(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 536 980 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92309101.1**

(51) Int. Cl.^{5} : **B41J 2/175**

(22) Date of filing : **06.10.92**

(30) Priority : **10.10.91 IT 910763**

(43) Date of publication of application :
14.04.93 Bulletin 93/15

(84) Designated Contracting States :
DE FR GB NL

(71) Applicant : **Ing. C. Olivetti & C., S.p.A.**
Via G. Jervis 77
I-10015 Ivrea (IT)

(72) Inventor : **Scardovi, Alessandro**
Via Burzio 1
I-10015 Ivrea (IT)
Inventor : **Morandotti, Roberto**
Via Donio 10
I-10010 Mercenasco (IT)

(74) Representative : **Robson, Aidan John**
Reddie & Grose 16 Theobalds Road
London WC1X 8PL (GB)

(54) Method and apparatus for replenishing an ink-jet head with ink.

(57) An ink-jet print head has a supply reservior (10) filled with a spongy body (1) impregnated with ink. An ink replenishing device consists of a connecting element (32) made of porous material having one end immersed in a main container (48) separate from the head and the other end making contact with the spongy body (1) via an opening (30) in a wall of the supply reservoir (10). By to capillary action, when the spongy body (1) is partially empty of ink, the porous connecting element transfers the ink from the main container (48) to the supply reservoir.

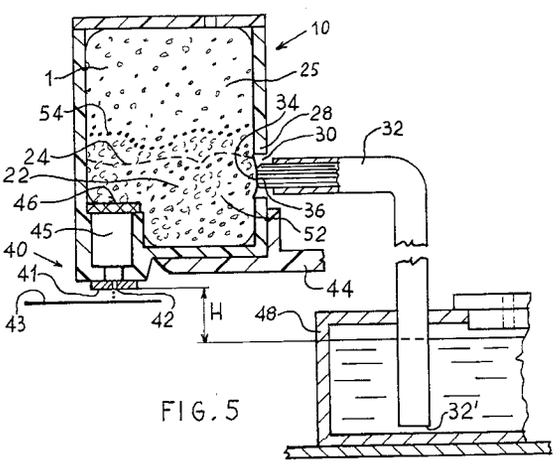


FIG. 5

EP 0 536 980 A2

Background of the Invention

The present invention relates to a method and apparatus for replenishing an ink-jet print head with ink and more particularly to a device for use with ink-jet print heads incorporating an ink reservoir confining a porous body soaked with ink.

An apparatus for rapidly connecting and disconnecting a main reservoir located at a distance from the head to/from the ink container of the head containing a spongy body soaked with ink is known from US Patent No. 4,999,652. Through a hole formed in a wall of the container filled with a spongy body, it is possible to insert into the spongy body a hollow needle connected, via a tube, to the main reservoir. Thus the sponge, when it is partially empty, sucks from the main reservoir, by capillary action, a quantity of ink which replaces that previously used up.

Since the head is mounted on a carriage movable along a line of print, the connecting tube must have a considerable length in order to cover the maximum distance of the head from the main reservoir. Moreover, during the to-and-fro movement of the carriage, the tube is repeatedly bent, with the risk of the tube itself being damaged.

A further drawback which restricts, over time, the use of such a device is in the fact that repeated insertion and withdrawal of the needle into/from the sponge causes the walls to be perforated with a large number of pores resulting in a reduction in the capillary action in the part of the sponge adjacent to the needle. This drastically reduces the sponge's capacity to be charged with a fresh supply of ink.

Summary of the Invention

Preferred embodiments of the present invention provide a device for continually replenishing a print head designed to be repeatedly supplied with ink any number of times, without damage to the sponge contained in the head reservoir. The replenishing device consists of a connecting element made of porous material and having one end immersed in a main ink reservoir. ,The other end can make contact with the spongy body in the print head ink reservoir via a hole in the wall of the head's reservoir. When the spongy body is partially empty of ink the porous connecting element supplies further ink thereto by capillary action.

In one embodiment of the invention the spongy body of a print head is replenished each time the head stops in a parked position, for example during replacement of a sheet of paper.

The invention is defined with more precision in the appended claims to which reference should now be made.

Detailed Description of Preferred Embodiments

Preferred embodiments of the invention are now described in detail by way of example with reference to the accompanying drawings, in which:

Fig. 1 shows a simplified diagram of a correction between a spongy body and a main ink reservoir, obtained by means of a porous element used in the invention;

Figs. 2-4 show modifications to the arrangement of Fig.1;

Fig. 5 shows a replenishing device for the reservoir of a print head, using the arrangement of Fig. 1;

Fig. 6 is a variation of Fig. 5;

Fig. 7 shows an application, to a printer, of the replenishing device of Fig. 5;

Fig. 8 shows a modification to the printer of Fig. 7;

Fig. 9 shows a print head used on the printer of Fig. 8.

Figs. 1-4 illustrate the physical principle on which the ink replenishing device according to the invention is based.

As is known, when two spongy bodies 1 and 2 soaked to a differing extent with a liquid, for example ink, are brought into contact, hydraulic continuity is established via the contact surface 3.

The greater negative pressure existing in the spongy body which is less soaked with ink (the body 1 in the case of Figs. 1-5) causes ink to be drawn from the other, more soaked body 2 until an equilibrium is established between the negative pressures in the two bodies 1 and 2. Therefore, since the body 2 is completely soaked with ink, being immersed in a main reservoir 4 full of ink 5 with a free surface making contact with the atmosphere via a hole 6, the body 1, when it is partially empty of ink, sucks ink from the reservoir 4 until it is almost entirely impregnated.

Figures 2-4 illustrate a few useful measures for ensuring initiation of the ink suction process by the spongy body 1.

In Fig. 2 a spongy body 1 is contained in a reservoir 10 having a hole 12 formed in a wall 11 for accommodating the body 2. A sleeve 14 is inserted into the hole 12, said sleeve projecting inside the reservoir 10 so as to create in the spongy body 1 a zone 15 which is more compressed and therefore has a greater capillarity than the part of the sleeve 14 which is further away.

During emptying of the ink from the spongy body 1, for example in order to supply a print head (not shown in the drawings), the zone 15 will be the last zone to be emptied. Therefore, by arranging end-of-ink sensors (not shown in the drawings) in the vicinity of the zone 15 it is possible to know when this zone starts to become empty. By bringing at this point the free end 2′ of the body 2 up to the body 1 through the

sleeve 14, hydraulic continuity is established in a reliable manner between the two bodies 1 and 2.

Fig. 3 shows the use of a spongy body 2 which is per se more rigid than the spongy body 1, or has been rigidified by a tubular support 16. In this case the body 2 is pressed through the hole 12 against the spongy body 1 so as to compress it locally inside the contact surface 3. In order to ensure initiation of the ink suction process by the body 1, the latter is packed inside the reservoir 10 so as to form a zone 18 which is more compressed in the vicinity of the bottom 11 and the hole 12.

Fig. 4 shows the use of a thin layer 20 of a rigid porous material, for example porous ceramic or Porex (registered trademark), i.e. a sufficiently rigid thin sheet which is obtained using sintered nylon microscopic balls. The porous layer 20 advantageously replaces the measures illustrated in Figs. 2 and 3.

Fig. 5 illustrates use of the principle of replenishment of the reservoir 10 with ink, in order to supply an ink-jet print head. The reservoir 10 is filled with a spongy body 1, subsequently referred to simply as a sponge, packed on the bottom so as to form a more compressed zone 22 which is roughly delimited with respect to the upper part 25 by a broken line 24.

The side wall 28 has formed in it a hole 30 for accommodating a spongy or fibrous body 32, referred to below as a connecting element for the ink, of the type indicated by 2 in Figs. 1-4.

More particularly the element 32 consists of a porous or fibrous material having a plurality of capillary ducts arranged in a bundle each with a diameter varying between 50 and 500 μm. The element 32 has an elongated cylindrical shape with a prismatic circular crows-section much larger than the cross-section of each capillary duct. The transverse dimension or diameter of the element 32 may vary between 3 and 15 mm.

The hole 30 leaves exposed a part 34 of the surface of the sponge 1, up to which one end 36 of the element 32 is brought. The element 32 may be made using one of the following materials:

1) Expanded polymer materials (sponges), for example consisting of:
   - Polyether urethane
   - Melamine resins
   - Polyvinyl alcohol

2) Fibrous materials
   - Polyurethane-coated polyester fibres (nibs)
   - Natural fibres in general (wool, vegetable fibres)
   - Polyamide fibres

   These fibrous materials may be in the form of fabric, felt or "non-woven fabric".

3) Ceramic materials
   - Porous ceramics in general
   - Porex (registered trademark) (sintered nylon balls)

In the case where expanded polymer materials are used for the element 32, they are advantageously enclosed in a tubular sleeve 38 similar to that indicated by 16 in Fig. 3.

The reservoir 10 carries an ink-jet print head 40 integrally fixed to its bottom part. The head 40 may consist of a multi-layer plate 41 incorporating capillary cells each containing a resistance which can be actuated so as to expel drops of ink from corresponding nozzles 42 so as to print onto a horizontal sheet 43. The reservoir 10 together with the head 40 are mounted on a structure 44 forming part of a movable carriage (not illustrated for the sake of clarity) of a printer.

The plate 41 may be, for example, of the type described in European Patent Application No. 401996 published on 12 December 1990, in the name of the present Applicant.

A main reservoir 48 filled with ink is arranged underneath the head 40 so that the level of the ink forms a pressure head H of about 1-3 cm with respect to the head 40. The other end 32′ of the element 32 is immersed in the reservoir 48.

Simply bringing the element 32 up against the surface 34 of the sponge 1 causes the meniscuses of the capillary channels of the element 32 to be combined, and hence eliminated, with the meniscuses of the corresponding capillary channels of the sponge 1, thus creating hydraulic continuity between the ink inside the main reservoir 45 and the ink contained in the sponge 1. In extreme cases, hydraulic continuity is established even if the capillary channels of the sponge 1, which emerge at the surface 34, contain no ink. In fact, the meniscuses present at the end 36 of the element 32 rise up back along the channels of the sponge 1 until they encounter the ink which soaks them in a zone far from the surface 34.

However, to ensure hydraulic continuity, it is preferable for the hole 30 to be arranged so that it uncovers a zone of the sponge 1 where, owing to the compression exerted by the walls of the cartridge 10, there is a high degree of capillarity and hence the guarantee that this zone is emptied only just before all of the ink is used up.

It is in fact preferable that the contact between the sponge and the element 32 should occur in a zone which is always soaked with liquid connected to the ink contained in a chamber 45 supplying the plate 41 so that the sucking action always occurs at the right time.

The chamber 45 is always kept full of ink so as to prevent the presence of air bubbles in it affecting proper operation of the head. In this connection it is possible to pack the sponge inside the reservoir so as to obtain localised compression at the contact point. Or else, it is possible to use a sponge of varying capillarity (polyvinyl alcohol for example) so that it has

a greater capillarity in a zone 52 close to the hole 30 and the chamber 45.

By way of example in Fig. 5, the zone 52 has been delimited by a (dotted) line 54 indicating a surface separating the part 52 with greater capillarity and the upper part 25 with reduced capillarity.

Obviously, in the embodiment of the ink replenishing device shown in Fig. 5, according to the invention, the measures illustrated in Figs. 2, 3 and 4 may be advantageously used to establish at the right time hydraulic continuity between the element 32 and the sponge 1.

In an alternative embodiment, the reservoir 10 may be replaced by a removable cartridge 55 (Fig. 6) inserted from above into the support 56 in turn mounted on the structure 44 of Fig. 5. The cartridge 55 contains a sponge 1 soaked with ink.

In the embodiment of Fig. 6, the print head 40 is integral with the support 56 and is not replaced together with the cartridge 55. The chamber 45 is delimited at the top by a sleeve 57 through which a porous or fibrous element 58 passes.

The element 58 is made using one of the materials listed above in connection with the element 32 of Fig. 5 and projects at the top by a distance so as to penetrate into a hole 59 of the cartridge 55 until it comes into contact with a free portion 60 of the sponge 1.

This system for achieving the hydraulic connection between the cartridge 55 and the chamber 45 supplying the plate 41 advantageously replaces other known and more complicated connecting systems which use, for example, a hollow needle associated with a filter for the ink. In fact, the element 58, as a result of its own capillarity, establishes a hydraulic connection between the sponge 1 and the chamber 45, performing at the same time a rigorous filtering action as regards all the impurities which may be present in the ink. Furthermore, the element 58 prevents air from passing into the chamber 45 even when no cartridge 55 is present, thus ensuring that there are no air bubbles inside the chamber 45.

Fig. 7 illustrates an application, to an ink-jet printer, of the device for replenishing the reservoir of the print head with ink, in accordance with the invention.

A print head 61 of the same type as that shown in Fig. 5 is mounted on a carriage 62 movable along a guide 64. The carriage is moved by a motor 65, via a cable 66, so as to print on a sheet 67 in both the directions indicated by the double arrow A.

At one end of its travel, the head 61 stops in a parked position R where an ink release element 70 comes into contact with the sponge 1 contained in the cartridge 10 of the head 61.

The release element 70 is entirely similar to that indicated by 32 in Fig. 5 and is formed using the materials listed above. The bottom end 72 of the element 70 is immersed inside a main reservoir 74 fixed to the structure 63 of the printer. The reservoir 74 contains 1 to 8 times as much ink as that contained in the cartridge 10 when the sponge 1 is completely soaked with ink.

The reservoir 74 is located lower down than the head 61 so that the pressure head H (Fig. 5) between the free surface of the ink inside the reservoir and the nozzles of the head 61 is between about 1 and 3 cm.

Each time the head 61 is kept in the parked position R, for example after printing a page on the sheet 67, the element 70 releases to the sponge 1, as a result of the capillary action, a quantity of ink which substantially replaces that used during printing.

Therefore, since replenishing of the reservoir 10 with ink may be performed very frequently, each time the head 61 stops in the position R, the dimensions of the reservoir 10 may be very small, for example so as to contain a minimum of 3 cc of ink, sufficient on average to print about 50 pages of standard A4 format.

Therefore, with the repeated replenishing system according to the invention, use of the same head or of the same cartridge may be greatly prolonged, notably reducing the printer running costs of the user.

Fig. 8 shows a printer using an ink-jet print head 75 (Fig. 9) for printing on a sheet 78 arranged vertically. The head 75 is mounted on a carriage 77 and is integral with the reservoir 76.

A bottom wall 80 of the reservoir 76 has formed in it a hole 82 for exposing a portion 83 of the sponge 85 and for accommodating an ink release element 87 intended to replenish the sponge 85 with a fresh supply of ink.

The release element 87 is similar, as regards its shape and the material form which it is made, to the elements 32 of Fig. 5 and/or 2 of Figs. 1-4.

The element 87 is supported inside a sleeve 89 integral with a main ink container 90 mounted on the frame 93 of the printer and slidable vertically on guides 92. The container 90 is situated underneath the reservoir 76 and in the region of a parked position R (Fig. 7) at one end of the travel of the carriage 77 where the print head 75 is kept immobile during a pause.

A lever 94 hinged at a point 95 of the frame 93 is rotated in a clockwise direction by the head 75 when it reaches the position R, so that an arm 94′ of the lever 94 raises the reservoir 90 so as to bring the element 87 into contact with the sponge 85.

In the non-limiting example of Fig. 8, the release element 87 consists of a material which is more rigid than the sponge 85. Therefore, the element 87 is pressed against the sponge 85 so as to create a limited compression zone 97, hence with a greater capillarity, so as to ensure the prompt and correct flow of ink between the reservoir 90 and the sponge 85.

Normally in the parked position R, a nozzle suction and protection device (not shown in the figures)

is provided with an elastic cap surrounding the nozzles.

To prevent a quantity of air entering through the hole 82 (Fig. 9) as a result of the sucking action applied to the nozzles, an elastic cap 98 is preferably applied to the support 89 in order to seal the opening 82 during parking of the head.

It is understood that modifications, replacements or the addition of parts may be made to the device for replenishing a print head with ink according to the invention, without departing from the scope of the invention.

Claims

1. Apparatus for replenishing an ink-jet print head with ink, comprising a supply reservoir (10) connected to the head and containing a body (1) of a spongy material, for supplying ink to the head, a main container (4) filled with ink at atmospheric pressure and means (2) for selectively connecting said supply reservoir to the main container, characterised in that the supply reservoir comprises at least one opening (12) communicating with the surrounding atmosphere in order to expose a portion of the spongy body, and the connecting means (2) comprise a connection element made of porous material partially immersed in the main container and designed to be brought up to the exposed portion of the spongy body via the opening in order to establish hydraulic continuity between the container and the spongy body, so that the spongy body is replenished with ink sucked from the container as a result of capillarity.

2. Apparatus for replenishing an ink-jet print head with ink according to claim 1, characterised in that the connection element (2) comprises a plurality of capillary ducts parallel to a longitudinal axis of the element each duct having an average diameter of between 50 and 500 μm.

3. Apparatus for replenishing an ink-jet print head with ink according to claim 1 or 2, characterised in that the connection element consists of expanded polymer material.

4. Apparatus for replenishing an ink-jet print head with ink according to claim 3, characterised in that the polymer material is a polyether urethane resin.

5. Apparatus for replenishing an ink-jet print head with ink according to claim 3, characterised in that the polymer material is a melamine resin.

6. Apparatus for replenishing an ink-jet print head with ink according to claim 3, characterised in that the polymer material is based on a polyvinyl alcohol.

7. Apparatus for replenishing an ink-jet print head with ink according to claim 1 or 2, characterised in that the connection element consists of a fibrous material.

8. Apparatus for replenishing an ink-jet print head with ink according to claim 7, characterised in that the fibrous material comprises fibre of a polyurethane-coated polyester.

9. Apparatus for replenishing an ink-jet print head with ink according to claim 7, characterised in that the fibrous material comprises polyamide fibres.

10. Apparatus for replenishing an ink-jet print head with ink according to claim 1 or 2, characterised in that the connection element is composed of an open-cell porous ceramic material.

11. Apparatus for replenishing an ink-jet print head with ink according to claim 2 to 11, characterised in that the connection element has a substantially cylindrical shape, having a transverse dimension of at least one order of magnitude greater than the diameter of each of the capillary ducts.

12. Apparatus for replenishing an ink-jet print head with ink according to any one of the preceding claims, characterised in that the supply reservoir (10) includes an annular compression element (14) fixed in the opening (12) and projecting inside the reservoir so as to compress the spongy body (1) locally, the compression element comprising a through-hole for exposing the portion of the spongy body and for receiving the connection element (2).

13. Apparatus for replenishing an ink-jet print head with ink according to any one of claims 1 to 12, characterised in that the connection element (20) has a rigidity greater than the rigidity of the first spongy body and in that the connection element is introduced partially into the opening (12) so as to compress locally the spongy body (1), so that hyraulic continuity is rapidly achieved between the main container and the spongy body.

14. Apparatus for replenishing an ink-jet print head with ink according to any one of claims 1 to 12, characterised in that the supply reservoir (10) includes a separator element (20) located between the spongy body (1) and the opening (12), the

separator element being composed of a rigid porous material having a capillarity greater than the capillarity of the spongy body, so that when the connection element is brought up to the separator element, hydraulic continuity between said main container and the supply reservoir is achieved in a rapid and reliable manner.

15. Apparatus for replenishing an ink-jet print head with ink according to any preceding claim, characterised in that the main container (4) contains ink up to a level such as to create, with respect to the print head, a pressure head (H) with an absolute value less than the characteristic negative pressure of the spongy body.

16. Apparatus for replenishing an ink-jet print head with ink according to one of claims 1 to 12, characterised in that the head is mounted on a support structure (44) comprising a chamber (45) for supplying the head, kept full of ink, and in that the ink reservoir (55) can be removably inserted into the support so as to allow replacement thereof when the ink is used up, connecting means (58) being provided on the support for transferring the ink from the reservoir to said head.

17. Apparatus for replenishing an ink-jet print head with ink according to claim 16, characterised in that the connecting means (58) comprise a porous element with one end immersed in the supply chamber (45) and with another end projecting with respect to the support, the reservoir having an opening in the region of the porous element for bringing the spongy body into contact with the porous element when the reservoir (55) is inserted into the support.

18. Ink-jet printer comprising a print head (61) movable between two end positions and connected to a supply reservoir (10) containing a spongy body (1) adapted to be soaked with ink for supplying the head, a main ink container (74, 90)) arranged adjacent to one of the end positions and means (70, 87) for connecting hydraulically said container to the supply reservoir, characterised in that the connecting means comprise a connecting element (70, 87) made of porous material partially immersed in the container (74, 90) and designed to be brought up to the spongy body (1) through an opening (82) in the reservoir (10) for exposing a zone of the spongy body, when the head is located in said one end position in order to establish hydraulic continuity between the main container and the supply reservoir, so that the spongy body is replenished with ink sucked from the container as a result of capillarity.

19. Printer according to claim 18, characterised in that the opening (82) is formed through a bottom wall of the supply reservoir and that the main container (74, 90) is movable vertically from a rest position to a replenishing position occupied when thehead is located in one end position in order to bring the connecting element (87) up to the spongy body via the opening.

20. Printer according to claim 19,, characterised in that the main container is moved by a lever (94) actuated by the head when it reaches the end position.

21. Method for replenishing with ink an ink-jet print head comprising a supply reservoir connected to the head and containing a spongy body (1) adapted to be soaked with ink, the method comprising the following steps:

a) providing the reservoir with an opening (12) communicating with the exterior so as to expose a zone (3) of the spongy body;

b) arranging a container (4) full of ink in the vicinity of the supply reservoir with the free surface of the ink forming a hydraulic head (11), with respect to said print head, having an absolute value less than the characteristic negative pressure exerted by the spongy body;

c) arranging a porous element (2) with capillary ducts so as to be partially immersed in the container;

d) bringing a non-immersed part of the porous element (2) projecting from the container up to the zone (3) via the opening (12) in order to establish hydraulic continuity between the porous element and the spoongy body (1), so that the supply reservoir is replenished with ink sucked from the container (4) as a result of capillarity.

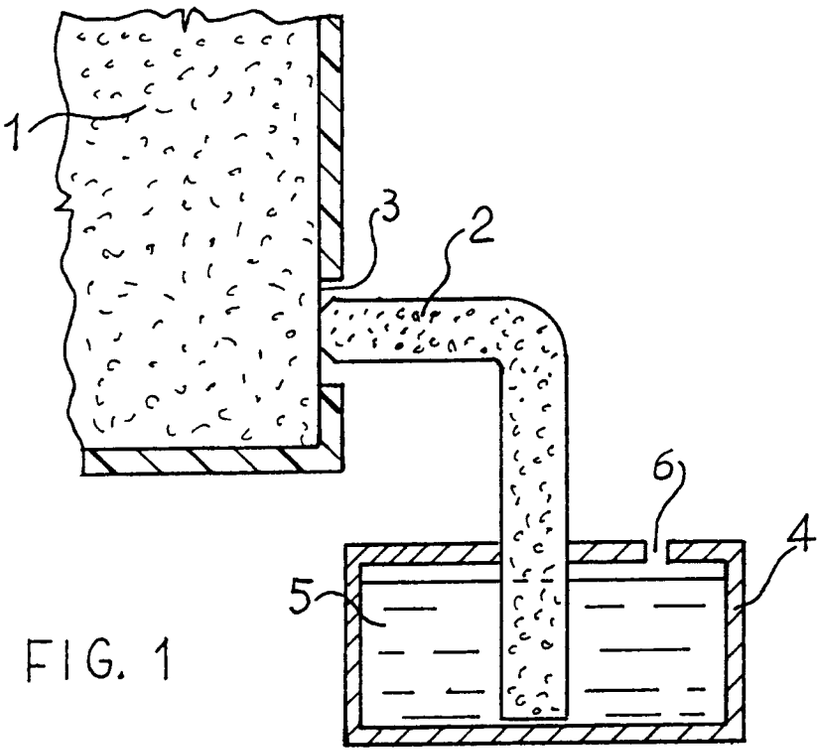


FIG. 1

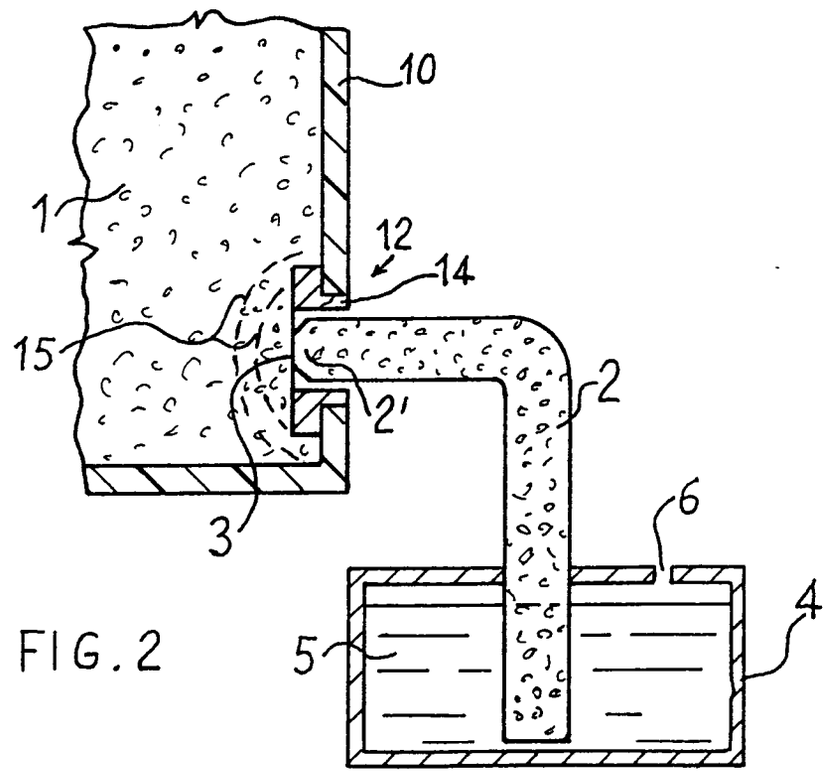


FIG. 2

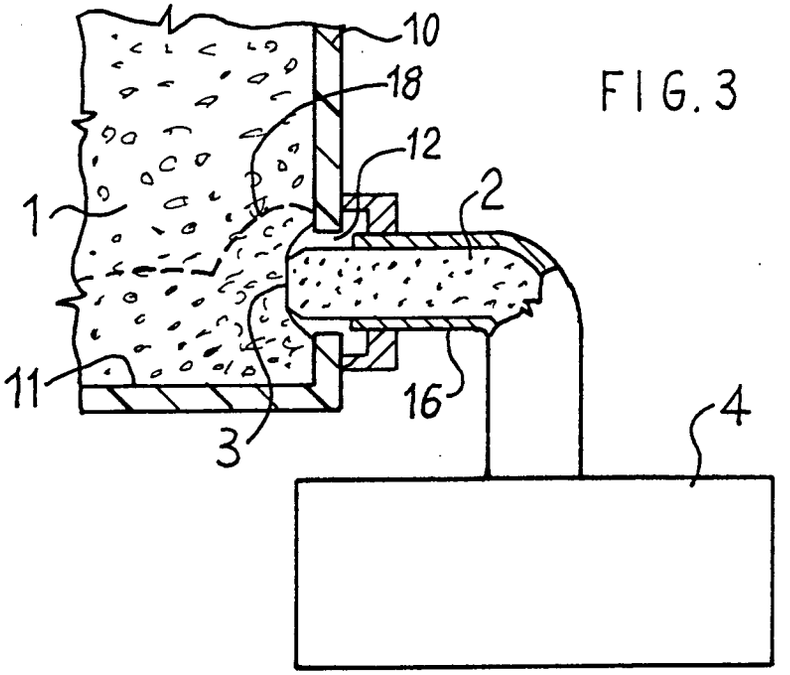


FIG. 3

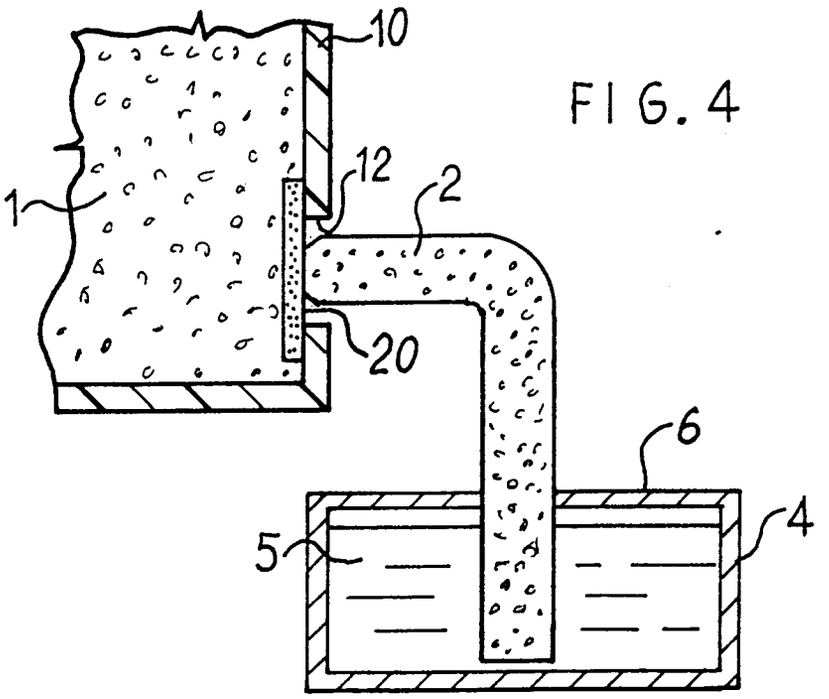


FIG. 4

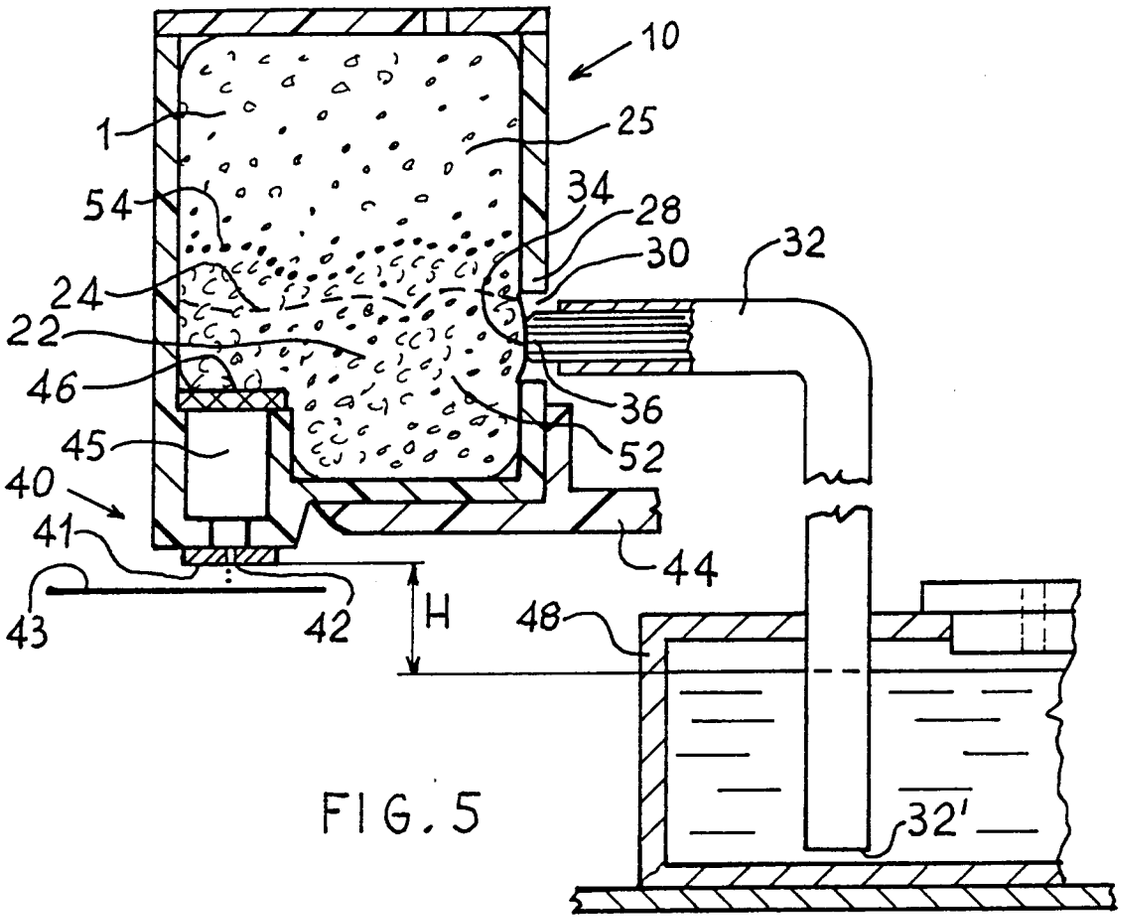

10
1
25
54
34
28
30
32
24
22
46
36
52
45
40
41
44
43
42
H
48
32'

FIG. 5

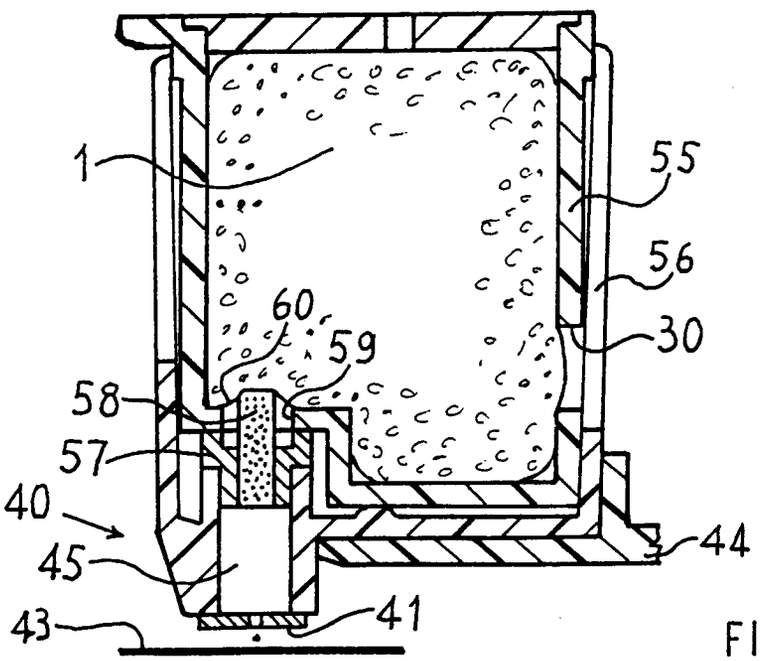

1
55
56
60
59
30
58
57
40
45
44
43
41

FIG. 6

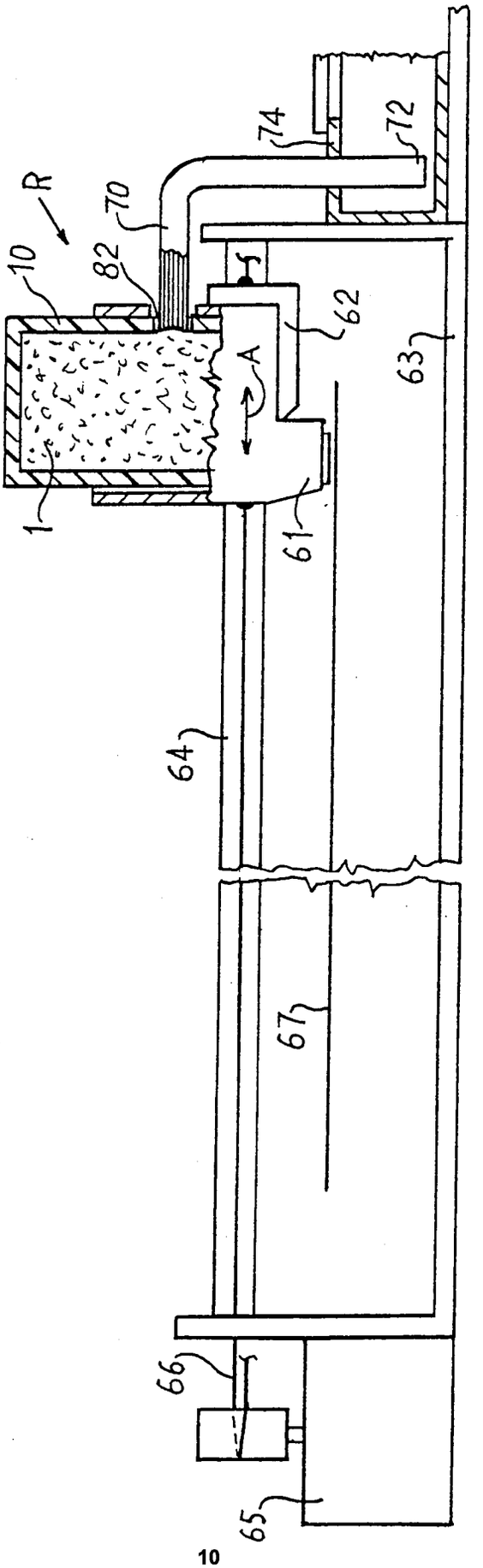


FIG. 7

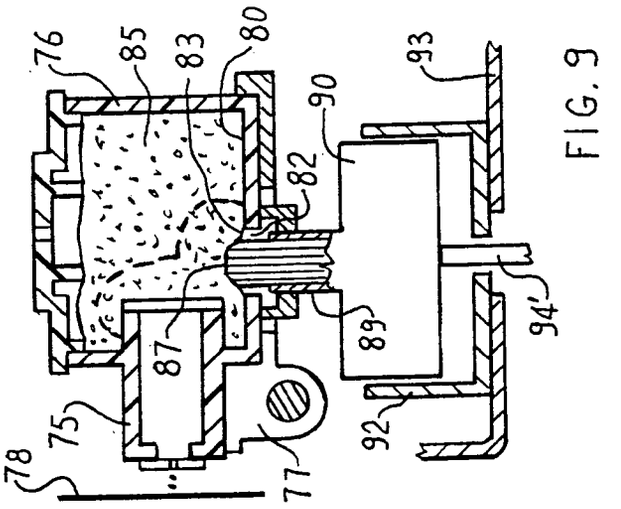

76
85
83
80
93
90
82
94'
89
87
75
92
78
77

FIG. 9

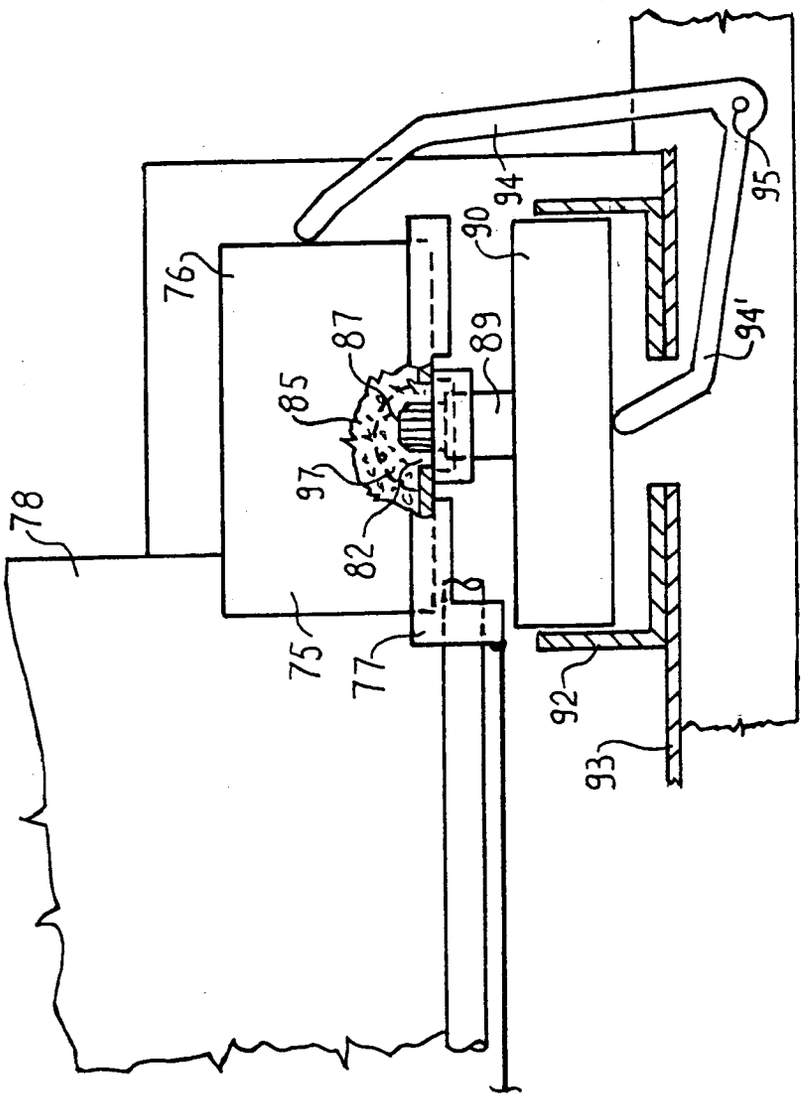

94
95
90
76
87
89
94'
85
97
78
82
75
77
92
93

FIG. 8