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54 **Process and apparatus for the deposition of bearing alloys.**

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## Description

The present invention relates to alloys suitable for bearing applications and particularly to a process suitable for depositing such alloys.

Where overlays have been applied to bearings by electroplating techniques they have conventionally been applied by plating in well-known plating vats or baths with the bearings being totally immersed in the plating solution.

Particular problems arise in the deposition of overlay alloys on aluminium alloys as distinct from other bearing alloys such as those based, for example, on copper.

Most plating of overlays comprising, for example, lead or tin-based alloys has been carried out either in fluoroborate plating baths which are highly acidic in nature or in other, also highly acidic, plating solutions. Such plating methods involve a lengthy series of process steps. Firstly the bearing surface must be cleaned and provided with what is normally known as a zincate layer to inhibit reoxidation of the cleaned aluminium alloy surface and to promote adhesion of the subsequent interlayer. An interlayer, often of nickel, copper or an alloy based on one of these metals is plated on top of the zincate layer. The primary purpose of the interlayer is to protect the zincate layer from corrosive attack by the fluoroborate or other acidic plating solution from which the overlay alloy is to be deposited.

This plating sequence brings with it its own specific problems. The principal problem of these relates to the inter layer. There is evidence to suggest that the presence of the interlayer tends to render a bearing more seizure-prone when the co-operating shaft wears through the overlay. A further problem also related to the interlayer concerns the change in alloy composition of the deposited overlay. Where, for example, lead-10% tin is plated onto a nickel interlayer a diffusion effect at engine operating temperatures tends to cause depletion of tin in the overlay by reaction with the nickel. The effect of tin depletion is to render the overlay more prone to corrosion. The overall effect of the presence of the interlayer is to render the bearing alloy system unstable over its operational life perhaps even shortening the operational life of the bearing.

Other less acidic plating systems do exist but are very much more expensive; in some cases the cost of the overlay plating solutions may be very high and not commercially viable. Therefore, such plating solutions may be dismissed on the basis of cost alone. It has been found, however, that even where such expensive solutions are used, the long term integrity between the overlay and the zincate layer is questionable as corrosion between overlay and zincate layer in hot oil has been observed. Tin

and zinc is known to comprise a corrosion couple which has resulted in the complete delamination of the overlay from the zincated aluminium alloy.

A process has now been discovered which permits the direct plating of overlay onto the aluminium or aluminium alloy bearing surface without the need for intervening zincate and other interlayers.

According to the present invention, there is provided a process for the electro-deposition of a uniform coating thickness of an overlay-type alloy, selected from the group comprising Pb-based alloys, Sn-based alloys, Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn-Co, Sn, Sn-Cu, Pb, Pb-In, In, Sn-In, Sn-Sb-Cu and Cd-Ni onto a bearing material, the process comprising the steps of cleaning the bearing material surface, providing relative motion between the bearing material surface and a porous pad in contact with the surface, providing a flow of electroplating solution to the porous pad which is in contact with the bearing material surface whilst applying a voltage difference between the bearing material surface which is cathodic and an anode connected to the porous pad characterised in that the bearing material is aluminium or an aluminium alloy and the overlay is deposited directly onto the surface.

The method is generally known as brush plating and is described in GB-A-760,016 but, however, has not been used for the deposition of lead, tin or cadmium based overlays directly to the surface of an aluminium alloy bearing material.

Relative velocity between anode and surface being plated preferably lies within the range 0.05 to 2 m.s.<sup>-1</sup> and more preferably in the range 0.1 to 1m.s.<sup>-1</sup>.

The porous pad may comprise a covering on the anode.

The method has proved to show unexpected benefits in the plating of overlays onto aluminium-based bearing alloys. It has been unexpectedly found possible to deposit overlays directly onto the aluminium alloy substrate without the need for pre-treatments such as zincating and, therefore, without the need for interlayers such as nickel. Furthermore, the method of the present invention reduces the number of cleaning stages to two instead of six as in a conventional plating bath method. This latter benefit clearly has important consequences on the size and cost of the plating plant required and also on the actual processing costs.

In one embodiment of apparatus according to the present invention the bearings may be held in cylindrical pairs and rotated about their axis.

The electrolyte may be supplied to the outside of the porous material or may be supplied by passing through the material from the inside, for example, via the anode itself.

The anode may be cylindrical and mounted on a swinging arm which biases the anode against the bearing surface to be plated.

It has been found that when plating relatively soft alloys of the kind often employed for bearing overlays that a soft, porous textile material is preferable. An example of such a suitable type of material is that sold under the trade name of Selvyt cloth.

In order that the invention may be more fully understood some examples will now be described with reference to the accompanying drawings of which:

Figure 1 shows a schematic part sectioned view of apparatus according to the present invention set up to brush plate pairs of half bearings;

Figure 2 shows a part sectioned side view through one of the plating tanks of Figure 1 and its associated apparatus;

Figure 3 which shows a schematic general arrangement of the bearings to be plated and the plating electrodes etc.

Referring now to the drawings and where the same features are denoted by common reference numerals.

The apparatus comprises a clean and etch tank denoted generally at 10, wash tanks denoted generally at 11 and 12 and a brush plating tank denoted generally at 13. Bearings to be plated 14 are held in a jig 15 which is mounted on a plate 16 which is itself fixed to a shaft 17 of a motor 18. The motor 18 is mounted on threaded shafts 19 which are adapted to move the motor 18 and bearing jig 15 in a direction parallel to the axis of the motor shaft 17. The threaded shafts 19 are themselves part of a gantry 20 having grooved wheels 21 which co-operate with rails 22 which support the gantry 20 for transverse motion with respect to the row of tanks 10, 11, 12 and 13. The gantry 20 is moved along the rails 22 by a chain drive 23 which is controlled by sprockets driven by an electric motor (not shown) having known control means (not shown). The motor 18 is moved parallel to the direction of the shaft 17 by means of the threaded shafts 19 which co-operate with threaded holes in a mounting block 30. The motor is moved by rotation of the shafts 19 which are driven by pulleys 31 and 32 linked by a toothed belt 33, the pulley 32 being driven by an electric motor 34 having known control means (not shown). The clean and etch tank 10 and the plating tank 13 and their associated systems comprise lower collector troughs 40 and upper splash guards 41. Clean and etch or plating solutions are supplied to the tanks 10 and 13 from reservoirs 42 pumped at a controlled rate by peristaltic pumps 43 through conduits 44. Used solutions are returned to the reservoirs 42 from the collector troughs 40 via drain conduits 45, pumps

46 and refrigeration units 47. Solutions are supplied via the conduits 44 to a cylindrical plating brush 50 which comprises a central core 51 of graphite forming the anode the graphite being covered with a sleeve 52 of Selvyt cloth (trade mark). The anode may also comprise non-reactive metals such as, for example, platinum. The brush 50 is mounted on a swinging arm 53 which is pivoted on a shaft 54 held in a support pillar 55. Connected to the swinging arm 53 and brush 50 via the pivot shaft 54 is a motor and clutch unit 56 adapted to move the brush 50 through an arc to bring it into contact with the bore of the bearings 14 to be plated at a controlled load. The wash tanks 11 and 12 have lower collector troughs 60 and upper splash guards 61. The troughs 60 have drain conduits 62 connected to a manifold 63 to take away waste water. Clean wash water is supplied from a pump 64 via a manifold 65 to conduits 66. Water is allowed to access the bearings 14 through conduits 67 by operation of solenoid valves 68. Suitable electrical contacts 70 are provided to make the bearing surface cathodic. A known power supply 71 is also provided to control both voltage, current and time; the power supply 71 also has the facility to change polarity of the electrodes.

Operation of the above apparatus will now be described in relation to the deposition of a tin-cobalt overlay onto an aluminium-20 wt% tin-1 wt% copper bearing alloy. Bearings 14 of 53mm dia and 30mm length and comprising a steel backing having the stated aluminium alloy thereon were degreased in trichloroethylene and loaded into the jig 15 in three sets of two pairs effectively forming a cylindrical tube of bearings. The jig 15 was then assembled onto the plate 16 of the motor 18. With the mounting block 30/motor 18 at the furthest extent of its travel to the left on the threaded shafts 19 the gantry 20 was traversed along the rails 22 until the jig and bearings were opposite tank 10. The bearings 14 were then advanced into the clean and etch tank 10 to allow penetration of the brush 50 into the jig 15. The bearings were then rotated at 120 rev./min. with the bearings anodic at 9 volts whilst 10% hydrochloric acid was pumped into the region where the bearing surface and Selvyt cloth contacted. This was continued for 2 minutes at a current of about 8 amps. The polarity of the bearings was then reversed to cathodic and the process repeated for a further 2 minutes under the same conditions.

The bearings were then withdrawn from the tank 10 and the gantry 20 advanced to the wash tank 11 where they were rinsed with clean water with the bearings rotating at 40 rev./min. The bearings were then advanced to the plating tank 13 where they were plated with a Sn-Co overlay. The plating solution used comprised 50 gm/lit stannous

sulphate, 40 gm/lit cobalt sulphate, 50 gm/lit sodium heptonate and the pH was adjusted to 2 by means of acetic acid. The jig and bearings were rotated at 120 rev./min. with a plating solution flow of approximately  $0.2\text{cm}^3\text{-}1\text{sec.}$  and a brush pressure of approximately  $20\text{ gm/cm}^2$ . The bearings were cathodic at a potential of about 15v with an initial current flow of 8A rising to about 16A. The bearings were plated for a time sufficient to deposit between 20 and 25  $\mu\text{m}$  of overlay. The bearings were then rinsed in tank 12 and dried.

The resulting overlay possessed an average of 8% Co in the Sn matrix.

The resulting plated bearings were tested in a known "Sapphire" testing machine which measures the fatigue rating of the overlay. The testing schedule comprised the following procedure and conditions:

Shaft speed 2800 rev./min.

Initial load 62 MPa

Load increased after 20 hours at each load by 7 MPa until failure

Oil temperature  $80^\circ\text{C}$

Sinusoidal load pattern

Test results of 97, 103, 103, 90 and 90 MPa were obtained on the bearings produced by the method described.

Further bearings were produced with an additional surface treatment of a zincate layer on the aluminium alloy but without an additional interlayer. Fatigue test results on the "Sapphire" machine gave ratings of 62, 62 and 76 MPa demonstrating an adverse effect of the zincate layer.

For the purposes of comparison the same Al-20Sn-1Cu alloy overlay plated with a known Pb-10Sn overlay by a known conventional immersion plating method in a fluoroborate-type bath with zincate and nickel interlayers gives a fatigue rating typically in the region of 70 MPa on a "Sapphire" test rig.

In the above the bearings are themselves rotated, however, it will be appreciated that the anode may be rotated instead or in addition.

The electrolyte may be supplied into the plated surface and anode gap or via the anode itself.

It is envisaged that the method of the present invention could be applied to the plating of continuous strip with overlay. The overlay coated strip may then be processed into bearings by known techniques. Such a process may alleviate one of the most serious drawbacks of the plating of bearings which is the labour intensive and, therefore, costly step of jiggling and dejiggling bearings before and after plating.

The method of the present invention may be applied to many other overlay metals and alloy systems, examples of which may include Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn, Sn-Cu,

Pb, Pb-In, In, Sn-In, Sn-Sb-Cu, Cd-Ni.

### Claims

- 5 1. A process for the electro-deposition of a uniform coating thickness of an overlay-type alloy, selected from the group comprising Pb-based alloys, Sn-based alloys, Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn-Co, Sn, Sn-Cu, 10 Pb, Pb-In, In, Sn-In, Sn-Sb-Cu and Cd-Ni onto a bearing material, the process comprising the steps of cleaning the bearing material surface, providing relative motion between the bearing material surface and a porous pad (52) in contact with the surface, providing a flow of electroplating solution to the porous pad which is in contact with the bearing material surface whilst applying a voltage difference between the bearing material surface which is cathodic and an anode connected to the porous pad characterised in that the bearing material is aluminium or an aluminium alloy and the overlay is deposited directly onto the surface.
- 15 2. A process according to claim 1 characterised in that the plating solution is supplied through the porous pad.
- 20 3. A process according to either claim 1 or claim 2 characterised in that the plating solution is supplied via the anode (51).
- 25 4. A process as claimed in any one preceding claim characterised in that the velocity of relative motion between the alloy surface and said porous pad lies in the range from  $0.05\text{ to }2\text{m.s}^{-1}$ .
- 30 5. A process as claimed in any one preceding claim characterised in that the velocity lies in the range from  $0.1\text{ to }1\text{m.s}^{-1}$ .
- 35 6. A process according to any one preceding claim wherein the anode is cylindrical and the porous pad is formed by a covering of porous material around the anode, and wherein during electro-deposition the axis of the anode is transverse to the direction of relative motion and substantially parallel to the alloy surface.
- 40 7. A process according to any one preceding claim characterised in that the bearing alloy is in flat strip form.
- 45 8. A process according to any one of preceding claims 1 to 6 characterised in that the bearing alloy is in cylindrical or semi-cylindrical bearing (14) form.
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9. A process according to any one preceding claim characterised in that the porous pad is made from a soft textile material.
10. A process according to claim 8 characterised in that the bearings are held in cylindrically arranged pairs and rotated about their axes relative to the porous pad.

#### Revendications

1. Procédé pour déposition par l'électrolyse d'une épaisseur de revêtement uniforme d'un alliage de revêtement ou "overlay", choisi parmi le groupe comprenant des alliages à base de Pb, des alliages à base de Sn, Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn-Co, Sn, Sn-Cu, Pb, Pb-In, In, Sn-In, Sn-Sb-Cu et Cd-Ni sur un palier ou coussinet, le procédé comprenant les étapes consistant à nettoyer la surface du palier au coussinet, assurer un mouvement relatif entre la surface de palier et un tampon poreux (52) en contact avec la surface, assurer un flux de solution d'électroplacage sur le tampon poreux qui est en contact avec la surface du palier tout en appliquant une tension différentielle entre la surface du palier qui est cathodique et une anode reliée au tampon poreux, caractérisé en ce que la matière du palier de l'aluminium ou un alliage d'aluminium et le revêtement ou "overlay" est déposé directement sur la surface.
2. Procédé selon la revendication 1, caractérisé en ce que la solution de placage est amenée par le tampon poreux.
3. Procédé selon l'une ou l'autre des revendications 1 ou 2, caractérisé en ce que la solution de placage est amenée via l'anode (51).
4. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la vitesse du mouvement relatif entre la surface d'alliage et le tampon poreux se situe dans la plage de 0,05 à 2 m.s<sup>-1</sup>.
5. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la vitesse se situe dans la plage de 0,1 à 1 m.s<sup>-1</sup>.
6. Procédé selon l'une quelconque des revendications précédentes, dans lequel l'anode est cylindrique et le tampon poreux est formé par un recouvrement de matière poreuse autour de l'anode, et dans lequel pendant l'électroplacage l'axe de l'anode est transversal par rapport

à la direction du mouvement relatif et sensiblement parallèle à la surface de l'alliage.

7. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'alliage du palier est sous forme d'une bande plate.
8. Procédé selon l'une quelconque des revendications 1 à 6, caractérisé en ce que l'alliage du palier est sous forme d'un palier 14 cylindrique ou semi-cylindrique.
9. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le tampon poreux est réalisé à partir d'une matière textile tendre.
10. Procédé selon la revendication 8, caractérisé en ce que les paliers sont maintenus par paires, agencées cylindriquement et mis en rotation autour de leurs axes par rapport au tampon poreux.

#### Patentansprüche

1. Verfahren zur galvanischen Abscheidung einer Überzugslegierung in einer gleichmäßigen Schichtdicke, auf einen Lagerwerkstoff wobei die Legierung aus der Gruppe ausgewählt wird, die Legierungen auf Pb-Basis, Legierungen auf Sn-Basis, Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn-Co, Sn, Sn-Cu, Pb, Pb-In, In, Sn-In, Sn-Sb-Cu und Cd-Ni umfaßt, wobei das Verfahren die Schritte des Reinigens der Oberfläche des Lagerwerkstoffs, des Schaffens einer Relativbewegung zwischen der Oberfläche des Lagerwerkstoffs und einem porösen, in Kontakt mit der Oberfläche befindlichen Kissen (52) sowie des Erzeugens eines Stroms einer Galvanisierungslösung zum porösen Kissen hin umfaßt, das sich in Kontakt mit der Oberfläche des Lagerwerkstoffs befindet, während eine Spannungsdifferenz zwischen der Oberfläche des Lagerwerkstoffs, die kathodisch geschaltet ist, und einer an das poröse Kissen angeschlossenen Anode angelegt wird, **dadurch gekennzeichnet**, daß der Lagerwerkstoff aus Aluminium oder einer Aluminiumlegierung besteht und der Überzug direkt auf die Oberfläche abgelagert wird.
2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die galvanische Lösung durch das poröse Kissen zugeführt wird.
3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die galvanische Lösung

über die Anode (51) zugeführt wird.

4. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Geschwindigkeit der Relativbewegung zwischen der Legierungsoberfläche und dem porösen Kissen im Bereich von 0,05 bis 2 ms<sup>-1</sup> liegt. 5
5. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Geschwindigkeit im Bereich von 0,1 bis 1 ms<sup>-1</sup> liegt. 10
6. Verfahren nach einem der vorhergehenden Ansprüche, bei dem die Anode zylindrisch und das poröse Kissen durch eine Hülle aus porösem Material um die Anode herum gebildet ist, und bei dem die Achse der Anode während der galvanischen Abscheidung quer zur Richtung der Relativbewegung und im wesentlichen parallel zur Legierungsoberfläche liegt. 15  
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7. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Lagerlegierung in Form eines Flachstreifens ausgebildet ist. 25
8. Verfahren nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die Lagerlegierung in Form eines zylindrischen oder halbzyklindrischen Lagers (14) ausgebildet ist. 30
9. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das poröse Kissen aus weichem Textilmaterial hergestellt ist. 35
10. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß die Lager in zylindrisch angeordneten Paaren gehalten und um ihre Achsen relativ zum porösen Kissen verdreht werden. 40

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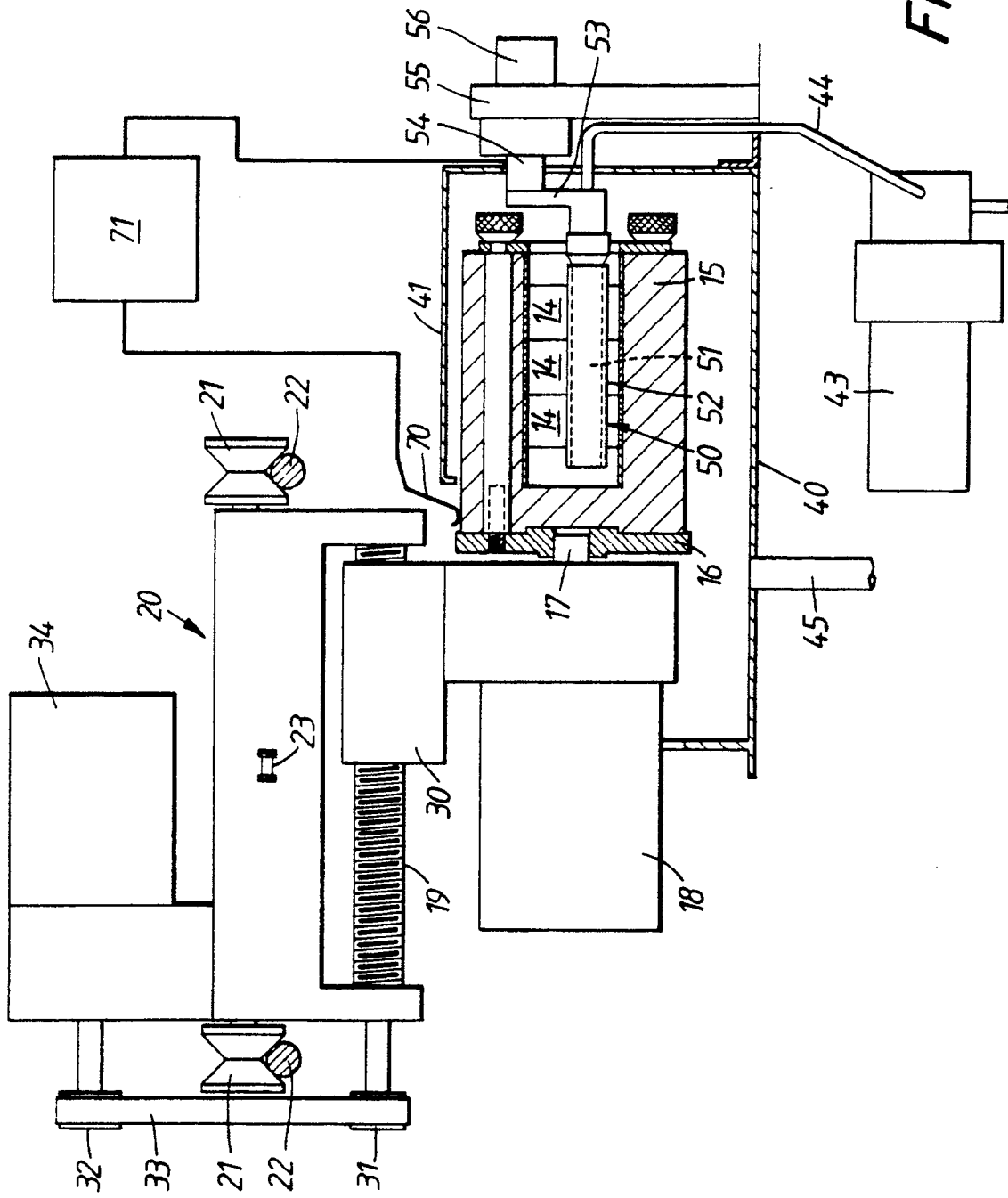
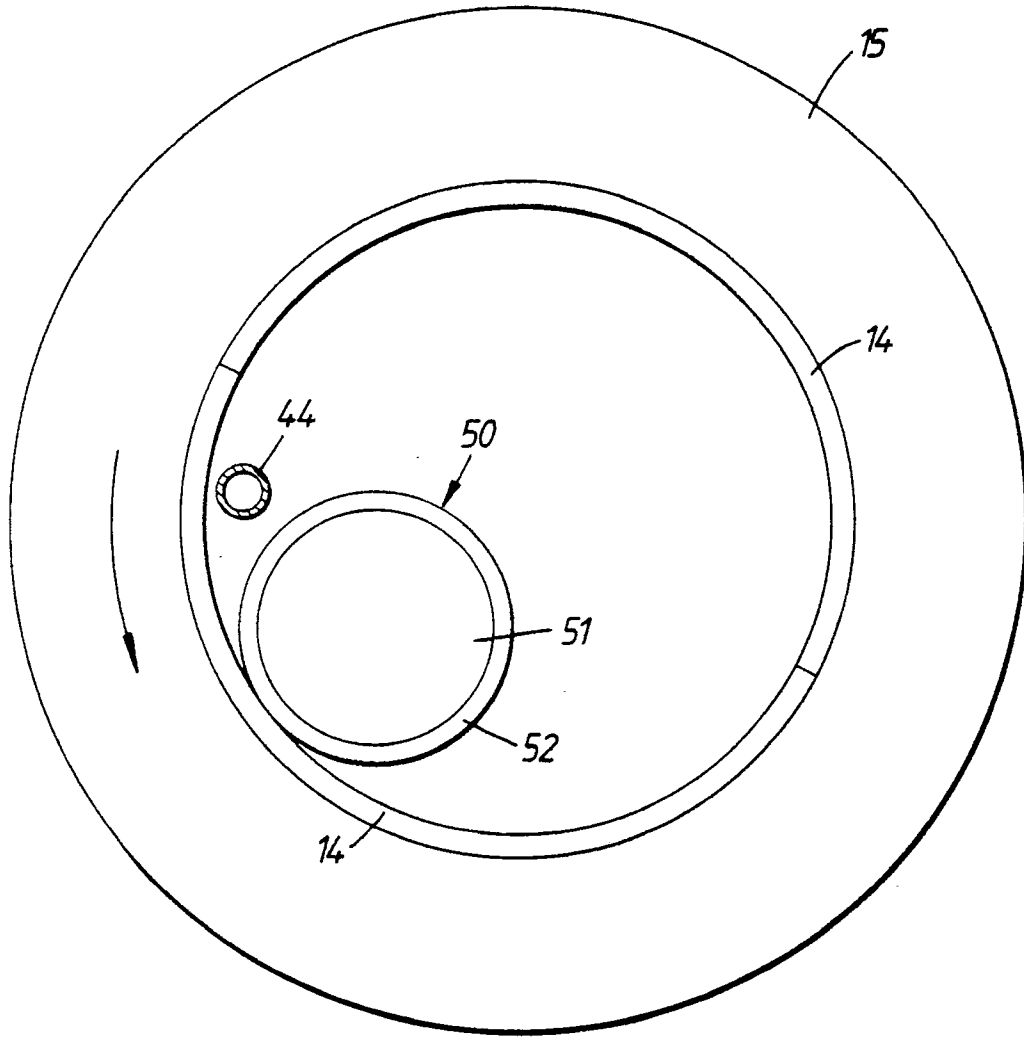


FIG. 2.



*FIG. 3.*