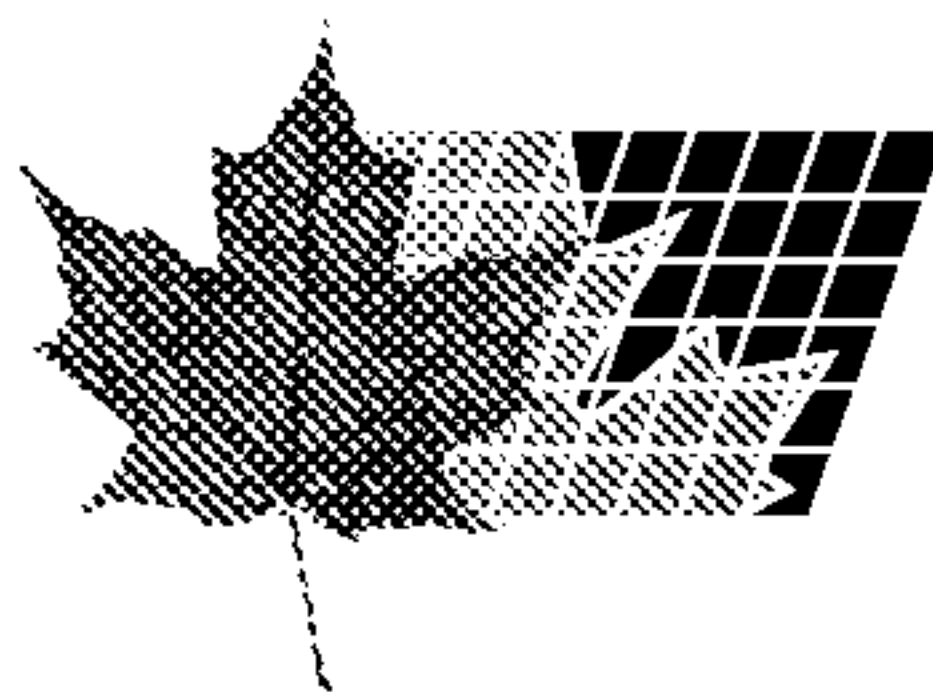




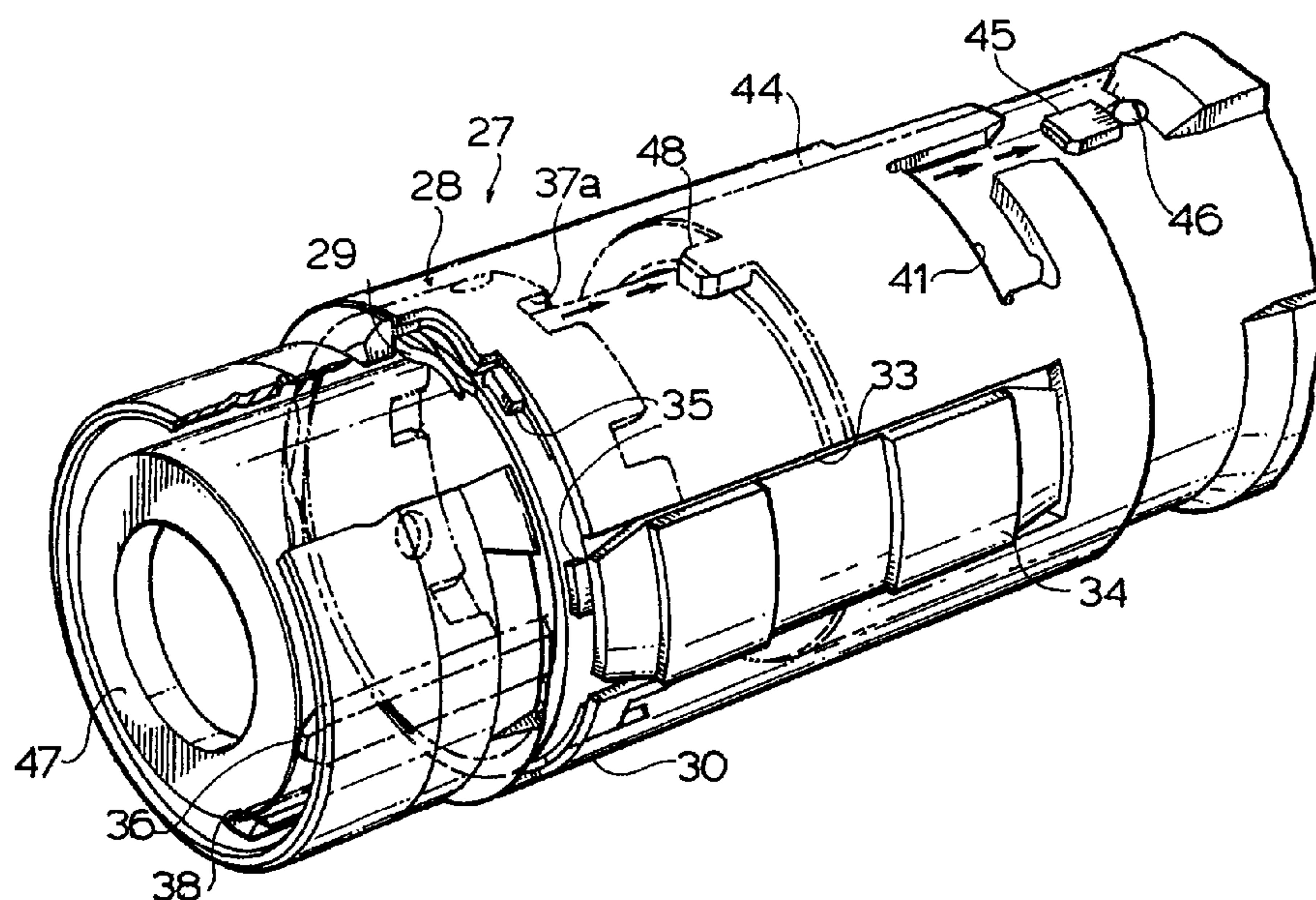
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(54) **DISPOSITIF DE TELEPRELEVEMENT D'ECHANTILLONS
PAR RACLAGE DE LA PAROI DES CANAUX DE
COMBUSTIBLE NUCLEAIRE SOUS EAU, AVEC MAINTIEN
DE L'ORIENTATION DE L'OUTIL**

(54) **FUEL MACHINE DELIVERY SYSTEM FOR WET SCRAPE
WHILST MAINTAINING TOOL ORIENTATION**



(57) Apparatus for remotely obtaining sample scrapings from the inner surface of a fuel channel of a nuclear reactor with coolant in the fuel channel. A sampling tool is introduced into a fuel channel. The sampling tool has a cylindrical casing in which are mounted cutters for obtaining the scrapings. Forward movement of a central shaft in the sampling tool actuates the cutters in sequence to project through a slot as they move forwards and the sample scrapings fall into sample receiving pockets in the sampling tool. A pusher having a cylindrical casing of substantially the same inner diameter as the inner diameter of the fuel channel has a floating plunger mechanism with a sliding internal housing mounting a plunger rearwardly biased in the housing. The ram head of a fuelling machine engages the trailing end of the plunger, moves the housing forwardly until it stops against the casing of the sampling tool and then advances the plunger to cause forward movement of the central shaft of the sampling tool to obtain the scraping. A preferred form of the apparatus obtains sample scrapings at desired orientations. For example, it obtains scrapings at desired ones of a 11:00 o'clock, 12:00 o'clock or 1:00 o'clock orientations. An orientation device is installed in the end of a fuel channel and it has a rotatable ring which may be rotated to one of three selectable positions corresponding to respective ones of the 11:00 o'clock, 12:00 o'clock and 1:00 o'clock orientations. A ring key on the orientation device cooperates with a keyway in the sampling tool to orient the sampling tool.

FUEL MACHINE DELIVERY SYSTEM FOR WET SCRAPE WHILST
MAINTAINING TOOL ORIENTATION

Abstract of the Disclosure

Apparatus for remotely obtaining sample scrapings from the inner surface of a fuel channel of a nuclear reactor with coolant in the fuel channel. A sampling tool is introduced into a fuel channel. The
5 sampling tool has a cylindrical casing in which are mounted cutters for obtaining the scrapings. Forward movement of a central shaft in the sampling tool actuates the cutters in sequence to project through a slot as they move forwards and the sample scrapings fall
10 into sample receiving pockets in the sampling tool. A pusher having a cylindrical casing of substantially the same inner diameter as the inner diameter of the fuel channel has a floating plunger mechanism with a sliding internal housing mounting a plunger rearwardly biased in
15 the housing. The ram head of a fuelling machine engages the trailing end of the plunger, moves the housing forwardly until it stops against the casing of the sampling tool and then advances the plunger to cause forward movement of the central shaft of the sampling
20 tool to obtain the scraping.

A preferred form of the apparatus obtains sample scrapings at desired orientations. For example, it obtains scrapings at desired ones of a 11:00 o'clock, 12:00 o'clock or 1:00 o'clock orientations. An
25 orientation device is installed in the end of a fuel channel and it has a rotatable ring which may be rotated to one of three selectable positions corresponding to respective ones of the 11:00 o'clock, 12:00 o'clock and 1:00 o'clock orientations. A ring key on the
30 orientation device cooperates with a keyway in the sampling tool to orient the sampling tool.

FUEL MACHINE DELIVERY SYSTEM FOR WET SCRAPE WHILST
MAINTAINING TOOL ORIENTATION

Background of the Invention

This invention relates to a system and apparatus for providing a wet scrape of the inner surface of a fuel channel of a nuclear reactor, and in particular it relates to a system for and apparatus for use in providing, at a particular orientation, a wet scrape of the inner surface of a fuel channel.

It is known to obtain samples or scrapings from the inner surface of a fuel channel in a nuclear reactor for metallurgical analysis. Such an analysis indicates the condition of the metal wall of the fuel channel and thereby, amongst other things, indicates the remaining useful life of the fuel channel.

In the past, to obtain samples or scrapings from the wall of a fuel channel, the nuclear reactor was first shut down. The selected fuel channel or fuel channels were then defuelled and drained. Then one or more persons entered the vault which housed the nuclear reactor and, with a long handled tool, obtained a scraping from the inside surface of the selected fuel channels.

It is, of course, preferable to avoid having people in the vault. It is also preferable to avoid having to drain the fuel channels. The present invention makes this possible with a minimum of
5 inconvenience. In addition, useful information may be derived if samplings are taken at particular orientations, and the present invention also makes this possible.

10 Summary of the Invention

The present invention provides a system for and apparatus useful for obtaining a wet scraping from the inside surface of a fuel channel. That is, it provides means for obtaining a sample or scraping from a
15 fuel channel while there is still coolant in the fuel channel. This is referred to as a wet scrape. In other words, the reactor is shut down, but it is not necessary to drain the coolant from any of the fuel channels. The flow rate of the coolant is normally reduced but it may
20 continue to flow. Fuel bundles are removed from the desired fuel channels, as will be described in more detail hereinafter, and a scraping obtained at a desired place. An improved embodiment provides also an orientation tool, which works in conjunction with a
25 scraping tool, to cause a scraping to be obtained with the tool in a desired orientation. For example, the orientation tool may provide for a scraping to be obtained in a selected fuel channel at the 11:00 o'clock, 12:00 o'clock, and 1:00 o'clock orientations.
30 This sampling is done by machine, with no one being required in the vault.

When the wet scrape is completed, the fuel bundles are replaced and the reactor may be put into operation.

35 It is therefore an object of the invention to

provide an improved system for obtaining a wet scrape from the inner surface of a fuel channel of a nuclear reactor.

5 It is a further object of this invention to provide an apparatus for use with a scraping tool that provides for a desired orientation of the scraping tool.

It is yet another object of the invention to provide an improved system for obtaining a wet scrape without requiring anyone in the reactor vault.

10 Accordingly there is provided apparatus for obtaining samples at a plurality of orientations spaced on either side of and including the 12:00 o'clock orientation, from the inner surface of a fuel channel of a nuclear reactor having a plurality of horizontally
15 extending fuel channels, each said fuel channel having a liner locking lug on the inner surface adjacent at least the end from which the sampling is to be done, comprising an orientation device having a generally cylindrical housing with a liner locking lug receiving
20 slot therein for receiving said liner locking lug and fixing said housing in a desired position, an orientation device ring mounted within said housing for rotation between a plurality of positions each corresponding to one of said plurality of orientations
25 and with corresponding spacing, a ring key mounted to said orientation device ring projecting inwardly and extending forwardly of said ring, a sampling tool having a cylindrical casing with a front and a back end and a longitudinally extending keyway, said cylindrical casing
30 fitting within said fuel channel with said ring key at least partly within said keyway, a tool carriage within said cylindrical casing fastened to a centrally located shaft and mounted for longitudinal movement within said cylindrical casing, said shaft having a terminating end
35 at said back end of said casing, said tool carriage

having at least one sampling tool cutter mounted in a sample receiving pocket and being responsive to forward longitudinal movement of said tool carriage to move outwardly for engaging the inner surface of said fuel channel to scrape away a sample, said cylindrical casing of said sampling tool having a slot extending longitudinally above said sampling tool cutter for permitting said cutter to move outwardly and forwards, and means for engaging said terminating end of said shaft for moving said shaft and said tool carriage longitudinally forward.

Brief Description of the Drawings

The invention will be described with reference to the accompanying drawings, in which

Figure 1 is a top view, in block form, showing a nuclear reactor and fuelling machines;

Figures 2A and 2B are simplified end views of a downstream and upstream magazine;

Figure 3 is a sectional side view of a fuel channel showing a portion of the arm of a fuelling machine;

Figure 4 is an isometric view of an orientation device and an installation tool used for installing the orientation device;

Figure 5 is a simplified sectional view of an orientation device housing showing the housing in position on a locking lug of a fuel channel liner;

Figure 6 is an isometric view of an orientation device, from a different angle to that used in Figure 4;

Figures 7-10 are sectional side views of an end of a fuel channel with various tools and carriers useful in describing various stages in obtaining a wet scrape,

Figure 11 is a sectional view of a sampling tool;

Figure 12 is an end view of the sampling tool of Figure 11;

5 Figure 13 is a sectional view of a sampling tool carrier;

Figure 14 is an end view of the sampling tool carrier of Figure 13;

Figure 15 is a sectional view of a spacer;

10 Figure 16 is an end view of the spacer of Figure 15;

Figure 17 is a partial isometric view of the nose end of the spacer of Figure 15;

15 Figure 18 is a side view, partly in section, of a spacer carrier;

Figure 19 is an end view of the spacer carrier of Figure 18; and

Figure 20 is a sectional side view of a pusher.

20 **Description of the Preferred Embodiments**

Referring to Figure 1 there is shown in block form a nuclear reactor 10 having one of its fuel channels 11 indicated by broken lines. The fuel channel 11 has an end fitting 12 at one end and an end fitting 25 12' at the other end, both of greater diameter than the fuel channel 11. The end fittings 12 and 12' will accommodate, for example, a shield plug and a channel closure as is known.

30 Fuelling/defuelling machines 14 and 15 are substantially similar and may hereinafter be referred to as fuelling machines or more simply as machines. Fuelling machines 14 and 15 are capable of transverse, longitudinal and vertical movement to align them with any desired fuel channel. The fuelling machines 14 and

15 include respectively arms 16 and 17. Each of the arms 16 and 17 has longitudinal or axial movement. Each machine 14 and 15 has a magazine 18 and 20 respectively, which are rotatably mounted on a longitudinal axis. The
5 magazines 18 and 20 have a number of longitudinally extending openings and may be rotated so that any desired opening is aligned with the arm 16 and 17 of the respective machine 14 and 15, whereby the arm may extend
10 through the opening and couple onto devices stored in the aligned opening. The arms may also withdraw fuel bundles, tools or other devices and leave them in an aligned opening. This will be explained in more detail subsequently. The arms 16 and 17 of fuelling machines 14 and 15 have limited longitudinal movement. This
15 requires the use of extensions or spacers on the ends of the arms so that the farthest fuel bundle position in the fuel channel may be reached. These spacers, as well as tools and fuel bundles are stored in the openings or compartments in magazines 18 and 20.

20 Referring now to Figures 2A and 2B, there are shown end views of magazines 18 and 20. Each magazine has eleven openings or compartments. In magazine 18 the openings are designated M1 to M11. In magazine 20 the openings are designated N1 to N11. For example,
25 openings M1 and N1 may be used to hold respective channel closures, openings M2 and N2 may be used to hold respective shield plugs, and M3 and N3 may be used to hold orientation tools with installation tools (to be subsequently described). The other openings may hold
30 carriers for fuel bundles, carriers for spacers or extensions, carriers for pushers, and carriers for sampling tools as required.

Referring to Figure 3, there is shown a sectional side view of a fuel channel with fuel bundles
35 21a-21m. At the upstream end there is a shield plug 22

adjacent fuel bundle 21m and a channel closure 23. At the downstream end, the shield plug and closure have been removed and a ram head 24 on the end of arm 17 is shown with a surrounding charge tube 25. The ram head
5 24 and the charge tube 25 are capable of independent movement.

In accordance with one aspect of the invention, a wet scrape may provide a scraping at any desired distance from an end of a fuel channel by
10 inserting the scraping tool a desired distance before actuating the tool and withdrawing the tool to obtain the sample. However, the scraping will be taken at a random orientation. It is often desirable to take sample scrapings at the same specific orientation, and
15 the apparatus and the manner of doing this will be described.

Referring to Figures 4, 5 and 6, an orientation device or tool 27 has an orientation ring 28 and a housing 30. A wave spring 29 biases ring 28 from
20 abutting against the reduced diameter portion of housing 30. A detent lug 31 is held clear of the spaced apart detent slots 32 in housing 30 by wave spring 29. When the ring 28 is pressed forward, spring 29 is compressed, and detent lug 31 may enter one of the detent slots 32A,
25 32B or 32C, whichever is positioned appropriately.

A slot 33 in housing 30 receives liner locking lug 34 on the fuel channel liner, and this positions the orientation device 27 within the fuel channel. A pair of ring lugs 35 on the orientation device ring 28 are
30 spaced apart so that, when the ring 28 is correctly oriented, the lugs 35 will pass on either side of the liner locking lug 34 as the ring 28 is advanced. Once ring 28 is in position, rotation of ring 28 will move one of the lugs 35 behind the locking lug 34, as shown
35 in Figure 4, to prevent outward movement of the

orientation device 27. A ring key 36 projects from the forward end or inward end of the orientation device ring 28 to provide for the orientation of other tools or equipment, as will be described.

5 In the forward or nose end of housing 30 is a leaf spring detent 38 for assisting in holding adjacent components axially, as will be described. At the rear facing edge of orientation device ring 28 are slots 37A, 37B and 37C whose purpose will subsequently be
10 described.

The housing 30 has at its rearward facing side a guide finger 40, an L-shaped slot 41, a 30 degree drive slot 42, and a 60 degree drive slot 43, whose use will become apparent from the following description.

15 An installation tool 44 is used to install the orientation device 27. Prior to installation, the installation tool 44 and the orientation device 27 are coupled together with installation tool button 45 in L-shaped slot 41. A ball detent 46 in the installation
20 tool 44 helps prevent the orientation device 27 from vibrating off the installation tool 44 during installation and removal. The installation tool 44 has a long cylindrical nose piece 47 of smaller diameter which extends within the orientation device 27 to push
25 fuel bundles ahead, if necessary. A finger 48 on the installation tool 44 enters and engages slot 37A as the installation tool 44 advances to couple with orientation device 27. Slot 37A is one of three slots 37 spaced at particular locations around orientation device ring 28.

30 The particular orientations at which samples or scrapings are to be obtained are, in this description, the 11:00 o'clock, the 12:00 o'clock, and the 1:00 o'clock positions or orientations. It will be seen that there are 30 degrees between the 1:00 o'clock
35 and the 12:00 o'clock orientations or positions, and 60

degrees between the 1:00 o'clock and the 11:00 o'clock orientations or positions. As will subsequently become apparent, by changing, for example, the position of the liner locking lug 34 or the slot 33 in housing 30, the particular orientations to be sampled may be changed. However, because the samples scraped from the wall of the fuel channel fall into a pocket in the sampling tool, the orientations used cannot be much greater than, say 10:30 on one side and 1:30 on the other side.

The slot 37A may be referred to as the 1:00 o'clock slot in the orientations used herein. There is also a slot 37B for the 12:00 o'clock orientation and a slot 37C for the 11:00 o'clock orientation. As the installation tool 44 is advanced by the charge tube with finger 48 in slot 37A, the wave spring 29 is compressed and the detent lug 31 moves clear of slot 32A. The charge tube 25 (Figure 3) with the installation tool 44 is rotated by 35 degrees clockwise to stall. This rotation moves installation tool button 45 out of the foot end of the L-shaped slot 41 to bear against the straight side of slot 41. This, in effect, uncouples the installation tool 44 from the orientation device 27. Also, the clockwise rotation of the installation tool 44 rotates the orientation device ring 28 because the installation tool finger 48 is in slot 37A. This places the ring key 36, particularly as seen in Figure 5, 10 degrees below horizontal and to the left when looking towards the reactor. Because the keyway in the sampling tool (the keyway which receives ring key 36) is 130 degrees relative to the cutter, the sampling tool cutter will be at the 1:00 o'clock position (i.e. 10 degrees for the position of the ring key below horizontal, plus 90 degrees from horizontal to vertical, plus 30 degrees from the vertical or 12:00 o'clock orientation to 1:00 o'clock, totals 130 degrees). In addition, the

clockwise rotation places one of the ring lugs 35 in line with the liner locking lug 34 so that the orientation device 27 cannot inadvertently uncouple itself from the fuel channel liner, and the rotation
5 positions ring detent lug 31 opposite slot 32A in housing 30. When the installation tool 44 is withdrawn or retracted, ring detent lug 31 is pressed into slot 32A by wave spring 29. The orientation device 27 is now installed for taking a scraping or sample at the 1:00
10 o'clock orientation. The orientation device 27 is initially installed with the ring key 36 at 10 degrees below horizontal, as described and shown in Figure 5. As was explained, this is the 1:00 o'clock orientation for sampling.

15 If it is desired to obtain a wet scrape at an orientation of 12:00 o'clock, the installation tool 44 is again brought into position by the charge tube with the installation tool button 45 within the 30 degree drive slot 42 at the most counter clockwise edge, but
20 not advanced axially sufficiently to engage installation tool finger 48 in a slot. Now the charge tube rotates installation tool 44 clockwise by 30 degrees to stall the installation tool button against the far edge of drive slot 42, that is, against the most clockwise edge
25 of the 30 degree drive slot 42. Now the installation tool 44 is advanced to stall. This causes the installation tool finger 48 to enter slot 37B in orientation device ring 28 and also compresses wave spring 29 so that detent lug 31 is clear of slot 32A.
30 The charge tube now rotates the installation tool 44 by 30 degrees counter clockwise to stall the installation tool button 45 against the opposite edge of the 30 degree drive slot 42 (i.e. against the most counter clockwise edge). This rotates the orientation device
35 ring 28 by 30 degrees counter clockwise and thus moves

the ring key 36 by 30 degrees counter clockwise. This will give the orientation of 12:00 o'clock for the sampling tool (10 degrees for the original position of ring key 36, plus 30 degrees for the rotation just
5 described, plus 90 degrees from horizontal to vertical, gives a total of 130 degrees which is the amount of displacement between the ring key 36 and the cutters of the sampling tool). It will be seen that the same procedure, using the 60 degree drive slot 43 would give
10 an orientation for the sampling tool cutters of 11:00 o'clock.

The orientation device 27 is seen in Figure 7, in simplified schematic form, as it is installed by installation tool 44. Once the orientation device 27 is
15 installed, the installation tool 44 is withdrawn and stored, for example, in compartment N3 of magazine 20 (Figure 2B). Then a sampling tool carrier with a sampling tool 50 is picked up from, for example, compartment N4 of magazine 20 (Figure 2B).

Referring now to Figure 11, there is shown an example of a sampling tool 50. Sampling tool 50 does not form part of this invention although it has been adapted to cooperate with the orientation means of the invention. The sampling tool 50 has a cylindrical
20 casing 51 having an inner cylindrical wall 52. A shaft 53 has at one end a head 54 which faces open end 55 of casing 51. Adjacent the other end of sampling tool 50, inside casing 51, is a sampling tool carriage 56 with sampling tool cutters 57 and 58. The sampling tool
25 cutters are mounted in small containers or pockets 60 and 61 in the top of cutter carriers 62 and 63, respectively. The sampling tool cutters 57 and 58 are directly beneath a slotted opening 67 in casing 51. The cutter carriers 62 and 63 are biased downwardly (as
30 shown) by springs 64 and 65. An actuator 66 is mounted

to the lower part of casing 51 in line with wheels 70 and 71 on the lower ends, respectively, of cutter carriers 62 and 63.

When sampling tool 50 has been placed in a
5 desired position in a fuel channel, head 54 is advanced
and shaft 53 moves sampling tool carriage 56 ahead (to
the left in Figure 11). As wheels 70 and 71, in turn,
move over actuator 66 the respective cutter carriers 62
and 63 are moved upwards carrying the sampling tool
10 cutters 57 and 58. The sampling tool cutters 57 and 58
move upwards, i.e. move outwards, through slotted
opening 67 as they move ahead. Sampling tool cutter 57,
which is the first cutter to be moved outwards, engages
the inner surface of the fuel channel in which it is
15 located, and its purpose is to remove oxides present on
the surface. The removed material falls into pocket 60.
Sampling tool cutter 58 follows and removes a sample or
scraping (with the oxide substantially removed) which
falls into pocket 61. The sampling tool 50 is
20 subsequently removed with the samples of material.

Referring for the moment to Figure 12, there
is shown an end view of the sampling tool 50. A keyway
72 in the side of sampling tool 50 receives ring key 36
(Figures 4, 5 and 6, for example) of orientation device
25 27 as sampling tool 50 moves through the orientation
device 27. This ensures the sampling tool 50 is in the
desired orientation. Two sockets 73 and 74 are provided
in the end of casing 51 to receive alignment members
from whatever tool or device is behind sampling tool 50,
30 to retain the desired orientation as the sampling tool
50 moves beyond the orientation device 27.

There is, of course, a sampling tool carrier
75 for carrying sampling tool 50 and this is shown in
Figures 13 and 14. A sampling tool carrier 75,
35 containing a sampling tool 50 may, for example, be

stored in compartment N3 of magazine 20. Referring to Figures 13 and 14, the sampling tool carrier 75 has a generally cylindrical outer casing 76 with a nose end 77 and a trailing end 78. The trailing end 78 may have an L-shaped slot 80 or other known device or arrangement for suitable coupling to the charge tube 25 (Fig. 7, for example). A keyway 82 is in the outer wall with an inwardly extending key 83. The key 83 fits into keyway 72 (Figure 12) to aid in guiding keyway 72 onto ring key 36 (Figures 4, 5 and 6).

Referring for the moment to Figure 8, a sampling tool 50 is shown in simplified schematic form in a fuel channel 11 as it would appear just after being pushed out of its sampling tool carrier 75 by ram head 24.

It may be desired to take a wet scrape farther inwards along fuel channel 11 than is shown in Figure 8. This is done by introducing one or more spacers into the fuel channel 11. Spacers may conveniently be of two sizes - that is, with a length substantially equal to one fuel bundle and with a length substantially equal to two fuel bundles. There is, of course, a spacer carrier for the spacer. Figures 15, 16 and 17 show, respectively, a sectional view of a spacer, an end view of the trailing end of a spacer, and an isometric view of the nose end of a spacer.

Referring to Figures 15, 16 and 17, a spacer 85 has a cylindrical casing 86 with inwardly extending bearing surfaces 87 in which a shaft 88 is mounted for slidable axial movement. Shaft 88 is preferably hollow to reduce weight, and has a head end 90 and a trailing end 92. The head end 90 will engage the head 54 (Fig. 11) of the sampling tool 50, if the spacer 85 is behind and adjacent a sampling tool 50. If the spacer 85 is behind and adjacent another spacer, the head end 90 will

engage the trailing end 92 of the spacer in front when the shaft 88 is moved ahead. Springs 94 and 95 bias the shaft 88 to its rearward or rest position as shown in Figure 15. In Figure 16, a keyway 96 is shown extending the length of casing 86. Also shown are a pair of alignment sockets 97 and 98. There are corresponding alignment projections 84 and 89 on the nose end of casing 86 as may be seen in Figure 17. The mating of the alignment projections and the alignment sockets ensure that the orientation determined by the orientation device 27 (Figures 4, 5 and 6, for example) is maintained.

Referring now to Figures 18 and 19, there is shown a side view, partly in section, and an end view of a spacer carrier 100. The design of a spacer carrier 100 is quite similar to the design of a sampling tool carrier 75 (Figures 13 and 14). The spacer carrier 100 has a tubular casing 101 of sufficient inner diameter to contain a spacer. The tubular casing 101 has a nose end 102 and a trailing end 103. In the trailing end 103 of tubular casing 101 there may be an L-shaped slot 104 or other known arrangement for coupling to a charge tube 25 (Fig. 7). A keyway 106 is in the outer surface of tubular casing 101 and an inwardly extending key 107 is on the inner surface. The inwardly extending key 107 need not be continuous over the length of casing 101 but may be in two or more spaced locations as the key 107 is intended only as an aid in positioning the spacer which it carries in the correct orientation for device 27. The orientation in Figure 19 is for a 12:00 o'clock sample, that is, the key 107 is 40 degrees below horizontal.

Referring for the moment to Figure 9, there is shown, in simplified schematic form, a portion of a fuel channel 11 with a sampling tool 50 and a spacer 85 just

as ram head 24 has pushed spacer 85 from spacer carrier 100. This advanced the sampling tool 50 further into the fuel channel 11. Figure 9 shows the trailing end of the spacer 85 is still within orientation device 27 and consequently will be in a desired orientation as determined by orientation device 27. Because spacer 85 is engaged with sampling tool 50 (that is, alignment projections 84 and 89, Fig. 17, are in engagement with sockets 73 and 74, Fig. 12), the sampling tool 50 will be in the same desired orientation.

Referring now to Figure 20, there is shown a side view, partly in section, of a pusher 110 having a tubular casing 111 with a floating plunger housing 112 in which a tubular shaft 114 is mounted for slidable axial movement. The tubular shaft 114 has a nose end 115 and a trailing end 116. The nose end 115 contacts trailing end 92 of shaft 88 (Fig. 15) if a spacer 85 is ahead and adjacent, or contacts head 54 (Figures 11 and 12) if a sampling tool 50 is adjacent and ahead. A spring 118 biases tubular shaft 114 to its rearward or rest position as shown in Figure 20. The trailing end of casing 111 may have an L-shaped slot 120 or other known arrangement for coupling to a charge tube 25 (Fig. 7). The tubular shaft 114 may be advanced by ram head 24 moving ahead and engaging trailing end 116 and pressing it forwards (i.e. in a direction extending into a fuel channel). This moves the floating plunger housing ahead until it abuts the back end of a spacer. Then the shaft 114 moves ahead so that the nose end 115 engages the trailing end 92 of the adjacent spacer (or the head 54 of a sampling tool). This may, perhaps, be seen more clearly in Figure 10 which is a sectional side view, in simplified schematic form with some components omitted for ease of illustration, of a fuel channel 11 with a sampling tool 50, a spacer 85, and a pusher 110

in position to obtain a wet scrape.

A brief description of the procedure involved will be given with reference to Figures 7-10. It should be remembered that the upstream end of the fuel channel 11 has a fuelling machine 14 with an arm 16 (Figure 1) which must cooperate with the actions which take place at the downstream fuelling machine 15. Because the actions which take place at the upstream end are largely routine (such as removing and storing fuel bundles), and require no special components, these actions will not be described in detail.

When a sample or samples from a fuel channel are desired, the reactor is shut down and preferably the rate of flow of coolant is reduced. The channel closures and shield plugs are removed from the channel where samples are desired at both the upstream and downstream ends. The channel closure and shield plug from the downstream end may be stored, for example, in compartments N1 and N2 of magazine 20. The channel closure and shield plug from the upstream end may be stored, for example, in compartments M1 and M2 of magazine 18. The wet scrape is normally done from the downstream end, although if samples are required from areas adjacent the upstream end, it is possible to obtain them from the upstream end.

It should be remembered that, even though the rate of flow of coolant is reduced, there will be a tendency depending on the rate, to press fuel bundles towards the downstream end.

Once the channel closures and shields have been removed, magazine 18 is rotated to align a compartment containing an empty fuel bundle carrier, for example compartment M6, with arm 16. Arm 16 is advanced to pick up an empty fuel bundle carrier 125 and position it to receive a fuel bundle. Ram head 126 of arm 16

advances to a position to receive the end fuel bundle 21m (Figure 3). Magazine 20 is rotated to align a compartment containing an orientation device and installation tool, for example compartment M3, with arm 17. Arm 17 is advanced and charge tube 25 picks up installation tool 44 with orientation device 27 and installs the orientation device 27 as previously described. This is shown in Figure 7. The nose piece 47 (Figure 4) of the installation tool 44 presses on fuel bundle 21a (Figure 3) to permit the string of fuel bundles 21 to move upstream. Charge tube 25 then retracts to leave the installation tool 44 in the same compartment, for example compartment M3. The magazine 20 is rotated to bring a compartment containing a sampling tool carrier with a sampling tool, for example compartment M4, into alignment with arm 17. Arm 17 advances and charge tube 25 picks up the sampling tool carrier 75. As was previously mentioned, the carriers may have an L-shaped slot or other known arrangement to aid in coupling to the charge tube 25. The charge tube 25 advances the sampling tool carrier 75 to the end of the fuel channel 11. Charge tube 25 rotates the sampling tool carrier 75 so that keyway 72 (Figure 12) lines up with ring key 36 (Figure 4). Ram head 24 is then advanced to move sampling tool 50 into fuel channel 11. The sampling tool 50 is left with at least some portion within orientation device 27 so that ring key 36 remains engaged with keyway 72 (Figure 12) to maintain the desired orientation. At the upstream end, ram head 126 must withdraw or retract as the string of fuel bundles is moved by the advancing sampling tool 50. When the fuel bundle carrier becomes full it is stored in a compartment in magazine 18 and another empty fuel bundle carrier is positioned to receive fuel bundles. The sampling tool 50 is now in the position shown in

Figure 8.

The sampling tool carrier 75 is then retracted by charge tube 25 and stored in the same compartment, for example compartment M4 of magazine 20. Assuming
5 that a scrape or sample is to be obtained farther inwards along fuel channel 11, then one or more spacers must be introduced into fuel channel 11. We will assume that one spacer 85 is required. The magazine 20 is rotated until a compartment containing a spacer in a
10 spacer carrier, for example compartment M7, is aligned with arm 16. Then arm 16 is advanced and charge tube 25 engages and locks with spacer carrier 100 and carries spacer carrier forward to fuel channel 11. Spacer carrier 100 is rotated so that key 107 (Figure 19) is
15 aligned with ring key 36 (Figure 4). Because spacer 85, within carrier 100, has its keyway 96 (Figure 16) engaged with key 107, ram head 24 can advance spacer 85 through orientation device 27. Keyway 96 will engage ring key 36 ensuring that spacer 85 is in the desired
20 orientation. The alignment projections 84 and 89 (Figure 17) at the front end of spacer 85 engage sockets 73 and 74 in sampling tool 50 (Figure 12) and ensure that the sampling tool 50 is in the desired orientation. The spacer 85 remains with the rear portion inside
25 orientation device 27 so that the orientation is maintained. As before, at the upstream end, as fuel bundles are moved in the upstream direction, the ram head 126 retracts and fuel bundles move into a fuel bundle carrier. When the fuel bundle carrier is full,
30 the carrier and fuel bundles are stored in a compartment in magazine 18 and another empty fuel bundle carrier is brought into position. Figure 9 shows a fuel sampling tool 50 with one spacer 85 in position.

The spacer carrier 100 is then moved into the
35 same compartment, for example compartment M7, and

magazine 20 is rotated to bring a compartment containing a pusher, for example compartment M10, into position in alignment with arm 17. Charge tube 25 is advanced to engage and to lock with pusher 110. It then advances
5 until pusher 110 abuts orientation device 27. The various components are now as shown in Figure 10. The upstream ram head 126 holds the string of fuel bundles 21, the sampling tool 50, and the spacer 85 against axial movement during the sampling operation. The
10 downstream ram head 24 now moves ahead causing tubular shaft 114, shaft 88, and shaft 53 to move forward. As shaft 53 moves forward it moves the sampling tool carriage 56 (Figure 11) ahead and a sample is taken, as previously described.

15 The procedure is then reversed. Very briefly, the pusher 110 is withdrawn and stored, the spacer carrier 100 is positioned to receive the spacer 85 and the spacer 85 is moved into the spacer carrier 100 by ram head 126 moving the string of fuel bundles, the
20 spacer carrier 100 with spacer 85 is stored. Reference was previously made, in connection with Figure 4, of a leaf spring detent 38. If, for example, two spacers were used, and one spacer was being returned to its spacer carrier, it is possible that the projections 84,
25 89 (Fig. 17) might stick in the alignment sockets 97, 98 (Fig. 16) of the spacer in front of it. The leaf spring detent 38 (Fig. 4) helps to detain the front spacer in the orientation device so that the spacer being withdrawn does not stick. To continue, the sampling
30 tool carrier 75 is positioned to receive the sampling tool 50 (with samples), the sampling tool 50 is moved into the sampling tool carrier 75, the sampling tool carrier 75 with sampling tool 50 is stored, and the shield plug and end closure are replaced. While this is
35 taking place, at the upstream end, the fuel bundle

carriers with the previously removed fuel bundles are positioned and moved into fuel channel 11 by ram head 126 as required. When all the fuel bundles have been replaced, the upstream shield plug and end closure are
5 replaced.

It is believed the preceding description will provide an understanding of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Apparatus for obtaining samples at a
5 plurality of orientations spaced on either side of the 12:00 o'clock orientation, from the inner surface of a fuel channel of a nuclear reactor having a plurality of horizontally extending fuel channels, each said fuel channel having a liner locking lug on the inner surface
10 adjacent an end thereof, comprising:

an orientation device having a generally cylindrical housing with a liner lug receiving slot therein for receiving said liner locking lug for a fuel channel from which a sample is to be taken,

15 an orientation device ring mounted within said housing for rotation between a plurality of positions each corresponding to one of said plurality of orientations and with corresponding spacing,

a ring key mounted to said orientation device
20 ring and projecting inwardly and extending forwardly of said ring,

a sampling tool having a cylindrical casing with a front and back end and a longitudinally extending keyway, said cylindrical casing fitting within said fuel
25 channel with said ring key within said keyway,

a tool carriage within said cylindrical casing fastened to a centrally located shaft mounted for longitudinal movement within said cylindrical casing, said shaft having a terminating head end at said back
30 end of said casing,

said tool carriage having at least one sampling tool cutter mounted in a sample receiving pocket and being responsive to forward longitudinal movement of said tool carriage to move outwardly and
35 engage the inner surface of said fuel channel,

said cylindrical casing of said sampling tool having a slot extending longitudinally above said sampling tool cutter for permitting said cutter to move forwardly and outwardly, and

5 pushing means engaging said terminating head end of said shaft for moving said shaft and said tool carriage longitudinally forwards.

2. Apparatus as defined in claim 1 in which said plurality of orientations is three orientations.

10 3. Apparatus as defined in claim 2 in which said three orientations are 11:00 o'clock, 12:00 o'clock and 1:00 o'clock.

4. Apparatus as defined in claim 3, in which there are two sampling tool cutters in longitudinal
15 alignment, one behind the other, each mounted in a sample receiving pocket of a respective cutter carrier, each said cutter carrier being slidably mounted in said tool carriage for movement in a radial direction from a retracted position with said tool cutters beneath said
20 slot to an actuated position with said tool cutters projecting through said slot in a fuel channel engaging position, and further comprising spring means biasing said cutter carriers to their retracted positions, and an actuator on the inner surface of said cylindrical
25 casing opposite said slot, for engaging said cutter carriers and moving them in sequence to their fuel channel engaging positions as said tool carriage is moved in a forward direction.

5. Apparatus as defined in any one of claims
30 2, 3 and 4 and further comprising:

a spacer for spacing said sampling tool inwards from said orientation device and having a cylindrical spacer casing for fitting within said fuel channel and a central shaft extending substantially from
35 a front end to a back end of said spacer mounted for

slidable longitudinal movement from a rest position with the back end of said shaft substantially at the back end of said spacer to an extended position with the shaft projecting from the front end of said spacer,

5 spring means biasing said central shaft of said spacer to said rest position, said front end of said shaft of said spacer abutting said terminating head end of said shaft of said sampling tool, and said back end of said shaft of said spacer being engaged by said
10 pushing means for moving forwards said shaft of said spacer and said shaft of said sampling tool.

6. In a nuclear reactor having a plurality of horizontally extending fuel channels containing fuel bundles and having coolant therein, a fuelling machine
15 at each end of said reactor, each fuelling machine having a longitudinally movable arm and having means for vertical and transverse movement for aligning said arm with a desired fuel channel, each said arm having a central ram head and surrounding charge tube each
20 capable of independent movement, apparatus for obtaining sample scrapings from the inner surface of a desired fuel channel, comprising:

 sampling tool means having a generally cylindrical casing for fitting within a fuel channel and
25 an axially extending slot in said casing, said sampling tool means having a front end and a back end,

 cutter means in said cylindrical casing beneath said slot and having a retracted position and an extended position projecting through said slot for
30 engaging the inner surface of said fuel channel,

 said sampling tool means having a shaft with a head at said back end, slidably mounted within said cylindrical casing, movement of said shaft with said head towards said front end actuating said cutter means
35 from said retracted position to said extended position

for obtaining a scraping from the inner surface of said fuel channel, and

5 pusher means having an outer cylindrical casing of substantially the same inner diameter as said fuel channel and a floating plunger mechanism having a housing slidably mounted within said outer cylindrical casing with a tubular shaft slidably mounted within said housing, said tubular shaft having a nose end and a trailing end and a biased rest position with said nose
10 end substantially at a forward end of said housing and an advance position with said nose end projecting beyond the front end of said housing,

 said ram head engaging said trailing end and advancing said floating plunger mechanism until the
15 housing stops against the back end of said sampling tool means and then moving said tubular shaft from said rest position towards said advance position engaging said head of said sampling tool means for obtaining a scraping.

20 7. The invention of claim 6 and further comprising spacer means between said sampling tool means and said pusher means for positioning said sampling tool means inwardly, said spacer means comprising

 a cylindrical casing with a front and a back
25 end and fitting within said fuel channel, said spacer means having a central shaft with a front end and a trailing end, said central shaft being slidably mounted for axial movement within said cylindrical casing of said spacer means, said central shaft being spring
30 biased to a rearward position with said trailing end substantially flush with the back end of said cylindrical casing of said spacer means and movable to a forward position with said front end of said central shaft projecting beyond said front end of said
35 cylindrical casing of said spacer means,

said trailing end of said spacer means being engaged by said tubular shaft of said pusher means and moving said central shaft to its forward position thereby engaging said head of said sampling tool means
5 and moving the shaft of said sampling tool means forward for obtaining a scraping.

8. In a nuclear reactor having a plurality of horizontally extending fuel channels containing fuel bundles and having coolant therein, each said fuel
10 channel having a liner locking lug on the inner surface adjacent an end thereof, a fuelling machine at each end of said reactor each having a longitudinally movable arm, each said fuelling machine having means for transverse and vertical movement for aligning said
15 respective arms with a desired fuel channel, and each arm having a central ram head and a surrounding charge tube each capable of independent movement, apparatus for obtaining sample scrapings at a desired orientation from the inner surface of a desired fuel channel, comprising:
20 an orientation device having a generally cylindrical housing with a liner lug receiving slot therein for receiving said liner locking lug of said desired fuel channel for fixing the orientation and position of said orientation device on said fuel
25 channel,

a ring key on said orientation device at a predetermined orientation, peripherally located and projecting forwardly,

sampling tool means having a cylindrical
30 casing of an outer diameter for fitting within said orientation device and said fuel channel, said sampling tool means having a front end and a back end, said cylindrical casing of said sampling tool means having a keyway for receiving said ring key and providing a
35 desired orientation of said sampling tool means with

respect to said fuel channel,

an opening in said cylindrical casing of said sampling tool means and at least one sampling tool cutter within said casing beneath said opening, and an
5 actuating shaft having a terminating head at said back end of said casing, movement of said head and said shaft in a forward direction actuating said sampling tool cutter to move it outwardly through said opening into engagement with the inner surface of said fuel channel
10 for obtaining said scraping, and

pushing means engaging said terminating head of said sampling tool means for moving said terminating head and shaft forwardly.

9. The invention of claim 8 in which said
15 pushing means comprises

a pusher having an outer cylindrical casing with substantially the same inner diameter as the inner diameter of said fuel channel,

a floating plunger mechanism within said outer
20 cylindrical casing having a housing mounted for axial sliding movement within said casing and a tubular shaft slidably mounted for axial movement within said housing and having a nose end and a trailing end, said housing having a front end facing inwardly to said fuel channel,

25 spring means engaging said housing and said tubular shaft and biasing said tubular shaft to a rest position with said nose end substantially at the front end of said housing,

said ram head engaging said trailing end of
30 said tubular shaft for advancing said floating plunger mechanism to a stop against said back end of said cylindrical casing of said sampling tool means and then advancing said tubular shaft within said housing for moving forwardly said terminating head of said sampling
35 tool means.

10. The invention of claim 9 and further comprising:

a spacer between said sampling tool means and said pusher for positioning said sampling tool means
5 farther inwards from said pusher and having a cylindrical casing with a front end and a back end, said cylindrical casing of said spacer having an outer diameter for fitting within said orientation device and said fuel channel,
10 a central shaft within said spacer having a front end and a trailing end and being slidably mounted for axial movement within said cylindrical casing of said spacer, said central shaft being spring biased to a rearward position with said trailing end substantially
15 at said back end of said cylindrical casing of said spacer and movable to a forward position with said front end of said central shaft projecting past said front end of said cylindrical casing of said spacer,
said cylindrical casing of said spacer having
20 an axially extending keyway for receiving said ring key to provide a desired orientation of said cylindrical casing of said spacer as said spacer moves through said orientation device,
said front end of said cylindrical casing of
25 said spacer and said back end of said cylindrical casing of said sampling tool means having cooperating alignment means for maintaining the orientation of said sampling tool means with respect to said orientation device.

11. The invention of any one of claims 8, 9
30 and 10 in which the desired orientations for obtaining sample scrapings are 11:00 o'clock, 12:00 o'clock and 1:00 o'clock, and in which said orientation device has a rotatable ring on which said ring key is mounted, said rotatable ring having three selectable positions with
35 each position corresponding to a respective one of said

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11:00 o'clock, 12:00 o'clock and 1:00 o'clock orientations.

12. The invention of any one of claims 8, 9
and 10 in which said sampling tool means has a pair of
5 aligned sampling tool cutters each mounted in a
respective scraping receiving pocket, said sampling tool
cutters projecting in sequence, the first to remove
oxide and the second to obtain a sample scraping.

FIG. 1

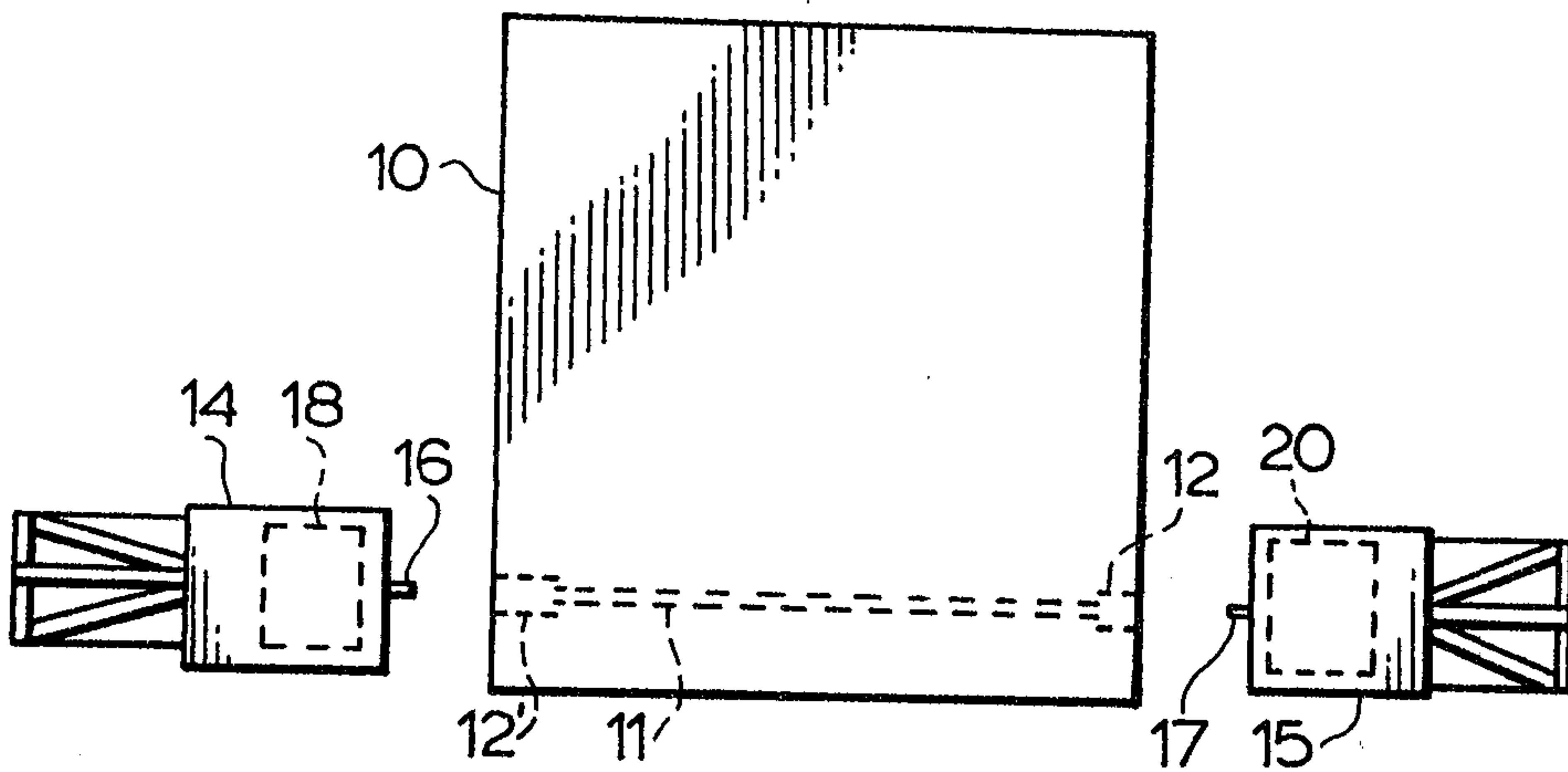


FIG. 2A

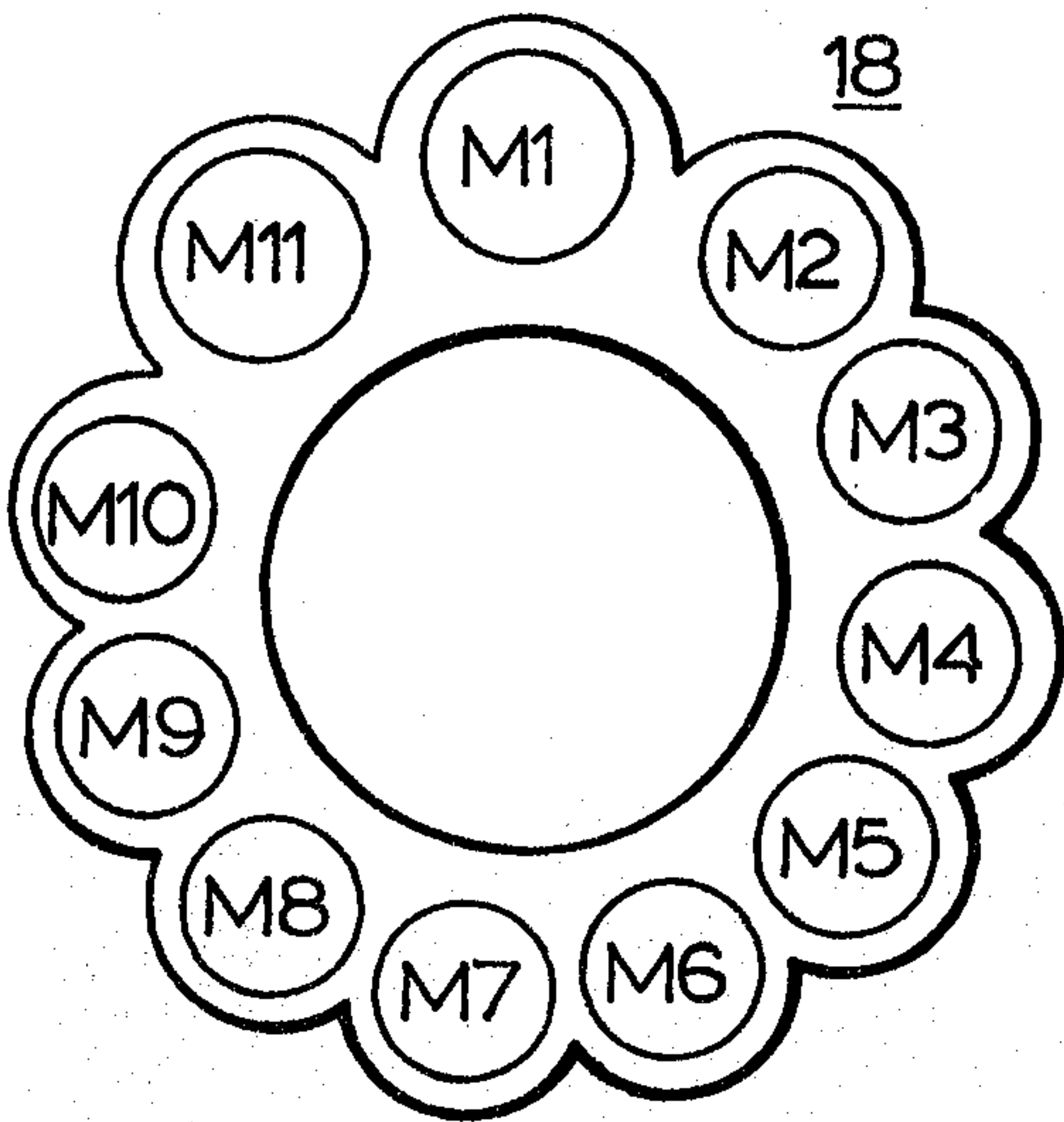


FIG. 2B

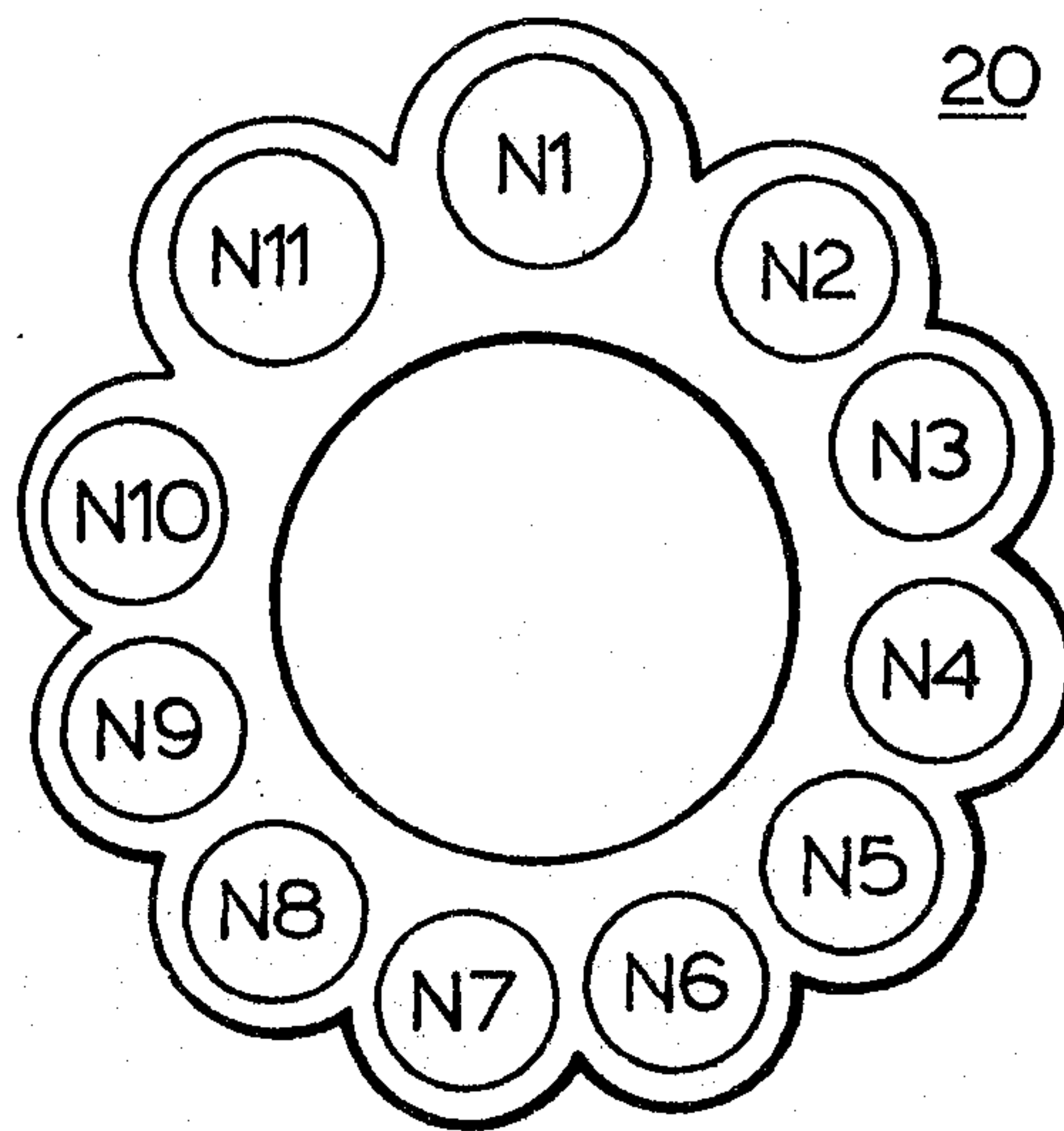
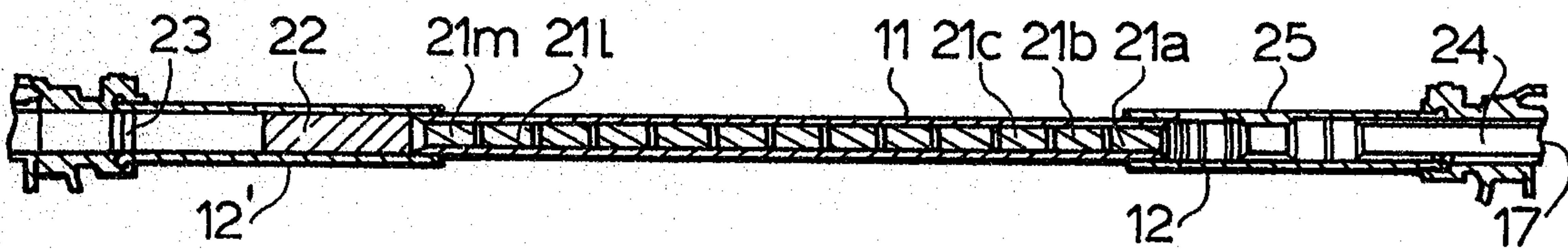
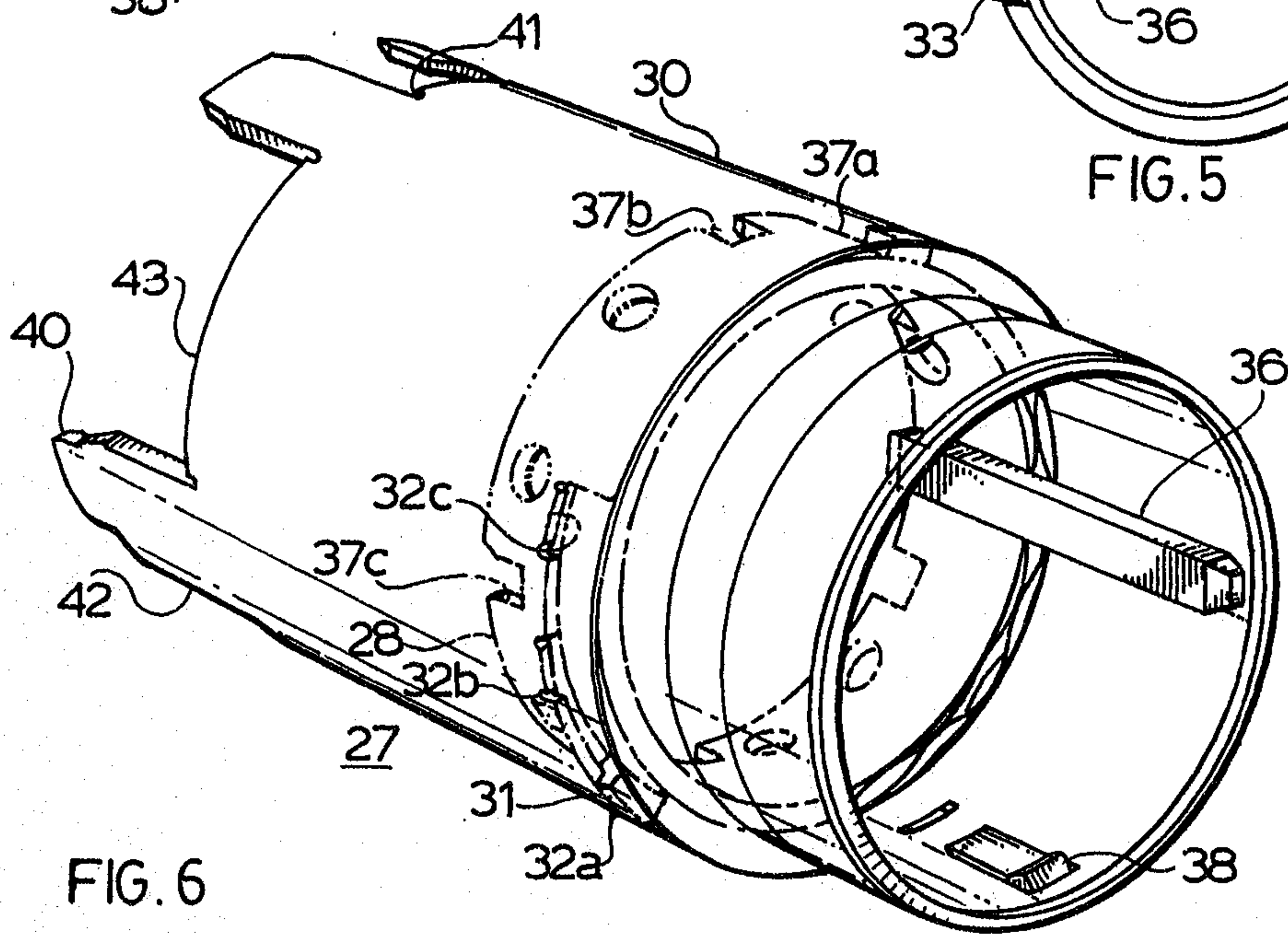
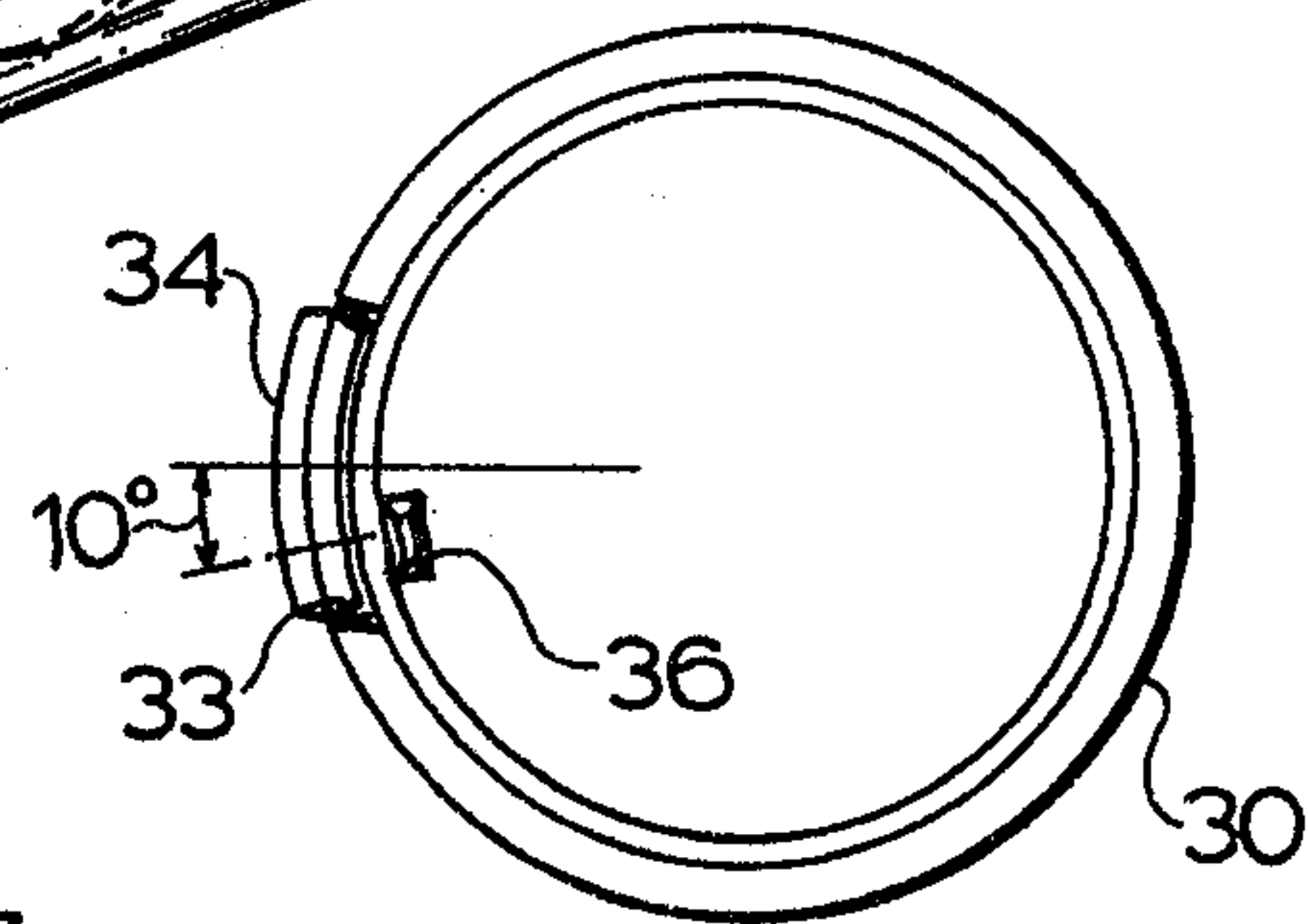
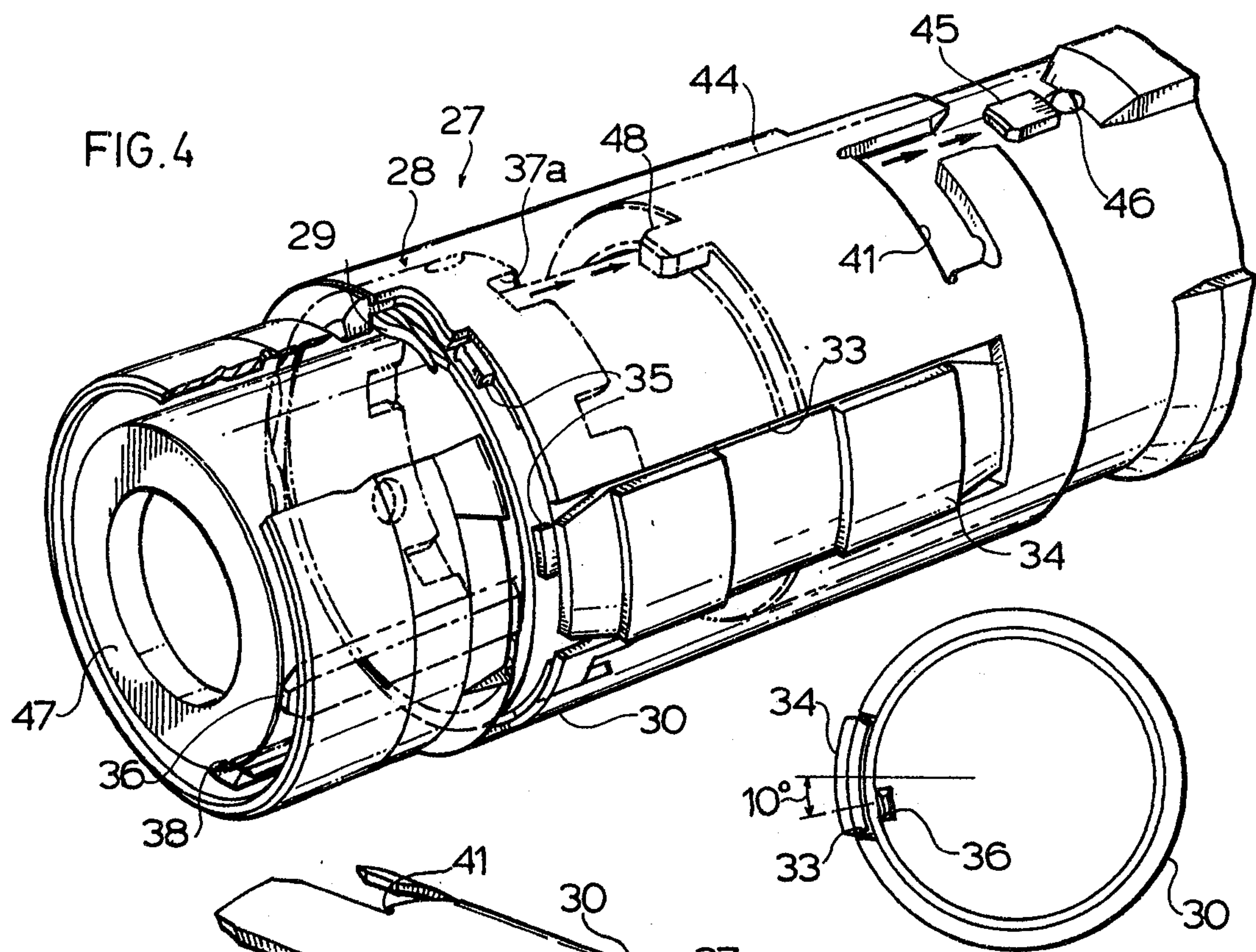


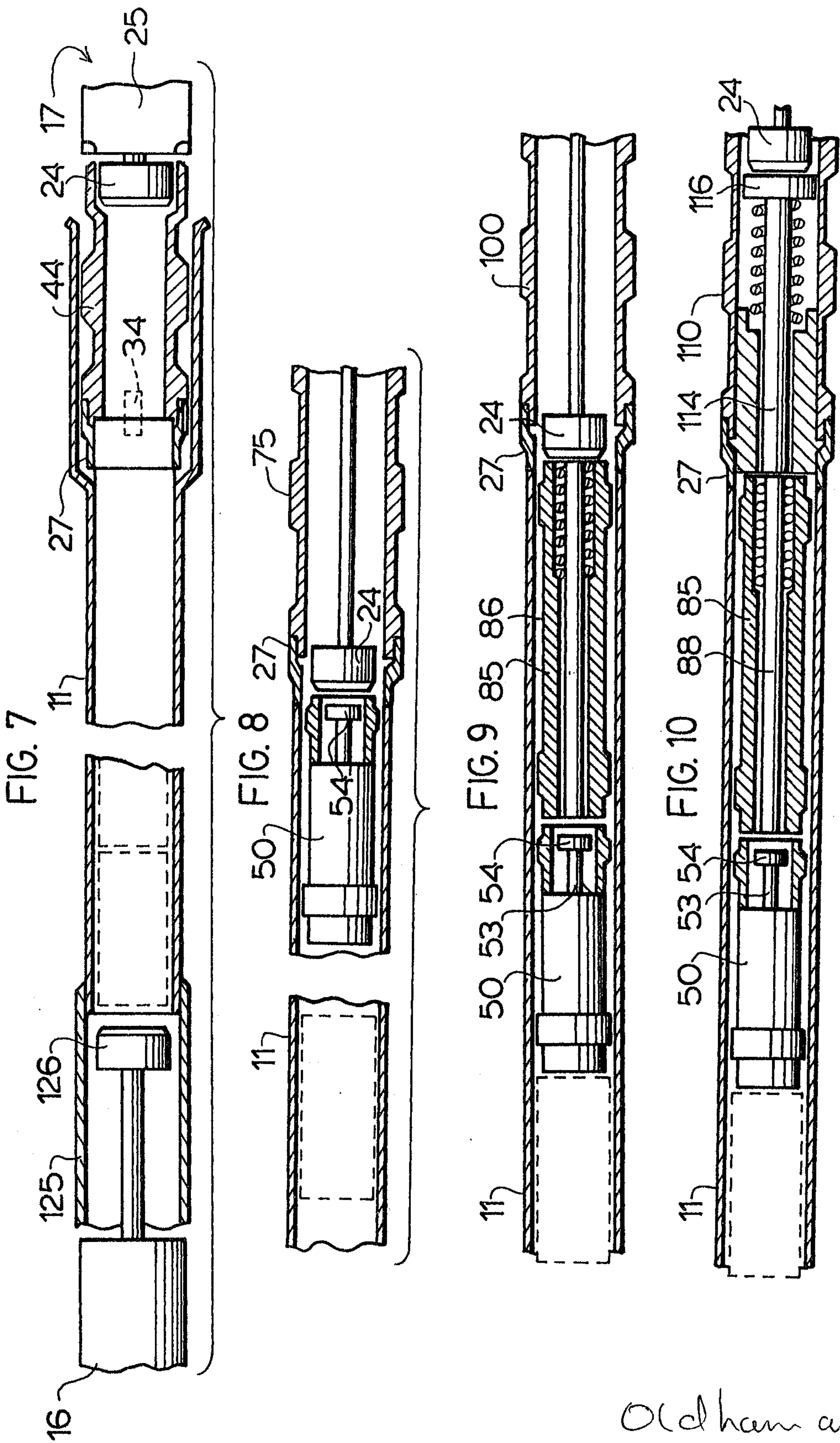
FIG. 3



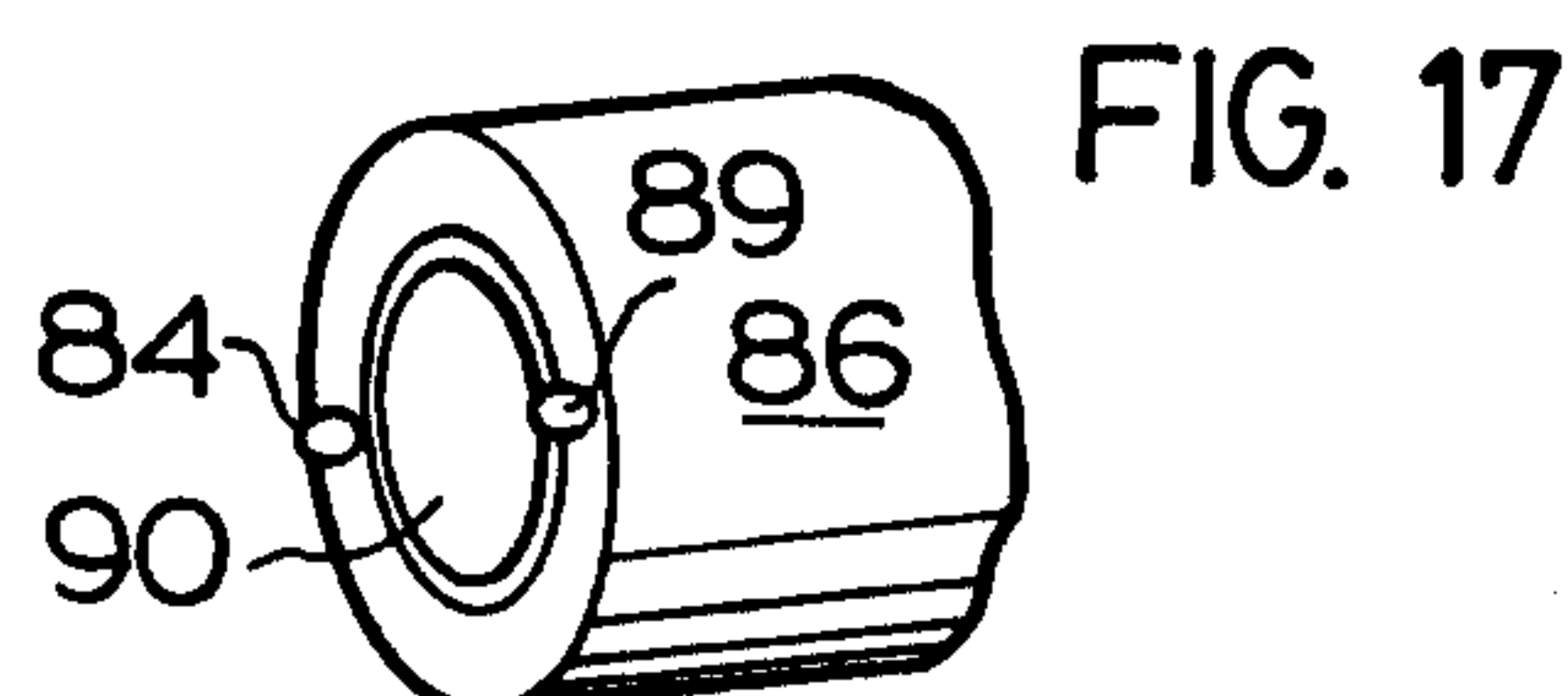
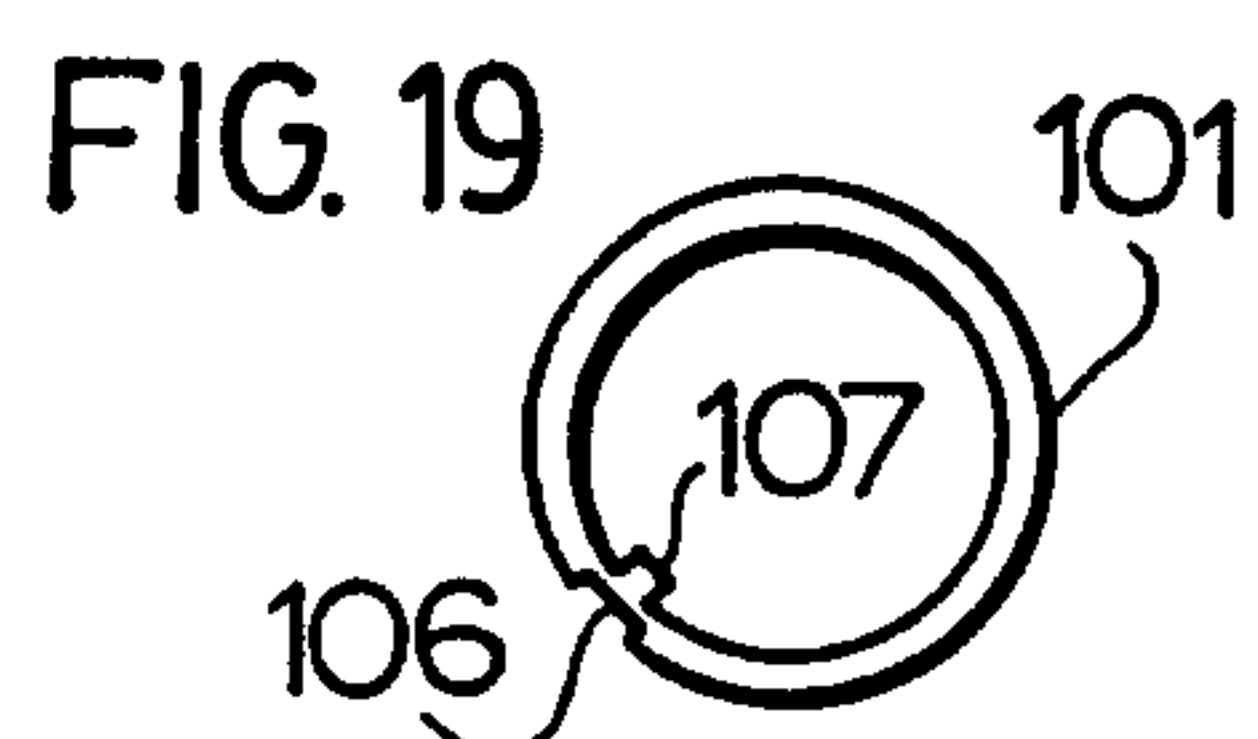
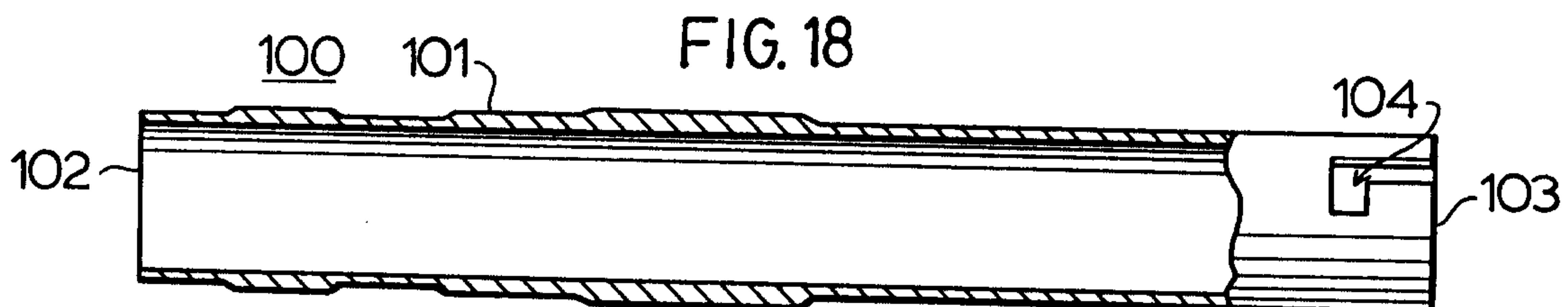
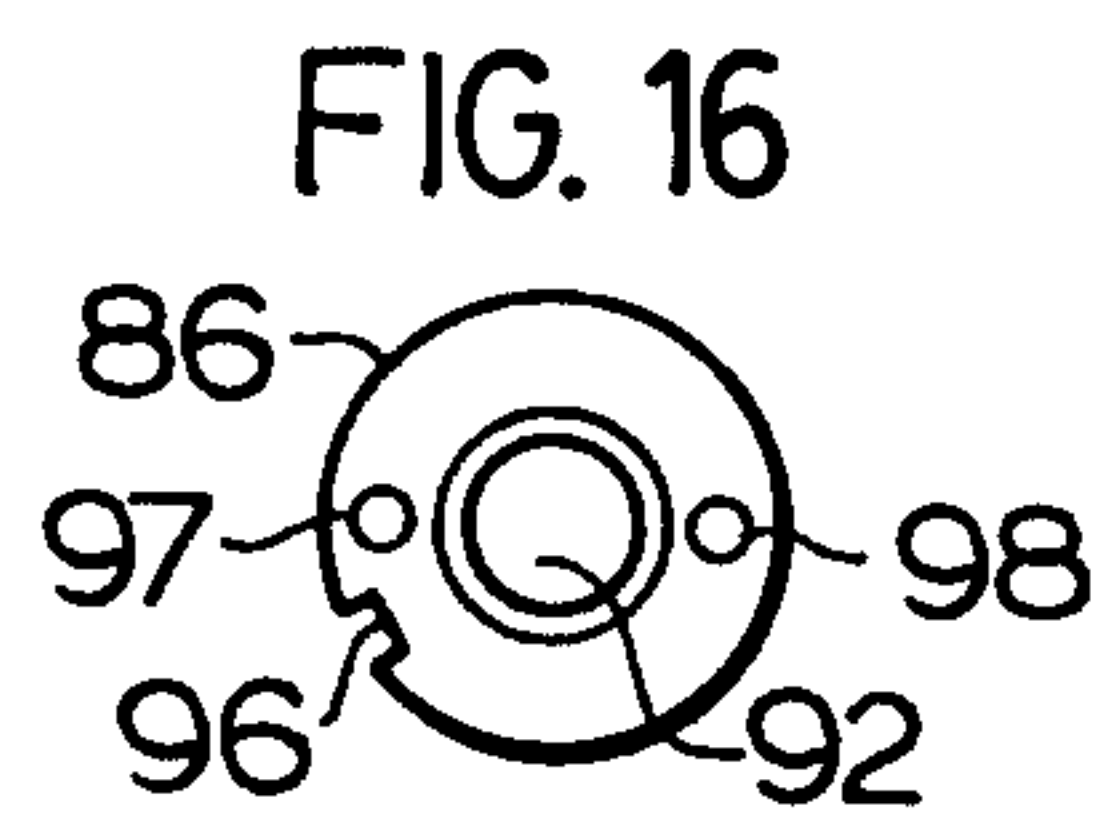
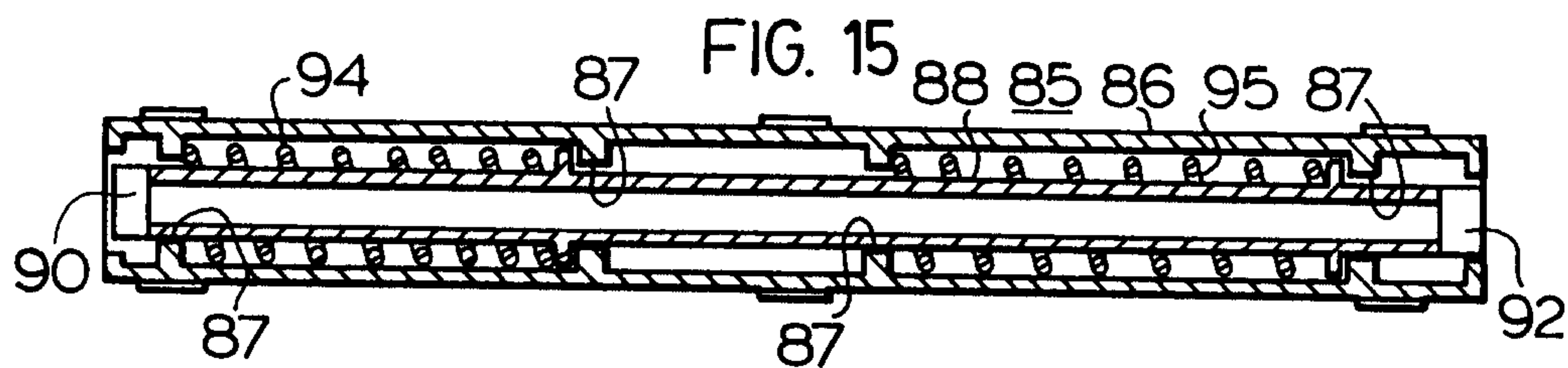
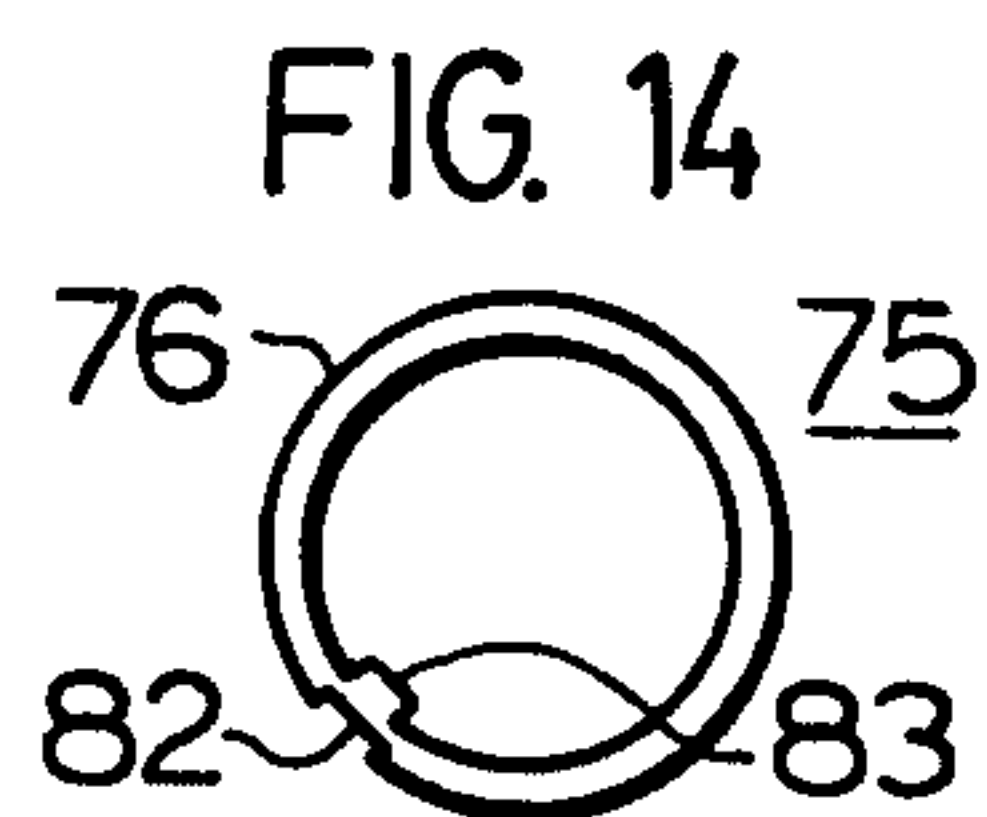
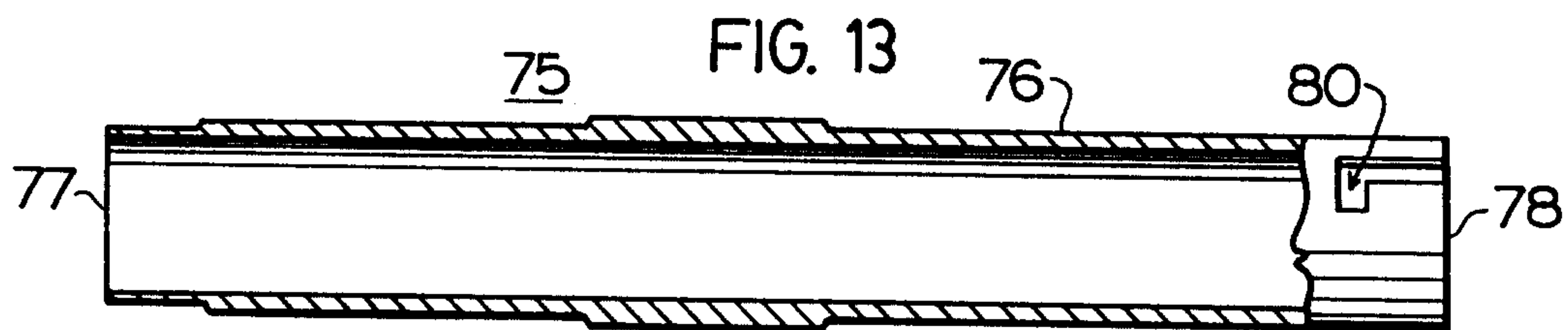
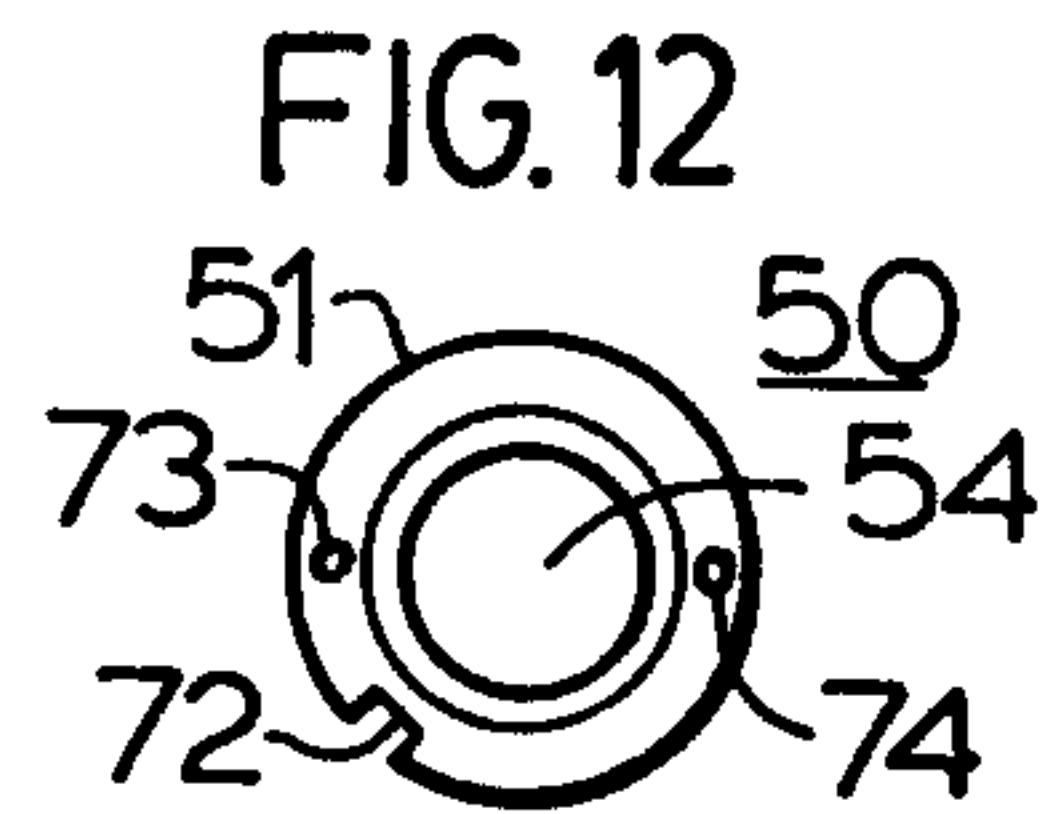
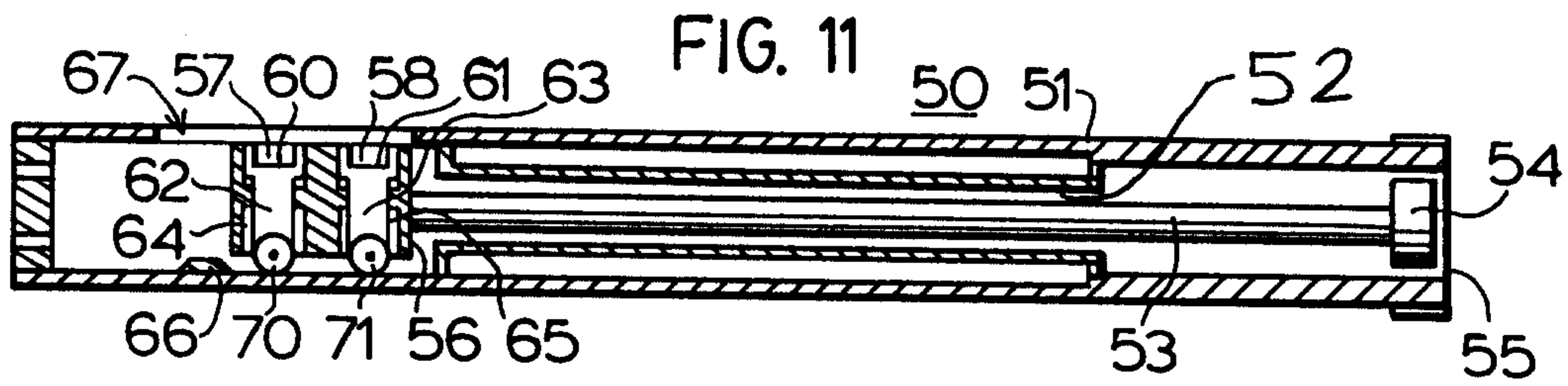
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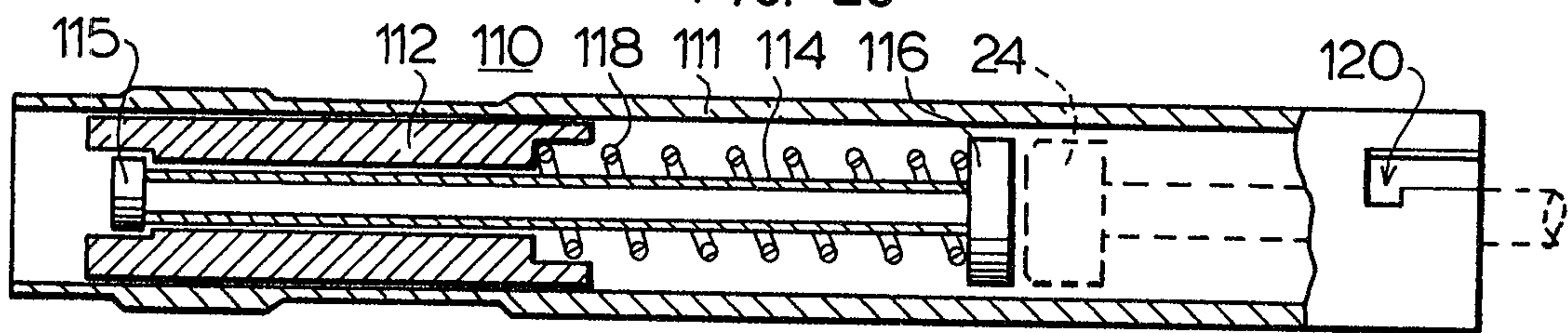


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FIG. 20



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