Jan. 2, 1923. 1,440,886

A. F. NESBIT.

ART OF PRODUCING ELECTRICAL PRECIPITATION, ETC.

FILED SEPT. 7, 1916.

4 SHEETS-SHEET 1

FIG.1.

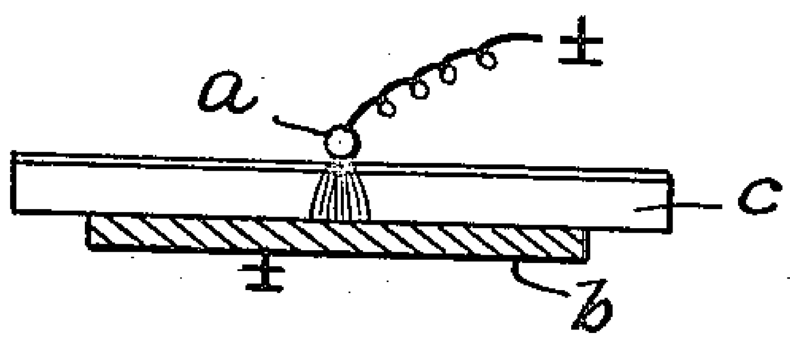


FIG.2.

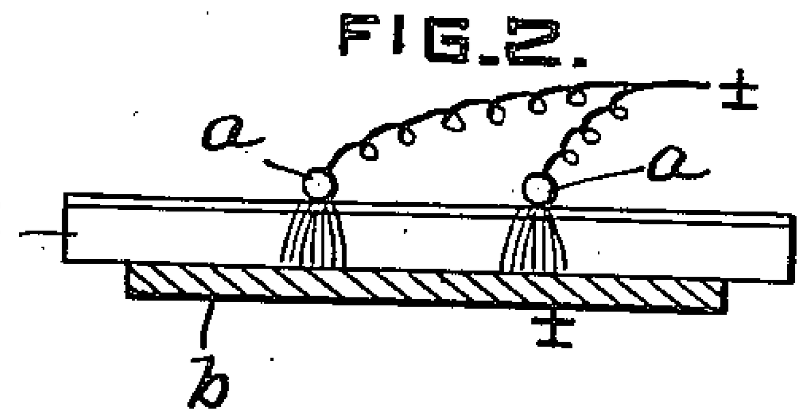


FIG.3.

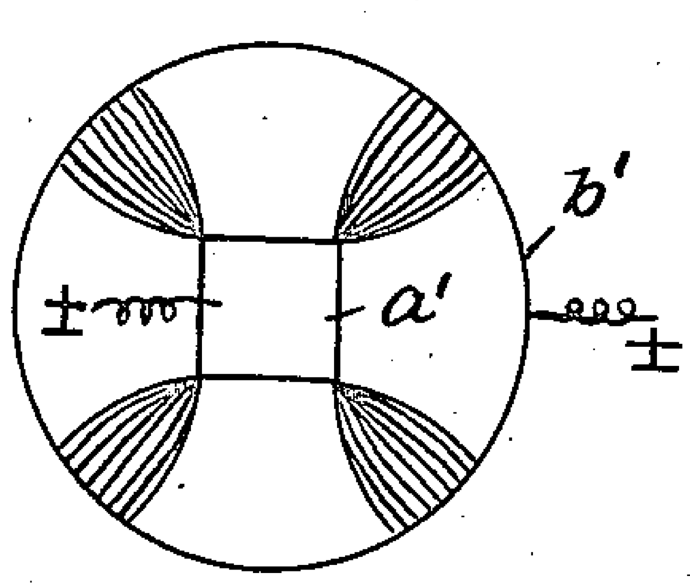


FIG.4.

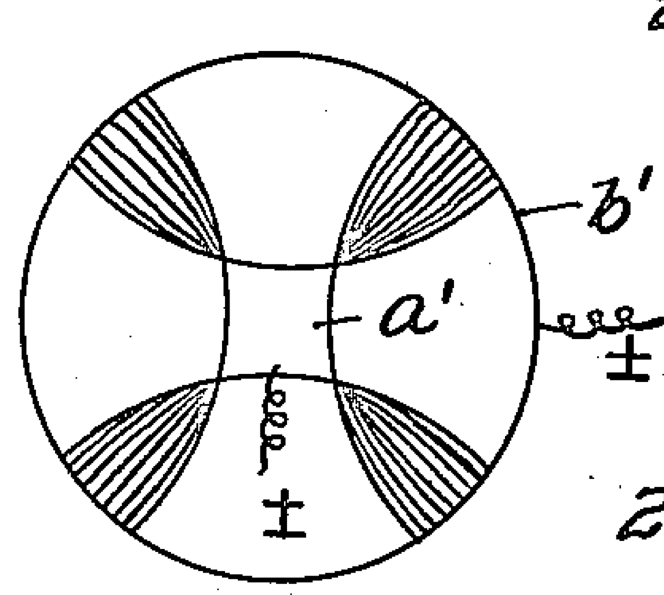


FIG.5.

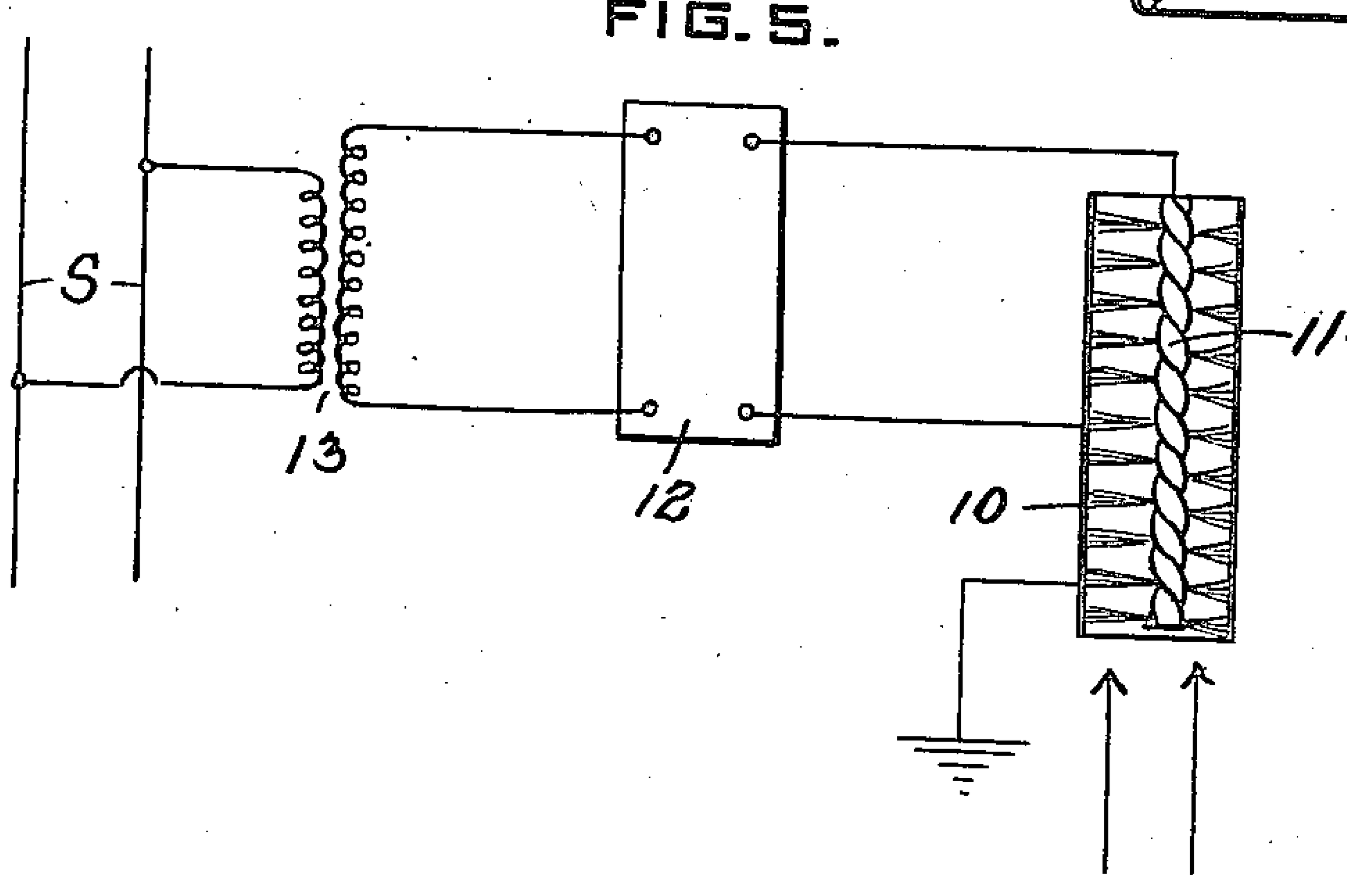
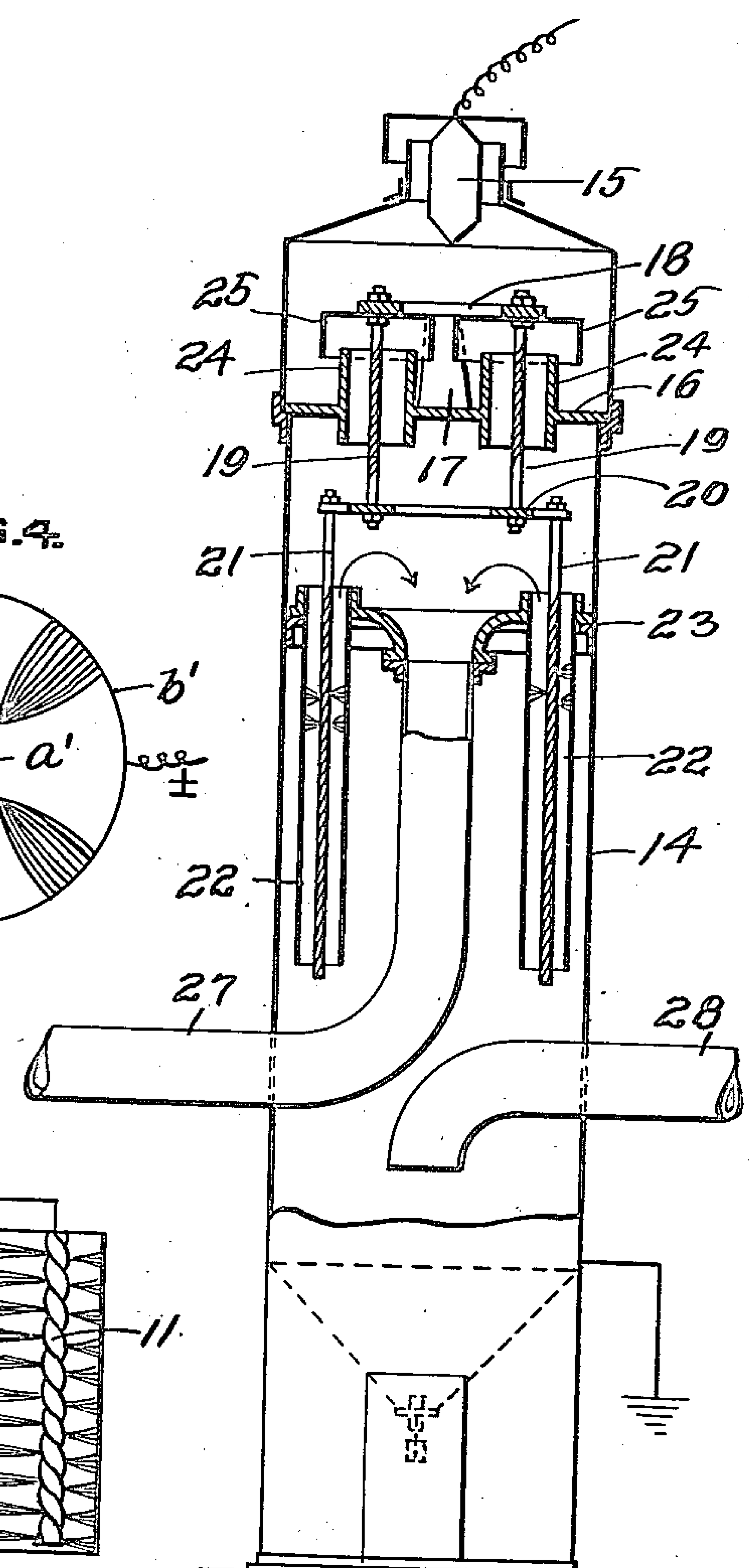


FIG.6.



WITNESSES

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FILED SEPT. 7. 1916. 4 SHEETS-SHEET 2

FIG. 7.

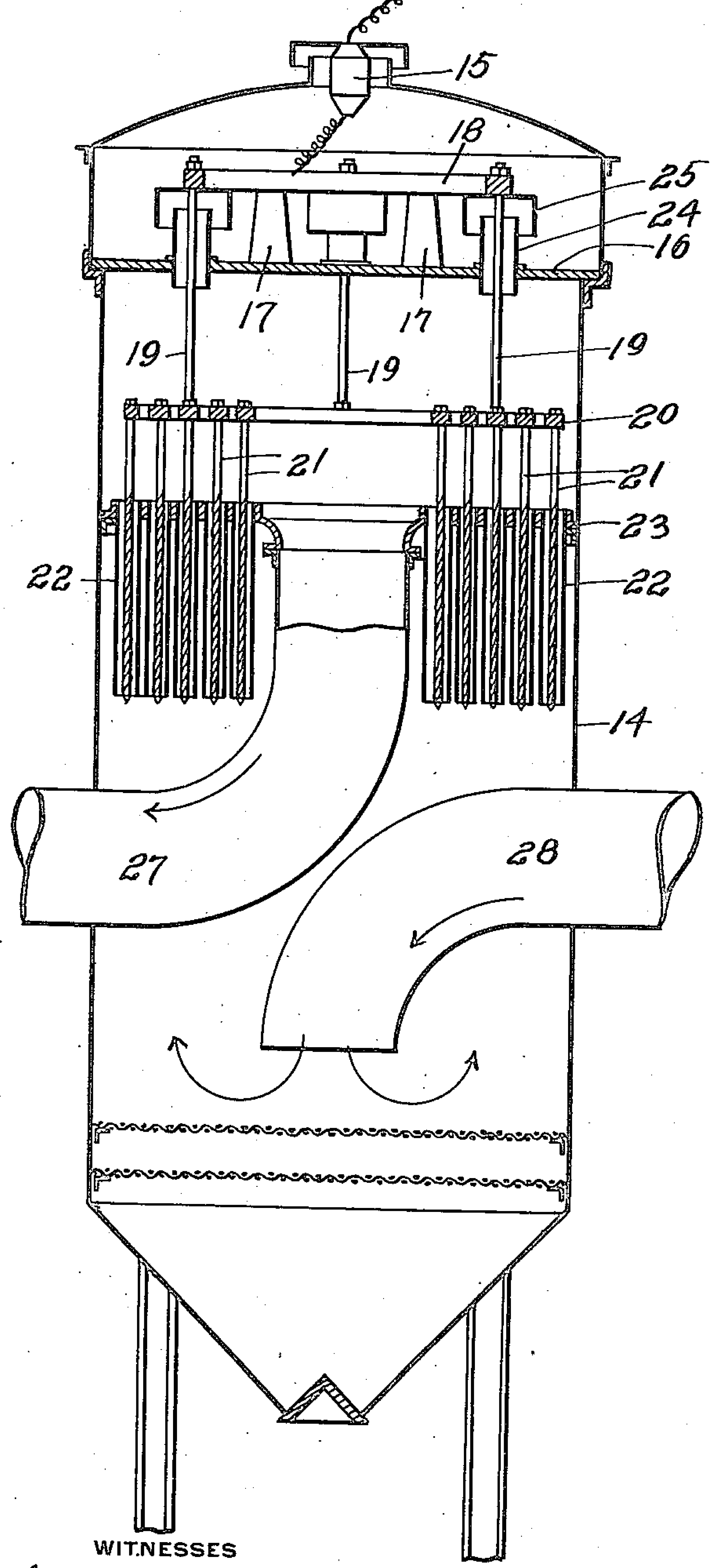
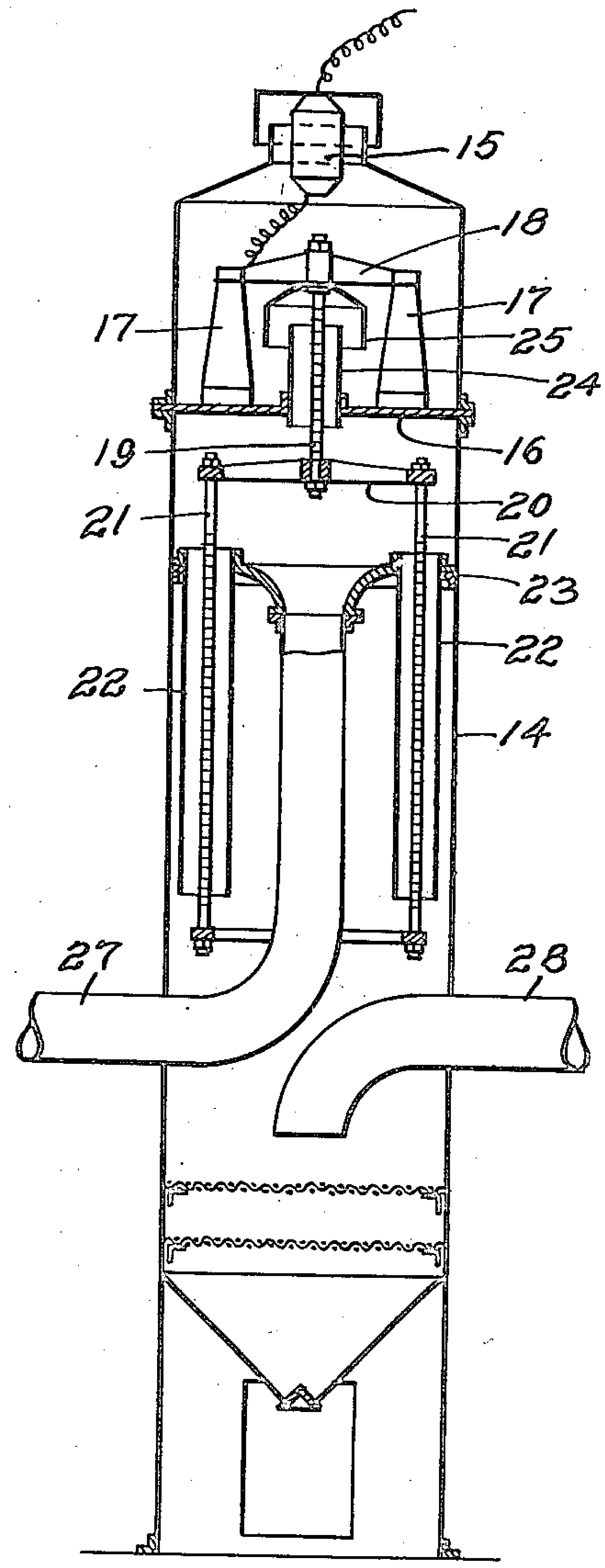


FIG. 8.



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4 SHEETS-SHEET 3

FIG. 9.

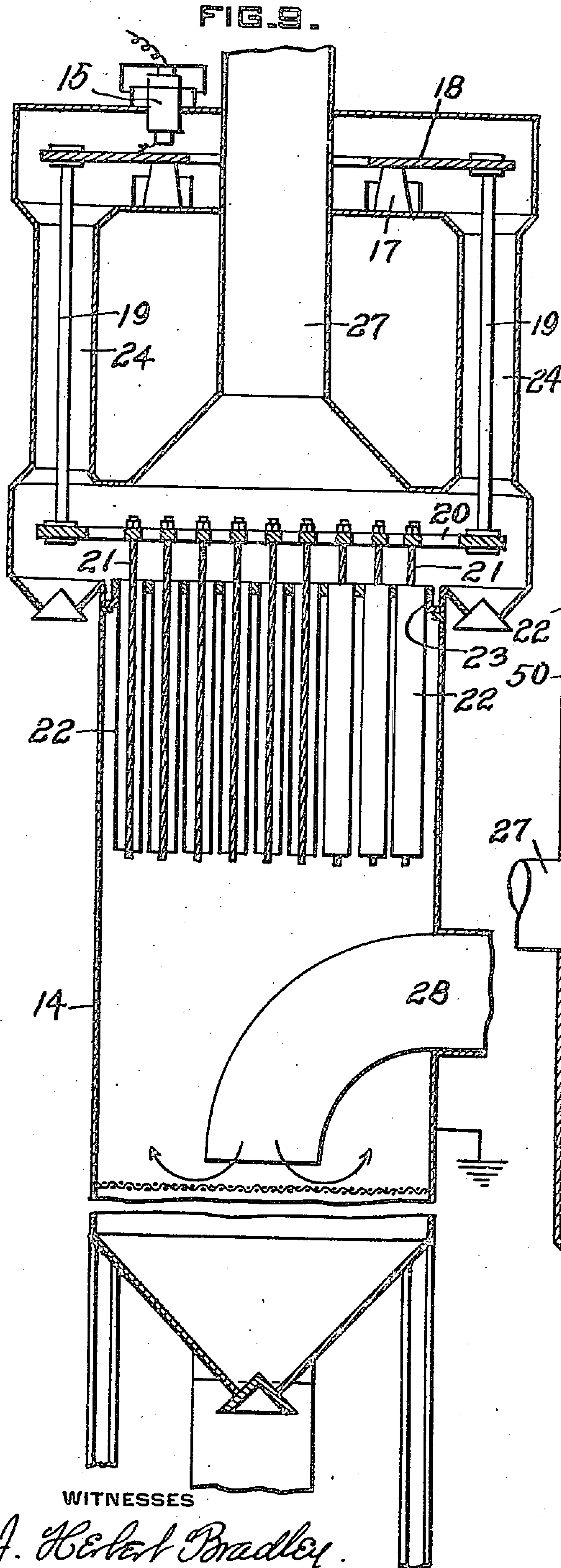
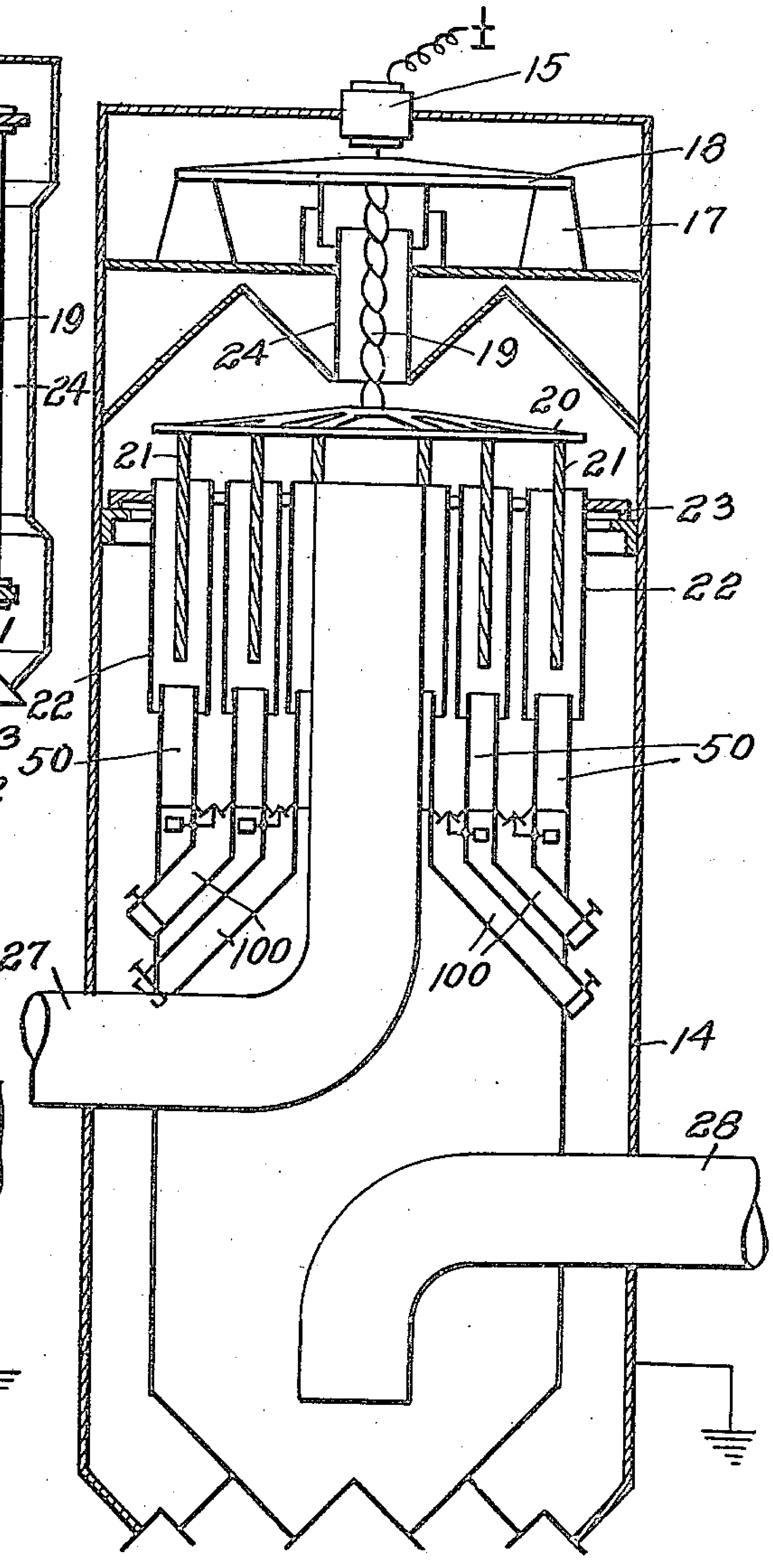


FIG. 10.



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4 SHEETS-SHEET 4

FIG.11.

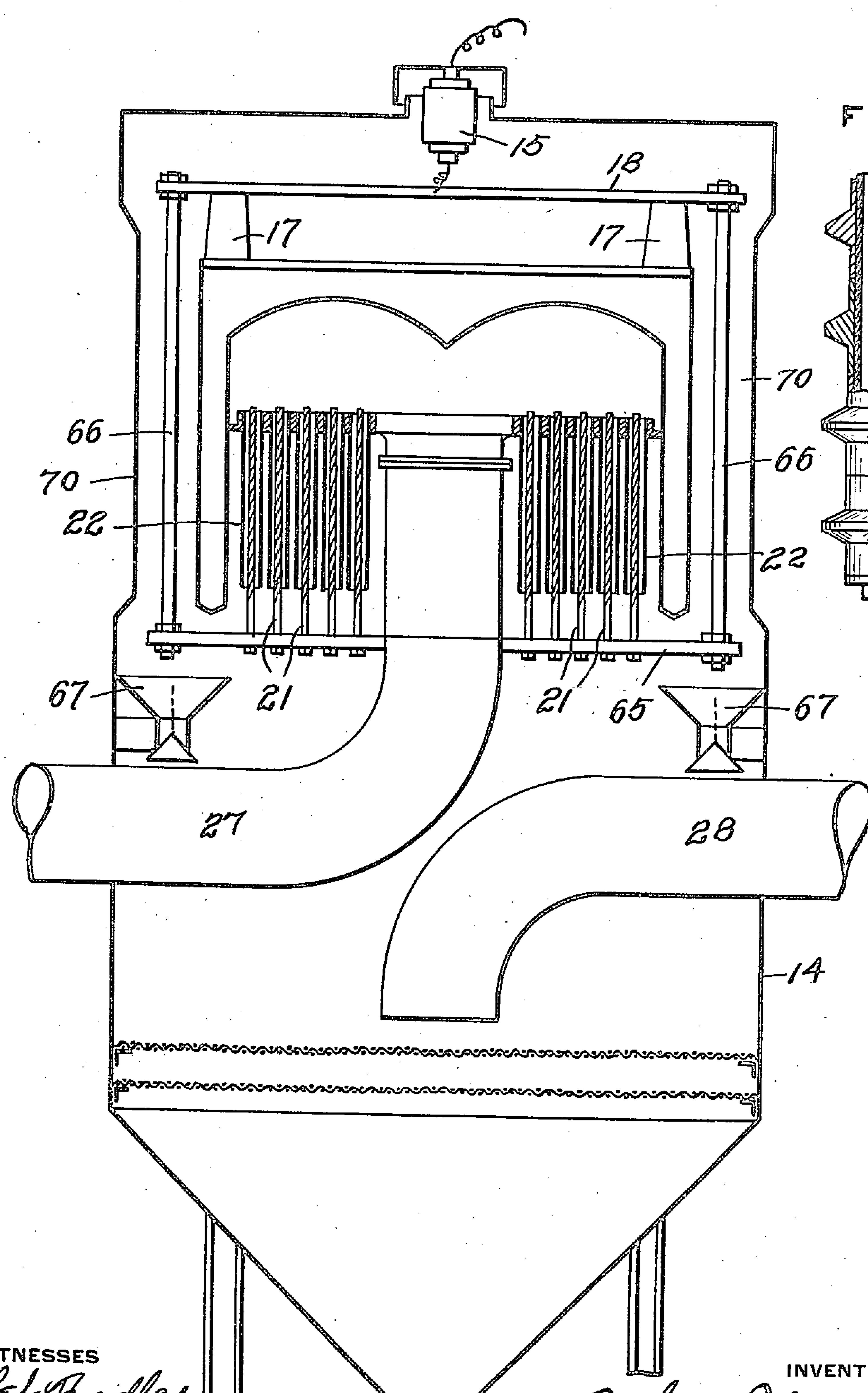
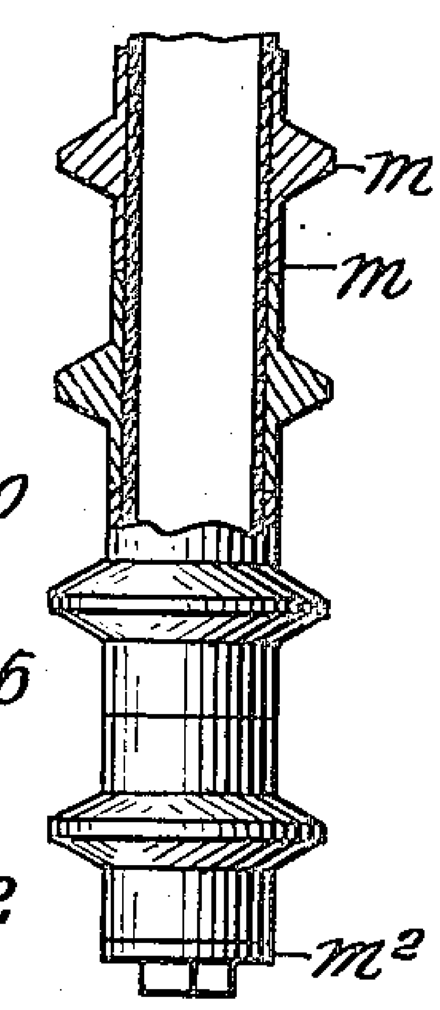


FIG.12.



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UNITED STATES PATENT OFFICE.

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ART OF PRODUCING ELECTRICAL PRECIPITATION, ETC.

Application filed September 7, 1916. Serial No. 118,899.

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 certain new and useful Improvements in the Art of Producing Electrical Precipitation, etc., of which the following is a specification.

My invention relates to the art of separating solid and liquid particles from gaseous or fluid streams by electrical precipitation.

Separation of particles from streams of these types by subjecting the streams to the action of opposing electrode systems has been heretofore proposed and apparatus for such purpose has been placed in service to a limited extent. Various ways of meeting service conditions have been suggested, but the difficulties incident to the particular uses of apparatus of this type have been such as to generally provide unsatisfactory results.

The early developments of the art provided for the formation of fields based on the point discharge theory of operation, as by the use of barbed wire, filamentous material, wire mesh, and electrodes with serrated edges as the discharge electrodes. While these structures provided separating fields, the fields were of a type in which the discharge is normally localized, a structure inherently lending itself to the ready formation of disruptive discharges through the fact that the localization effect is present at all times and requires but a slight change in conditions to reach a point where breakdown of the stream occurs resulting in the formation of the disruptive discharge.

During these developments the idea of employing spaced-apart opposing flat plates as electrodes was used, but the efficiency, excepting under especially favorable conditions, was comparatively small due to the general inability to concentrate the discharges.

Later developments indicated the superiority of the corona type of discharge, such as is provided by the use of wires located in tubes, each wire extending axially through a tube and forming therewith a unit adapted to provide separating action by passing the stream through the tube, the wire and tube forming the opposing electrodes, the surfaces of the electrodes having a concentric relation one to the other and providing a uniform field surrounding the discharge electrode.

As a result of a number of tests, experimental and otherwise, I found that, although the formation of symmetrical fields by the tube and wire structure provides for serviceability, more efficient results can be obtained by partially or wholly concentrating the strain lines of the field thereby increasing the ionizing effect of the field. For instance, I have located the wire electrode with its axis out of the symmetrical axis of the tube electrode, thus tending to concentrate the strain lines on that face of the wire electrode closest to the surface of the tube. In another form, I have produced a somewhat similar result by making the surface opposing the wire electrode of a larger radius than that of the surface of the wire, and have extended this idea to a point where such opposing surface is substantially flat so that the non-concentric relation between the surface of the two electrodes tended to produce ionization zones. One development of the latter idea is to provide a plurality of such zones in the direction of travel of a stream through the ionization field. As will be understood, the inner or discharge electrodes in these cases are a wire with the usual circular cross sectional contour. As better results are obtainable with wires of smaller diameter, due to greater concentration of strain lines at the surface, the application of the discoveries indicated above is limited to such use as would not damage the wire. I also found that this use may be amplified to a certain extent by the substitution of a metallic bar for the wire, such bar having an edge to produce the concentration, this edge extending in the direction of length of the bar, but while this construction added strength to the electrode and thereby provided additional stability to the apparatus as a whole, its application is limited to uses where conditions would not materially affect the integrity of the bar or its support, as for instance, conditions where tendency of expansion and contraction of the bar under varying temperatures of gases would not be present to material extent. This limitation is due to the fact that the efficient operation of such apparatus is dependent to a great extent on maintaining the discharge between the opposing electrodes as close to the disruptive discharge point as will permit operation without normally producing such disruptive discharge. Where expansion and contraction of the electrode becomes a factor in materially varying this distance between electrodes, the possibilities of efficient operation are greatly reduced. Where, therefore, the integrity of the bar is affected, as by the action of comparatively high temperature, an example of which would be the use of apparatus for the purpose of cleaning the hot gases in blast or other furnace work, cement manufacture, etc., expansion and contraction of the bar may so affect the bar as to greatly decrease such efficiency.

As the result of further experiments and tests, I have found that the general idea of this concentration of active surfaces of opposed electrodes can be obtained in various other ways. For instance, by the use of a bar of considerable cross-sectional area, the bar itself having its contour angular in cross section, the apices of the angles forming edges which are at least equally as effective in concentrating the strain lines as are the curved surfaces of the wire electrodes. I also found that by subjecting the bar to a twisting action, each edge would form one or more spirals in the direction of length of the bar, thus providing a plurality of spiral discharge zones when located within a tubular electrode, the zones being continuous if the tubular electrode is circular in cross section, or interrupted if of noncircular configuration.

During my experiments, it was found that a twisted bar of this form, under expansion action, tended to elongate by slightly untwisting, so that while the untwisting action might slightly affect the spiral, such result would not materially affect the distance between the edge and the opposed electrode surface. Hence, by firmly suspending the bar electrode at its upper end, it could be employed in connection with installations where gases of high temperatures were encountered, the elongation of the electrode not materially affecting the radial length of the gap between electrodes, so that variations in temperatures of the gases would not affect operation, thus enabling the bar structure to be usable under conditions short of actual destruction of the bar by high temperatures.

Not only does this discovery provide for meeting conditions with respect to noneffective destruction of the electrodes, but in addition provides an electrode structure in which it is possible to control to a certain extent the operations of the apparatus. This is due to the fact that the twisting of the bar causes its edges to form spiral zones in the direction of length of the ionization field without the formation of objectionable pockets; as there is a tendency of the gases to attempt to dodge these zones, the gases will tend to take a spiral course through the field, thereby tending to set up a centrifugal action within the gases. As will be obvious, however, the amount of deflection of the gases spirally will depend to a great extent upon the velocity of the gases passing through the field, a more rapid velocity decreasing the deflection from a straight course and thus causing the gas to be subjected to the action of an increasing number of zones; since the normal action of the apparatus is designed to cause the path of travel of the gases to intersect—to a more or less degree—the direction of length of the zones, it will be clear that change in velocity would tend to vary the angularity of such intersection.

Such formation tends to produce the effect of a threaded electrode, the edges extending spirally in the direction of length of the collecting electrode similar to the threads of a threaded bar; where the structure is produced by machining instead of by twisting, a finer pitch may be produced.

I have also discovered that where conditions are favorable, satisfactory results can be obtained by breaking the continuity of the spiral zones, as, for instance, by varying the contour of the outer electrode to vary the distance between the two electrode surfaces. I have further found that this effect can be produced by substituting an annular ridge for the spiral thread arrangement, thus shifting the direction of length of the thread from that of a spiral to that located on a single cross-sectional plane of the discharge electrode. By such arrangement, the zones are located on planes extending at direct right angles to the axis of the electrodes, causing the gaseous or fluid stream to intersect the zones at such direct right angle. Consequently, in such form, the outer electrode may be concentric with the discharge edge, producing a continuous circular zone, the ridges being spaced apart in the direction of length of the electrodes to provide the interruption effect.

In providing this result, especially under high temperature conditions, I preferably form the discharge electrode of separate units, each carrying a ridge, the units being axially aligned. This not only permits of simplicity in manufacture with an assurance of similarity in unit configuration, but also enables any desired spacing of zones to meet operating conditions, as well as permitting the use of any desired number of zones. In addition, the unit structure provides for unit expansion and contraction and permits manufacture in a manner to practically prevent any material change in the distance between opposing electrodes under expansion and contraction.

To these and other ends, the nature of which will be readily understood as the invention is hereinafter disclosed, said invention consists in the methods and structures hereinafter fully described, illustrated in the accompanying drawings, and more particularly pointed out in the appended claims.

In the accompanying drawings, in which similar reference characters indicate similar parts in each of the views,

Fig. 1 is a diagrammatic sectional view illustrating one way of concentrating electric lines of force.

Fig. 2 is a similar view showing the use of parallel electrodes arranged to concentrate the electric lines of force in zones.

Fig. 3 is a diagrammatic cross section of opposing electrode systems adapted to produce ionization zones with concentrating electric lines of force.

Fig. 4 is a view similar to Fig. 3 but showing the discharge electrode as having been subjected to a torsional twisting action.

Fig. 5 is a diagrammatic view showing a simple arrangement of apparatus for providing the electric pressure for producing the ionization field.

Figs. 6–10 inclusive are diagrammatic cross sectional views showing various ways in which the present invention may be developed.

Fig. 11 is a diagrammatic sectional view showing a different form in which the invention may be applied.

Fig. 12 is a detail view, partly in section and partly in elevation, showing a modified arrangement of discharge electrode.

As heretofore referred to, in developing the art of separation by the use of ionization fields, the concentration of the strain lines was found to provide greater efficiency than where the field was made uniform by locating the axis of the discharge electrode on the symmetrical axis of the opposing tube electrode with the surfaces of the two electrodes concentric with each other. This increase of efficiency is due to the fact that the strain lines are concentrated instead of diffused, thereby providing a zone of increased ionization effect.

As is well known, when two flat metallic plates are separated by a pane of glass of similar dielectric having a thickness approximately one-eighth inch, and a difference of electric pressure is maintained between these plates (acting as electrodes) it is difficult to discover any electric action as taking place between the two plates until an effective pressure of six or seven thousand volts is applied. The first visible evidence of such electrical action is in the form of a pale violet light termed "the corona" at the edges of the plates or electrodes. By increasing the difference of electrical pressure, the corona brightens and broadens out and may be accompanied by thin and brilliant streamers emanating from the electrodes and darting in all directions over the surface of the glass.

When, however, the discharge electrode is in the form of a fine wire, as in Fig. 1, the axis of the wire being parallel to the glass plate and the opposite electrode, the corona discharge takes place at the lower part of the surface of the wire only, the strain lines being concentrated and increasing the ionization effect. When the dielectric flux density attains a value that will rupture the dielectric, the latter gives way at this particular region, and the dielectric flux is replaced by an electric current. This action is shown more particularly in Figs. 1 and 2 in which *a* represents a wire electrode, and *b* the opposing electrode in the form of a plate and which may be grounded, *c* representing the flat glass plate forming the dielectric. As shown in Fig. 1, wherein but one wire is employed, the electric lines of force or strain lines diverge from a very limited portion of the under surface of the wire, passing through the glass plate *c* in accordance with the well known laws of refraction of electric lines of force and terminate upon the upper surface of the plate C. In Fig. 2, a pair of wires are shown, illustrating the zonal effect produced when the discharge electrode is in the form of a pair of wires arranged parallel to each other and to the opposing electrode.

As will be understood, this concentration effect is due to the fact that the opposing surfaces of the electrodes have a non-concentric relation. Obviously, the concentrating effect becomes more apparent as the diameter of the wire decreases. While this concentration effect increases with the decrease in the diameter of the wire, however, stability of the structure decreases in correspondence; in view of the fact that commercial use of such apparatus must be accompanied by stability, the efficiency produced by the concentration is limited by the size of wire capable of providing the desired stability.

As heretofore referred to, this limitation may be eliminated by the use of a bar formed with a sharp edge, the latter opposing the plate electrode, a preferred arrangement disclosed in such applications being the use of parallel bars carried by a frame with the length of the bar intersecting the travel path of the stream and thus forming a plurality of independent zones in such travel path, the stream passing successively through the zones. This arrangement provides for stability owing to the increased cross sectional area of the bars, but possesses the disadvantage that where it is employed as a part of apparatus adapted to operate upon gases of comparatively high temperatures, expansion and contraction of the metal of the bars may serve to affect the normal operation and the stability of the structure. Consequently, the uses of such prior development cannot well be extended to installations where temperature conditions of the gases or other medium may affect the integrity of the structure.

As heretofore pointed out, developments as a result of further experiments and tests have shown that it is possible to employ this idea of strain line concentration and non-concentric relation between the opposing electrode surfaces where the outer electrode is tubular and without the limitations provided by the use of wire as the discharge electrode, this result being obtained, in one form, by the use of a bar having its axis on the symmetrical axis of the tube, but having its cross sectional contour angular, thus providing a plurality of parallel edges extending in the direction of length of the tube, each edge acting to concentrate the electric lines of force or strain lines, as indicated more particularly in Fig. 3, in which the outer electrode is shown in the form of a tube *b′*, and the discharge electrode as in the form of a bar *a′* of considerable area in cross section and having its cross sectional contour in the form of a square, thus forming four parallel spaced-apart zones extending from one end to the other of the field.

Inasmuch, however, as the gases would travel in the direction of length of the zones, such structure would be somewhat ineffective by reason of the fact that the tendency of the stream would be to dodge the zones and pass through the free spaces between zones.

To overcome this objection, and yet maintain the increased stability provided by a bar of the character mentioned, I preferably form the bar in such manner as to cause each edge to form a spiral extending around the bar. This spiral arrangement may be produced in any suitable manner, as by machining a bar of proper cross section to form the spiral. However, I prefer to produce this result by a twisting action on the bar itself, thus not only producing the spiral effect in a simple manner, but in addition, tending to slightly change the cross sectional contour of the bar by slightly concaving its sides between the edges, see Fig. 4, with the result that the angle at the meeting faces of the sides forming the edge is decreased from the initial form, thus increasing the concentrating effect.

This twisting action does not affect the formation of spaces between the edges or between the zones at points adjacent the discharge edges, the twisting action simply shifting these spaces into spiral form. As a result, any tendency of the stream to dodge the zones by attempting to pass through the spiral spaces would give a spiral movement to the stream around the discharge electrode, an action which would tend to set up centrifugal action on particles within the stream and tend to throw them toward the outer electrode *b′*.

Obviously, the speed of the gases in traversing the field will tend to control the separating action. If the flow be sufficiently slow as to permit the gases to freely follow the spiral spaces, the action will be somewhat similar to that provided by the arrangement of Fig. 3. Where, however, the rate of flow is increased so that the gases must traverse the field in a time length less than that which would be required to pass when following the spiral spaces, the gases will be forced to intersect the zones, the degree of angularity at which such intersection takes place increasing with the increase in the rate of flow of the gases. Hence, the structure lends itself particularly to the type of apparatus in which the gases are moved at considerable rapidity, especially in view of the fact that the length of the field is not limited by the factor of rigidity in the discharge electrode. In this latter respect, the structure is superior to that of the flexible wire structures, structures in which the vibratory effect and its disadvantages rapidly increase with the increase in length of the wire.

I have found that a twisted bar of this character is particularly advantageous where the streams are formed of gases of comparatively high temperatures, the expansion action produced by the temperature of the gases tending to elongate the bar, the elongation, however, being with a tendency to untwist to a more or less extent, depending upon the temperature. While this untwisting tendency may slightly affect the path of the spiral edges, the effect is comparatively small, thus retaining the action of the spiral zones, the untwisting action, however, possessing the great advantage of practically retaining the length of the radial gap between an edge and the outer electrode substantially constant. As a result, the change in the bar provided by this expansion action is ineffective to materially change the character of the ionization zone provided by the edge; if any change be present, it will simply be in a slight shifting of the zone itself tending to straighten out the spiral. Consequently, an electrode system of this form can be employed where the gases vary considerably as to temperature, expansion and contraction of the bar having no material effect on the ionization zone itself.

Obviously, the bar may have other angular cross sectional contours, thus enabling the formation of any desirable spiral arrangement. An additional advantage in this general arrangement is the fact that other variations may be had by varying the contour of the outer electrode. As will be readily understood, a discharge electrode such as described, will, where the radial distance between an 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. If, however, the tube be non-circular in contour, the ionization zone will be interrupted in the direction of its length, since the radial length of the zone will vary, and, in accordance with the usual effect under such conditions, the strain lines will be concentrated more particularly at the points where such radial length is least.

As will be understood, the pitch of the spiral edges may be arranged to meet the conditions of service. It may be such that adjacent convolutions are close together, but in such case I may change the spiral arrangement to that of circular ribs, this being an arrangement more easily produced by machining, the spaces, in such case, extending circularly instead of spirally. In such arrangement, the outer electrode is concentric with the discharge edge to form a complete circular zone with the spaces independent of each other. Obviously, the stream, in this form, intersects the direction of length of the zones at direct right angles.

This latter idea can be applied under conditions of high temperature by employing a structure in which the effect of expansion and contraction does not materially vary the radial distance of the gap. A preferred way of producing such construction is to form each rib as a unit, as indicated, for instance, in Fig. 12, in which *m* indicates a tubular member of suitable length formed with an external rib *m'*, preferably wedge-shaped and having its periphery brought to an edge, preferably a blunt edge. The unit is adapted to slip over and fit a carrier which may be either in bar or tubular form, of any desired cross-sectional configuration. Each member *m* is preferably of similar configuration, although this may vary, if desired. Obviously, a plurality of units can be placed on a single carrier, the latter being connected to the source of electrical supply, each unit being adapted to produce an independent zone when the carrier is mounted in a complemental electrode. The units may be clamped in position in suitable manner, preferably in a way which will permit removal individually, if desired, or they may simply rest one on another, a washer m^2 forming a supporting abutment for the entire series, the weight of the units retaining them in position. The expansion and contraction effect will be more or less individual on the units, in addition to which the electrode is of the desired strength and in a form which permits of easy manufacture and repair, and provides for uniformity in zones, in addition to which, any desired spacing of zones can be provided.

Obviously, a unit may have more than a single rib, and may, if desired, include all of the ribs, in which case, the arrangement permits substitution of the edges of a discharge electrode without disturbing the connection of the carrier with its spider support.

As will be readily understood, the ionization field produced when the arrangement of Fig. 12 above described is employed differs to some extent from the spiral form, in that each zone is symmetrically continuous on a cross sectional plane of the tubular or collecting electrode corresponding in position to the position of that portion of the discharge electrode which produces the zone. In other words, the zone intersects the direction of flow of the gases at direct right angles and is symmetrically continuous on the line of intersection, so that the gases are forced to pass through the successive spaced-apart zones in traversing the field.

By these developments, I am able to provide a discharge electrode of sufficient cross sectional area as will insure stability even though it be supported from one end only. For instance, I have employed electrodes of this type up to three inches in diameter, a construction which affords stability under exacting operating conditions, the outer electrodes being in the form of tubes in excess of fifteen inches in diameter.

In addition to providing for stability as a discharge electrode, the bar may itself form a supporting element, thus aiding in producing a more efficient apparatus as a whole, in that such bars can operate to support the separating electrodes and additionally act in connection with tubular members to reduce the possibility of dust particles collecting on the insulators which support the system. In such cases, the radial length of the additional or supplemental zones is preferably greater than that of the main or separating zones to reduce liability of disruptive discharge in such supplemental zones and thus affect the entire system.

I have found that the twisted bar is not only very efficient in operation, but it additionally presents a structure of great strength and integrity, due to the fact that the bar itself may be produced by the usual rolling mill operation to provide the desired initial cross section, the twisting action not materially affecting the structure of the bar excepting such as would be produced by the twisting action, thus retaining all of the metal of the bar and its general composition in the completed bar.

As will be readily understood, the general idea may be employed in various ways, dependent upon the capacity which the installation is to provide, the drawings indicating several ways in which this result may be obtained.

The structure is designed for use in connection with electrical currents of high potential. These may be of the alternating or the direct current type, and may be oscillating or pulsating in character.

In Fig. 5 I have shown a diagrammatic arrangement of parts where a rectified alternating current is employed, 10 indicating the tubular outer electrode connected to ground, 11 a twisted bar electrode suspended therein, the bar being connected up to a rectifier 12 of suitable type operating to rectify the product of a transformer 13, the primary of which is connected to a suitable source of supply indicated at S, the rectifier being connected also to the tube 10, this arrangement providing a more or less pulsating unidirectional current to the bar 11, the voltage being sufficiently high to provide the corona discharge action on the several edges of the bar, thus producing an ionization field between the bar and the tube 10, the field being formed of a plurality of ionization zones arranged spirally in the direction of length of the tube. Consequently, if gases or other fluids be introduced at the lower end of the tube at a predetermined velocity, these gases will pass upwardly through the tube and intersect these ionization zones, the angle of intersection depending upon the pitch of the spiral and the velocity of the gases, thus insuring that all portions of the gas will pass through one or more of these zones in reaching the opposite end of the tube.

However, I prefer to employ the unidirectional type of current such as is provided by generators of the Girvin type, this type of apparatus providing a unidirectional electromotive force of sufficiently high voltage with a minimum fluctuation between maximum and minimum vales, avoiding the more or less intermittent operation of the general type of rectifying apparatus. As the e. m. f. developed by this type of apparatus is unidirectional, the polarity of the bar remains the same and the electric intensity remains practically constant at all times, such fluctuations that may exist being within well defined limits; hence there is no intermittance of the electric discharge from the active electrode provided the voltage is kept above the corona-forming value.

In Figs. 6–10 I have shown various ways in which a bar may be employed in operating upon gases of comparatively high temperatures, such for instance, as waste gases from blast furnaces.

In Fig. 6 I have shown a vertically extending tubular casing provided at its top with an insulator 15 by means of which the lead from the source of supply enters the casing the latter being indicated at 14. Arranged near the top of the casing is a suitable diaphragm 16 forming a support for post insulators 17, the chamber above said diaphragm being intended primarily as an insulator chamber, said insulators supporting a spider 18 from which depend a suitable number of bars 19, the lower ends of which are connected to a spider 20 which forms the support for the discharge electrode bars 21, said bars extending into the tubular electrodes 22 supported by a diaphragm or other support 23.

The diaphragm 16 is provided with tubular sleeves 24 through which bars 19 extend, said sleeves having an inner diameter such as to provide a radial distance between a sleeve and its rod 19 greater than the distance between a bar 21 and its tube 22, each rod or bar 19 being preferably formed with spirals to produce spiral ionization zones within the sleeve, although these bars may obviously be smooth. Suitable baffles 25 are located above the sleeves 24.

Diaphragm 23, in this form, preferably has a central down-turned portion providing an opening, the lower end of said portion being connected to an out-going pipe 27, the tubes 22 having their upper ends extending above the plane of diaphragm 23. 28 indicates the incoming pipe for the gases, this preferably having its outlet projecting downwardly within the casing 14.

In this form of device, a plurality of tubes 22 and a corresponding number of bars 21 are provided, these being arranged in a circle about the pipe 27. When gases are introduced through pipe 28 into the casing 14, with a definite velocity, the only escape from the casing is upwardly through the tubes 22 which form part of the electrode system, having the spirally arranged ionization zones heretofore referred to. The gases after emerging from the tubes 22 pass into the chamber between diaphragms 16 and 23, from which they pass outward through pipe 27.

Should the action of the electrode systems be insufficient to thoroughly clean the gases and there be a tendency of the latter to pass upwardly through the sleeves of diaphragm 16, the secondary electrode system provided by the bars or rods 19 and the sleeves would subject the gases to the action of such secondary ionization zones, thus tending to still further eliminate the particles. As the gases would be required to follow a tortuous path in entering the insulator chamber, through the presence of the shields or baffles, the tendency to deposit on the insulators is practically eliminated.

As a result, not only are the gases subjected to the main electrode systems, but such gases as might reach the insulator chamber are subjected to the action of the supplemental or secondary ionization fields and are required to traverse tortuous channels in reaching such chamber. Consequently, the deposit of dust within the insulator chamber is greatly reduced, if not entirely eliminated.

From the above, it will be seen that a structure is provided in which the discharge electrode system comprises supporting bars which may themselves act as secondary discharge electrodes and the bars 21, together with their connections. Since the bars are of ample cross section (bars 19, in a commercial embodiment based on the disclosure of Fig. 6, having a diameter of four inches and bars 21 a diameter of approximately two inches), it will be readily understood that the structure thus produced is rigid and of a character able to withstand the usage to which it is to be put, the radial length of the ionization zone of the main system being approximately six inches while that of the secondary systems is approximately eight inches.

In Fig. 7 I have shown a somewhat similar arrangement but of larger capacity, the main electrode system having its tubes arranged in concentric circles, the spider being properly arranged to support the bars 21 with respect to the tubes 22, thus greatly increasing the number of tubes 22 which may be employed. For instance, the structure shown in this view is designed to employ about one hundred and fifty tubes 22, this structure being designed to provide a capacity in excess of one hundred thousand cubic feet of gas per minute at a comparatively low velocity.

Obviously, the general arrangement may be varied, Fig. 8 indicating one way in which this result may be obtained, this view indicating the possibility of tying the lower ends of bars 21 together by a spider.

Fig. 9 indicates another application, this structure providing for an upward discharge of the gases, after separation, instead of downwardly as in the previous views, the insulator chamber in this instance being supplemental to casing 14 and provided in the form of an annular structure surrounding the outlet, the supporting bars 19 extending downwardly through openings in the casing 14. As will be readily understood, this particular arrangement permits the diaphragm or header 23 to extend entirely across the casing.

In Fig. 10 I have shown another form, spider 20 carrying the depending electrodes 21 which extend into the tubes 22, the lower ends of the tubes, however, being adapted to receive tubes 50 of smaller diameter which extend from the chamber below the separating zones into the tubes 22, the difference in diameter of tubes 22 and tubes 50 being such as to provide an annular space therebetween. The gases enter tubes 22 through tubes 50 and as the electrode systems are designed to carry the particles into contact with the walls of tubes 22, it will be readily understood that such particles as may be separated will pass downward along these walls and through the space between tubes 22 and 50, passing into suitable pockets, which may have suitable controlled discharge outlets 100, the tubes 50 being supported in suitable manner, such support, if desired, forming the bottom of the pockets.

In this form, the supplemental separating zone is also employed.

If desirable, suitable screen or arrester structures may be provided in the lower portion of the casing, these structures being suitably supported and, in the types herein disclosed, face the discharge end of the gas inlet 28, being spaced therefrom a desired distance. This screen structure is designed more particularly to eliminate the larger particles which may enter with the gas, the latter discharging into the screen, and since the direction of flow of such gases within the casing is reversed in reaching the separating fields, the screen structure will tend to prevent the larger particles from being retained within the gas streams when reversing action is had.

It is characteristic of the forms shown in Figs. 6–10 that the discharge electrodes are practically suspended or supported from their upper ends, although in Fig. 8, I have shown the lower ends of the electrodes as tied together. However, this manner of supporting these electrodes is not compulsory, Fig. 11 indicating a reversal in that the bars forming the discharge electrodes are supported from a spider 65 located in the casing below the tubes 22. In this form, the spider is supported by rods 66 leading downwardly from the insulator chamber through suitable pipes 70 external of the main casing, suitable deflectors 67 being positioned below said pipes 70 and may be formed to catch particles which may be separated through the action of the supplemental ionization fields formed by the rods or bars 66 and the tubular members 70. These deflectors tend to force the gases toward the main separating fields and away from the supplemental fields. The tendency to prevent the passage of gases into the supplemental fields is additionally reduced through the fact that these fields and the insulator chamber tend to form a dead space, being out of the general circulation paths through the apparatus. In this form, the top of the casing may have a configuration tending to direct the gases which lead from the main separating fields towards the gas exit 27.

In each of these forms, the gas is introduced below the main separating fields and passes upwardly through these fields and thence to the exit, the suplemental separating fields being designed to restrict, as far as possible, the entrance of dust particles into the insulator chamber, it being understood that it is desirable that such chamber be kept from damaging effects as far as possible while providing the support and circuit connections for the discharge electrodes.

It will be noticed that in these various forms, the structure is not only one involving stability, but that such stability is obtained with a minimum amount of material and arranged in a comparatively compact member.

These various arrangements indicate the wide possibilities of unit structure to meet various conditions of installation and of capacity, these generally employing the basic ideas relative to the formation of the ionization fields pointed out herein. While I have shown these various forms, it will be obvious that other variations or modifications embodying the general ideas may be provided to meet exigencies of use, and I therefore desire to be understood as reserving the right to make any and all such changes and variations as may be found necessary or desirable in so far as the same may fall within the spirit and scope of the invention as expressed in the accompanying claims.

In the following claims, it is to be understood that the discharge electrode may be of either of the forms shown and described, excepting where a particular form is indicated.

What I claim is:—

1. In the art of producing electrical precipitation from fluid or gaseous streams, the combination of opposing electrode systems with the discharge system including a rigid electrode of angular cross-section, said electrode having a plurality of spiral discharge edges and said discharge edges being continuous in length.

2. In the art of producing electrical precipitation of particles from fluid or gaseous streams, the combination of a plurality of tubular collecting electrodes, a rigid discharge electrode of angular cross-section extending axially within each tubular electrode and having a spiral discharge edge, said discharge edge being in a plane concentric with the inner surface of its tubular electrode, means for introducing a stream into one end of each tubular electrode, and means for receiving and collecting the treated streams at the other end of said tubular electrodes.

3. In the art of producing electrical precipitation of particles from fluid or gaseous streams, the combination of a plurality of tubular collecting electrodes, a rigid discharge electrode of angular cross-section extending axially within each tubular electrode and having a spiral discharge edge, said edge being in a plane concentric with the inner surface of its tubular electrode, means for introducing a stream into one end of each tubular electrode, means for receiving and consolidating the treated streams at the other end of said tubular electrodes, and means adjacent to one end of said tubular electrodes for segregating the precipitated particles in said streams.

4. In the art of producing electrical precipitation of particles from fluid or gaseous streams, the combination of a plurality of tubular electrodes, a rigid discharge electrode extending axially within each tubular electrode and having a plurality of spiral discharge edges, said edges being in a plane concentric with the inner surface of its tubular electrode, means for introducing a stream into one end of each tubular electrode, means for receiving and consolidating the treated streams at the other end of said tubular electrodes, and means adjacent to one end of the tubular electrodes for segregating the precipitated particles in said streams.

5. In the art of producing electrical precipitation of particles from fluid or gaseous streams and in combination, a plurality of suspended tubular electrodes, a corresponding number of discharge electrodes extending axially within the tubular electrodes, means for suspending the discharge electrodes, said means including a bar connected electrically to the discharge electrodes, a tubular member adapted to co-operate with said bar to produce an ionization field of less intensity than the fields produced by the discharge electrodes, and means for passing a stream through the ionization fields produced by the discharge electrodes said supporting bar ionization field supplementing the action of the main ionization fields with respect to stream contents passing through the supplemental field.

6. In the art of producing electrical precipitation of particles from fluid or gaseous streams and in combination, a casing, opposing electrode systems within said casing, one of said systems including a plurality of discharge producing electrodes, an insulator chamber within said casing, means for supporting the discharge electrodes from the insulator chamber, said means including elements adapted to produce ionization fields of less intensity than the fields produced by said electrode systems, and also includ-

ing baffles to provide a tortuous path for stream contents in reaching such chamber, whereby said chamber will be protected against deposits by said supplemental ionization fields, and means for passing a stream through the main ionization fields.

7. In the art of producing electrical precipitation of particles from fluid or gaseous streams and in combination, a casing, opposing electrode systems within said casing, one of said systems including a plurality of discharge producing electrodes, an insulator chamber within said casing, means for supporting the discharge electrodes from the insulator chamber, said means including elements adapted to produce ionization fields of less intensity than the fields produced by said systems, whereby said chamber will be protected against deposits by said supplemental ionization fields, and means for passing a stream through the main ionization fields.

8. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems including a collecting electrode structure, said systems being adapted to produce an ionization field for diverting particles from the stream and collecting them in proximity to the collecting electrode, and means in approximate alignment with the electrode structure for isolating the collected particles from the stream.

9. In the art of producing electrical precipitation of particles from fluid or gaseous streams, the combination of opposing electrode systems, said systems including a plurality of tubular collecting electrodes, a rigid discharge electrode within each collecting electrode, means at one end of the tubular electrodes for supplying a stream to each tubular electrode, means for consolidating the streams emerging from said tubular electrodes, and means adjacent to one end of the electrodes for trapping the particles collected within said tubular electrode and separating the particles from the outgoing streams.

10. In the art of producing electrical precipitation of particles from fluid or gaseous streams, opposing electrode systems including a collecting electrode structure, said systems being adapted to produce an ionization field for diverting particles from the stream and collecting them in proximity to the surface of the collecting electrode, said collecting electrode being made in sections and the contiguous ends of said sections forming a trap on the surface of the collecting electrode for isolating the collected particles from the stream.

In testimony whereof, I affix my signature in presence of two witnesses.

ARTHUR F. NESBIT.

Witnesses:
CHARLES LOMBARDO,
EDWARD MCKINLEY.