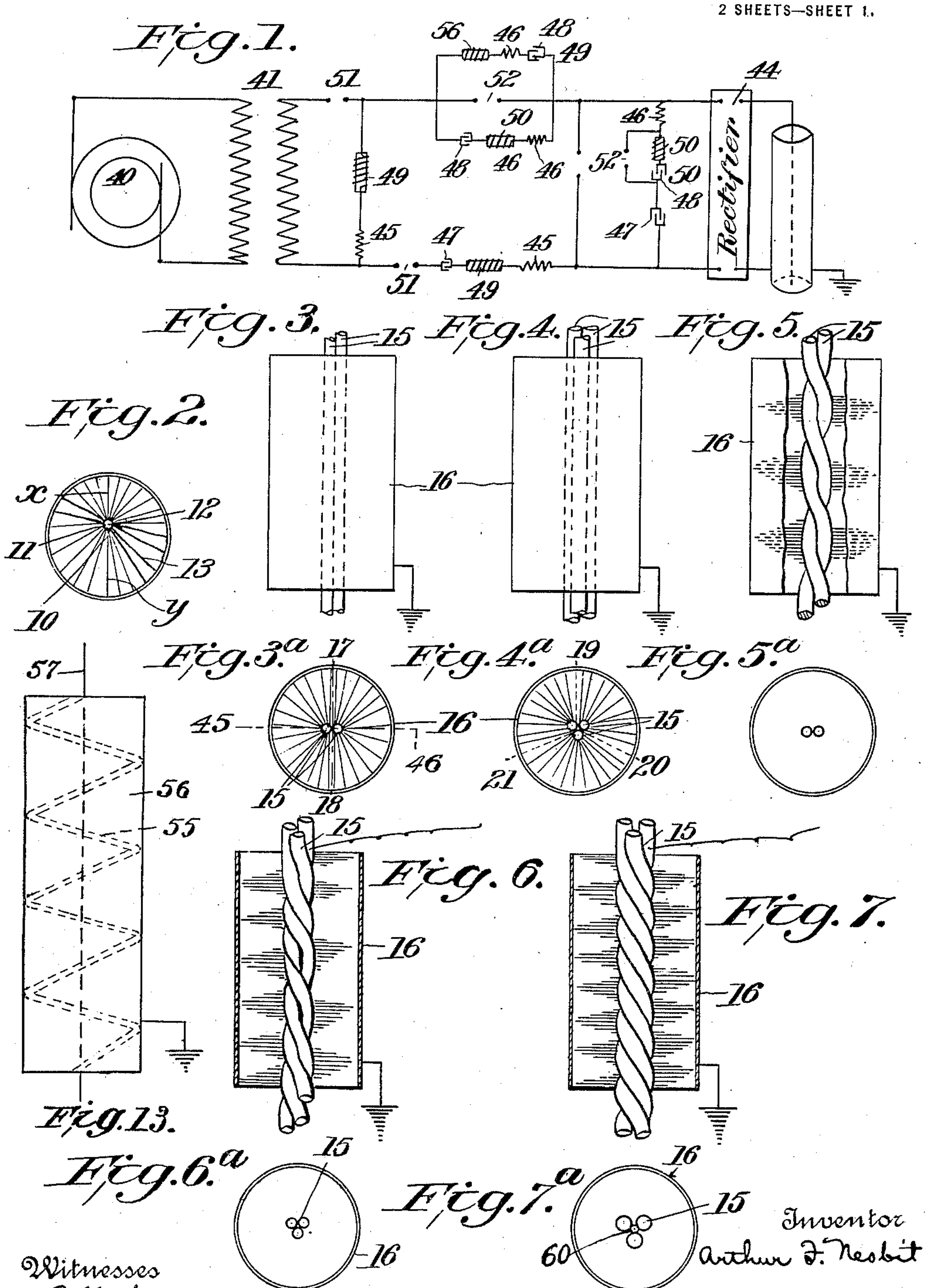
A. F. NESBIT.

ART OF REMOVING SUSPENDED PARTICLES FROM FLUID OR GASEOUS BODIES.

APPLICATION FILED NOV. 17, 1914.

1,357,201. **Patented Oct. 26, 1920.**

2 SHEETS—SHEET 1.



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2 SHEETS—SHEET 2.

Fig. 8.

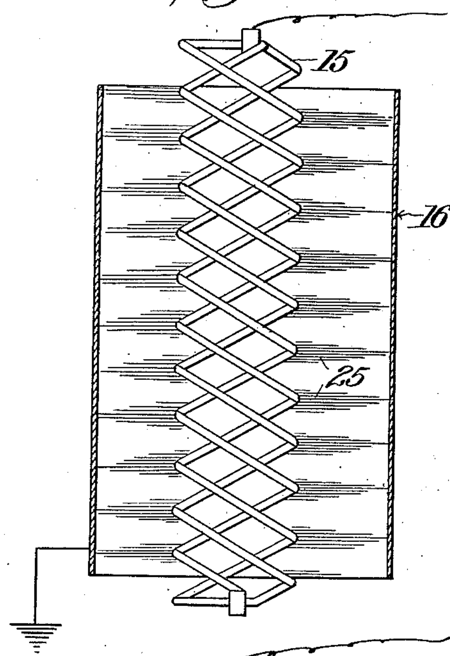


Fig. 9.

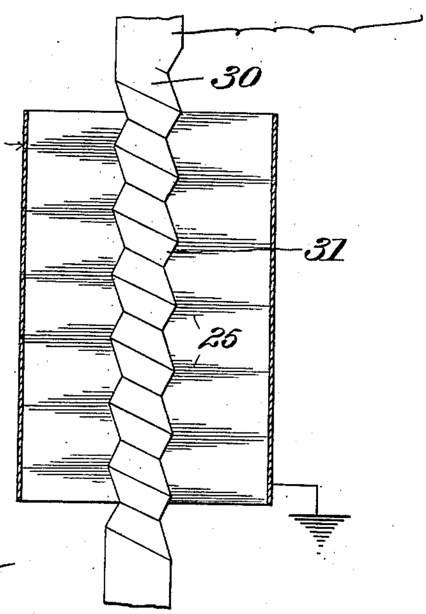


Fig. 10.

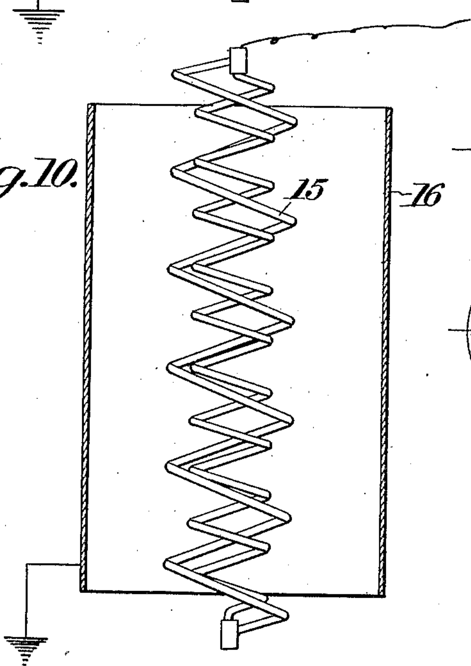


Fig. 11.

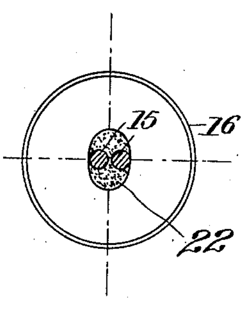
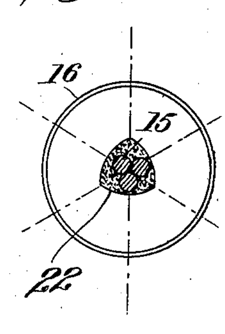


Fig. 12.



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UNITED STATES PATENT OFFICE.

ARTHUR F. NESBIT, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO INTERNATIONAL PRECIPITATION COMPANY, A CORPORATION OF CALIFORNIA.

ART OF REMOVING SUSPENDED PARTICLES FROM FLUID OR GASEOUS BODIES.

1,357,201. Specification of Letters Patent. Patented Oct. 26, 1920.

Application filed November 17, 1914. Serial No. 872,618.

To all whom it may concern:

Be it known that I, Arthur F. Nesbit, a citizen of the United States, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in the Art of Removing Suspended Particles from Fluid or Gaseous Bodies, of which the following is a specification.

This invention relates to the art of removing particles of matter from fluid bodies in which they are held in suspension.

Heretofore electrical discharges have been employed for the purpose of removing suspended matter from fluids, which discharges may consist of brush discharges, the electrical wind, the corona discharge, etc. The nature of these discharges is not well known but they involve, among other phenomena, secondary ionization of the fluid medium, which may be due to the collision of the ions with the fluid particles, or it may be due in part to electromagnetic waves or pulses. It is known, however, that electrical discharges of this kind result in a copious production of ions. Any discharge can be effected only by the use of one or more electrodes placed in or near the said fluid medium, and the electrical discharge may be caused to take place from one electrode, which is designated the active electrode. In the art of removing matter from fluids the electric field may be made very concentrated near the active electrode in order that the luminous, heat, and ionization effects may be localized in the neighborhood of said electrode. The secondary ionization produced in this region results in the production of a large number of positive and negative ions. The ions having charges dissimilar to that of the active electrode are attracted toward it and are said to give up their charge to this electrode as ions of the said sign of charge. Ions possessing a sign of charge that is the same as that of the active electrode are repelled from it and if the secondary ionization is sufficiently intense and continuous, this flow of ions will be designated as a stream of ions, or an electric current.

One of the objects of the present invention is to utilize these phenomena in removing suspended matter from fluids, by passing the fluids containing the matter to be removed between an active and a grounded electrode, the latter preferably surrounding the former wholly or in part. It is obvious that the grounding of either electrode is a matter of convenience, and hereafter the term "grounded electrode" will be used to designate the electrode near which the intensity of the electrical field is comparatively weak. A further object is to provide variable and shifting electric fields through which the fluids are caused to pass, whereby the highest possible precipitation of the suspended particles is obtained.

The shape of the grounded electrode may vary according to the work to be done, depending upon the conditions under which the fluids containing the matter to be removed are to be treated. These different conditions may well be illustrated in the problems of the precipitation of smoke produced in round houses, railroad tunnels, and in general wherever incomplete combustion takes place; the precipitation of fumes and the dust from blast furnaces of various types, etc. The velocity of the fluid or fluids to be treated, the space available for the precipitation chambers, and the possible methods for cleaning, differ widely, depending upon the particular problem under consideration and the results to be effected.

The invention will be hereinafter fully set forth and particularly pointed out in the claims.

In the accompanying drawings:—

Figure 1 is a diagrammatic view illustrating my invention. Fig. 2 is a plan or end view illustrating the relation of the electrodes in their simplest form. Figs. 3 and 3ª, and Figs. 4 and 4ª are side and plan views respectively, illustrating the theory of the present invention. Figs. 5 and 5ª, Figs. 6 and 6ª, and Figs. 7 and 7ª are side and plan views, respectively, of various modifications. Figs. 8, 9 and 10 are sectional views illustrating additional modifications. Figs. 11 and 12 are end views illustrating the manner in which fields are shifted by deposits on the active electrodes. Fig. 13 is a side elevation of another modification.

As above pointed out, it is a well known fact that the discharge of electricity into a gaseous or fluid medium containing suspended particles gives rise to a more or less complete precipitation of these particles. To accomplish this result the gaseous or fluid bodies are made to pass through the electric field. It is evident, however, that in the part of the field where the discharge is weakest there will be found the least tendency toward precipitation. To illustrate, a wire, circular in cross section, may be placed a trifle out of the axis of a surrounding cylindrical casing or pipe of conducting material, and it will be readily observed that under these conditions, the intensity of the electric field will not be uniform, and there will not be a perfect radial symmetry to the electrical discharge from the wire because of the eccentric position of the latter; in other words, the ionization field produced between the electrodes is unsymmetrical in the intensity of the field on a cross section of the electrode systems or the stream flowing through the field. Thus, in Fig. 2 the center of the pipe is at 10 and the axis of the wire 11 is at 12, the distribution of the electric strain lines being somewhat as indicated by the lines 13 radiating from said wire. If smoke, cement dust, fine ashes, alumina dust, or similar suspended particles should be blown through the pipe 10, the density of the suspended particles within the pipe will be greatest in that portion of the electric field which has the least number of strain lines. That is, that part of the gases carrying the suspended particles which passes through the region x will experience a more complete cleaning or precipitation of its contained particles than in the region y.

If, in lieu of the eccentric wire, a group of two or more smooth and bare wires, either parallel to each other, or uniformly twisted together or twisted about a central wire is placed within a pipe or casing which may or may not be grounded, the electric field will have its strain lines somewhat as illustrated in Figs. 3ª and 4ª, whatever may be the potential above the corona formation value, up to the sparking voltage; in other words, the ionization field will be dissymmetrical in field intensity on a cross section of the electrode systems of the stream passing through the field, each of the wires producing the unsymmetrical intensity effect with respect to the portion of the field which is produced by it. In Figs. 3, 3ª, 4 and 4ª, the wires 15 are parallel to each other throughout their length and inclosed by the surrounding electrode 16. The wires are so placed that they form a symmetrical grouping about an imaginary line coinciding with the axis of the pipe, *i. e.* the wires are eccentric with respect to the axis of the pipe. The strain lines are as represented, and 17 and 18, Fig. 3ª, and 19, 20, and 21 in Fig. 4ª, are the least active portions, due to the mutually repellent action of the strain lines in the cusp-like portion of the medium about the surfaces of the wires, and symmetrical about the lines 17—18, Fig. 3ª, and 19, 20, and 21 of Fig. 4ª, respectively. As the particle laden gaseous or fluid stream passes through the pipe there is a tendency of the suspended particles to flock into this neutral or inactive cuspal zone, as it might be called. Just as soon as this occurs there is an increase in the dielectric capacity of this cuspal zone in the case of all gaseous or fluid bodies for which a greater density of suspended particles corresponds to a less resistance to the flow or discharge of electricity. As a result of this increase in the dielectric capacity of this region, the electric strain lines having their origins or terminals on these wires, flock more thickly into this same region and simultaneously become less dense in the regions where the electrical field was formerly of greatest intensity. It will thus be seen that the electric strain lines are subjected to a shifting of their ends and origins between the directions 17—18, and 19, 20 and 21, or the converse. This swaying, traveling, or swinging electric field has a beneficial effect in dislodging the deposit or accumulation of the suspended particles which may have been precipitated upon the inner walls of the pipe or conduit.

The tendency of these cusp-like regions to become filled with tarry or other substances of greater dielectric capacity than air will after a time cause the accumulations to assume the appearance indicated in Figs. 11 and 12, in which the deposited material is indicated at 22. Just as soon as the radial depth of this deposit becomes sufficient for the voltage difference maintained between the wires and the pipe to cause a disruptive discharge along such path, there will be an immediate breaking loose of a large patch of this accumulation about the cuspal zone through which the disruptive discharge takes place. The result is a dislodgment of this deposit, in the vicinity of the spark, not only along the lines indicated, but more or less along all the regions symmetrical to the radial lines indicated, and to some distance along the wire either side of the point at which the discharge occurs. This dislodgment is also aided by the tendency of the wires to be set into more or less feeble vibration. These operations are occurring simultaneously and are associated with the lateral shifting of the strain lines in their to and fro excursions, and may take place at any region throughout the length of the wires. What has thus far been said about the groups of wires in Figs. 3, 3ª, 4 and 4ª, may be extended to twisted or braided groups of wires as indicated in the other figures.

In Figs. 5 to 9 the electric field takes the form of a double cork screw of greater or less pitch depending upon the closeness with which the twists are made. Thus, the corona discharge from each wire takes place most copiously along one of the twisted elements of the surface of the said wire farthest from the symmetrical axis of their grouping. This corkscrew form of field causes the smoke, fumes, or other particle-laden gaseous or fluid bodies to take up a more or less helical or tortuous path during its passage through the pipe. Hence, for a given length of pipe such groupings of smooth wires as suggested by Figs. 5, 6 and 7 will have the advantage of being more or less self-cleaning of deposited material due to the swinging action of the corkscrew field and at the same time will be equivalent to a longer pipe with straight wires within it. The wires should be quite small in diameter consistent with the tension to which they are subjected to prevent anything but the slightest vibration, and at the same time have the electric field as intense as possible at the surface of the wires. The more intense the field is maintained at the surface of the wires, corresponding to a value of the voltage difference between the wires and the pipe, (just below the break down voltage) the more rapidly will ionization take place, and the precipitation of the suspended particles in the gaseous or fluid bodies will be more complete. In Fig. 7, 60 indicates the central wire about which the other wires may be wound.

The spirals may be wound more or less closely together as indicated in Figs. 5, 6, and 7, or they may be separated in diameter and pitch as indicated in Fig. 8. Such a spiral, helical, or corkscrew grouping of wires for the active electrode will give a very decided tendency for the gaseous and fluid streams to assume a tortuous or helical form of path in their travel through the pipe or surrounding conductor. When such a grouping is made of fine wires the tendency for harmonic vibration of each individual helix may be destroyed by tying them together at intervals. Again, there may be one helical spiral within another, and of smaller diameter, and of the same or reversed winding, as illustrated in Fig. 10. These cork-screw or spiral electric fields, by imparting to the gaseous or fluid bodies, a spiral or helical form of flow during their passage through the electric field, cause the said bodies as well as the particles suspended therein, to be acted upon by a centrifugal force which tends to throw them out radially toward the inner wall of the surrounding conductor.

The centrifugal forces which are thus brought into existence play a more or less prominent part themselves in causing a separation of the gaseous and fluid bodies from the particles suspended therein. In other words the centrifugal "process" is quite efficient, in itself, in producing a separation of suspended particles from gases, for the reason that there is usually a considerable difference in the masses of the particles to be separated. This is particularly true in the application to the separation of ore dust from blast furnace gases, in the cement and aluminum industries, and in fact wherever the relative densities of the gaseous or fluid bodies and the suspended particles are very different. A more intense localized spiral field may be obtained as shown in Fig. 13 by placing within the outer electrode 56 and against its inner wall, a helical wall 55 of the same pitch as that of the active electrode 57 here described. This electrode 57 is indicated simply in dotted lines; but may take any of the forms herein described. The centrifugal forces here introduced are very important.

The same results may be obtained by the use of a single conductor 30, as illustrated in Fig. 9, or a fine wire wound upon the V-ridge of an insulating or non-conducting support. In Fig. 9 the conductor is provided with a helical groove or thread 31. The pitch of this groove or thread may vary, depending upon the number of spiral turns into which it is desired to throw the gaseous or fluid stream during the passage through the electric field and also upon the velocity of these same particle laden streams. The distribution of the electrical strains in all of the figures in which the spiral field is maintained is indicated at 25.

As will be readily understood, a discharge electrode, such as described, will, where the radial distance between the edge and the outer electrode remains constant throughout the length of the edge, even though the edge be in spiral form, produce a zone which will be continuous throughout the length of the edge, a result which is obtainable by the use of a tubular outer electrode, circular in cross section, with the axis of the discharge electrode on the symmetrical axis of the tube.

In the construction shown in Figs. 6, 7, and 9 it will be further apparent that the spiral discharge electrodes offer but slight resistance to the direct flow of the gases and that the radial length of the flow path is substantially equal to the radial length of the ionization zone.

It will be obvious to those skilled in the art that the process of producing variable and shifting electric fields is modified slightly by the form assumed by the closed conductor or pipe surrounding the wires, and I accordingly do not desire to limit myself to the pipe of circular cross section, which is merely used for illustrative purposes. In practice the central group of wires and the surrounding pipe or conductor are commonly termed the active and grounded electrodes, respectively. The active electrode constitutes the group of wires since the electric field is most intense at its surface and it is here that the ionization is most intense. The outer electrode or pipe is usually grounded as a precaution against danger and as a means of saving insulating material.

The electric current may be supplied in any suitable or desired manner. In the drawings, Fig. 1, I have illustrated a generator 40, and a transformer 41 having a primary low potential circuit and a high potential circuit, the latter being connected to a suitable rectifying device 44 of any preferred construction. In the method of cleaning the electrodes by a disruptive discharge, as herein described, it is necessary to have certain predetermined relations between the capacity, self induction, and resistance factors of the high tension circuit so that the discharge is disruptive when the distance between the electrode and the deposited matter is less than the disruptive potential distance of the gaseous or fluid bodies. For the purpose of producing disruptive or oscillatory discharges various suitable conditions may be imposed upon the electrical circuits connected to the active and grounded system of electrodes. For the purpose of illustration, besides the resistance, capacity and self-induction of the transformer itself, I have shown in Fig. 1 certain combinations of resistances 45 and 46, capacities 47, 48, self-inductances 49, 50, and spark gaps 51, 52, distributed in the secondary circuit, so that under working conditions electro-magnetic oscillations of the proper frequency and damping factor are produced. These resistances, capacities, self-inductances and spark gaps are placed in whatever parts of the circuit found most suitable or desirable for the results desired, and for obvious reasons I do not limit myself to the precise arrangement illustrated, either as to the relative positions of the rectifiers, resistances, inductances and capacities, or of the type of rectifier employed.

Having now described the manner of producing the variable and shifting electric fields of more or less complex form, what I claim as new and for which I wish Letters Patent is hereinafter set forth:—

1. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems adapted to produce an ionization field, the discharge system comprising a plurality of wires constituting the discharging means arranged spirally in the direction of length of the system, each wire having its axis out of the axis of symmetry of the opposing electrode system to produce a dissymmetrical field intensity on cross sections of the systems, field portions of like intensity varying as to position relative to a longitudinal plane of such field, whereby the stream will tend to flow spirally through the field.

2. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems adapted to produce an ionization field, the discharge system comprising a spiral discharge electrode constructed and arranged to offer but slight resistance to the direct flow of the gases and having continuous spiral discharge edges.

3. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems adapted to produce an ionization field, the discharge system comprising twisted continuously linear discharge electrodes.

4. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems adapted to produce an ionization field, the discharge system comprising twisted wires which constitutes the discharging means.

5. That improvement in the art of producing electrical precipitation from fluid or gaseous streams which consists in establishing a continuous ionization zone extending spirally in the direction of the length of the flow path and making the radial length of the flow path substantially equal to the radial length of the ionization zone.

6. That improvement in the art of producing electrical precipitation from fluid or gaseous streams which consists in establishing a plurality of continuous ionization zones in the flow path of a stream, said zones extending spirally in the direction of length of the stream flow path and making the radial length of the flow path substantially equal to the radial length of the ionization zones.

7. A discharge electrode for electrical precipitating apparatus, consisting of a conductor having projecting and discharging portions extending longitudinally thereof, said conductor being twisted so that the projecting and discharging portions extend spirally thereof.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

ARTHUR F. NESBIT.

Witnesses:
Albert H. Kotsch,
W. J. Moore.