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 Applicant: **STAMICARBON B.V.**
 Mijnweg 1
 NL-6167 AC Geleen(NL)


 Inventor: **Hendriks, P.F.A.M.**

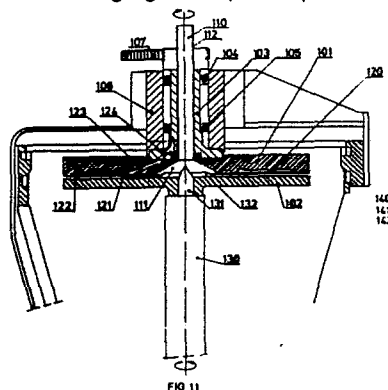
deceased(NL)
 Inventor: **Goorden, J.J.P.M.**
 Haagstraat 29
 NL-6133 VR Sittard(NL)
 Inventor: **Stienen, Johannes Alfons**
 Cremerstraat 3
 NL-6301 GD Valkenburg(NL)
 Inventor: **de Ruiter, Jan Arnold**
 Leeuwerikstraat 20
 NL-6432 JB Hoensbroek(NL)


 Representative: **Hoogstraten, Willem Cornelis**
Roeland et al
OCTROOIBUREAU DSM Postbus 9
 NL-6160 MA Geleen(NL)


Process and device for drying solid, porous particles.


 Process for drying solid, porous, liquid-containing particles, each particle being caused to rotate individually, at an angular velocity whereby the force the liquid on and within the particle exceeds or exceeds the forces binding the liquid to the particle, the liquid removed from the particle being separated off.

Device for treating powdered material, consisting of a two surfaces of equal shape and arranged parallel and at a short distance from each other and driven at relatively different speeds, further having means for feeding the powdered material to the gap between the two surfaces, means for removing the powdered material from the gap between the surfaces, and means for discharging the liquid separated from the powdered material.



PROCESS AND DEVICE FOR DRYING SOLID, POROUS PARTICLES

The invention relates to a process for drying solid, porous liquid-containing particles.

A similar process is known from NL-A-7109221.

In the known process a gas flow blows the material to be treated, at a high speed, against at least one impact device, which is designed and arranged in such a manner that the impact causes the solid particles to leave the main gas flow, upon which they are caught as a separate fraction, while the liquid flung from the particles by the impact is carried off by the main flow of the gas. This process is particularly suitable for removing liquid, to very low concentrations, from granules with principal dimensions of >0.5 mm, which do not have a fine internal pore structure and which, in addition, are not fragile.

A disadvantage of the known process is that, in the case of particles with an internal pore structure and particles <0.5 mm (principal dimensions), the final liquid content of the particles to be dried is > 10 wt.%, which means that a relatively large amount of expensive thermal energy is required for the further drying of the particles. This is explained by the fact that the velocity and the deflections of the particles are so small and brief, on account of the strong relative frictional forces between the small particles and the gas, the particles' poor impact elasticity and the hindrance they cause each other, that the inertial forces are not strong enough to overcome the adhesion forces between the liquid and the surface and the capillary force in the pores of the particles and, in some cases, an additional underpressure holding the liquid in the pores.

In addition, the amount of energy required by the above-mentioned particles >0.5 mm or by particles with a fine internal pore structure to reach the above-mentioned percentages is intrinsically high in the known process, because the velocity of the gas flow or of the particles must be very high to realize any removal of liquid. The acoustic emission of a device according to the known process is also relatively high.

The aim of the invention is to provide a process which does not present or hardly presents the above disadvantages.

To this effect each particle is caused to rotate individually, according to the invention, at such an angular velocity that the resultant force or forces on the liquid on and within the particle exceeds or exceed the forces binding the liquid on and in the particle, in which process the liquid removed from the particle is separated off simultaneously or in a subsequent process step.

By applying the process according to the invention, small to very small particles which, on account of their small dimensions, are subject to relatively large frictional forces from the surrounding medium can be caused to rotate effectively individually with little energy, at such a velocity and for a sufficiently long time that liquid bound to and in the fine pore structure of the particle is spun out and off.

In the process according to the invention it is essential that the particle rotates at such an angular velocity that the centrifugal pressure $\frac{1}{2} \rho_L \omega^2 R$ exceeds the sum of the pressure of the adhesional force which binds the liquid to and in the particle and any underpressure holding the liquid in a pore. In a formula:

$$\frac{1}{2} \rho_L \omega^2 R > \frac{4 T \cdot \cos \theta}{d} + \Delta P$$

In this formula:

ρ_L = the density of the liquid

ω = the angular velocity

R = the principal size of the radius of a particle

T = the surface tension of the liquid

θ = the contact angle between the liquid and the material of a particle

d = the greatest radius of a pore in the particle.

In the process according to the invention, the frictional reaction required to rotate individual particles can be generated by, for example,

method a: a velocity profile of the medium around the particle, ensuring sufficient rotational velocity, combined with a particle holdup in the apparatus, enabling the particles to rotate individually without hindering each other too much. The density of the particles must then be $< 0.75 \times$ the bulk density.

method b: a sufficiently large normal force of the particles on a plane, with the properties of the surface of the plane being such that the particles and the plane have a sufficiently high frictional coefficient and frictional force. The normal force of the particle results from inertial forces (centrifugal force, coriolis force or combinations of components of the forces), for example by causing the particle to describe a curved path.

5 The additional inertial forces are required because the gravitational force of the small particles considered here is insufficient for generating a sufficiently large normal force, because, for example, turbulence forces of the medium and Magnus' forces acting on the moving particle are already equal to or greater than the gravitational force, which they therefore cancel.

10 The active forces (contrary to the already-mentioned reaction forces) which neutralize the frictional forces acting on the particle, thus enabling the particle to describe the path desired at the minimum required velocity, are generated by the velocity of the particle with the surrounding medium or a contact force of the particle with a moving surface or a combination of the two.

One embodiment of the process according to the invention is characterized in that the curvature of the trajectory of the particle, for example along a fixed surface, depends on the nature of the material to be dried, so that there is sufficient friction between the particles and the plane and the conditions of the forces are chosen such that the particle is given the required relative velocity with respect to the plane and that the particle retains this rotational velocity for a sufficiently long time for the liquid held in and on the particle to be spun out and off.

20 It is to be prevented that the particle slips too much and that the geometry of the equipment and the conditions imposed on non-round particles are such that the moment of the propulsive force with respect to the point or points of contact of the particle and the plane must be larger than the greatest tilting moment of the particle.

The particles must be supplied to the surface at such a speed that they can rotate unhindered or reasonably unhindered. The supply capacity per m (Φ) must therefore be smaller than

25

$$\frac{\pi v R \rho (1 - \epsilon)}{2 a^2}$$

30

v = the relative velocity of the particle with respect to the plane

R = half of the diameter of the particle

ρ = skeleton density of the particle

35 ϵ = sum of the internal and external porosities

a = measure of the amount of room surrounding a particle; a is larger than 1.

If the particle may not slip or may slip only little, the conditions must be chosen such that the frictional force exceeds the propulsive force.

40 The process according to the invention is also extremely suitable for removing liquid from particles bound together by liquid, for example in a wet filter bed or even slurries.

The liquid spun out and off can be removed from the particle flow by sucking the liquid separated off according to the above-mentioned methods practically in situ through a surface previous to liquid. In some cases convenient use may be made of a secondary air flow generated in the apparatus, which carries off the small droplets of liquid spun out, but not the particles to be dried.

45 In cases in which the particle density is not too great, the liquid and the treated particles can be classified outside the apparatus, for example by sifting. The strict requirement in the known process that the liquid phase be carried off by the main flow does therefore not apply to the invention.

In the process according to the invention, a final liquid content of approx. <1 wt.% can be obtained, dependent on the nature of the dried particles.

50 The process of introducing granular and fibrous products into a gas flow which is then fed to a separating device is known per se. In this process the actual drying is done in the gas flow, which has been heated for this purpose, so that the liquid to be removed is first evaporated and then removed in gaseous form. The known separating device, for example a cyclone, only serves to separate the dried product from the drying gas containing the absorbed liquid. In the process according to the invention, however, the particles are caused to rotate and the resultant centrifugal forces force the liquid out of the pores.

55

The invention also relates to a device in which the above process can be carried out, which device is characterized by a first and a second surface, which two surfaces are of identical shape and are arranged parallel, at a short distance from each other, and that it also contains means for driving these surfaces at relatively different speeds, means for feeding the powdered material to the space between the two surfaces, means for removing the powdered material from the space between the surface and means for discharging the liquid thus separated from the particles.

Other characteristics and advantages of the invention will become clear from the following description, in which reference is made to the drawings included. In the drawings:

Fig. 1 is a schematical representation of a first embodiment of a device according to the invention.

Fig. 2 is a schematical cross section of another embodiment, altered with respect to figure 1, of a device according to the invention.

Fig. 3 is a schematical cross section of another embodiment, altered with respect to figure 1, of a device according to the invention.

Fig. 4 is a schematical representation of a second embodiment of a device according to the invention.

Fig. 5 is a schematical representation of a third embodiment of a device according to the invention.

Fig. 6 is a schematical representation of a fourth embodiment of a device according to the invention.

Fig. 7 is a schematical representation of a fifth embodiment of a device according to the invention.

Fig. 8 is a schematical representation of another embodiment, altered with respect to figure 7, of a device according to the invention.

Fig. 9 is a schematical representation of a sixth embodiment of a device according to the invention.

Fig. 10 is a schematical representation of a seventh embodiment of a device according to the invention.

Fig. 11 is a cross section of the embodiment according to figure 1, showing the working and the design in greater detail.

Fig. 12 is a cross section of an embodiment altered with respect to fig. 11.

Fig. 13 is a cross section of a device according to the invention, consisting of a number of devices according to figure 11, arranged in parallel.

Fig. 14 is a graphical representation of the mass percentages of the passed and the retained particles, dependent on the particle size of PVC powder.

Fig. 15 is a graphical representation in percentages of the internal and external pore volumes.

Fig. 16 is a graphical representation of the mass percentages of passed and retained particles, dependent on the particle size of a sample based on isododecane.

Fig. 17 is a graphical representation of the incremental pore volume (X-axis) in cm^3/g as a function of the pore radius (Y-axis) in μm of a polypropylene-polyethylene block polymer.

Fig. 18 is an enlarged photographic reproduction of a product to be dried before the experiment.

Fig. 19 is an enlarged photographic representation of a product to be dried before the experiment.

Fig. 20 is an enlarged photographic representation of the product according to figure 18 after the experiment.

Fig. 21 is an enlarged photographic representation of the product according to figure 19 after the experiment.

In an embodiment of the process according to the invention the particles are introduced between two more or less identically shaped planes, which planes have a relative speed at an angle with the direction in which the particle is moving, with the liquid spun out being sucked off through one or both planes. The velocity of the plane relative to each other creates a gas velocity profile between the planes. The frictional forces acting on the particle and some contact between the particle and the walls cause the particle to rotate. As a result of this rotation, the liquid is spun out. The liquid spun out can be sucked through one or both of the planes or can be separated from the solid particles via sifting in a subsequent process step. The distance h and the relative velocity of the planes are chosen such that the following equation is met:

$$\frac{\rho L \frac{v}{h} \cdot \frac{2}{R}}{R} > \frac{4 T \cos \theta}{d} + \Delta P$$

In this equation:

ρ_L = the density of the liquid

ν = the relative viscosity of the planes with respect to one another

h = the distance between the planes

5 T = the surface tension of the liquid

θ = the contact angle of the liquid

R = half of the diameter of a particle

d = the greatest pore radius in a particle

10 In this embodiment the axis of the planes is, where possible, preferably perpendicular to the direction in which the particles are transported through the device. In that case these are variables that can be set independently.

A first embodiment is shown in figure 1, in which the mentioned planes are the two opposite surfaces of the parallel flat discs 1 and 2, whose axes of symmetry coincide and whose planes rotate in opposite
15 direction around the axis of symmetry in the horizontal plane. If the device is limited to two discs, the product to be treated is introduced between discs 1 and 2 via an aperture 3 in the centre of disc 1.

The air velocity profile generated and frictional forces between the surfaces of the discs and the particles cause the particles to rotate at a velocity sufficient to spin out moisture. In transporting the particles to the circumference of the discs, the moisture within and adhering to the particles is thus
20 effectively removed.

By giving one or both of the discs 1 and 2 a hollow shape and providing the sides facing each other with moisture-permeable walls 5 and 6, as shown in figure 2, and aspirating the moisture through these walls, the moisture spun out of the particles can be removed from the product flow.

The aspiration can be brought about by additionally providing discs 1 and 2 with blades 4 to avoid the need
25 to seal moving parts.

The advantage of this embodiment with respect to the known process is that:

- particles to a very small diameter with fine pore structures can be dried to < 1 wt.%;
- the energy consumption is much lower;
- the process is suitable for particles of any shape;
- 30 -there are no requirements as to the hardness, roughness or impact elasticity of the particles;
- the acoustic emission is much lower.

Example 1 deals with the conditions to be obtained in further detail.

By generating an inwardly directed air flow between discs 1 and 2 in the above embodiment, it is possible to introduce the product to be treated at the circumference and to discharge it from the centre, as
35 illustrated in fig. 3. The discharge tube 7 is then situated in the centre of disc 2.

This process can effect the same removal of liquid and presents the advantage that the product to be treated becomes available on a small cross section, which is an advantage in downstream systems like pneumatic transport systems, pneumatic conveyors, etc.

In a different preferred embodiment the planes are the opposite planes of coaxially arranged hollow
40 cylinders. See figure 4. Feed is indicated by 10, dried product is discharged via 11 and liquid is sucked off at 12.

In another preferred embodiment the planes are the opposite planes of coaxially arranged hollow cones, rotating in opposite directions. See fig. 5, in which 10, 11 and 12 also indicate the inlet, the dried-product outlet and the liquid aspirator. The last two embodiments may be applied in specific cases requiring a more
45 compact design.

It is the most advantageous to remove the liquid via the inner tube or the inner cone. This is indicated in the mentioned figures.

In yet another preferred embodiment the particles are fed through a rotating cloth in the form of a bag. See fig. 6. This process in many respects resembles the embodiment according to fig. 1 and is suitable for
50 drying very fragile particles. The particles are supplied and discharged via 15 and 16, respectively.

In an embodiment operated according to method b), see fig. 7, the particles are supplied radially via a rotating fan 20 with blades 21. The shape and the material of the blade are such that the particles are caused to rotate or bounce as a result of the frictional force acting on them along the blade and that they bounce and rotate in such a manner that the internal and external moisture is forced out. The frictional
55 reaction force can be composed of components of the centrifugal force and/or coriolis force, resulting from the contact force of the moving blade on the particle. In addition, the pull of the gas flow generated by the blade itself can be used as pull or a gas flow can be applied between the blades, via external devices, of whose pull use is then made.

The moisture can be separated off by giving blade 21 a hollow shape and making wall 22 pervious to moisture or by separating the moisture from the particle flow by sifting. In the removal of the moisture, use can also be made of the secondary air flow generated by the blade.

In a preferred embodiment of this process the fan has straight blades 21. The particles to be treated are supplied in the centre and then roll and bounce across the straight blades towards the circumference, in the process of which the internal and external moisture is effectively spun out and off. The coriolis force on the particles rolling and bouncing towards the circumference provides the normal force required for rotation.

The moisture is removed via the blade, which is pervious to liquid. The rotating motion of the blade itself provides the required suction. The particles are centrally supplied at 23, the liquid being discharged from the device via 24 and the dried product via 25.

The advantages of this embodiment with respect to the known process are:

- particles to very small dimensions and very fine pore structures can be dried with this device to a moisture content of < 1 wt.%, because the particles can be rotated at a very high speed;
- the energy consumption is much lower;
- the design may be much more compact and relatively simple. It is, for example, possible to replace dispersers, which are used in several thermal dryers to which a wet cake is supplied, by a device employing the process according to the invention. Not only can the dispersers be dispensed with, but in addition a considerably smaller amount of water need be supplied to such a device;
- the acoustic emission is also much less.

In another preferred embodiment the blades 21 are curved in such a manner that the frictional force exceeds the force propelling the particles by only very little, which can be achieved by choosing a blade curved specially for that purpose. The rest of the process is the same as described in the previous example. The advantage of this process with respect to the known process is that the normal forces acting on the particles are smaller, which means that less friction and fracture will occur in the case of fragile substances.

In a different preferred embodiment (see fig. 8) the product to be treated is introduced between the blades of a fan, with the curved blades rotating in a direction opposite to the normal rotation direction of a pump impeller. In this process the particles are supplied from the outer circumference of the fan and, under the influence of the forces and, if necessary, an externally generated air flow flowing between the blades from the outer circumference towards the inner circumference, rotate and bounce towards the inner circumference of the blades. If so desired, the moisture may be removed in the manner illustrated in fig. 5. The particles are supplied via 30, the liquid being discharged via 31 and the dry particles via 32.

The advantage of this process is that the treated powder becomes available on a small cross section which is an advantage in the further transport by means of pneumatic systems and in conveying the particles to pneumatic conveyor dryers. (Also called flash dryers or through-flow dryers).

In a different embodiment (according to principle b), the particles are transported across the concave side of a curved surface by pneumatic propulsion. The frictional force resulting from the normal force provides the couple required to rotate the particle. The frictional force must be sufficient to ensure that the particle rotates at the required speed. This is achieved by selecting a plane with a suitable curvature and of a suitable material (coefficient of friction between the particle and the plane) and ensuring that the particle moves across the curved plane at a sufficiently high speed.

In the case of non-round particles, the normal force must be so small as to ensure that the couple of the pneumatic propulsive force always causes the particle to tilt. It must be ensured that the particles can rotate individually. If so desired, the curved surface may have rotational motion to increase the residence time of the particle in the apparatus or reduce any normal force. In a preferred embodiment the particles are introduced, by means of an air flow, between curved surfaces, if so desired of similar shape. The distance between the two surfaces must be chosen such that the energy is as low as possible at the required air velocity.

In this process it is advantageous to select, where necessary, several surfaces of the same shape, and, where necessary, fit these together in the form of a coil. The liquid can be separated off by ensuring that the curved surface is pervious to liquid and removing the moisture by suction. An advantage of this process with respect to the already-mentioned process is that it requires no moving parts.

In another preferred embodiment of this embodiment the air flow is generated by a blade moving along the curved surface. The surface of the roll path may then be a circular, curved plate with a product supply 40 and discharge 41, as shown in fig. 9. The liquid is removed via 42. The air flow generated by the blades can be used for the discharge of the moisture in the manner illustrated in fig. 10. As a result, the small droplets spun out are discharged at the centre of the roll path. A surface pervious only to liquid is then no longer required to separate off the liquid. The product is supplied and discharged via 50 and 51,

respectively. The liquid is discharged via 52.

The advantages of this embodiment with respect to the known embodiment are:

-a much lower energy consumption;

-particles to a very small diameter with fine pore structures can be dried to < 1 wt.%.

5 Rolling drums and adapted monoclone and cyclone-like equipment may also be used in the latter embodiment (in which use is then made of the classifying effect of this type of equipment). Combination of the illustrated processes can be used to advantage in specific cases.

The device illustrated in Fig. 11 comprises a first circular disc 101 and a second circular disc 102, rotatably mounted parallel and at a short distance from one another. Disc 101 is connected to a shaft 103, which is rotatably mounted, by means of ball bearings 104 and 105, in a frame of which only part 106 is shown.

The shaft can be caused to rotate by means of a gear belt that co-operates with a toothed upper part of the shaft 102 on the one side and, on the other, with a motor which is not illustrated.

The shaft 103 is provided with a hollow passage 110, ending in a central conical passage 115 in disc 15 101. The hollow passage 110 is lined with a stationary tube 112, which is rotatably supported on bearings within the shaft 103, so that the tube 112 is stationary with respect to the shaft 103 when the latter is driven in rotation to rotate.

The side of disc 101 facing disc 102 is provided with an annular recess 120, covered by means of a ring 121 of filter material. Sintered stainless steel powder, available under the trade name Poral-Inox-plate 20 (supplied by Alliages Frittés Metafram), is preferably used for this purpose, but other filter materials may equally be used, provided that they have the required mechanical properties. The recess 120 is connected to the environment via one or more channels 122 and to a vacuum pump, not illustrated, via a channel 123 in disc 101 and a channel 124 in the shaft 103, so that an underpressure can be maintained in the recess 120.

25 Disc 102 is mounted on a shaft 130 which can be driven in rotation in a manner not indicated. Disc 105 is provided with a central passage, through which the conical end 131 of the shaft 130 projects. A number of blades 132 have been moulded on top of disc 102.

The assemblage of discs 101 and 102 and their means of suspension is mounted in a cyclone as - schematically illustrated in figure 1, in which the discs are situated in the top part of the cyclone. An annular 30 recess 141 has been applied in a wall section 140 of the cyclone, on a level with the gap between discs 101 and 102. This recess is covered by a ring 162 of filter material, with the recess 141 being connected to a suction device which is not illustrated. The filter material of ring 142 may be the same as the already-mentioned filter material of the ring 121. However, it may also be of a different material, because the mechanical requirements are much less stringent.

35 The device is operated as follows. Powdered material with a certain moisture content is supplied via tube 112 and is dropped onto the conical part 131, as a result of which it is pushed towards the blades 132, which force the powdered material further towards the circumference of disc 102.

Discs 101 and 102 are caused to rotate, with at least a relative difference in speed, but preferably in opposite directions, in order to realize an as large as possible relative difference in speed. Although the 40 mechanism is not entirely clear, it is assumed that the particles will begin to roll as soon as they are introduced into the gap between discs 101 and 102, which rolling motion is a result of the relative differences in speed between the discs and the differences in speed thus generated between the air layers dragged along.

If the relative differences in speed between discs 101 and 102 are high enough, the centrifugal force in 45 the particles will be sufficient to force the liquid within each particle towards the surface and even spin it off. Part of the liquid thus spun off will be sucked through the ring 121 and the appurtenant recess 120.

While rolling, the particles will move towards the circumferences of discs 101 and 102. This effect can be generated purposely by causing discs 101 and 102 to rotate in a suitable direction and at a suitable speed.

50 As a result, the particles will then leave the gap between discs 101 and 102 with a certain radial velocity component. Any liquid still being released is sucked off via ring 142 and recess 141. The particles themselves are slowed down further in the cyclone, in which process more liquid can be removed from the particles, if required, and collected at the bottom of the cyclone. If so desired, the walls of the cyclone may be provided with sloping baffles, along which the particles can move downwards. This may cause an 55 additional rolling motion, which may effect further drying.

The embodiment according to fig. 2 differs from the embodiment described above with respect to the top disc and the way in which the liquid is discharged.

In this embodiment the top disc 150 is a solid disc without recesses for the discharge of the liquid. A so-called perforated screen 151, as described in further detail in NL-A-7109221, has been applied opposite the circumference of discs 150 and 102. The perforated screen 151 is a finely meshed net, polished smooth on one side, in this case the inside, the apertures in the net becomes wider from the polished side.

5 This can be obtained, for example, by selecting wires with a suitable cross section for the net.

A number of channels have been applied in wall sections 152, which form coil-shaped passages from the outside of the cyclone towards the inside of the cyclone. The orientation of these channels is opposite to the direction in which disc 150 rotates. These channels end just above disc 150 on the inside of the cyclone and ensure an air flow opposite to the air flow created by the air drawn along by plate 150. The result is a practically stationary mass of air above disc 150.

10 This device operates in essentially the same way as the device according to figure 11. However, in this case no liquid is discharged while the particles are still between discs 150 and 102, although the liquid may already be at least partly separated from the powder. As soon as the particles and the liquid leave the gap between discs 150 and 102, they collide against the perforated screen 151. The liquid passes the screen and, in addition, any liquid still remaining on or in the particles is released from the particles and can be removed via the perforated screen. Special devices may be applied for the removal of the liquid between the perforated screen 151 and the inside of the cyclone. Such devices may consist of a collecting duct and a discharge tube.

In the embodiment according to figure 3 a number of discs 167 are mounted on a vertical shaft 160. The shaft 160 is provided with a central passage 130 and is mounted rotatably in bearings 162 and 164. Bearing 162 in turn rests on a housing 161 and bearing 164 on a shaft section 163, which is, in turn, mounted rotatably, via a bearing 163, in a frame 166, in which, if so desired, may be integrated in the housing 161.

The assemblage of circular disc 167 is surrounded by a system of discs 171, which are connected to one another and to the shaft 163. The design of the entire system is such that a disc 171 projects between each successive pair of discs 167. Each disc 171 is provided with a recess 172. At least part of the all of each disc 171 is made of filter material as described with reference to ring 121 in figure 1. On the side furthest removed from the shaft 160, each recess 172 leads into a circular duct 174, with a U-shaped cross section, which is shown only on the right-hand side in fig. 3, which duct 174 leads to outside the device, via a channel 175 through a wall 176, with each channel 175, if necessary, being connected to a device for generating an underpressure, which is not illustrated.

This device is operated as follows.

The shafts 160 and 163 are driven at relatively different speeds, preferably in opposite directions. Powdered material from which liquid is to be removed is supplied via the central passage 180 and at least part of this powder is at each disc 171 diverted, via means not illustrated, from passage 180 and is then directed through the radial apertures in the shaft 160 to the gap between discs 167 and 171. The means referred to may consist of blades or baffles with which at least part of the falling powder can be retained and directed towards the radial openings. In this manner the supplied powder can be distributed to the various levels, while any excess powder can be discharged via a passage in shaft 163 in order to be recycled.

40 The rolling drying process then takes place at all levels between each pair of discs 167 and 171, as described with reference to figures 11 and 12.

The liquid separated off in this process can be discharged via recess 172, duct 174 and channel 175. The powder particles are discharged via openings 163 between two successive discs 171 and drop to the bottom, where they are collected.

45 In this manner a number of devices according to figure 11 or 12 can be connected in parallel.

Example 1

50 The product is introduced into a device as schematically represented in fig. 1, consisting of two flat, round, horizontally mounted discs, whose axes of symmetry coincide, which discs are set 2.5 mm apart and have a relative speed with respect to one another. The water particles spun out are separated off by means of classification outside the device. The product is introduced between the plates via an aperture in the centre of the top plate.

55

Experiment 1

The particles to be dried are in powder form, the principal size of the particles being 10 μm . Figure 14 shows the particle size distribution, the X-axis being the size of retained particles in mass %, the Y-axis being the size of the particles passed in mass % and the Z-axis being the particle size in μm . The powder has an internal pore distribution as illustrated in fig. 15, the X-axis being the pore radius in μm and the Y-axis being the pore volume in % of the total partial volume.

10 Experiment 1a

The product supplied is a wet filter cake containing 30 wt.% water. The two discs rotate in opposite directions, the top discs rotating at a speed of 3375 rpm and the bottom disc at a speed of 3545 rpm. When the product has been introduced between the discs 1 $\times$ and the water has been removed by
15 classifying the treated product, the product still contains 16.4 wt.% moisture. A second treatment of this product results in a moisture content of 6.4 wt.%. A third treatment results in a product containing 0 wt.% water.

Photographs taken with an electron microscope show that the product is not damages. See figures 18 (before drying) and 20 (after drying).

20

Experiment 1b

The product supplied contains 39 wt.% water. The top disc is stationary and the bottom disc rotates at
25 a speed of 3545 rpm. After having been treated 1 $\times$, the product still contains 22 wt.% water.

After two treatments, the water content is 14.9 wt.%.

After three treatments, it is 6.0 wt.%.

After four treatments, is is 0.3 wt.%.

Photographs taken with an electron microscope show that the product is not damaged (see figures 19 and
30 21, before and after drying, respectively).

Experiment 1c

35 The product supplied contains 24.3 wt.% tetradecane. The top disc rotates at a speed of 3375 rpm. The bottom disc rotates at a speed of 3545 rpm.

After having been treated 1 $\times$, the product contains a residual 21.0 wt.% liquid.

After having been treated 2 $\times$, the product contains a residual 18.4 wt.% liquid.

After having been treated 3 $\times$, the product contains a residual 15.7 wt.% liquid.

40 After having been treated 4 $\times$, the product contains a residual 13.5 wt.% liquid.

Experiment 1d

45 The product supplied contains 25 wt.% isododecane.

The top disc rotates at a speed of 3375 rpm and the bottom disc at a speed of 3545 rpm.

After having been treated 1 $\times$, the powder still contains 2.9 wt.% isododecane.

50 Experiment 2

The particles to be dried have a particle size distribution as illustrated in figure 16, the X, Y and Z-axis being the same as in figure 14. The principal size is 350 micrometers. The particles have an internal pore structure as illustrated in fig. 17. The product supplied contains 77.6 wt.% isododecane
55 (pentamethylheptane). After having been treated 1 $\times$, the product still contains 1.1 wt.% liquid.

Example 2

The device consists of a fan with straight blades as shown in fig. 7. The liquid is discharged through the material of the blade. The fan rotates at a speed of 400 rpm.

- 5 The product to be treated is the same as in example 1 and contains 39 wt.% water and is supplied to the inside of the blades. After one treatment, the water content of the product leaving the outside of the blades has decreased to 4.1 wt.%.

10 Example 3.

The device consists of a circular, curved roll path in which a blade rotates (See fig. 10).

The diameter of the roller path is 260 mm.

The diameter of the blade is 250 mm.

- 15 The speed of the blade S is 3750 rpm.

The roller path is made of sintered metal.

The product has an initial moisture content of 45 wt.%.

After treatment for 15 seconds, the residual moisture content is 30 wt.%.

After treatment for 30 seconds, the residual moisture content is 12.5 wt.%.

- 20 After treatment for 60 seconds, the residual moisture content is 0.5 wt.%.

Claims

- 25 1. Process for drying solid, porous, liquid-containing particles, characterized in that each particle is caused to rotate individually, at such an angular velocity that the resultant force or forces on the liquid on and within the particle exceeds or exceed the forces binding the liquid to and in the particle, the liquid removed from the particle being separated off simultaneously or in a next process step.

- 30 2. Process according to claim 1, characterized in that the particles are introduced between two more or less equally shaped planes, which planes have a relative speed at an angle with the direction in which the particle is moving, with the moisture spun out and off being sucked off through one or both planes.

3. Process according to claim 1, characterized in that the particles are fed through a rotating fan-shaped device with blades, with the geometry of the blades being such that the particles are caused to rotate across the surface of the blade and the moisture spun out and off is removed via the surface of the blade.

- 35 4. Process according to claim 1, characterized in that the particles are caused to rotate over the concave side of a curved surface.

5. Process according to any one of claims 1-4, characterized in that a gas flow is used to transport the particles.

- 40 6. Process according to any one of claims 1-5, characterized in that the particles and the moisture removed from the particles are separated in a classifying device.

7. Device for treating powdered material, consisting of a first and a second surface, which two surfaces are of equal shape and are arranged parallel and at a short distance from each other and

-means for driving these surfaces at relatively different speeds,

- means for feeding the powdered material to the gap between the two surfaces,

- 45 -means for removing the powdered material from the gap between the surfaces,

-and means for discharging the liquid separated from the powdered material.

8. Device according to claim 7, characterized in that the surfaces are cylindrical and that powdered material is supplied near one end and discharged near the other end.

- 50 9. Device according to claim 7, characterized in that the surfaces are conical and that powdered material is supplied near the top and discharged near the bottom.

10. Device according to claim 7, characterized in that the surfaces are circular and that powdered materials is supplied near the centre and is discharged near the edge.

11. Device according to claim 7, characterized in that at least one of the surfaces is coated with porous material, which is connected to a discharge duct for the liquid on the side not facing the gap between the
55 two surfaces.

12. Device according to claim 11, characterized in that an underpressure is maintained in the discharge duct.

13. Device according to any one of claims 7-19, characterized in that a perforated screen is installed opposite the place where the powdered material is discharged from the gap between the two surfaces.

14. Device substantially as described and illustrated in the appended figures.

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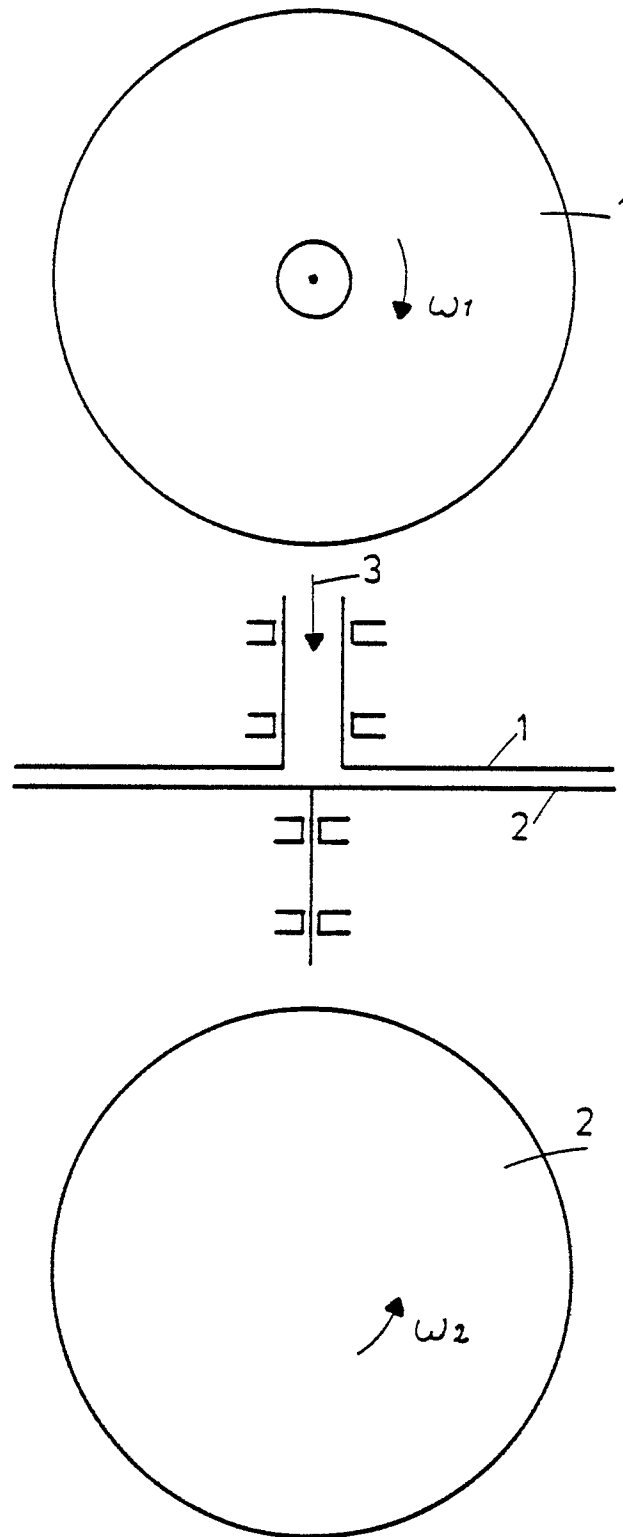


FIG.1

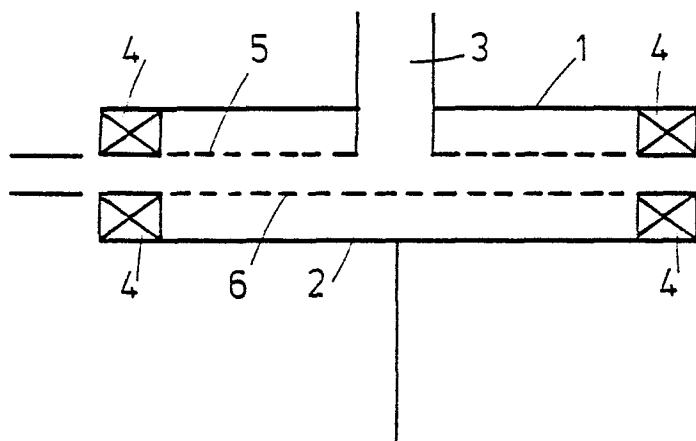


FIG. 2

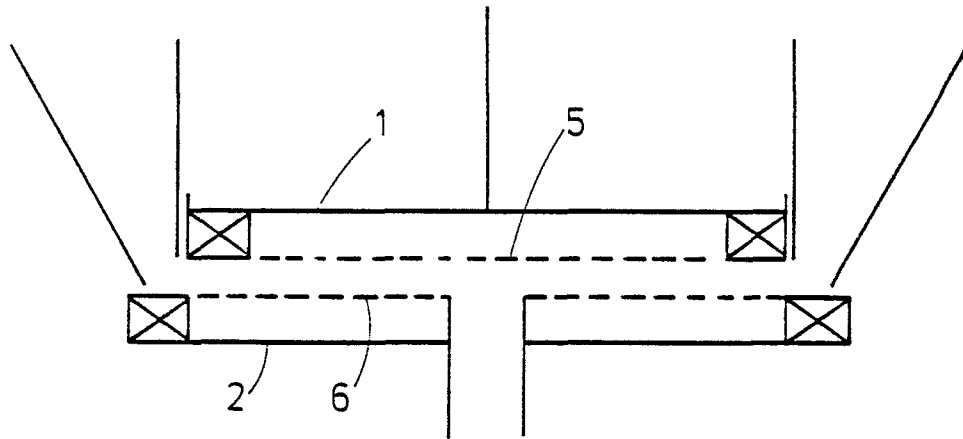


FIG. 3

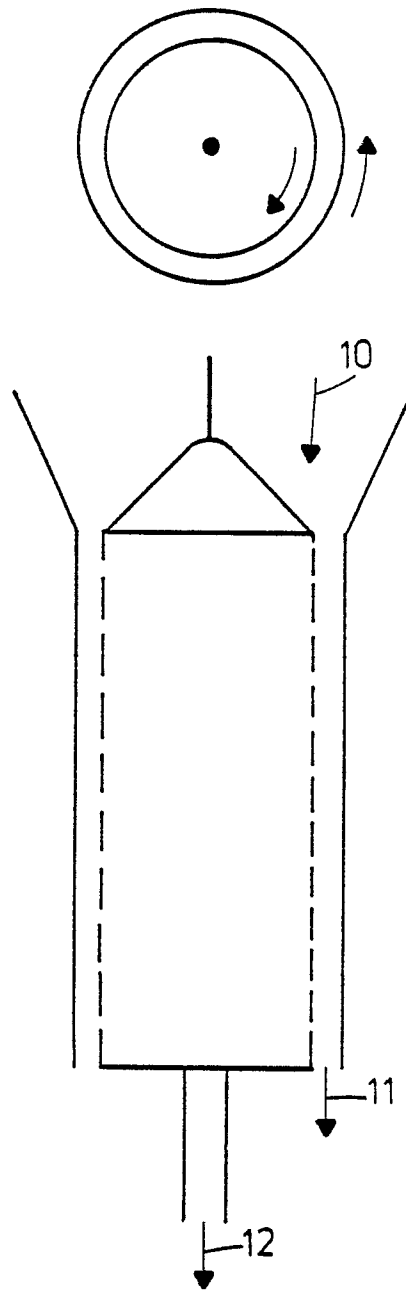


FIG.4

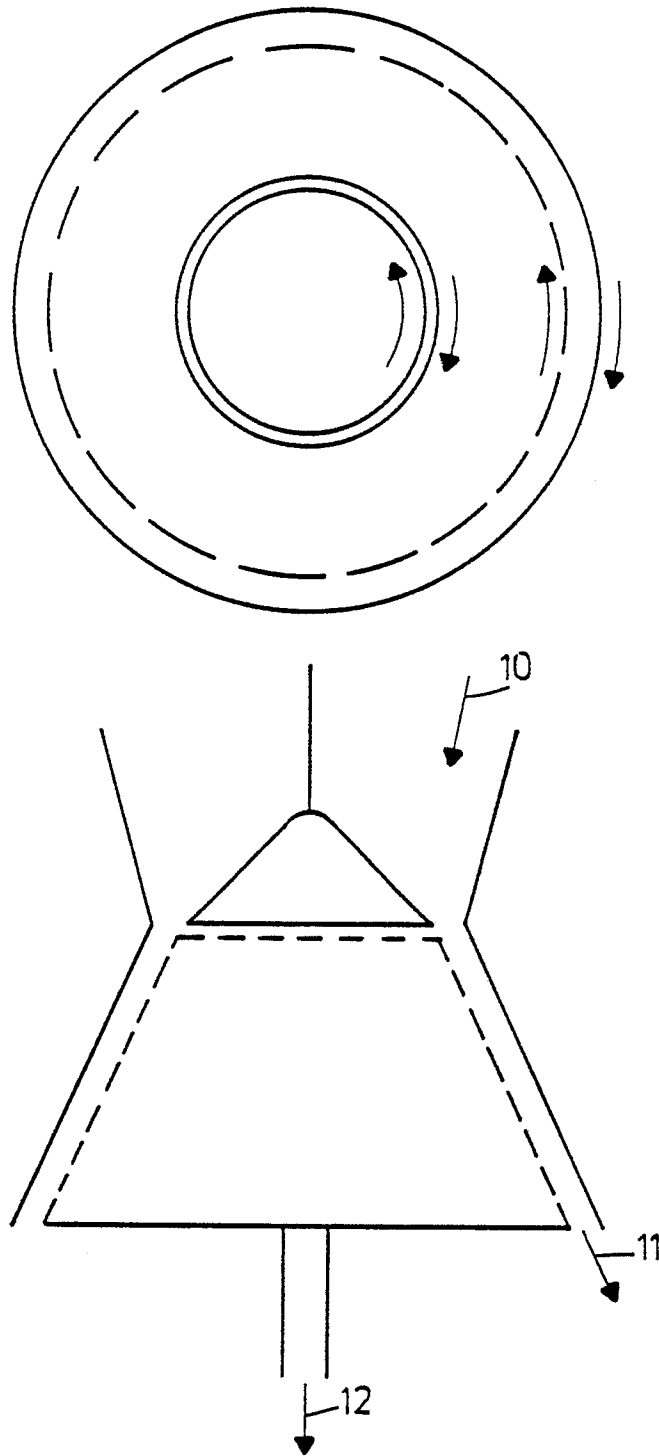


FIG.5

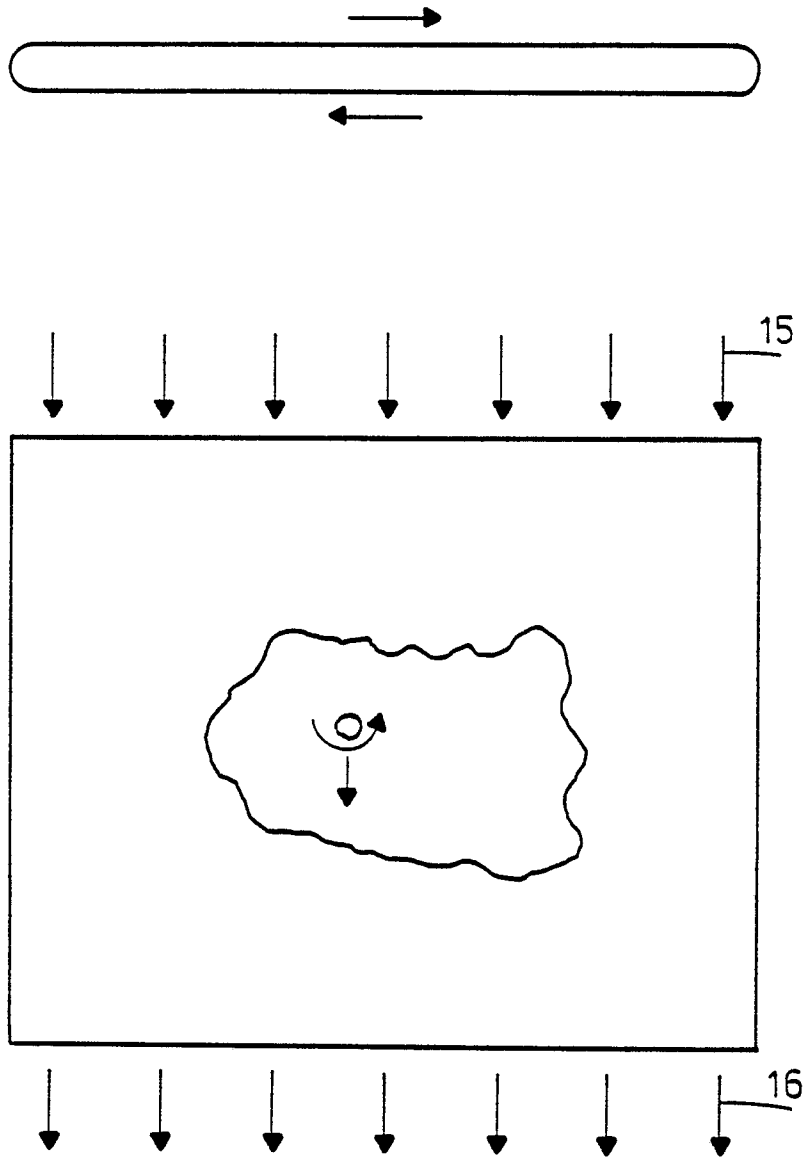


FIG.6

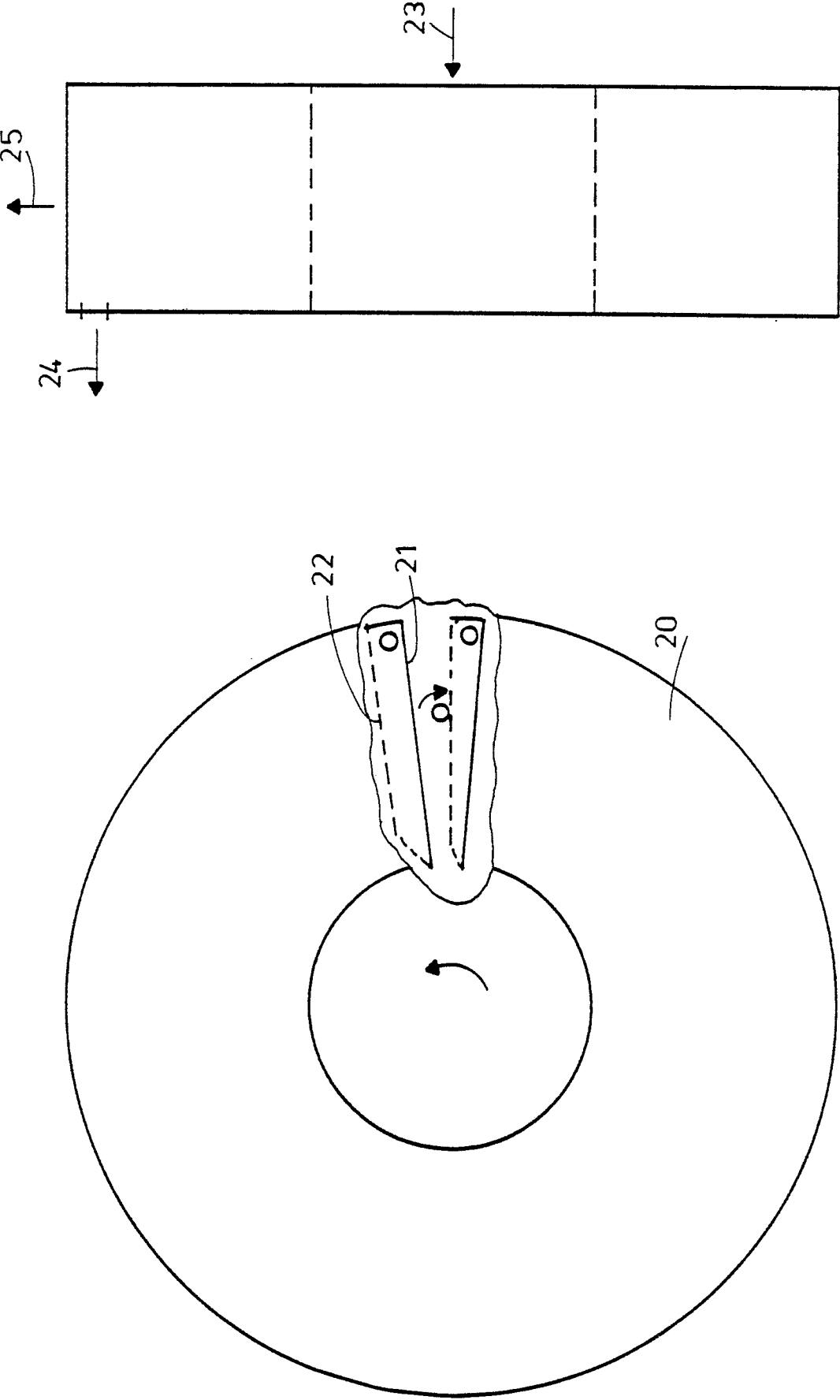


FIG. 7

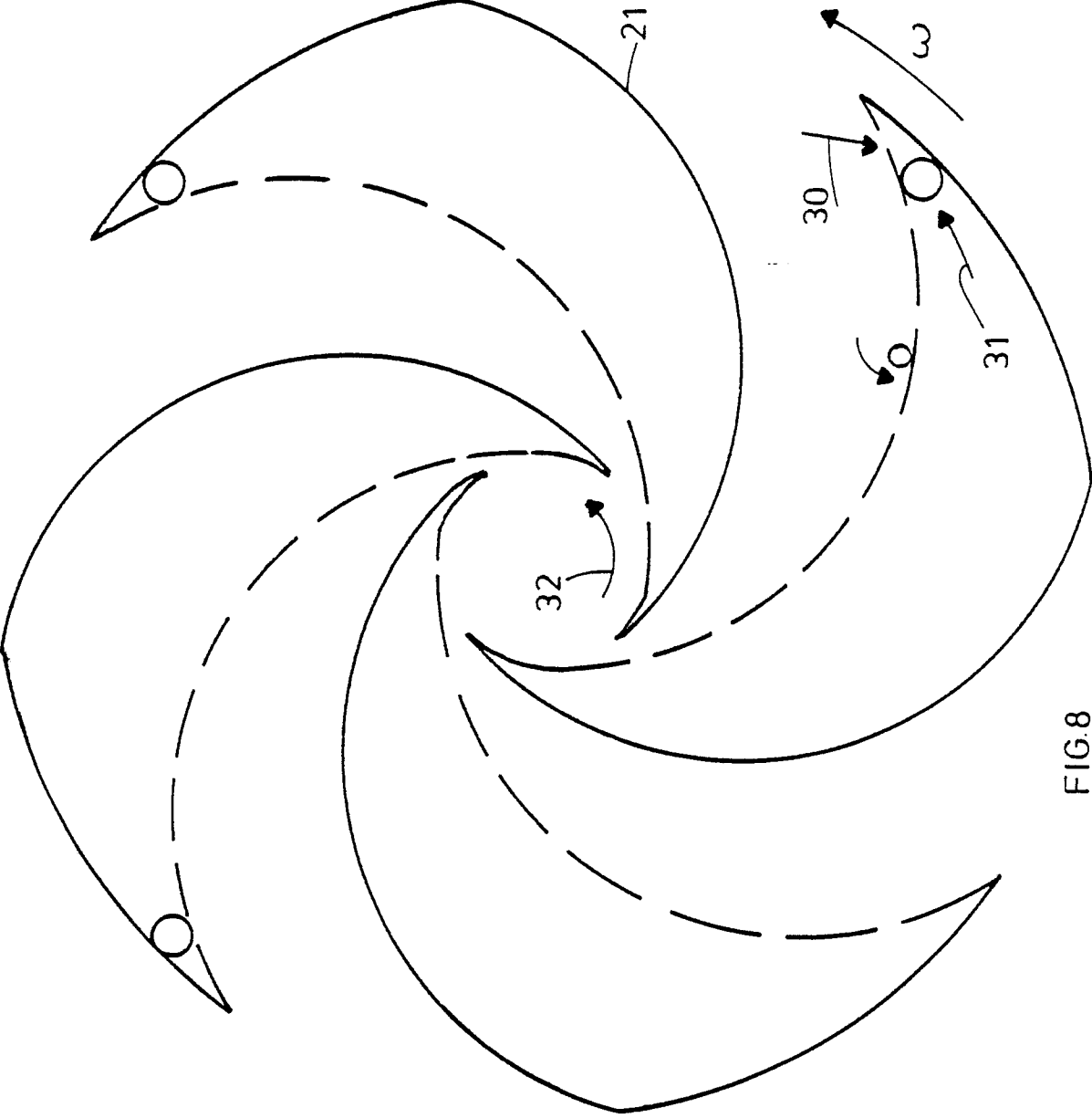


FIG.8

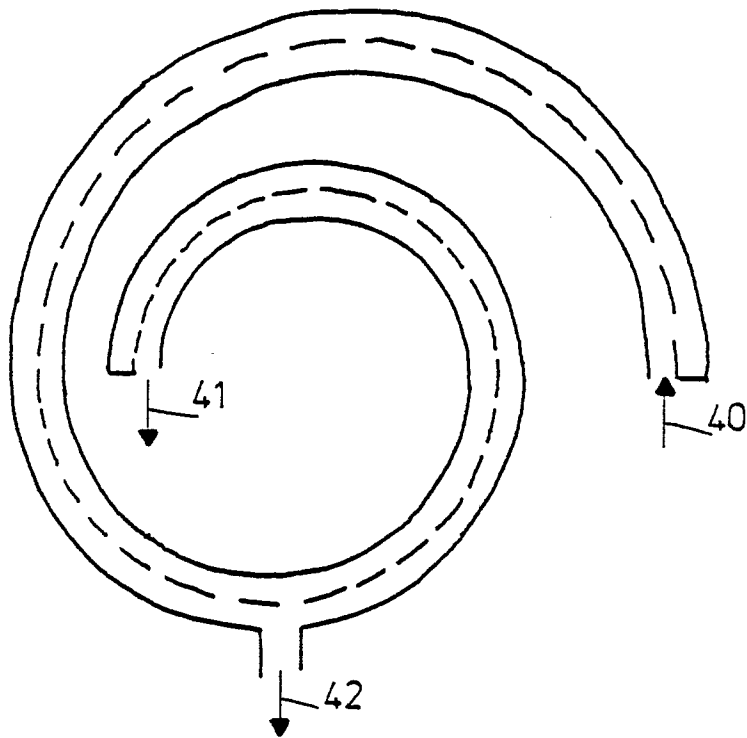


FIG. 9

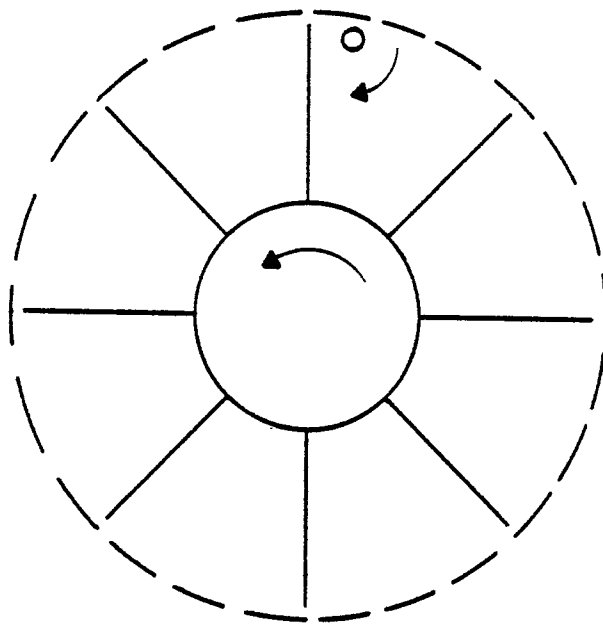
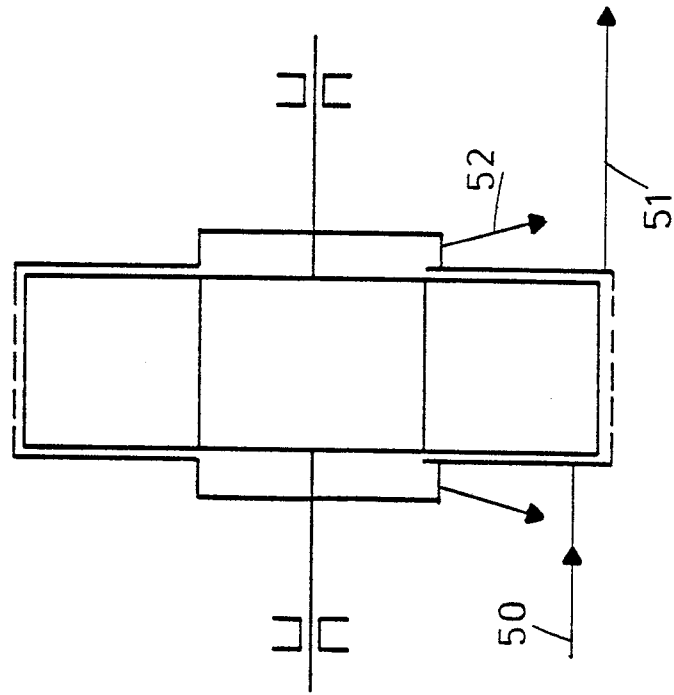


FIG.10

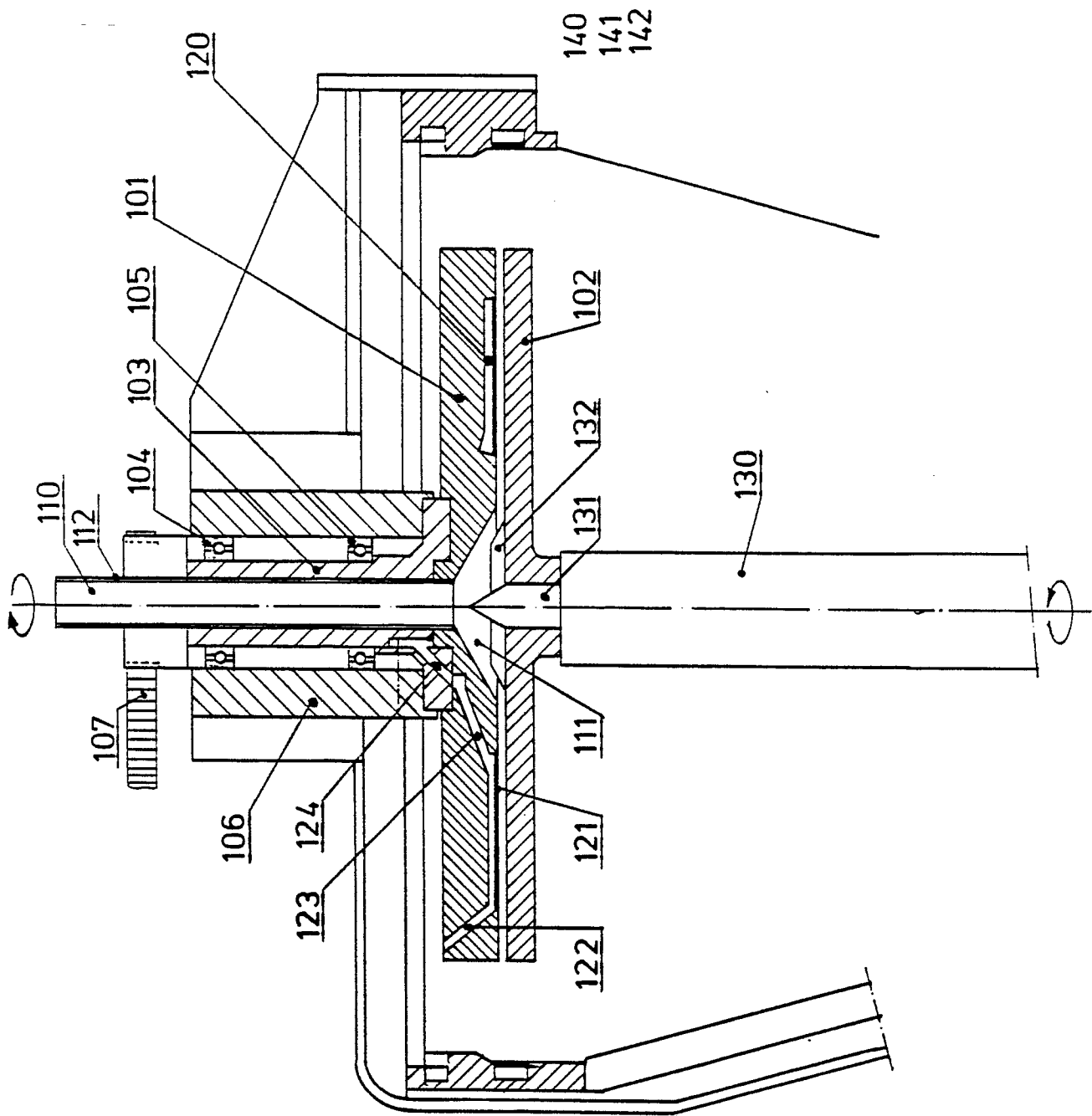


FIG.11

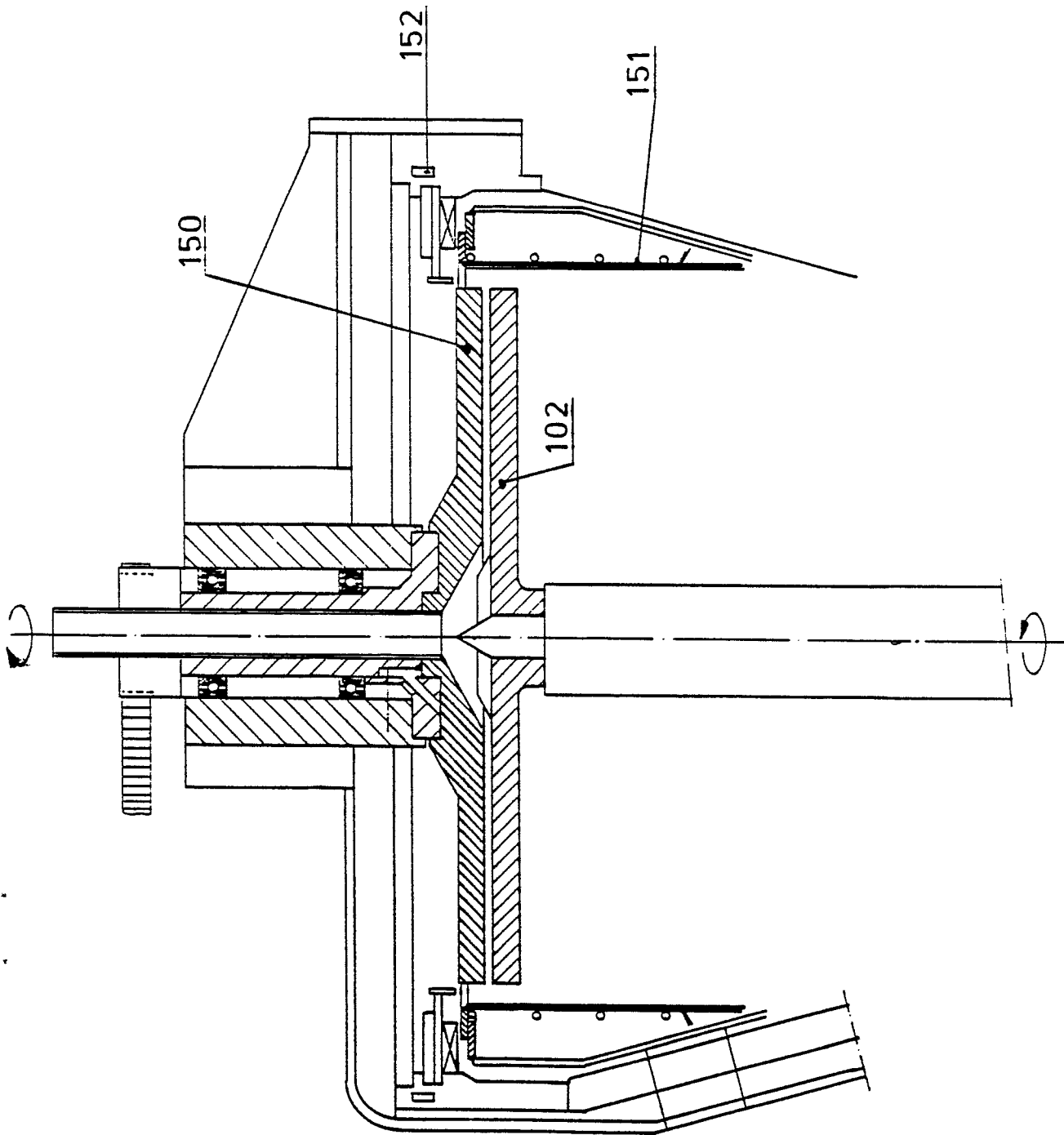


FIG.12

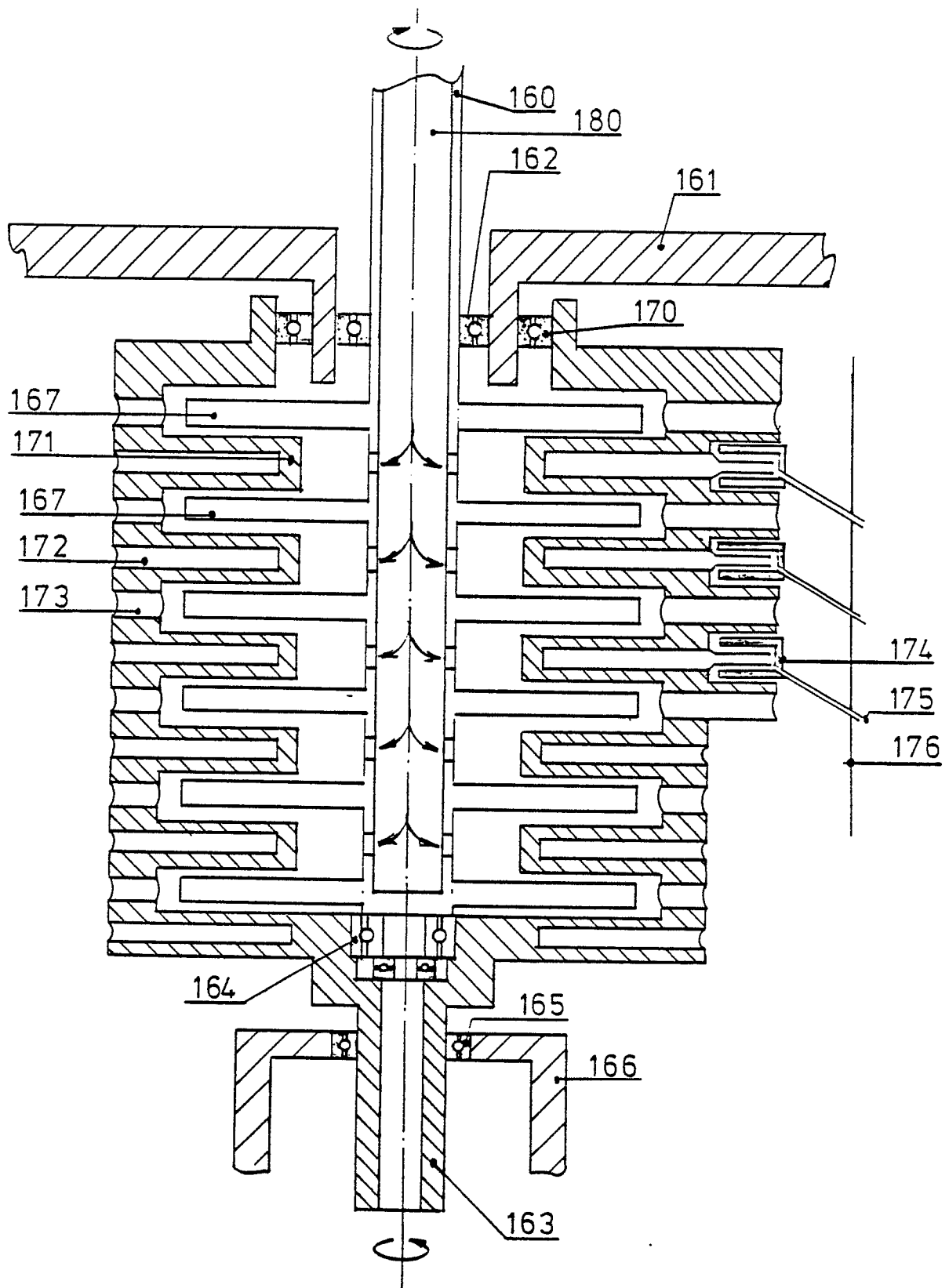


FIG.13

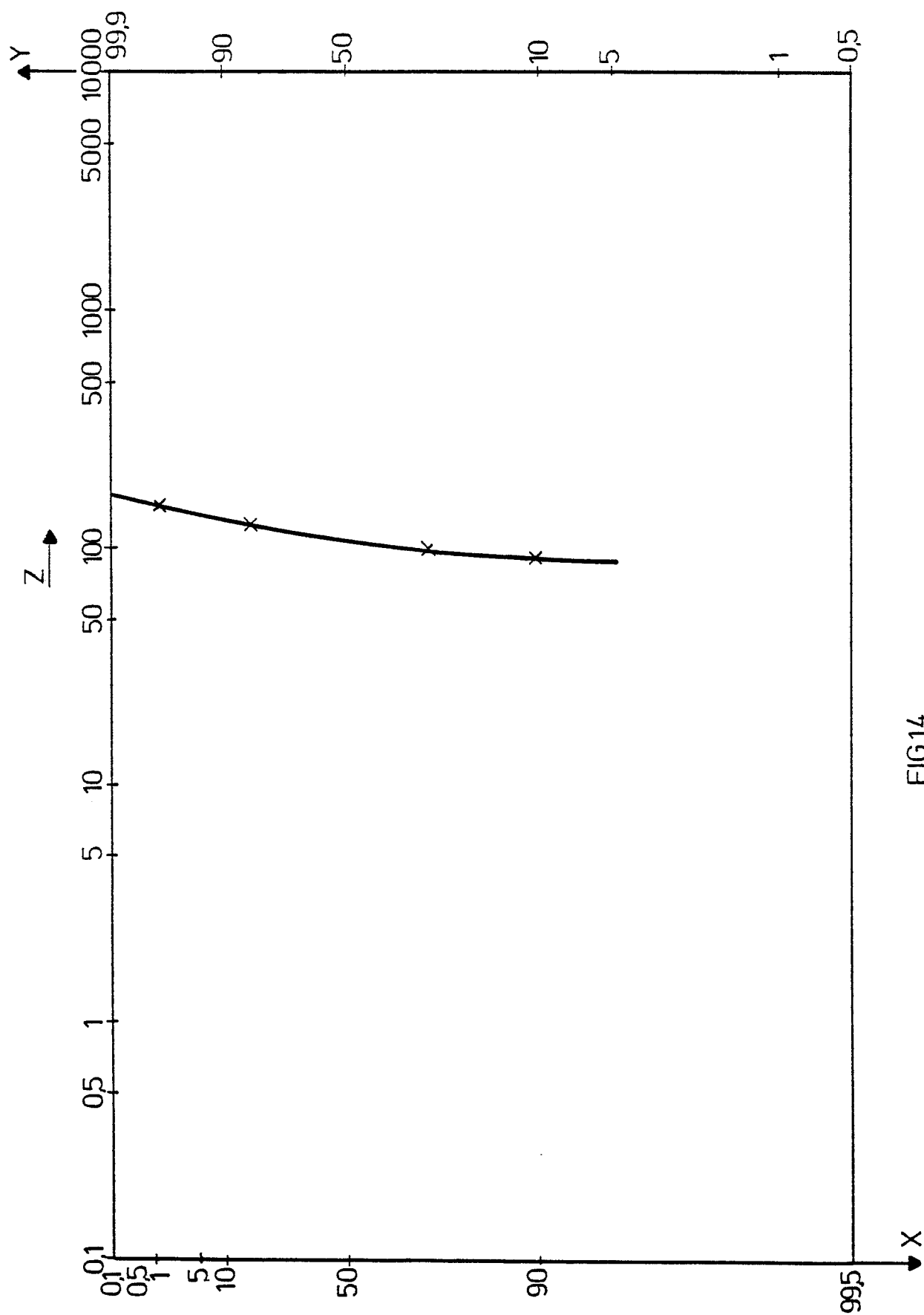
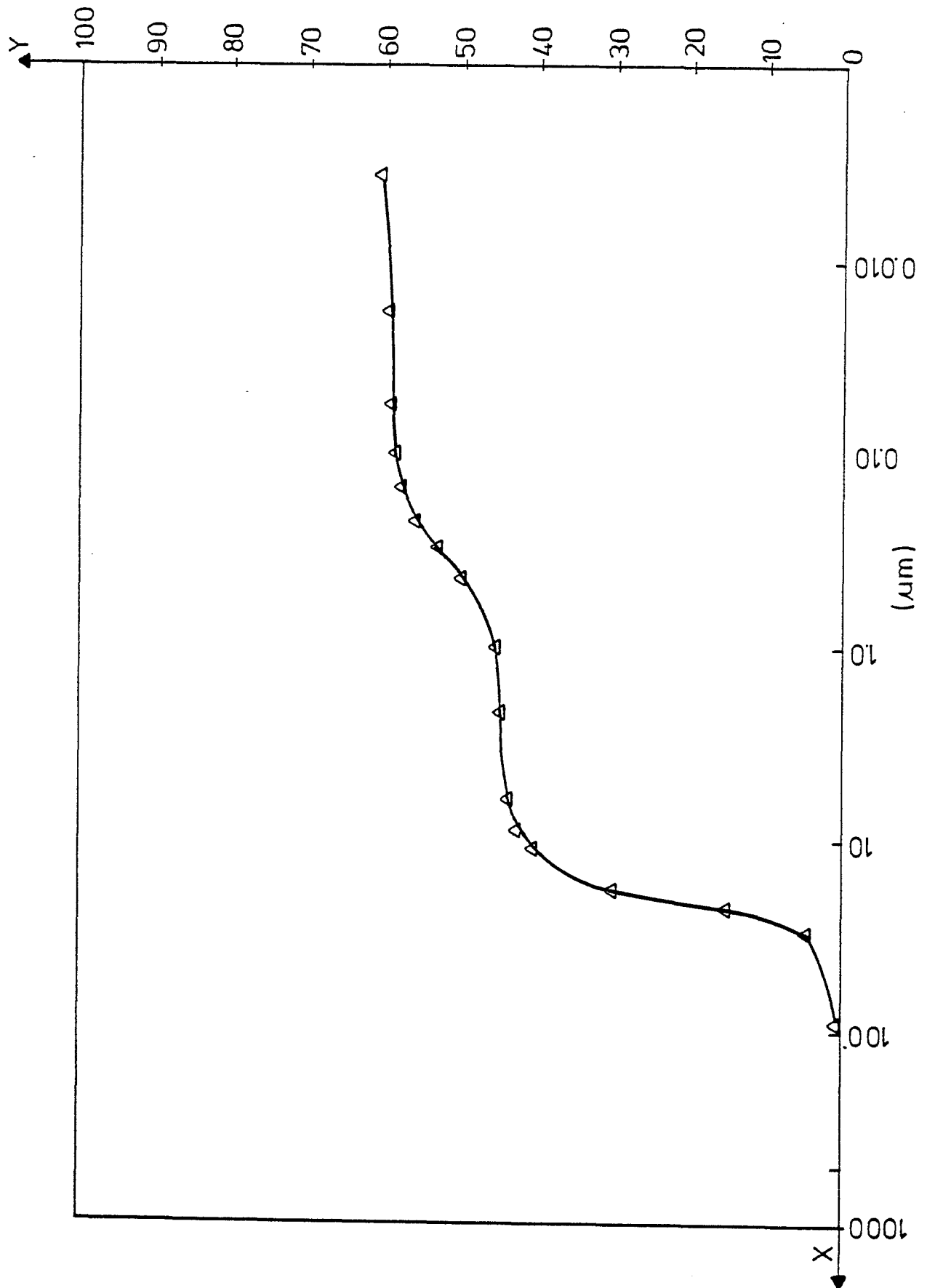


FIG.14



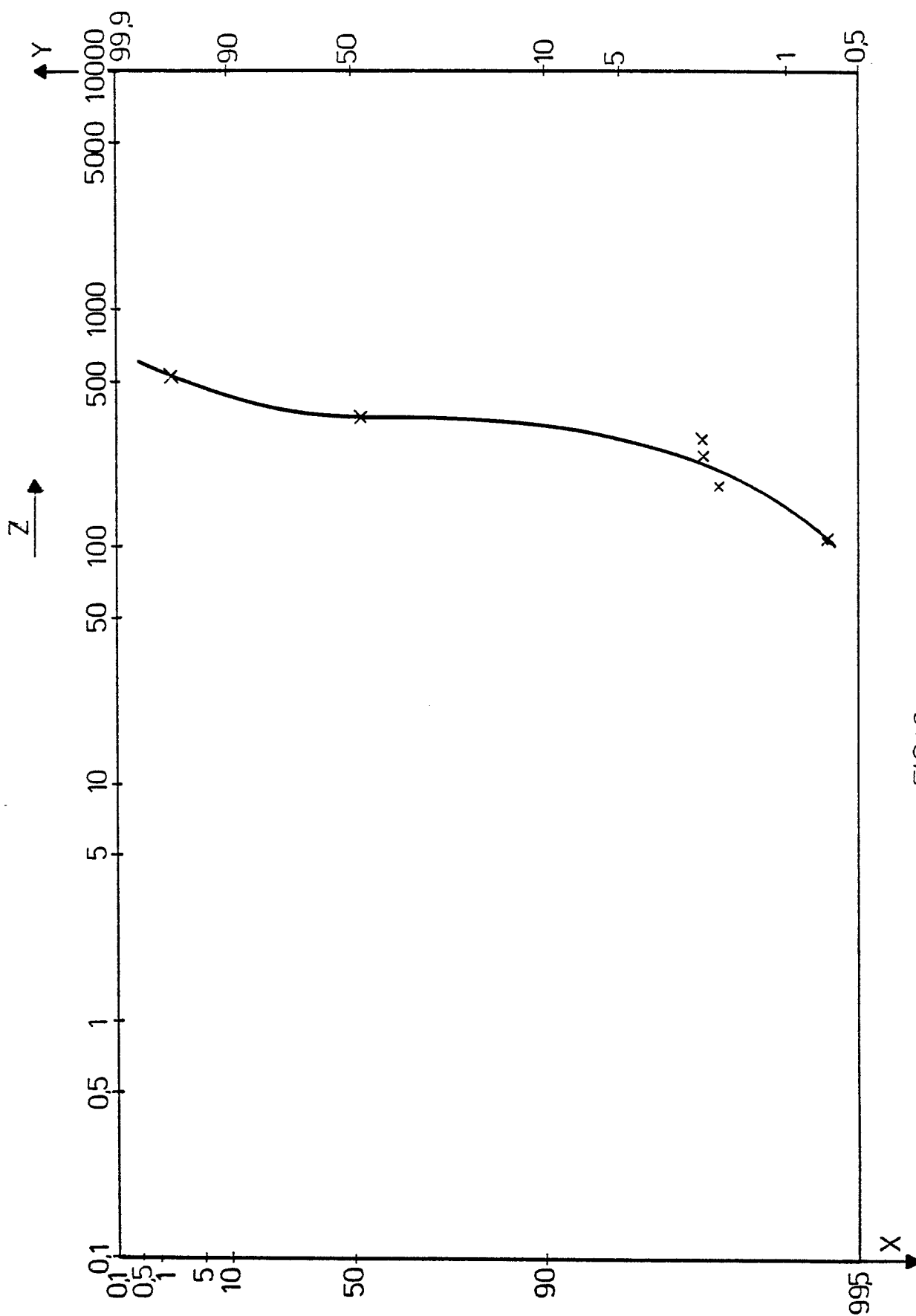


FIG.16

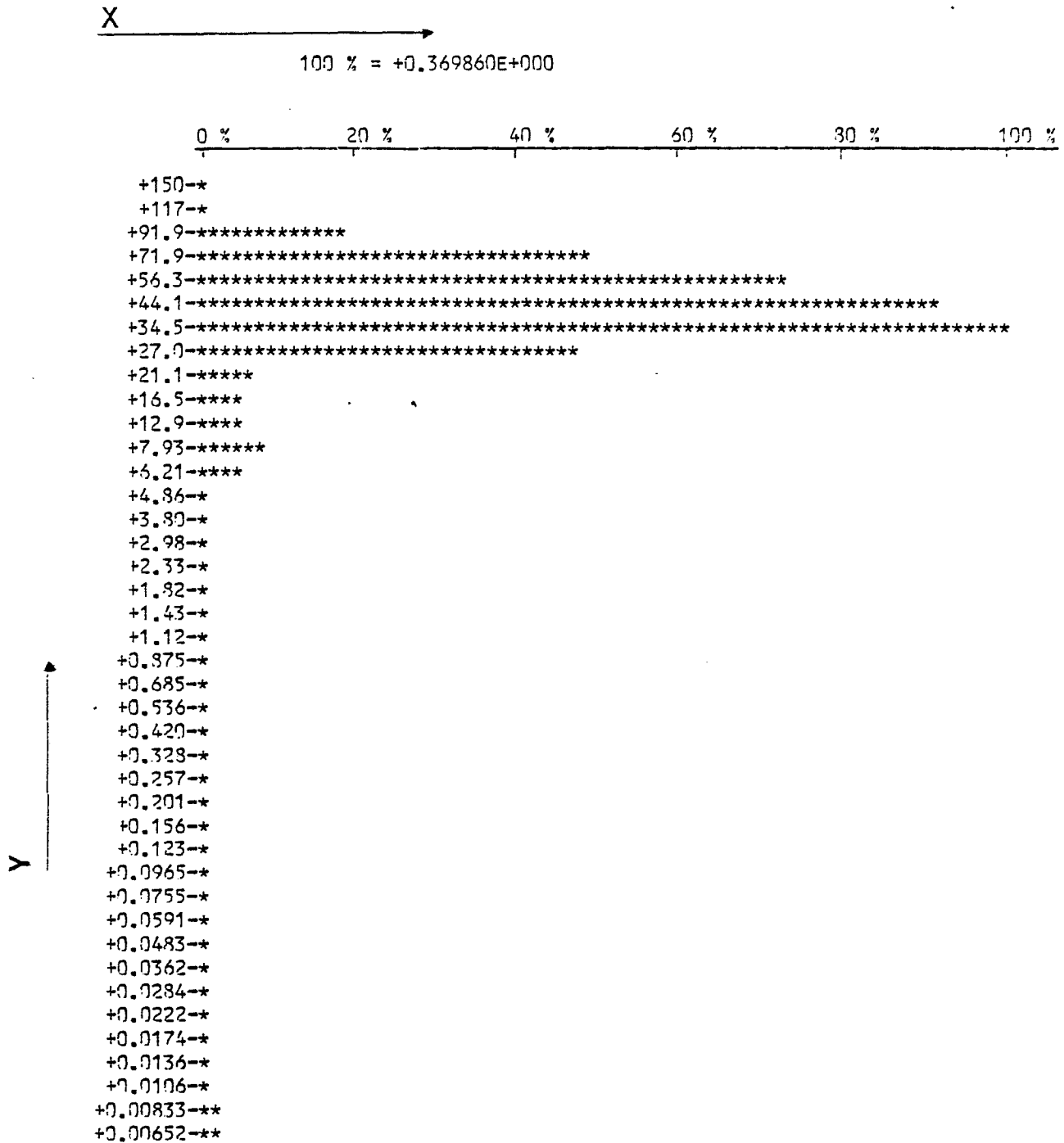


FIG. 17

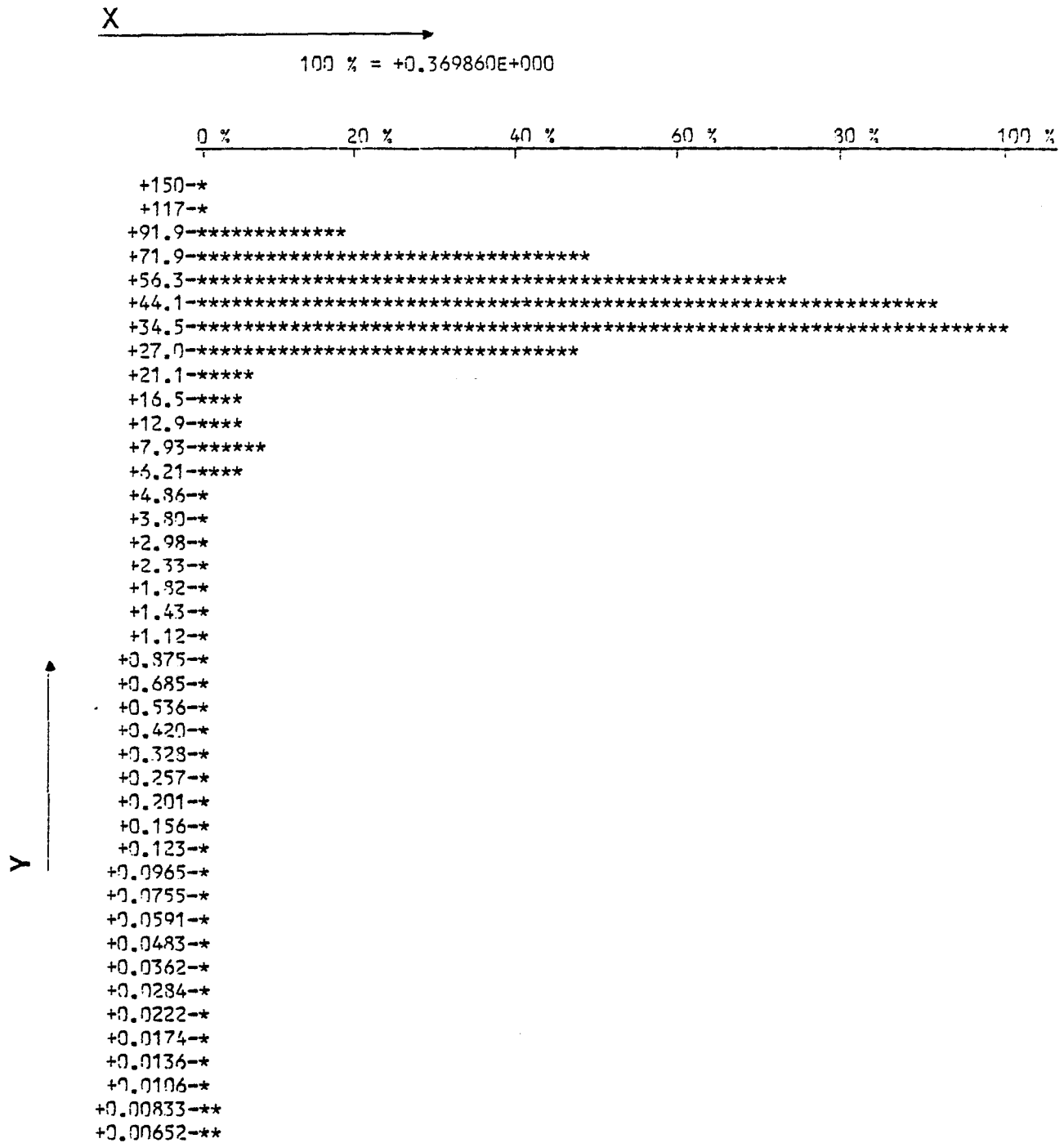


FIG. 17

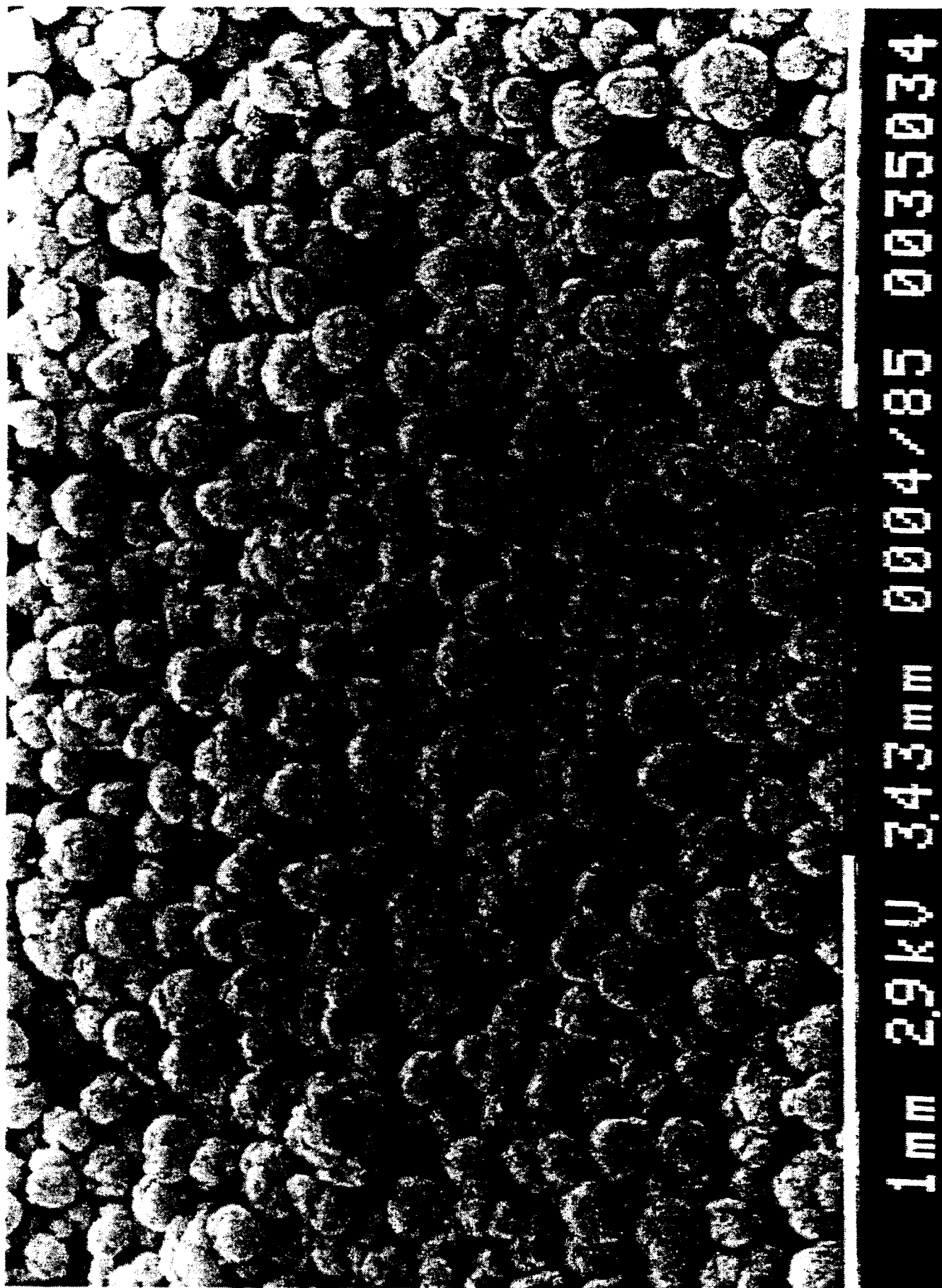


FIG. 18

V= 90



FIG.19

V=400

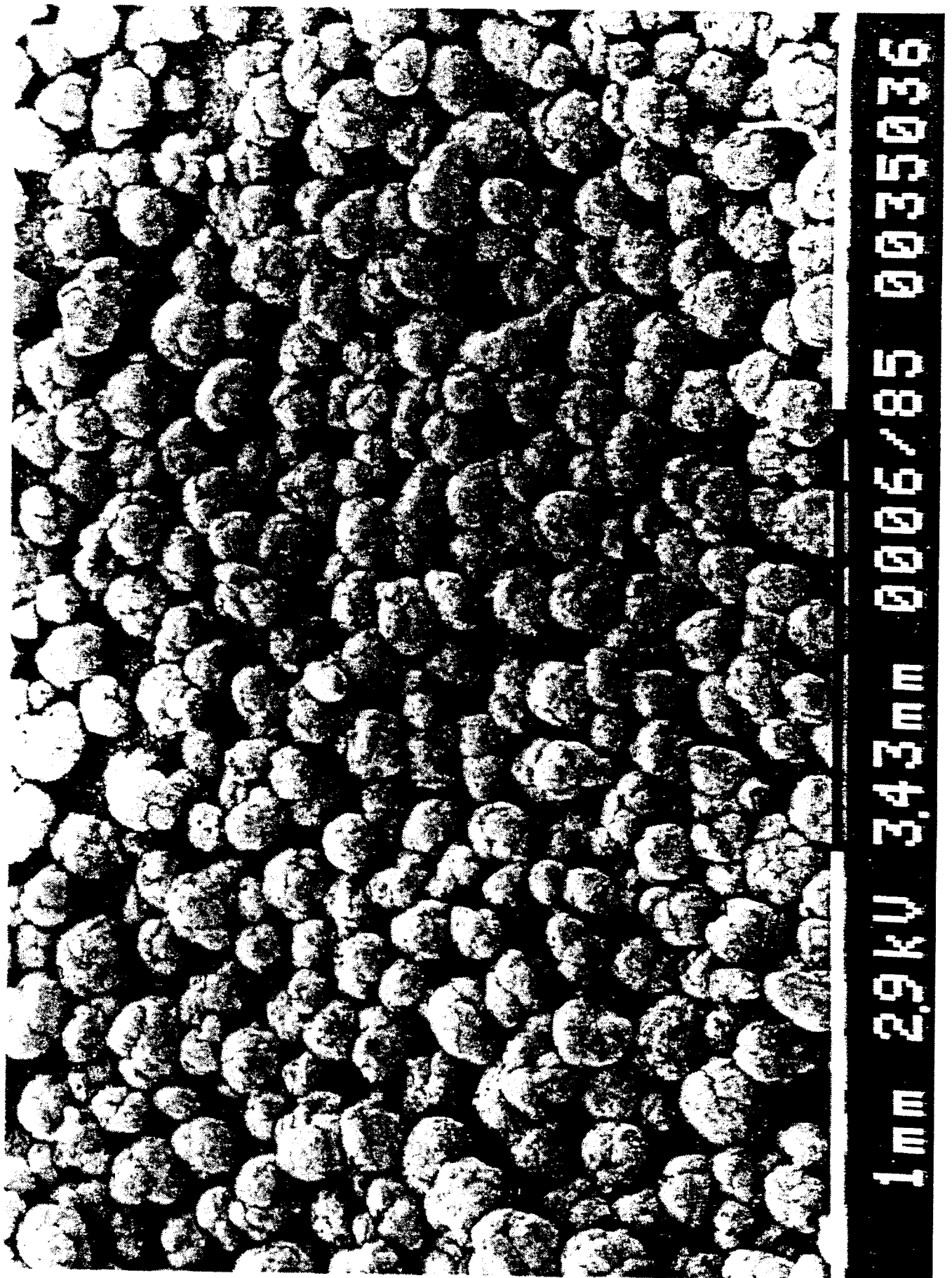


FIG. 20

V= 90

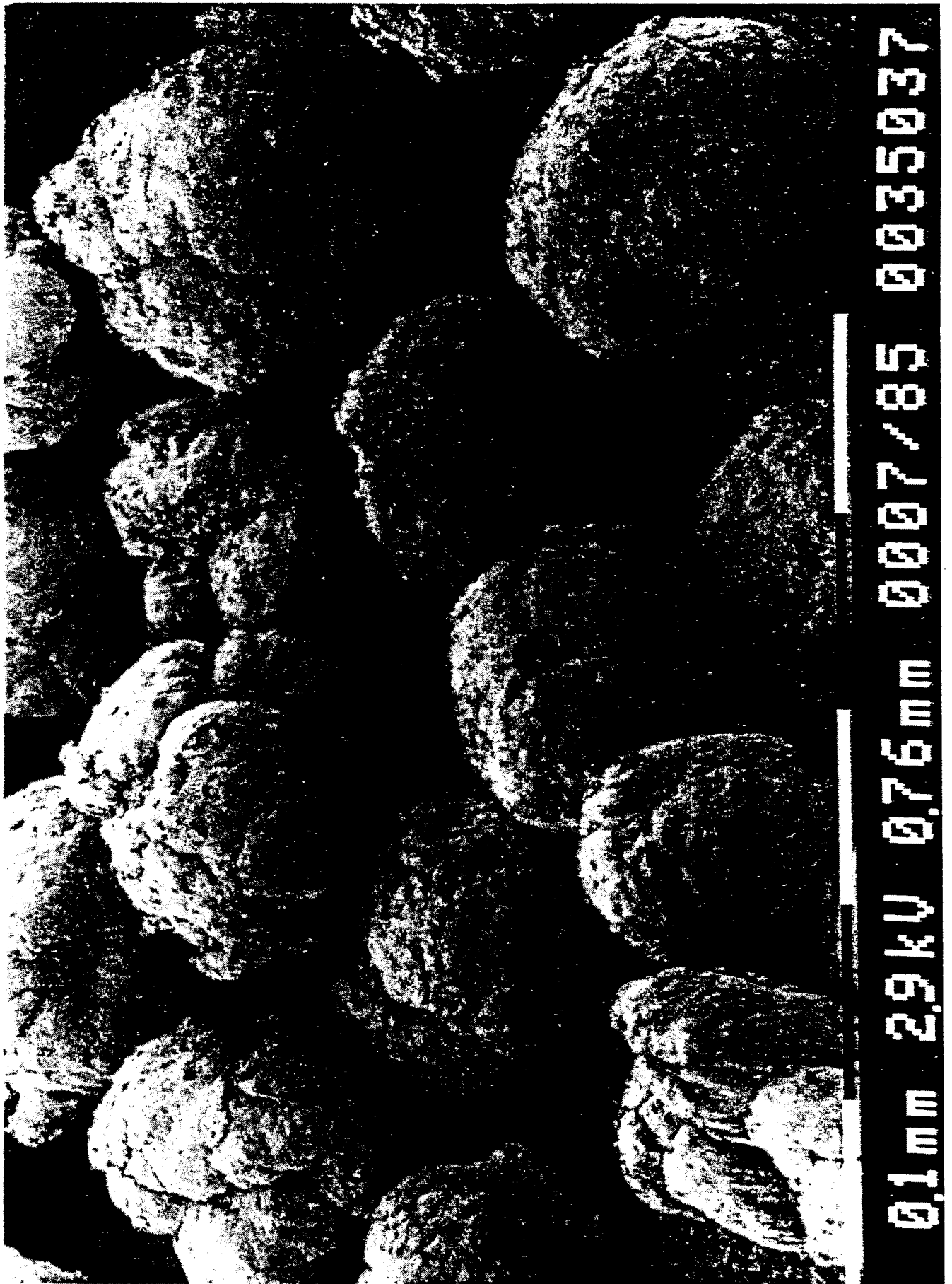


FIG.21

V= 400



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	NL-A-7 109 221 (STAMICARBON) & US-A-3 805 401 (Cat. D)		F 26 B 5/08 B 29 B 13/06 C 08 F 6/10
A	--- GB-A-2 068 764 (KRAUSS-MAFFEI)		
A	--- PATENT ABSTRACTS OF JAPAN, vol. 7, no. 9 (M-185)[1154], 14th January 1983; & JP-A-57 167 208 (KENSAKU NAKAMURA) 15-10-1982 -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			F 26 B B 04 B B 29 B C 08 F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-11-1987	Examiner PESCHEL G.
CATEGORY OF CITED DOCUMENTS			
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