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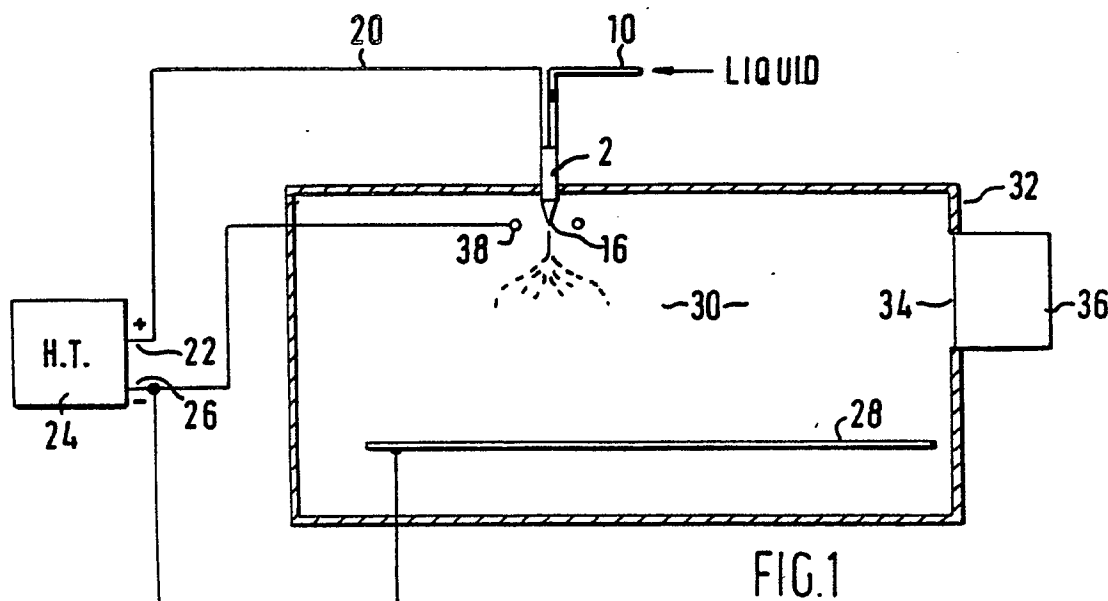
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(54) Apparatus and process for spraying.

(57) Electrostatic spraying apparatus and process for spraying liquids for which curing is initiated by in flight treatment to produce a coating or a powder.



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FIG.1

APPARATUS AND PROCESS FOR SPRAYING

FIELD OF THE INVENTION

This invention relates to apparatus and a process for spraying liquids capable of wholly or partly curing.

BACKGROUND OF THE INVENTION

There are a number of advantages to be obtained from increasing the speed with which a liquid which is sprayed, e.g. a paint, wholly or partly cures.

SUMMARY OF THE INVENTION

In accordance with the invention there is provided apparatus for spraying liquids which can be wholly or partly cured to produce particles or coatings, comprising: an electrostatic spray head having a spraying site, an electrically conducting or semiconducting liquid contacting surface and means for delivering the said liquid to the spraying site; high voltage supply means for charging the liquid contacting surface to a high voltage of one polarity relative to a reference surface, said voltage being sufficiently high and in combination the spraying site being sufficiently sharp, as to intensify the electric field strength at the spraying site sufficiently when covered, in use, by the liquid being sprayed, that the liquid at the spraying site is drawn out preponderantly by electrostatic forces into at least one cone from which a corresponding ligament issues and breaks up into electrically charged droplets; and means for treating the droplets in flight to initiate curing.

Initiating curing in flight can significantly reduce cure times. There are several effects which can contribute. Compared with initiating curing when the droplets have deposited on a target, there is a small time advantage in initiating curing in flight. The liquid sprayed is more finely divided as droplets in flight, than it would be as a coating on a target, so the treatment is effective over a larger surface of the liquid. Compared with initiating curing before spraying there can be an advantage in the possibility of using a faster chemical system which might cause problems by curing inside conventional spraying apparatus. The use of the electrostatic field to produce the ligaments enables the droplets to be produced of closely similar size.

This ensures that the liquid is all treated substantially equally. If the droplet size differed greatly, the liquid in larger droplets would receive less treatment than smaller droplets.

In accordance with the invention there is also provided a process for spraying liquids which can be wholly or partly cured to produce particles or coatings, comprising: delivering said liquid to a spraying site of an electrostatic spray head, making electrical contact with said liquid via an electrically conducting or semiconducting liquid contacting surface; charging the liquid contacting surface to a high voltage of one polarity relative to a reference surface, to intensify the electric field strength at the spraying site sufficiently that the liquid at the spraying site is drawn out preponderantly by electrostatic forces into at least one cone from which a corresponding ligament issues and breaks up into electrically charged droplets; and treating the droplets in flight to initiate curing.

In the process of the invention, the curing reaction is initiated while the composition in spray form is in flight towards a target object. The extent to which the reaction takes place depends upon the rate of the reaction, the speed of flight and the distance to the target object. To form a coating, the conditions are chosen so that curing will proceed to such an extent that the composition can still flow to form a film on the target. the curing reaction can be accelerated by heating.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-section through apparatus embodying the invention for making powders;

Figures 2, 3 and 4 are schematic cross-sections through alternative spray heads which can be used in the apparatus of Figure 1; and

Figure 5 is a perspective view of a further alternative spray head which can be used with the apparatus of Figure 1.

DETAILED DESCRIPTION

Referring to Figure 1, the apparatus has an electrostatic spray head 2. The spray head is shown in more detailed cross section in Figure 2. The spray head is linear, having a generally constant cross section. The spray head is made large-

ly of insulating material. Liquid to be sprayed is supplied via one or more channels 10 to a gallery 12. The liquid may be clear or may contain pigment or other matter. The gallery 12 distributes liquid to a slot 14 communicating with the centre of a spraying site in the form of an edge 16. Although the slot, naturally, has two sides, the electrostatic effect is that of one edge. That is to say only one set of ligaments is formed centrally. If the effect were that of two edges, ligaments would be produced off the "edges" at both sides of the slot. This concept of one edge fed by a central slot may, perhaps, be better understood by considering that the liquid to be sprayed has significant conductivity and will, in use, bridge the slot.

Near the exit from the slot 14 at the spraying edge 16, is positioned a strip of conducting or semiconducting material, over the surface of which the liquid passes on its way to the spraying edge 16.

The conducting or semiconducting surface 18 is connected via a high voltage supply lead 20, to one of the high voltage output terminals 22 of a high voltage generator 24. Another output terminal 26 of the high voltage generator is connected to a reference surface 28 on which the article to be sprayed is placed.

In use the electric field is defined between the reference surface and the liquid arriving at the edge 16. The edge 16 is sharp to a degree sufficient, in combination with the voltage produced by the high voltage generator, to define an intense electrical field. Assuming the surface 18 has a positive potential relative to the reference surface, negative charge is conducted away from the liquid at its contact with the conducting or semiconducting surface, leaving a net positive charge on the liquid. The electric field at the liquid/air boundary at the edge 16 is sufficiently intense that the liquid is drawn out into ligaments spaced along the edge 16.

The liquid becomes positively charged, negative charge being conducted away by the conducting surface 18, leaving a net positive charge on the liquid. The charge on the liquid produces internal repulsive electrostatic forces which overcome the surface tension of the liquid, forming cones of liquid at spaced intervals along the edge 16. From the tip of each cone a ligament issues. At a distance from the edge 16, mechanical forces produced by travelling through the air cause it to break up into charged droplets of closely similar size. The number of ligaments which is formed, depends on the flow rate of the liquid and on the electric field intensity, amongst other factors such as the resistivity and the viscosity of the liquid. All

other things being constant, controlling the voltage and the flow rate, controls the number of ligaments, which enables the droplet size to be controlled and very closely similar, say 40 to 50 microns.

We find it necessary to dimension the spacing of the edge 16 from the conducting or semiconducting surface 18 suitably, in relation to the resistivity of the liquid being sprayed. We find that spraying will not take place if, given a spacing, the resistivity of the liquid is too high or, conversely, given a particular resistivity, the spacing is too great. A possible explanation for this observation is that in addition to the liquid becoming charged as it passes over the conducting or semiconducting surface, there is also conduction of charge away from the liquid at the edge 16 through the liquid. The resistance of this path must not be so high that the voltage drop across it results in the voltage at the edge 16 being too low to produce an atomising field strength. The distance between the edge 16 and the conducting or semiconducting surface 18 must therefore be sufficiently small to allow for the resistivity of the liquid being used. We have found that a suitable position can be found for the surface even when spraying, say, a liquid having a resistivity in the range of 10^6 to 10^{10} ohm cm.

The spray head 2 is directed into a chamber 30. Means is provided in the form of a source of ultra violet radiation 36, to treat the droplets in flight. The source 36 illuminates the droplets through a quartz window 34. The apparatus is used to coat an article, which is placed on the conducting surface 28 below the spray head 2, with the liquid coating in which the cure has already started as a result of the treatment in flight. Subsequent baking at elevated temperature may be used to accelerate the curing reaction.

The electrostatic field between the spray head and the article causes the spray to wrap around the article to a subsequential degree, so that undersurfaces can be coated even when only sprayed from above. The spray head could be made portable, however, to increase accessibility of, say undersides and to improve the evenness of the coating. In this case, the source of ultraviolet radiation may remain fixed if that would still enable the droplets to be exposed in flight. Alternatively, the source 36 could be mounted on and mobile with the spray head 2.

Other forms of treatment may be used. For example, the source 36 may be replaced with a source of other electromagnetic radiation or with a means of mixing a gas or vapour catalyst with the droplets in flight.

In the present example, the liquid comprised a mixture of N-vinyl pyrrolidone 88%, benzophenone 4%, Irgacure 184 4% and dimethylethanolamine 4%. The mixture is found to cure quickly to form a

dry surface when exposed to ultraviolet radiation. To provide the correct environment, the walls 32 of the chamber 30 include a quartz window 34. The source 36 of ultra violet radiation is arranged to illuminate the inside of the chamber 30 through the window 34. If the liquid being sprayed cures very fast, it may be necessary to shield the ligaments from exposure to the ultraviolet.

In other examples, with other liquids the ultraviolet source may be replaced with any suitable electromagnetic radiation source.e.g. visible light, infra red, micro wave, radio frequency etc.

Although only one spray head is illustrated, clearly a plurality could be used in the same chamber. Further the configuration of the spray head could be other than linear. For example, if very low outputs were required for some special use, the spray head could comprise an arrangement to produce a single ligament such as a single conducting capillary tube. An alternative form to give a higher output is an annular spray head in which, say, Figure 2 is a section through one side of an annular ring.

In order to reduce the voltage required to produce electrostatic spraying, the reference surface may include a field adjusting electrode 38 positioned near the spray head. The electrode may be at the same potential as the surface 28, as illustrated, or at some intermediate potential. As the field adjusting electrode is much closer to the spray head than is the surface 28, it requires a much lower potential difference between them to produce an electric field strength to induce electrostatic spraying. A position, generally behind or level with the spraying edge 16, can be found at which virtually none of the liquid being sprayed deposits on it. Almost all the spray deposits as surface dry particles on the article 6 to be sprayed under the influence of the field between the spray head and the article. In the case of a linear spray head, the electrode 38 would extend along both sides of and parallel to the spraying edge 16. In the case of a single capillary tube or annular spray head, the electrode 38 would be a ring surrounding the spray head.

In an alternative form, a gas or vapour catalyst is introduced into the chamber 30 via an inlet 56.

An example of a chemical system suitable for this arrangement is a liquid epoxide sprayed from the spray head and air with a trace of BF_3 vapour introduced at the inlet 56. Examples of alternative catalysts in different systems are sulphur dioxide, oxygen, water vapour. Liquids which cure when catalyzed by water vapour include ketimines. In cases where atmospheric oxygen would act as an inhibitor, the air could be replaced by, say, nitrogen.

If it is desired to spray a two component liquid, it can be advantageous to use the spray heads illustrated in cross-section in Figures 3 and 4. As shown in Figure 4, the spray head has two slots 14a and 14b, one for each of the liquid components. the exits of the slots 14a and 14b lie parallel to but spaced from the spraying edge 16. The liquid component in each slot 14a and 14b passes over the surface 18a or 18b of a conducting or semiconducting strip which is connected to the output of the high voltage generator 24. The two liquid components leave the slots 14a and 14b and pass over exterior surfaces 58a and 58b where the components remain separated. The components only meet at the spraying edge where the cones and ligaments which form contain both components. Although in the ligaments the components may not mix particularly well, when a droplet separates from a ligament it is thought to undergo several violent oscillations which mix the components. Whatever the explanation, the components are well enough mixed in the droplets to effect a cure.

The spray head illustrated in Figure 4 has its liquid contacting conducting or semiconducting surface at the edge 16. That is to say the edge 16 is formed in the conducting or semiconducting material.

In other alternatives, three or more component liquids may be used, each liquid being fed to a common spraying edge, but only meeting the other components on the exterior of the spray head. Thus a central slot in the spraying edge, as in Figure 2, could supply a third liquid component. Further liquid components could be provided via further slots over exterior surfaces 60a and 60b in Figures 3 and 4.

The quality of the spray and the uniformity of the droplet size is sensitive to two factors amongst others.

When the spraying edge 16 is plain, at any given flow rate, the number of ligaments formed depends on the field strength at the edge. Increasing the field strength increases the number of ligaments. Increasing the number of ligaments at the same overall flow rate, has the effect that each ligaments is finer so that the droplets it breaks up into are smaller.

The provisions of gas or vapour catalyst may disturb or destroy the ligaments on which the uniform droplet size relies.

The sensitivity to these two factors may be reduced by use of a spray head having a spraying edge 16 formed with spaced tips as shown in Figure 5. The tips are provided in the example illustrated by teeth 72. The teeth 72 are formed in a body member 74 of insulating plastics material. Liquid to be sprayed is provided via an inlet (not

illustrated) to a liquid distribution gallery 12 in the body 74. A closing plate 76 is spaced from and sealed to the body member 74 by a gasket 78. The gasket is open sided adjacent the teeth 72 defining a linear slot 14 between the body member 72 and the closing plate 76. The gasket is so shaped as to provide channels 80 to supply liquid from the distribution gallery 12 to the slot 14. Upstream from the mouth of the slot 14, a conducting or semiconducting strip 18 is inset into the body member 42 to provide a liquid contracting surface. The strip 18 is connected to the high voltage output of a high voltage supply (not shown in Figure 6) to charge the liquid so that spraying takes place. In use the electric field strength at the tip of each tooth 72 is sufficient to produce a ligament, but the field strength between the teeth 72 is not sufficient to produce a ligament. This condition pertains over a wide range of voltages supplied by the high voltage generator, reducing the sensitivity of the droplet size to variations in voltage.

Because each ligament is located at a particular physical point: the tip of a tooth, it is much less prone to disturbance by an air or gas stream passing the sprayhead.

Claims

1. Apparatus for spraying liquids which can be wholly or partly cured to produce particles or coatings, comprising: an electrostatic spray head (2) having a discharge site (16), an electrically conducting or semiconducting liquid contacting surface (18) and means (12, 14) for delivering the said liquid to the spraying site (16); high voltage supply means (24) for charging the liquid contacting surface (18) to a high voltage of one polarity relative to a reference surface (38,42), said voltage being sufficiently high and in combination the spraying site (16) being sufficiently sharp, as to intensify the electric field strength at the spraying site (16) sufficiently when covered, in use, by the liquid being sprayed, that the liquid at the spraying site (16) is drawn out preponderantly by electrostatic forces into at least one cone from which a corresponding ligament issues and breaks up into electrically charged droplets; and means (36) for treating the droplets in flight to initiate curing.

2. Apparatus as claimed in claim 1, wherein the spraying site (16) has a plurality of spaced tips (72) spaced along a spraying edge (16), the tips (72) being so shaped that, in use, when covered by the liquid to be sprayed, the electrostatic field strength is intensified sufficiently, at the voltage produced by the high voltage supply means, that liquid only at the tips (72) is drawn out into the ligaments.

3. Apparatus as claimed in claim 1 or 2, wherein the reference surface comprises a field adjusting electrode (38) spaced from the spraying site (16).

4. Apparatus as claimed in any preceding claim, wherein the means for treating comprises means (36) for exposing the droplets in flight to electromagnetic radiation.

5. Apparatus as claimed in claim 4, wherein the radiation is ultraviolet.

6. Apparatus as claimed in any of claims 1 to 3, wherein the means for treating the droplets includes means for supplying a stream of gas and/or vapour catalyst to mix with the droplets in flight.

7. Apparatus as claimed in any preceding claim, wherein the spray head includes means (14a,14b) for providing two liquids separately to the spraying site (16) so that the or each ligament contains both liquids.

8. A process for spraying liquids which can be wholly or partly cured to produce particles or coatings, comprising: delivering said liquid to a spraying site (16) of an electrostatic spray head (2), making electrical contact with said liquid via an electrically conducting or semiconducting liquid contacting surface (18); charging the liquid contacting surface (18) to a high voltage of one polarity relative to a reference surface (28,38), to intensify the electric field strength at the spraying site (16) sufficiently that the liquid at the spraying site (16) is drawn out preponderantly by electrostatic forces into at least one cone from which a corresponding ligament issues and breaks up into electrically charged droplets; and treating the droplets in flight to initiate curing.

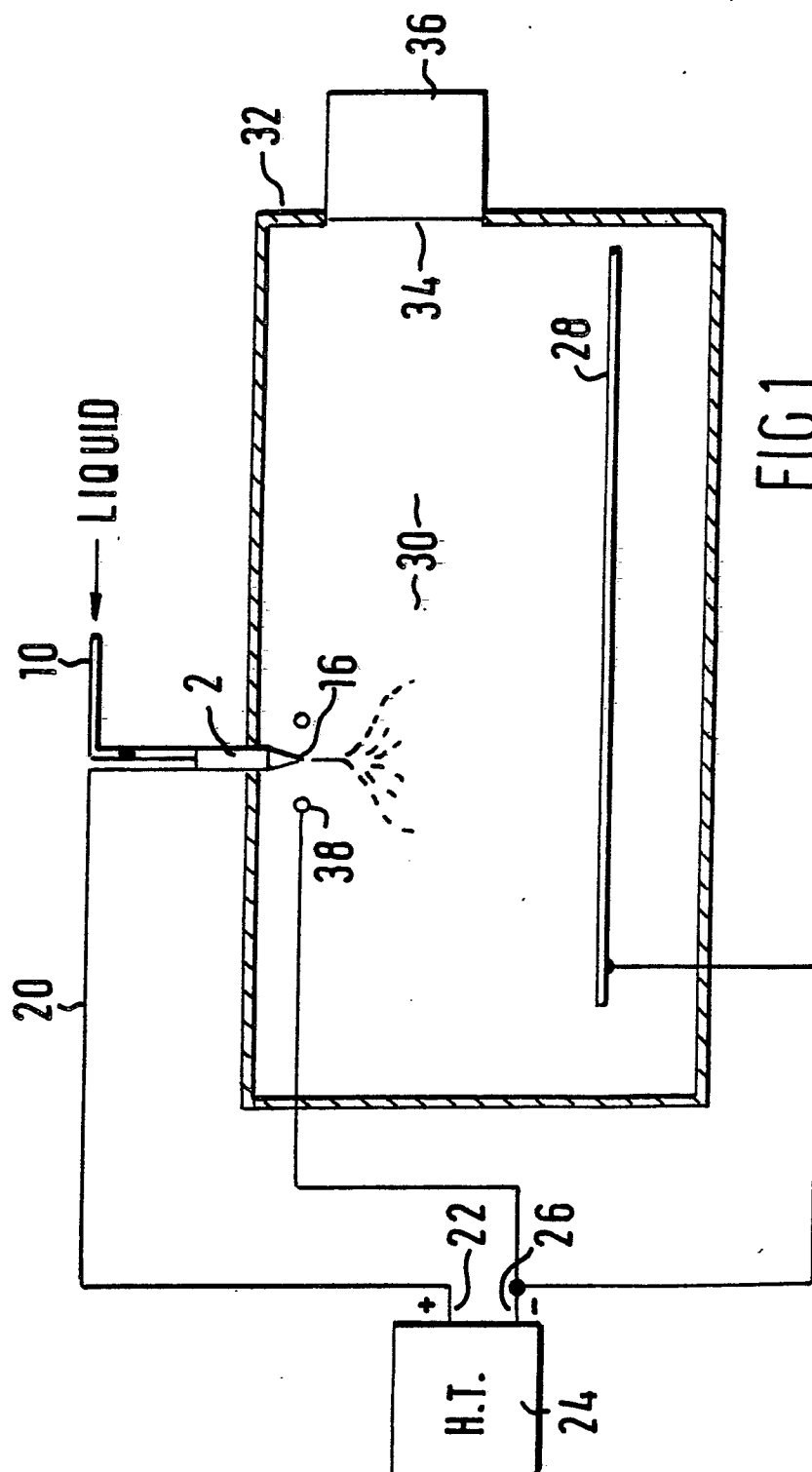
9. A process as claimed in claim 8, wherein the reference surface comprises a field adjusting electrode (38) spaced from the spraying edge.

10. A process as claimed in claim 9 or 10, including introducing a stream of air or gas past the spray head (16).

11. A process as claimed in any of claims 8 to 10, wherein treating the droplets includes introducing a gas or vapour curing agent to mix with the droplets in flight.

12. A process as claimed in any of claims 8 to 11, wherein treating the droplets includes exposing the droplets to electromagnetic radiation in flight.

13. A process as claimed in any of claims 8 to 12, including providing two liquids separately to the spraying site (16) so that the or each ligament contains both liquids.



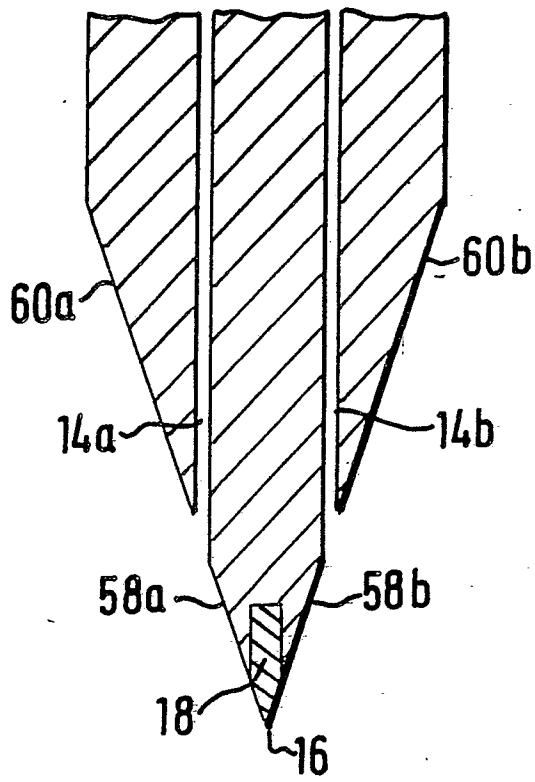


FIG. 3

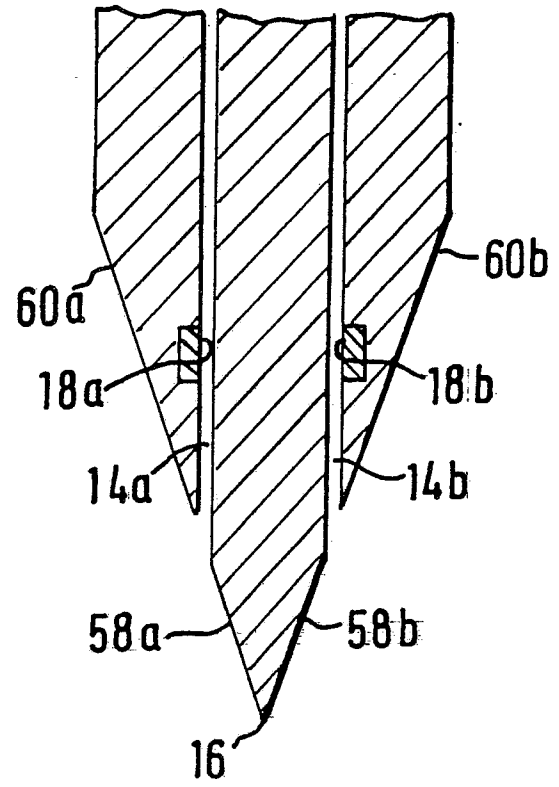


FIG. 4

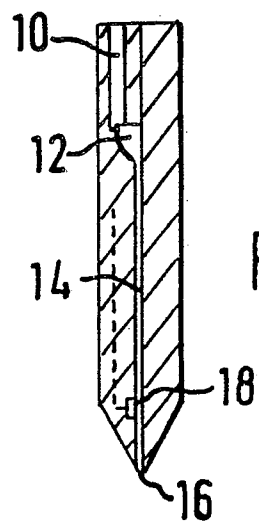


FIG. 2

