Jan. 30, 1940. H. A. WINTERMUTE 2,188,695

ELECTRIC PRECIPITATOR

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Fig. 1.

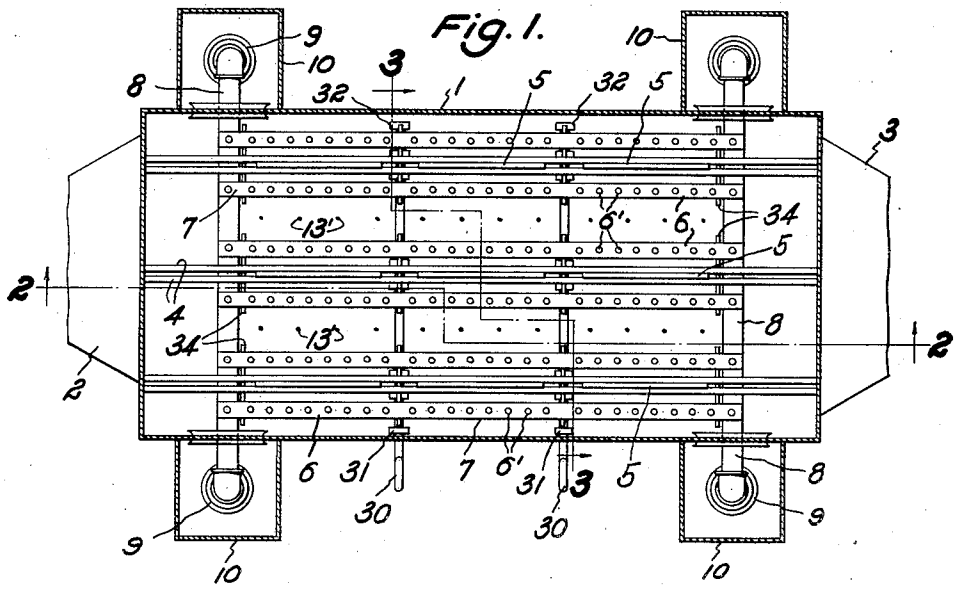
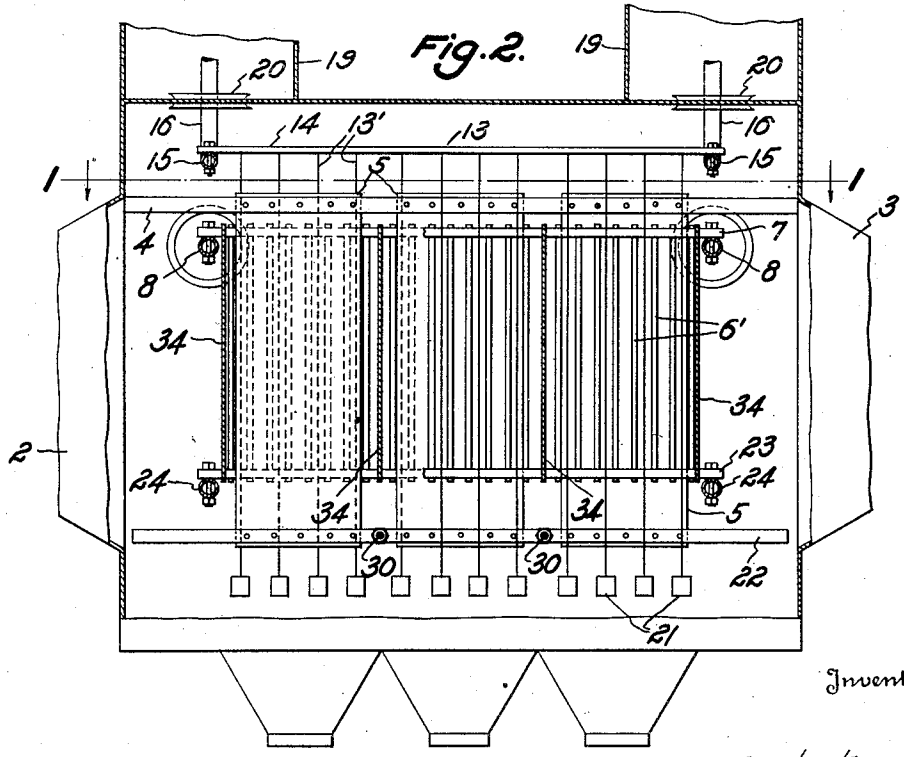


Fig. 2.



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Fig. 3.

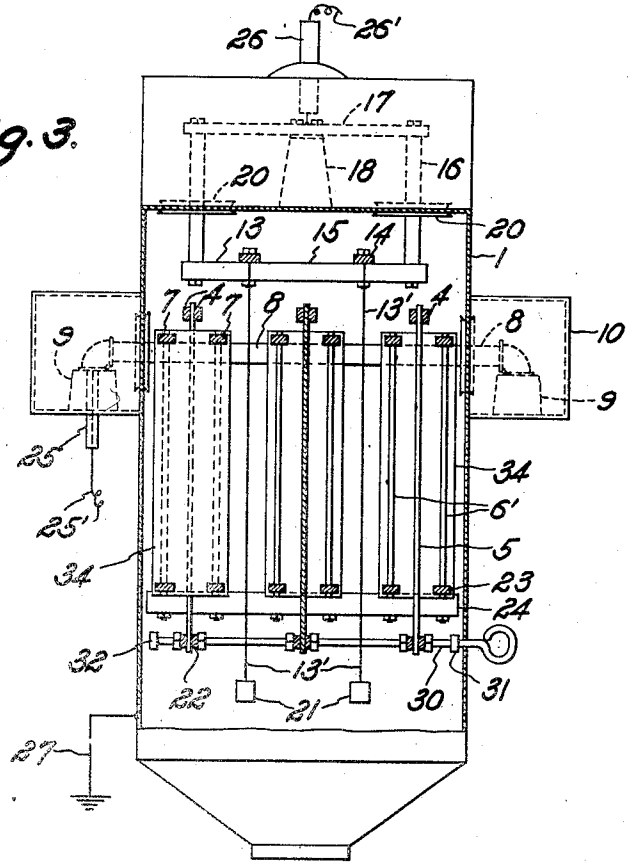
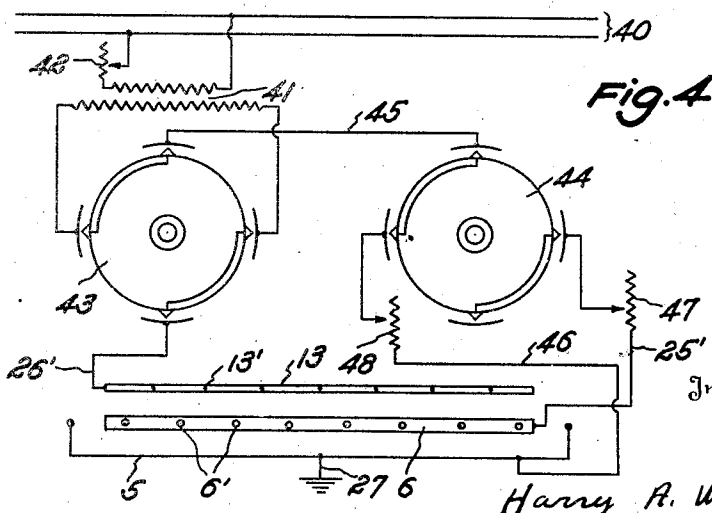


Fig. 4.



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ELECTRIC PRECIPITATOR

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Fig. 5

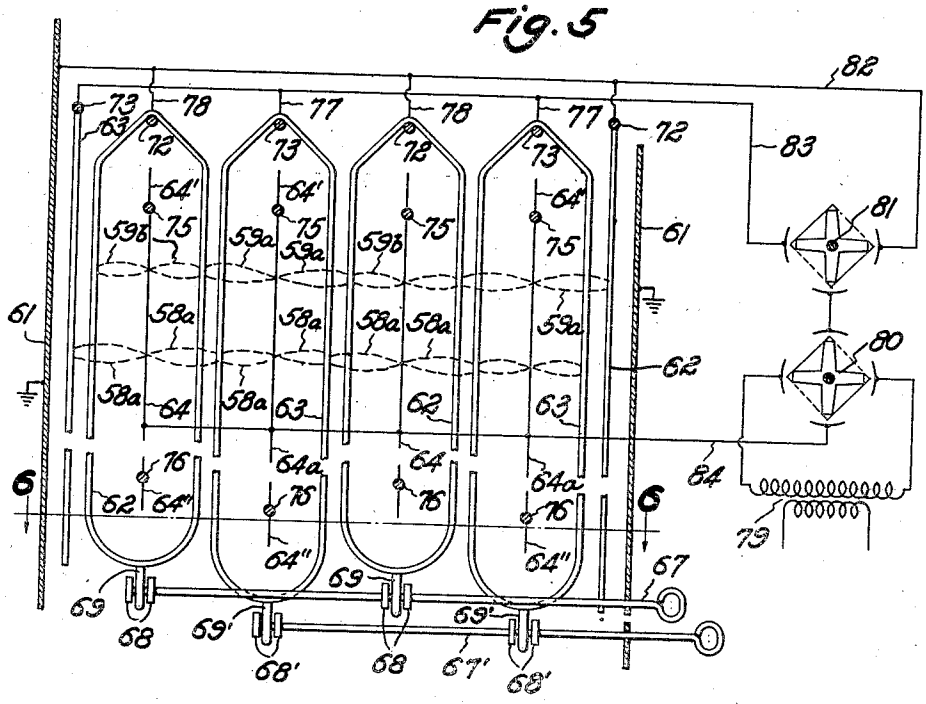
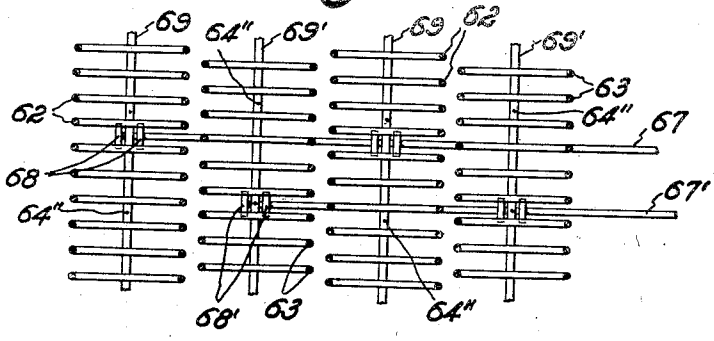


Fig. 6.



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Fig. 7.

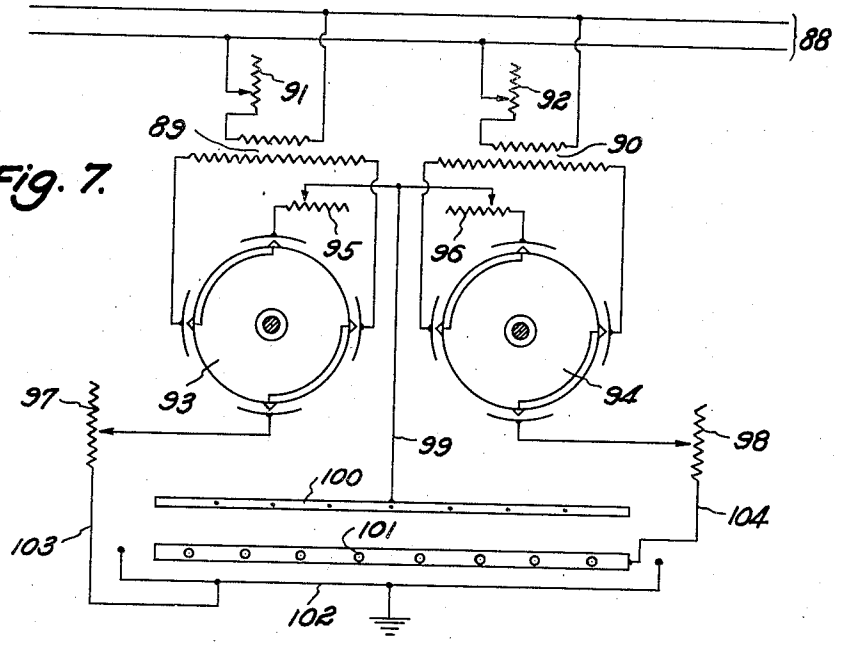
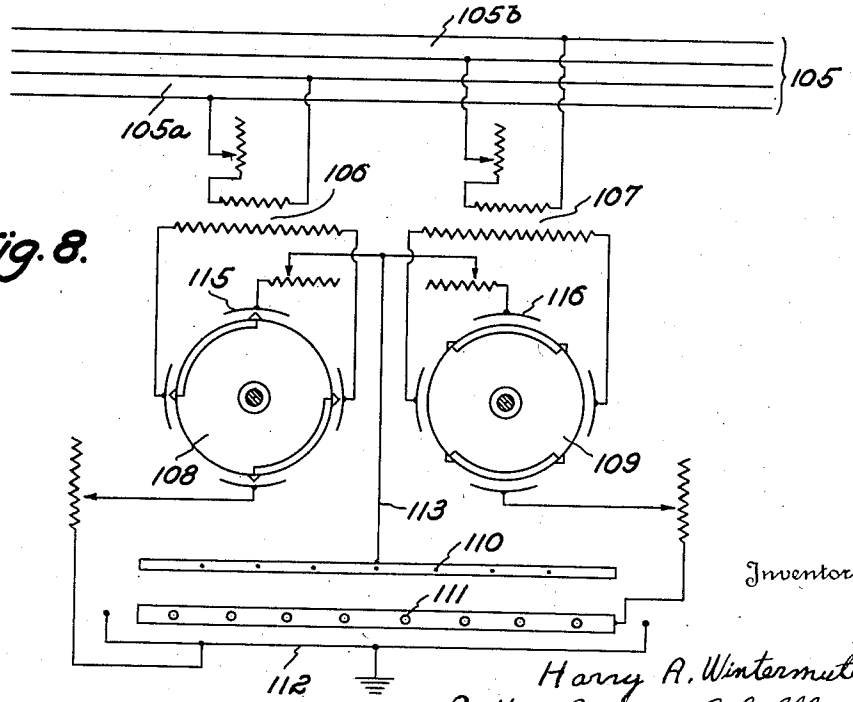


Fig. 8.



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Fig. 9.

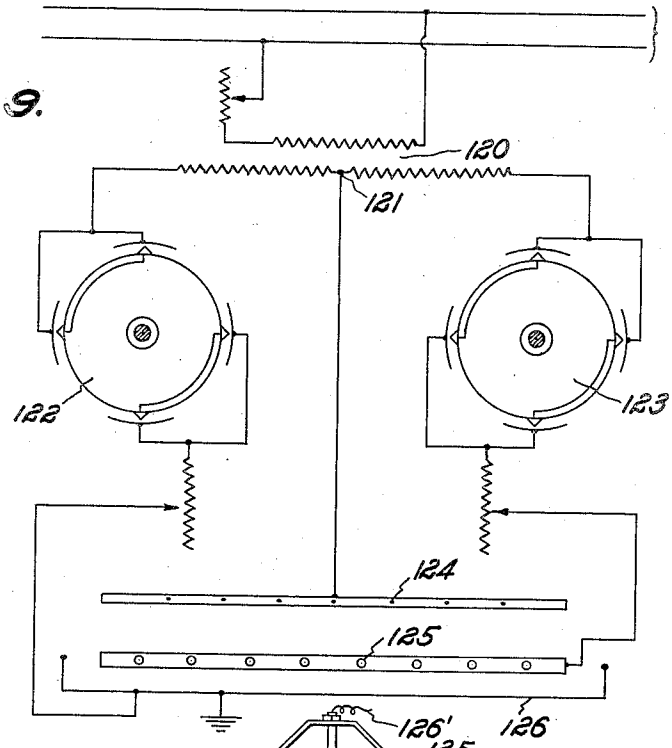
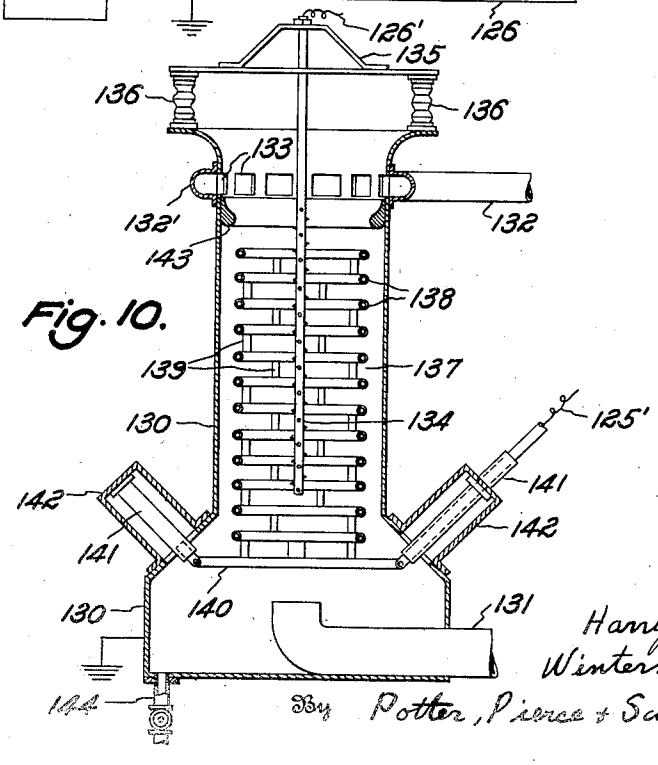


Fig. 10.



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Patented Jan. 30, 1940

2,188,695

UNITED STATES PATENT OFFICE

2,188,695

ELECTRIC PRECIPITATOR

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Application December 22, 1937, Serial No. 181,239

24 Claims. (Cl. 183—7)

The invention relates to a method and apparatus for electrically treating fluids and particularly to the removal of suspended particles from fluids comprising the use of apparatus including a discharge electrode system and a plurality of non-discharge electrode systems which are separately or differently connected to or influenced by means providing electrical energization.

Typically the apparatus of the invention comprises essentially a discharge electrode system and two non-discharge electrode systems. One of the non-discharge electrode systems is positioned and energized to act as a collecting electrode and the other non-discharge electrode system acts as an auxiliary or intermediate electrode, or the two non-discharge electrode systems alternately function as collecting and auxiliary electrodes. The two non-discharge electrode systems are so mounted and connected electrically that the electric fields between each of these systems and the discharge electrode system are different at any given instant. They may be so connected to a source of current through suitable energy-directing devices that an electric potential is connected between the discharge electrode system and each of the non-discharge electrode systems alternately. In the intervals between positive energization the non-discharge electrodes may be de-energized by proper connections, or they may be allowed to "float" in the field terminating on the other electrode, by so arranging the connections in these intervals that the electrode system which is to float is substantially insulated from the other electrode systems. If one of the non-discharge electrode systems always functions as the principal collecting electrode, it may be arranged continuously to float in the field terminating in the auxiliary electrode system by substantially insulating it from the discharge and the auxiliary electrode system so that the field to the collecting electrode system is at all times an "induced" field.

A principal object of the invention is to provide improved means for electrically removing suspended particles from fluids comprising discharge electrodes and a novel arrangement of non-discharging electrodes with energizing means therefor whereby an efficient removal of the particles with apparatus of small size is obtained.

An important object of the invention is to provide apparatus for removing suspended particles from a fluid stream comprising non-ionizing electrodes so arranged that a region of low fluid velocity exists adjacent said electrodes which provides conditions favorable for precipitation of the suspended particles.

An object of the invention is to use a plurality of electric fields to charge suspended particles in a fluid stream and cause the particles to migrate into a zone where the fluid is moving at low velocity and across which an electric field is maintained a sufficient proportion of the time to insure efficient precipitation of the particles.

Another object of the invention is to electrically remove suspended particles from a fluid stream and collect them adjacent electrode surfaces where they are agglomerated and precipitated by novel and efficient means comprising both electrical and mechanical forces.

The means by which the above-mentioned and other objects of the invention are realized will now be described with the aid of the drawings in which:

Fig. 1 is a plan view of a section, taken at 1—1 of Fig. 2, showing a preferred embodiment of apparatus constructed in accordance with the invention;

Fig. 2 is a side elevational view, in section, taken at 2—2 in Fig. 1, of the preferred apparatus;

Fig. 3 is a cross-sectional view of the preferred apparatus taken at 3—3 in Fig. 1;

Fig. 4 is a diagrammatic representation of an arrangement of switching and rectifying apparatus suitable for the energization of the apparatus shown in Figs. 1 to 3;

Fig. 5 is a diagrammatic representation in partial sectional elevation of another embodiment of the invention;

Fig. 6 is a fragmentary section on line 6—6 of Fig. 5;

Figs. 7, 8 and 9 illustrate alternative schemes, within the scope of invention for arranging the electrical connections between the electrode and the current source, and

Fig. 10 is a sectional elevation of an embodiment of the invention particularly adapted for the electrical treatment of liquids.

Apparatus comprising a preferred embodiment of the invention will be described as applied to the removal of suspended solid particles from gases. Many of the forces acting, conditions set up, and results obtained will be realized when apparatus constructed in general accordance with the following description is applied to the treatment of liquids.

Referring to Figs. 1, 2 and 3, numeral 1 identifies a casing or chamber in which the electrodes

serving as terminals for the electric fields which effect precipitation of suspended particles are positioned. The gas to be cleaned or otherwise treated enters casing 1 through inlet 2 and leaves by outlet 3. Members 5, here shown as vertical plates supported by longitudinally extended members 4 which are in turn dependent from casing 1 and to which they are electrically connected, comprise what are commonly known as collecting electrodes and provide the surfaces upon which much of the suspended matter is electrically precipitated. The inside lateral surfaces of casing 1 also serve as collecting surfaces. Spaced from plates 5 are auxiliary electrodes 6. These electrodes commonly, as here shown, comprise vertically extending rods 6', spaced horizontally from one another and from plates 5 and are supported by horizontally extending members 7 which are in turn supported by members 8 resting on insulating means 9 in sheltering boxes 10. Discharge electrode assembly 13 is made up of the actual discharge elements 13', from which corona discharges emanate when energized to a suitable potential, and supporting members. It comprises attenuated members 13', commonly wires, depending from members 14, supported in turn through members 15, 16 and 17 by insulators 18, only one of which is indicated, in boxes 19 on top of casing 1. Orifice rings 20 permit high potential members 16 to pass through the bottom of boxes 19 without discharging thereto. Members 13' are held taut by weights 21. In an illustrative apparatus which has been operated with very satisfactory results, plates 5 were spaced 12 inches apart with discharge elements 13', made of ⅛ inch diameter (or twisted ⅛ square) rods, placed midway between the plates upon 7½ inch centers. Rods 6' were ½ inch in diameter and spaced 1½ inches apart, center to center. Rods 6' were positioned with their centers 1¾ inches from the surface of plate 5. When plates 5 are of corrugated material the spacing from plate to plate may advantageously be 14 inches. Good results have been obtained with elements 13' spaced as close together as 4 inches, center to center.

Across the bottom of electrodes 5 are aligning members 22 and electrode elements 6' are held in alignment by horizontally extending members 23 which are tied together at their ends by members 24. The collecting electrodes 5 and 6 are shaken or "rapped" by agitation of bar 30 which is connected to the several bars 22 and projects outside casing 1 so that it may be reciprocated manually or by power means, not shown. Upon reciprocation of bar 30, electrodes 5 are pulled out of their vertical position and strike upon members 23 and shake them, and, elements 6', being attached to members 23, are shaken also. The sides of casing 1 can be rapped from without to remove material deposited upon their inner surfaces but it is desirable to mount stops 31 and 32 on bar 30 making this bar serve to rap the sides of the casing while limiting the extreme movements of bar 30. The method of rapping just described makes rapping possible without disconnecting the current source. The rod curtain electrodes 6 are grounded when they contact electrodes 5 but this condition offers no electrical difficulty as will be pointed out when the method of electrode energization is described. In fact, occasionally grounding the electric charge on electrode 6 appears to be a contributing factor in the dislodging of the material from the surfaces of this electrode.

Material shaken from the collecting electrodes is prevented from moving horizontally between the electrodes by transversely positioned baffle means 34 which tend to prevent the gas being treated from moving along the collecting surfaces and carrying the detached material in suspension towards exit 3. Baffles 34 are supported by the same structures which support electrode elements 6' and are maintained at the same potential as elements 6'. Grounded plates 5 are positioned far enough away from baffles 34 to prevent sparking between these members.

Casing 1 and electrodes 5 are commonly maintained at ground potential, the connection to ground being indicated at 27. Auxiliary electrodes 6 are connected to a source of energy to be described later by a conductor 25' passing through bushing 25 in one of the insulators 9. Discharge electrodes 13 are energized through conductor 26' in insulating bushing 26 passing through the top of one of the insulator boxes 19.

Fig. 4 illustrates diagrammatically a preferred method of energizing a precipitator constructed in accordance with the invention, in particular, the precipitator shown in Figures 1, 2 and 3. A transformer 41 draws current from a single phase source 40, a ballasting reactance 42 being utilized in the low voltage circuit for controlling the voltage and as a ballasting load. A rectifier 43 of the mechanical type revolving in synchronism with the alternations of current flow in source 40 rectifies the current from the high voltage winding of transformer 41 and makes all half waves available through conductor 26' at one polarity, usually negative polarity being preferred for the energization of discharge electrodes 13. All the half waves of the rectified current flow through conductor 45 to synchronous selector 44 which permits every other half wave to flow through resistance or other voltage control 47 and conductor 25' to electrode 6 and alternate half waves through voltage control 48 and conductor 46 to grounded electrode 5. The three groups of electrodes are insulated from one another so it will be seen that at every other half wave, with the revolving switches as shown, a circuit exists which includes lead 46, electrode 5, lead 26', electrode 13, and the gaseous medium between electrodes 5 and 13. At alternate half waves, when the switches have turned 90 mechanical degrees, corresponding, assuming a four pole motor revolving at 1800 R. P. M., to 180 electrical degrees of a 60 cycle current source, an alternate circuit is completed which includes conductor 25', electrode 6, lead 26', electrode 13, and the gaseous path between electrodes 6 and 13. At half cycles when conductor 25' is not connected to the current source (as shown in the figure), electrode 6 floats, electrically, with a potential which reaches a value depending upon the residual potential it retains from the previous half cycle and the number of charged particles and ions resulting from the discharge from electrode 13 which deliver electric charges to it.

The apparatus shown in Figs. 1, 2 and 3 and energized with the circuits outlined in Fig. 4 is of particular value in removing supended solid particles from gases. Gases passing through chamber 1 are, to a considerable degree, ionized by the strong electric fields existing alternately between electrodes 13 and 5 and between electrodes 13 and 6. The gaseous ions become attached to solid particles and propel them to the surfaces of, or at least, to the vicinity of, the electrodes. The results depend upon several fac-

tors, in particular, the conductivity of the particles and the humidity and other characteristics of the gases in which they are suspended. Non-conducting particles when suspended in a dry gas, which enables them to retain their non-conducting characteristic, are difficult to collect in precipitators of the usual type. Shortly after the beginning of operation a condition termed "back corona" becomes evident and thereafter collection of the particles is not satisfactory. Also, certain granular particles which may be relatively good conductors but which do not agglomerate are difficult to collect because they jump back and forth between electrodes like the pith ball in the common laboratory experiment. It is to the overcoming of such difficulties that the present invention is especially directed.

In the invention a quiescent zone is established, both as regards gas flow and electrical conditions, between collecting electrodes 5 and 6 which facilitate the collection, agglomeration, and precipitation of suspended particles. During the half cycle when the electric field exists between electrodes 13 and 5 many of the ionized particles are driven between rods 6' and precipitated upon the surfaces of electrodes 5. During much of this period ions are continually forced toward the collecting surfaces and upon the deposited particles and hold the particles to the surfaces. Some of the ions and "ionized" suspended particles are deposited at least momentarily, upon rods 6' because these rods are at lower potential than discharge elements 13'. During the succeeding half cycle, with the electric fields extending from electrode 13 terminating upon electrode 6, a considerable portion of the suspended particles may be deposited on the rods. Some of the particles, however, due to their momentum, to the extension of parts of the field to electrode 5, and to local gas movements, pass between the rods. During this half cycle, when the electrodes 5 are not being bombarded with a surplus of ions originating adjacent the discharge electrodes 13', the collected material on the surfaces of electrodes has an opportunity to give up to electrode 5 the charges which cause it to be attracted to the electrode and falls immediately by gravity into a hopper provided for the purpose below the electrodes; or, it may flutter back and forth between the plate and rod electrodes as it moves downwards towards the hopper. With forces alternately applied, as described, the spaces between the rods remain open and a minimum of material stays upon the rods.

A complete theoretical explanation of what happens in apparatus such as that just described is not available and will not be attempted, but the results obtained are unique and make for increased efficiency in gas cleaning with electrical fields. The shifting of one terminal of the electric field between an intermediate perforate electrode system, as illustrated by the rod curtain construction 6, and another system here illustrated by plates 5, makes for localized movements of the collected material as it moves downwards. The contrast between the operation of an electric precipitator without the auxiliary perforate electrodes and apparatus comprising auxiliary electrodes in accordance with the present invention is striking. In the usual precipitator, when deposited material of refractory electrical characteristics loses its charge and drops away from a collecting electrode or is repelled because it retains or takes up charges of opposite sign, it wanders back into the gas stream to be recharged and reprecipitated, if effective corona discharge is present, and as this is repeated many of the agglomerates and larger particles move along the electrode surfaces towards the exit. The requirement that this dislodged material be reionized before it is redeposited often overburdens the capacity of the apparatus, and, as it moves out into regions of high gas velocity, it may be carried along to the exit before being reprecipitated, or it may move about and build up peculiar formations on the electrode surface which are conducive to back corona.

With the apparatus described herein, material breaking away from the collecting surfaces keeps within the space between the auxiliary collecting electrodes 6 and the electrodes 5 and either reprecipitates or drops into the hopper with or without periods of reprecipitation. The fact that the gas velocity is low in the spaces between the electrodes, especially when baffles are positioned across the spaces as indicated by members 34, makes for a more definite settling of the material. Another condition favorable for precipitation is the electric field of changing characteristics that extends across this space. Rod curtain or screen type electrodes have previously been placed in front of impervious collecting electrodes either at the same potential (e. g. ground) or at such potential as they can assume when suspended by insulating means and independent of energizing agencies. The results have not been as expected. With the electrodes at a common potential a Faraday cage condition exists making it impossible to drive more than minor portions of the charged particles between the rods unless they are spaced far apart. Instead, the material collects upon and bridges across the rods. And with insulated rods the potential is never brought to a definite value with regard to the discharge electrodes, but builds up to values approaching those on the discharge electrodes resulting in arcing between the rods and the usually grounded plate electrodes.

As mentioned before, while the electrical conditions provided by the invention are favorable for the dislodgement and settling of material which has been deposited and agglomerated on the collecting electrodes it has been found advisable to provide mechanically or manually operated rapping means. As the mechanical forces are applied to the plate members between the rods, there is no evident disturbance of the electrical conditions during rapping periods. With plates 5 hanging in their usual vertical position, electrodes 6 probably retain sufficient charge so that they never reach ground potential. But when plates 5 and rod electrodes 6 are rapped together to dislodge deposited material electrodes 6 are frequently grounded. As the half waves that energize the system through conductor 46 are permitted to build up to higher potential above ground than are alternate half waves conducted through conductor 25', because the distance between electrodes 13 and 5 is greater than between electrodes 13 and 6, it is advantageous if not necessary to lower the voltage in this circuit at times of rapping. When rapping is taking place electrode 6 is brought to ground potential and, as the distance between electrodes 13 and 6 is not great enough to sustain the voltage set up in the circuit including conductor 46, this voltage is reduced during rapping to approximately the voltage in the parallel circuit including conductor 25' by increasing resistance 48 or by other means known to the art.

The invention as illustrated diagrammatically in Figs. 5 and 6 comprises a collecting electrode system of open or perforate electrodes only, except that the walls of the casing that house the electrodes may be utilized as collecting surfaces. Within casing 61 are parallel rows of vertically positioned rods 62 depending from horizontally extending members 72 which may in turn be supported by insulating means (not shown) but which are commonly supported by the grounded structural frame (not shown) to which casing 61 is attached. Other rods 63 extend parallel to each other and to rods 62. Rods 63 depend from horizontally extending supports 73 and these are supported by insulating means (not shown) which permits them to be energized at suitable potentials. A row of discharge elements 64, for instance, small rods or wires, is suspended vertically between the parallel rows of rods 62 and a row of similar discharge electrode elements 64*a* is suspended between the parallel rows of rods 63. Discharge elements 64, 64*a* are supported by horizontal supports 75 which are in turn supported by insulators in the manner known to the art although not indicated in the figures. It will be noted that in this embodiment of the invention, adjacent pairs of rods 62 and adjacent pairs of rods 63 are brought together, respectively, at top and bottom to form closed links and that these links hanging in spaced relationship along members 72 and 73 respectively, form passages with perforate walls for the gas being treated. It is also to be noted that discharge elements 64, 64*a* positioned in the passages or treating cells, extend above members 75 as indicated by extensions 64' and below steadying members 76 as indicated by extensions 64'' so that the electric fields and resulting corona discharge will extend into these end regions of the cells.

Rods 62 and 63 may be shaken to loosen deposited material which may cling tenaciously to them by the mechanism indicated, comprising a horizontally extending anvil extension 69, attached to the several pairs of rods or links making up a collecting electrode assembly and a rapping rod 67 upon which are hammer members 68 that loosely guide anvil 69 and strike against it when rod 67 is given a reciprocating motion. A single bar 67 can, by the proper location of sets of hammer members 68, strike all the anvils connected to electrode links of common potential. Another bar 67', spaced sufficiently distant from bar 67 to eliminate the possibility of sparkover from one bar to the other, can be made to jar the anvils on the alternate rows of links. While bars 67 and 67' are shown in Fig. 6 at different levels for the sake of clearness, they would ordinarily be provided at the same levels.

The electrodes in the arrangement shown in Figs. 5 and 6 are energized from a single phase source, the current being rectified and distributed by mechanical switches 80, 81 in the manner illustrated in Fig. 4. Discharge electrodes 64, 64*a* are maintained at a high potential above ground and at constant polarity by means of conductor 84 which is alternately connected to first one high voltage terminal and then the other high voltage terminal of transformer 79. Rods 62, preferably connected to ground, are connected every other half cycle by conductors 82 and 78 to the end of transformer 79 then opposite to the terminal connected to conductor 84. At alternate half cycles rods 63 are connected by conductors 83 and 77 to transformer 79. The voltages impressed between the electrodes and the electric fields set up can be easily comprehended by noting dotted lines 58 and 59. When the transformer voltage is impressed across the gas between electrodes 64, 64*a* and electrodes 62 (the solid line connections at the rectifiers indicate this condition) the electric fields extend from the discharge electrode 64 to collecting electrode rods 62 as indicated by lines 59*b* and from electrodes 64*a* to rods 62 as indicated by lines 59*a*. Rods 63 are electrically "floating" during this half cycle and assume a potential intermediate the potential of discharge electrodes 64*a* and ground potential. The electric fields pass through and between rods 63 and terminate upon rods 62 during this half cycle and the gas and solid particles in the precipitating space between rods 62 and 63 are subjected to the forces of such fields during this period. During alternate half cycles of the energizing current when the transformer voltage is impressed across the gas between electrodes 64, 64*a* and 63, electric fields are established between electrodes 64*a* and 63 as indicated by lines 58*b* and possibly between electrodes 64 and rods 63 as indicated by lines 58*a*. This latter relationship cannot be given with certainty because it depends upon the capacitance of the transformer windings and other conductors to ground, insulator leakage, and other factors but it can be stated that during these half cycles different conditions of field and ion bombardment in the precipitating space between electrodes 62 and 63 do exist from the conditions that exist during the alternate half cycles. These changing conditions cause agglomeration and precipitation of the suspended particles in the gas in more efficient manner than is obtained with electric precipitators as commonly constructed and energized.

Fig. 7 diagrammatically illustrates an arrangement of electrical apparatus which will simultaneously but independently energize two separate groups of electrodes such as those shown in Figs. 1, 2 and 3. Transformers 89 and 90 both receive current at comparatively low voltages from single phase source 88 and step the voltage up to values required by the gas treater. The current supplied through transformers 89 is rectified by rotary switch 93 and caused to flow through conductors 103 and 99 across the gas between discharge electrode 100 and grounded plate electrode 102. Rectifier 94 is used to rectify the current from transformer 90 and this current flows through conductor 104, common conductor 99, and the gas between electrode 100 and auxiliary collecting electrode 101, e. g. of rod curtain construction. With the connections shown, full wave current at constant polarity flows through both systems of electrodes simultaneously. That the voltages may be of suitable values and the current may be properly divided, resistances or other voltage control and current ballasting means are utilized. Low voltage resistance 91 and high voltage resistance 95 and 97 are inserted into the circuit comprising transformer 89 and similar resistances 92, 96 and 98 are used, respectively, in the circuit comprising transformer 90. The potential of rod curtain electrode 101 may change shortly after applying voltage but thereafter becomes more or less constant and is maintained at such value that a considerable percentage of the current leaving electrode 100 as corona discharge returns to the

source by conductor 104 but some current carried by the ionized gas and charged particles passes through electrode 101, reaches electrode 102, and returns through conductor 103. The voltage distribution is arrived at by trial. For instance, a voltage drop from electrode 101 to electrode 102 should provide a strong enough field to cause precipitation of charged particles on electrode 102 but should not be strong enough to cause disruptive breakdown of the gases between these electrodes.

Fig. 8 shows a schematic hook up using a two phase circuit 105 for energization. With this arrangement increments of both half waves are used to energize both circuits but because of the phase relationship of the two phases the increments or peaks of the voltage waves are impressed alternately between discharge electrode 110 and electrode 111 and between electrode 110 and electrode 112. This is accomplished by using very short stationary shoes 115, 116 on rectifiers 108 and 109, respectively. If shoe 115 is very short it permits only the peaks of the current waves from phase 105*a* to flow through the circuit of which it is a part, including transformer 106, and this current flow is terminated or nearly terminated before shoe 115 makes contact with the revolving connectors of rectifier 109 and permits current to flow from phase 105*b* through transformer 107. By using short shoes and setting rectifier 109 radially 45 mechanical degrees from rectifier 108 so that advantage is taken of the 90 electrical degree displacement of the phases, a sequence of energization is set up which comprises an electrical impulse from phase 105*a* to energize the circuit which includes the gap between electrode 110 and electrode 112 immediately followed by an impulse from phase 105*b* to energize the circuit including the gap between electrodes 110 and 111. This sequence is repeated, all voltage peaks from one phase being rectified and impressed at constant polarity across one set of electrodes and all voltage peaks from the other phase being impressed at constant polarity across the other set of electrodes but 90 electrical degrees later. This system, with a single high tension connection 113 to electrodes 110, causes a very long peak voltage condition to exist adjacent discharge electrode 110 although grounded collecting electrode surface 112 is used as a terminal for such condition only half the time or the usual time for single phase peak wave energization. The conditions existing between electrode 111 and electrode 112 are favorable for precipitation and deposition of the material in the hoppers below the electrodes.

Fig. 9 illustrates, schematically, how one single phase transformer 120 with a mid-point terminal 121 can be used with two rectifiers 122, 123 to distribute energizing impulses in accordance with the invention. This arrangement leaves discharge electrode 124 continuously connected to the mid-point 121 of the high tension winding of transformer 120 and alternately connects one half the winding across the gap between discharge electrode 124 and auxiliary collecting electrode 125 and the other half of the winding across the gap between discharge electrode 124 and grounded electrode 126. By utilizing one half the transformer winding during one half (say, the negative half) of the current wave and the other half of the transformer winding during the other half of the current wave, the ends of the winding will always, when connected, be at the same polarity with relation to the mid-point. In other words, for example, electrode 125, and electrode 126, can always be maintained positive with regard to electrode 124.

In all the figures mechanical switching devices have been shown as rectifying means. Other devices such as hot cathode tubes can be used as rectifiers in some instances, examples of such use being shown in my Patents Nos. 2,000,654 and 2,069,692.

Fig. 10 shows apparatus particularly suited to the treatment of liquids. It comprises a circular shell 130 open at the top (although the top can be closed for outdoor use or in treatments involving explosive components) and closed at the bottom. The liquid to be treated, for example, petroleum oil contaminated with a small amount of water in dispersed form, enters through inlet 131 and leaves through outlet 132. The outlet encircles the shell 130 near the top as an annular passage 132′ and slots 133 in the wall of the shell permit the oil to pass into the oulet. The liquid during treatment is prevented from moving along the side of shell 130 at any appreciable velocity by baffle means 143.

Discharge or concentrated field electrode 134 is suspended axially in the shell from supporting structure 135 which is supported on insulators 136. Auxiliary or intermediate electrode 137 is positioned concentrically within the shell and comprises torus rings, preferably of metal tubing, vertically spaced and supported by metal struts 139. The composite electrode or cage 137 is supported on a horizontal open frame 140 and this frame is supported in desired position by insulators 141 in remote boxes 142. Electrode 134 is energized through conductor 126′ and electrode 137 is energized through conductor 125′ passing through an insulator 141. Conductors 126′ and 125′ are connected to a source of energy such as that shown in Fig. 4 and shell 130 is grounded.

The electrical and hydraulic conditions present in the apparatus, in the region between electrode 137 and shell 130 in particular, are favorable for the agglomeration and collection of the water particles. The water collects in masses large enough to overcome surface tension and other buoyant forces and settles to the bottom of the apparatus to be drawn off through pipe 144.

The term "non-discharge electrode", as used herein, is intended to denote an electrode of such configuration as to substantially prevent or minimize corona discharge therefrom at elevated potentials below the potential at which disruptive discharge occurs.

I claim:

1. Apparatus for electrically treating a fluid comprising a discharge electrode, two non-discharge electrodes insulated from the discharge electrode and from each other and means for alternately establishing an electric field between the discharge electrode and each of said non-discharge electrodes.

2. Apparatus for electrically treating a fluid comprising a discharge electrode, two non-discharge electrodes insulated from the discharge electrode and from each other and means for establishing an electric field between the discharge electrode and each of said non-discharge electrodes, including means for independently varying the strength of the electric field between the discharge electrode and at least one of said non-discharge electrodes.

3. Apparatus for electrically treating a fluid

comprising a discharge electrode, two non-discharge electrodes insulated from the discharge electrode and from each other, and energy-directing means for establishing independent unidirectional electric fields of the same polarity between said discharge electrode and each of said non-discharge electrodes.

4. Apparatus for electrically treating a fluid comprising a discharge electrode, two non-discharge electrodes insulated from the discharge electrode and from each other, energy-directing means for establishing unidirectional electric fields of the same polarity between said discharge electrode and each of said non-discharge electrodes and means for independently varying the strength of at least one of said fields.

5. Apparatus for electrically treating a fluid stream comprising a discharge electrode, a collecting electrode spaced from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode, and energy-directing means for establishing independent intermittent electric fields of the same polarity between the discharge electrode and the other two electrodes.

6. Apparatus for electrically treating a fluid stream comprising a discharge electrode, a collecting electrode spaced from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode, and energy-directing means establishing independent discharges between the discharge electrode and the other two electrodes.

7. Apparatus for electrically treating a fluid stream comprising a discharge electrode, a collecting electrode spaced from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode, and energy-directing means establishing dual electric fields from the discharge electrode, one of the said fields terminating on the collecting electrode and the other on the non-discharge electrode.

8. Apparatus for electrically treating a fluid comprising a discharge electrode, a collecting electrode insulated from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode and insulated from both the other electrodes, and energy-directing means whereby an electrical field is established between the discharge electrode and the non-discharge electrode.

9. Apparatus for electrically treating a fluid comprising a discharge electrode, a collecting electrode insulated from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode and insulated from both the other electrodes, and energy-directing means whereby an electrical field is intermittently established between the discharge electrode and the non-discharge electrode.

10. Apparatus for electrically treating a fluid comprising a discharge electrode, a collecting electrode insulated from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode and insulated from both the other electrodes, and energy-directing means whereby an electrical field is established between the discharge electrode and the collecting electrode.

11. Apparatus for electrically treating a fluid comprising a discharge electrode, a collecting electrode insulated from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode and insulated from both the other electrodes, and energy-directing means whereby an electrical field is intermittently established between the discharge electrode and the collecting electrode.

12. Apparatus for electrically treating a fluid stream comprising a discharge electrode, a collecting electrode spaced from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode, means for establishing independent intermittent electric fields of the same polarity between the discharge electrode and the other two electrodes and baffle means positioned to at least partially shield the space between the non-discharge and the collecting electrodes from the flow of the fluid stream.

13. Apparatus for electrically treating a fluid stream comprising a discharge electrode, a collecting electrode spaced from the discharge electrode, a non-discharge electrode positioned between the discharge electrode and the collecting electrode and closer to the collecting electrode than to the discharge electrode, and means for establishing independent intermittent electric fields of the same polarity between the discharge electrode and the other two electrodes.

14. Apparatus for electrically treating a fluid stream comprising a discharge electrode structure extending in the direction of flow of the stream, a collecting electrode structure spaced from and parallel to said discharge electrode structure, an additional non-discharge electrode structure positioned between said discharge electrode structure and said collecting electrode structure, baffle means positioned in the space between the collecting electrode structure and the non-discharge electrode structure, and means for establishing independent intermittent electric fields of the same polarity between the discharge electrode structure and the other two electrode structures.

15. Apparatus for electrically energizing a treater having a discharge electrode system and two non-discharge electrode systems comprising a high voltage transformer having its low voltage winding connected to a source of alternating current, means connecting the mid-point of the secondary winding of the transformer to the discharge electrode system and means connecting each of the terminals of the secondary with one of said non-discharge electrode systems including energy-directing devices adapted electrically to connect each of said non-discharge systems with the corresponding terminal only at alternate and opposite half-cycles of alternation.

16. Apparatus for electrically energizing a treater having a discharge electrode system and two non-discharge electrode systems comprising a pair of high voltage transformers having their low voltage windings connected to the same source of alternating current, means connecting said electrode systems with the secondary windings of said transformers including energy-directing devices adapted to connect said discharge electrode system to each of said secondary windings at terminals of the same polarity in synchronism with the alternations in current and to connect each of said non-discharge electrode systems in alternation to the opposite ends of one of said secondary windings.

17. A method of treating fluids which comprises passing a fluid in a stream adjacent a zone of relative quiescence, establishing a high potential field across said stream and causing said

field to terminate in alternation on electrode surfaces on each side of said zone of relative quiescence.

18. A method of treating fluids which comprises passing a fluid in a stream adjacent a zone of relative quiescence, establishing a high potential field across said stream, causing said field to terminate in alternation on electrode surfaces on each side of said zone of relative quiescence and varying the potential of said field with each alternation.

19. A method of treating fluids which comprises passing a stream of fluid along a discharge electrode system and adjacent a quiet zone defined by two non-discharge electrode systems and subjecting said fluid alternately to a high potential electric field terminating on one of said non-discharge electrodes to charge particles in the fluid stream and initiate movement of the particles in the stream and to the other of said non-discharge electrodes to remove the particles out of the fluid stream.

20. A method of treating fluids which comprises establishing a fluid stream adjacent a collecting zone and in alternation establishing an electric field across the fluid stream and then across the fluid stream and the collecting zone.

21. Apparatus for electrically treating a fluid stream comprising a plurality of sets of discharge electrodes, a plurality of sets of permeable non-discharge electrodes spaced from said discharge electrode sets, circuit elements electrically connecting said sets of non-discharge electrodes in two groups, each consisting of alternating sets of non-discharge electrodes, with said discharge electrode sets whereby independent intermittent electric fields of the same polarity may be established between the sets of discharge electrodes and each of said groups of non-discharge electrode sets.

22. Apparatus for electrically treating a fluid stream comprising a plurality of sets of discharge electrodes extending transversely of said gas stream, a plurality of sets of permeable non-discharge electrodes spaced from said discharge electrode sets, circuit elements electrically connecting said sets of non-discharge electrodes in two groups, each consisting of alternating sets of non-discharge electrodes, with said discharge electrode sets whereby independent intermittent electric fields of the same polarity may be established between the sets of discharge electrodes and each of said groups of non-discharge electrode sets.

23. A method of removing suspended material from a fluid which comprises passing a stream of the fluid adjacent a quiescent zone, establishing an electric field across said stream and intermittently extending said field across said quiescent zone whereby suspended particles in the fluid are transported into the quiescent zone and are therein permitted to settle by gravity into a removal zone displaced from the fluid stream.

24. A method of treating fluids which comprises passing a stream of fluid along a discharge electrode system and adjacent a quiet zone defined by two non-discharge electrode systems and subjecting said fluid to a high potential electrical field terminating on one of said non-discharge electrode systems while maintaining the other non-discharge electrode system substantially insulated from the first non-discharge electrode system and from the discharge electrode system.

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