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(54) Fluid pump dispenser for pharmaceutical applications.

(57) The dispenser comprises a first cylinder (11), a first hollow piston (2) disposed slidably in the first cylinder (11), a second cylinder (12) coaxial with the first cylinder (11) and forming a prolongation thereof of smaller diameter, the inner wall of the second cylinder (12) having an enlarged horizontal annular recess (13) at the jontion of the first and second cylinders, a second piston (3) disposed slidably in the second cylinder (12), a vertical stem (4) disposed slidably within the first piston (2) and engaging the second piston (3) and a spring (6) extending within the second cylinder (13) between its lower end and the lower end of the second piston (3).

The first piston (2) is provided with an enlargement (14) intermediate its ends defining an upper portion (27A) and a lower portion (27B). The upper portion (27A) extends slidably above and within the first cylinder (11) and the lower portion (27B) extends slidably within the first cylinder (11) and the second cylinder (12). The enlargement (14) peripherally engages and defines a first unbroken seal (S1) with the inner surface of the first cylinder (11). The second piston (3) peripherally engages and defines a second seal (S2) with the inner surface of the second cylinder (12), the second seal (S2) being unbroken except when the second piston (3) is aligned with and spaced from the annular recess (13).

The lower portion (27B) of the first piston (2) is provided with a plurality of vertical grooves (30) or helical grooves (31).

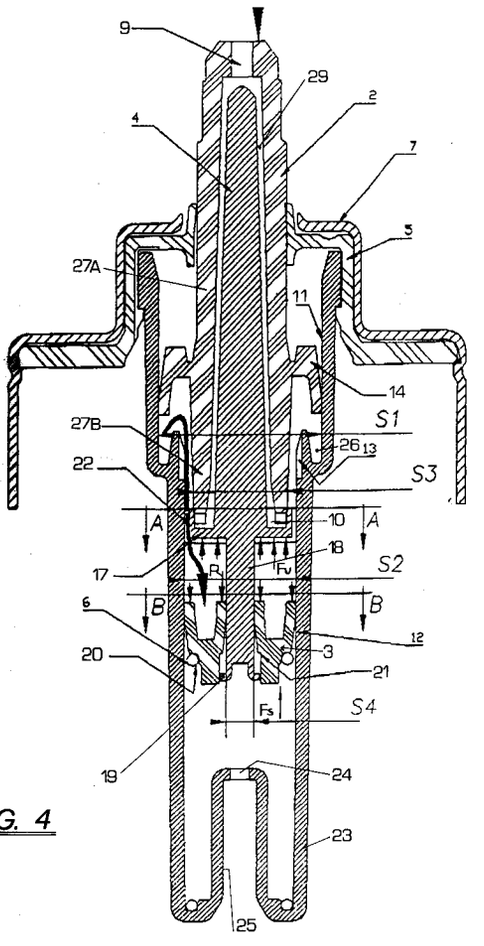


FIG. 4

EP 0 614 702 A2

This invention generally relates to pharmaceutical type pump dispensers and, more particularly, to pharmaceutical type pump dispensers having improved characteristics.

EP-A2-0 450 267 discloses a fluid pump dispenser for pharmaceutical use wherein the fluid is discharged at a predetermined pressure and wherein a predetermined dosage is delivered regardless of the method of actuation. These dispensers have outlet ports through which the fluid is discharged and have inlet ports through which the fluid to be dispensed is fed into the dispensers from a container supplying the fluid. To insure delivery of a predetermined dosage, the dispenser is designed so that its exit port is held closed during actuation until a predetermined point on the down stroke of the pump piston is reached. At this point the outlet port is opened and the discharge of the predetermined dosage is initiated. The dispensers disclosed in the above identified patent application employ an additional spring, other than the conventional return spring, which is used to hold the outlet port closed during part of the actuation. In these dispensers the closure of the exit port occurs at the bottom end of the pump piston.

EU-A1-0 499 073 discloses a fluid pump dispenser for pharmaceutical use, having a structure similar to that of the EU-A2-0 450 267, but in which the closure of the exit port occurs at the top end of the pump piston, so that any fluid remaining in the path after the discharge port is closed is sealed in the pump and not exposed to the atmosphere.

In the above described fluid pump dispensers the elimination of the additional spring is most desirable, since such semplification decreases manufacturing difficulties, thus increasing performance and quality of the product.

Furthermore, when the pharmaceutical pump dispensers are used to dispense suspensions of particulate matter in fluids or mixtures of liquids of different densities, the solids and similarly the higher density fluids tend to settle to the bottom of the dispenser pump chamber. To prevent improper delivery of the product, the user is instructed to actuate the dispenser several times before use in order to assure proper suspension or proper mixture. However, the user may fail to follow the instructions and the formulation may be delivered improperly, with unpleasant and even dangerous results.

Accordingly, it is an object of the present invention to provide new and improved pharmaceutical dispensers wherein the use of an additional spring is eliminated.

It is another object of the present invention to provide new and improved pharmaceutical dispensers wherein the exit port is held closed during at least a portion of actuation solely by the use of hydraulic forces.

It is a further object of the present invention to provide new and improved pharmaceutical dispensers having reduced manufacturing complexity and enhanced performance.

It is still another object of the present invention to provide new and improved pharmaceutical dispensers wherein the hydraulic forces holding closed the exit port are used for automatically mixing particulate matter and fluid of fluids of different densities for obtaining and automatic and proper dispensing thereof.

More particularly, the finger actuated pump dispenser according to the present invention is of the type having:

a first upper hollow cylinder with a first diameter and open upper and lower ends;

a first vertical hollow piston having open top and bottom ends and disposed slidably in the first upper hollow cylinder;

a second lower hollow cylinder coaxial with the first cylinder and forming a prolongation thereof of smaller diameter, the inner wall of the second cylinder having an enlarged horizontal annular recess at the jontion of the first and second cylinders,

a second vertical piston disposed slidably in the second cylinder,

a vertical stem disposed slidably within the first piston and engaging the second piston,

a spring extending within the second cylinder between its lower end and the lower end of the second piston,

characterized in that:

the first piston is provided with an enlargement intermediate its ends defining an upper portion and a lower portion, the upper portion extending slidably above and within the first cylinder and the lower portion extending slidably within the first cylinder and the second cylinder, the enlargement peripherally engaging and defining a first unbroken seal with the inner surface of the first cylinder,

the second piston peripherally engages and defines a second seal with the inner surface of the second cylinder, the second seal being unbroken except when the second piston is aligned with and spaced from the annular recess.

According to a feature of the present invention, the second piston has a central bore extending therethrough and the vertical stem is provided with an outwardly extending central horizontal flange secured thereto intermediate its ends, the bottom open end of the lower portion of the first piston engaging and defining a third seal with the flange, the third seal being broken when the bottom open end of the lower portion of the first piston is separated from the flange, a portion of the stem below the flange extending vertically and slidably down-

wards through the central bore of the second piston and engaging and defining a fourth unbroken seal with said bore.

According to another feature of the present invention, the vertical stem is secured at its lower end to the upper end of the second piston, the stem being longer than the first piston so that there is always a vertical separation between the bottom end of the lower portion of the first piston and the lower end of the stem.

The dispensers according to the present invention will be described in more detail in the following drawings, wherein:

Fig 1 shows a vertical cross sectional view, in simplified diagramatic form, of a first dispenser in accordance with the invention as shown in rest position.

Fig 2 is a view of the embodiment of Fig 1 shown during a downstroke.

Fig 3 is a view of the embodiment of Fig 1 shown during a discharge.

Fig 4 is a more detailed vertical cross sectional view of a first preferred embodiment of the invention as shown during a downstroke.

Fig 5 is a detail cross section taken along line A-A in Fig 5.

Fig 6 is a detail cross section taken along line B-B in Fig 5.

Fig 7 shows a vertical cross sectional view in simplified diagramatic form of a second dispenser in accordance with the invention using the hydraulic forces of the embodiment of Figs. 1-6 for mixing fluids of different but similar densities.

Fig 8 is a horizontal cross section of a modification of the structure of Fig 7 as adapted for mixing fluids of substantially different densities.

Fig 9 shows a more detailed vertical cross sectional view of a dispenser in accordance with the invention as adapted for mixing fluid and particulate precipitated matter.

Fig 10 is a horizontal cross section taken along line A-A in Fig 7.

Fig 11 is a horizontal cross section taken along line A-A in Fig 8.

Fig 12 is a horizontal cross section of a modification of the structure shown in Fig 9 which provides an additional mixing action.

Fig 13 is a horizontal cross section taken along line A-A in Fig 12.

Referring first to Figs 1-3, a finger actuated pump dispenser employs a first upper hollow vertical cylinder 11 with a first diameter and open upper and lower ends and a second lower hollow vertical cylinder 12 with a second and smaller diameter and a closed lower end with a central opening. The lower end of the first cylinder 11 is joined to an open upper end of the second cylinder 12. The inner wall of the second cylinder 12 has a horizontal annular recess 13.

A first vertical hollow piston 2 having a top opening 9 and a bottom opening 10 extends slidably above and within first cylinder 11. The first piston 2 has an enlargement 14 intermediate its ends peripherally engaging and defining a first unbroken seal S1 with the inner surface of the first cylinder 11. The enlargement 14 of the first piston 2 defines an upper portion 27A and a lower portion 27B. The upper portion 27A extends slidably above and within the first cylinder 11 and the lower portion 27B extends slidably within the first cylinder 11 and partially in the second cylinder 12. The outer surface of the lower portion 27B of the first piston 2 is smooth.

A second vertical piston 3 having a central vertical bore 15 is disposed slidably within the second cylinder 12. The outer periphery 16 of the second piston 3 peripherally engages and defines a second seal S2 with the inner surface of the second cylinder 12, the second seal being unbroken except when the second piston 3 is aligned with and spaced from the annular recess 13.

A vertical stem 4 is disposed slidably within the first piston 2 and is spaced therefrom. The stem 4 has an outwardly extending central horizontal flange 17 secured thereto intermediate its ends, the bottom opening of the lower portion 27B of the first piston 2 engaging and defining a third seal S3 with the flange 17. The third seal S3 is broken when the bottom opening of the lower portion 27B of the first piston 2 is separated from the flange 17.

A portion of the stem 4 extends below the flange 17, defining a shaft 18 which extends slidably downwards through the central bore 15 of the second piston 3 and has a bottom end with a flare or rim 19. The flare or rim 19 has an outer diameter which is larger than the inner periphery of the bore 15 and prevents the second piston 3 from becoming completely separated from the shaft 18. The shaft 18 engages and defines a fourth seal S4 with the inner surface of said bore 15.

A spring 6 extends within the second cylinder 12 between its lower end and the lower end of the second piston 3. A collar 5 closes off the top of the upper cylinder 11 and is provided with a central opening through which the first piston 2 extends. The collar 5 is usually surrounded by a cup 7 which attaches the dispenser to a container. The top opening in the first piston 2 communicates with the discharge path of the top mounted actuator 8.

As will be explained in more detail below, the diameter of the first seal S1 is larger than the diameter of the second seal S2, the diameter of the second seal S2 is larger than the diameter of the third seal S3, and the diameter of the third seal S3 is larger than the diameter of the fourth seal S4.

Initially, the upper cylinder 11 is filled with fluid. When the actuator 8 is depressed, the first piston 2, stem 4 and second piston 3 travel downward. When the second piston 3 passes the recess 13 the inlet port is closed. Since the fluid is incompressible, as the first piston 2, stem 4 and second piston 3 continue to travel downward, the fluid is displaced from the larger upper cylinder 11 into the lower smaller cylinder 12, forcing the second piston 3 to move downwardly along the shaft 18.

As can be seen in Fig. 4, the fluid in the chamber is pressurized at pressure P in proportion to the force Fs of the spring 6 and the area of the second piston 3 which is exposed to the fluid bearing down upon it. This area is defined as the difference between the area A of seal S2 and the area D of seal S4. Hence, $P = Fs/(A - D)$.

While the second piston 3 is free to move downwardly along the shaft 18, this pressure P exerts an upward force Fu on the flange 17 which is equal to the products of P and the area C of seal S3 less the area D of seal S4. Hence $Fu = P/(C - D)$. This force maintains the outlet port closed.

The displacement of the second piston 3 continues until the lower end thereof engages the flare or rim 19 at the bottom of shaft 18. Further displacement of fluid from the upper cylinder 11 to the lower cylinder 12 forces the stem 4 and engaged second piston 3 to move downwardly together. This action breaks the third seal S3, opening the outlet port and causing the fluid to pass therethrough upwardly in the space 29 between the first piston 2 and the stem 4 out of the top opening 9 in the first piston 2 and discharge through the actuator 8.

When the lower end of the second piston 3 engages the flare 19, the down pressure of the fluid P increases relative to the difference between the area A of seal S2 and the area C of seal S3 so that $P = Fs/(A - C)$, resulting in an increase in the actuating force.

Once the outlet port opens, the actuating force is reduced by a decrease in pressure to $P = Fs/C$. This sudden decrease in pressure makes it impossible for the user to interrupt the actuation once discharge has begun. The pressure reverses its force on the stem 4. Since the entire stem 4 is now surrounded by fluid, except for the portion that protrudes within the second piston 3, the stem 4 is forced away from the first piston 2 with a force F equal to the product of P and the area D of the fourth seal S4 so that $F = PD$. This downward force maintains the outlet port open throughout the discharge.

It will be apparent that the period of time between the beginning of the downstroke and the initial start of discharge, defined as the delay period, is determined by the time required for the lower end of the second piston 3 to engage the flare 19 at the bottom of the shaft 18, since this engagement causes the outlet port to open, thus initiating the discharge.

The duration of the delay period increases or decreases as the length of the shaft 18 is increased or decreased. When the shaft length is reduced, the lower end of the second piston 3 engages the flare 19 during an earlier portion of the downstroke, the outlet port is opened correspondingly early and the duration of the delay period is reduced. As the shaft length is increased, the outlet port is opened correspondingly later during the downstroke and the duration of the delay period is increased. The length of the shaft 18 can be so chosen that the entire contents of the upper cylinder 11 can be displaced into the lower cylinder 12 prior to opening the port. In this case, the duration of the delay period is increased to a maximum and the discharge rate is controlled solely by the spring 6 and the pump geometry.

Once the outlet port is opened, the second piston 3 travels upwardly along the shaft 18, forcing complete discharge of the fluid. Once the entire contents of fluid in the cylinders has been discharged, the second piston 3 engages the flange 17, pushing it into engagement with the bottom opening of the lower portion 27B of the first piston 2 and closing the outlet port. When the finger pressure on the actuator 8 is removed, the spring 6 moves both pistons and the stem upward. As the second piston 3 moves into engagement with the recess 13, the inlet port is opened, and the fluid is forced into the first cylinder 11.

The dispenser shown in Figs. 4-6 has the same components as the dispenser of Fig. 1-3 and therefore these components are identified by the same reference numbers. However, for ease of manufacture and assembly the structure of the dispenser of Figs. 4-7 is slightly modified as explained below.

Referring now to Figs. 4-6, second piston 3 has a spring seat 20 for receiving the upper end of spring 6. Piston 3 also has a ledge 21 which is engaged by the rim 19 when the piston 3 and shaft 18 move downward together. The ledge 21 and rim 19 are free to separate when the piston 3 moves upwardly with respect to the shaft 18.

The flange 17 forms a cup 22 which is engaged by the open bottom end of the lower portion 27B of first piston 2 in such manner as to engage both the flat horizontal surface and the vertical sides of the cup 22.

The lower end 23 of cylinder 12 has an opening 24 recessed upwardly via a channel 25 which can receive a dip tube when necessary. The lower end of cylinder 11 is connected to the upper end of cylinder 12 by a circular groove 26 which can

receive the end of the lower portion 27B of the first piston 2.

The dispensers shown in Figs. 4-6 and in Figs. 1-3 function in exactly the same manner and use the same four seals having the same diametrical relationships.

Referring to Figs 7 and 10, there is shown a modification of the finger actuated pump dispenser of the invention which is particularly suitable for automatically mixing fluids of different densities. All the components similar to those of Figs. 1-6 are given the same references.

Also in thi case the second vertical piston 3 is disposed slidably in the second cylinder 12. However, the stem 4 is longer than the first piston 2 and always extends below the bottom open end 10 of the piston 2. The bottom end of the stem 4 is secured to the upper end of piston 3. The outer surface 28 of stem 4 is smooth.

In this case the upper portion 27A of piston 2 with opening 9 and the upper end of the stem forms the outlet port. The outlet port is closed when the upper end of the stem engages and closes opening 9. When the upper end of the stem is disposed below and out of engagement with opening 9, the outlet port is open.

Initially, the upper cylinder 11 is filled with liquid and defines a pump chamber. The liquid is constituted by two or more fluids of different densities. The lower density fluid has settled to the bottom 34 of the pump chamber. The outlet port is closed. When the actuator 8 is depressed, the first piston 2, stem 4 and second piston 3 travel downward. When the second piston 3 passes the recess 13, the inlet port is closed.

Since the liquid is incompressible, as the first piston 2, stem 4 and second piston 3 continue to travel downward, the liquid is displaced from the larger upper cylinder 11 into the lower smaller cylinder 12 via the narrow region between the lower portion 27B of the first piston 2 and the inner wall of the smaller cylinder 12. Since the region is so narrow, the forces on the liquid produce thorough and complete mixing of fluids of similar but different densities. These forces also cause the second piston 3 and the stem 4 to move downwardly with respect to the first piston 2, opening the outlet port. The fluids so mixed pass through channel 29 between the stem 4 and the first piston 2 out of the open port, and the mixture of fluids is discharged through the actuator 8.

As shown in Figs 8 and 11, the outer surface of the lower portion 27B of the first piston 2 is provided with a plurality of equidistantly spaced vertical grooves 30. Fluids of substantially different densities are not confined to the entire region between the lower portion 27B of the first piston 2 and the inner wall of the lower cylinder 12, but instead are further confined in the vertical grooves 30. This arrangement produces the additional mixing forces required.

When the liquid to be dispensed consists of fluid and particulate matter, the outer surface of the lower portion 27B of the first piston 2 should have one or more helical grooves 31, as shown in detail in Fig 9.

The components of the dispenser shown in Fig 9 which are the same as the components of the dispenser shown in Fig 7 are identified by the same numbers. However, the outer surface of the lower portion 27B of piston 2 shown in Fig 8 has a plurality of helical grooves 31. In addition, the upper end of the second piston 3 has a circular recess 32. This recess 32 defines the lowest region of the pump chamber, and the particulate matter will be deposited therein. Upon actuation in the same manner as previously described, the fluid will swirl downward along the grooves 31 with considerable force and be drawn into the sediment in recess 32. When the outlet port is opened, a mixture of fluid and lifted solids continues to spin travelling toward the outlet port via the conduit 29 formed between the first piston 2 and the stem 4.

The number of grooves 31 and the pitch thereof is determined by the density of the particulate and the size of the particles relative to the amount of fluid employed. If the particulate is not too dense and the particle sizes are sufficiently small, the structure shown in Figs 8 and 11 can be used in place of the structure in Fig 9.

As shown in Figs 12 and 13, the structure shown in Fig 9 can be modified by inserting least one slot 33 (two oppositely disposed slots 33 are shown in Figs 12 and 13) interconnecting the interior of the second cylinder 3 with the space 29 between the first piston 2 and the stem 4. While not shown, the same slot or slots 33 can be used in the embodiment shown in Fig 8. In either embodiment, the fluid in the interior of the second cylinder 12 is mixed with the mixture of fluids or fluid and particulate being discharged through the space 29 between the first piston 2 and the stem 4, thus providing an enhanced mixing action.

While the embodiments of dispenser in Figs 7-13 have been described in their particular use in dispensing fluid suspensions or mixtures of fluids of different densities, it is apparent that also the embodiments of dispenser in Figs. 1-6 lend themselves to be employed for the same purpose.

Claims

1. Finger actuated pump dispenser of the type having:

a first upper hollow cylinder (11) with a first diameter and open upper and lower ends;

a first vertical hollow piston (2) having open top and bottom ends and disposed slidably in the first upper hollow cylinder (11);

a second lower hollow cylinder (12) coaxial with the first cylinder (11) and forming a prolongation thereof of smaller diameter, the inner wall of the second cylinder (12)having an enlarged horizontal annular recess (13) at the jontion of the first and second cylinders,

a second vertical piston (3) disposed slidably in the second cylinder (12),

a vertical stem (4) disposed slidably within the first piston (2) and engaging the second piston (3),

a spring (6) extending within the second cylinder (12) between its lower end and the lower end of the second piston (3),

characterized in that:

the first piston (2) is provided with an enlargement (14) intermediate its ends defining an upper portion (27A) and a lower portion (27B), the upper portion (27A) extending slidably above and within the first cylinder (11) and the lower portion (27B) extending slidably within the first cylinder (11) and the second cylinder (12), the enlargement (14) peripherally engaging and defining a first unbroken seal (S1) with the inner surface of the first cylinder (11),

the second piston (3) peripherally engages and defines a second seal (S2) with the inner surface of the second cylinder (12), the second seal (S2) being unbroken except when the second piston (3) is aligned with and spaced from the annular recess (13).

2. Dispenser of claim 1, characterized in that the second piston (3) has a central bore (15) extending therethrough and the vertical stem (4) is provided with an outwardly extending central horizontal flange (17) secured thereto intermediate its ends, the bottom open end of the lower portion (27B) of the first piston (2) engaging and defining a third seal (S3) with the flange (17), the third seal (S3) being broken when the bottom open end of the lower portion (27B) of the first piston is separated from the flange (17), a portion of the stem (4) below the flange (17) extending vertically and slidably downwards through the central bore (15) of the second piston (3) and engaging and defining a fourth unbroken seal (S4) with said bore (15).

3. Dispenser of claim 1, characterized in that the vertical stem (4) is secured at its lower end to the upper end of the second piston, (3) the stem (4) being longer than the first piston (2) so that there is always a vertical separation between the bottom end of the lower portion (27B) of the first piston (2) and the lower end of the stem (4).

4. Dispenser of claims 1 and 2, characterized in that said stem portion is a shaft (18).

5. Dispenser of claim 4, characterized in that the shaft (18) has a lower end (19) having a diameter larger than the diameter of the bore (15) of the second piston (3).

6. Dispenser of claim 5, characterized in that the third seal (S3) is broken at a point during the downstroke when the lower end (19) of the shaft (18) engages the lower end of the second piston (3), the period of time between the time of initiation of the downstroke and the time at which the third seal (S3) is broken being defined as the delay period, the delay period increasing with increasing length of the shaft (18) and decreasing with decreasing length of the shaft (18).

7. Dispenser of claims 1 and 2, characterized in that the diameter of the first seal (S1) is larger than that of the second seal (S2), the diameter of the second seal (S2) is larger than that of the third seal (S3), and the diameter of the third seal (S3) is larger than that of the fourth seal (S4).

8. Dispenser of claims 1,2 and 4, characterized in that the second piston (3) is in peripherally and sealing engagement with the inner surface of the second cylinder (12) except when the second piston (3) is aligned with and spaced from the annular recess (13), the second piston (3) and the recess (13) defining an inlet port which is open when the piston is aligned with the recess (13) and is otherwise closed and the bottom open end and the flange (17) define an outlet port which is open when the bottom open end is separated from the flange (17) and is otherwise closed.

9. Dispenser of anyone of the preceding claims, characterized in that the lower surface of the lower portion (27B) of the first piston (2) is provided with a plurality of spaced downwardly extending grooves (30).

10. Dispenser of claim 9, characterized in that the grooves (30) are vertical.

11. Dispenser of claim 9, characterized in that the grooves are pitched helical grooves (31).

12. Dispenser of claim 11, characterized in that the upper end of second piston (3) has a circular recess (32).

13. Dispenser of claim 12, characterized in that the recess (32) surrounds the lower end of the stem (4).

14. Dispenser of claims 1 and 3, characterized in that it further includes at least one slot (33) in the lower portion (27B) of the first piston which extends between the interior of the second cylinder (12) and the space (29) between the first piston (2) and the stem (4).

15. Dispenser of claim 14, characterized in that it contains two oppositely disposed slots (33).

16. Dispenser of claims 1 and 3, characterized in that the upper end of the stem (4) and the upper end of the first piston (2) define an outlet port which is closed when these two upper ends are engaged in contact with each other and which is open when these two ends are separated.

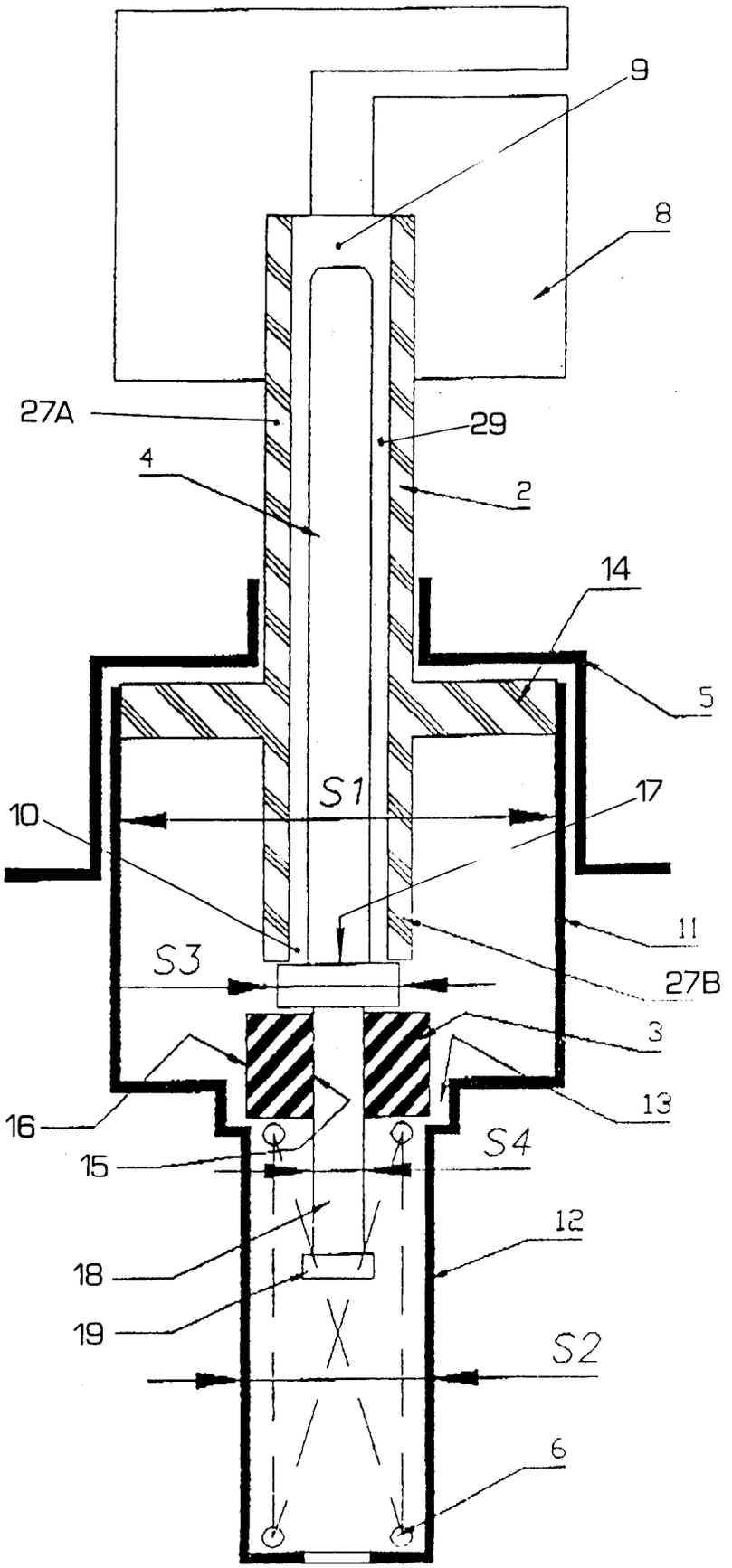
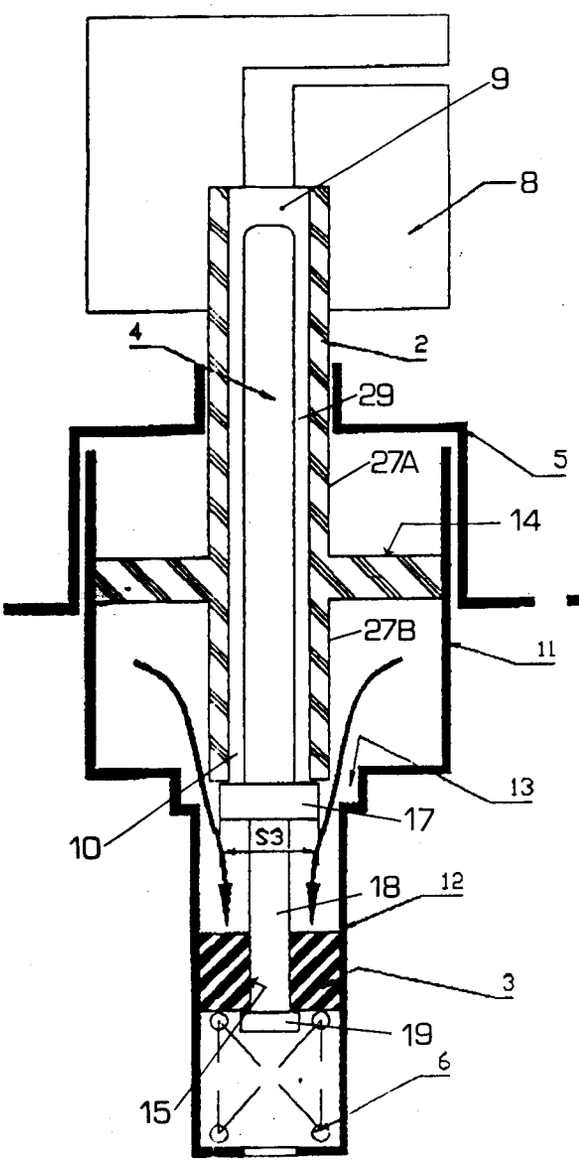


FIG. 1


9
8
4
2
29
27A
5
14
27B
11
13
10
17
S3
18
12
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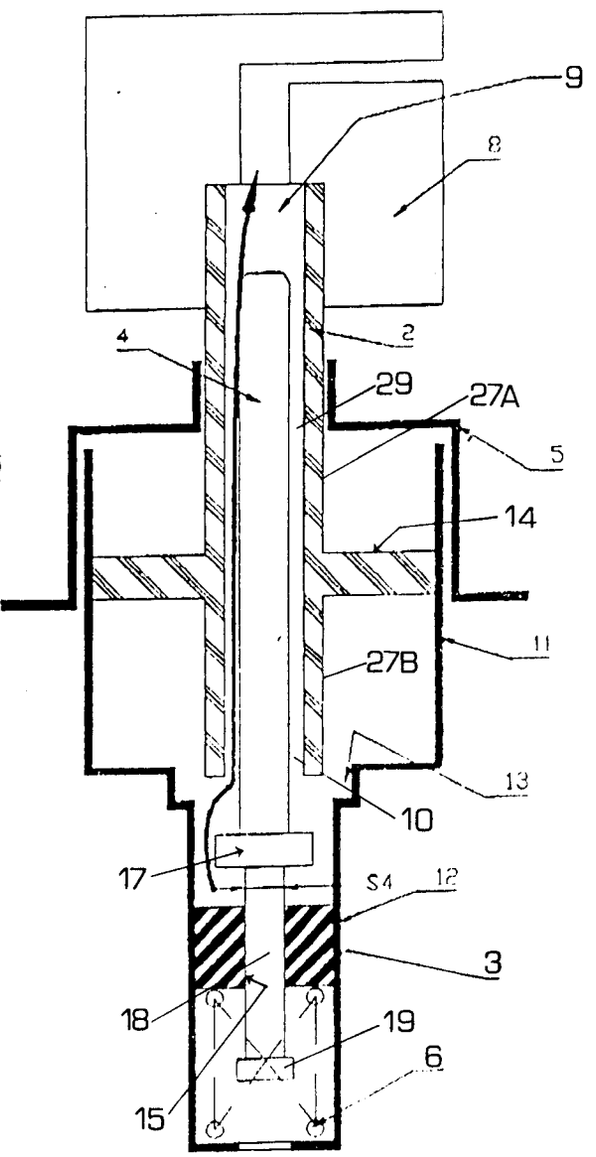
19
6
15

FIG. 2


9
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27B
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S4
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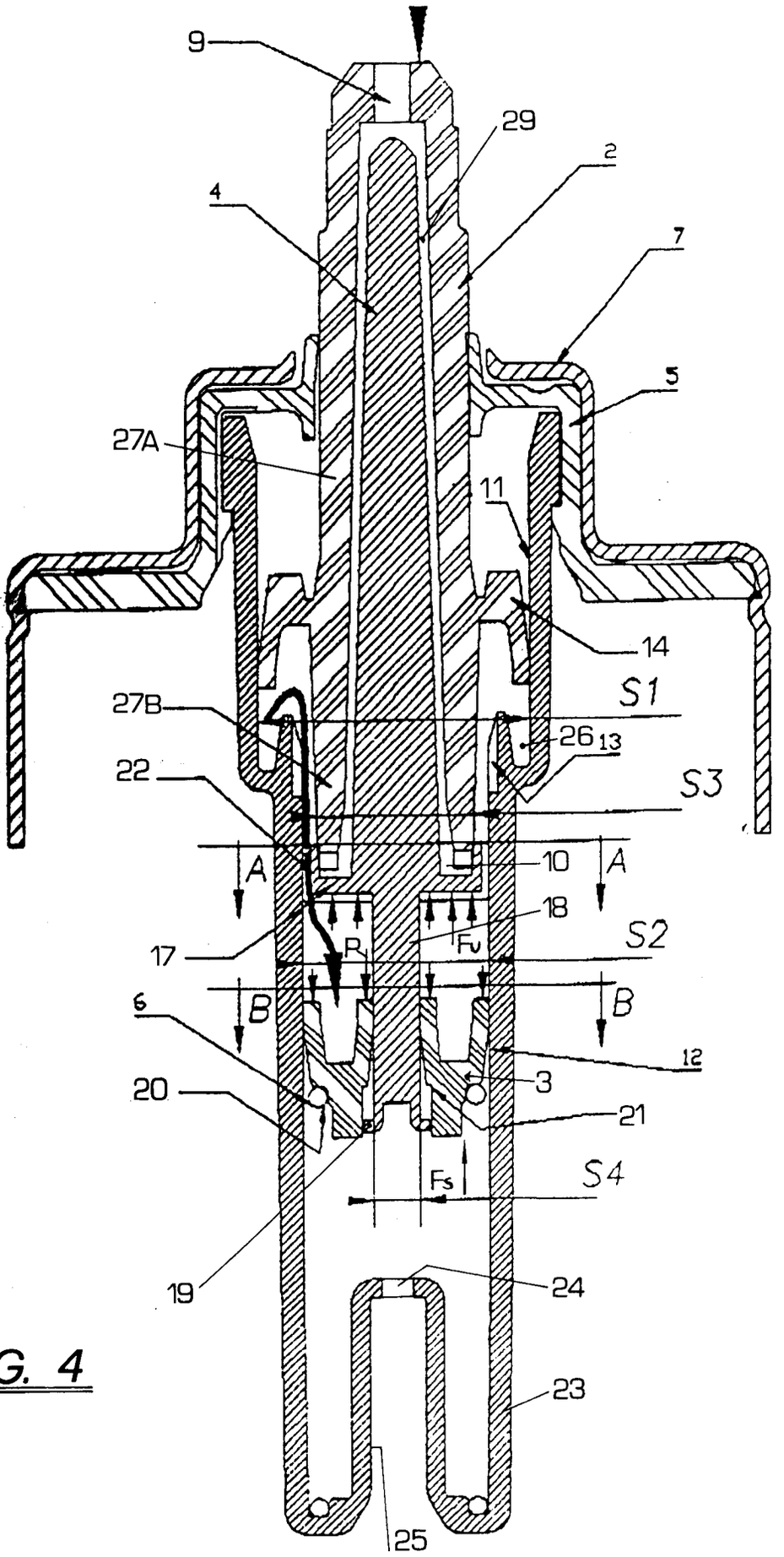
6
15

FIG. 3


9
29
2
4
7
5
27A
11
14
S1
27B
26
13
22
S3
A
10
A
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20
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S4
19
24
23
25

FIG. 4

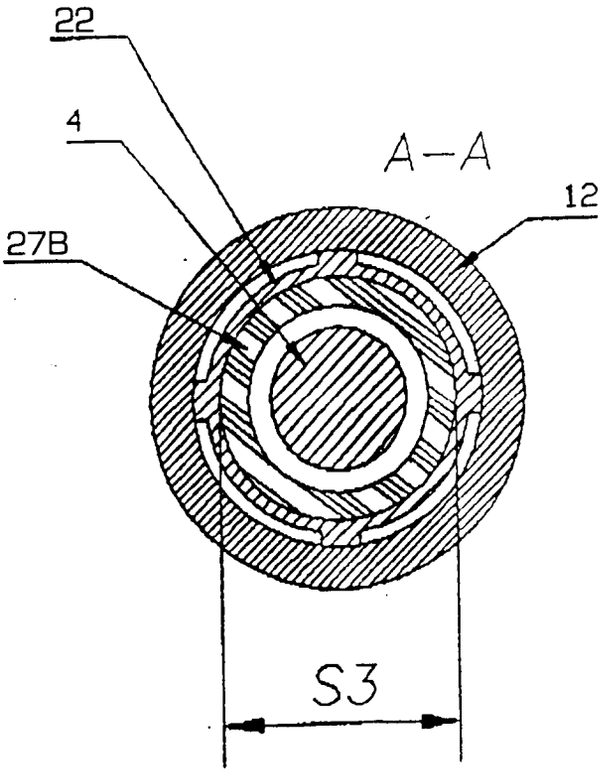

FIG. 5

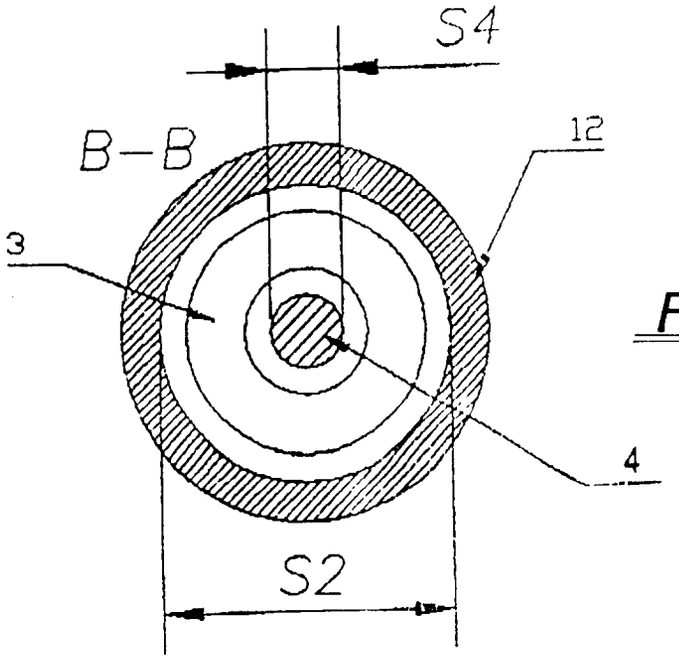

FIG. 6

FIG. 7

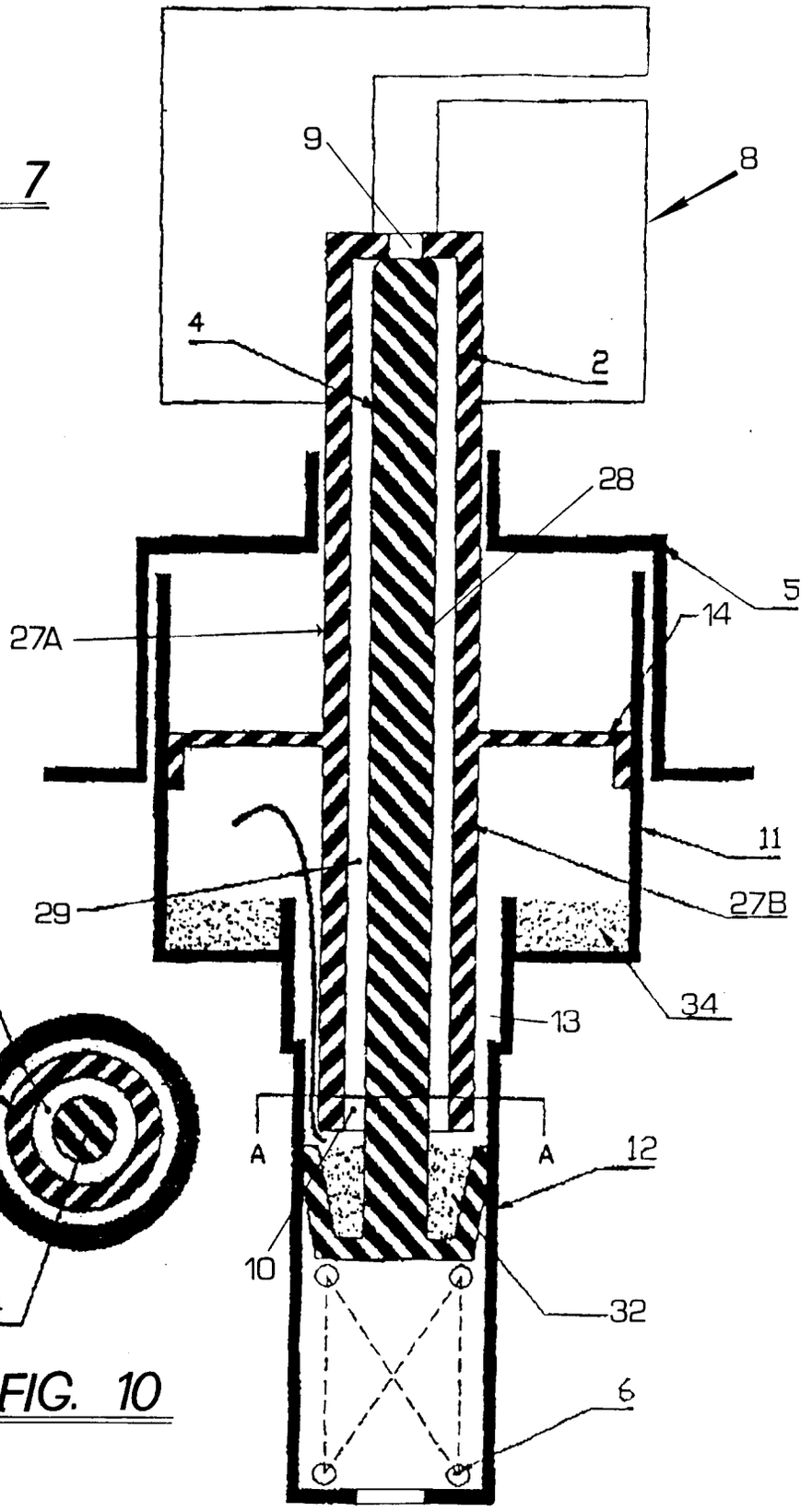

FIG. 10

FIG. 8

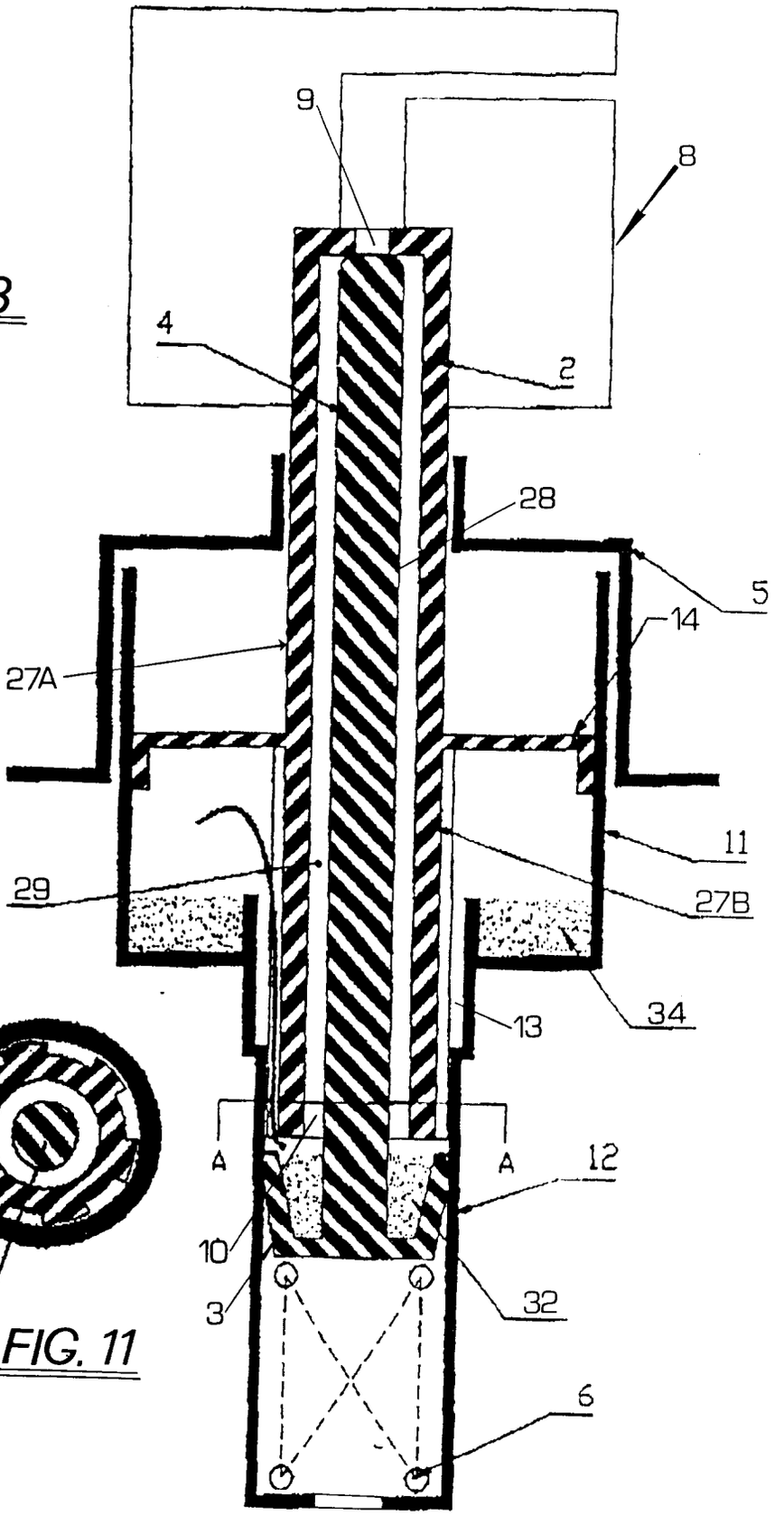

FIG. 11

FIG. 9

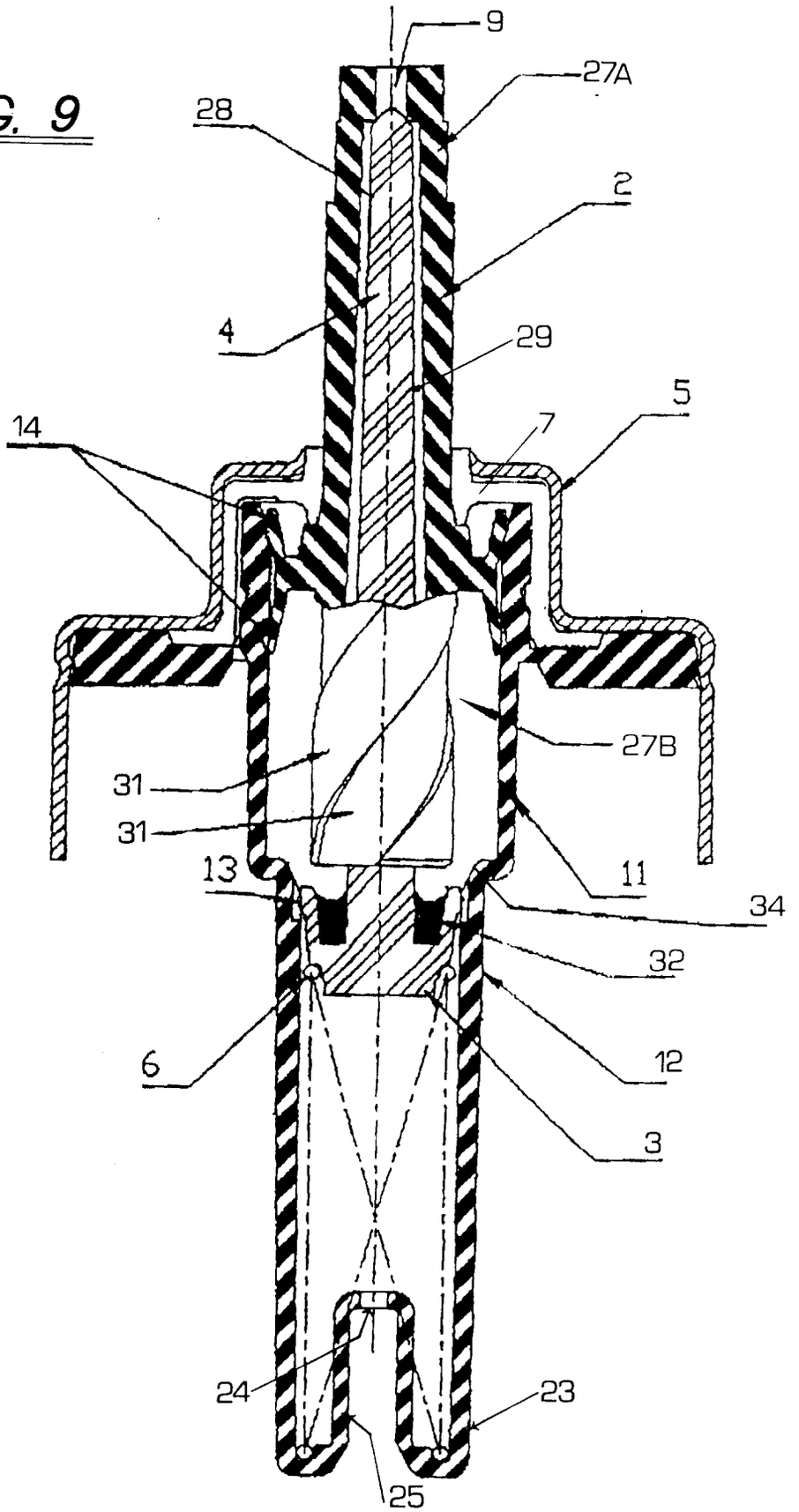

FIG. 12

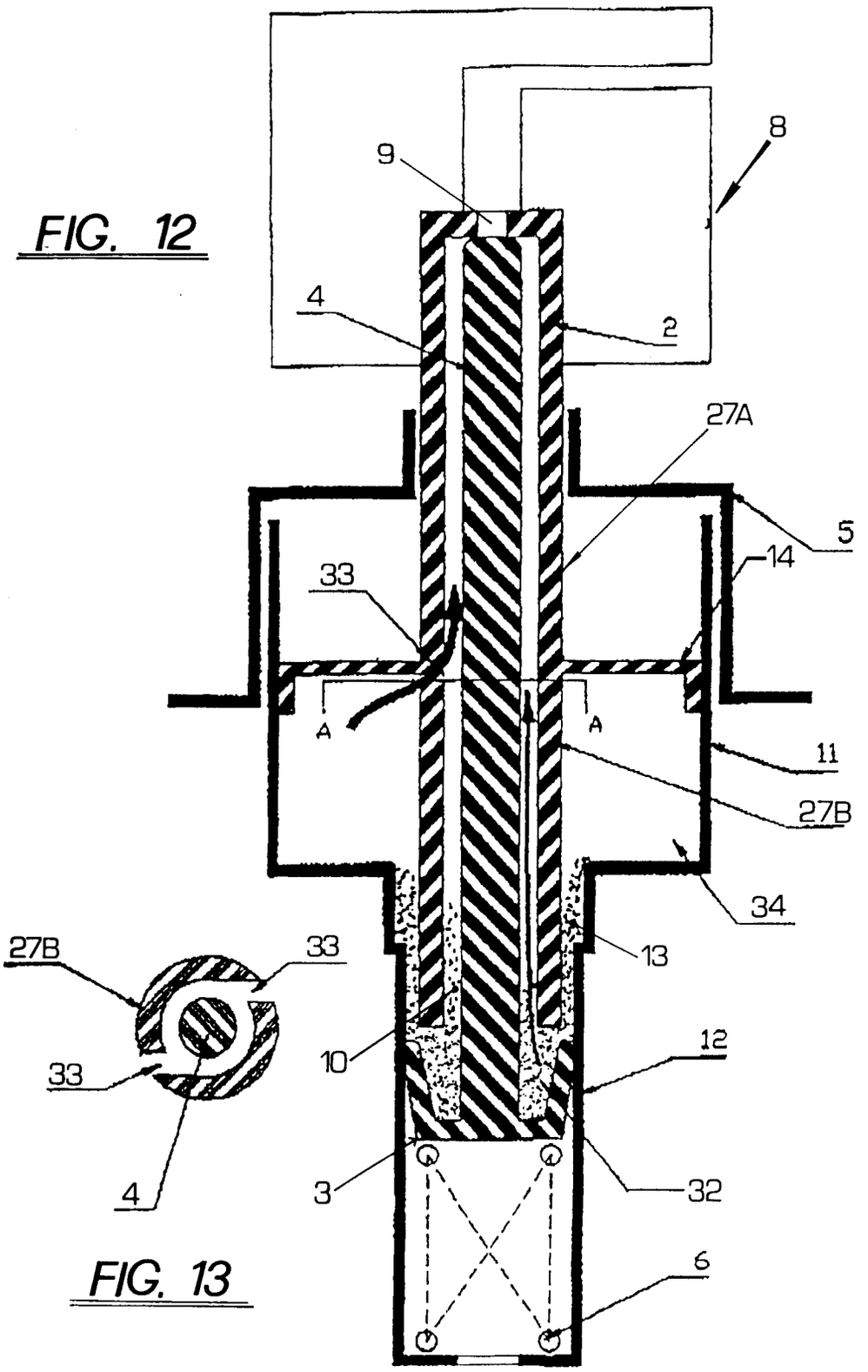

FIG. 13