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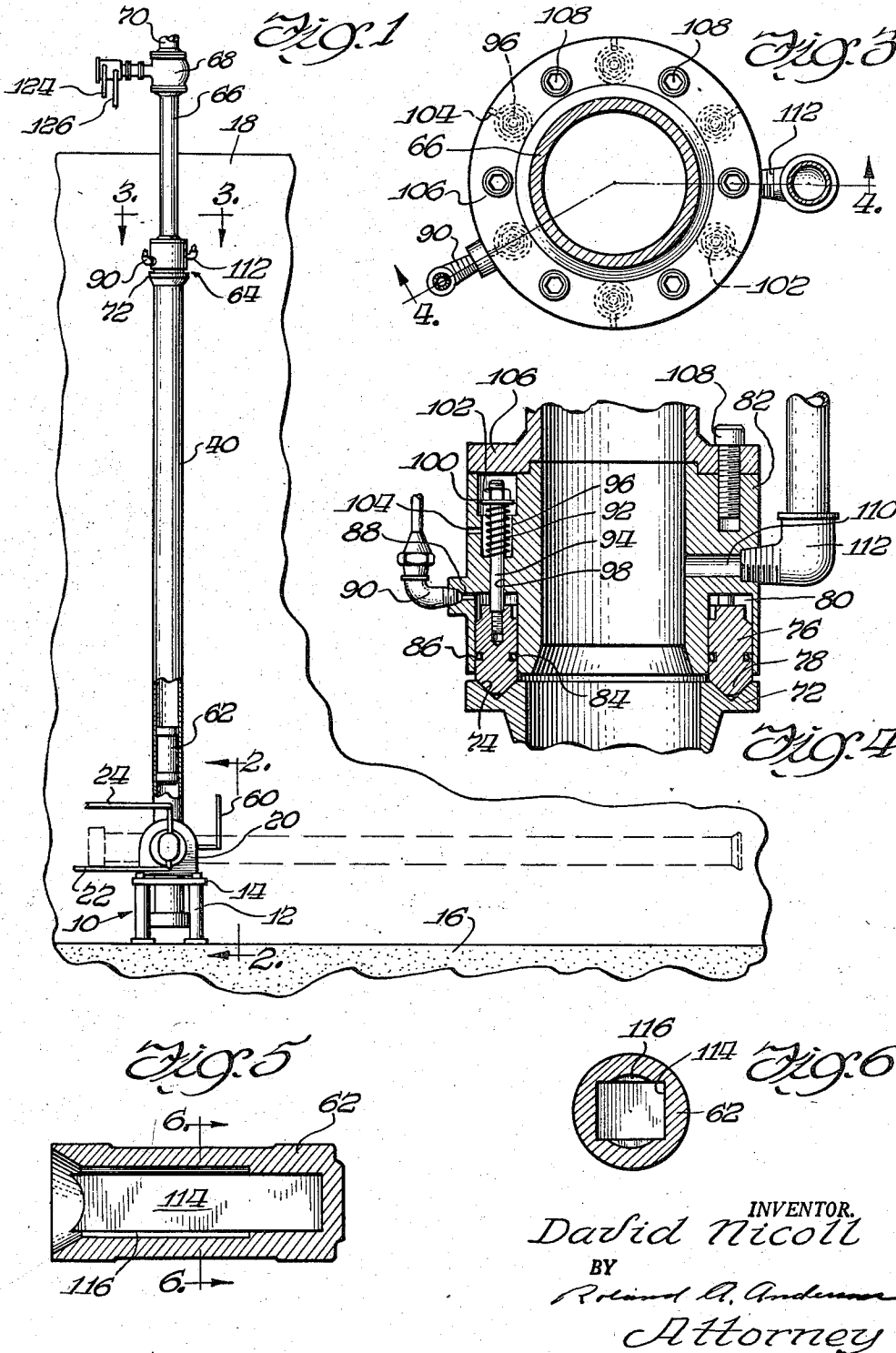
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METHOD AND APPARATUS FOR HANDLING RADIOACTIVE PRODUCTS

Filed Feb. 28, 1956

3 Sheets-Sheet 1



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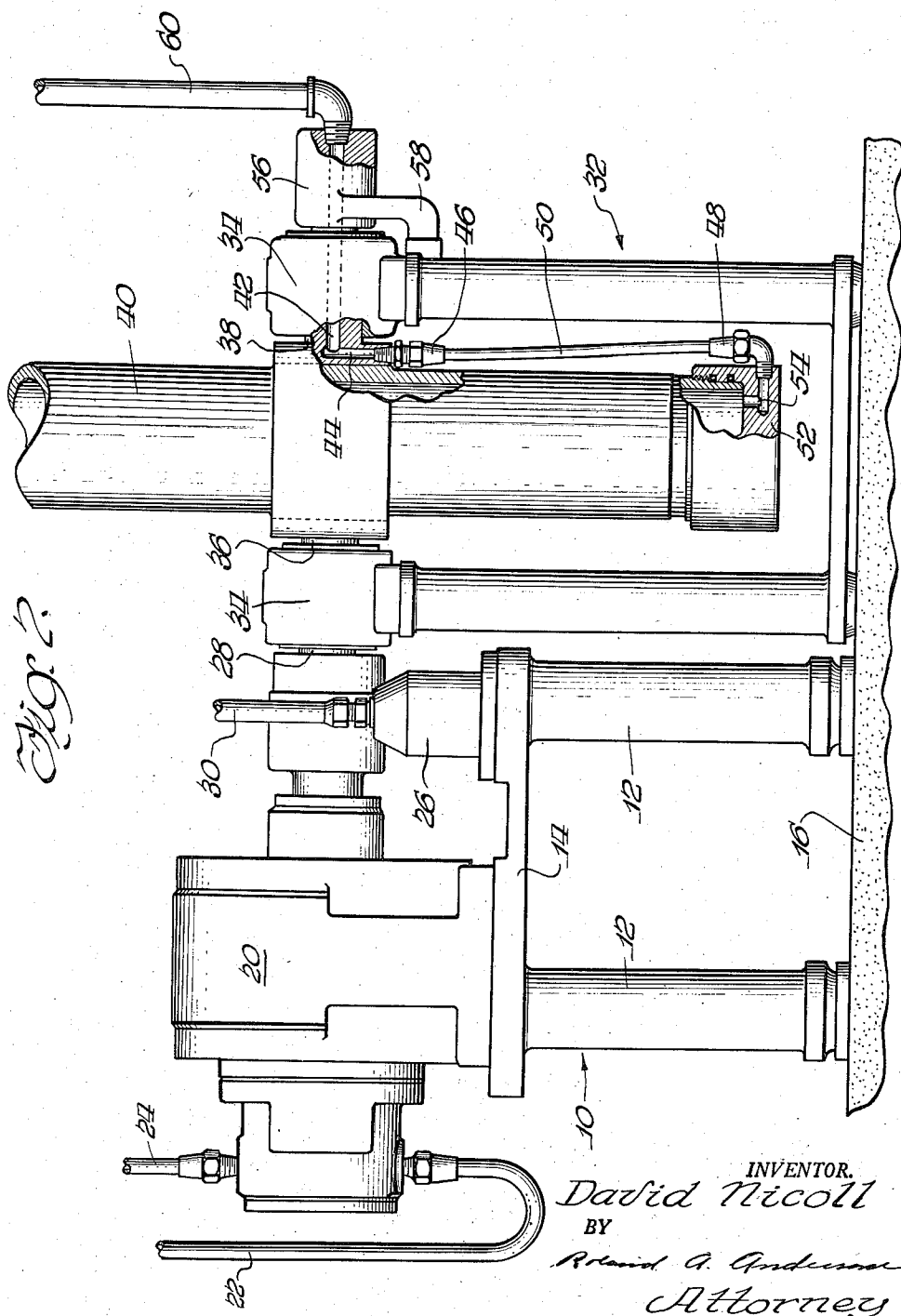
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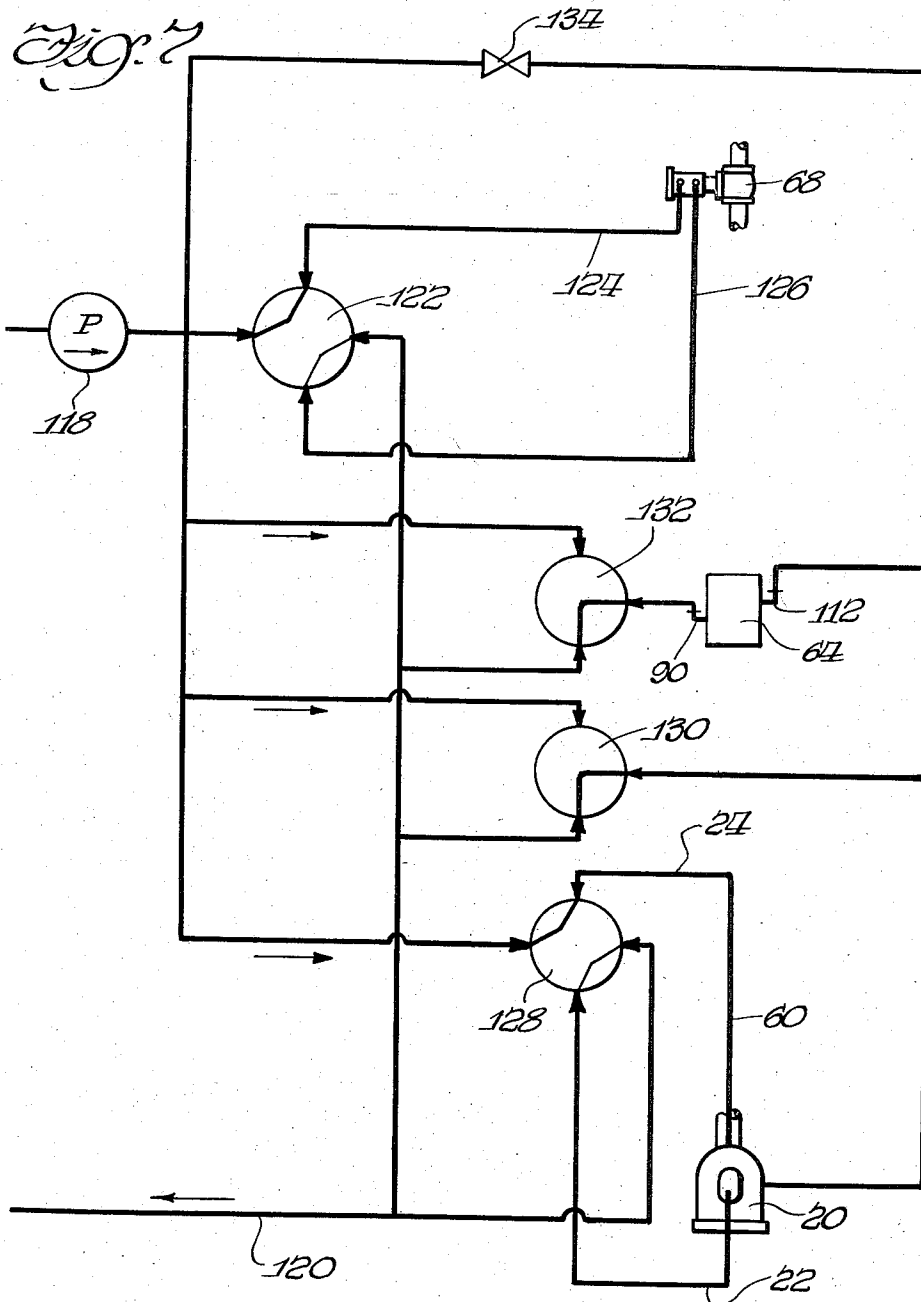
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3 Sheets-Sheet 3



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METHOD AND APPARATUS FOR HANDLING RADIOACTIVE PRODUCTS

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6 Claims. (Cl. 250—106)

This invention relates to a method and apparatus for handling and storage of radioactive materials. More specifically the invention relates to a method and apparatus whereby radioactive materials in the form of solid bodies may be removed from a liquid contaminated with radioactivity and stored in a clean body of liquid without introducing into the clean liquid contamination other than the solid body thus removed.

It is common to store intensely radioactive bodies in large bodies of shielding liquid, normally water. In connection with the operation of neutronic reactors, it is very common to provide adjacent to the reactor a large container of water sunk into the earth for the subsequent handling and storage of spent fuel elements from the reactor, which are of course highly radioactive. Such containers are normally referred to as "canals" and frequently extend from the region of the reactor to other regions of the building in which the reactor is located or even to other buildings, such as chemical processing plants for processing of the spent fuel elements. When the radioactive bodies are on the bottom or floor of the canal the liquid (water) within the canal acts as a complete radiation shield, in cooperation with the concrete of which the canal is constructed and the earth surrounding the canal. Such a structure offers the great advantage that radioactive bodies may be moved from place to place and processed by suitable remote control devices while remaining in the fluid shielding medium.

In the operation of neutronic reactors, it is sometimes desirable to remove radioactive bodies, particularly spent fuel slugs, from the reactor without draining the coolant liquid of the reactor. The fuel elements themselves are normally jacketed in impervious sheaths to prevent the escape of the highly radioactive fission products, so that the reactor or coolant is not directly contaminated with radioactive materials from this source. Likewise, when the fission products are stored in the canal or other container after removal from the reactor, the fission products cannot escape into the shielding liquid, so that the thickness of the shielding liquid interposed between the radioactive material and the surroundings is the entire depth of liquid in the storage container. However, the coolant liquid of the reactor is itself contaminated with radioactivity, from sources other than the fuel material. The primary source of the radioactivity in the coolant is the transmutation of otherwise inert atoms of the coolant into radioactive isotopes by the neutrons present in the reactor. In the case of water, for instance, O^{16} is converted to N^{16} , a highly radioactive isotope which remains dissolved in the coolant in elemental or compound form. This isotope is very short in half-life. However, the coolant is also contaminated with other radioactive isotopes, such as those removed from structural parts of the reactor by corrosion and erosion. If any of the coolant fluid were permitted to escape into the canal or other storage container, the contamination thus conveyed to the fluid in the container would diffuse through the shielding liquid, thus destroying the effectiveness of the

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shielding liquid for its required purpose of preventing the existence of radioactivity at the surface.

It is the principal object of the present invention to provide a suitable method and apparatus for handling and storage of radioactive bodies, particularly neutronic reactor components such as fuel elements, to permit withdrawal of the solid bodies from a container such as the tank of a neutronic reactor into a container such as a reactor or canal without permitting contamination of the liquid in the storage container by the liquid in the container from which the body is being removed. The invention also provides a conveyor or handling device which permits the depositing of the radioactive bodies on the floor or bottom of the canal or other storage container in a simple manner which is well adapted for remote control.

For a complete understanding of the invention, reference is made to the attached drawing in which:

Figure 1 is a view in elevation, partially broken away in section, of the apparatus of the invention, the storage container or canal being shown fragmentarily;

Figure 2 is a view in front elevation of a tilting or tipping device constituting a portion of the apparatus of Figure 1, taken along the line 2—2 of Fig. 1 in the direction indicated by arrows;

Figure 3 is a horizontal sectional view taken along the line 3—3 of Figure 1;

Figure 4 is a sectional view taken along the line 4—4 of Figure 3;

Figure 5 is an enlarged sectional view of a piston constituting a portion of the device of Figure 1;

Figure 6 is a transverse sectional view of the piston of Figure 5 taken along the line 6—6 of that figure; and

Figure 7 is a schematic representation of an hydraulic system, including portions of the device of Figure 1 and the components employed for operation thereof.

Referring first to Figures 1 and 2 of the drawing, it will be seen that a base generally designated 10, consisting of upright legs 12 and a support plate 14, rests on the concrete floor or bottom 16 of a reactor canal having concrete side walls 18 (only one of which is seen in the drawing). Mounted on the plate 14 is a rotary hydraulic cylinder 20 employed in the device as a tipping cylinder. The cylinder 20 is provided with hydraulic feed lines 22 and 24 and a suitable limit stop and shock absorber 26 adapted to permit rotation of the cylinder shaft 28 through a 90° angle, the position or direction of motion being determined by selectively connecting one of the feed lines 22 and 24 to an hydraulic pressure source and the other to an exhaust. An auxiliary line 30 is provided for remote indication of the position of the shaft of the tipping cylinder 20. The assembly thus far described in connection with the tipping cylinder 20 constitutes a commercially available type of assembly which is employed for various purposes and is familiar to persons skilled in the art and therefore is not described or illustrated in further detail.

An additional base 32 supports bearings 34 in which are journaled trunnions 36 and 38 secured to an elongated cylinder or tube 40. The trunnion 36 constitutes an extension of the shaft 28 of the cylinder 20, so that operation of the cylinder 20 tips the tube or cylinder 40 through a 90° angle between vertical and horizontal positions. The trunnion 38 has an axial bore 42 connecting with a radial bore 44 which is coupled by fittings 46 and 48 interconnected by tubing 50 to a cap 52 suitably bored at 54 to connect the hydraulic feed line 50 to the lower end of the interior of the cylinder or tube 40. The trunnion 38 terminates in an hydraulic swivel connector 56 rigidly mounted on the base 32 by a bracket 58, suitable hydraulic piping 60 being connected to the connector 56, so that the piping 60 is connected to the lower end of the

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interior of the cylinder 40 in all rotational positions of the latter.

Within the elongated cylinder or tube 40 is a sliding piston 62. At the upper end (with the cylinder or tube 40 vertical) is a remotely disengageable coupling 64 joining the end of the tiltable cylinder 40 to a vertical tube or conduit 66, which is fixedly mounted by means not illustrated.

At the upper end of the tube or conduit 66 is an hydraulically operated gate valve 68 connected to a further conduit 70, illustrated fragmentarily, which in turn extends upwardly to the tank or container (not illustrated) of a neutronic reactor from which materials are to be removed for storage in the canal.

The construction of the coupling 64 is shown in Figures 3 and 4. The upper end of the cylinder 40 is formed with a flange 72 having a V-groove 74 formed in the end surface thereof. An annular sealing member 76 having the lower end thereof formed and finished at 78 to conform to the groove 74 and make a fluid-tight seal therewith, is reciprocable in a groove 80 formed in the lower end of the body 82 of the coupling, inner and outer O-rings 84 and 86, respectively, establishing a fluid-tight sliding connection between the sealing member 76 and the interior of the groove 80. The upper end of the groove 80 is connected by an aperture 88 to a suitable fitting 90 for introducing fluid pressure into the groove 80 to force the sealing member 76 into secure engagement with the groove 74. The sealing member 76 is withdrawn into the body 82 in the absence of fluid pressure in the groove by the action of compression springs 92. The springs 92 surround rods 94, the lower ends of which are threaded into the sealing member 76. The upper ends of the rods 94 reciprocate in wells or bores 96 in the upper end of the body 82. The bores 96 are connected to the groove 80 by apertures 98 through which the rods 94 slide with a minimum of fluid leakage. The lower ends of the springs 92 rest on the bottom of the bores 96, and the upper ends seat against washers 100 which are secured to the rods 94 by nuts 102. Ports 104 connect the wells or bores 96 to the exterior, and assure that any leakage which may exist through the apertures 98 along the rods 94 cannot build up sufficient pressure in the bores 96 to interfere with proper operation of the device. The conduit 66 is formed with a flange 106, which is secured to the body 82 of the coupling by bolts 108. Connection of an external source of fluid under pressure is made to the interior of the central passage of the coupling through an aperture 110 in the body 82 and a suitable fitting 112.

The piston 62 is illustrated in enlarged form in Figures 5 and 6. It is formed with a socket 114 in the upper end, adapted to receive the lower end of a fuel body removed from the reactor to which the conduit 70 is attached. In the illustrated embodiment, the socket 114 is rectangular in cross section to receive fuel bodies of the same shape. In addition, in the upper portion of the cylinder, opposing sides of the rectangular socket are machined away at 116 in the form of arcs of a circle; it will thus be seen that the piston 62 will snugly receive fuel bodies or other reactor elements which conform either to the rectangular shape of the socket 114, or to the circular shape delineated by the arcs 116.

In Figure 7 is shown in schematic form the hydraulic fluid system to which the various connections previously described may be made. The entire system is fed by a pump 118 and returns to an exhaust 120. A 4-way valve 122 selectively connects the two fluid lines 124 and 126 of the gate 68 to the pressure and exhaust lines, respectively, to open and close the gate. A similar valve 128 connects the pressure and exhaust lines to the feed lines 22 and 24 of the tipping cylinder 20, which is accordingly elevated to the vertical position or lowered to the horizontal position in accordance with the manipulation of the valve 128. A 3-way valve 130 selectively connects the piping 60, and thus the portion of the cylinder 40

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beneath the piston 62, to the pressure and exhaust sides of the system to raise and lower the piston. A further 3-way valve 132 connects the fitting 90 on the coupling 64 to the pressure or exhaust side of the line, selectively, thus making and breaking the seal between the coupling 64 and the upper end of the cylinder 40. The fitting 112, which, as previously described, connects with the axial portion of the apparatus into which the radioactive material is received, is connected to the pump 118 by a pressure-reducing valve 134.

The structure of the device having been thus described, the manner of operation thereof will be readily understood. When the device is not in use, as during the normal operation of the neutronic reactor with which the device is employed, the cylinder 40 normally is withdrawn to its horizontal position, indicated by dotted lines in Figure 1. When it is desired to remove fuel elements from the reactor, operation of the pump 118 is commenced with the valve 134 closed, the valve 122 in the position to keep the valve 68 in its closed position, the valve 132 in the position to connect the groove 80 to the exhaust line, the valve 130 connecting the bottom portion of the cylinder 40 to the exhaust line, and the valve 128 in the position wherein the cylinder 40 is horizontal. (These are the positions of the valves shown in Figure 7.)

In commencing the operation of removal of bodies from the reactor container, the cylinder 40 is first elevated to the vertical position by reversing the condition of the valve 128. Operation of the valve 132 thereupon connects the groove 80 to the fluid pressure source, thus driving the sealing member 76 into operative engagement with the groove 74, the conical or V-shaped meshing serving to correct any slight misalignment of the cylinder 40 with the stationary pipe 66. The valve 134 is then opened sufficiently to produce in the cavity formed by the cylinder 40 and the pipe 66 a pressure somewhat in excess of the pressure which is known to exist in the reactor system, i. e., in the region above the closed gate valve 68. When the gate valve 68 is then opened by operation of the valve 122, the flow of water which ensues is upward into the water-cooled reactor system, so that during the subsequent operations no contaminated water may enter either the hydraulic control system or the cavity or the canal. The piston 62 is then raised to the top of the cylinder 40 by operation of the valve 130, the slight constriction of the valve body 82 with respect to the cylinder 40 constituting a stop for the piston at the upper end of its path. By suitable means such as a remote-controlled crane or other handling apparatus, the fuel element is then lowered through the pipe 66 against the flow of water, and the lower end is seated in the socket 114 in the piston. The piston is then lowered by operation of the valve 130, the gate valve 68 is closed by means of valve 122, the pressure-reducing valve 134 is again closed, the seal between the cylinder 40 and the pipe 66 is opened by means of valve 132, the cylinder is brought back to the horizontal or lowered position by operation of valve 128, and the fuel element is ejected onto the bottom of the canal or onto a suitable receiving table for further handling.

It will of course be understood that the embodiment of the invention illustrated in the drawing and described above is merely one embodiment selected for illustration and description in accordance with the patent laws. Persons skilled in the art, upon inspection of the drawing herein, and study of the above description, will readily devise other particular structures, which, although they may greatly differ both in details of construction and general appearance from the embodiment herein illustrated and described, nevertheless utilize the basic teachings of the invention. Accordingly, the scope of the protection to be afforded the invention should not be determined by any particular embodiment, but should be determined only from the appended claims.

What is claimed is:

1. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a conduit extending downwardly into the container, a cylinder, means for pivotally mounting the cylinder within the container beneath the end of the conduit for rotational motion between a vertical position wherein the mouth of the cylinder is in register with the mouth of the conduit to form a continuous internal cavity and a horizontal position wherein the mouth of the cylinder is remote from the top of the container, means for selectively rotating the cylinder between said positions, cooperating disengageable sealing means on the mouths of the cylinder and the conduit, means operable to open and close the conduit, means for causing liquid under pressure to issue from the conduit away from the cylinder when the conduit is open, a piston within the cylinder, and means to position and drive the piston in the cylinder.

2. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a cylinder, means for pivotally mounting the cylinder within the container for rotational motion between a vertical position wherein the mouth of the cylinder is in the top portion of the container and a horizontal position wherein the mouth of the cylinder is remote from the top portion of the container, means for causing liquid under pressure to issue from the mouth of the cylinder, a piston within the cylinder, and means to position and drive the piston in the cylinder.

3. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a conduit extending downwardly into the container, a receptacle, means for pivotally mounting the receptacle within the container beneath the end of the conduit for rotational motion between a vertical position wherein the mouth of the receptacle is in register with the mouth of the conduit to form a continuous internal cavity and a horizontal position wherein the mouth of the receptacle is remote from the top of the container, cooperating disengageable sealing means on the mouths of the receptacle and the conduit, means for causing liquid under pressure to issue from the conduit away from the receptacle, and means within the receptacle to eject a radioactive body therefrom when the receptacle is in the horizontal position.

4. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a conduit extending into the container and having a mouth in the upper region of the container, a

receptacle within the container, means for moving the receptacle between a position wherein the mouth of the cylinder is in register with the mouth of the conduit to form a continuous internal cavity and a position wherein the mouth of the receptacle is remote from the upper region of the container, cooperating disengageable sealing means on the mouths of the receptacle and the conduit, means operable to open and close the conduit, and means for causing liquid under pressure to issue from the conduit away from the cylinder when the conduit is open.

5. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a conduit extending downwardly into the container, a cylinder, means for pivotally mounting the cylinder within the container beneath the end of the conduit for rotational motion between a vertical position wherein the mouth of the cylinder is in register with the mouth of the conduit to form a continuous internal cavity and a horizontal position wherein the mouth of the cylinder is remote from the top of the container, cooperating disengageable sealing means on the mouths of the cylinder and the conduit, means operable to open and close the conduit, means for causing liquid under pressure to issue from the conduit away from the cylinder when the conduit is open, a piston within the cylinder, and means to introduce liquid under pressure into the lower end of the cylinder.

6. A device for handling and storage of radioactive bodies comprising a container adapted to hold a shielding liquid, a cylinder, means for pivotally mounting the cylinder within the container for rotational motion between a vertical position wherein the mouth of the cylinder is in the top portion of the container and a horizontal position wherein the mouth of the cylinder is remote from the top portion of the container, and means for causing liquid under pressure to issue from the mouth of the cylinder.

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