

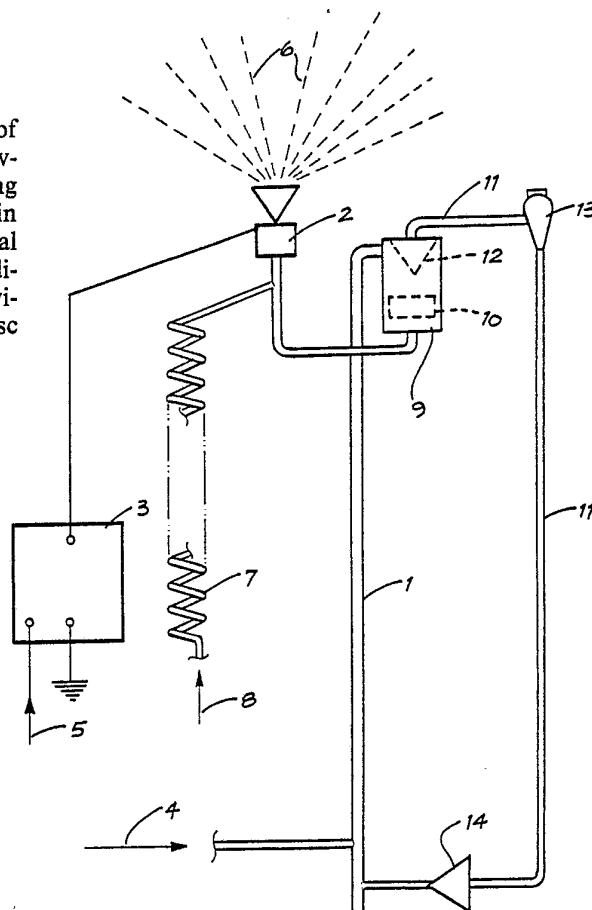


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification³ : B05B 5/00, 5/02; B05D 1/04 B03C 3/16	A1	(11) International Publication Number: WO 82/ 01481 (43) International Publication Date: 13 May 1982 (13.05.82)
(21) International Application Number: PCT/AU81/00153 (22) International Filing Date: 23 October 1981 (23.10.81) (31) Priority Application Number: PE 6204/80 (32) Priority Date: 24 October 1980 (24.10.80) (33) Priority Country: AU (71)(72) Applicant and Inventor: HANSEN, Ronald, Peter [AU/AU]; 4 Jonathon Place, Frenchs Forest, N.S.W. 2086 (AU). (74) Agent: HODGKINSON, Hugh, Rudyard; H.R. Hodg- kinson & Co., 26A Alfred Street, Milsons Point, N.S.W. 2061 (AU).		(81) Designated States: AU, DE (European patent), FR (Eu- ropean patent), GB (European patent), JP, SE (Euro- pean patent), US. Published <i>With international search report.</i>

(54) Title: DUST MITIGATION SYSTEM**(57) Abstract**

Method of production of electrically charged droplets (6) of water for reduction of air borne dust and to apparatus for achieving this. The problem of short circuiting is solved by using a long and narrow bored supply tube (1) of non-conductive material in conjunction with a high voltage generator (3) with high internal resistance and an insulated spray load. Variations include addition of a second fluid such as air or oil to decrease the conductivity of the water, the spraying of water into a charged deflector disc and the modulation of the amplitude of the applied voltage.



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DUST MITIGATION SYSTEM

This invention relates to novel forms of dust mitigation systems and in particular to a method relying upon the distribution of an electrically charged fluid spray for use therein.

Environmental pollution by airborne dust particles is of increasing concern. Particulate substances emitted from material stockpiles, handling operations, and industrial processes can reach nuisance levels in most situations, and
10 become a severe health hazard in extreme cases.

Hitherto, the available methods of alleviating such problems have been limited to:-

1. Total enclosure of the site, stockpile and/or handling operation.
2. Maintaining a high level of moisture and/or adhesive substances in the material being handled, to prevent emission
20 of dust during handling or standing in stockpiles.
3. Continuous or intermittent application of water sprays with or without chemical additives, to stockpiles and the vicinity of handling points.

In a majority of cases, (1) above is prohibitively costly, or impracticable for other reasons.

Presence of high moisture levels in particulate materials
30 as in (2) above frequently increases handling and flow problems, and may degrade the value of the material. For example, excessive moisture in coal materially reduces the combustion energy available. Also, unless supplemented by (3), surfaces of stockpiles or conveyor loads exposed to sun and wind can dry out very rapidly, and dust fines may be generated from such surfaces even while the bulk of the material below retains



excessive moisture content.

In drying conditions, continuous spraying of water plus additive on dust-nuisance areas can only effectively treat the principal source of such dust (the stockpile and handling system.) This is of limited effectiveness unless very high water volumes are applied, to a degree which may itself be an environmental nuisance to personnel working in the vicinity. The continuous application of such sprays may also cause an
10 increase in the moisture content of the subject material sufficient to degrade its end purpose. Some materials, such as flour or cement, cannot tolerate added moisture at all.

A disadvantage of such spray systems is that other major sources of dust, such as roads and remote corners of the terminal site, may escape treatment altogether and remain a major source of dust over the entire area.

Once airborne, dust is extremely difficult to suppress
20 in open-air conditions. All current methods of dust-mitigation are based on techniques of attempting to prevent dust becoming airborne by the various methods outlined above. At the same time, dust from a number of other sources, including those beyond the site boundaries and hence outside the control of the operating authority, may be continually airborne and carried to considerable distances into adjacent residential, commercial, or natural areas.

The difficulty of suppressing airborne dust is, in
30 simple terms, related to the relative numbers of airborne dust particles and the number and size of water droplets necessary to effectively capture them. The added mass thus causes rapid movement of the water droplet to the ground.

Since the rate of fall of any particulate substance in air is related to its mass, density, and the viscosity of air,



any effective water spray must produce droplets of a substantial size compared to the dust particles to be effective. To remove even a major proportion of airborne dust from a given air volume requires the spraying of a mass of water many times greater than the mass of dust particles. This is clearly impractical except in special circumstances.

However, if the water droplets can be charged, their dust-capture effect is increased by a very large factor.

10

Experiments have shown the dust captured by a given volume of water falling as discrete particles (droplets) relates approximately to the square of the applied voltage. The polarity of the voltage has been found to be relatively insignificant, although for some dust materials small differences in capture efficiency were found, depending on whether the charge was positive or negative to earth.

20 Observations on dust particles falling freely between a pair of charged metal plates of opposite polarity have indicated that some substances can carry small charges generated spontaneously by air friction or other causes of a magnitude of the order of twenty millivolts or so. This is considered to account for observed differences in capture rates of positively charged and negatively charged water droplets.

Experiments involving the simplest form of our invention have been most satisfactory in that a quite unusual amount of dust was captured.

30

In a typical test by this method, approximately 250mls of water was caused to fall through a dust cloud as discrete droplets along an insulated nylon guide thread through a small orifice to a collecting vessel. The average size of each droplet was about 0.05ml. An electric charge was applied to each droplet by a DC source of variable voltage. The quantity of dust collected was measured after each 250ml run,



to ± 0.001 gram. Results were:-

Run No.	1.	2.	3.	4.	5.	6.	7.	8.
Water (gm)	250	248	246	253	250	254	250	244
No. of Droplets	5000	4960	4920	5060	5000	5080	5000	4880
Voltage (kv)	0	0	+10	-10	+15	-15	+24	-24
Dust captured (dry wt., mg)	2	2	8	7	18	16	46	41

- 10 Clearly, electrostatic charging of the water spray droplets will greatly increase dust-capture effectiveness. This fact is very well known, but practical application requires that the spray nozzle be insulated from earth and supplied by a water source of very high electrical resistance to earth. In any conventional water supply the piping and the watercolumn therein constitute a low-resistance short-circuit.

In this context and throughout this specification "droplet" means any self-cohesive volume of water restrained
20 by its surface tension only.

The necessarily high internal impedance R_i of any practical high-voltage generator of electrostatic charge, when connected to such a spray nozzle, would result in almost complete loss of the applied potential, from the equation:-

$$\text{Effective voltage} = \frac{\text{Resistance of leakage path } (R_1)}{R_i \times R_1} \times V_g$$

- 30 wherein R_i is the internal impedance, R_1 is the leakage resistance, and V_g is the voltage generated within the generator.

Furthermore, any significant leakage currents in such a system will cause electrolytic corrosion of any conducting materials and possibly of adjacent metallic equipment.



Measures involving supply of spray water to electrostatically charged nozzles from an insulated tank also present problems. The electrical capacity of such a large conductive mass creates the danger of electric shock, potentially lethal at the high voltages involved. There are also difficulties in replenishment of the tank during long periods of operation.

It is an object of our invention to provide a dust mitigation system which substantially overcomes the defects experienced in the prior art.

In accordance with the present invention therefore there is provided a method of producing electrically charged liquid droplets for dust mitigation purposes, in which said liquid is supplied by means of a relatively long and narrow-bore duct of substantially non-conductive material to a point of application of high electrical potential relative to earth, said duct having a ratio of length to cross-sectional area satisfying the equation:-

$$\frac{L}{A} = \frac{V_s \times R_i \times S}{(V_g - V_s) \times 10^6} \quad (1)$$

Where L = length of duct (cm)

A = cross-section area (internal bore),
(sq. cm)

S = conductivity of sprayed liquid or
mixture of liquid and fluid.
(microsiemens)

V_g = generated voltage

V_s = required nett voltage at spray nozzle,

and

R_i = internal resistance of generator (ohms)

In one embodiment of the invention, a substantially non-conductive second fluid, immiscible with the working liquid



is injected into the working liquid supply line at a point at or near the point of earth potential, in such manner that the turbulent mixture so formed is substantially non-conducting. The non-conducting fluid may be air or oil.

In a further embodiment of the present invention, there is provided a method of electrically charging liquid droplets in a dust mitigation system, whereby the applied voltage is amplitude modulated at a rate substantially lower than the
10 rate of generation of liquid droplets, the applied voltage being varied in peak potential, or in polarity to earth, or any combination thereof.

The invention will now be further described with reference to the accompanying drawings, in which :-

Fig. 1 schematically represents the apparatus in its most elementary form.

20 Fig. 2 illustrates the addition of a surfactant wetting agent to the working fluid of the apparatus of Fig. 1.

Fig. 3 shows modifications required if the working fluid is of high conductivity.

Fig. 4 represents the apparatus when applied to boundary dust mitigation installations.

Fig. 5 is a plan view of a stockpile site layout.

30

Fig. 6 is a side elevation of a stockpile controlled by one embodiment of the invention.

Fig. 7 illustrates a variation of Fig. 1 where the spray nozzles are at or below the level of the water feed point.

Fig. 8 is a cross sectional elevation of the first fluid second fluid junction of the arrangement of Fig. 7, and



Fig. 9 illustrates a further variation of the present invention wherein the first fluid is subject to nil electrical potential until departure from the delivery pipe.

A number of embodiments of our invention will now be described:-

The simplest form is a method for increasing the electrical resistance of the leakage path from the spray
10 nozzle to earth to a magnitude sufficient for connection to a practical high-voltage generator with high internal resistance, when the conductivity of the water being used is low or moderate. See Figures 1 and 2.

With modern high-strength plastic materials, tubing can be constructed with very high electrical insulation values, yet capable of withstanding high fluid pressures. By accepting some loss of pressure from water flow (i.e. friction loss) in a relatively narrow-bore duct, an insulated
20 spray nozzle can be supplied via a long length of such tubing without significantly reducing the electrical resistance to earth.

The duct may be linear, or for convenience coiled as a spiral, a helix or as a zig-zag within an insulated casing. The ratio of length to cross-sectional area will be determined by several factors:-

1. The conductivity of the water supply.
- 30 2. The internal impedance of the power supply unit (voltage generator).
3. The allowable leakage current to earth therefrom, determined by the considerations listed above.
4. The desired charge voltage on the water droplets.

In a typical case, the available water has a conductivity of 150 microsiemens, the desired voltage is 20 kilovolts at the



spray nozzle, generator capacity is 24 kv, 2 ma DC, and the internal impedance is 12×10^6 ohms. Minimum leakage path resistance is 60×10^6 ohms. Hence, this required ratio of length: cross-sectional area = 9000:1

In its simplest form as shown in Figure 1, the invention includes an apparatus having a length of electrically non-conducting ducting (1), said duct having a ratio of length to internal cross-section of bore satisfying the equation:-

10

$$\frac{L}{A} = \frac{V_s \times R_i \times S}{(V_g - V_s) \times 10^6} \quad (1)$$

Where L = length of tubing (cm)

A = cross-section arc (internal bore),
(sq.cm.)

S = conductivity of water supply
(microsiemens)

V_g = generated voltage

20

V_s = required nett voltage at spray nozzle,

and

R_i = internal resistance of generator (ohms)

The additional load on the generator, of charging current to the water droplets, is very small compared to the leakage current via the water-filled tubing, and negligible for the purpose of determining $\frac{L}{A}$ above.

30

The duct is supplied with water (4) from a source at earth potential electrically, and feeds spray nozzles (2) insulated from earth. A transformer/rectifier unit or electrostatic generator (3) is connected between the nozzles (2) and earth, and supplied with electrical energy from a source (5), usually mains voltage 230 volts 50 Hz.



Water droplets (6) are emitted from the spray nozzles (2) bearing an electric charge of voltage determined by the equation:-

$$E_s = E_g \times \frac{R_2}{R_1 + R_2}$$

where E_s is the spray droplet potential

E_g is the generator voltage

10 R_1 and R_2 are as above.

The charged droplets (6) will capture dust particles at a rate determined by the voltage E_s , the viscosity of the air, the rate of fall of each droplet, the number and mass of dust particles present per unit volume of air, and by the hydrophobic or hydrophilic property of the dust particle surface, relative to the water being sprayed.

Generally, the voltage on the droplets is the
20 determining factor in the rate of contact between each falling water droplet and dust particles. However, if the dust particle is hydrophobic, such particles may simply acquire a similar charge by contact with the droplet, and not be captured by wetting action. The now-charged dust particles will then be repelled by the like-charge effect, and capture efficiency will actually be reduced.

In such conditions, the form of the invention is slightly altered. A suitable surfactant wetting agent, being
30 a polar compound with lipophilic and hydrophilic properties, may be added to the water supply at (4). Alternatively, as in Figure 2, a second line of tubing (7) may conduct the surfactant additive (8) to the water at spray nozzles (2). Since the required proportion of such an additive to the water is only from 0.01% to 1.0% in most cases, relatively small-bore tubing is adequate for the surfactant supply line (8), and hence of high resistance. The consequent reduction of earth-leakage resistance by the shunting effect of (7) is



negligible.

A second embodiment of the invention is used in situations where the available water supply for dust mitigation is relatively impure, i.e. of high conductivity. See Figure 3.

In this arrangement, the water feed duct (1) is again of non-conducting material such as nylon, polyvinyl chloride, etc. but may be of any ratio of length to cross-section. This supplies elevated and/or insulated spray nozzles (2), via an air-separator chamber (9) containing a cyclone separator element (12) and a float (10).

The air outlet from the cyclone is conveyed via non-conducting tubing (11) through a suction-relief valve (13) to a small compressor unit (14) and injected again at the base of (1). Surfactant, if required, is injected at the spray nozzle (2) via non-conductive tubing (7) from a supply source (8) into the water outlet from (9) from which air has been removed by the action of cyclone separator (12).

The injection of air into the flow of water in (1) reduces the electrical conductivity of the water column to an insignificant figure, such that the voltage output from the generator (3) may be connected directly to (2) without excessive loss by leakage current through (1). The internal resistance of the generator may be made very high, so that accidental contact by personnel does not create an excessive hazard, the relative conductivity of the human body being low enough to effectively short-circuit the generator voltage with only minute current flow through the person.

The capacity of the compressor (14) is small, since the nett pressure difference between its input and output is little more than the hydraulic head differential between (4) and (2). The air volume required is only a fraction of the



water flow rate. In one example an air volume of 10 percent of the water flow in a tube of 18mm internal diameter, raised the electrical resistance of a 10-metre length of the tubing plus water and air turbulent mixture to 180×10^6 ohms.

Should the air volume in the circuit fall below an amount determined primarily by the volume of (9), the float (10) on the increasing level of water within the chamber (9) rises to block the air outlet exhaust path through the cyclone cone (12). This results in a nett suction in tubing (11), and valve (13) then opens to admit atmospheric air to the intake of compressor (14). The increased air volume thus injected lowers the water level in (9), the float falls, opening the escape path again to (11), and recirculation of air is resumed.

A third embodiment of the present invention involves the application of low-frequency modulation of the applied charge. This important feature lies in the design of the electrostatic generator (3) shown schematically in Figures 1, 2 and 3.

In practical terms this can be achieved by applying a.c. voltage at mains frequency (50 Hz) and the appropriate voltage (usually 10 - 50 Kv), to a spray nozzle generating droplets at rates greater than 100 per second, preferably several times this rate.

The generator is so designed that the voltage applied to spray nozzles (2) may be modulated at low frequencies to change the magnitude and/or polarity of the charge imparted to water droplets (6). By reversing polarity at a frequency significantly lower than the number of droplets emitted per second, the dust-capture effectiveness and precipitation efficiency are materially improved over a charged spray system of constant polarity.



Each charged droplet collects dust particles by the well-known effect of attraction of opposite charges. The charge on a water droplet induces opposite charges on the nearer surface of adjacent dust particles, and like charges on the far side. The nett effect is a force of attraction between droplet and particle.

10 Droplets emitted during one half-cycle of the charging cycle are followed through the air by droplets of opposite charge emitted during the succeeding half-cycle. Due to variations of droplet size and velocity of emission, droplets of opposite polarity intermingle in flight a short interval after emission, with an average spacing determined largely by the spray nozzle design and applied water pressure.

20 Thus for a short period in free flight, each droplet collects dust by the aforementioned action of electrostatic attraction. The rate of movement of dust particles towards water droplets is an inverse function of the mass of each dust particle, which is generally very much less than the mass of the droplet.

In addition, the charged droplets will move towards each other, but at a much slower rate due to their greater mass. Thus each droplet collects a number of dust particles before joining with another droplet of opposite charge, at which point the charge on each is neutralised. This increase in total agglomerated mass of water-plus-dust causes a sharp increase in the rate of fall through the air, which for small
30 droplets is a function of size (mass).

The precipitation rate to ground is therefore greatly increased and offsets the normal lowering of precipitation rate due to evaporative loss of mass from the surface of each droplet during fall.



A further embodiment of the principles of our invention outlined above is illustrated at Figures 4, 5 and 6. In this application, it is possible to capture and precipitate dust blown from a stockpile or handling operation without spraying water directly onto the stockpile of material or on the actual handling point.

The assembly shown schematically in Figure 1,2 or 3 may, instead of generating charged droplets (6) from spray nozzles (2), have the fluid output from the top of (1) carried via an additional length of non-conducting tubing (21) to a length of tubing (15), via a tee or Y junction piece (18). The tubing (15) is suspended above ground by supporting masts (23) at a minimum height sufficient to clear all stacking cranes, conveyors, and handling equipment. Support from the masts (23) is by tension insulators (20) and chain or wire stirrups (22) to eye-bolt anchors (19) in the end of each catenary section of tubing (15), or other alternative supports providing electrical isolation of the suspended tubing from earth.

Tubing (15) completely surrounds the site in three or more sections, and has its upper surface perforated with fine orifices (17) such that thin jets of fluid are directed upward therefrom. These jets quickly disperse by the action of wind and fluid turbulence into separate droplets (16).

Being effectively insulated at each end, tubing (15) is at substantially uniform potential along its length, said potential being that at the output terminal of the high voltage generator (3) as corrected for leakage resistance by equation 1 above. The ejected droplets thus carry charges at a potential approximately that of (2) in the arrangements of Figures 1, 2 or 3 as relevant.

Charged droplets ejected upwards before falling downward



form a curtain of charged water surrounding the site to a height somewhat higher than the supporting masts and catenary tubing. It has been found that this curtain captures nearly all of the dust particles becoming airborne from the site without significant addition of water to the stockpiled material. Dust capture is by the same process of electrostatic attraction outlined above relevant to the arrangements shown schematically in Figures 1, 2 and 3.

10 A further embodiment of this invention is the non-conducting feeder methods described above, but in which the charge-modulation effect is produced by a pair of adjacent but separate spray nozzles or catenary-tube curtain sprays. Each such droplet emitter therein is connected to separate D.C. high voltage generators of opposite polarity, the emitted droplets of opposite charge then mingling in flight as previously described, to produce similar dust-capture effects.

20 A slight excess of negatively charged droplets is preferable in the air around such locations as it is now commonly accepted that a slight excess of negative ions in air has significant beneficial effects on human physiology. The converse, a slight excess of positive ions, has deleterious effects.

30 It is known that in dry dusty conditions an excess of positive ions is frequently created, and in fact many of the complaints around mineral-handling sites may be due to the resultant physiological disturbances that are not appreciated by the persons concerned. The systems described herein can improve this situation, as well as greatly improving the dust-mitigation effects of the spray.

Yet a further embodiment of the invention is illustrated by Figures 7 and 8. Where it is possible to locate spray nozzles below or near the same altitude as the water-feed



point, (if necessary at some horizontal distance therefrom), the required reduction of conductivity may be achieved by the arrangement shown.

Water is supplied at moderate to high pressure at the feed point (4), and passes through an orifice plate (25) or venturi section, with air inlet ports (26). The velocity of the water, and the relative areas of the tubing (1) and venturi throat or orifice (25) are so arranged that a
10 suitably large proportion of air aspirated into the liquid within tubing (1), thus reducing electrical conductivity of the fluid column.

High voltage is applied at the spray head, in the same manner as Figure 1. The leakage path to earth via the column of air and liquid in (1) is of sufficiently high resistance to enable a high potential to be maintained at spray head (2), from a source (3) of high internal resistance and low current output.

20

A further alternative arrangement is illustrated in Figure 9. A jet nozzle (27) containing a venturi section or orifice plate (25) having air-aspiration ports (26) is connected to a water source (4) of high or moderate pressure.

At a distance from the nozzle and on the same axis, a deflector plate (28) of non-conducting material is mounted on a tubular support (29) also of non-conducting material. Within the tubular member is a current limiting resistance of
30 80 to 300 meg ohms (30) in series with the connection from a high voltage generator (3) via wiring (31) within the tubing, to a small electrode (32) on the jet-contact face of the deflector plate (28).

Water emitted from the nozzle contains air bubbles sucked in through the ports (26), and the jet is therefore



of high resistance. The jet impinges on the deflector plate (28), and is broken up into spray droplets on impact. The shape of the emitted spray pattern is determined by the profile and angular setting of the deflector plate (28) and may be designed thus to virtually any desired spray pattern, with a charge on the droplets determined by equation (1), imparted by the electrode (32).



The claims defining the invention are as follows:

Claim 1. A method of producing electrically charged liquid droplets for dust mitigation purposes, in which said liquid is supplied by means of a relatively long and narrow-bore duct of substantially non-conducted material to a point of application of high electrical potential relative to earth, said duct having a ratio of length to cross-sectional area satisfying the equation:

$$\frac{L}{A} = \frac{V_s \times R_i \times S}{(V_g - V_s) \times 10^6}$$

Where L = length of duct (cm)

A = cross-section area (internal bore),
(sq.cm)

S = conductivity of sprayed liquid or
mixture of liquid and fluid
(microsiemens)

V_g = generated voltage

V_s = required nett voltage at spray nozzle,

and R_i = internal resistance of generator (ohms)

Claim 2. A method as claimed in Claim 1, wherein a fluid, immiscible with said liquid, is introduced into said liquid at a point at or near the point of earth potential in said duct such that the turbulent mixture so formed is substantially non-conducting.

Claim 3. A method as claimed in Claim 1 or Claim 2, wherein the applied voltage is amplitude modulated at a rate substantially lower than the rate of generation of liquid droplets, the applied voltage being varied in peak potential, or in polarity to earth, or in any combination thereof.

Claim 4. Apparatus for producing electrically charged liquid droplets for dust suppression, said apparatus including a spray-head insulated from earth, means to provide a high electrical potential to said spray-head, and a length of relatively long and non-conductive ducting connected to said spray-head for supplying said spray-head with liquid to



be charged and sprayed, said ducting having a ratio of length to internal cross-sectional area of bore satisfying the equation

$$\frac{L}{A} = \frac{V_s \times R_i \times S}{(V_g - V_s) \times 10^6}$$

Where L = length of duct (cm)

A = cross-section area (internal bore),
(sq.cm)

S = conductivity of sprayed liquid or
mixture of liquid and fluid
(microsiemens)

V_g = generated voltage

V_s = required nett voltage at spray nozzle

and R_i = internal resistance of generator (ohms)

Claim 5. Apparatus for producing electrically charged liquid droplets for dust suppression in which the said liquid is of relatively high conductivity, said apparatus including a spray-head insulated from earth, means to provide a high electrical potential to said spray-head, a non-conductive duct for supplying said spray-head with said liquid via an air separator chamber containing a cyclone separator element and a float, wherein said liquid supply ducting may be of any suitable length and which conveys said liquid to said air separating chamber where air is removed from said liquid by action of the cyclone separator and passed by non-conductive tubing through a suction relief valve to air compressor for injection into said liquid supply ducting upstream of said air-separating chamber, in order to reduce the conductivity of said liquid to be sprayed.

Claim 6. Apparatus as claimed in Claim 4 or Claim 5, wherein a second duct is introduced into said liquid supply duct to supply a surfactant to said liquid in the proportion 0.005% to 3.0% by volume.

Claim 7. Apparatus for producing electrically charged liquid droplets for dust suppression as claimed in any one of Claims 4, 5 and 6 wherein said spray-head comprises electrically insulated perforated tubing for linear spraying applications.

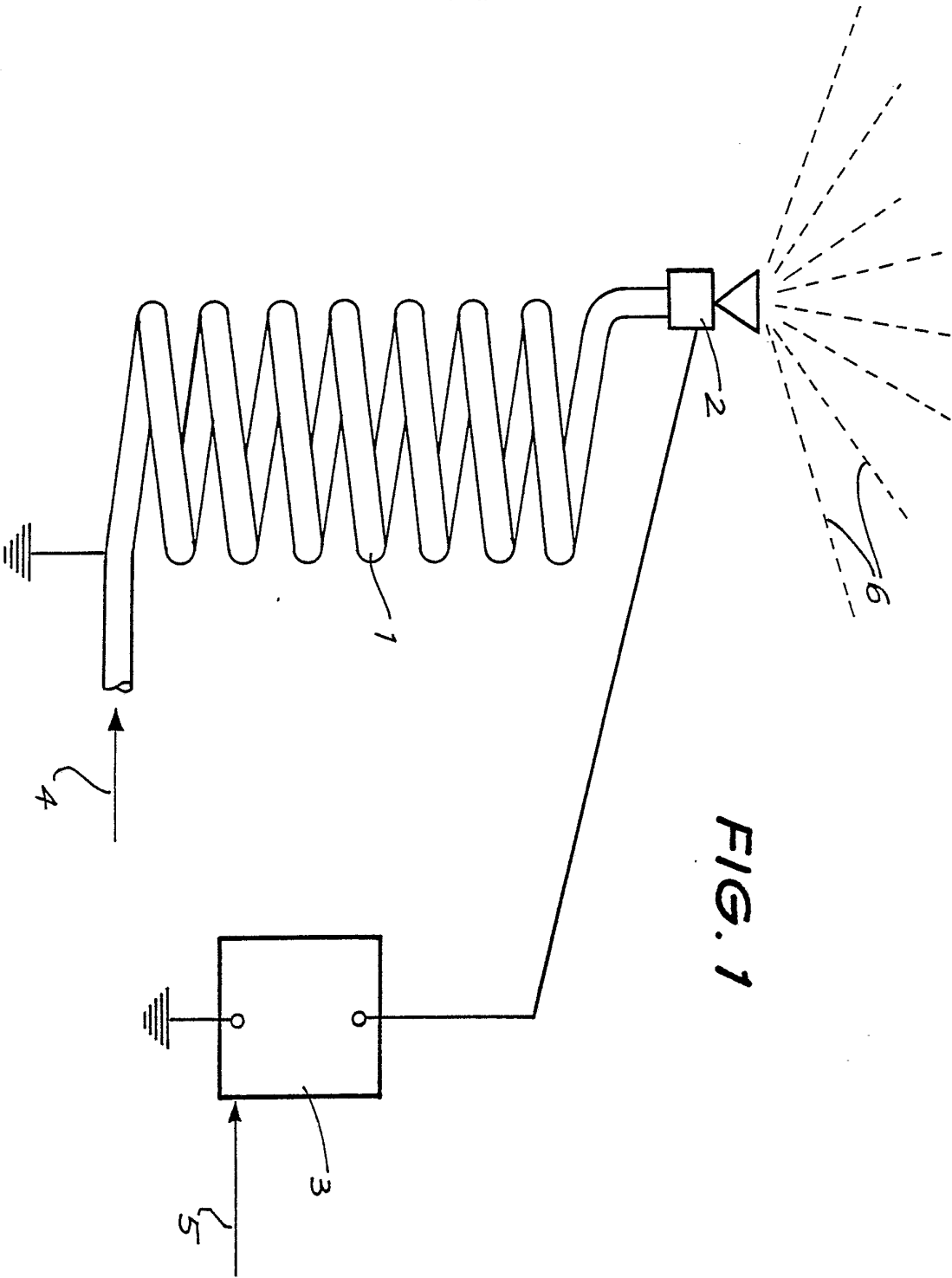


Claim 8. Apparatus for producing electrically charged liquid droplets for dust suppression comprising a spray-head insulated from earth, said spray-head being fed by spray liquid at moderate to high pressure, said liquid being forced through an orifice plate in the supply duct, said duct being provided with air inlet ports immediately adjacent to the spray-head side of the orifice plate, the arrangement causing the spray liquid to become suitably aspirated prior to passing through said spray-head to which a high electrical potential is applied.

Claim 9. Apparatus for producing electrically charged liquid droplets for dust suppression comprising a jet nozzle insulated from earth, said nozzle receiving spray liquid at moderate to high pressures, and a deflector plate insulated from earth spaced apart from said nozzle and arranged to deflect in droplet form aerated liquid emitted by said nozzle, said deflector plate being provided with an electrode to impart a charge onto said droplets.

Claim 10. Apparatus as claimed in any one of Claims 4 to 9 wherein a low-frequency modulation is effected in the applied charge.





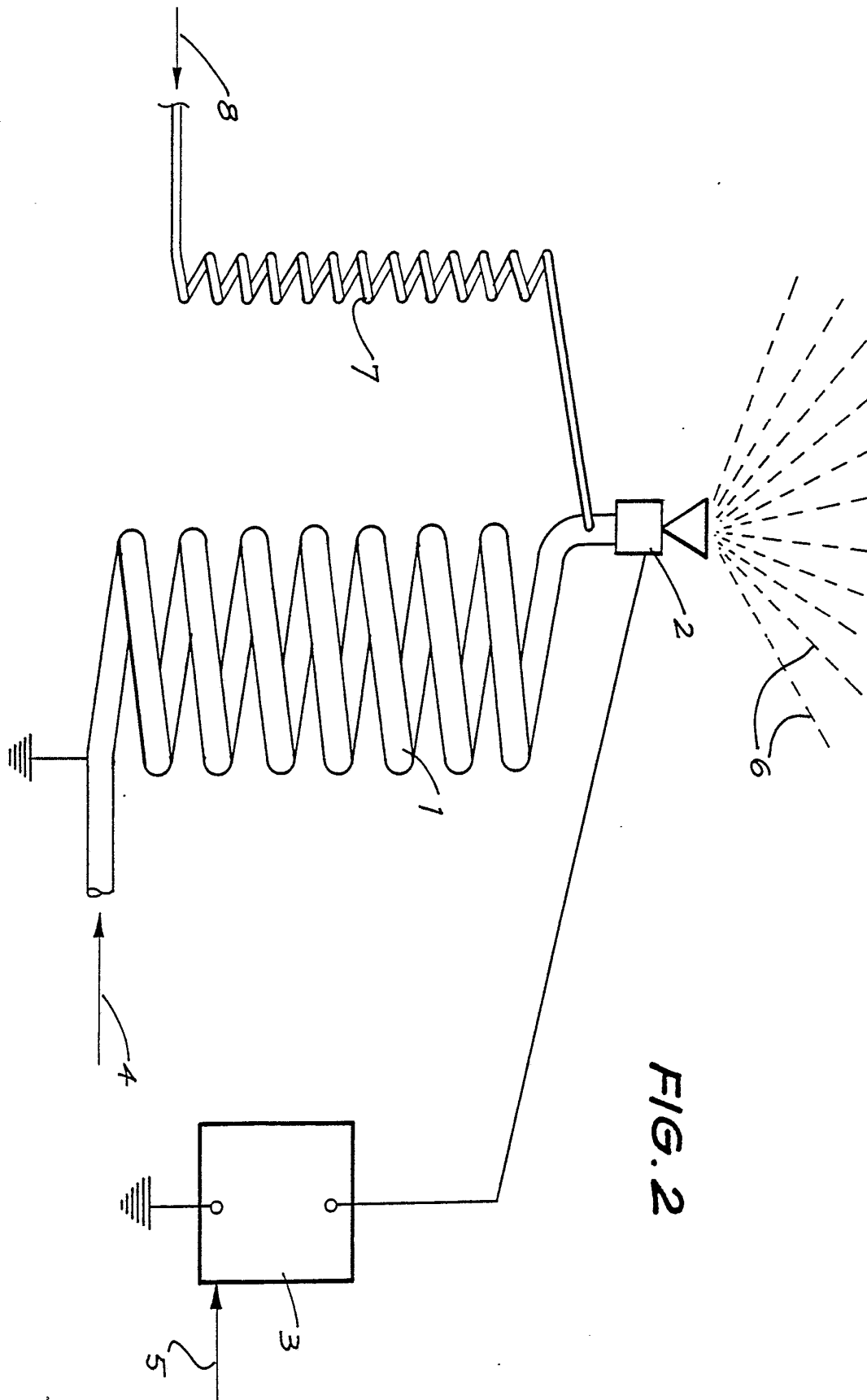
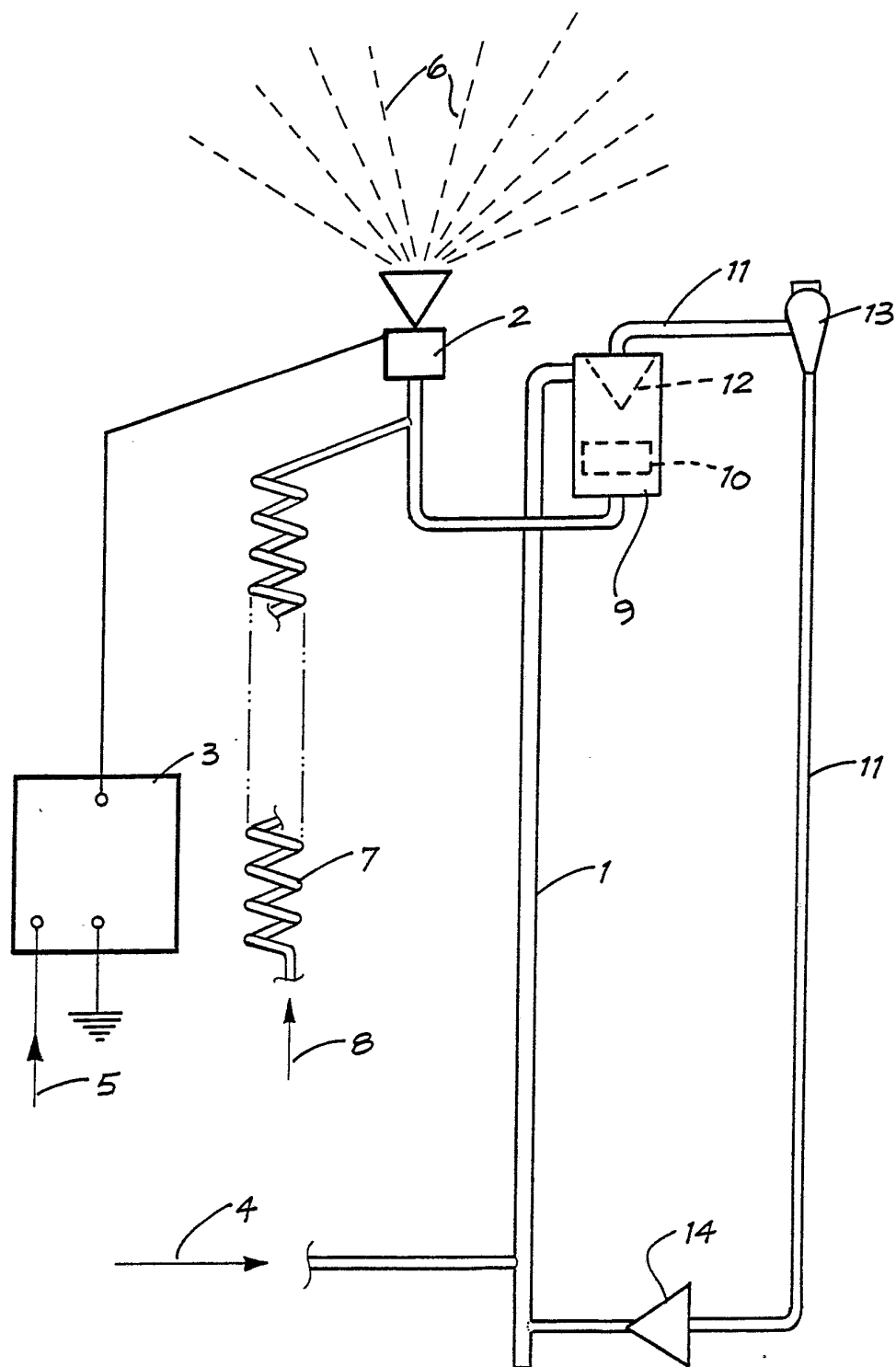
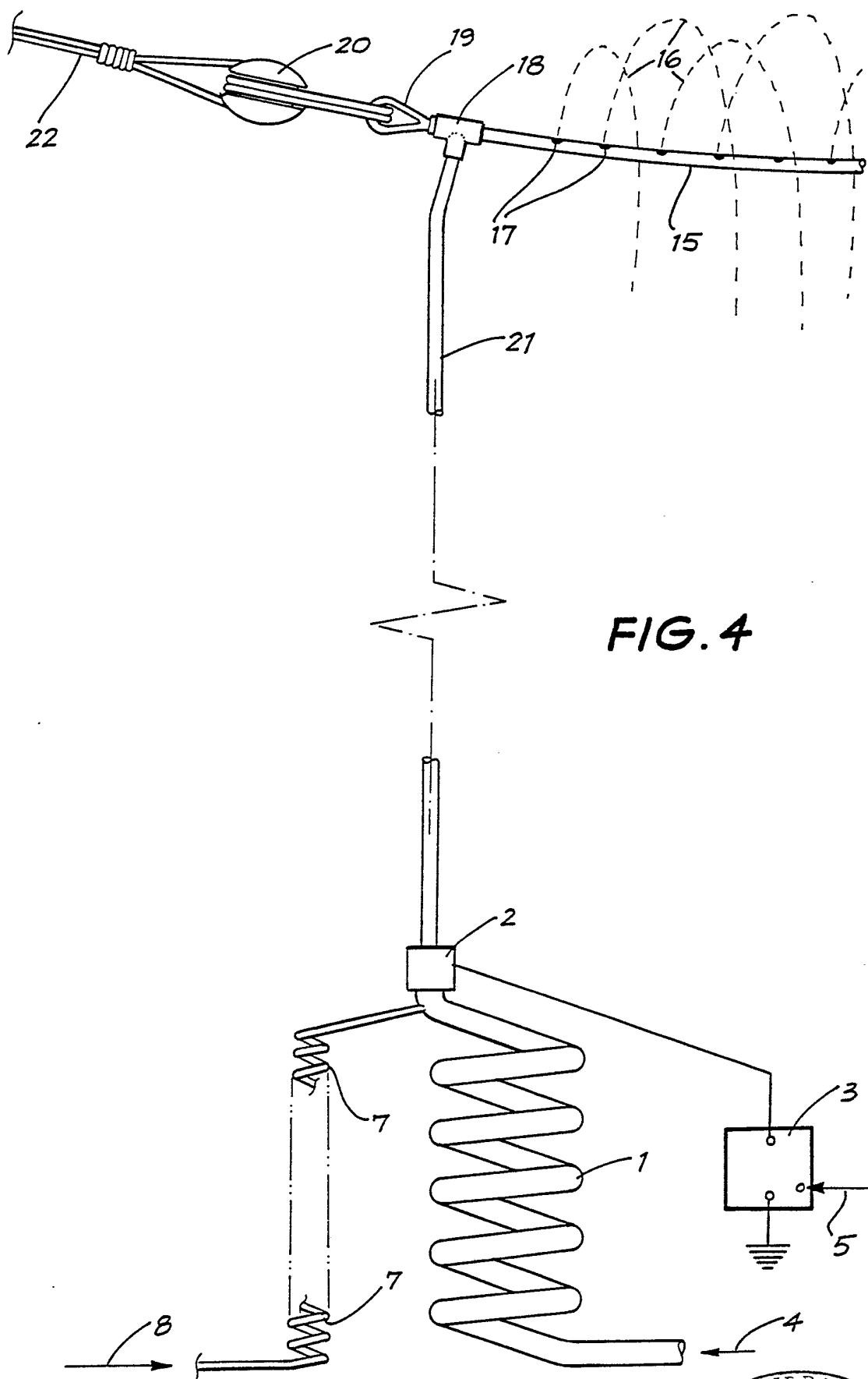
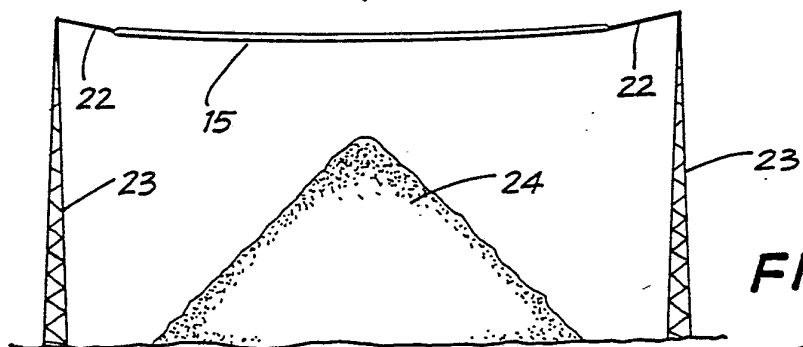
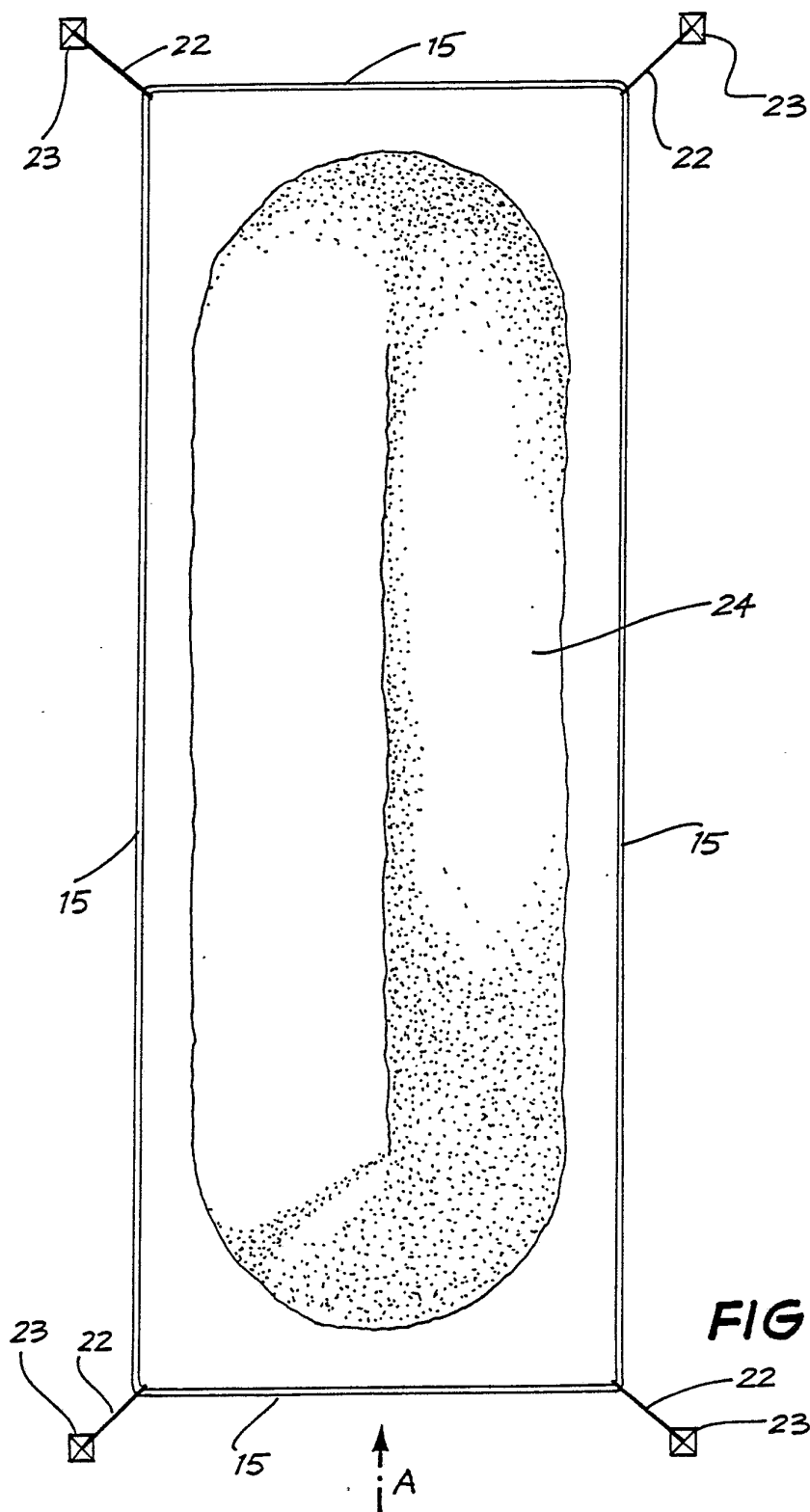
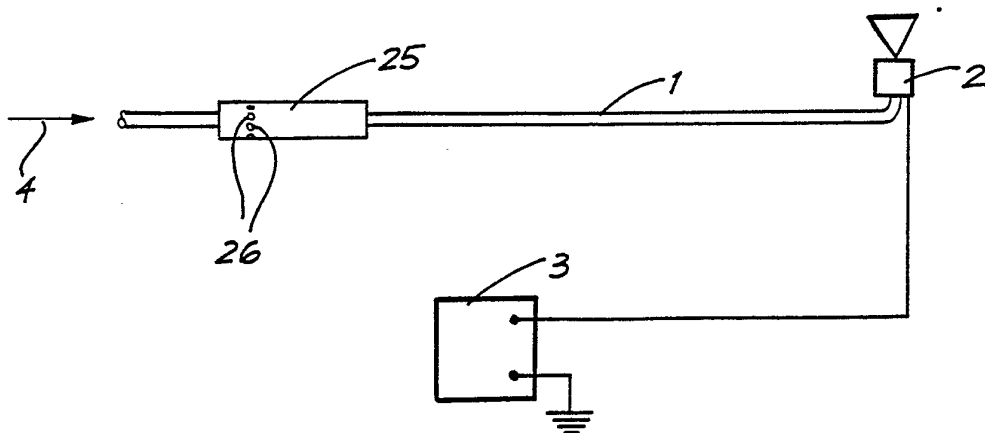
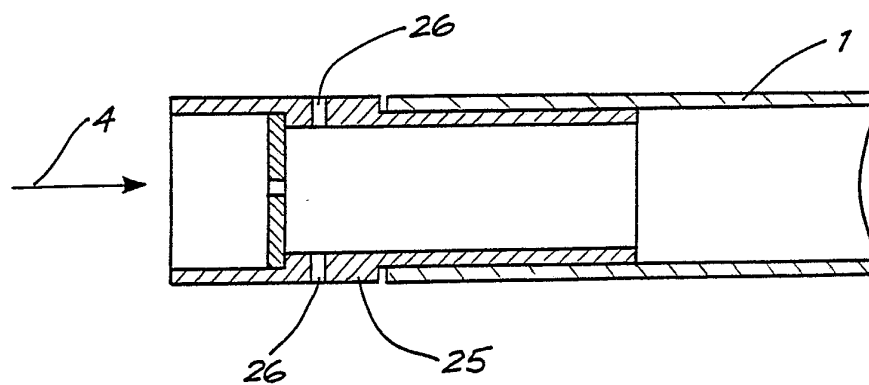


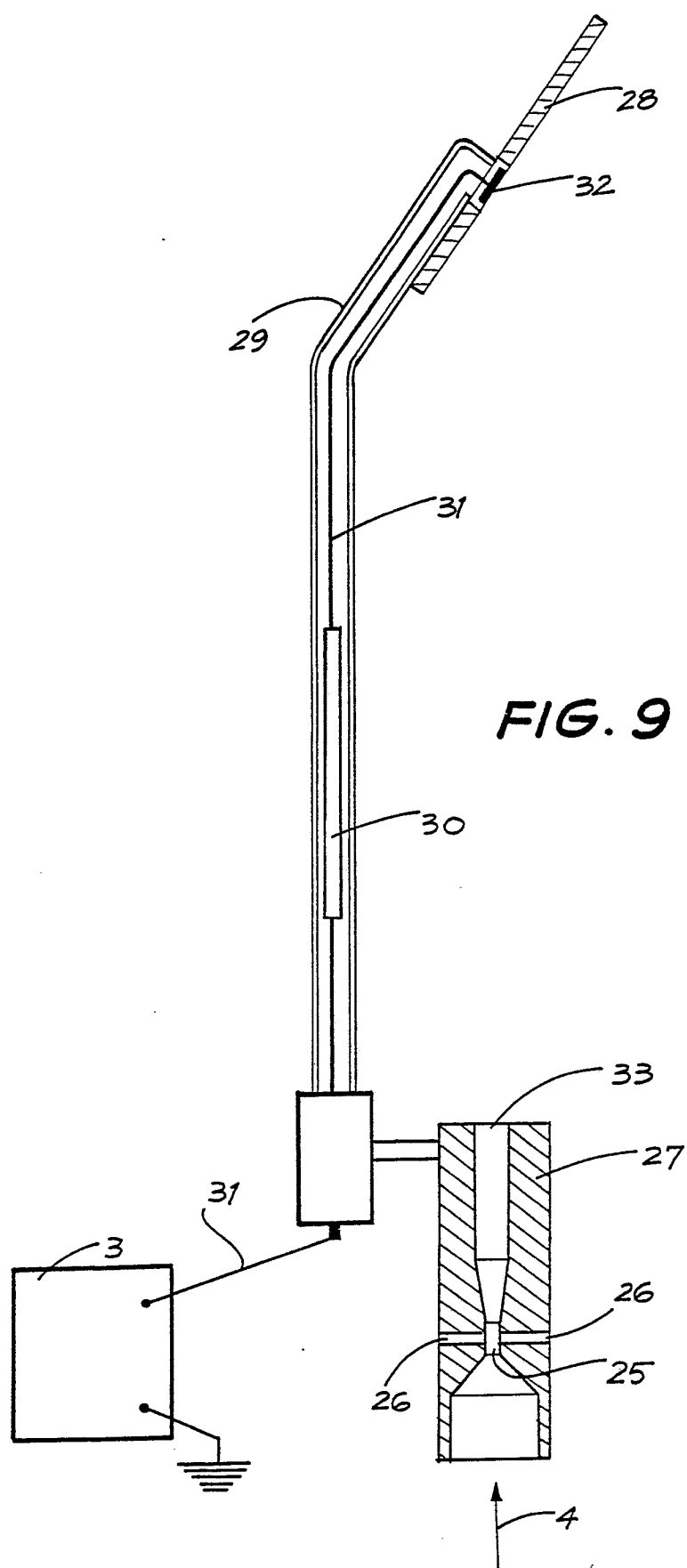
FIG. 2

**FIG.3**





**FIG. 7****FIG. 8**



INTERNATIONAL SEARCH REPORT

International Application No **PCT/AU81/00153**

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³ According to International Patent Classification (IPC) or to both National Classification and IPC Int. Cl. ³ B05B 5/00, 5/02, B05D 1/04, B03C 3/16																										
II. FIELDS SEARCHED Minimum Documentation Searched ⁴ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%;">Classification System</th> <th style="width: 80%;">Classification Symbols</th> </tr> <tr> <td>IPC</td> <td>B05B 5/02</td> </tr> <tr> <td>US Cl.</td> <td>239/706</td> </tr> </table> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵ AU: IPC as above			Classification System	Classification Symbols	IPC	B05B 5/02	US Cl.	239/706																		
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[*] Special categories of cited documents: ¹⁵ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family																										
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> Date of the Actual Completion of the International Search ¹ 16 November 1981 (16.11.81) </td> <td style="width: 50%; padding: 5px;"> Date of Mailing of this International Search Report ² 24 December 1981 (24-12-81) </td> </tr> <tr> <td style="width: 50%; padding: 5px;"> International Searching Authority ¹ Australian Patent Office </td> <td style="width: 50%; padding: 5px;"> Signature of Authorized Officer ²⁰ A. S. MOORE <i>AS Moore</i> </td> </tr> </table>			Date of the Actual Completion of the International Search ¹ 16 November 1981 (16.11.81)	Date of Mailing of this International Search Report ² 24 December 1981 (24-12-81)	International Searching Authority ¹ Australian Patent Office	Signature of Authorized Officer ²⁰ A. S. MOORE <i>AS Moore</i>																				
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
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A,Y	US,A, 3735925 (BENEDEK et al) 29 May 1973 (29.05.73)	1-10
A,Y	US,A, 3896994 (WALBERG) 29 July 1975 (29.07.75)	1-10
A,Y	US,A, 3747850 (HASTINGS et al) 24 July 1973 (24.07.73)	1-10