

April 28, 1936.

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2,039,094

ELECTRICAL PRECIPITATION APPARATUS

Filed Aug. 2, 1932

3 Sheets-Sheet 1

Fig. 1.

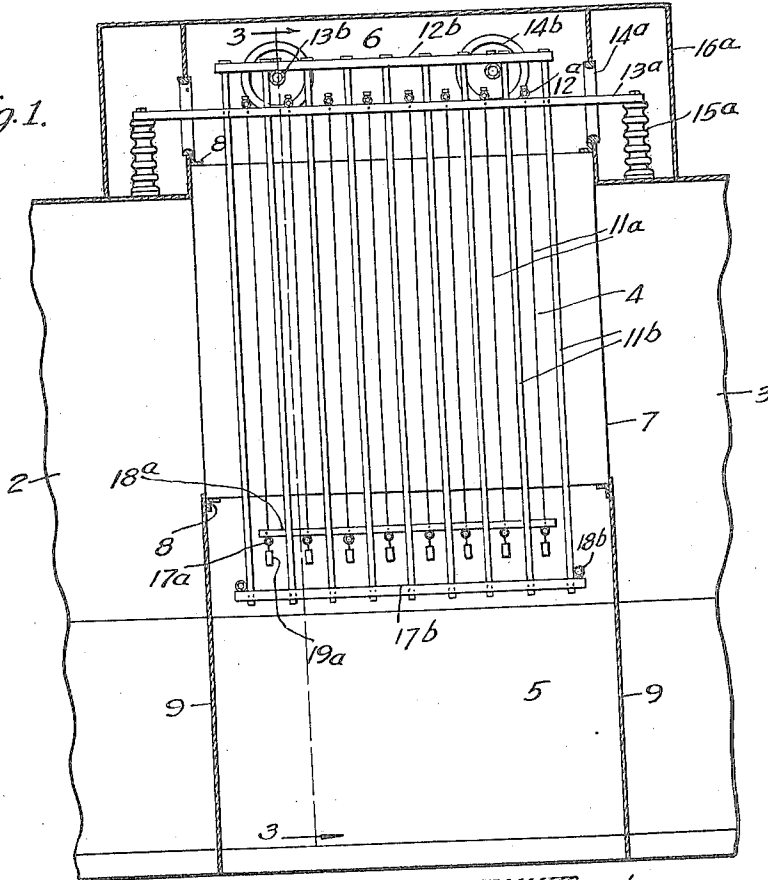
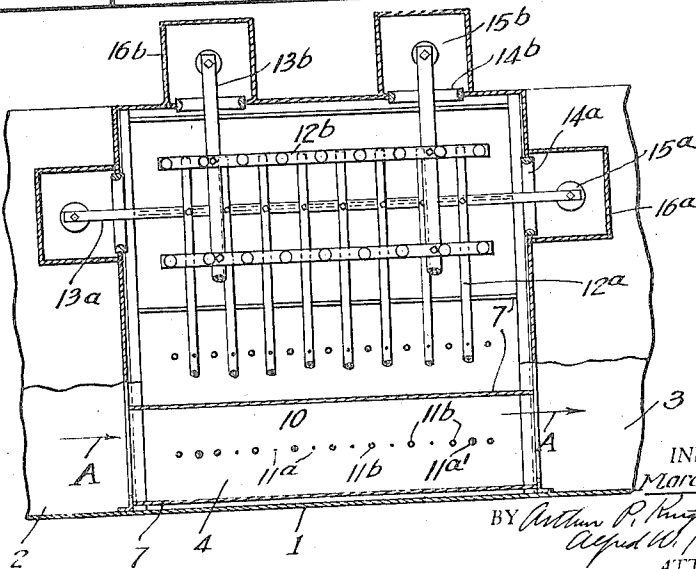


Fig. 2.



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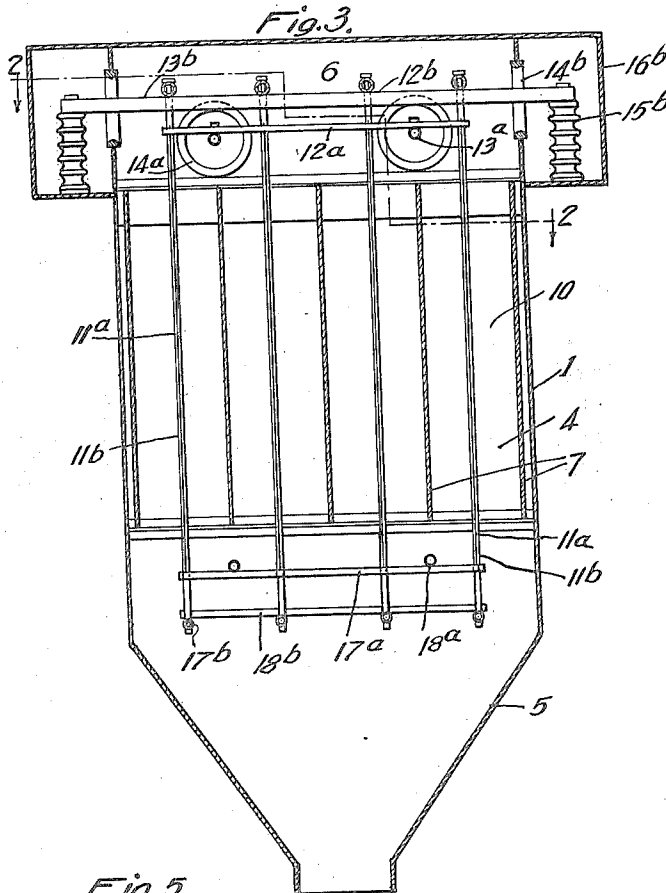
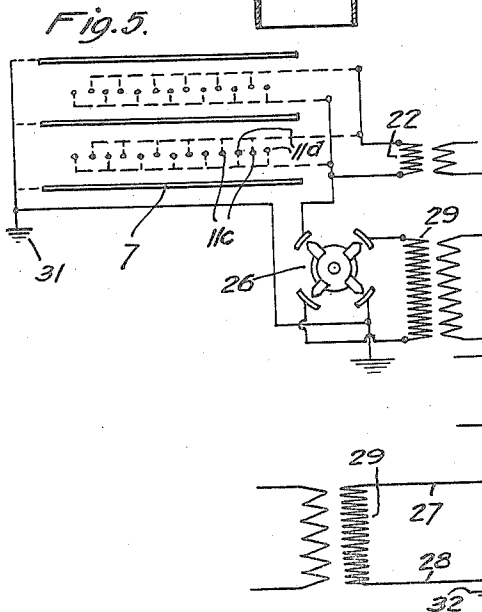
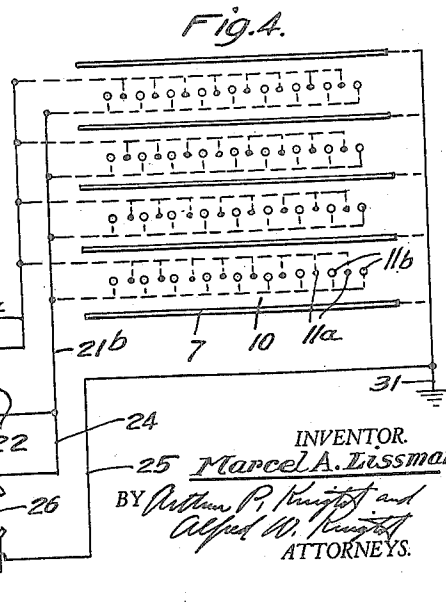
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Filed Aug. 2, 1932

3 Sheets-Sheet 2



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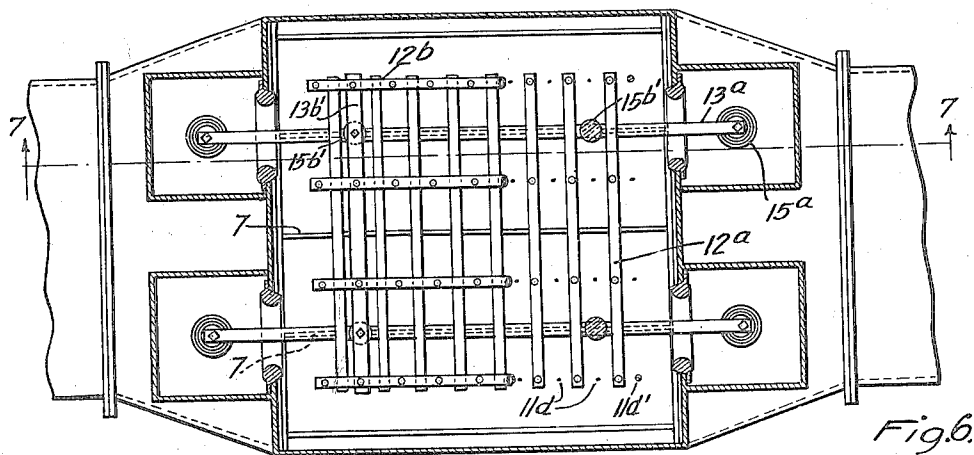
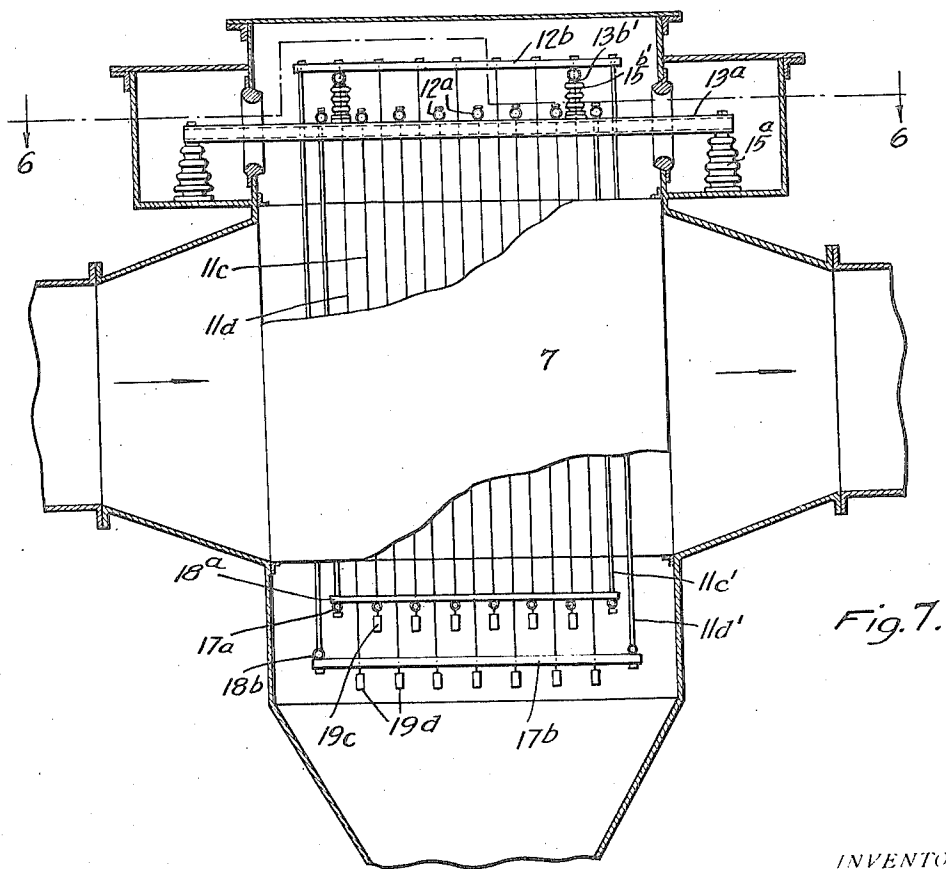
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ELECTRICAL PRECIPITATION APPARATUS

Filed Aug. 2, 1932

3 Sheets-Sheet 3



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2,039,094

ELECTRICAL PRECIPITATION APPARATUS

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Application August 2, 1932, Serial No. 627,249

7 Claims. (Cl. 183-7)

This invention relates to apparatus for the electrical precipitation of suspended particles from gases, and the principal object of the invention is to provide an advantageous construction of such an apparatus, which has a high efficiency of operation, so as to effect a high degree of precipitation of suspended particles from a relatively large volume of gas in an apparatus of minimum size and with a minimum consumption of electrical energy, and which is also so designed as to eliminate electrical disturbances and irregularities in operation such as occur in electrical precipitators now in use.

A particular object of the invention is to provide for more effective ionization by means of a separate ionizing electric field, resulting in a more rapid rate of electrical charging of the suspended particles, while the particles are simultaneously subjected to another electric field, which may be termed a precipitating field, adapted to cause precipitation of the charged particles upon suitable receiving electrodes.

The ordinary type of electrical precipitation apparatus comprises opposing discharge and receiving electrodes, the receiving electrodes ordinarily consisting of plates, screens, pipes or other members of relatively extended surface and the discharge electrodes ordinarily consisting of wires, or rods of small diameter, suitably spaced from one another and extending parallel to the surfaces of the receiving electrodes, said discharge and receiving electrode means being insulated from one another and connected to the opposing terminals of a suitable source of electric current, preferably unidirectional, at sufficient voltage to maintain ionizing discharge from the discharge electrodes, and means being also provided for passing gas containing suspended particles through the spaces between the discharge and receiving electrodes and for removing and collecting the material precipitated. In such apparatus the electric potential between the discharge and receiving electrodes is utilized both for maintaining ionizing or corona discharge from the discharge electrode members and for maintaining the electrostatic force between said discharge electrode members and the receiving electrodes for effecting migration of charged particles toward the receiving electrodes. Practical considerations make it necessary to space the discharge electrode members a considerable distance from the receiving electrodes, this space being ordinarily from about 3 to 6 inches, so that a relatively high electric potential is required in order that the potential gradient at the discharge

electrode shall be sufficient to bring about a suitable degree of ionization for charging of the suspended particles. Furthermore, it is found that efficient ionization can be realized only when this electric potential is fairly close to the arcing potential between the discharge and collecting electrodes, so that in operation arcing sometimes occurs due to accumulation of suspended particles on the electrodes or to occurrence of high voltage surges produced in the electric circuit. Formation of an arc between the electrodes not only represents a waste of electrical energy but also lowers the potential difference between the electrodes to such an extent that ionization is no longer effected or is reduced to a minimum. This reduction in potential difference ordinarily results eventually in a breaking of the arc and a restoration of the normal potential difference, but the precipitator is substantially ineffective during the period of maintenance of the arc. In many cases, particularly in the collection of certain types of suspended material or in the treatment of certain types of gases, this arcing is of such frequent occurrence as to seriously reduce the efficiency of the apparatus.

Furthermore, it has been found that in an apparatus of the type above described the discharge electrode members must be spaced not less than a certain distance from one another in order to avoid an interfering action therebetween resulting in a suppression of electrical discharge therefrom. It may be said that in ordinary practice it has been found that maximum electrical discharge and ionization from each individual discharge electrode member can be obtained only when the spacing between adjacent discharge electrode members is not less than and preferably somewhat greater than the shortest distance between the discharge electrode members and the receiving electrodes. It is evident that this relationship imposes a limitation upon the closeness of spacing of the discharge electrode members and hence upon the number of discharge electrode members which may be provided in an apparatus of a given size, using a practical spacing of discharge electrodes from receiving electrodes. Thus, a limitation is placed upon the amount of ionization and consequent charging of the particles which can be effected in an apparatus of a certain size.

It is the purpose of the present invention to provide apparatus of relatively simple construction in which the above-mentioned disadvantages of ordinary electrical precipitation apparatus are largely overcome, so that arcing or disruptive dis-

charge between the electrodes is avoided and a maximum amount of ionization is provided in an apparatus of a given size and with a minimum consumption of electrical energy.

Electrical precipitation apparatus now in common use consists of two general types. In the "plate type" precipitator the receiving electrodes may consist of plates of metal, concrete or other suitable material or of plate-like members such as screens or rod curtains, such plates or plate-like members being disposed in parallel planes, ordinarily vertical, defining ducts or passages through which the gas is passed either horizontally or vertically, while the discharge electrode members ordinarily consist of wires or rods of small diameter disposed in suitably spaced relation to one another in planes extending parallel to the receiving electrodes and midway therebetween. In the "pipe type" precipitator the receiving electrodes consist of pipes or tubes through which the gas is passed longitudinally, said pipes generally extending vertically and usually being cylindrical in shape although sometimes of square, rectangular or other suitable shape, while the discharge electrode members consist of wires or rods of small diameter extending longitudinally and substantially axially within the respective pipes.

The present invention is applicable to best advantage to electrical precipitators of the plate type. In applying the invention to an apparatus of this type, the receiving electrodes are as before formed as plates or plate-like members of extended surface disposed in substantially parallel and preferably vertical planes. However, instead of providing only a single set of discharge electrode members between each pair of adjacent receiving electrodes, I provide two sets of oppositely charged ionization field electrode members spaced from one another, both sets being preferably disposed in or adjacent a common plane extending parallel to and midway between adjacent receiving electrode plates, and the electrode members of one set being preferably alternately disposed with respect to the electrode members of the other set.

The two sets of ionization field electrodes are so supported as to be insulated from one another and also from the receiving electrodes, and separate electric potentials are applied between the respective sets of ionization field electrodes, and between one or both sets of ionization field electrodes and the receiving electrodes. For this purpose the two sets of ionization field electrodes are connected to opposite terminals of a source of either alternating or unidirectional electric current at sufficient voltage to maintain an ionizing or corona discharge from one or both of these sets of electrodes, in what may be termed an ionization field, while the receiving electrodes and one of the sets of ionization field electrodes are connected to opposite terminals of a second source of electric current, preferably unidirectional current, at sufficient voltage to maintain an effective precipitating field therebetween.

According to a preferred embodiment of the invention, one of the sets of ionization field electrodes comprises a plurality of bare metallic elements of relatively small diameter such as wires or small rods whose diameter is sufficiently small to provide ionization or corona discharge therefrom under the electrical potential applied between said elements and the elements of the other set, while the other set of ionization field electrodes, arranged alternately with respect to

the first set, comprises a plurality of bare metallic elements of somewhat greater diameter, for example larger rods or pipes, whose diameter is sufficiently large to substantially prevent or inhibit electrical discharge therefrom under said electric potential. With such an arrangement, ionization occurs substantially wholly at or adjacent the electrode members of smaller diameter, while the larger diameter electrode members act as opposing electrodes for maintaining the necessary potential gradient for producing such ionization. Either the large diameter or small diameter electrode members may be connected to one terminal of the electric current source used for maintaining the precipitating field between said members and the receiving electrodes. It is evident that with separate ionization and precipitation fields as above described, the oppositely charged ionization field electrodes may be spaced quite closely together in their respective planes, without regard to the relation of this spacing to the distance between the plane of the ionization field electrodes and the surface of the adjacent receiving electrodes. It is possible, therefore, to space the ionization field electrodes at a relatively great distance from the receiving electrodes and to maintain a sufficient potential difference therebetween to produce substantially complete migration of charged particles across this space and onto the receiving electrodes, while at the same time spacing the ionization field electrode members relatively close together, and preferably at a closer spacing than the distance between the ionization field electrodes and the receiving electrodes, so as to provide a large number of ionization field electrodes and a consequent high production of ions in an apparatus of a given size. The invention therefore provides for utilization of electrical energy and also of the available space in the most efficient manner, both in the ionization of the gas and the consequent charging of the suspended particles and also in the electrical attraction or migration of the charged particles toward and upon the receiving electrodes.

The invention also comprises novel and advantageous means for supporting the two sets of ionization field electrodes in such manner as to insulate the same from one another and from the receiving electrodes.

The accompanying drawings illustrate apparatus embodying my invention and referring thereto:

Fig. 1 is a longitudinal section of a plate type precipitator according to a preferred embodiment of my invention.

Fig. 2 is a horizontal section thereof on line 2-2 in Fig. 3.

Fig. 3 is a transverse section on line 3-3 in Fig. 1.

Fig. 4 is a wiring diagram showing a preferred means of maintaining the separate electric fields above mentioned.

Fig. 5 is a wiring diagram illustrating a possible modification of the ionization electrode members.

Fig. 6 is a horizontal section of a modified form of plate type precipitator, on line 6-6 in Fig. 7.

Fig. 7 is a longitudinal section of the precipitator shown in Fig. 6, taken on line 7-7 therein, with the nearest receiving electrode partly broken away.

The apparatus shown in Figs. 1 to 4 inclusive comprises a housing 1 provided with means such as inlet flue 2 and outlet flue 3 for effecting passage of gas through said housing, it being under-

stood that the actual flow of gas at the desired velocity may be produced by either natural or induced draft. Said housing comprises a central portion 4 constituting a precipitating chamber, a lower portion 5 formed as a receiving hopper or bin for the precipitated material and an upper portion 6, in which are disposed the supporting means for the ionization electrodes as hereinafter described. In the precipitating chamber are provided a plurality of receiving electrodes 7 which may be formed as plates or plate-like members disposed in parallel vertical planes. By way of example, said receiving electrode members are shown as metal plates extending parallel to the direction of gas flow as indicated by the arrows at A in Fig. 2, said plates being supported and positioned in any suitable manner as by means of bars 8. Gas passage ducts 10 are thus provided between the receiving electrodes. Transverse partitions 9 are shown as extending across the housing 1 below the receiving electrode plates so as to obstruct flow of gas below said plates and cause the gas flow to be confined substantially to the spaces or ducts 10.

The two sets of ionization field electrodes are indicated at 11a and 11b respectively, there being a plurality of electrode members of each set disposed vertically in spaced relation in a vertical plane extending midway between each pair of adjacent receiving electrodes, and the electrode members 11a and 11b being alternately disposed in each such plane. The electrode members 11a are shown as being of relatively small diameter so as to provide corona discharge therefrom, said members consisting, for example, of wires or small diameter rods. Said members may be supported at their upper ends by means of bar 12a which extend transversely over the tops of the receiving electrode plates and are carried by main supporting bars 13a which extend through openings 14a in the end walls of the upper housing portion 6 and rest on insulating supports 15a in inclosed insulator compartments 16a. Said electrode members 11a are also preferably spaced at their lower ends as by means of rods 17a which may be connected by rods 18a so as to form a lower spacing frame, and are preferably kept in tension by means of weights 19a. Said lower spacing frame may be supported by certain of the electrode members such as indicated at 11a' which may for this purpose be made of larger diameter and greater strength than the other of said members.

The other electrode members 11b are shown as rods or pipes of considerably larger diameter than the members 11a so as to substantially prevent or inhibit corona discharge therefrom at the electrical potential employed, and are supported at their upper ends by means of bars or rods 12b which extend longitudinally with respect to the planes in which said electrode members are disposed, and which are carried by main supporting bars 13b. Said supporting bars 13b extend through openings 14b in the side walls of the upper housing portion 6 and rest on insulating supports 15b in inclosed insulator compartments 16b. Said electrode members 11b are also preferably supportingly connected at their lower ends to longitudinal bars or rods 17b which are in turn connected by rods or bars 18b so as to provide a lower spacing and positioning frame therefor. It will be understood that the supporting members 12b and 13b for the electrode members 11b are at all points spaced sufficiently from the supporting members 12a and 13a for the other

set of ionization field electrode members 11a to substantially prevent electric discharge between said supporting members. Similarly, the bottom spacing members 17b and 18b are spaced sufficiently from the members 17a and 18a to prevent electric discharge therebetween.

As shown in Fig. 2, the ionization field electrodes are spaced relatively close to one another as compared to the distance between the planes of said electrodes and the adjacent receiving electrodes, and the dimensions are preferably such that the distance between successive electrodes adapted to produce ionization, namely, in the present case the electrode members 11a, is less than the distance between said electrode members and the receiving electrode members 7.

As shown in Fig. 4 the ionization field electrode members 11a and 11b respectively, are connected by means of electrical conductors 21a and 21b to the opposing terminals of a transformer 22, or other suitable source of alternating current at sufficient voltage to maintain a corona or ionizing discharge from the electrode members 11a of smaller diameter. The electrode members 11b of relatively large diameter and the receiving electrode members 7 are shown as connected by means of electrical conductors 24 and 25 respectively, to the output terminals of a current rectifying device such as mechanical rectifier 26 whose operation is well understood, the input terminals of said rectifying device being in turn connected by wires 27 and 28 to a transformer 29 or other suitable source of alternating current at sufficient voltage to maintain an electric field of the desired strength between the electrode members 11b and 7. The receiving electrodes 7 and the terminal of the rectifying device which is connected thereto are also preferably grounded as indicated at 31 and 32 respectively.

It will be understood that it is within the scope of the invention to connect the unidirectional precipitating field circuit to the electrode members 11a instead of 11b, if desired, and also that a current rectifying device, such as a mechanical rectifier similar to the rectifier 26 may, if desired, be connected between the transformer 22 and the two sets of ionization field electrodes so as to utilize unidirectional current instead of alternating current in the ionization field circuit.

In view of the relatively close spacing between the ionization field electrodes as compared to the spacing of said ionization field electrodes from the receiving electrodes, the voltage required in the ionization field circuit, that is, the output voltage of transformer 22, may in general be considerably less than the voltage required in the precipitating field circuit, that is, the output voltage of transformer 29. For example, the transformer 22 may be of such size as to maintain a potential difference of between 2,000 and 10,000 volts between the respective sets of ionization field electrodes, while the transformer 29 may be adapted to maintain a potential difference between 30,000 and 100,000 volts between the ionization field electrodes and the receiving electrodes.

In the operation of this form of the invention the gas containing suspended particles is passed through the apparatus and through the gas passage ducts 10 in a horizontal direction such as indicated by the arrows A in Fig. 2. The electric field between electrode members 11a and 11b causes ionization to occur adjacent the electrode members 11a, while the electric field between the electrode members 11b (or 11a) and the receiving electrodes 7 causes the ions thus produced to be

largely directed out into the gas stream in the ducts 10 so as to cause charging of the suspended particles contained in the gas, and also causes the particles thus charged to be drawn toward and precipitated upon the receiving electrodes 7. The material so precipitated may be allowed to fall by gravity, with the assistance if necessary of any suitable means such as commonly employed for rapping or jarring the receiving electrodes to dislodge such material therefrom, and such material collects in the hopper or bin 5 from which it may be removed by any suitable means.

It may be pointed out that if a unidirectional potential of relatively large magnitude is employed in the precipitating field and an alternating potential of relatively small magnitude in the ionization field, both the electrode members 11a and 11b will be at high potential with respect to the receiving electrodes, so that the precipitation field, which also serves to drive the ions out into the gas stream, will exist between both sets of ionization field electrodes and the receiving electrodes, and not only from the particular ionization field electrodes 11d which are directly connected in the precipitating field circuit. Furthermore, the potential difference between the electrode members 11a and the receiving electrodes will be greater during half of each cycle and less during the next half of each cycle than the potential difference between the electrodes 11b and said receiving electrodes, so that the precipitating field will at certain times be principally between the electrode members 11a and the receiving electrodes and at other times principally between the electrode members 11b and the receiving electrodes.

As shown in Fig. 5, instead of employing electrode members of different diameters in the two sets of ionization field electrodes, I may employ ionization electrode members 11c and 11d of like diameter, both of such sets of electrode members consisting, for example, of wires or rods of small diameter. Said electrode members may be mounted substantially as above described and in a similar relation with respect to the receiving electrodes 7 and the respective electrode members may be similarly connected, so as to connect transformer 22 in the ionization field circuit and rectifying device 26 and transformer 29 in the precipitation field circuit, in the same manner as before.

The operation of this form of the invention is substantially the same as in the form of the invention first described with the exception that ionization occurs adjacent both sets of ionization field electrodes 11c and 11d.

The form of apparatus shown in Figs. 6 and 7 is similar to that shown in Figs. 1 to 3 inclusive, with the exception that the ionization field electrode means are shown as comprising two sets of electrode members 11c and 11d, both consisting of wires or rods of small diameter, in the manner shown in Fig. 5, and with the further exception that somewhat different means are provided for supporting the respective sets of ionization field electrode members. The electrode members 11c are suspended, as before, from transversely extending rods or bars 12a which are in turn carried by longitudinal supporting bars 13a resting on insulating supports 15a. The other set of electrode members 11d are shown as suspended from longitudinally extending supporting bars or rods 12b which are in turn carried by transverse supporting bars 13b'. These last-mentioned supporting bars 13b', instead of being provided with

separate insulating supports, are shown as resting on insulating supports 15b' carried by the longitudinal supporting bars 13a. It will be seen, therefore, that the longitudinal supporting bars 13a serve not only to directly support the electrode members 11c and the supporting members 12a therefor, but also to support the electrode members 11d and their supporting members 12b and 13b', which latter supporting members are insulated therefrom by the aforesaid insulators 15b'.

The respective sets of ionization field electrode members may, as before, be provided at their lower ends with spacing members 17a and 18a, and 17b and 18b, and certain of the electrode members of each set, such as indicated at 11c' and 11d', may be made of sufficiently great diameter to support the respective spacing members from the upper supporting means. Both sets of electrode members 11c and 11d may be provided at their lower ends with tensioning weights 19c and 19d respectively.

The operation of this form of apparatus is substantially the same as that shown in Figs. 1 to 3 inclusive, with the exception that ionization occurs adjacent both sets of ionization electrode members, as described before in connection with Fig. 5.

I claim:—

1. An electrical precipitator comprising a plurality of plate-like collecting electrodes disposed in parallel vertical planes, ionization electrode means disposed in vertical planes between the respective collecting electrodes, the ionization electrode means in each of said planes comprising two sets of electrode members spaced from one another and disposed in alternate relation, a plurality of supporting members extending longitudinally in the respective planes of the ionization electrode members and supporting all of the electrode members of one of said sets, additional supporting members extending transversely with respect to said planes, spaced from said first-named supporting members, and serving to support all of the electrode members of said other set, means supporting said first-named and second-named supporting members and insulating the same from one another, means connected to the respective sets of ionization electrode members for maintaining an electric field therebetween, and means connected to said collecting electrodes and to one of the sets of ionization electrode members for maintaining a separate electric field therebetween.

2. An electrical precipitator as set forth in claim 1, said first-named and second-named supporting members being each provided with separate means for supporting the same and for insulating the same from one another and from the collecting electrodes.

3. An apparatus as set forth in claim 1, in which the means for supporting and insulating said supporting members comprises means mounted on insulating supports and serving to directly support the supporting members for one of the sets of ionization electrode members, and additional supporting means mounted thereon and insulated therefrom and serving to support the supporting members for the other set of ionization electrode members.

4. In an electrical precipitator, the combination of a collecting electrode having an extended surface, a linear ionization field electrode consisting of a bare metallic element of sufficiently

small diameter to provide corona discharge therefrom, another ionization field electrode consisting of a bare metallic element of sufficiently large diameter to substantially prevent electrical discharge therefrom, spaced from and parallel to said first-named ionization field electrode, both of said ionization field electrodes extending parallel to the surface of said collecting electrode and spaced therefrom, electric power supply means connected to said ionization field electrodes for maintaining therebetween an electric field of sufficient intensity to cause corona discharge from said electrode of small diameter, and electric power supply means connected to one of said ionization field electrodes and to said collecting electrode for separately maintaining an electric precipitating field between said ionization field electrodes and said collecting electrode.

5. In an electrical precipitator, the combination of a plate or plate-like collecting electrode, a series of parallel linear ionization field electrodes disposed in a plane substantially parallel to the collecting electrode, alternate ones of said ionization field electrodes consisting of bare metallic elements of sufficiently large diameter to substantially prevent electrical discharge therefrom, and the other ionization field electrodes consisting of bare metallic elements of sufficiently small diameter to provide corona discharge therefrom, electric power supply means connected to said collecting electrode and to one of the sets of alternate ionization field electrodes for maintaining a unidirectional high potential electric precipitating field between said ionization field electrodes and the collecting electrode, and separate electric power supply means connected to said ionization field electrodes for separately maintaining an electric field of relatively small potential between the two sets of alternate ionization field electrodes sufficient to cause corona discharge from said electrodes of small diameter.

6. In an electrical precipitator, the combination of a collecting electrode having an extended surface, a linear ionization field electrode con-

sisting of a bare metallic element of sufficiently small diameter to provide corona discharge therefrom, another ionization field electrode consisting of an element of sufficient large diameter to substantially prevent electrical discharge therefrom, spaced from and parallel to said first-named ionization field electrode, both of said ionization field electrodes extending parallel to the surface of said collecting electrode and spaced therefrom, electric power supply means connected to said ionization field electrodes for maintaining therebetween an electric field of sufficient intensity to cause corona discharge from said electrode of small diameter, and electric power supply means connected to one of said ionization field electrodes and to said collecting electrode for separately maintaining an electric precipitating field between said ionization field electrodes and said collecting electrode.

7. In an electrical precipitator, the combination of a plate or plate-like collecting electrode, a series of parallel linear ionization field electrodes disposed in a plane substantially parallel to the collecting electrode, alternate ones of said ionization field electrodes consisting of elements of sufficiently large diameter to substantially prevent electrical discharge therefrom, and the other ionization field electrodes consisting of bare metallic elements of sufficiently small diameter to provide corona discharge therefrom, electric power supply means connected to said collecting electrode and to one of the sets of alternate ionization field electrodes for maintaining a unidirectional high potential electric precipitating field between said ionization field electrodes and the collecting electrode, and separate electric power supply means connected to said ionization field electrodes for separately maintaining an electric field of relatively small potential between the two sets of alternate ionization field electrodes sufficient to cause corona discharge from said electrodes of small diameter.

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