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(12) (19) (CA) **Brevet-Patent**

(11) (21) (C) **2,018,551**
(22) 1990/06/08
(43) 1990/12/23
(45) 2000/03/28

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(51) Int.Cl.^{5} B05B 17/06
(30) 1989/06/23 (8914506.4) GB

(54) **PROCEDE ET APPAREIL DE PULVERISATION ELECTROSTATIQUE**

(54) **ELECTROSTATIC SPRAY PROCESS AND APPARATUS**

(57) An electrostatic liquid spraying apparatus has a sprayhead comprising a pair of atomising edges extending side-by-side, liquid feed means to each of the atomising edges and a plurality of field intensifying electrodes extending lengthwise of the atomising edges. A pair of the field intensifying electrodes are associated with each atomising edge with one disposed on either side thereof and forwardly of the associated atomising edge. Electric power supply means impose a potential difference between said atomising edges and said electrodes. In order to achieve satisfactory spraying: a) the spacing between the atomising edges is in the range, 20-300 mm. b) the spacing between each of the electrodes and its associated atomising edge is not less than 3 mm. and c) The measurable potential difference between the conductors through which the potential difference is imposed between the atomising edges and the electrodes is in the range 1-3 KV per mm. of the spacing of said electrodes from the atomising edges.

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ABSTRACT OF THE DISCLOSURE

ELECTROSTATIC SPRAY PROCESS AND APPARATUS

An electrostatic liquid spraying apparatus has a sprayhead comprising a pair of atomising edges extending side-by-side, liquid feed means to each of the atomising edges and a plurality of field intensifying electrodes extending lengthwise of the atomising edges. A pair of the field intensifying electrodes are associated with each atomising edge with one disposed on either side thereof and forwardly of the associated atomising edge. Electric power supply means impose a potential difference between said atomising edges and said electrodes. In order to achieve satisfactory spraying:

a) the spacing between the atomising edges is in the range, 20-300 mm.

b) the spacing between each of the electrodes and its associated atomising edge is not less than 3 mm. and

c) The measurable potential difference between the conductors through which the potential difference is imposed between the atomising edges and the electrodes is in the range 1-3 KV per mm. of the spacing of said electrodes from the atomising edges.

(Illustrate Figure 5)

Electrostatic Spraying Process and Apparatus

This invention relates to a process and apparatus for the electrostatic spraying of liquids. More particularly the invention is concerned with a process and apparatus utilising a sprayhead in which liquid is fed along a surface to an edge of the surface, hereafter termed "an atomising edge" and a high voltage is imposed between the atomising edge and a field intensifying electrode, sometimes referred to as a field adjusting electrode spaced from said atomising edge, whereby an atomising field strength is created so that the liquid is atomised at least preponderantly by electrostatic forces to form electrically charged particles which are projected away from said atomising edge. Such a process and apparatus are disclosed in Canadian Patent No. 1,071,937 issued on February 19, 1980.

Large scale spraying, for example paint spraying in the car industry, has typically involved the use of conventional electrostatic spray systems. Such systems fall into two general classes, the first is where liquid to be sprayed is first atomised and the spray so formed is then charged; the second involves a spinning element for example a disc or bell that is maintained at a high voltage and atomises the liquid mainly by g-forces. Currently only such systems deliver the necessary volumes of liquid with spray characteristics (for example particle size) appropriate for film formation. The difficulty with such conventional systems is firstly they produce polydisperse spray particles containing a large population of fines of less than 10 μm. Secondly, charging of the spray is less than 100% effective.

This results in atmospheric pollution because fine particles of respirable size escape into the air. A further cause of pollution from such known systems is that their transfer efficiency tends to be low for example of the order of 60%.

These disadvantages were substantially overcome by the spray apparatus described in EP 186983 granted March 22, 1989 particular reference being made to Figures 4 to 7 and the associated description. Such apparatus produces a near monodisperse spray (as expressed by the ratio of the volume median diameter to the number median diameter for the droplets) and the particle size can be controlled such that risk of respiration is reduced. In addition complete charging of the spray and relatively improved transfer efficiency further reduce the risk of inhalation and atmospheric pollution. The problem presented by the apparatus described here is that it can only operate at relatively low flow rates that are too low for large scale spraying such as paint spraying.

Various solutions have been proposed for increasing flow rate whilst maintaining a desired small particle size. The solution proposed in EP 193348 granted April 4, 1990 is to cause a stream of gas to flow through the region of the electrical field, the direction and velocity of the stream of gas being such as to remove charged droplets of liquid from the said region, thereby to reduce any build-up in space charge which affects the magnitude of the electric field.

Another solution is proposed in EP 186983 granted March 22, 1989. This is to form the field intensifying electrode as a core of conducting or semiconducting material sheathed in a material of dielectric strength sufficiently high to prevent sparking between the electrode and the sprayhead and volume resistivity sufficiently low to allow charge collected on the surface of the sheathing material to be conducted through that material to the conducting or semi-conducting core. It has been found that the use of such an electrode, inter alia enables a higher potential difference to be applied between the sprayhead and field intensifying electrode without disruptive sparking. Hence the flow rate can be increased when such an electrode is used whilst maintaining the desired particle size, since the higher the potential difference, the greater the permitted flow rate for a given particle size.

An aspect of this invention is to further increase the flow rate whilst maintaining a desired particle size.

The invention is based upon the very surprising discovery that two atomising edges and their associated field intensifying electrodes can be brought close to each other without substantial uncontrollable electrostatic interference between them.

The normal expectation by a person skilled in the art would have been that as the atomising edges were moved closer so that they effectively formed one spray head this would lead to a major loss of atomising power because of the interaction of the electric fields produced by the electric potentials of the same polarity at the two atomising edges and the result would have been little different from using just one atomising edge.

According to the invention, an electrostatic liquid spraying apparatus has a sprayhead comprising a pair of atomising edges extending side by side, liquid feed means to each of said atomising edges, a plurality of field intensifying electrodes extending lengthwise of the atomising edges, a pair of said electrodes being associated with each atomising edge with one disposed on either side thereof and forwardly of the associated atomising edge, and electric power supply means for imposing a potential difference between said atomising edges and said electrodes; and

a) the spacing between said atomising edges is in the range 20-300mm.,

b) the spacing between each of said electrodes and its associated atomising edge is not less than 3mm., preferably 1cm., and

c) the measurable potential difference between the conductors through which the potential difference is imposed between said atomising edges and the electrodes is in the range 1-3 KV per mm. of the spacing of said electrodes from the atomising edges.

Thus the sprayhead has two atomising edges which can be disposed so close together that they can spray substantially the same area of a target which is moving relatively to the sprayhead within a period of time which is so short that in terms of paint spraying it is equivalent to one spray. However for a given particle size the atomising edges are delivering almost twice the number of particles per unit area per unit time as would a single atomising edge.

The operating parameters of the apparatus may, be so selected that for a liquid with a viscosity of 8cP and a resistivity of 2 x 10^8 ohm cm a spray can be achieved with a median particle size diameter not exceeding 100μm. at flow rates up to 20 cc/sec/metre length of sprayhead.

If the spacing of the atomising edges is more than about 300 mm. the spray coating is not laid down properly and results in a mottling or striping effect. The practical space requirements do not allow a spacing between the atomising edges of less than 20 mm.

It has been found that the longer the atomising edges the further apart they can be spaced. For example for atomising edges whose length is of the order of 150 mm. the spacing between the atomising edges is preferably in the range of 20 to 100 mm., whereas for atomising edges whose length is of the order of 600 mm. the spacing between the atomising edges is preferably in the range 100 to 300 mm.

If the spacing between each of said electrodes and its associated atomising edge is less than about 3 mm. liquid is deposited on the electrodes and can form a liquid bridge seriously affecting the atomisation. If the spacing is much greater than about 1 cm. then potential gradient is lost and there can be contamination problems which can only be overcome by working at much higher voltages. Ideally, the potential gradient between each said electrode and its associated atomising edge should be as great as possible without reaching break down or contamination.

Advantageously the present invention utilises the sheathed electrode construction disclosed in EP 186983 granted March 22, 1989 so that the higher levels of potential gradient within the above specificed range of 1-3 KV per mm. without breakdown can advantageously be achieved.

For the larger spacings between the atomising edges it is necessary to use four field intensifying electrodes. However at small spacings three field intensifying electrodes can be used, the central one being common to both atomising edges. In order to vary the spray footprint or pattern, the potential on the two adjacent electrodes, where four are used, or the middle one where three are used may be varied in value with respect to the potential on the two outer electrodes.

Advantageously the potential with respect to earth at the atomising edges is as high as is practical. The higher the potential the more compressed is the footprint between the two atomising edges and hence the higher the density of the spray over this area. This compression effect also increases with increase in the lengths of the atomising edges. It has been found that this increase in spray density is very beneficial in achieving a good spray coating.

To permit flexibility in use of the apparatus the power supply means preferably is capable of adjustment to supply adjustable potentials to the atomising edges and the field intensifying electrodes. Preferably it is also capable of supplying different potentials to different ones of the field intensifying electrodes.

The invention will now be further explained by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 shows a cross-section of one form of sprayhead in accordance with the invention,

Figures 2 to 4 show various spray patterns which can be achieved using various potentials on the sprayheads and field intensifying electrodes.

Figure 5 shows diagrammatically a modified sprayhead to that shown in Figure 1 and the spray pattern achieved with it, and

Figures 6a and 6b illustrate the effect of using different length atomising heads, Figure 6a showing the spray pattern for the relatively short atomising head of Figure 2 and Figure 6b showing the spray pattern for the longer atomising heads of Figure 5.

The sprayhead shown in Figure 1 comprises two linear and substantially parallel nozzle assemblies 10 and 11 the edges 12 and 13 of which form respective atomising edges. Each nozzle assembly 10,11 is formed of two plate members 14 and 15 arranged face to face. The facing surfaces are so configured that they butt over their portions 16 but are spaced apart over the remainder to form a liquid flow slot 17 extending over the whole length of the plates 14 and 15 and leading from a gallery 18 to the atomising edge 12,13. One of the facing surfaces extends beyond the other to form a projecting lip 20 leading from the outlet of the slot 17 to the atomising edge 12,13. The edges of the plates 14 and 15 are bevelled as shown. The edges 12 and 13 may be toothed or straight. The gallery 18 comprises a longitudinally extending channel formed in the surface of the plate member 15. Each gallery 18 is connected with a liquid supply source (not shown) through tubes 19. As an alternative the edges of the plates 14 and 15 could be aligned as shown in Figures 2 to 4.

The plates 14 and 15 are of insulating material and to enable an electrical potential to be applied to the liquid feed an electrode 22 is provided in each of the nozzles 10 and 11. Each electrode 22 is positioned adjacent the atomising edge 12, 13 and is located in the facing surface of the plate 15. Each of the electrodes 22 is connected to a high voltage generator through insulated leads 23. The actual potential on the atomising edge 12,13 will depend upon the potential drop between the electrode 22 and the atomising edge 12,13 through the liquid being sprayed. The resistivity of liquid paint is of the order of 10^7 ohm cm. and at an applied potential of between 40-80KV a potential drop of about 10% can be tolerated. The essential requirement is that the electric field at the atomising edge is sufficient to produce the required ligamentary spray. As an alternative to the electrodes 22 one or both of the plates 14 and 15 of each nozzle may be made of electrically conducting or semi-conducting material and connected to the high voltage generator.

The nozzles 10 and 11 are supported in a suitable frame 25 which also supports three linear electrodes 26,27 and 28, termed herein field intensifying electrodes, but also sometimes referred to as field adjusting electrodes.

These electrodes extend substantially parallel to each other and to the atomising edges 12 and 13 with the electrodes 26 and 27 on the outer sides of the atomising edges 12 and 13 and the electrode 28 extending midway between the atomising edges 12 and 13. The electrodes 26 to 28 are disposed forwardly in the spraying direction of the atomising edges 12 and 13. Thus a pair of electrodes 26 and 28 are associated with atomising edge 12 and a pair of electrodes 27 and 28 are associated with atomising edge 13.

Each of the electrodes 26 to 28 comprises a core 30 of electrically conducting material such as carbon and a sheath 31 of semi-insulating material such as soda-glass. The resistivity of the sheath is of the order of 10^{11} ohms cm. These electrodes are of the form described in detail in EP 186983. The cores 30 of the electrodes may be held at earth potential. Alternatively a voltage with respect to earth may be imposed on them, which voltage creates the desired potential difference between the atomising edges 12 and 13 and the electrodes 26 to 28.

In Figure 1 the atomising edges are shown spaced apart a distance _a_. The nearest point on the nozzles 10 and 11 to the surfaces of the associated electrodes 26 to 28 are the atomising edges 12 and 13. The distance between the atomising edges and the surfaces of electrodes 26 to 28 is labelled _b_ in Figure 1.

In one experimental example of paint spraying utilising the apparatus of Figure 1 the value of _a_ was 36 mm. The spacing _b_ was about 1 cm. It is to be noted that the drawings are not to scale. The atomising edges 12 and

13 can be of any desired length and in this example were 150 mm. The effect of varying the length will be demonstrated hereafter. The width of each slot 17 was such as to allow the desired flow rate from each nozzle with a normal reservoir pressure head taking into account the viscosity of the liquid to be sprayed. In this example it was set to deliver at least 10 cc per second per metre length of sprayhead per nozzle of a liquid having a viscosity of 8 cP so that the total liquid delivered per second per metre length of the sprayhead was at least 20 cc. The flow rate was advantageously adjustable to different values.

In use of the apparatus a high voltage with respect to earth as specified hereafter was imposed on each of the nozzle electrodes 22 and a lower voltage with respect to earth as also specified was imposed on each of the cores of electrodes 26 to 28 so that a potential difference existed between the nozzle electrodes 22 and the electrodes 26 to 28. The flow rate of liquid paint supplied from a reservoir was also adjusted to a desired value. The liquid reaching the atomising edges was subjected to a high intensity electric field created by the imposed potential difference and this caused the liquid to form a series of ligaments extending from each of the edges 12 and 13 and which at a distance from the edges 12 and 14 broke up into atomised particles as is fully described in our aforementioned Canadian Patent No.

1,071,937 granted February 19, 1980 and EP Patent 186983 granted March 22, 1989

Referring to Figures 2 to 4 these show various spray patterns which were achieved within this example by imposing various voltages on the electrode 26 to 28.

In all of Figures 2 to 4 the voltage on the nozzle electrodes 22 was 40 KV. In Figure 2 the voltage on all the field intensifying electrodes 26 to 28 was 15 KV. This produced a spray pattern which had a slight overlap between the two sprays as shown.

In Figure 3 the voltage on the outer electrodes 26 and 27 was again 15 KV but that on the central electrode 28 was 11 KV. This produced a large overlap between the two sprays as shown.

In Figure 4 the voltage on the outer electrodes 26 and 27 was again 15 KV and that on the inner electrode 28 was 19 KV. This caused a spacing of the two sprays as shown. It can thus be seen that there is no significant interference between the sprays and that in fact the spray pattern is controllable simply by varying the voltages. It could similarly be varied by varying the distances b so that it was different for the central electrode 28.

In another example shown diagrammatically in Figure 5, the spacing a between the two atomising edges 12 and 13 was 20 cms. This was so large that it was necessary to use two central electrodes which have been referenced for consistency with the other Figures as 28a and 28b. The distance b was 180 mm. The length of each atomising edge was 60 cm.

The voltage on the electrode 22 was 80 KV and the voltage on the field intensifying electrodes 26 to 28 was 40 KV. The target surface which was at earth potential was at a distance of 30 cms. from the atomising edges 12 and 13 and moved at a speed equivalent to 1 meter in 19 secs. The liquid paint which was a red grey surfacer used in the automotive industry had a resistivity of 4 x 10^7 ohms/cm. and a viscosity of about 3 poise. Its flow rate was about 100 cc. per min. through each nozzle.

It was found that the resulting coating had a good flat appearance with high gloss, low mottle and no striping. The coat thickness was about 34-60μm.

Referring now to Figures 6a and 6b, these show a comparison of the spray patterns achieved using the apparatus of Figure 2 and Figure 5. The lengths of the atomising heads and spacings a referred to in Figures 2 and 5 are shown proportionally in Figures 6a and 6b. Also the spray patterns are shown in contour form so that the closer the contours to each other, the denser the spray pattern. It can be seen that with the longer atomising edges 12 and 13 of Figure 5 the end effect i.e. the end spread is not so pronounced and there is more compression of the spray pattern between the atomising edges. This produces a denser spray which is very advantageous for paint spraying. A similar compression effect can be achieved by increasing the voltage with respect to earth on the electrodes 22.

The twin nozzle arrangement of the present invention cannot only be arranged to produce a relatively high delivery rate for a given median particle size as described, but can also be used in two component systems which require substantially simultaneous application of the components on to a target, one component being supplied through one nozzle and the other component through the other nozzle.

WE CLAIM:

1. An electrostatic liquid spraying apparatus having a sprayhead comprising a pair of atomising edges extending side-by-side, liquid feed means to each of said atomising edges, a plurality of field intensifying electrodes extending lengthwise of the atomising edges, a pair of said electrodes being associated with each atomising edge with one disposed on either side thereof and forwardly of the associated atomising edge, and electric power supply means for imposing a potential difference between said atomising edges and said electrodes; and

a) the spacing between said atomising edges being in the range, 20-300 mm.

b) the spacing between each of said electrodes and its associated atomising edge being not less than 3mm. and

c) the measurable potential difference between the conductors through which the potential difference is imposed between said atomising edges and the electrodes being in the range 1-3 KV per mm. of said spacing of said electrodes from the atomising edges.

2. An electrostatic spraying apparatus according to claim 1, wherein three field intensifying electrodes are provided, one of which is associated with both said atomising edges.

3. An electrostatic liquid spraying apparatus according to claim 2, wherein the length of said atomising edges is of the order of 150 mm. and the spacing between said atomising edges is in the range 20 to 100 mm.

4. An electrostatic spraying apparatus according to

claim 1, wherein the length of said atomising edges is of the order of 600 mm. and the spacing between the atomising edges is 100 to 300 mm.

5. An electrostatic spraying apparatus according to claim 1, wherein each of said field intensifying electrodes comprises a core of electrically conducting material and a sheath of semi insulating material.

6. An electrostatic spraying apparatus according to claim 1, wherein the electric power supply means is connected to impose a first potential with respect to earth on the atomising edges and a second lower potential with respect to earth on the field intensifying electrodes.

7. An electrostatic spraying apparatus according to claim 6, wherein the electric power supply means is capable of applying adjustable potentials to the atomising edges and to the field intensifying electrodes.

8. An electrostatic spraying apparatus according to claim 7 wherein the electric power supply means is capable of applying different potentials to different ones of the field intensifying electrodes.

9. An electrostatic spraying apparatus according to claim 1 and whose operating parameters are so selected that for a liquid with a viscosity of 8cP and a resistivity of 2 $x10^8$ ohms cm. a spray can be achieved with a median particle size diameter not exceeding 100μm. at flow rates of up to 20 cc/sec/metre length of sprayhead.

10. A method of electrostatic spraying comprising disposing a pair of atomising edges side-by-side, connecting a liquid feed means to each of said atomising edges,

arranging a plurality of field intensifying electrodes lengthwise of the atomising edges, a pair of said electrodes being associated with each atomising edge with one disposed on either side thereof and forwardly of the associated atomising edge connecting electric power supply means so that a potential difference is imposed between said atomising edges and said electrodes;

a) the spacing between said atomising edges being in the range, 20-300 mm.

b) the spacing between each of said electrodes and its associated atomising edge being not less than 3mm., and

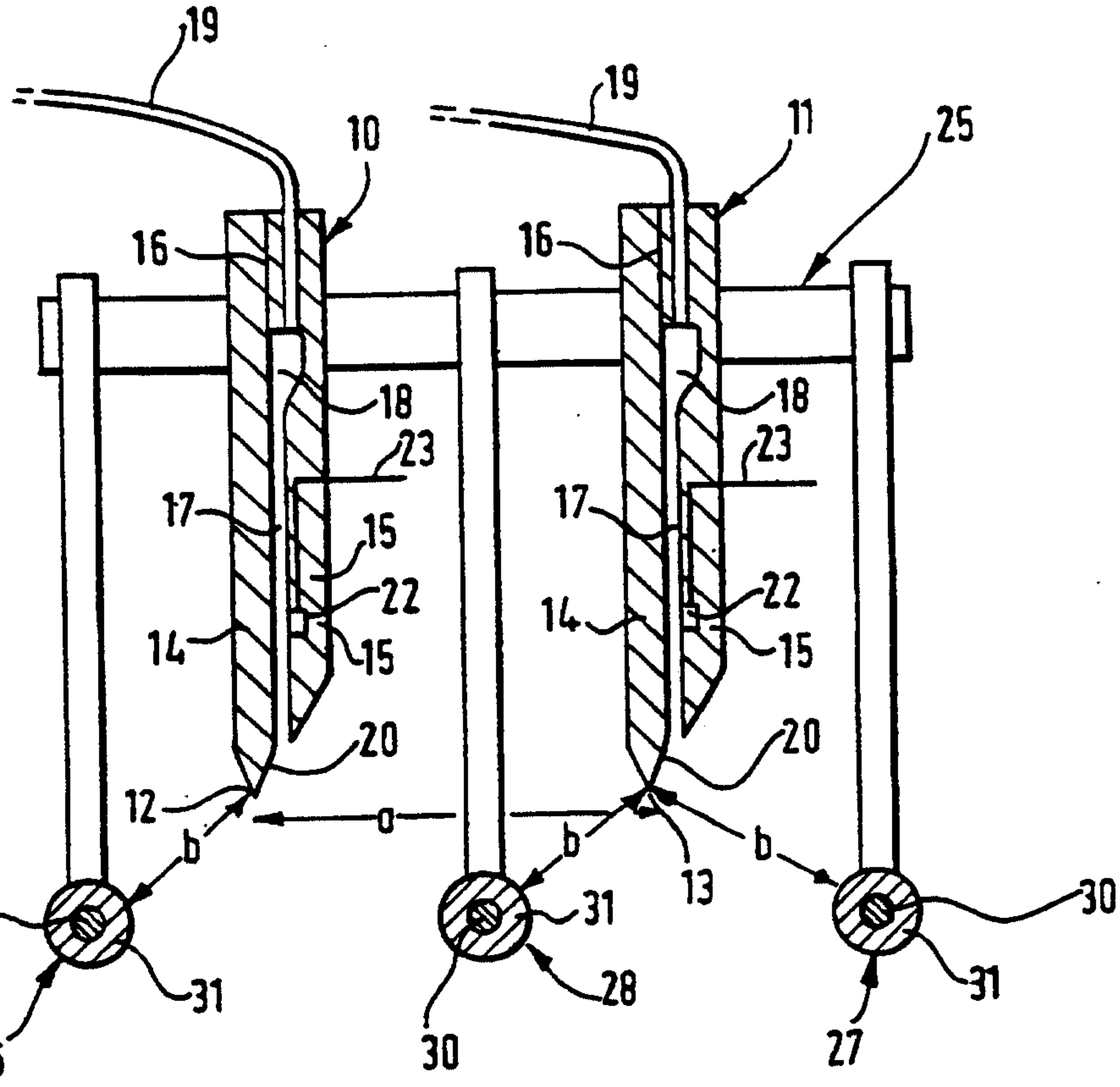
c) the measurable potential difference between the conductors through which the potential difference is imposed between said atomising edges and the electrodes being in the range 1-3 KV per mm. of said spacing of said electrodes from the atomising edges,

disposing a target at a distance forwardly of said electrodes, and supplying the liquid to be sprayed to said atomising edges whereby said target becomes electrostatically sprayed.

11. A method of electrostatic spraying according to claim 10, wherein the voltage applied to the atomising edges is of the order of 80 KV and the voltage applied to the field intensifying electrodes is of the order of 40 KV and the target is at earth potential.

12. A method of electrostatic spraying according to claim 10, wherein the potential applied to the field intensifying electrode or electrodes disposed between the two atomising edges is different from that applied to the

field intensifying electrodes on the outer sides of the two atomising edges.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20
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b
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28
27

Fig.1.

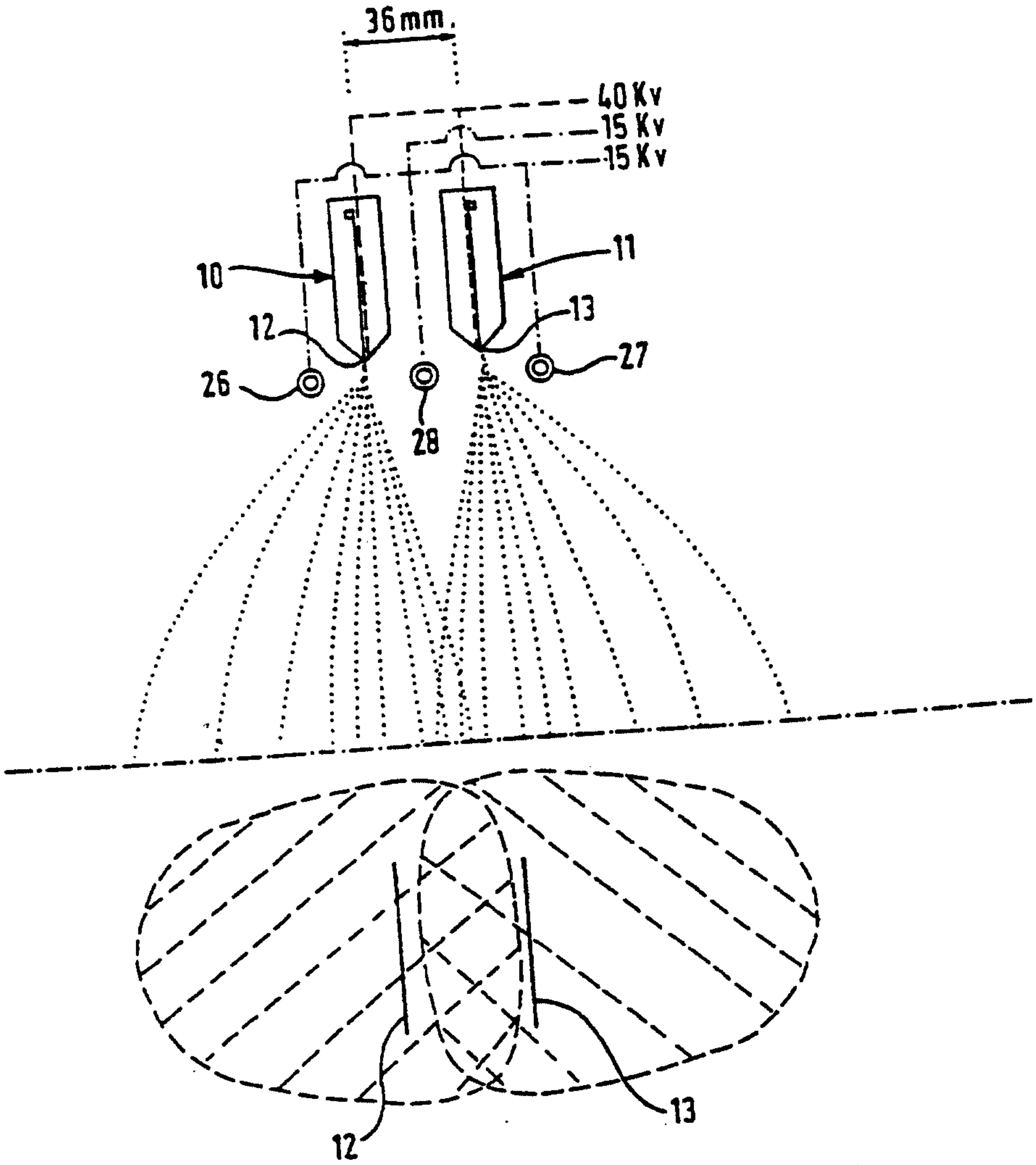


Fig.2.

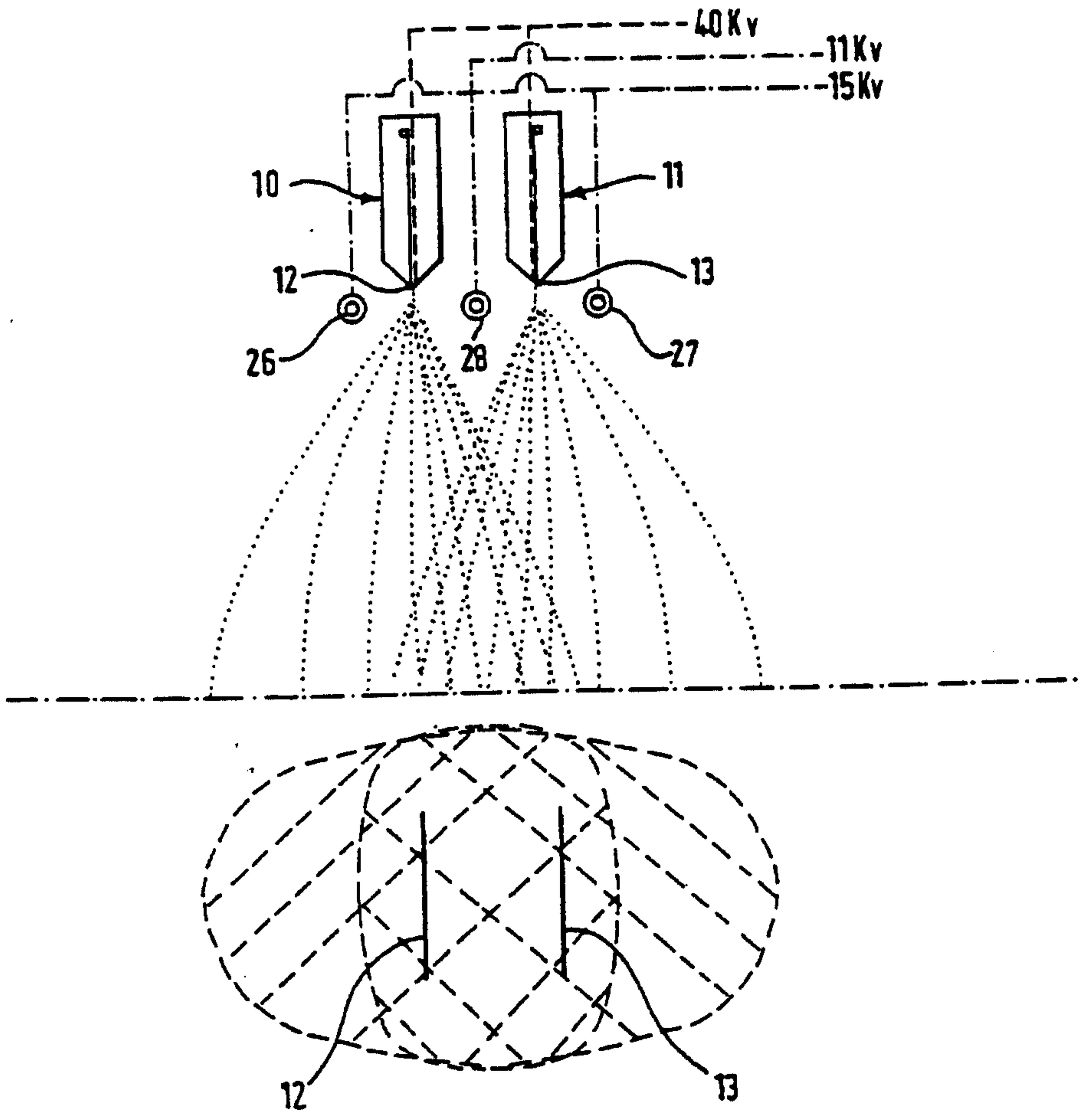


Fig.3.

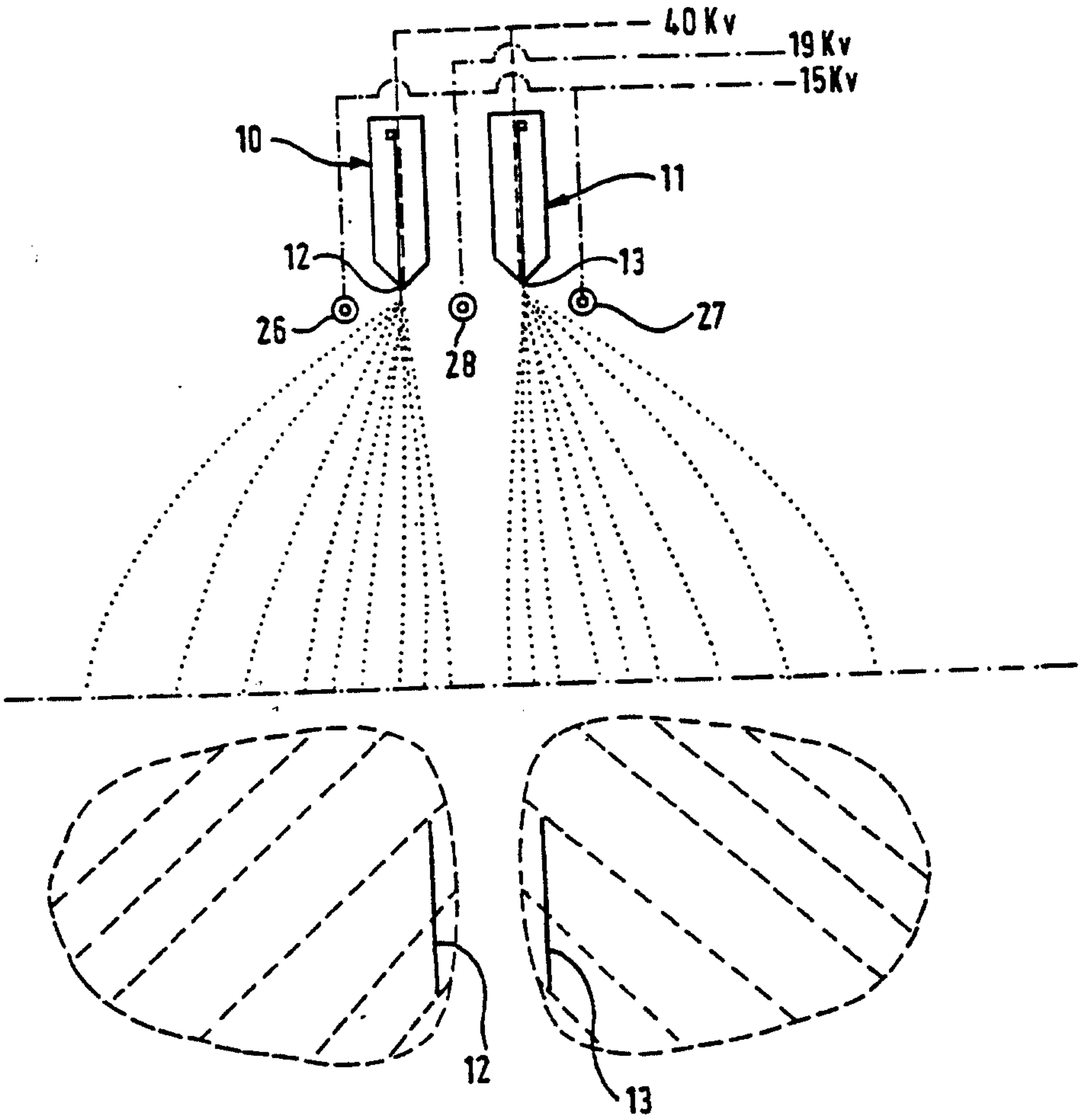
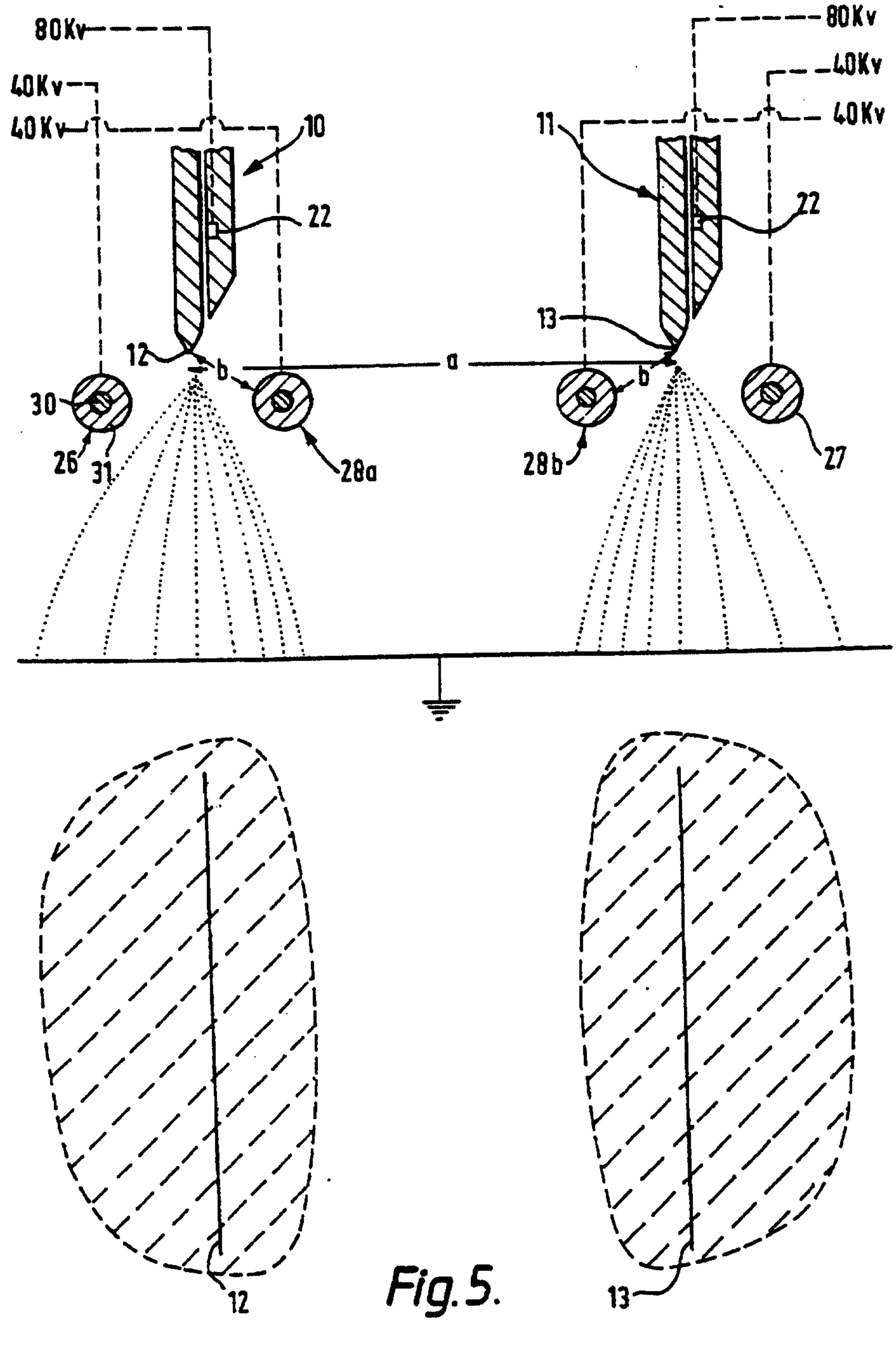


Fig.4.


80Kv
40Kv
40Kv
10
22
12
b
a
30
26
31
28a
80Kv
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40Kv
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13
b
28b
27
12
13

Fig.5.

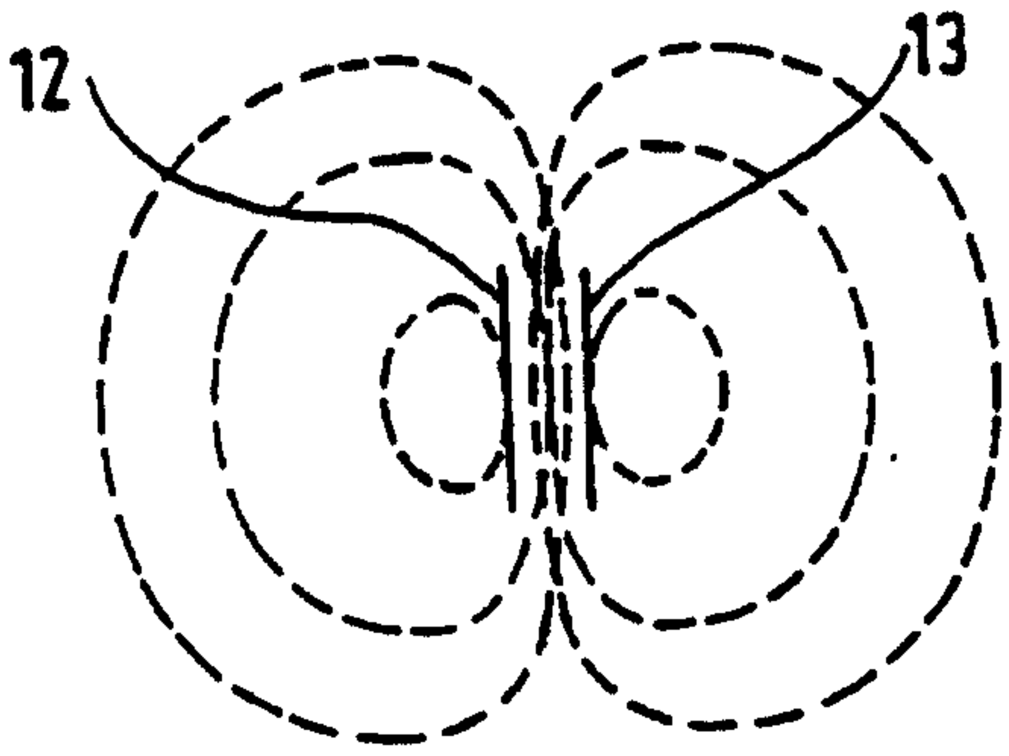

Fig.6a.

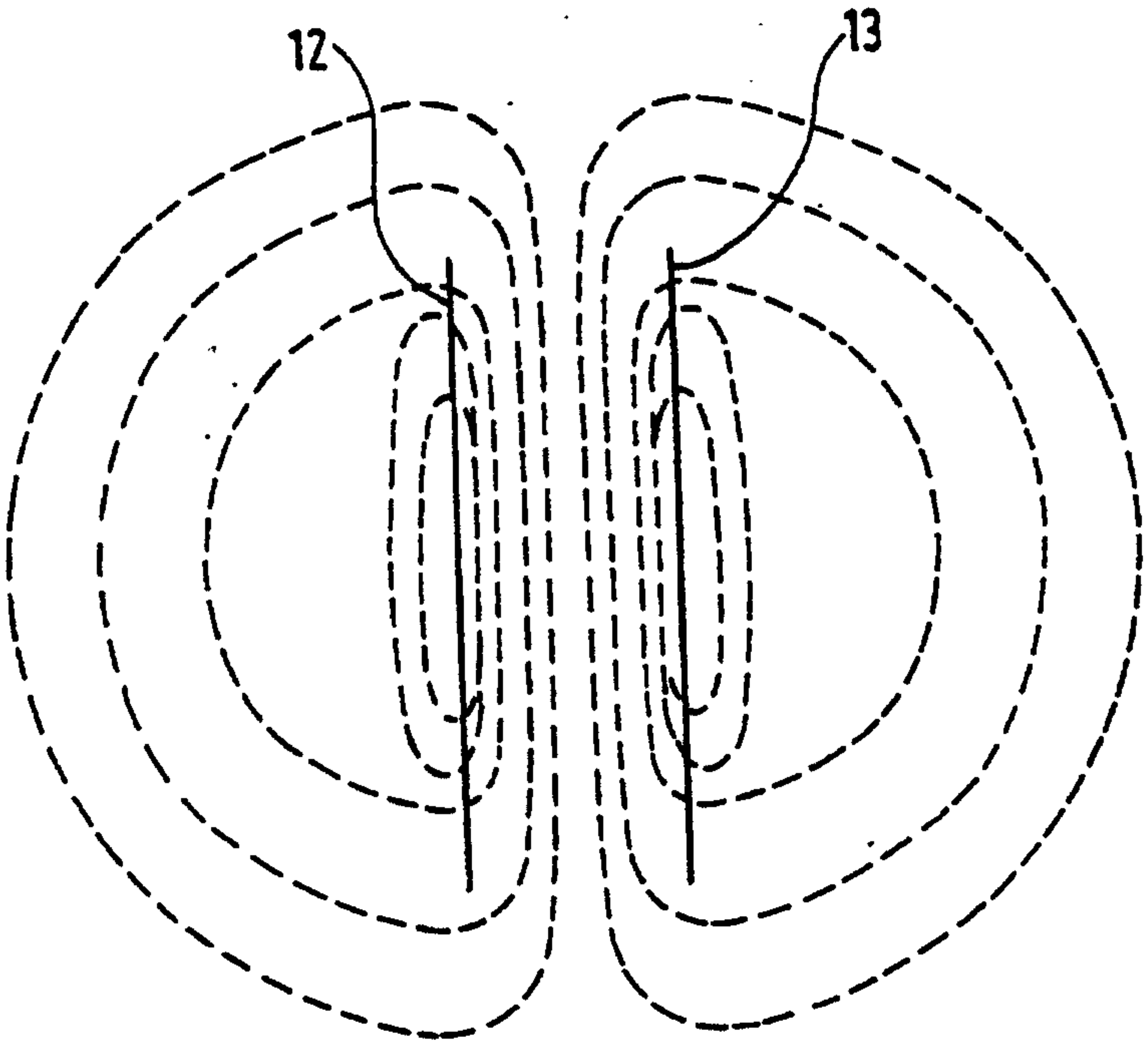

Fig.6b.