June 5, 1945. H. J. WHITE 2,377,391

CHARGING SUSPENDED PARTICLES

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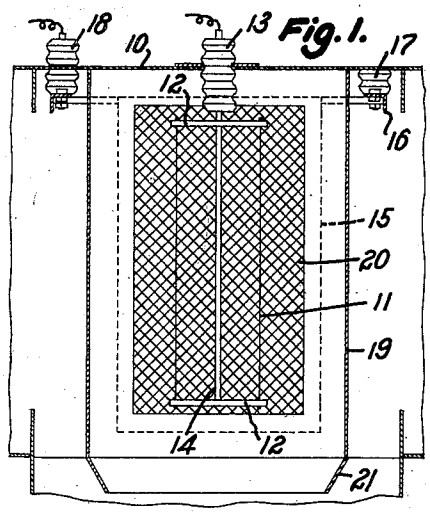


Fig. 1.

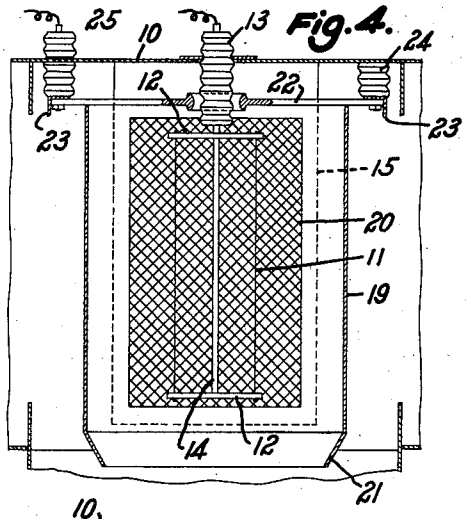


Fig. 4.

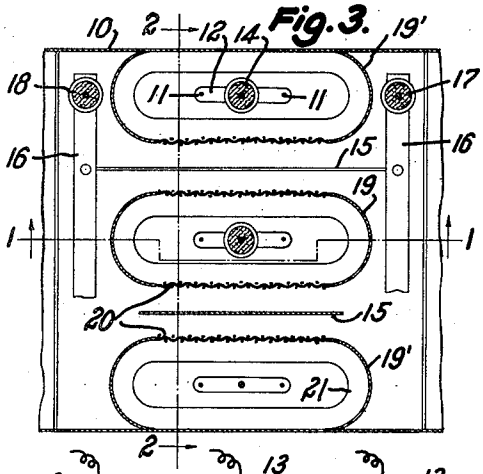


Fig. 3.

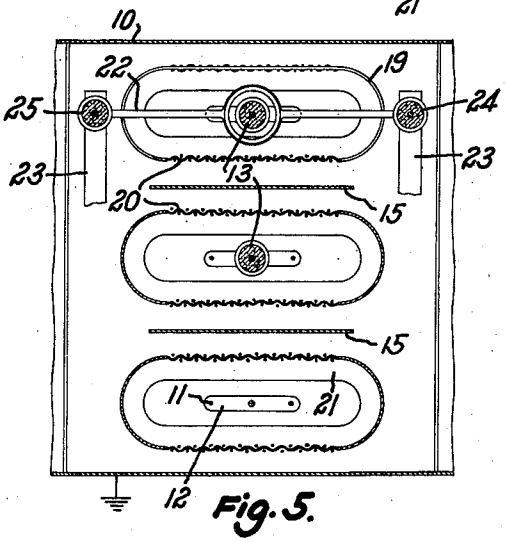


Fig. 5.

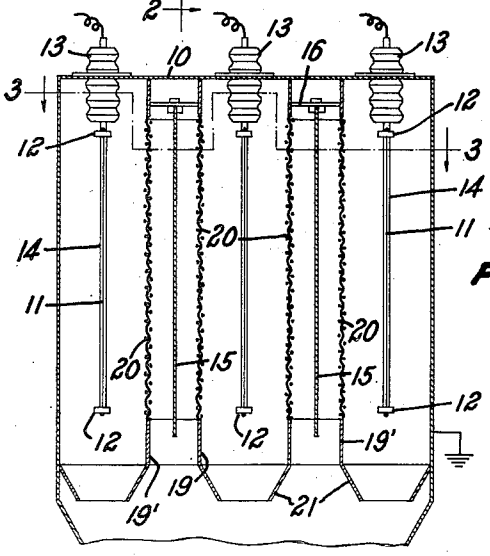


Fig. 2.

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Fig. 6.

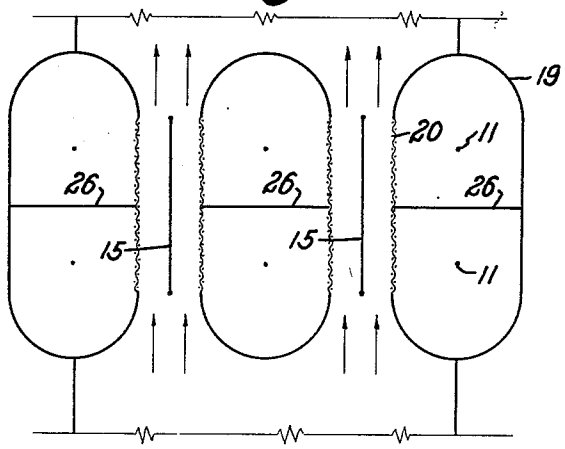
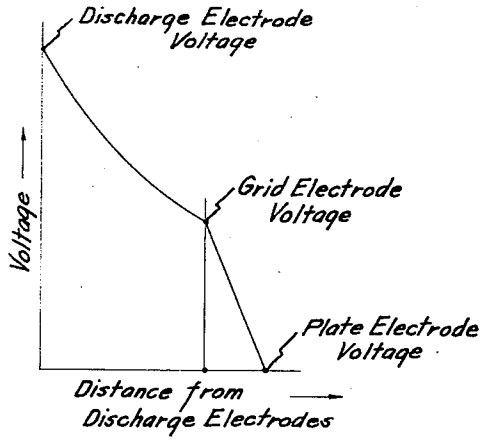


Fig. 7.



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UNITED STATES PATENT OFFICE

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CHARGING SUSPENDED PARTICLES

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Application April 24, 1943, Serial No. 484,502

7 Claims. (Cl. 183—7)

This invention relates to a method and apparatus for the charging of suspended particles contained in a gas for the purpose of facilitating the removal of the particles from the gas by the effect of an electric field.

The method and apparatus of the invention are particularly suitable for charging suspended particles for subsequent removal in a separate precipitating field, as practiced in so-called "two-stage" or "separated field" precipitators. Typically in such precipitators, the gas containing suspended particles is subjected to the action of two successive fields, the first of which is maintained between two electrodes one of which is a discharge electrode and the other of which is a non-discharge electrode, while the second field is maintained between two or more substantially non-discharging electrodes.

In the following description and appended claims, the term "discharge electrode" will be understood to designate an electrode that facilitates corona discharge therefrom, because it has a configuration that establishes a sufficiently high potential gradient at or near its surface to create corona discharge before there is a disruptive discharge or sparkover. For this purpose, the discharge electrode usually takes the form of a member of small surface area, such as a small diameter wire or a rod provided with sharp edges or points, whereby there may be created in the immediate vicinity thereof a sufficiently high electric field intensity to cause ionization and corona discharge. The term "non-discharge electrode" will be understood to designate an electrode that minimizes or prevents corona discharge therefrom because it has a configuration that establishes a sufficiently low field concentration at or near the surface to suppress corona discharge at elevated potentials lower than the voltage required for disruptive discharge or sparkover. For this purpose, a non-discharge electrode usually is one of extended surface area, substantially free from sharp corners or other parts of sharp surface curvature at all portions which are located within the electric field, so as to substantially avoid ionization or corona discharge at that electrode.

In the charging of suspended particles by the effect of corona discharge in an electric field, if an adequate supply of unipolar ions is present, both the rate of charge and the maximum charge of any given particle are directly proportional to the field strength. However, the average strength of the electric field between a discharge electrode and a non-discharge electrode is limited by the occurrence of arcing above a limited value which for negative corona discharge in air is not, in general, substantially above 6 kv. per centimeter, although the breakdown field strength between large spheres or suitably shaped plates for spacings of the order of a few inches in air is around 25 kv. per centimeter.

A principal purpose of the invention is the provision of an improved method and apparatus for the charging of suspended particles.

A further purpose of the present invention is to provide a method and apparatus whereby the field strength of a particle charging field may be substantially increased to bring about a greater rate and effectiveness of charging.

Broadly speaking, the invention comprises increasing the strength of the electric field between a discharge and a non-discharge electrode in the portion of the field adjacent the non-discharge electrode. This may advantageously be effected by providing a pervious, non-discharging auxiliary or grid electrode member between the discharge electrode and non-discharge electrode, and maintaining a substantially greater potential difference per unit of spacing between the auxiliary electrode and non-discharge electrode than between the discharge electrode and the auxiliary electrode. The auxiliary electrode is maintained at a potential between that of the discharge electrode and that of the non-discharge electrode, so that the polarity of the field between the discharge electrode and the auxiliary electrode is the same as that of the field between the auxiliary electrode and the non-discharge electrode. In general, it is advantageous to ground the auxiliary electrode and to maintain the discharge electrode at a negative potential and the non-discharge electrode at a positive potential with respect to the auxiliary electrode, although the non-discharge electrode may be grounded and the auxiliary and discharge electrodes maintained at high (preferably negative) potentials with respect to the non-discharge electrode. It is also advantageous to provide an auxiliary electrode structure of such form that it shields the space between the discharge and the auxiliary electrodes from the direct flow of the gas being treated and causes the gas to pass through the electric field portion of enhanced strength between the auxiliary electrode and the non-discharge electrode.

The invention will be more particularly described with reference to the accompanying drawings showing illustrative embodiments of the invention. In the drawings:

Fig. 1 is a partial vertical sectional elevation of a particle charging apparatus embodying the principles of the invention;

Fig. 2 is a transverse sectional elevation of the apparatus of Fig. 1;

Fig. 3 is a sectional plan view of the apparatus of Fig. 1 on line 3—3 of Fig. 2;

Fig. 4 is a partial vertical sectional elevation of another embodiment of the invention;

Fig. 5 is a sectional plan view of the apparatus of Fig. 4;

Fig. 6 is a diagrammatic plan view of a further embodiment of the invention, and

Fig. 7 is a diagrammatic representation of typical electric potential relationships in the method and apparatus of the invention.

In the particle charging apparatus of Figs. 1 to 3, 10 is a suitable shell providing a horizontal passage for gases to be treated. Suspended within the passage are discharge electrode assemblies consisting of discharge elements 11, shown as wires, and support members 12, carried by rods 13 which pass through insulating bushings 14 and serve to support and transmit electrical energy to the discharge electrode assemblies.

Positioned in spaced relation between the discharge electrode assemblies are non-discharge electrodes, shown as plates 15. The plates 15 are carried by members 16, which are supported by insulators 17 and insulating bushings 18 and are energized through the latter.

Surrounding each discharge electrode assembly are grounded auxiliary or grid electrodes 19, 19'. The auxiliary electrodes 19, 19' are provided with grid portions 20 between each discharge electrode assembly and the nearest non-discharge electrode, the grid portions comprising smooth rounded members, free from portions of sufficiently small radius of curvature to cause corona discharge therefrom under the conditions of operation of the apparatus. The grid structure is relatively open so as to pass a substantial portion of the corona current. The solid end portions of the grid electrodes shield the space around the discharge electrode assemblies from the direct flow of the gases and confine the flow to the charging space between grid electrodes and the non-discharge or plate electrodes. The side walls of the shell 10 may form a part of the structure of the lateral grid electrodes 19', as shown.

By providing a relatively high potential between the grid electrodes and the non-discharge electrodes, a strong field is maintained in the charging space thereby increasing the rate and maximum amount of charging of the particles therein. For example, in the construction shown, the grid electrode may be spaced 2½ to 3 inches from the discharge electrodes and the latter maintained at 30 to 40 kv. negative potential, while the plate electrode may be 1 to 1½ inches from the grid electrode and maintained at 20 to 30 kv. positive potential.

In general, the field strength between the discharge electrode and the auxiliary electrode should approach but not attain the breakdown or arcing value, while the field strength between the auxiliary electrode and the plate electrode should be substantially higher, for example, 20 to 30 kv. per inch.

When used as the charging section of a two-stage precipitator, the construction shown may be advantageously joined to a precipitator section containing a plurality of spaced plates having a precipitating field maintained therebetween.

The grid electrode structures in Figs. 1 to 3 are provided with hopper shaped lower ends 21, which permit any material which collects on the electrode surfaces to drop into the bottom of the shell 10 and reduce the tendency of the gas to flow into the space adjacent the discharge electrodes.

In the form of the invention shown in Figs. 4 and 5, the general arrangement and form of the elements of the apparatus are similar to those of Figs. 1–3, but in this form the plate electrodes are grounded and both the discharge electrodes and the grid electrodes are insulated from the shell structure. The non-discharge electrodes 15 are supported directly from the shell 10, and the sides of the shell provide complementary non-discharge electrode surfaces for the lateral discharge electrodes.

The discharge electrode assemblies are supported by and energized through insulating bushing 13 as in Figs. 1–3.

The auxiliary or grid electrodes 19 are carried by members 22 which are supported by transverse members 23 suspended from supporting insulators 24 and insulating bushings 25.

In this form of the invention, with interelectrode spaces of the same order as those given by way of example for the apparatus of Figs. 1–3, the discharge electrode may advantageously be maintained at a negative potential of 50 to 70 kv., while the grid electrode is maintained at a negative potential of 20 to 30 kv., so that the average field strength or potential difference between the discharge and grid electrodes will be of the order of 12–15 kv. per inch and the average field strength or potential difference between the grid and plate electrodes will be at least 20 kv. per inch. The potentials may be advantageously supplied from a rectified alternating current power source in the manner well known in the electrical precipitation art.

In order to reduce circulation of the gas through the shielded space between the discharge and the grid electrodes, the shielded space may be provided with transverse partitions 26, as shown diagrammatically in Fig. 6.

Typical electric potential relationships in the method and apparatus of the invention are diagrammatically illustrated in Fig. 7 in which the ordinates represent the potential differences between the electrodes and the abscissae represent the positions of the electrodes. The vertical distance between any two points on the curve represents the potential difference between corresponding points in the apparatus.

In the operation of the charging apparatus of the invention, a gas containing suspended particles is passed through the gas passage, for example, from left to right through the apparatus of Figs. 1 to 5. The form of the grid electrodes 19, 19' directs the gas stream into the interelectrode spaces between the grids 20 and the plate electrodes 15.

In these spaces the particles contained in the gas are subjected to the charging effect of the ionizing discharge emanating from discharge elements 11, which is very greatly enhanced by the influence of the strong electric field in the grid-plate interelectrode space, and the particles are rapidly charged to a maximum charge. The charged particles are subject to a strong force tending to transport them to the plate electrode. Whether the charged particles are carried to the plate electrode and there collected or are carried out of the charging field in the gas stream to be precipitated in a subsequent precipitating field

will be determined by such factors as the electric field strength, the character of the suspended material and the rate of gas flow. One of the principal advantages of the invention is the possibility of maintaining a high efficiency of particle charging at high gas velocities.

It will be clear that the particular embodiments of the invention shown and described herein are merely illustrative of the principles of the invention and are subject to variation in form and arrangement without departing from the scope of the invention as defined in the appended claims.

I claim:

1. A method of charging particles which comprises generating an ionizing discharge in an electric field, directing said discharge into an electric field of substantially greater average strength than the average strength of the field from which said ionizing discharge emanates to establish therein a charging zone, and passing a gas containing suspended particles substantially wholly through said charging zone whereby substantially all of the particles are subjected to said ionizing discharge in said charging zone.

2. A method of charging suspended particles which comprises generating an ionizing discharge between a discharging electrode and a non-discharging electrode, establishing an electric field in that portion of the space between the electrodes adjacent the non-discharging electrode and spaced from the discharge electrode of an average strength substantially greater than the average field strength adjacent the discharging electrode, and passing a gas containing suspended particles substantially wholly through said ionizing discharge in the electric field of enhanced strength whereby substantially all of the particles are subjected to said ionizing discharge in said field of enhanced strength.

3. A method of charging suspended particles which comprises generating an ionizing discharge between a discharging electrode and a non-discharging electrode, establishing an electric field of at least about 20 kv. per inch average strength in that portion of the space between the electrodes adjacent the non-discharging electrode while maintaining the field strength adjacent the discharging electrode at less than the breakdown strength, and passing a gas containing suspended particles substantially wholly through said ionizing discharge in the electric field of enhanced strength whereby substantially all of said particles are subjected to said ionizing discharge in said field of enhanced strength.

4. Apparatus for charging suspended particles comprising a discharge electrode, a non-discharge electrode spaced therefrom, a gas-pervious, non-discharge, auxiliary electrode positioned between the discharge electrode and the first non-discharge electrode, means for establishing an electric field between said discharge electrode and said auxiliary electrode effective to cause an ionizing discharge from said discharge electrode, means for establishing a substantially stronger electric field of the same polarity between said auxiliary electrode and said first non-discharging electrode, and means for directing a stream of gas substantially wholly through the space between said auxiliary electrode and said first non-discharge electrode.

5. Apparatus for charging suspended particles comprising a discharge electrode, a non-discharge electrode spaced therefrom, a gas-pervious, non-discharge, auxiliary electrode positioned between the discharge electrode and the first non-discharge electrode, means for establishing an electric field between said discharge electrode and said auxiliary electrode effective to cause an ionizing discharge from said discharge electrode, means for establishing a substantially stronger electric field of the same polarity between said auxiliary electrode and said first non-discharge electrode, means for directing a stream of gas through the space between said auxiliary electrode and said first non-discharge electrode, and means for shielding the space between said discharge electrode and said auxiliary electrode from direct flow of gas.

6. Apparatus for charging suspended particles comprising a discharge electrode, a non-discharge electrode spaced therefrom, a gas-pervious, non-discharge, auxiliary electrode positioned between the discharge electrode and the first non-discharge electrode, means for establishing an electric field between said discharge electrode and said auxiliary electrode effective to cause an ionizing discharge from said discharge electrode, means for establishing an electric field of about 20 kv. per inch and of the same polarity as the first field between said auxiliary electrode and said non-discharge electrode, and means for shielding the space between the said first discharge electrode and said auxiliary electrode from direct flow of gas.

7. Apparatus for charging suspended particles comprising a discharge electrode, a non-discharge electrode spaced therefrom, an auxiliary non-discharge electrode surrounding said discharge electrode including a gas-pervious portion between the discharge electrode and the first non-discharge electrode and a non-gas-pervious portion positioned to shield the space between said discharge electrode and said auxiliary electrode from direct flow of gas, means for establishing an electric field between said discharge electrode and said auxiliary electrode effective to cause an ionizing discharge from said discharge electrode, and means for establishing a substantially stronger electric field of the same polarity between said auxiliary electrode and said first non-discharge electrode.

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