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(54) Manufacture of varistors

Herstellung von Varistoren

Production de varistors

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Description

[0001] The invention relates to production of varistors having a multiphase composition, such as, ZnO (zinc oxide) varistors.

[0002] The electrical characteristics of such varistors are determined by their detailed microstructure. The three main micro-structural features that are of importance for the performance of ZnO varistors containing bismuth oxide as one of the additives are for example, ZnO grains, grain boundaries and intergranular network of bismuth rich phases. These features constitute the functional microstructure which develops during fabrication and their detailed structure varies with changes in fabrication parameters. There is a correlation between the microstructure and the electrical (current-voltage) characteristics and this acts as an important tool to adjust the electrical property of the grain boundary as well as that of the grain to fit the requirements of a given application.

[0003] Such varistors are typically produced in one of two types of process, namely hot pressing and cold pressing.

[0004] The hot pressing technique is described, for example, in US4180483. This involves simultaneously pressing and heating the powder at a high temperature to provide a consolidated body. JP56101714 describes a variation of hot pressing, in which the powder is pre-sintered at 1000°C for 2 hours, is then compressed to a disc, and is then sintered again at 1000°C for 2 hours. The hot pressing technique is effective in some circumstances, however, the equipment required is expensive and the range of sizes which may be effectively produced in this manner is limited.

[0005] The cold pressing technique involves pressing the powder to provide what is referred to as a "green disc" of compressed powder. This is then sintered in a separate operation to consolidate the structure. An example of this technique is described in US 5004573, in which oxides are mixed, ground in a ball mill, pressed into discs using PVA as a binder, and are then sintered at 1200 - 1350°C. This process is relatively simple and is widely used for high-volume varistor production. However, it suffers from the problem that there is a high defect rate caused by discs becoming chipped between the pressing and sintering stations.

[0006] The invention is directed towards providing a cold pressing process to provide a reduced green disc defect rate. Another object is to achieve improved green disc consistency.

[0007] The invention is as set out in claim 1. Accordingly, the binder provides much reduced resistance to relative motion of the particles as they are compressed, to provide a more uniform and less brittle compressed body structure.

[0008] The powder heating temperature range ensures that the glass transition temperature of the binder is exceeded, and also that organics in the powder are not damaged.

[0009] Most preferably, the temperature is in the range of 20°C to 40°C above the glass transition temperature. These temperature ranges have been found to be particularly suitable to achieve a reduced green disc defect rate without adversely affecting the varistor performance.

[0010] In one embodiment, the powder is heated in a conduit leading to a press head. This is a particularly simple and effective way of heating the powder.

[0011] Preferably, the powder is heated in a series of baffles as it falls to the press head. Ideally, the baffles are mounted to provide a cascading action as the powder falls in the conduit. This arrangement causes turbulence in the powder as it falls to ensure that the heat is well distributed across the whole range of powder particles as they fall to the press head. As there are no moving parts, the arrangement is very reliable and effective.

[0012] Preferably, the baffles are electrically heated.

[0013] In one embodiment the powder transit time between heating and pressing is less than 5 seconds.

[0014] Preferably, the powder particle size is in the range 130 to 150 μm, and most preferably is approximately 140μm.

[0015] Preferably, the step of preparing the powder includes the sub-step of adding a plasticizer component to reduce the glass transition temperature of the binder.

[0016] In the latter embodiment, the ratio of binder to plasticizer is preferably 60:40 by weight.

[0017] The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings in which:

Figs 1(a) to Fig 1(f) are together a flow diagram illustrating a manufacturing method of the invention; and

Fig 2 is a perspective view of a pre-heating chamber used in the method.

[0018] Referring to the drawings, there is illustrated a method for producing ZnO varistors. In a step of the method, there is slurry preparation using an agitator 3 in a container 4. In this step, zinc oxide and various oxide additives are weighed and milled and are mixed with a PVA binder solution in a container 4 to provide a slurry 5. The particle size of the zinc oxide is approximately 2 μm. The PVA binder has a glass transition temperature Tg (at which it becomes soft and pliable) in the range of 70°C to 90 °C. A PEG plasticizer is also added in step 2. This lowers the glass transition temperature Tg of the PVA. The ratio of binder to plasticizer is 60:40 by weight.

[0019] The slurry is converted to powder 11 by spray drying in a spray drying chamber 12 feeding a batch container 13. The spray drying pump pressure is approximately 20 kg/cm^2, and the outlet temperature is approximately 145°C. These conditions achieve a consistent particle size in the range of 130μm to 150μm.

[0020] Referring now to Fig 1 (c), the powder 11 is pre-heated and is pressed. In detail, the powder is drawn from a batch container 13 through a vacuum tube 22 which is perforated along the length immersed in the powder. These perforations ensure that an even distribution of powder is drawn at any one time because they extend through the depth of the powder in the container 13.

[0021] The pre-heating step involves ejection of the powder from a nozzle 24 at the end of the vacuum tube 22 into a pre-heating chamber 23, shown in more detail in Fig. 2. The chamber 23 has insulated walls 25 which support a series of baffles 26 extending downwardly and inwardly. The baffles 26 are heated by application of electrical potential at silicon mat heaters 27. An outlet chute 28 is mounted at the base of the pre-heating chamber 23. The baffles 26 and the chute 28 are of aluminium material.

[0022] As the powder falls through the chamber 23, it is gradually heated by the baffles 26 until the glass transition temperature of the binder is exceeded. For example, for a glass transition temperature of 70°C, it has been found that a powder temperature of 100°C is suitable. The silicon mat heaters 27 have an upper temperature limit of 180°C. They are mounted on the sides of the chamber 23, the heat transferring by conduction to the baffles 26. This ensures that the powder is gently heated over a large surface area from ambient to approximately 100°C as it falls under gravity to the outlet chute 28 in a cascading action.

[0023] It has been found that a powder temperature in excess of Tg and below that at which the organics are damaged is suitable. For a Tg of 70°C, a powder temperature of 90°C to 140°C has been found to be suitable. The preferred value is in the lower portion of this range, 90°C to 110°C.

[0024] After heating, the powder is pressed by press heads 41 mounted on a carousel press over a powder bed 42. The powder is then in the form of compressed "green" discs. Referring now to Fig 1 (d), the discs 46 are delivered by a chute 43 onto a conveyor 44. Pick-and-place heads 45, pick the discs by suction and automatically pack them into racks.

[0025] As shown in Fig. 1 (e), the discs are sintered in an oven 51 through which they are conveyed on a conveyor 52 in racks 53. The discs 46 are mounted vertically in the racks 53.

[0026] As shown in Fig. 1 (f), leads 61 are applied to the discs 46. This is performed by an assembly unit having wire reels and soldier guns. The discs are coated in epoxy using an epoxy shell. The epoxy shell is mixed, pre-heated, cured, and assembled.

[0027] The pre-heating step of the invention achieves greater density and strength in the green disc. There is also improved consistency in the green discs. In one test, in room temperature pressing the green disc density was 2.937g/cm^3 and this improved to 3.005g/cm^3 for 70°C pre-heating and to 3.028g/cm^3 for 120°C preheating. The strength improved from 46.57N for room temperature to 74.44N for 70°C and to 103.19 N for 120°C. This improved strength significantly reduces the defect rate caused by discs being chipped *en route* to the sintering station. The defect rate was found to reduce by approximately 20%.

[0028] The invention is not limited to the embodiments described, but may be varied in construction and detail within the scope of the claims.

Claims

1. A method of producing zinc oxide type varistors, the method comprising the steps of:

   preparing an oxide powder (11) from a slurry (5) including a binder;
   pressing the powder (11) to form a compressed body (46);
   sintering the compressed body (46); and
   applying leads (61) and coating the compressed body (46) to provide a varistor (70), **characterised in that**
   the powder (11) is heated before pressing to a temperature above the glass transition temperature of the binder; and

   wherein the temperature is in the range of 20°C to 70°C above the glass transition temperature of the binder.

2. A method as claimed in claim 1, wherein the temperature is in the range of 20°C to 40°C above the glass transition temperature.

3. A method as claimed in any preceding claim, wherein the powder (11) is heated in a conduit leading to a press head (41).

4. A method as claimed in claim 3, wherein the powder (11) is heated by a series of baffles (26) as it falls to the press head.

5. A method as claimed in claim 4, wherein the baffles (26) are mounted to provide a cascading action as the powder (11) falls in the conduit.

6. A method as claimed in any of claims 3 to 5, wherein the baffles (26) are electrically heated.

7. A method as claimed in any preceding claim, wherein the powder transit time between heating and pressing is less than 5 seconds.

8. A method as claimed in any preceding claim, wherein the powder particle size is in the range 130 to 150 μm.

9. A method as claimed in any preceding claim, wherein the step of preparing the powder includes the substep of adding a plasticizer component to reduce the glass transition temperature of the binder.

10. A method as claimed in claim 9, wherein the ratio of binder to plasticizer is 60:40 by weight.

Patentansprüche

1. Verfahren zur Herstellung von Zinkoxid-artigen Varistoren, wobei das Verfahren folgende Schritte umfasst:

   Zubereiten eines Oxid-Pulvers (11) aus einer Aufschlämmung (5), die ein Bindemittel einschließt;
   Pressen des Pulvers (11) zur Bildung eines komprimierten Körpers (46);
   Sintern des komprimierten Körpers (46); und
   Anbringen der Anschlüsse (61) und Beschichten des komprimierten Körpers (46) zur Bereitstellung eines Varistors (70), **dadurch gekennzeichnet, dass**
   das Pulver (11) vor dem Pressen auf eine Temperatur über der Glasübergangstemperatur des Bindemittels erhitzt wird; und

   worin die Temperatur im Bereich von 20 °C bis 70 °C über der Glasübergangstemperatur des Bindemittels liegt.

2. Verfahren nach Anspruch 1, worin die Temperatur im Bereich von 20 °C bis 40 °C über der Glasübergangstemperatur liegt.

3. Verfahren nach einem der vorstehenden Ansprüche, worin das Pulver (11) in einem Führungsrohr, das zu einem Presskopf (41) führt, erhitzt wird.

4. Verfahren nach Anspruch 3, worin das Pulver (11) durch eine Reihe von Leitblechen (26) erhitzt wird, während es zum Presskopf fällt.

5. Verfahren nach Anspruch 4, worin die Leitbleche (26) zur Bereitstellung einer kaskadierenden Bewegung, während das Pulver (11) in das Führungsrohr fällt, angebracht sind.

6. Verfahren nach einem der Ansprüche 3 bis 5, worin die Leitbleche (26) elektrisch erhitzt werden.

7. Verfahren nach einem der vorstehenden Ansprüche, worin die Durchgangszeit des Pulvers zwischen dem Erhitzen und Pressen weniger als 5 Sekunden beträgt.

8. Verfahren nach einem der vorstehenden Ansprüche, worin die Partikelgröße des Pulvers im Bereich von 130 bis 150 μm liegt.

9. Verfahren nach einem der vorstehenden Ansprüche, worin der Schritt des Zubereitens des Pulvers den Teilschritt des Zugebens einer Weichmacher-Komponente zur Erniedrigung der Glasübergangstemperatur des Bindemittels einschließt.

10. Verfahren nach Anspruch 9, worin das Verhältnis von Bindemittel zu Weichmacher 60:40, auf das Gewicht bezogen, beträgt.

Revendications

1. Procédé de production de varistances du type oxyde de zinc, le procédé comprenant les étapes consistant à :

   préparer une poudre d'oxyde (11) à partir d'une pâte (5) comprenant un liant ;
   compresser la poudre (11) pour former un corps compressé (46) ;
   fritter le corps compressé (46) ; et
   appliquer des fils (61) et enrober le corps compressé (46) pour donner une varistance (70), **caractérisé en ce que** :

   la poudre (11) est chauffée avant la compression jusqu'à une température supérieure à la température de transition vitreuse du liant, et

   dans lequel la température est comprise dans la plage située de 20°C à 70°C au-dessus de la température de transition vitreuse du liant.

2. Procédé selon la revendication 1, dans lequel la température est comprise dans la plage située de 20°C à 40°C au-dessus de la température de transition vitreuse.

3. Procédé selon l'une quelconque des revendications précédentes, dans lequel la poudre (11) est chauffée dans une conduite menant à une tête de presse (41).

4. Procédé selon la revendication 3, dans lequel la poudre (11) est chauffée par une série de chicanes (26) alors qu'elle tombe vers la tête de presse.

5. Procédé selon la revendication 4, dans lequel les chicanes (26) sont montées pour fournir une action en cascade alors que la poudre (11) tombe dans la conduite.

6. Procédé selon l'une quelconque des revendications

3 à 5, dans lequel les chicanes (26) sont chauffées par l'électricité.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le temps de transit de la poudre entre le chauffage et la compression est de moins de 5 secondes.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel la taille des particules de la poudre se situe dans la plage allant de 130 à 150 μm.

9. Procédé selon l'une quelconque des revendications précédentes, dans lequel l'étape consistant à préparer la poudre inclut la sous-étape consistant à ajouter un composant plastifiant pour abaisser la température de transition vitreuse du liant.

10. Procédé selon la revendication 9, dans lequel le rapport du liant sur le plastifiant est égal à 60:40 en poids.

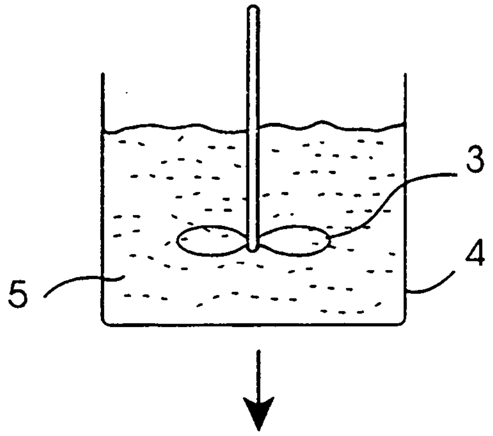

Fig. 1(a)

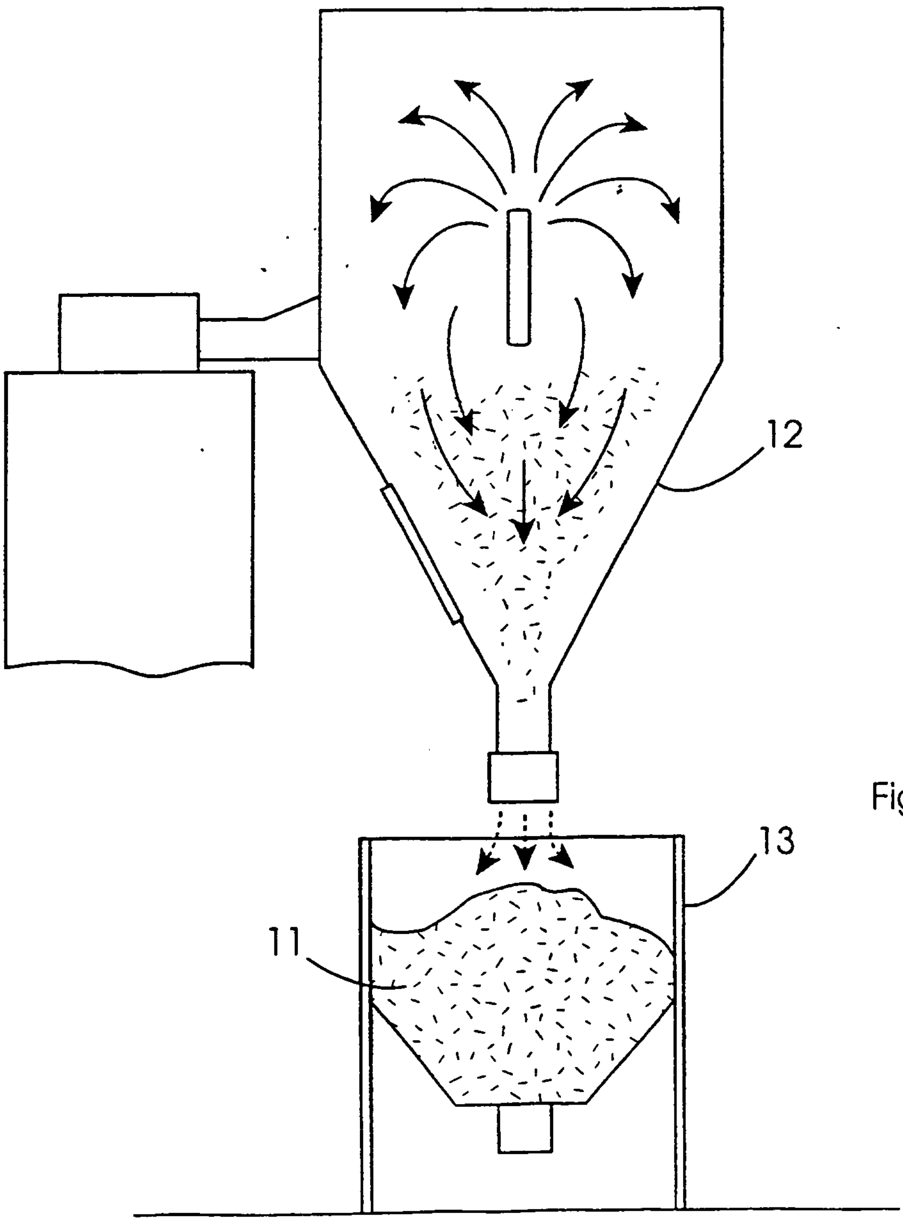

Fig. 1(b)

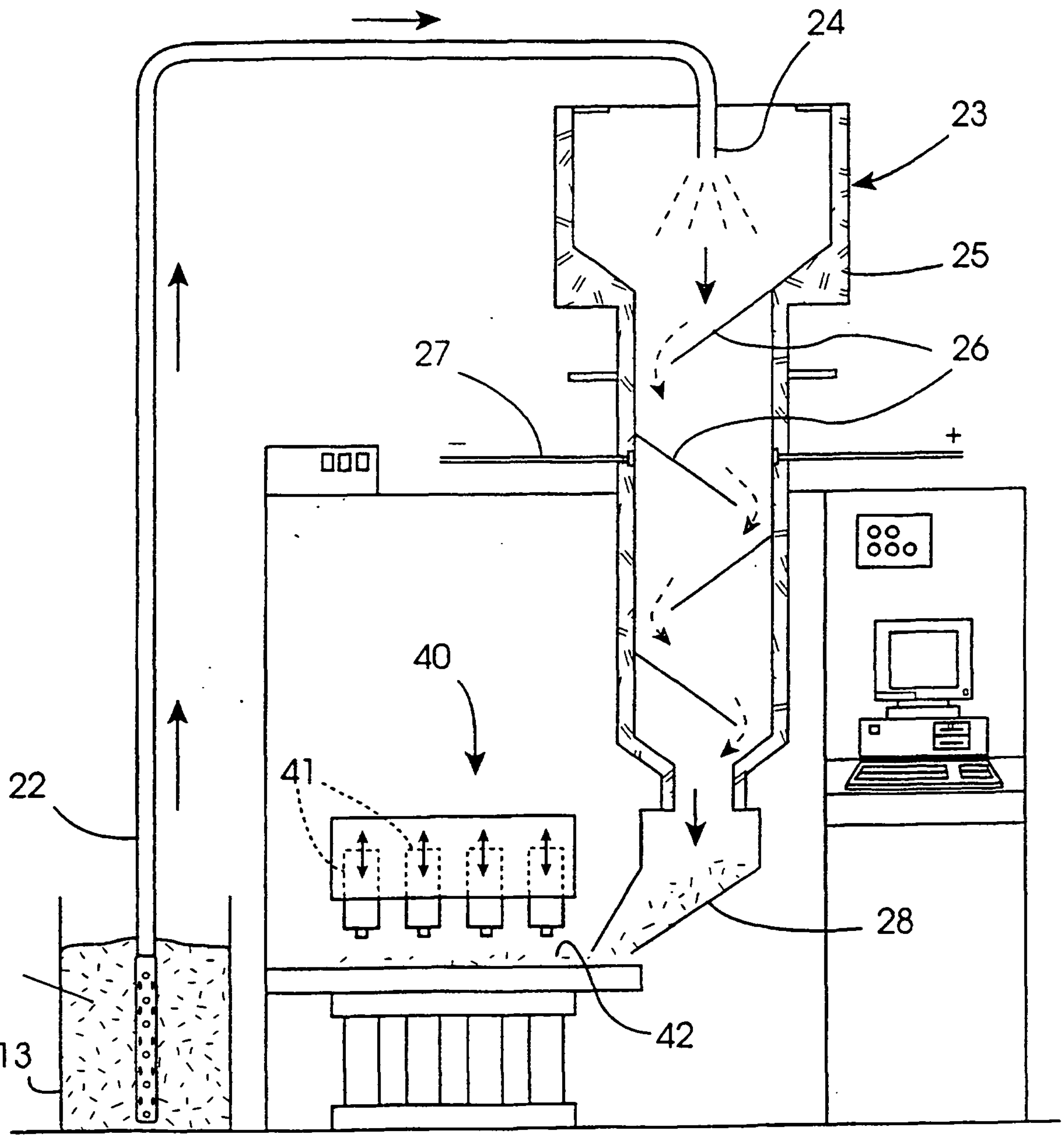

Fig. 1(c)

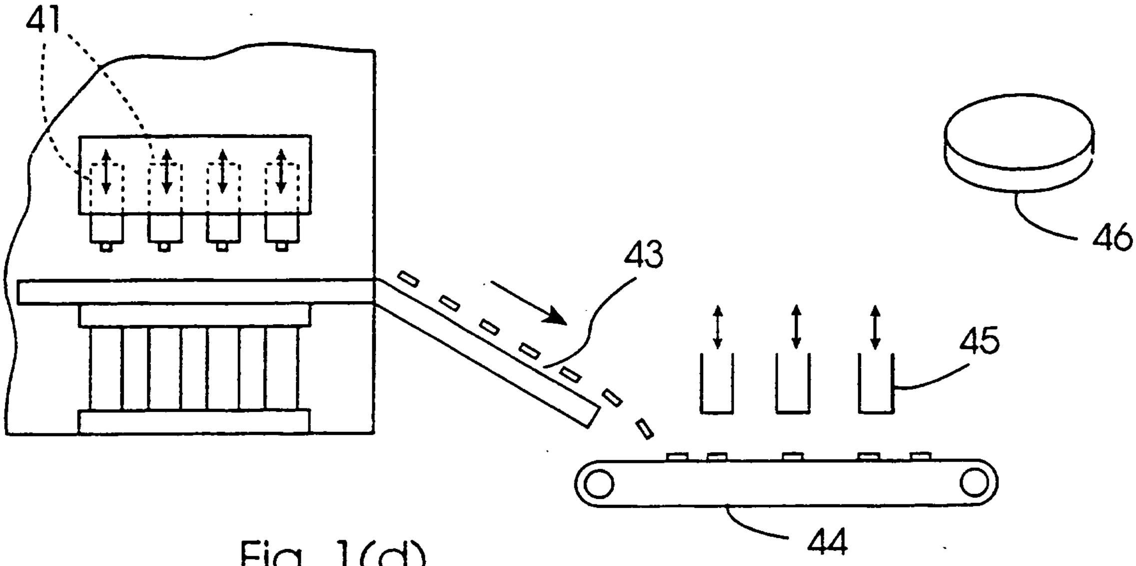

Fig. 1(d)

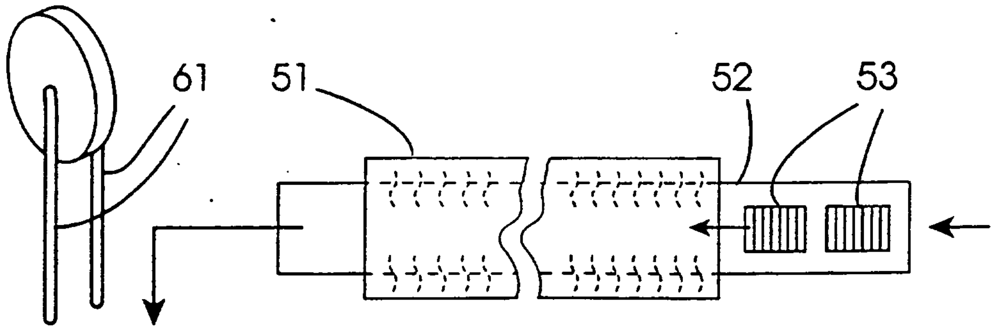

Fig. 1(e)

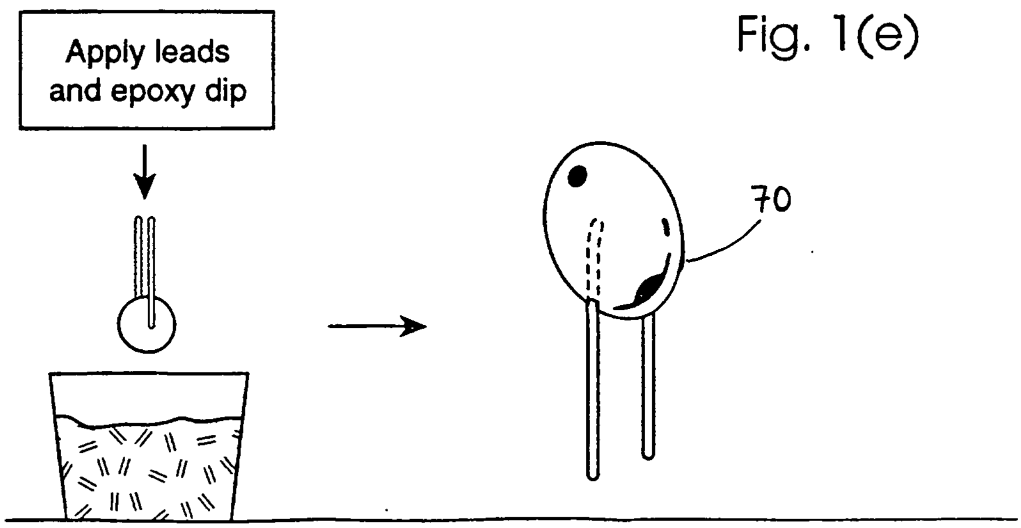

Fig. 1(f)

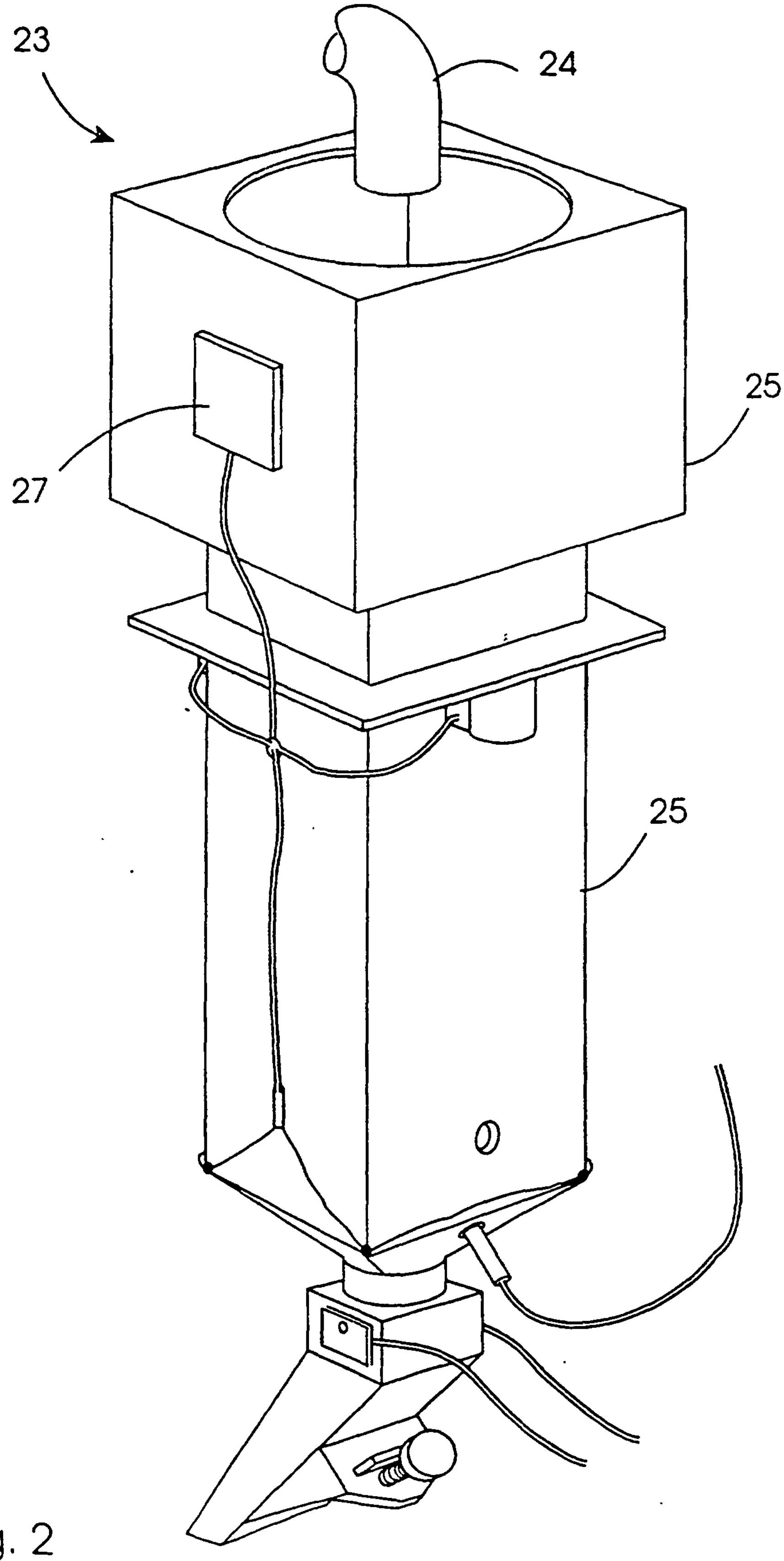

Fig. 2