(12) UK Patent Application (19) GB (11) 2 095 457 A

(21) Application No **8137869**
(22) Date of filing **16 Dec 1981**
(30) Priority data
(31) **217055**
(32) **16 Dec 1980**
(33) **United States of America (US)**
(43) Application published **29 Sep 1982**
(51) **INT CL^3 G21C 7/26**
(52) Domestic classification **G6C** CH **E2A** 106 130 428 M
(56) Documents cited **None**
(58) Field of search **E2A G6C**
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(54) **Rod drive and latching mechanism**

(57) Preferably, the pressurized reactor coolant is utilized to raise the drive rod into contact with and to pivot the latching mechanism so as to allow the drive rod to pass the latching mechanism. The pressure in the housing may then be equalized which allows the drive rod to move downwardly into contact with the latching mechanism but to hold the shaft in a raised position with respect to the reactor core. Once again, the reactor coolant pressure may be utilized to raise the drive rod and thus pivot the latching mechanism so that the drive rod passes above the latching mechanism. Again, the mechanism pressure can be equalized which allows the drive rod to fall and pass by the latching mechanism so that the drive rod approaches the reactor core.

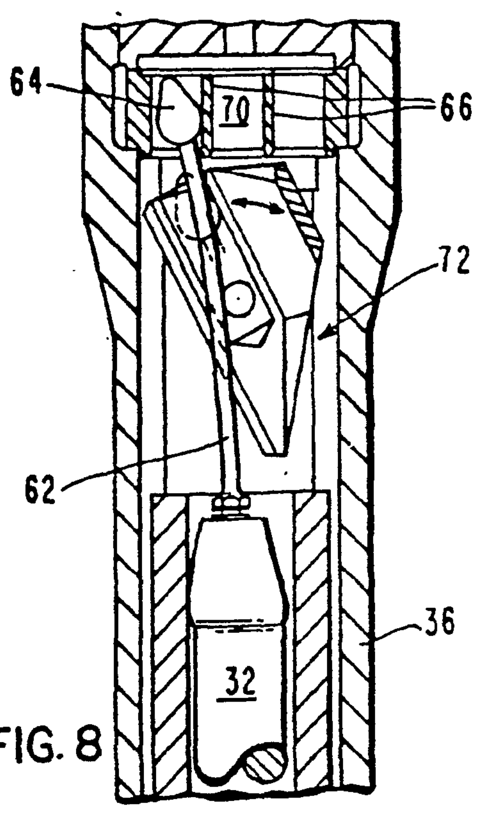

FIG. 8

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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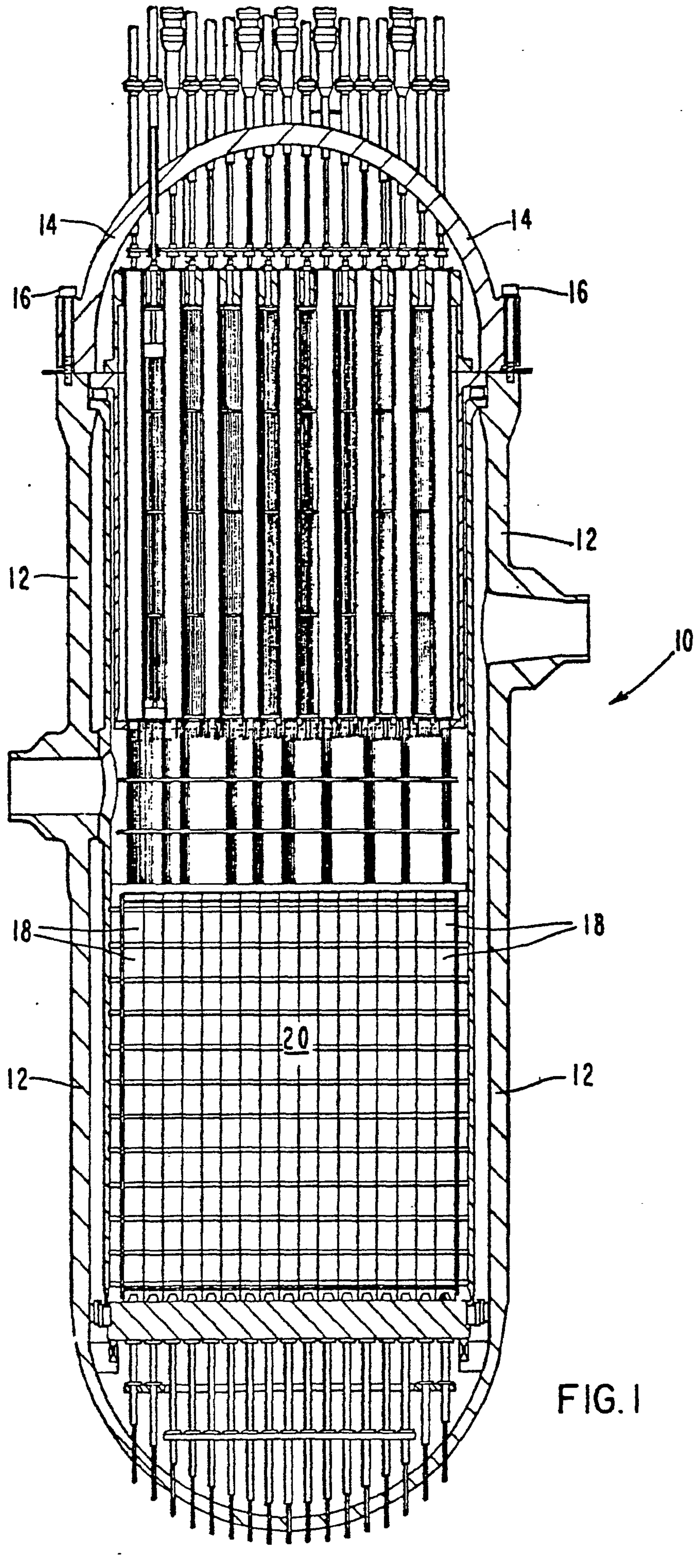

FIG. 1

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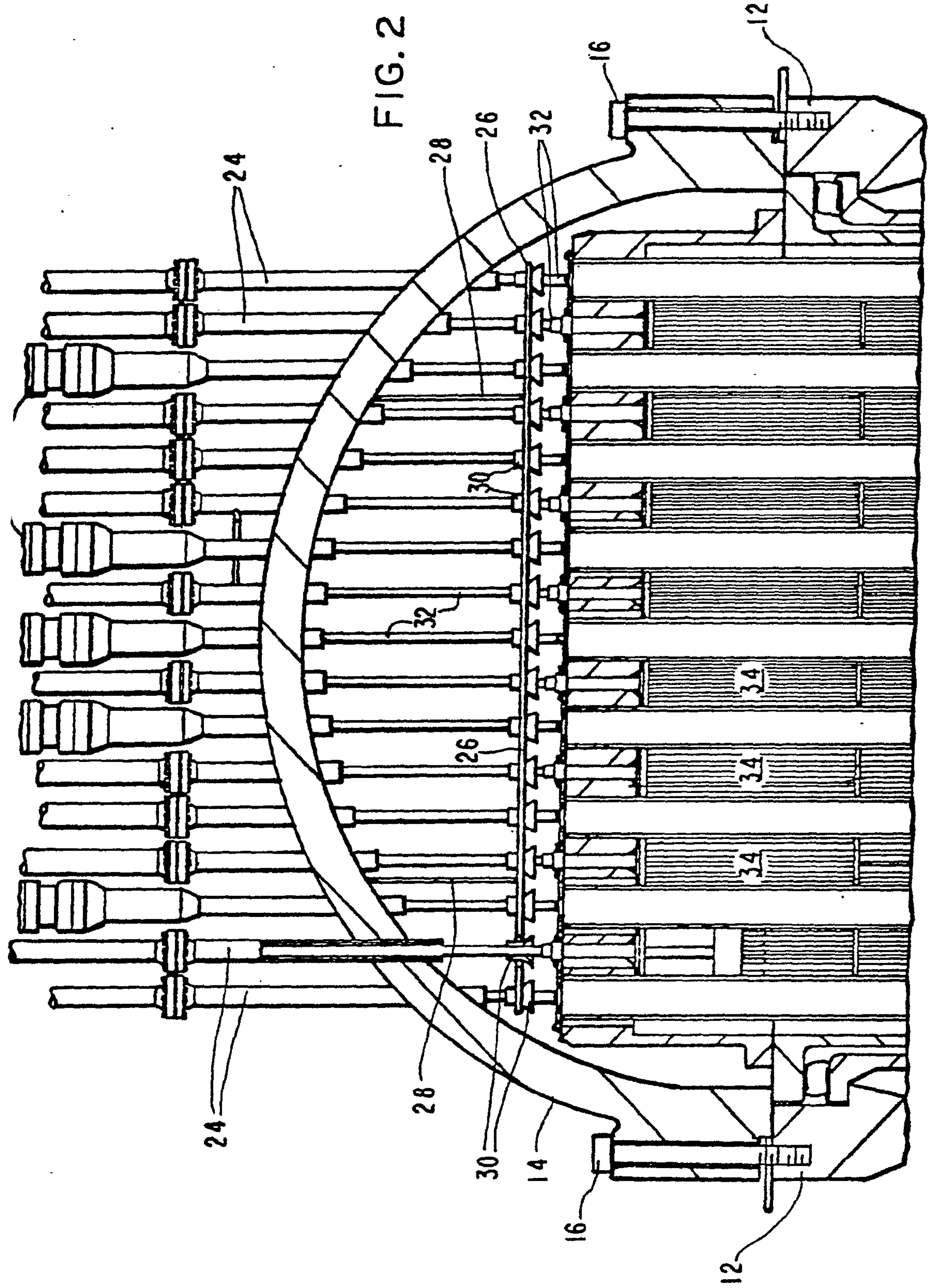
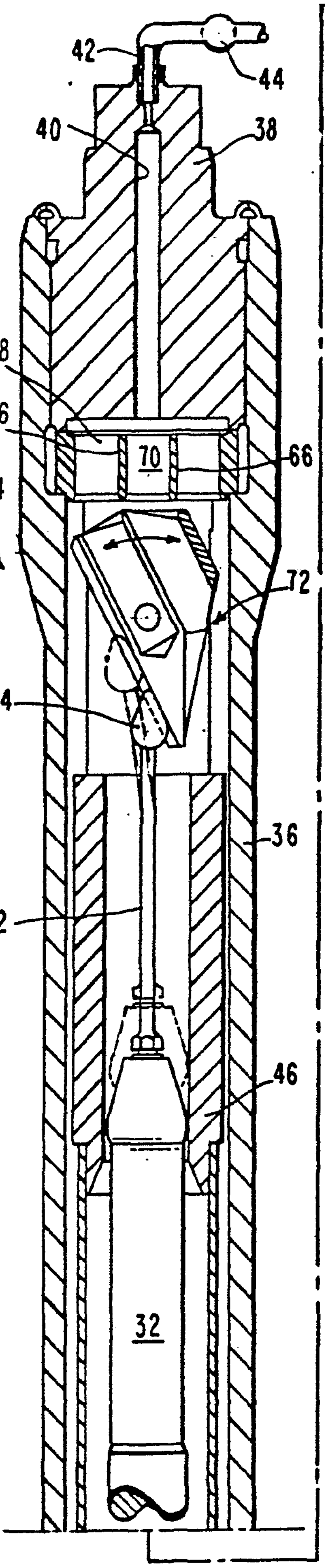


FIG. 2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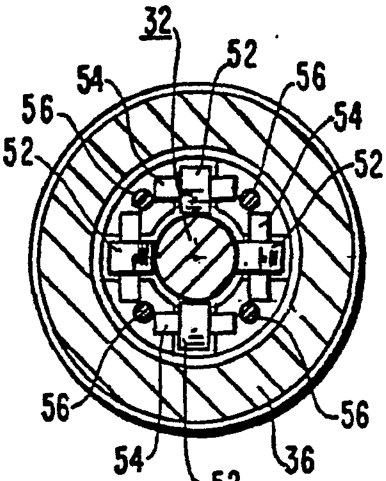
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FIG. 4

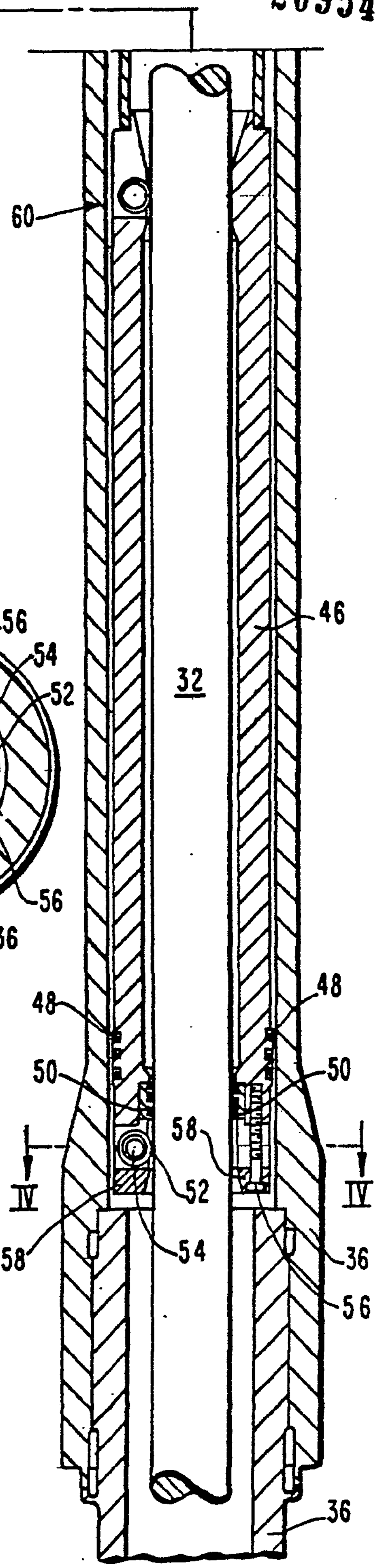
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FIG. 3

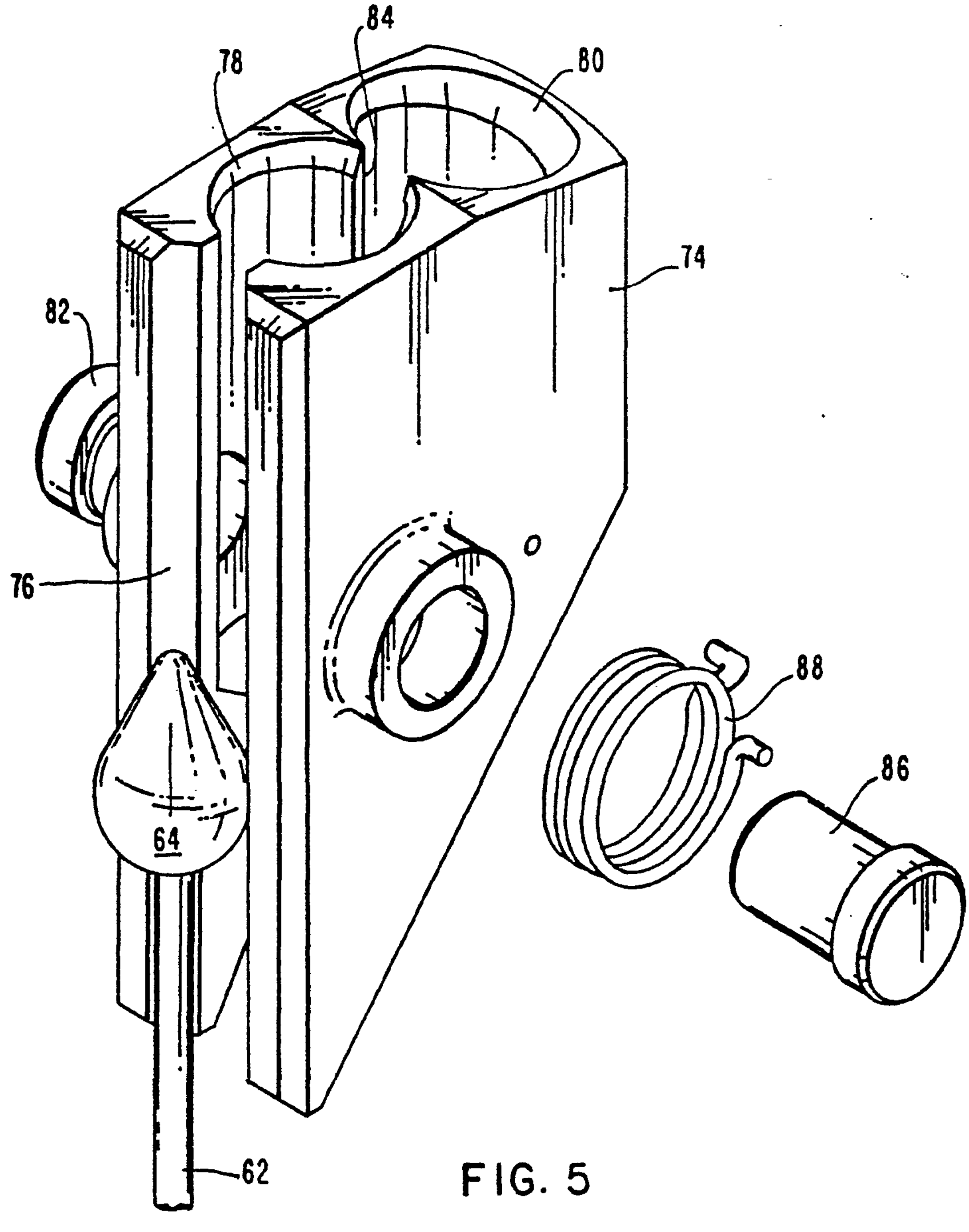

FIG. 5

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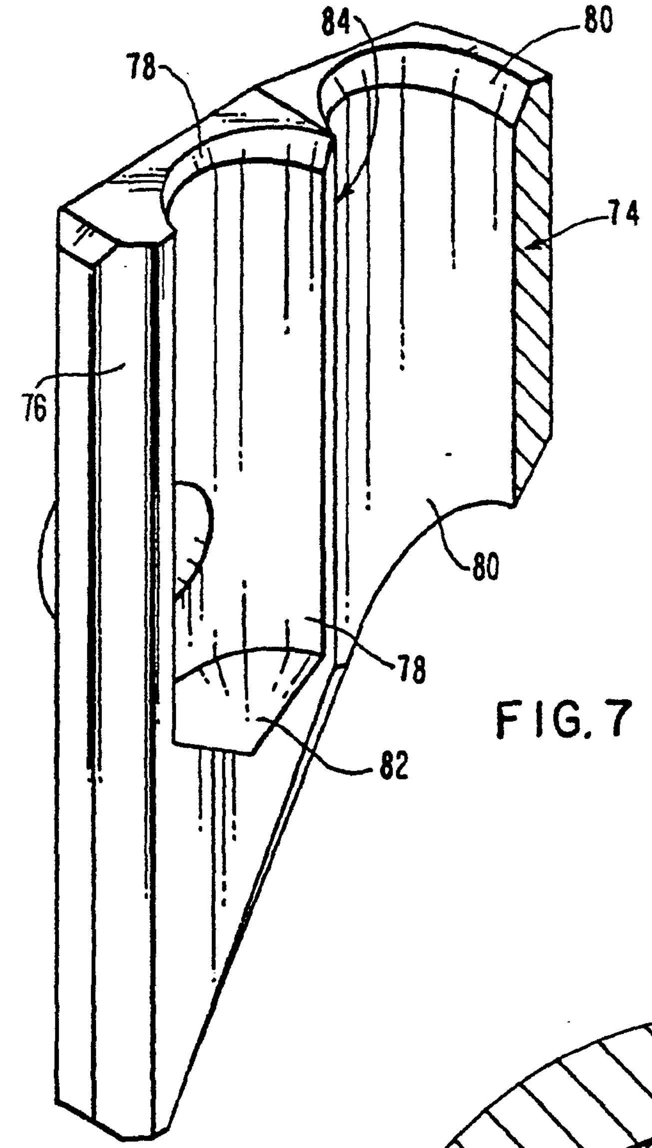

FIG. 7

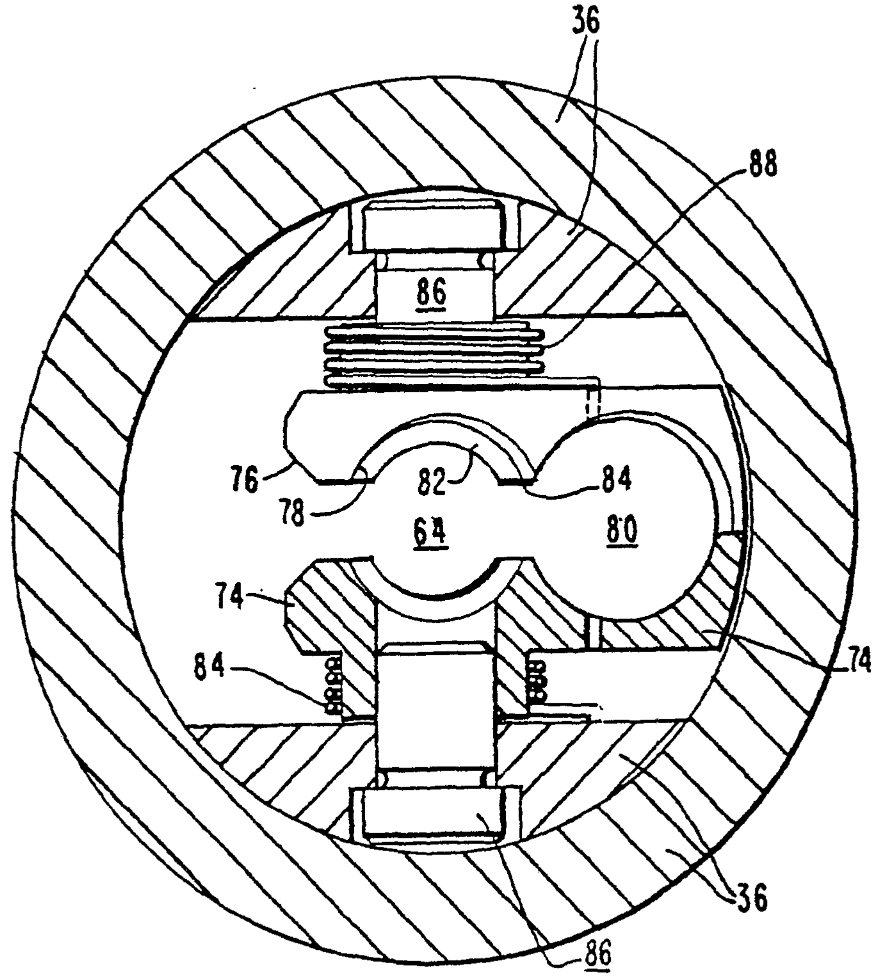

FIG. 6

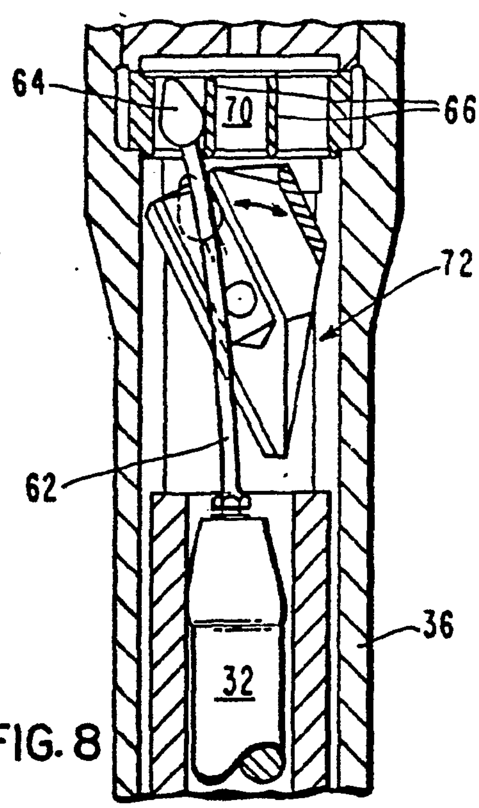

FIG. 8

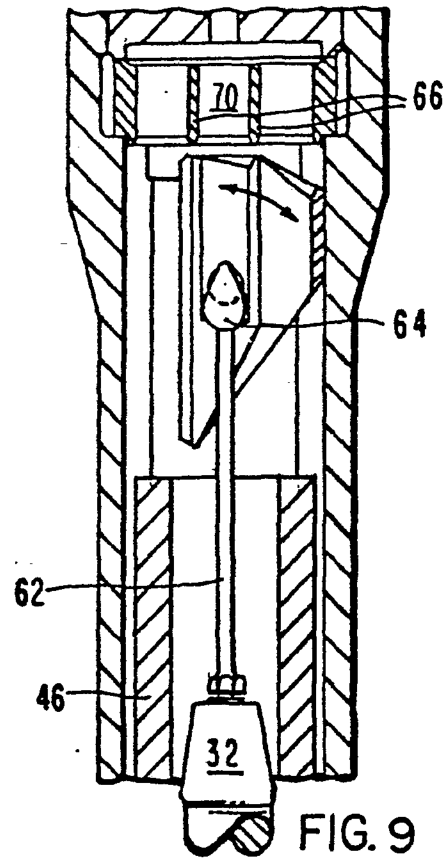

FIG. 9

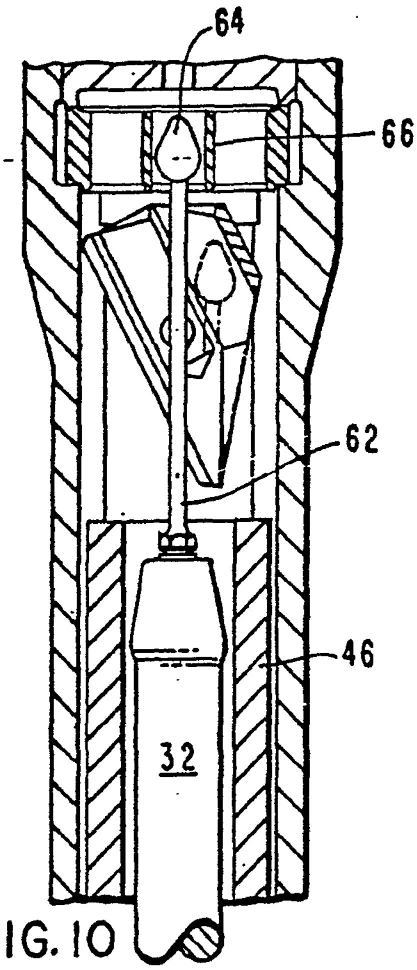

FIG. 10

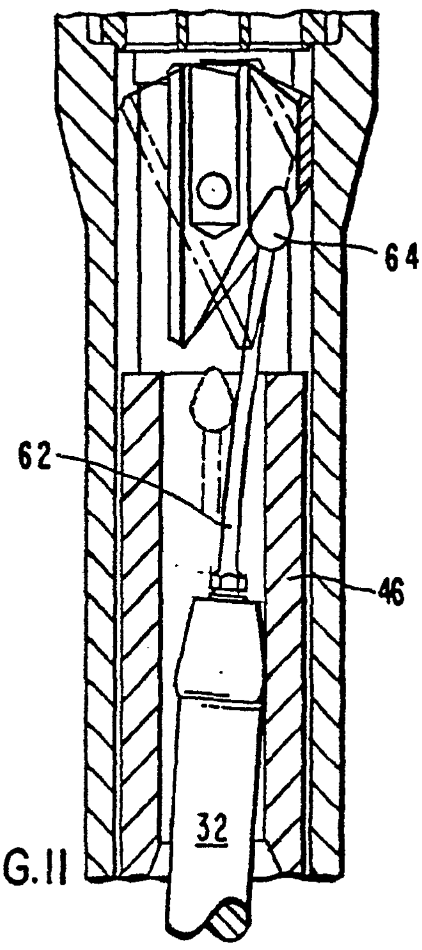

FIG. 11

SPECIFICATION

Rod drive and latching mechanism

This present invention relates to hydraulic drive and latching mechanisms and more particularly to hydraulic drive and latching mechanisms for driving reactivity control mechanisms in nuclear reactors and latching them in predetermined positions.

As is well known in the art, a nuclear power plant generates electricity from heat produced by fissioning of nuclear material. The nuclear material is contained within fuel assemblies which comprise the core of a nuclear reactor. As the reactor coolant is circulated through the nuclear reactor core heat is transferred from the core to the reactor coolant which is then conducted to a remote location for generating steam and electricity in a conventional manner.

Control of the nuclear reactor is usually achieved by control rods which are dispersed throughout the nuclear reactor core and are mounted for movement into and out of the core. The control rods function by absorbing excess nuetrons produced by the nuclear reaction. In addition to control rods, a nuclear reactor may also have displacer rods disposed therein which are also mounted for movement into and out of the core to effect ractivity of the core as described in copending United States Application Serial No. 217,060 entitled "Mechaical Spectral Shift Reactor".

After a period of operation of a nuclear reactor, it is necessary to be able to replaced the spent fuel assemblies in the reactor with fresh fuel assemblies. During this operation, it is necessary to remove the reactor vessel closure head so as to gain access to the fuel assemblies in the nuclear reactor core. Since the control rods and displacer rods are attached to their respective drive mechanisms which are mounted on the reactor vessel closure head, it is expident to disconnect the control rods and displacer rods from their corresponding drive mechanisms before removing the reactor vessel closure head while maintaining the control rods and displacer rods in the nuclear reactor core.

The ability of leaving the control rods and displacer rods in the nuclear reactor core during refueling may be achieved by providing a disconnect mechanism between the conrol rod and the control rod drive mechanism. One such disconnect mechanism is disclosed in United States Patent No. 4,147,589. There is described a control rod assembly for a nuclear reactor having a remotely disengageable coupling between the control rod and the control rod drive shaft. The coupling is actuated by first lowering then raising the drive shaft. The described motion causes actual repositioning of a pin in a grooved rotatable cylinder, each being attached to different parts of the drive shaft which are acially movable relative to each other.

It is the principle object of the present invention to provide a light, simple and reliable control operating mechanism which may be remotely released to remain in the reactor.

With this object in view, the present invention resides in and drive and latching mechanism comprising a drive housing having a drive shaft movably disposed therein characterized in that a pivotable member is pivotally disposed within said drive housing, said member having a first bore and a second bore therein and haviang a first slot along one side thereof extending from the top to the bottom ends of said pivotable member and extending into said first bore, said pivotable member having biasing means associated therewith for pivoting said pivotable member relative to said drive housing, said drive shaft carrying a contact member having a head on its free end and being capable of passing through said first slot with said head (64) being wider than said first slot; and drive means are associated with said drive shaft for moving it together with said head into contact with said pivotable member thereby pivoting said pivotable member relative to said drive housing thereby allowing said head to be inserted and seated in said first bore.

Preferably, the pressurized reactor coolant is utilized to raise the drive rod into contact with and to pivot the latching mechanism so as to allow the drive rod to pass the latching mechaism. The pressure in the housing may then be equalized which allows the drive rod to move downwardly into contact with the latching mechanism but to hold the shaft in a raised position with respect to the reactor core. Once again, the reactor coolant pressure may be utilized to raise the drive rod and thus pivot the latching mechanism so that the drive rod passes above the latching mechaism. Again, the mechanism pressure can be equalized which allows the drive rod to fall and pass by the latching mechanism so that the drive rod approaches the reactor core.

The invention will become more readily apparent from the following description of a preferred embodiment thereof shown, by way of example only, in the accompanying drawings, wherein:

Figure 1 is a partial cross-sectional view in elevation of a nuclear reactor;

Figure 2 is a cross-sectional view in elevation of the top portion of the nuclear reactor;

Figure 3 is a cross-sectional view in elevation of the drive mechanism;

Figure 4 is a view along line IV-IV of Figure 3;

Figure 5 is an exploded view in perspective of the latching mechanism;

Figure 6 is a cross-sectional view of the latching mechanism;

Figure 7 is a cross-sectional view of the latching mechanism; and

Figures 8-11 are cross-sectional views in elevation of the latching mechanism showing the steps of the latching procedure.

Figures 1 and 2 show a nuclear reactor referred to generally as 10 which comprises a reactor vessel 12 having a removable closure head 14 attached to the top thereof by means of bolts 16. A plurality of fuel assemblies 18 are disposed within the reactor vessel 12 and comprise a reactor core 20. A plurality of control rod drive mechanisms 22 which may be of the type generally used in the art are mounted on and extend through the closure head 14 for inserting and removing control rods (not shown) from the fuel assemblies 18 as is well understood in the art.

Still referring to Figures 1 and 2, a plurality of displacer rod drive mechanisms 24 are also attached to and extend through closure heat 14. A plate 26 is suspended from the inside of closure head 14 by supports 28. A multiplicity of funnel-shapedguide members 30 are attached to plate 26 and are arranged in line with each of the control rod drive mechanisms 22 and displacer rod drive mechanisms 24. Each guide member 30 has a hole therethrough that allows a drive rod 32 to be slidably disposed therein. Each drive rod 32 is either attached at its lower end to a cluster of displacer rods 34 and capable of being attached at its upper end to a displacer rod drive mechanism 24 or attached at its lower end to a cluster control rods (not shown) and at its upper end to a control rod drive mechanism 22. The arrangment of control rods and displacer rods may be such as that described in copending United States Patent Application Serial No. 217,060. Each drive rod 32 whether attached to a control rod drive mechanism 22 or a displacer rod drive mechaism 24, is capable of being disengaged from either its respective displacer rod drive mechanism 24 or control rod drive mechanism 22 so that closure head 14 may be removed carrying with it the control rod drive mechanisms 22, displacer rod drive mechanism 24 and plate 26 with guide members 30 attached thereto. Closure head 14 may be removed during the refueling process to replace spent fuel assemblies 18 with fresh ones The disconnectability of drive rod 32 from its respective drive mechanism enables this to be easily accomplished. When it is time to replace closure head 14, guide members 30 aid in aligning each drive rod 32 with its respective drive mechanism so that when closure head 14 is placed on reactor vessel 12, each drive rod 32 slides through its respective guide member 30 and into its respective drive mechanism.

Referring now to Figure 3, displacer rod drive mechanis 24 comprises a substantially cylindrical metal housing 36 which is welded to and extends through closure head 14. Housing 36 has a cap 38 attached to the top thereof which has a chanel 40 therethrough that is connected to conduit 42. Conduit 42 is connected to cap 38 and to a tank (not shown) and has a flow regulating valve 44 disposed therein. Since the interior of housing 36 is exposed to the interior of reactor vessel 12, the reactor coolant fills the void spaces within housing 36 and flows through conduit 42 when valve 44 is open. A bearing housing 46 is removably disposed within housing 36 and has a plurality of first piston rings 48 attached to the outside thereof near its lower end which extend into contact with the inside of housing 36 for aligning bearing housing 46 within housing 36 but allowing for the removal of bearing housing 46. Drive rod 32 slidably disposed within bearing housing 46 in a manner so as to be able to be moved axially with respect to bearing housing 46 and housing 36 under the influence of the reactor coolant pressure. A plurality of second piston rings 50 which may be Inconel (Registered Trade Mark) are removably disposed within bearing housing 46 so as to be able to contact drive rod 32. Second piston rings 50 provide a mechanism for allowing drive rod 32 to slide within bearing housing 46 while limiting the flow of reactor coolant through bearing housing 46 and housing 36 when valve 44 is open. In this manner, the movement of drive rod 32 can be controlled by opening and closing valve 44. Second piston rings 50 are arranged so that they may be replaced when bearing housing 46 is removed from housing 36.

Referring now to Figures 3 and 4, a plurality of roller bearings 52 are disposed on a like number of axles 54 in a manner so as to allow the outer surface of roller bearings 52 to contact the outer surface of drive rod 32 while allowing the rotation of roller bearings 52. As shown in Figure 4, four roller bearings 52 may be used so as to align drive rod 32 within bearing housing 46 while aiding in the movement of drive rod 32. A plurality of screws 56 corresponding to the number of roller bearings 52 are used to attached holding member 58 to bearing housing 46 so as to hold roller bearings 52 within bearing housing 46 yet allow replacement thereof by removal of screws 56 and holding member 58. In a like manner, a second set of roller bearings 60 are disposed at the other end of bearing housing 46 to provide alignment of drive rod 32.

Referring again to Figure 3, drive rod 32 has a flexible rod 62 attached to the top end thereof which may be an Inconel rod (Registered Trade Mark). Flexible rod 62 has a spear-shaped member 64 attached to the top end of it. A hollow cylindrical divider 66 is attached to the lower end of cap 38 and in colinear alignment with channel 40. Divider 66 defines at least three chambers in the bottom end of cap 38 such as first chamber 68 and second chamber 70 that are of the size to accomodate spear 64.

Referring now to Figures 3, 5, 6 and 7, a latching mechanism 72 is disposed within housing 36 and adjacent to first chamber 68 and second chamber 70 and comprises a metal pivotable member 74 having a first slot 76 extending the entire length of one side. First slot 76 is of the size small enough to prevent spear 64 from passing therethrough but of a size large enough to allow flexible rod 62 to pass therethrough. Pivotal member 74 also has a first bore 78 and a second bore 80 in the top end thereof with first bore 78 capable of being aligned with first chamber 68 and second bore 80 capable of being aligned with second chamber 70 when pivotal member 74 is properly pivoted. First bore 78 extends to near the bottom of pivotal member 74 and has a ledge 82 at its lower end. Whereas, second bore 80 extends the entire length of pivotal member 74. A second slot 84 is defined between first bore 78 and second bore 80 which also is of a size small enough to prevent spear 64 from passing throughout but a size large enough to allow flexible rod 62 to pass therethrough. Two pins 86 each haing one end rotatably disposed within pivotal member 74 and each having their other end rotatably disposed within housing 36 allow pivotal member 74 to pivot within and relative to housing 36 as shown in Figure 6. A plurality of biasing means 88 which may be coil springs, are disposed around each pin 86 and are attached at one end to housing 36 and at the other end to pivotal member 74 for urging pivotal member 74 into a position as shown in Figure 3. Biasing means 88 are chosen such that they are capable of pivoting pivotal member 74 in a manner such that the top end of slot 76 contacts the inside of housing 36. However, biasing means 88 are chosen such that when spear 64 contacts and moves along first sot 76 as shown in Figure 5, spear 64 can pivot pivotal member 74 in a manner so as to allow spear 64 to slide into first chamber 68.

Referring now to Figures 8-11, when it is desired to raise drive rod 32 thereby raising displacer rods 34 or other similar devices, valve 44 is opened which allows the pressure in the upper end of housing 36 to drop and which allows the reactor coolant inside reactor vessel 12 to exert a force on drive rod 32, which causes drive rod 32 to move upwardly toward cap 38. Since the pressure in reactor vessel 12 is normally about 160 kg/cm 2, this pressure acting on the lower end of drive rod 32 creates a force of approximately 318 kg on drive rod 32 which causes the lifting action. Since the fluid is permitted to escape only slowly from the housing 46, drive rod 32 is raised at a slow rate with respect to bearing housing 46. For example, under a force of approximately 318 kg, drive rod 32 will rise at a rate of approximately 30 cm/sec. This slow rate of rise, eliminates the need to have a slowing mechanism such as a fluid dashpot attached to or associated with drive rod 32 to slow its rise. The relatively tight seal of second piston rings 50 with drive rod 32 also limits the amount of reactor coolant that passes therebetween so that adjusting valve 44 can effectively control the rate of movement of drive rod 32. As drive rod 32 rises, spear 64 contacts first slot 76 and rides therealong as shown in Figure 5. Spear 64 exerts a force on pivotal member 74 so as to pivot pivotal member 74 when spear 64 passes the location of pins 86. This pivoting motion allows spear 64 to pass beyond pivotal member 74 and into first chamber 68 as shown in Figure 8. As spear 64 passes pivotal member 74, flexible rod 62 passes through first slot 76 and into first bore 78. As flexible rod 62 passes into first bore 78, pivotal member 74 is pivoted back into its original position under the action of biasing means 88 as shown in Figure 8. Next, valve 44 is closed and the weight of drive rod 32 and the members attached thereto cause drive rod 32 to slowly slide downwardly within bearing housing 46 such that spear 64 enters first bore 78 as shown in phantom in Figure 8. As spear 64 continues downwardly into first bore 78, it causes pivotal member 74 to pivot into a position as shown in Figure 9. The downward slide of drive rod 32 and spear 64 is halted when spear 64 reaches ledge 82 at the bottom of first bore 78. Ledge 82 at the bottom first bore 78 holds spear 64 therein. When in this position as shown in Figure 9, pivotal member 74 has been pivoted such that first bore 78 is in alignment with second chamber 70. Also, when in the position as shown in Figure 9, spear 64 and drive rod 32 are in the raised position with displacer rods 34 fully withdrawn from core 20. Also, when in this position, drive rod 32 is locked in the up position. This position may be maintained as long as it is desired to have displacer rods 34 out of core 20.

Referring now to Figures 9-11, when it is desired to lower displacer rods 34 into core 20, valve 44 is again opened which allows reactor coolant to flow through housing 36, channel 40, and conduit 42. This allows drive rod 32 to again rise with respect to housing 36. As drive rod 32 rises, spear 64 rises into second chamber 70. When spear 64 has risen into second chamber 70, spear 64 contacts cap 38 which prevents further rise of drive rod 32 as shown in Figure 10. Once again, when spear 64 has passed beyond pivotal member 74, pivotal member 74 is pivoted into contact with housing 36 and flexible rod 62 extends through second slot 84 as shown in Figure 10. Next, valve 44 can be closed which allows the pressure on both ends of drive rod 32 to reach the same level. Once again the pressure has thus reached the same level, the weight of drive rod 32 and mechanisms attached thereto, causes drive rod 32 to slowly move downwardly with respect to housing 36. As drive rod 32 moves downwardly, spear 64 enters second bore 80 as shown in Figure 10 in phantom. As spear 64 passes through second bore 80, it exerts a force on pivotal member 74 which causes pivotal member 74 to pivot into a position as shown in Figure 11. Since second bore 80 extends through the entire length of pivotal member 74, the downward slide of spear 64 is not halted. Rather, spear 64 and drive rod 32 continue to fall through bearing housing 46 until displacer rods 34 have reached their maximum low position, thus fully inserting displacer rods 34 in core 20. Therefore, it can be seen that invention provides an hydraulic drive mechanism by which a member can be held in an upper or lower position with respect to the reactor core.

CLAIMS

1. A drive and latching mechanism comprising a drive housing (30), having a drive shaft (32) movably disposed therein characterized in that a pivotable member (74) is pivotally disposed within said drive housing (30), said member (74) having a first bore (78) and a second bore (80) therein and having a first slot (76) along one side thereof extending from the top to the bottom ends of said pivotable member (74) and extending into said first bore (78), said pivotable member (74) having biasing means (84, 88) associated therewith for pivoting said pivotable member (74) relative to said drive housing (30), said drive shaft (32) carrying a contact member (62) having a head (64) on its free end and being capable of passing through said first slot (76) with said head (64) being wider than said first slot (76); and drive means are associated with said drive shaft (32) for moving it together with said head (64) into contact with said pivotable member (74) thereby pivoting said pivotable member (74) relative to said drive housing (30) thereby allowing said head (64) to be inserted and seated in said first bore (78).

2. A mechanism according to claim 1, charaterized in that bearings (52) are removably disposed within said drive housing (30) around said drive

shaft (32) for guidng said drive shaft (32) in said drive housing (30); seal means (50) are associated with said bearings (52) and disposed in contact with said drive shaft (32) for limiting leakage flow of a hydraulic fluid; and a hydraulic fluid source is connected to said drive housing (30) for providing a hydraulic pressure for moving said drive shaft (32) relative to said drive housing (30).

3. A mechanism according to claim 2, characterized in that said bearings (52) comprise a removable bearing housing disposed within said drive housing; and rollers (52) disposed ina bearing housing (46) and in contact with said drive shaft (32) for maintaining alignment of said drive shaft (32) with respect to said drive housing (30).

4. A mechanism according to claim 3, chracterized in that a plurality of piston seal rings (48) are disposed around the outside of said bearing housing (46) and in contact with the inside of said drive housing (30) for limiting the flow of hydraulic fluid between said bearing housing (46) and said drive housing (30).

5. A mechanism according to claim 4, characterized in that said seal means (50) comprises a plurality of position seal rings removably disposed in said bearing housing (46) and in contact with said drive shaft (32).

6. A mechanism according to claim 5 wherein said housing (30) is in a vertical position and at its lower end in communication with a pressurized water nuclear reactor and said drive shaft is connected to control devices in said reactor, characterized in that said valve is connected to said drive housing (30) for selectively allowing said hydraulic fluid to pass therethrough thereby changing the fluid pressure across said seal means thereby causing said drive shaft (32) to move relative to said drive housing (30) under the influcence of said hydraulic fluid pressure differential.

7. A mechanism according to any of claims 1 to 6, characterized in that said second bore (80) extends from the top to the bottom ends of said pivotable member (74) for allowing said head (64) to pass therethrough thereby disconnecting said drive shaft (32) from said pivotable member (74).

8. A mechanism according to claim 7, characterized in that said first bore (78) has a ledge (82) therein for capturing said head (64) while allowing said contact member (62) to extend therethrough.

9. A mechanism according to claim 8, characterized in that said pivotable member (74) has a second slot (84) therein extending between said first bore (78) and said second bore (80) for allowing said contact member (62) to pass therethrough while preventing said head (64) from passing therethrough.

10. A mechanism according to any of claims 1 to 9 characterized in that said contact member (62) is a flexible rod.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1982.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.