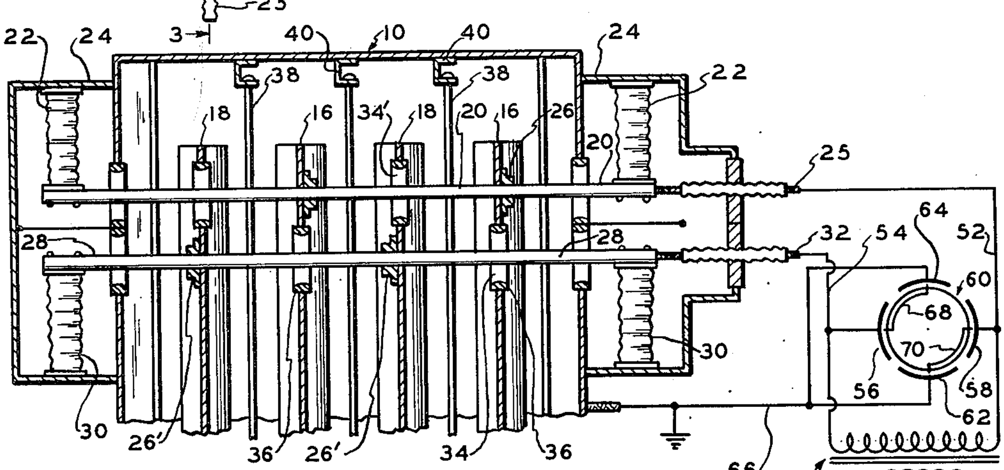

Fig. 3

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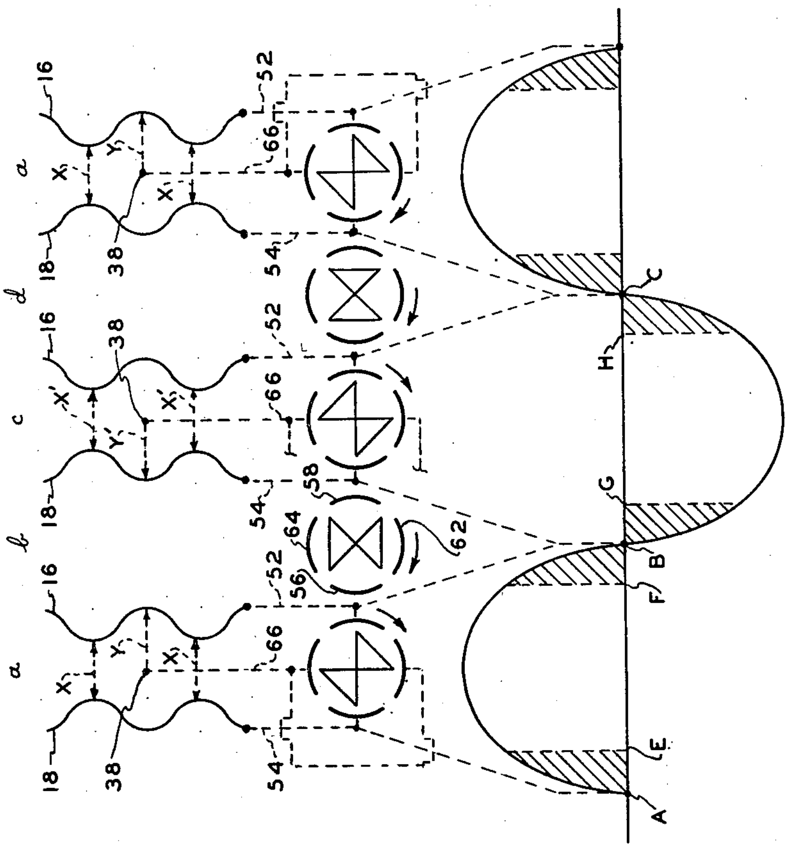

Fig. 4

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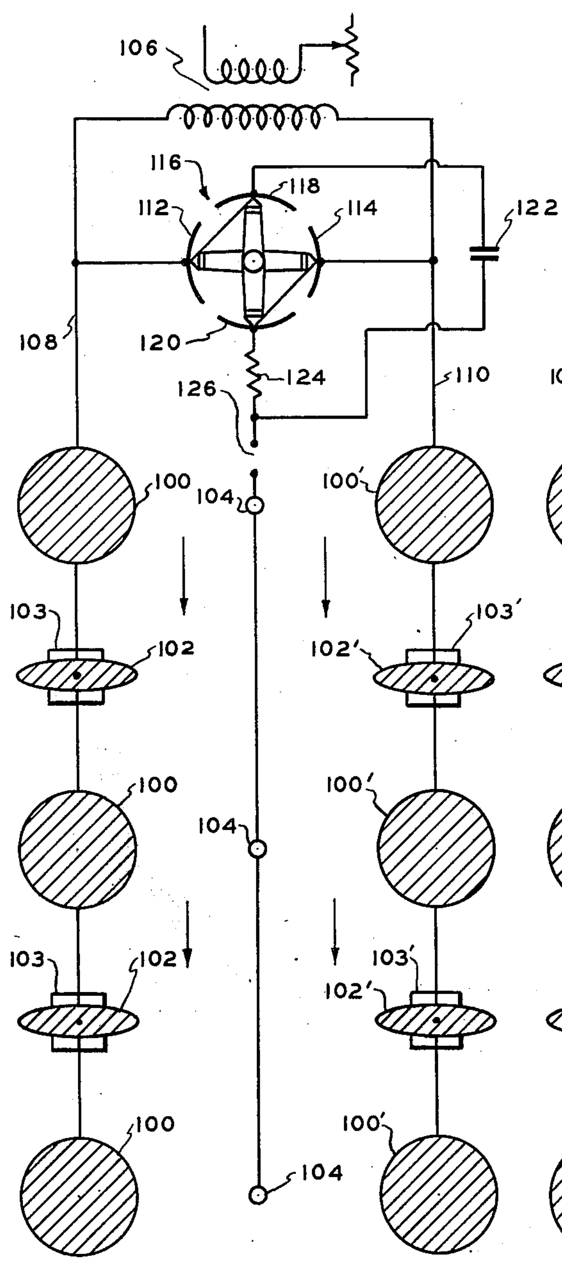

Fig. 5

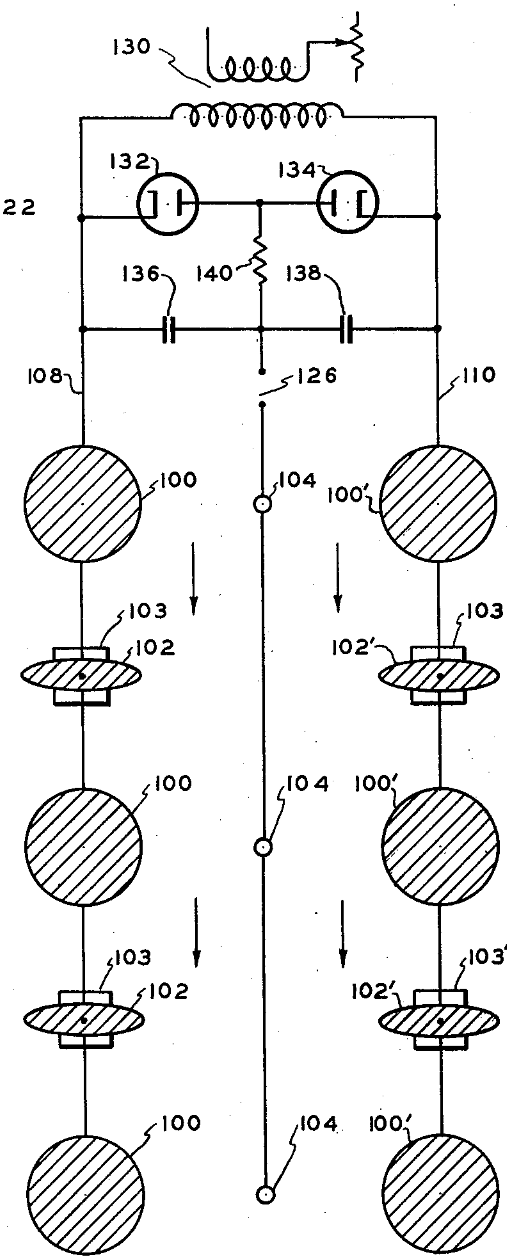

Fig. 6

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UNITED STATES PATENT OFFICE

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ELECTRICAL PRECIPITATOR

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10 Claims. (Cl. 183—7)

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This invention relates to apparatus for electrical precipitation of suspended particles from gases, and in particular to an apparatus for treating a gas stream carrying suspended particles with a series of spaced successive alternating current and unidirectional current high voltage fields.

In the past it has been the general practice to treat suspended materials in gas streams by passing the gas containing the suspended material through high potential electric fields maintained between complementary discharge and collecting electrodes. The high potential electric fields are generally either of an alternating or unidirectional type, or, as disclosed in U. S. Patent No. 2,440,455 to Harry J. White, both unidirectional and alternating fields may be employed.

The present invention is an improvement in apparatus of the latter type wherein the material suspended in the gas stream is successively subjected to both alternating high potential fields and spaced unidirectional high potential fields provided by a single current source.

It is an object of the present invention to provide such an apparatus wherein the high voltages for the alternating current fields and the high voltages for the unidirectional fields are supplied from a simple transformer.

A further object is to provide such an apparatus wherein the unidirectional fields and the corona discharges associated therewith are spaced from and substantially uninfluenced by the alternating current fields.

Another object is to provide such as apparatus wherein the polarity of the discharge electrodes is always the same and the corona discharge is alternately directed to adjacent collecting electrodes.

These and other objects and advantages are provided by the electrical precipitator of the invention which generally comprises a non-discharge electrode system providing a plurality of alternating non-discharge fields of successively low and high intensity therebetween the electrode system including a source of high potential alternating current, a discharge electrode system providing corona discharge fields in the low intensity alternating fields, the discharge electrode system including a rectifier connected to the source of alternating current, and means for passing gases containing suspended particles through the alternating fields.

The invention will be more particularly described with reference to the accompanying drawings in which:

Fig. 1 is a vertical sectional view of a horizontal

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gas flow electrostatic precipitator embodying the principles of the invention;

Fig. 2 is a section on line 2—2 of Fig. 1;

Fig. 3 is a section on line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic view of three successive half-cycles of the voltage distribution of the alternating and unidirectional currents of an electrostatic precipitator constructed in accordance with the principles of the present invention;

Fig. 5 is a diagrammatic view of another form of the invention; and

Fig. 6 is a diagrammatic view of the type of electrostatic precipitation apparatus shown in Fig. 5 in conjunction with another form of electrical energization circuit.

With reference to the drawings and in particular to Figs. 1 through 3, 10 is the shell or casing of a horizontal gas flow electrostatic precipitator having gas inlet and outlet conduits 12 and 14 respectively. Within the precipitator casing are a plurality of paired extended surface plate type electrodes 16 and 18. The conductive plates of the paired electrodes 16 and 18 are warped alternately toward and away from corresponding portions of opposed plates to provide a succession of alternately narrower and wider interelectrode zones extending across the faces of the plates.

The collecting electrodes are insulated from the casing of the precipitator and alternate electrodes are insulated from each other. Each electrode 16 is suspended adjacent its four corners from bus bars 20, so that the extended surfaces of the plates are parallel to the direction of flow of the gas stream. The bus bars 20 are supported at each side of the precipitator casing by insulating bushings 22 secured to insulator housings 24. Through one of the housings an electrical lead 25 from the precipitator energization circuit is connected to one of the bus bars 20.

Metallic bushings 26 are secured to the electrodes 16, for example by welding, at the points of contact between the plate and each of the four bus bars 20. These bushings help to maintain good electrical contact between the plate and the bus bars, and to give added strength to the plate at these points.

The collecting electrodes 18 are generally of identical shape and form as the collecting electrodes 16 hereinbefore described.

Each electrode 18 is suspended adjacent its four corners from bus bars 28, so that the extended surface of the plate is parallel with the corresponding plate 16.

The bus bars 28 are supported from insulating bushings 30 secured to the insulator housings 24. Through one of the housings an electrical lead 32 from the precipitator energization circuit is connected to one of the bus bars 28.

Metallic bushings 26' are secured to the electrodes 18 at the points of contact between the plate and each of the four bus bars 28.

In a preferred embodiment of the invention as shown in Figs. 1 through 3, the spacing between complementary collecting electrodes 16 and 18 is such that the distance between adjacent extended surfaces at their greatest spacing is approximately twice the distance between the plates at their nearest proximity.

To prevent electrical contact between the electrodes 16 and bus bars 28 apertures 34 are provided at the points where the bus bars 28 intersect the collecting electrodes. A smoothly rounded ring 36 may be secured within each aperture 34 to reduce arc-overs at these points.

Collecting electrodes 18 are similarly insulated from bus bars 20 by the apertures 34'.

Within the casing are a plurality of vertical discharge electrodes 38 which are electrically connected to the precipitator shell.

The discharge electrodes 38 are secured at their upper ends to channel bars 40, which are in turn fastened to the upper surface of the precipitator shell.

At the lower end of each discharge electrode is a tensioning weight 42 which is held against horizontal displacement by frame members 44. The frame members 44 extend in a horizontal plane across the lower portion of the precipitator casing at a distance sufficiently below the collecting plate electrodes 16 and 18 to prevent arc-overs and corona discharge between these structures.

Below the discharge electrode frame is a material collecting hopper 46.

As is more clearly seen in Fig. 2 of the drawings the discharge electrodes 38 pass vertically between the paired collecting electrodes midway between the lines of their furthest spacing so that the distance, in the preferred embodiment of the invention, between the discharge electrodes 38 and their complementary collecting electrodes is substantially equal to the distance between pairs of collecting electrodes at their nearest proximity.

In order to provide points of corona discharge for the outer surfaces of the collecting electrodes adjacent the sides of the precipitator casing, discharge electrodes 48, of the edge type extend outwardly from the opposite side walls of the precipitator. These electrodes 48 also serve as baffles for that portion of the stream of gas which passes between the side walls of the precipitator and the adjacent collecting electrodes.

In Fig. 3 of the drawings one form of electrical circuit for energizing the improved electrical precipitator of the invention is shown.

In Fig. 3 50 is an alternating current transformer which supplies high potential alternating current to the collecting plates 16 and 18 through conductors 52 and 54. Transformer 50 is also connected to stator members 56 and 58 of the synchronous rotary switch 60. The remaining stator members 62 and 64 are electrically joined externally and connected to the grounded casing of the electrostatic precipitator through lead 66. Adjacent pairs of contact points of the four element rotor are connected together by conductors 68 and 70.

The operation of the improved electrical precipitator will be described with reference to Figs. 1 though 3 and Fig. 4 which is a diagrammatic view of one cycle of voltage distribution for the precipitation apparatus shown in Figs. 1 through 3. In Fig. 4 elements corresponding to the elements shown in Figs. 1 through 3 are designated with like reference numerals. The letters *a, b, c,* and *d* designate four successive positions of the rotary switch 60, through one cycle of the alternating current source represented by the curve A, B, C. In the curve A—B and B—C are the periods in which voltage is applied across the collecting electrodes, and E—F and G—H are the periods in which voltage is applied between the discharge electrodes and the collecting electrodes as determined by the length of the stator shoes of the rotary switch.

In operation, a stream of gas containing suspended material enters the gas treating zone of the precipitator through gas inlet conduit 12 and divides into a plurality of parallel gas treating zones between the spaced collecting electrodes 16 and 18.

The gas stream as it passes through the gas treating zone is subjected to a series of spaced alternating current and unidirectional current voltages more fully described hereinafter.

In the gas treating zone the suspended material is precipitated from the gas stream and collected on the etxended surfaces of electrodes, from which it drops into the collecting hopper 46. In order to facilitate the removal of the collected material rapping means not shown in the drawings may be employed. The discharge electrode may be rapped by a direct connected vibrator, and the insulated collecting electrodes 16 and 18 may each be rapped with vibrators insulated from each other and from the ground.

The type and form of electrical energization will be described with reference to only one of the plurality of parallel gas treating zones and with reference to Fig. 4.

With the rotary switch element 60 positioned as in section *a*, voltage is applied between electrodes 16 and 18 in the direction shown by arrows X, for a period equal to the curve A—B. Since the electrodes 16 and 18 have various spacings therebetween the only effective field created by this voltage is in the region where the collecting electrodes are closest together.

At position *a* there is also a unidirectional voltage applied between discharge electrode 38 and collecting electrode 16 in the direction of the arrow *y*. The period during which this voltage is applied between electrodes 38 and 16 is equal to the curve E—F.

The position *b* of rotary switch 60 is the zero voltage position.

With the rotary switch positioned as in diagram *c*, voltage is applied between electrodes 16 and 18, in the direction of the arrows *x'*, for a period equal to the curve B—C. A unidirectional voltage is applied between discharge electrode 38 and collecting electrode 18 in the direction of arrow *y'*. The period during which this voltage is applied between electrodes 38 and 18 is equal to the curve G—H. Thus, between switch positions designated *a* and *c* there is a reversal of the direction of current flow between electrodes 16 and 18, and between the discharge electrode 38 and the collecting electrodes.

When the rotary switch is in the position designated *d*, the voltage is again at a zero potential.

From the foregoing description it will be seen that:

The single transformer supplies the high voltages for the alternating current fields, and the high voltages for the unidirectional fields;

The unidirectional fields and the corona discharge associated therewith are spaced from all alternating current fields and are substantially uninfluenced thereby;

The polarity of the discharge electrodes is always the same and the corona discharge is alternately directed to the collecting electrodes;

The electric fields between all the discharge electrodes and the opposed collecting electrodes are substantially identical;

The intensities of the alternating current fields are at a maximum at the points where there is substantially no unidirectional corona discharge; and

The corona discharges to both of the opposed collecting electrodes are balanced and of substantially the same intensity.

In Fig. 5 one parallel unit of a horizontal flow electrostatic precipitator is shown diagrammatically.

The gas stream carrying the suspended material flows in the direction of the arrows between opposed pairs of non-discharge electrodes **100**, **100'**, **102** and **102'** which may be in the form of conductive rods or tubes which extend vertically within the gas treating zone.

In the preferred form of the invention electrodes **100** and **100'** are in the form of cylindrical conductive rods or cylinders whose cross sections are circular. The electrodes **102** and **102'** are in the form of ellipsoidal cylindrical conductive rods, and they are positioned with their minor axes in opposed spaced relationship. The major axes of the ellipsoidal rods are preferably not less than the diameters of the cylindrical electrodes **100** and **100'**.

Means **103** and **103'** for supporting the ellipsoidal electrodes **102** and **102'** for axial rotation may be provided on installations where it is desired to vary the field strength between pairs of opposed electrodes. In the drawings the electrodes **102** and **102'** are positioned to provide maximum fields therebetween. By rotating the electrodes so that their minor axes are in opposed relationship, minimum fields for a given potential are obtained.

Spaced discharge electrodes **104** are positioned equidistant between the opposed collecting electrodes **100** and **100'** and are insulated from collecting electrodes **100**, **100'**, **102** and **102'**.

The collecting electrodes **100** and **102** are also electrically insulated from their corresponding collecting electrodes **100'** and **102'**.

A transformer **106** supplies high potential alternating current to the collecting electrodes **100**, **100'**, **102**, and **102'** through conductors **108** and **110** respectively.

The transformer **106** is also electrically connected to the stator elements **112** and **114** of the synchronous rotary switch **116**.

The remaining stator members **118** and **120** are electrically joined through a condenser **122** and a resistance member **124** and are connected thereafter to the discharge electrodes **104** through arc gap **126**. Thus the discharge electrodes **104** are energized with high frequency unidirectional pulses.

In operation, the device shown in Fig. 5 is substantially similar to the operation of the form of the invention described with reference to Figs. 1 through 4. During first half cycle of the alternating current source a current flows in one direction between electrodes **100** and **100'** and between electrodes **102** and **102'**. The effective field strength between electrodes **102** and **102'** is substantially greater than the effective field between electrodes **100** and **100'**.

Also during the first half cycle a high frequency pulsating current flows between the discharge electrodes **104** and one of the groups of collecting electrodes **100** or **100'**.

During the second half cycle of the alternating current source the direction of the current flow between the paired collecting electrodes is reversed, and the high frequency pulsating current flows between the discharge electrodes **104** and the other of the groups of collecting electrodes.

A further modification of the present invention is shown in Fig. 6 of the drawings. Due to the substantial similarity between the devices disclosed in Figs. 5 and 6, like elements are given the same reference numerals.

With reference to Fig. 6 one parallel unit of a horizontal flow precipitator is shown diagrammatically. The gas stream carrying the suspended material flows in the direction of the arrows between the opposed collecting electrodes **100**, **100'** and **102** and **102'**. The collecting electrodes are preferably in the form of conductive rods or tubes which extend vertically within the gas treating zone. Collecting electrodes **102** and **102'** are preferably mounted for rotation about this vertical axis so that the electrical field established between these electrodes may be varied by rotating the electrodes.

Spaced discharge electrodes **104** are positioned equidistant between the opposed collecting electrodes **100** and **100'**. The discharge electrodes **104** are insulated from the collecting electrodes, and the collecting electrodes **100** and **102** are also electrically insulated from their corresponding collecting electrodes **100'** and **102'**.

A transformer **130** supplies a high potential alternating current to the collecting electrodes **100**, **100'**, **102**, and **102'** through conductors **108** and **110** respectively.

The transformer **130** is also electrically connected to the discharge electrodes **104** through rectifiers **132** and **134**, condensers **136** and **138**, resistance **140** and spark gap **126**. The inclusion of the condensers, **136** and **138**, the resistance **140** and spark gap **126** in the circuit provides the electrodes **104** with high frequency unidirectional current pulses.

The operation of the device shown in Fig. 6 is the same as that described with reference to Fig. 5 of the drawings.

From the foregoing description it will be seen that the present invention provides an improved electrostatic precipitator whereby the aims, objects and advantages of the invention are fully accomplished.

It will be evident that various modifications may be made in the construction form of the electrostatic precipitator of the invention. For example, in the illustrative examples of the invention horizontal gas flow precipitators are shown having extended surface plate type and tubular collecting electrodes, however, the invention may be very satisfactory employed on vertical gas flow units. It is further evident that the unidirectional pulsating current employed to energize the discharge electrodes described with reference to Figs. 5 and 6, may be employed on the form of the invention shown in Figs. 1 through 4, or the condenser, resistance means shown in Figs. 5 and 6, may be removed from the circuits and nonpulsating unidirectional current may be employed to energize the discharge electrodes 104.

I claim:

1. An apparatus for the electrical precipitation of suspended particles comprising a non-discharge electrode system comprising spaced extended surface electrodes providing a plurality of alternating non-discharge fields of successively low and high intensity therebetween, said electrode system including a source of high potential alternating current, discharge electrode members positioned between said extended surface electrodes providing corona discharge fields in the low intensity alternating fields, said discharge electrode system including a rectifier connected to said source of alternating current, and means for passing gases containing suspended particles between said extended surface electrodes.

2. An apparatus for the electrical precipitation of suspended particles comprising a plurality of spaced non-discharge electrodes shaped and positioned to define therebetween gas passages having successive wide and narrow interelectrode zones, a source of high potential alternating current connected to said non-discharge electrodes, spaced discharge electrodes positioned between the non-discharge electrodes in the wide interelectrode zones, rectifier means connected to said alternating current source, means connecting the output of said rectifier to the discharge electrodes and means for passing gases containing suspended particles through said interelectrode zones.

3. An apparatus as defined in claim 2 wherein the means connecting the output of said rectifier means to the discharge electrodes includes means providing high frequency unidirectional current pulses.

4. An apparatus for the electrical precipitation of suspended particles comprising spaced non-discharge electrodes comprising conductive plates warped alternately toward and away from corresponding portions of opposed plates to provide a succession of alternately narrower and wider interelectrode zones extending across the faces of said plates, a source of high potential alternating current connected to said conductive plates, spaced discharge electrodes positioned between said plates in the wider interelectrode zone, rectifier means connected to said alternating current source, means connecting the output of said rectifier to the discharge electrodes and means for passing gases containing suspended particles through said interelectrode zones.

5. An apparatus for the electrical precipitation of suspended particles comprising spaced non-discharge electrodes comprising conductive plates warped alternately toward and away from corresponding portions of opposed plates to provide a succession of alternately narrower and wider interelectrode zones extending across the faces of said plates, a source of high potential alternating current connected to said conductive plates, spaced discharge electrodes positioned between said plates in the wider interelectrode zone, a synchronous rotary switch connected to said alternating current source, means connect-

ing said switch to the discharge electrodes and means for passing gases containing suspended particles through said interelectrode zones.

6. An apparatus for the electrical precipitation of suspended particles comprising spaced alternate pairs of opposed non-discharge electrodes, one of said pairs of electrodes having opposed surfaces of substantially larger area than the surfaces of the other of said pair of electrodes, a source of high potential alternating current connected to said non-discharge electrodes, spaced discharge electrodes positioned between one of said pairs of non-discharge electrodes, rectifier means connected to said alternating current source, means connecting the output of said rectifier to the discharge electrodes and means for passing gases containing suspended particles between said opposed non-discharge electrodes.

7. An apparatus as defined in claim 6 wherein the means connecting the output of said rectifier means to the discharge electrodes includes means providing high frequency unidirectional current pulses.

8. An apparatus for the electrical precipitation of suspended particles comprising spaced alternate pairs of opposed non-discharge electrodes, one of said pairs of electrodes comprising spaced cylindrical conductive members of circular cross-sections, the other of said pairs of electrodes comprising spaced ellipsoidal cylindrical conductive members positioned with their major axes in alined relationship, the major axes of said ellipsoidal conductive members being not less than the diameter of said circular cylindrical conductive members, a source of high potential alternating current connected to said non-discharge electrodes, spaced discharge electrodes positioned between the cylindrical conductive members, rectifier means connected to said alternating current source, means connecting the output of said rectifier to the discharge electrodes and means for passing gases containing suspended particles between said opposed non-discharge electrodes.

9. An apparatus as defined in claim 8 including means for axially rotating the ellipsoidal electrode members to vary the distance between the opposed surfaces of the paired ellipsoidal members.

10. An apparatus as defined in claim 8 wherein the means connecting the output of said rectifier means to the discharge electrodes includes means providing high frequency unidirectional current pulses.

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