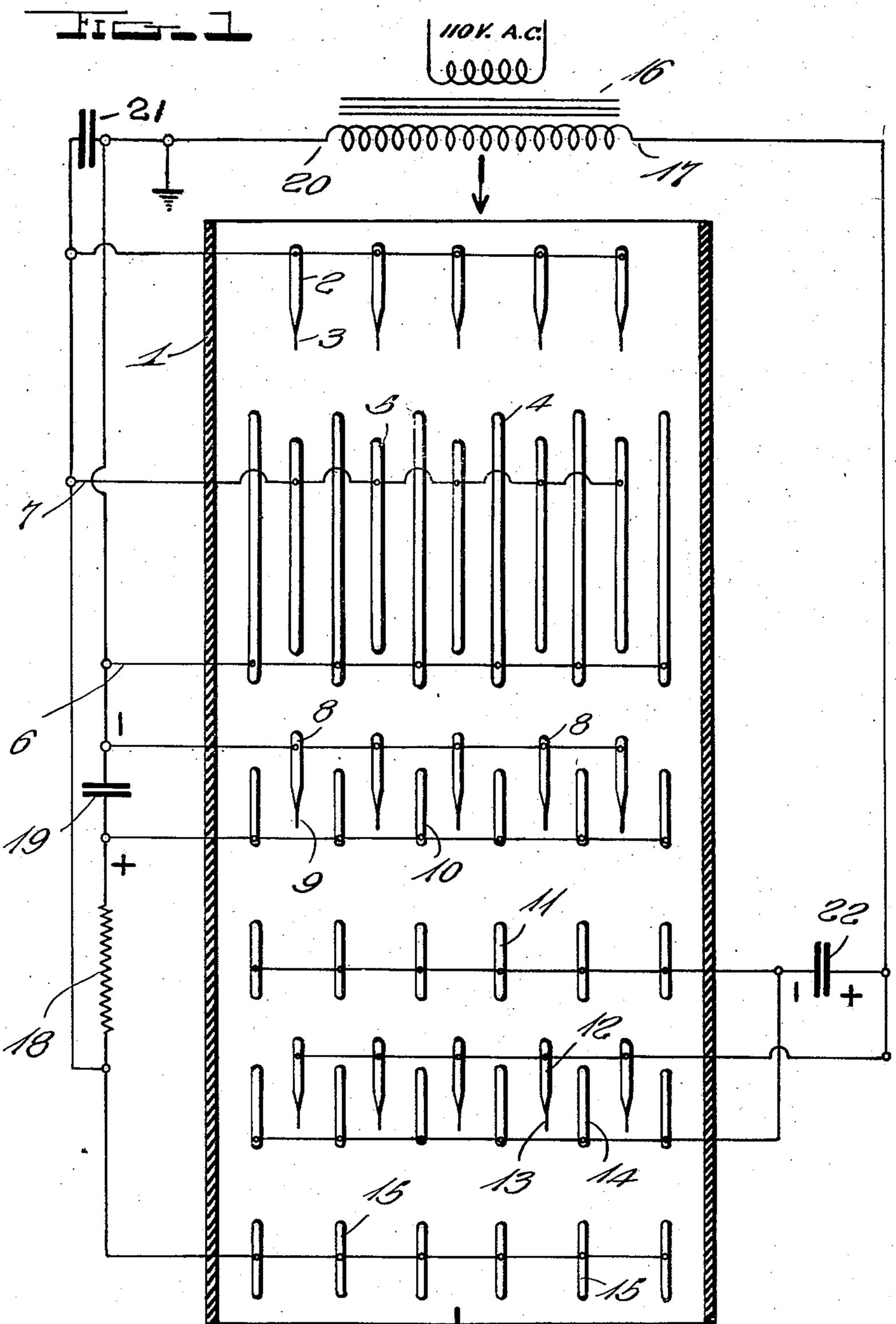
Sept. 8, 1942. W. H. BENNETT 2,295,152

FLUID MOVEMENT WITH PRECIPITATION

Filed Aug. 31, 1940 2 Sheets-Sheet 1

Fig. 1



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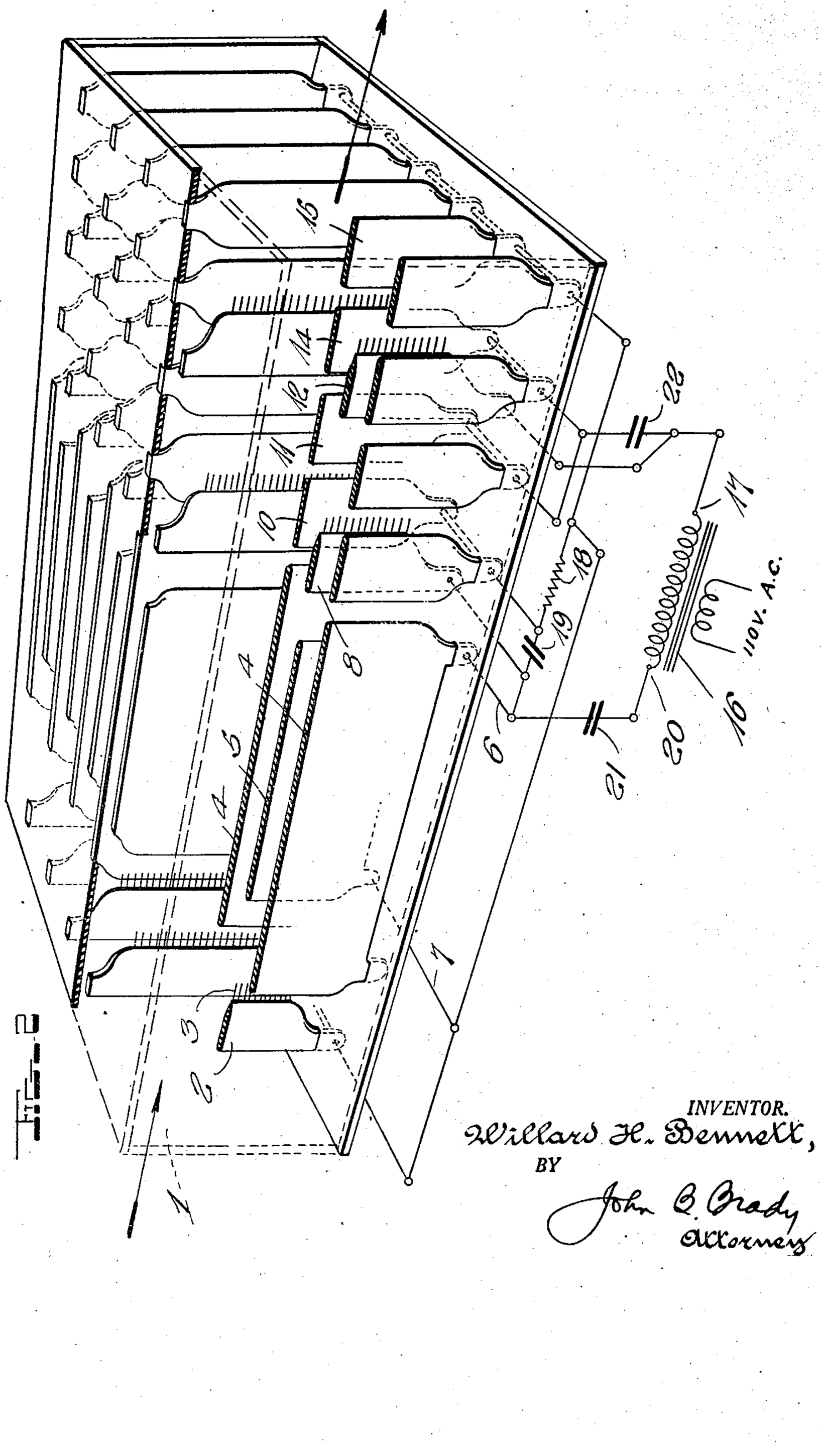

FIG. 2

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FLUID MOVEMENT WITH PRECIPITATION

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Application August 31, 1940, Serial No. 355,054

16 Claims. (Cl. 183—7)

My invention relates broadly to precipitation of solid particles suspended in a gaseous medium, such as dust in air, and more particularly to an electrode assembly for use in electric precipitation systems.

One of the objects of my invention is to provide an electrically operated precipitation unit which charges and precipitates finely divided particles of matter suspended in a gaseous medium and then blows the gaseous medium so cleansed, the blower portion also supplying the D. C. current to the precipitation portion of the device.

Another object of my invention is to provide in combination in an electrically related system an electrode arrangement for producing movement in a fluid medium and electrodes for precipitating solid particles from the medium prior to the action of the draft electrodes.

A further object of my invention is to provide an electrode arrangement for precipitation of charged particles from gaseous suspension, with the electrodes energized by a rectified voltage derived from an alternating current source through an electric discharge type of rectifier operative in conjunction with the precipitation electrode arrangement in the gaseous medium.

Still another object of my invention is to provide an electric precipitation circuit including filter means for the rectified voltage applied to the precipitation electrodes and a blocking condenser for localizing the bias voltage applied to the control means in the rectifier arrangement.

Another object of my invention is to provide an arrangement of electrodes for an electric precipitator in which a group of charging electrodes and a group of precipitation electrodes may be arranged in any selected or alternate order with respect to a set of driving electrodes.

A still further object of my invention is to provide an assembly of precipitator electrodes and electric discharge electrodes in which polarizing potentials for energizing the precipitator electrodes are derived directly from the operation of the electric discharge electrodes which operate to produce fluid movement.

Other and further objects of my invention reside in the electrode and circuit arrangement hereinafter described in more detail with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic plan view of the electrode arrangement employed in the system of my invention, with the circuit arrangement schematically illustrated in connection therewith; and Fig. 2 is a perspective view of the electrode assembly, with parts broken away and shown in section.

In the precipitation system of my invention, I employ a type of electric discharge which I have termed "diffuse discharge." , Diffuse discharge is characterized by the absence of the disruptive sparking, arcing and streamering conditions usually present in point to plane asymmetric electric discharge equipment. The manner in which the "diffuse discharge" is obtained is described in detail in my copending application, Serial No. 338,379, filed June 1, 1940, for "Method and apparatus for conversion of energy," and this invention employs this type of discharge in connection with an electrical precipitation system for charging particles in gaseous suspension.

For the purpose of this invention it will suffice to point out that the so-called "diffuse discharge" is obtained by controlling the maximum current density in the medium adjacent the emitting electrode so that this maximum current density does not exceed the amount which the electrode can sustain and convey either transiently or under steady conditions. More particularly the desired "diffuse discharge" is accomplished by predetermining (1) the spacing between the emitting and collecting electrodes, (2) conductivity of the emitting electrode, (3) diameter of the tips of the emitting electrodes and (4) spacial distance between adjacent emitting electrodes. The specifications of one particular construction which has been found to operate satisfactorily without arcing, sparking or streamering are given in the following description.

The electrical precipitation system of my invention is operable directly from a source of high potential alternating current and one of the principal functions involved is a conversion of alternating current to direct current for energizing the charging and precipitator plate electrodes; this function is effected by the operation of electric discharge means which at the same time serve to produce movement of the gaseous medium by a conversion of electrical to mechanical energy in accordance with the principles set forth in my copending application, Serial No. 338,379, supra. In general and, as will be more fully hereinafter set forth, the electric discharge takes place in an electron attaching gas wherein the electrons readily attach to molecules of the gas and form ions which are, of course, much larger than the electrons and provide the numerous collisions required to obtain the necessary movement of the gas. It has been found that the load factor of a precipitator comprising charging electrodes and

sets of precipitator plate electrodes may be efficiently met by a rectifier of a diffuse discharge type wherein a measure of the alternating current energy applied is converted into movement of the gaseous medium and a further portion is rectified and maintained at high potential for application to the charging and precipitator plate electrodes.

Referring to the drawings in more detail, reference character 1 designates a frame structure for housing the various electrodes and providing a duct for the passage of air and gases to be cleared of suspended particles, the inlet and the outlet being indicated by arrows on the drawings. At the inlet there is first a bank of charging electrodes, indicated generally at 2 and constituted as emitters provided with wires 3 terminating in discharge points. Next are two groups of precipitator plate electrodes 4 and 5, disposed in parallel and alternating in position. The plates 4 of one group are interconnected through bus 6 and have the leading edges thereof disposed in advance of the leading edges of plates 5 for coaction as target elements for the diffuse discharge from emitter wires 3. The alternate plates 5 are interconnected through bus 7. Electrodes 2, 4 and 5 comprise in particular the means for removing suspended particles from the gaseous medium and are required to be energized in fixed polarity at high potential. The means for providing such potentials and at the same time producing movement of the gaseous medium through the apparatus includes a first bank of discharge electrodes, indicated generally at 8 and constituted as emitters provided with wires 9 terminating in discharge points, a coacting bank of control electrodes at 10 and coacting target electrodes indicated generally at 11, and also a second bank of discharge electrodes, indicated generally at 12 and constituted as emitters provided with wires 13 terminating in discharge points, a coacting bank of control electrodes at 14 and coacting target electrodes indicated generally at 15.

A source of alternating current of high potential is provided at the transformer 16. A circuit extends from terminal 17 of the secondary of transformer 16 to discharge electrodes 12, which produce a diffuse discharge received at target electrodes 15, and continues through a ballast resistance 18 and condenser 19 back to terminal 20 of the secondary of transformer 16; a blocking condenser 21 is included in the lead to terminal 20 to permit condenser 19, and another condenser 22 in the system, to acquire independent charges for maintaining substantially constant bias potential differences across their terminals.

Another circuit extends from terminal 20 to the discharge electrodes 8 and continues through the condenser 22 back to the source at terminal 17. As a result, the disccharge from the electrodes 8 is inherently asymmetric and is predominantly negative in the absence of effective control of the discharge. Assuming that the discharge from the electrodes 8 is negative with respect to the target electrodes 11, it follows that the condenser 22 acquires a charge in the polarity indicated in Figure 1 and this difference of potential across the condenser 22 is employed as a bias voltage to control the discharge from the discharge electrodes 12. In detail, the negative side of the condenser 22 is connected to the control electrodes 14 and the positive side is connected to the discharge electrodes 12. Inasmuch as the control electrodes 14 are of negative potential with respect to the discharge electrodes 12, the negative phase of the electric discharge from the electrodes 12 is suppressed and, accordingly, the discharge from the electrodes 12 to the target electrodes 15 becomes predominately of positive polarity. The condenser 19 is connected in circuit with the target electrodes 15 and, as a result, acquires an electrostatic charge in the polarity also indicated in Figure 1.

The control electrodes 10 associated with the discharge electrodes 8 are connected to the positive terminal of the condenser 19 and suppress the positive phase of the discharge from the electrodes 8. As a result, this discharge is maintained predominately negative. It may be pointefd out at this time that while a small amount of discharge from the discharge electrodes 8 to control electrodes 10 may take place, nevertheless, this discharge is negligible as compared to the discharge from the electrodes 8 to the electrodes 11 because the latter are much more advantageously positioned with respect to the normal electron path from the tips of the electrodes 8. This is also true of the bank of electrodes 12 to 15, inclusive.

The electric discharges from both emitting electrodes 8 and 12 are produced in an electron attaching gas which is characterized in that electrons attach themselves to molecules of the gas and form ions. These molecules are many times greater in size than the electrons and produce a sufficiently large number of collisions to insure a substantial movement of the gas. In other words, electric energy is directly converted to kinetic energy in the gas by the above apparatus and this is evidenced by the fact that gas velocities of 150 feet per minute have been obtained in practice.

The difference in potential obtained across the condensers 19 and 22 as a result of the cooperative action of the electric discharge means 8 to 15, inclusive, superimposes a direct current bias potential on the alternating current. This superimposed direct current energizes the electrodes 2 to 5, inclusive, in such a manner that the charging electrodes 2 are predominately positive and the precipitator plate electrodes 4 and 5 are respectively predominately negative and positive. The plates 4 project beyond the plates 5 in a direction toward the charging electrodes 2 and coact with the latter in producing a discharge from the tips of the electrodes to the adjacent edges of the plates 4 which electrostatically charges the particles in suspension in the gaseous medium. In detail, one circuit extends from the positive terminal of condenser 19 through resistor 18 to emitters 2, which produce a diffuse discharge opposite the precipitator plates 4 and 5, and continues from plates 4 back to the negative terminal of condenser 19 through bus 6. Plates 4 are thus charged at negative potential, and in order to complete the circuit, plates 5 are connected through bus 7 to positive terminal of condenser 19. A voltage of upwards of 6000 volts has been observed at the terminals of condenser 19, and a field intensity of approximately 16,000 volts per inch is provided between the precipitator plates 4 and 5.

The electrodes employed in the apparatus of my invention may be of various types, shapes and sizes. By way of example, the electrodes shown are of composite construction comprising essentially a core of pressed paper, cardboard, wood or plastic material on the surface of which is disposed a layer of semi-conductive material such as a paper incorporating carbon black and hav-

ing a predetermined resistivity, or an ink or paint containing oxides of the required resistivity.

Beginning with the intake end of the precipitator, the charging bank contains the row of emitters 2, having a number of separate columns in the row. The wires used in the emitters are .001" diameter and are of tungsten. They are ¼" apart and ⅜" long. The core of the emitters is ⅛" cardboard coated with styrene, to seal it against moisture, and is covered with semi-conducting paper with a resistance of from 50–150 megohms. Adjacent the charging bank are the two sets of collecting plates 4 and 5. The plates of set 4 are 10" x 9¾" x ⅛" and the plates of set 5 are 7" x 11¼" x ⅛". Both have a center paper core ⅛" thick covered with a semi-conducting paper with a resistance of from 200–400 megohms.

Next to the charging plates is the combination fan and air rectifier which comprises the row of emitters 8, the row of control electrodes 10, and the row of targets 11, the second row of emitters 12, the second row of control electrodes 14, and the second row of targets 15. Each row of emitters has a number of emitter columns therein and each row of control electrodes and targets has columns one more in number than the number of emitter columns. Each electrode has a ⅛" cardboard core coated with styrene to seal it against moisture. The emitters are 9½" long, 1½" wide, and ⅛" thick, and are covered with a paper having a resistance of from 50–150 megohms. The control electrodes and targets are 1¼" wide, ⅛" thick, and 11½" long. The control electrodes are covered with a paper having a resistance of from 200–400 megohms and the targets are covered with a paper having a resistance of from 30–75 megohms. The purpose of the resistances specified is to produce as quiet a discharge as possible by providing the emitters with as much resistance as possible without affecting the operation thereof. The lateral spacing of the control electrodes, emitters, and targets is ⅞", that is, from one emitter to the next emitter is ⅞", and from one control electrode or target to the next control electrode or target, is ⅞". The control electrodes are spaced on each side of the emitters in a manner such that the leading edge of a control electrode is ¼" ahead of the leading edge of the wire in the coacting emitter, and the trailing edge of the target ish 1¼" directly in front of the corresponding control electrode, for most effective operation.

Of the three condensers in the system, the two of them between the control electrodes and the adjacent emitters have a capacity of .02 mfd., which is not particularly critical. The third condenser is a high-voltage blocking condenser having a capacity of .01 mfd.

In the operation of the precipitation system of my invention, diffuse electric discharge is initiated in the emitter banks 12 and 8, that from bank 12 being maintained positive while that from bank 8 becomes predominantly negative by virtue of the control bias from condenser 19 applied to control electrodes 10; at the same time, the resulting potential difference across condenser 22 serves to bias control electrodes 14 and increase the positive discharge from emitters 12. When stabilized conditions of operation are reached in this portion of the system, condenser 19 has acquired a sufficient charge for operation of the charging and precipitator plate electrodes, whereupon diffuse discharge is produced from emitters 2 and plates 4 and 5 assume high potentials which are predominantly of opposite polarity. By virtue of the diffuse discharges thus established, the air or whatever gaseous medium is supplied is placed in motion and passes through the apparatus at the proper velocity to permit the particles in suspension, now charged by the action of emitters 2, to be precipitated to the charged plates 4 or 5.

Suitable means may be provided for removal of the precipitated material from plates 4 and 5 as by scraping with mechanical means or flushing by fluid means, gas or liquid, when the apparatus is out of service, or means may be employed for the continuous removal of precipitated material during the operation of the apparatus. Such means form no part of my present invention.

It will be observed that the combined fan and air rectifier portion of the system of my invention includes a biasing component in electrodes 8—11 and a rectifier component in electrodes 12—15, through which condenser 19 is charged, in the circuit arrangement disclosed. That is, besides contributing to the production of movement in the gaseous medium, the electrodes 8—11 serve to produce a difference of potential across condenser 22 which is employed to bias the discharge from emitters 12 in the rectifier component 12—15. At the same time, the entire group of electrodes 8—15, which has been termed a combined fan and air rectifier, operates to produce movement in the gaseous medium and to establish a difference of potential across the condenser 19, by the cooperation of all the electrodes 8—15, sufficient to energize the charging electrode 2 and the precipitator plate electrodes 4 and 5 for effective operation.

In certain embodiments of my invention the functions of air movement and rectification may be more distinctly attributed to different groups of electrodes, each group being especially devised for the intended function. The essential cooperative relationship, however, will be maintained whereby the rectifier component is biased from a diffuse discharge means other than itself, and connected with the precipitation means for supplying direct potentials thereto. For example, a rectifier devised with consideration primarily for current carrying properties may be placed in cooperation with a fan devised with consideration primarily for air movement, in the manner set forth, and both the rectifier and the fan then combined with electric precipitation means, in accordance with my invention.

Thus, while I have described my invention in a preferred embodiment, I desire it understood that modfications may be made in the system and apparatus of my invention, and that no limitations upon my invention are intended except as are contained within the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An electrical system operative in a gaseous medium for precipitation of solids from said medium comprising a source of alternating current, charging electrodes connected to said source, plate electrodes for precipitating solids in proximity to said charging electrodes, fan electrodes for movement of the medium through said device, the fan electrodes being connected to said alternating source, the charging electrodes and plate electrodes being connected to the fan electrodes in a manner to receive rectified current from said fan electrodes.

2. An electrical system operative in a common gaseous medium in a unitary sphere of action for the precipitation of solids from gaseous suspension in said medium comprising a source of alternating current, electric discharge and target electrodes connected across said source and operative for charging the particles in suspension; electrical precipitation electrodes cooperative with said charging electrodes, and electric discharge and target electrodes disposed in proximity to said precipitation electrodes and constituting a voltage rectifier connected in series with said source across said precipitation electrodes.

3. An electrical system for the precipitation of solids from gaseous suspension as set forth in claim 2 and including a control electrode in said voltage rectifier, electric discharge and target means disposed in proximity to the electrodes constituting said rectifier and connected with said source of alternating current, said means being operative to provide a rectified bias potential for said control electrode, and a connection from the control electrode to the last said means.

4. An electrical precipitation system comprising charging electrodes, precipitator plate electrodes, electric discharge means including a rectifier component and a biasing component cooperative to convert alternating electric energy into direct electric energy and kinetic energy in the medium of the discharge and means for energizing said charging electrodes and said precipitator plate electrodes by the direct electric energy from the rectifier component of the last said means, said biasing component being connected with said rectifier component for increasing the direct electric energy output of said rectifier component.

5. An electrical precipitation system comprising charging electrodes, precipitator plate electrodes, electric discharge means including a rectifier component and a biasing component cooperative to convert alternating electric energy into direct electric energy and kinetic energy in the medium of the discharge, means for energizing said charging electrodes and said precipitator plate electrodes by the direct electric energy from said rectifier component, said biasing component being connected with said rectifier component for increasing the direct electric energy output of said rectifier component, and a biasing connection from said rectifier component to said biasing component for stabilizing the operation of said electric discharge means.

6. An electrical precipitation system comprising charging electrodes, precipitator plate electrodes, electric discharge means including a first group of emitter, control and target electrodes and a second group of emitter, control and target electrodes, means for energizing said discharge means by alternating electric energy including a capacitance in circuit with the emitter and target electrodes of each group, a biasing connection of one polarity from the capacitance in circuit with the emitter and target electrodes of one group to the control electrodes of the other group, a second biasing connection in opposite polarity from the other capacitance to the other control electrodes, each said capacitance being operative to maintain a substantially constant difference of potential thereacross, and means for energizing said charging electrodes and said precipitator plate electrodes by the difference of potential across one of said capacitances, said electric discharge means being operative to convert a portion of the alternating electric energy supplied thereto into kinetic energy in the medium of the discharge.

7. An electrical precipitation system comprising charging electrodes, precipitator plate electrodes, electric discharge means for converting alternating electric energy into kinetic energy for moving the medium to be clarified through said charging and precipitator plate electrodes, a capacitance in circuit with said diffuse electric discharge means operative to maintain a substantially constant difference of potential thereacross and means for energizing said charging and precipitator plate electrodes.

8. An electrical precipitation system comprising, in combination, charging electrodes, precipitator plate electrodes, and electric discharge means; said means being energized by alternating electric energy and operative to convert such energy partially into direct electric energy by rectification, and partially into kinetic energy by transformation; the direct electric energy being applied to said charging and precipitator plate electrodes for operation thereof, and said kinetic energy being expended in the movement of the gases to be clarified between said charging electrodes and said precipitator plate electrodes.

9. An electrical precipitation system comprising, in combination, charging electrodes, precipitator plate electrodes and diffuse electric discharge means; said means including a rectifier component and a biasing component energized by alternating electric energy and cooperative to convert such energy partially into direct electric energy by rectification in said rectifier component, and partially into kinetic energy by transformation in both said components; the direct electric energy being applied to said charging and precipitator plate electrodes for operation thereof, and said kinetic energy being expended in the movement of the gases to be clarified between said charging electrodes and said precipitator plate electrodes.

10. An electrical precipitation system comprising, in combination, charging electrodes, precipitator plate electrodes, and electric discharge means; said means including a rectifier component and a biasing component energized by alternating electric energy and cooperative to convert such energy partially into direct electric energy by rectification, and partially into kinetic energy by transformation; said biasing component being connected with said rectifier component for increasing the direct electric energy output of said rectifier component, and said rectifier component being connected with said biasing component for stabilizing the operation of said diffuse electric discharge means; the direct electric energy from said rectifier component being applied to said charging and precipitator plate electrodes for operation thereof, and said kinetic energy being expended in the movement of the gases to be clarified between said charging electrodes and said precipitator plate electrodes.

11. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, means for electrostatically charging the particles in suspension in the gaseous medium including emitting electrodes connected in a circuit with the source of alternating current and extending in the general direction of movement of the gaseous medium, electric discharge means also connected in a circuit with the source of alternating current

and operable to impart movement to the gaseous medium past the emitting electrodes, said electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of movement of the gaseous medium, precipitator plate electrodes supported between the emitting electrodes and the electric discharge means in a manner to require the gaseous medium to pass therebetween, and means electrically connecting the discharge means to the precipitator plate electrodes and emitting electrodes for energizing the emitting electrodes and precipitator plate electrodes with a direct current of different potential.

12. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, means for electrostatically charging the particles in suspension in the gaseous medium including emitting electrodes connected in a circuit with the source of alternating current and extending in the general direction of movement of the gaseous medium, electric discharge means also connected in a circuit with the source of alternating current and operable to impart movement to the gaseous medium past the emitting electrodes, said electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of movement of the gaseous medium; means for controlling the electric discharge between the discharge electrodes and collecting electrodes to produce an electric discharge predominately of one polarity therebetween, precipitator plate electrodes supported between the emitting electrodes and the electric discharge means in a manner to require the gaseous medium to pass therebetween, means electrically connecting the emitting electrodes to said collecting electrodes for energizing the emitting electrodes with the same potential as the controlled electric discharge between the discharge electrodes and collecting electrodes, and means for energizing the plate electrodes with a different potential.

13. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, means for electrostatically charging the particles in suspension in the gaseous medium including emitting electrodes connected in a circuit with the source of alternating current and extending in the general direction of movement of the gaseous medium, electric discharge means also connected in a circuit with the source of alternating current and operable to impart movement to the gaseous medium past the emitting electrodes, said electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of movement of the gaseous medium, means for controlling the electric discharge between the discharge electrodes and collecting electrodes to produce an electric discharge predominately of one polarity therebetween, precipitator plate electrodes supported between the emitting electrodes and the electric discharge means in a manner to require the gaseous medium to pass therebetween, a capacitance electrically connected to the electric discharge means and having a difference of potential across the same, and means respectively electrically connecting opposite sides of the capacitance to the emitting electrodes and precipitator plate electrodes.

14. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, means for electrostatically charging the particles in suspension in the gaseous medium including emitting electrodes connected in a circuit with the source of alternating current and extending in the general direction of movement of the gaseous medium, electric discharge means also connected in a circuit with the source of alternating current and operable to impart movement to the gaseous medium past the emitting electrodes, said electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of movement of the gaseous medium, means for controlling the electric discharge between the discharge electrodes and collecting electrodes to produce an electric discharge predominately of one polarity therebetween, precipitator plate electrodes supported between the emitting electrodes and the electric discharge means in a manner to require the gaseous medium to pass therebetween, a capacitance electrically connected to the electric discharge means and having a difference of potential across the same, means electrically connecting one side of the capacitance to alternate precipitator plate electrodes, and means electrically connecting the opposite side of the capacitance to the remaining precipitator plate electrodes.

15. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, electric discharge means connected to the source of alternating current and operable to electrostatically charge the particles in suspension in the gaseous medium, said means including emitting electrodes and collecting plate electrodes coacting with the emitting electrodes to produce an electric discharge in the direction of flow of the gaseous medium, precipitating plate electrodes alternating with the collecting plate electrodes and cooperating with the latter to precipitate particles from the gaseous medium, additional electric discharge means also connected in a circuit with the source of alternating current and operable to impart movement to the gaseous medium past the emitting electrodes and between the plate electrodes, said additional electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of flow of the gaseous medium, a capacitance electrically connected to the second electric discharge means and having a difference of potential across the same, means electrically connecting one side of the capacitance to the emitting electrodes and precipitator plate electrodes, and means electrically connecting the opposite side of the capacitance to the collecting plate electrodes.

16. Electric discharge equipment for precipitating particles from a gaseous medium having a predetermined direction of movement, comprising a source of alternating current, means for electrostatically charging the particles in suspension in the gaseous medium including emitting electrodes connected in a circuit with the

source of alternating current and extending in the general direction of movement of the gaseous medium, electric discharge means also connected in a circuit with the source of alternating current and operable to impart movement to the gaseous medium past the emitting electrodes, said electric discharge means including electric discharge electrodes and collecting electrodes coacting with the discharge electrodes to produce an electric discharge in the direction of movement of the gaseous medium, a second electrical discharge means also connected to the source of alternating current and including discharge electrodes and collecting electrodes coacting with the latter discharge electrodes to produce an electrical discharge in the direction of flow of the gaseous medium, means including the second electric discharge device for applying a direct current bias to the first electric discharge means to produce an electric discharge predominately of one polarity in the first named electric discharge means, means electrically connecting the emitting electrodes to the first named electric discharge means to energize the emitting electrodes with a direct current of the same polarity as the discharge of the first named electric discharge means, precipitator plate electrodes supported adjacent the emitting electrodes in a manner to require the gaseous medium charged by the emitting electrodes to flow therebetween, and means electrically connecting the precipitator plate electrodes to the first named electric discharge means to energize the precipitator plate electrodes with direct current of the opposite polarity.

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