Dec. 9, 1969 K. ANTONSEN ET AL 3,483,380

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 1

Fig 1

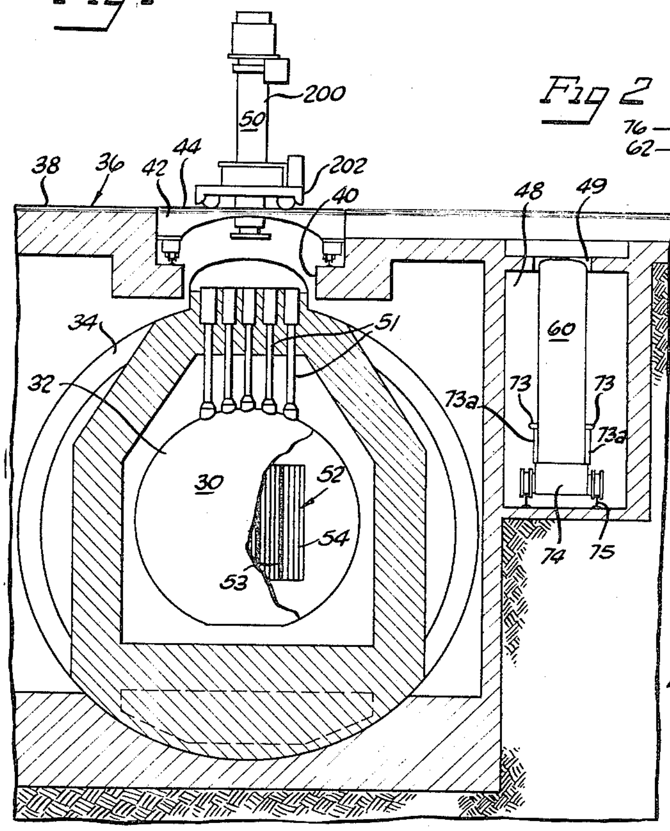
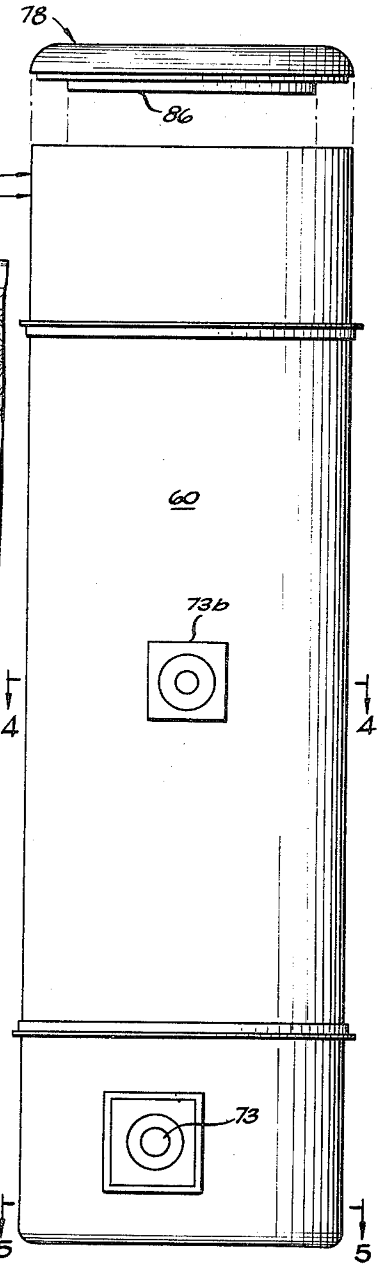


Fig 2



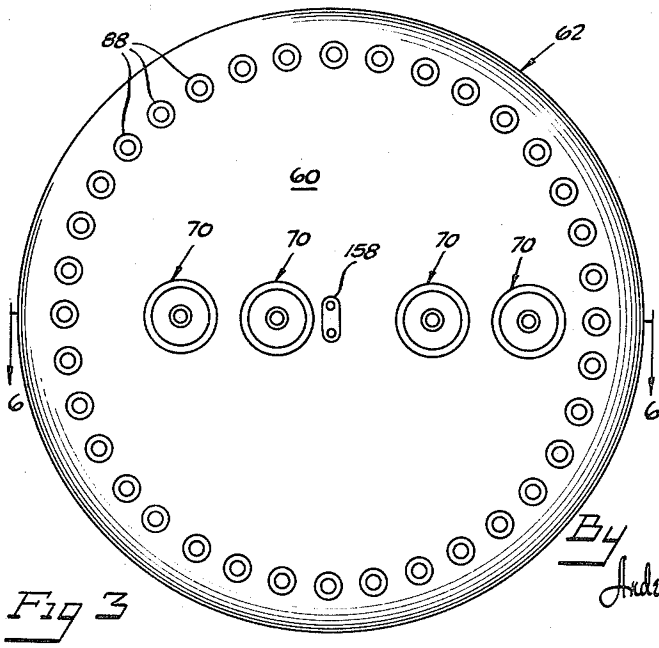


Fig 3

Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Att'y's

Filed April 9, 1965

Fig 4

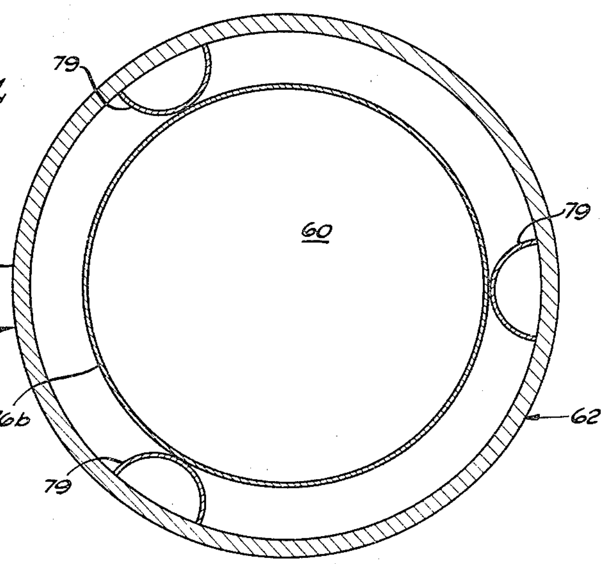
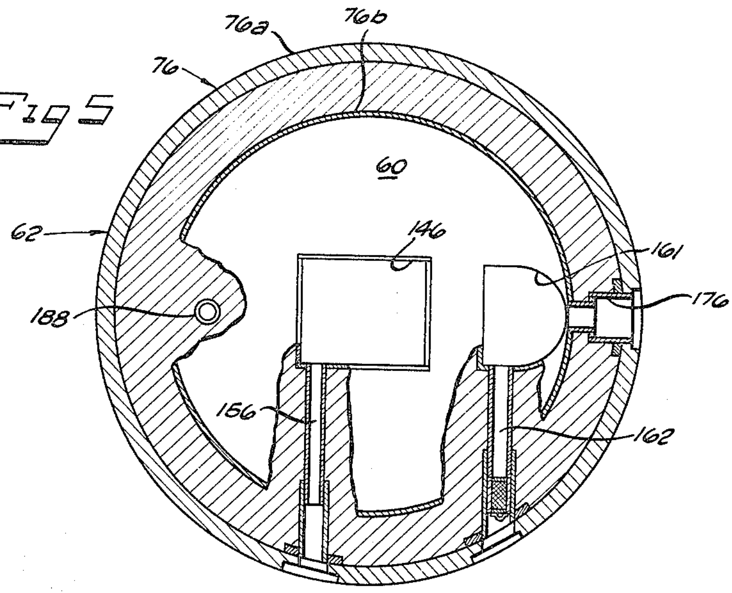


Fig 5



Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD
By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 3

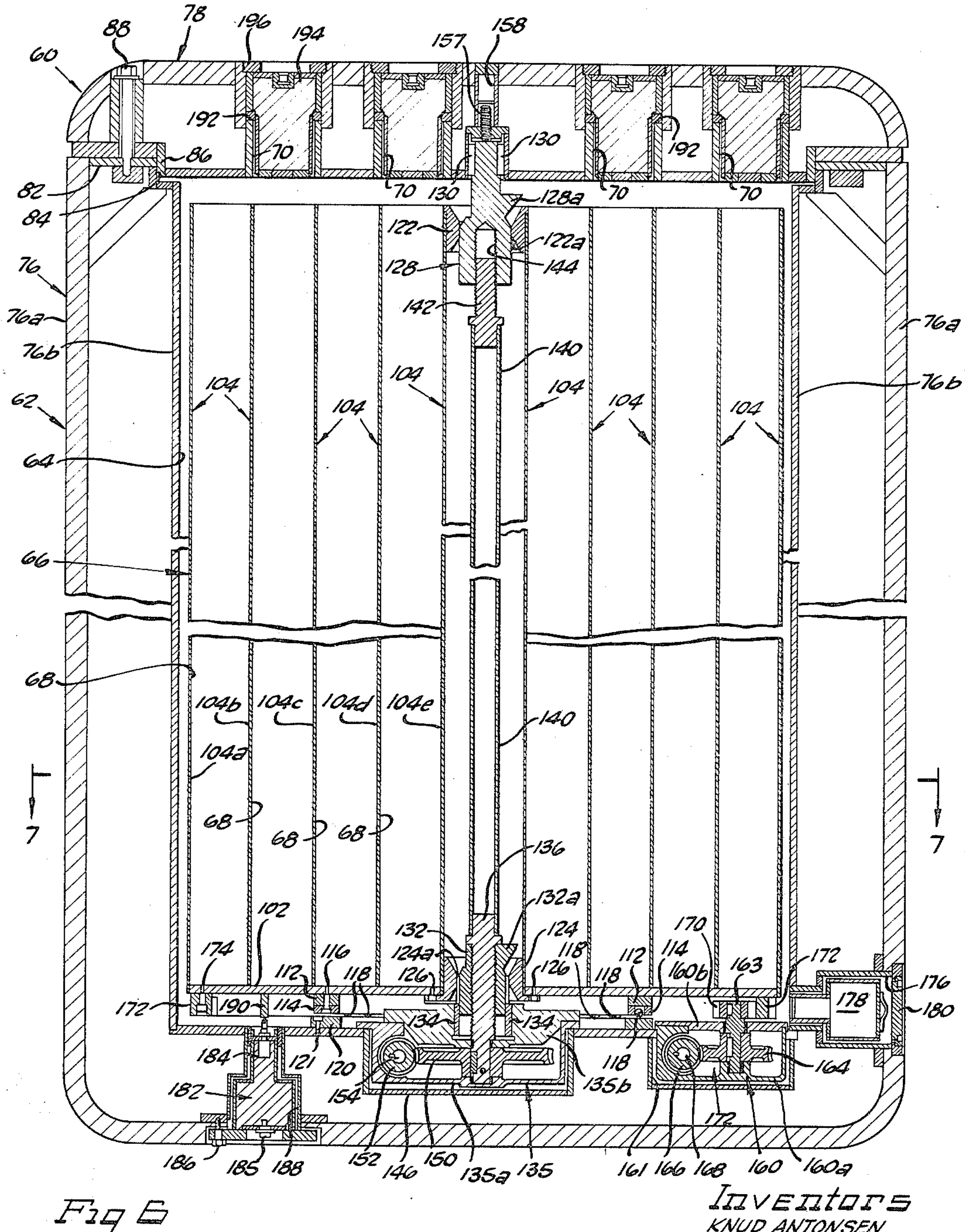


Fig 6

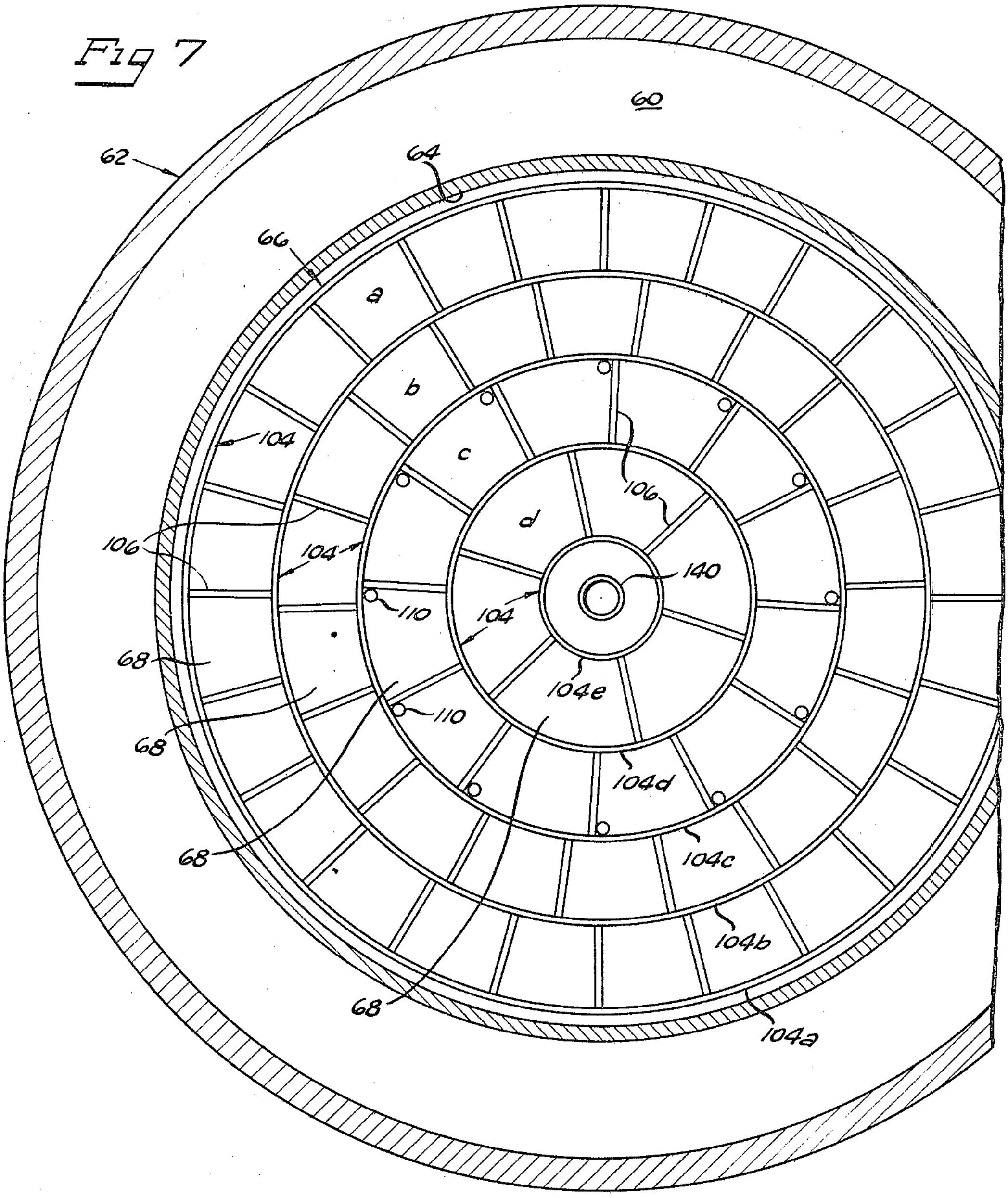
Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 4

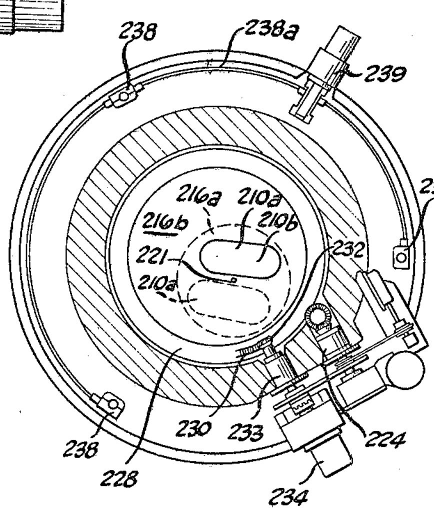
Fig 7



Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

Fig 9



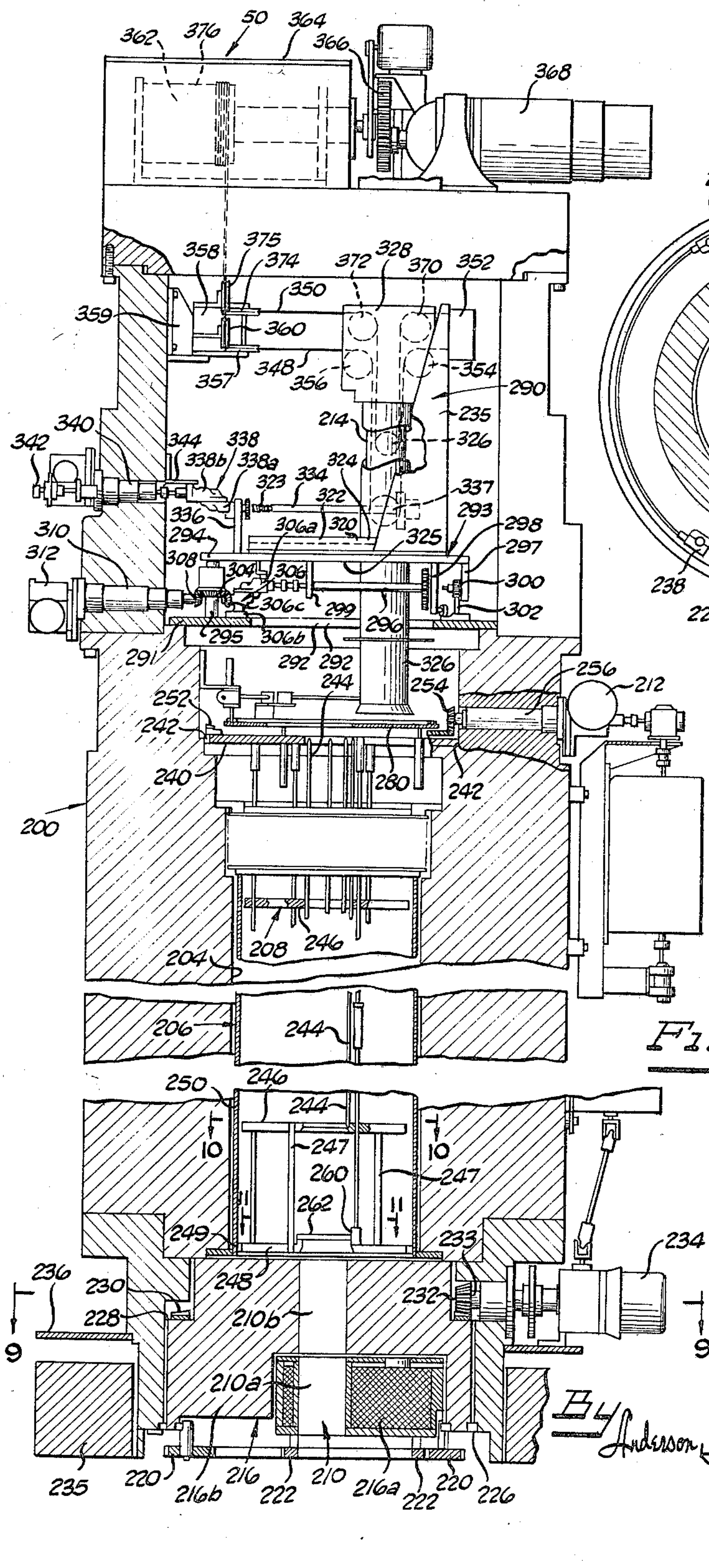


Fig 8

Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD
By Anderson, Luedeka, Fitch, Even & Tabin
Att'ys

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Fig 10

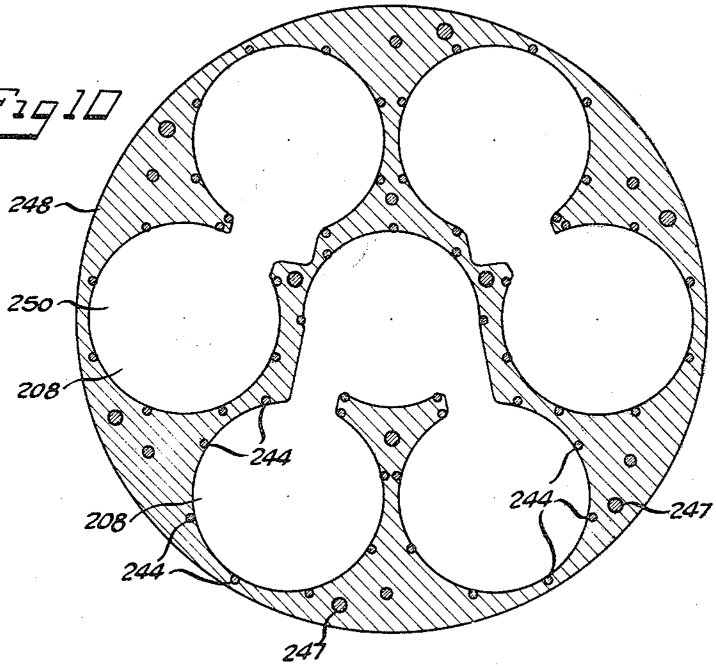
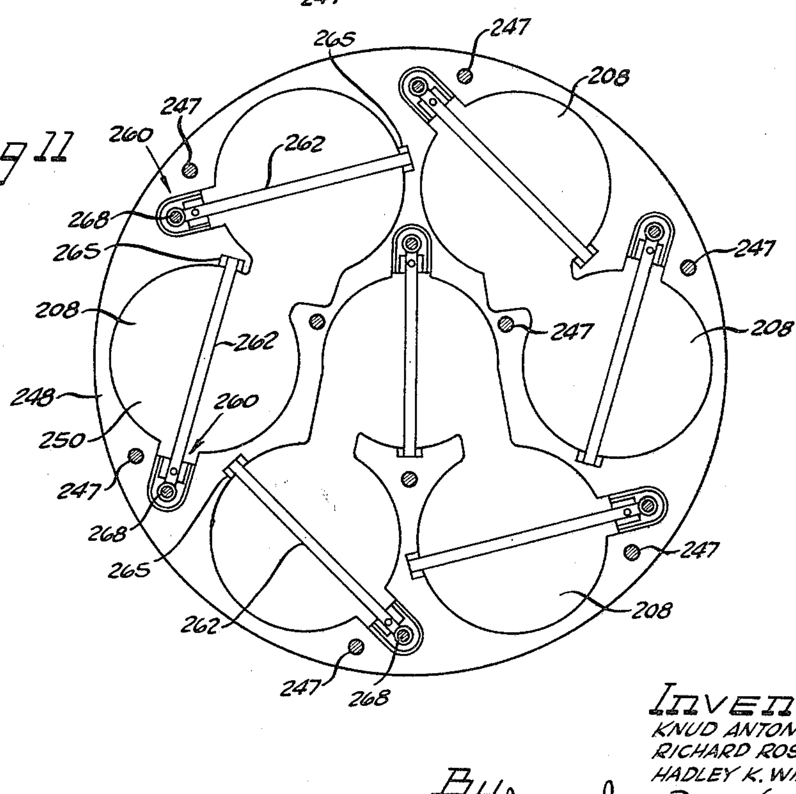


Fig 11



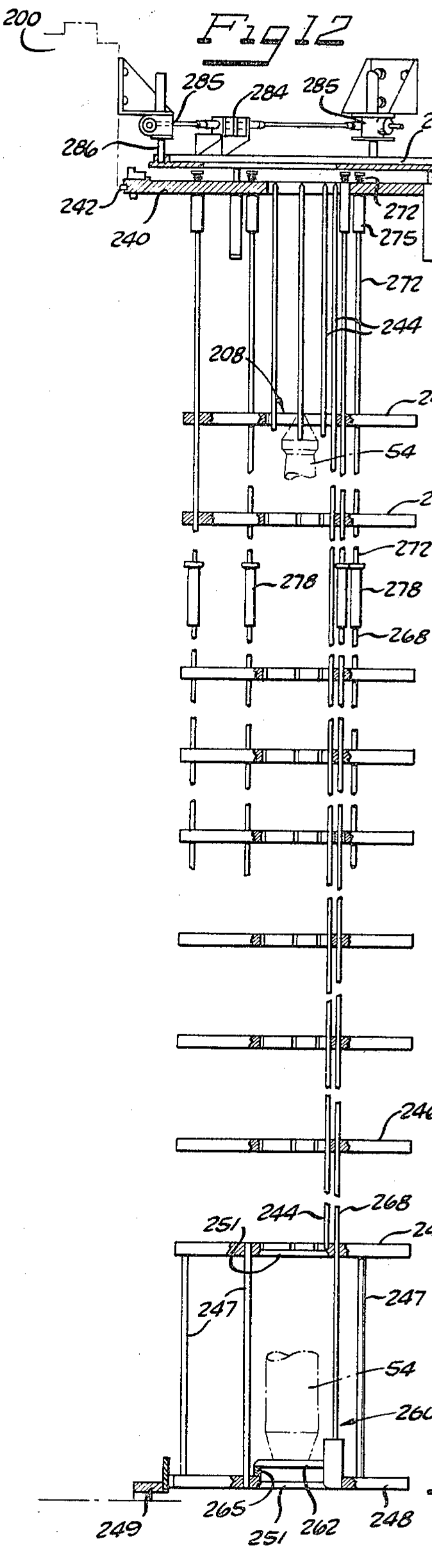
Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin, Atty's

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 7

Fig 12



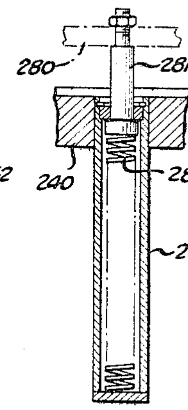
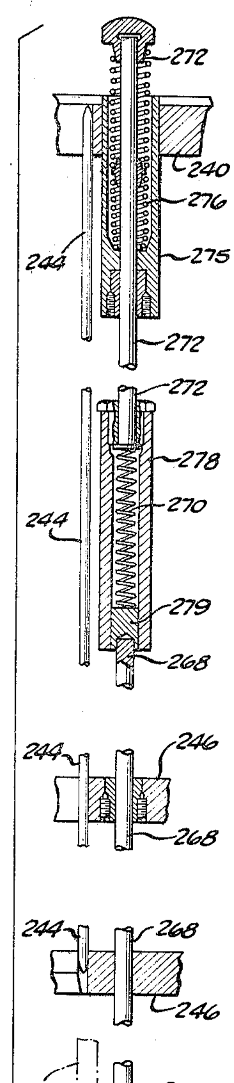
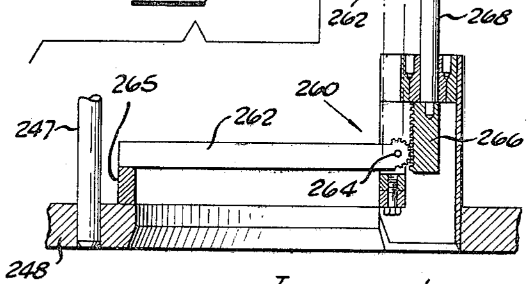


Fig 13

Fig 14





Inventors
KNUD ANTONSEN
RICHARD ROSENBURG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Att'ys

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 8

Fig 15

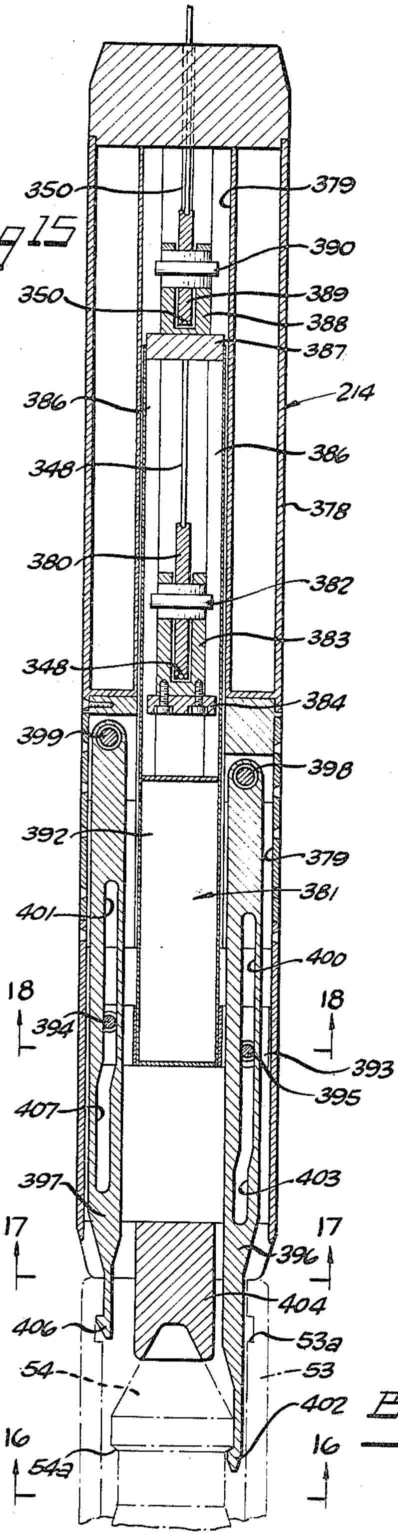


Fig 16

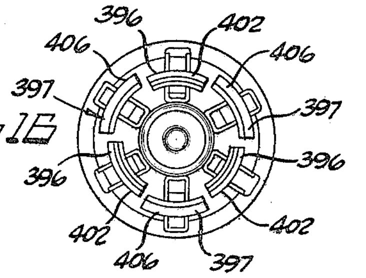


Fig 17

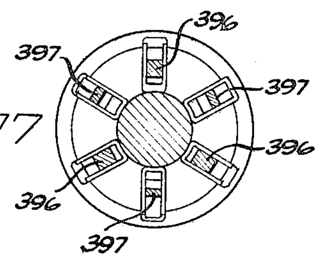
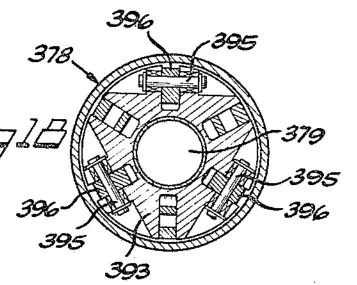


Fig 18



Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 9

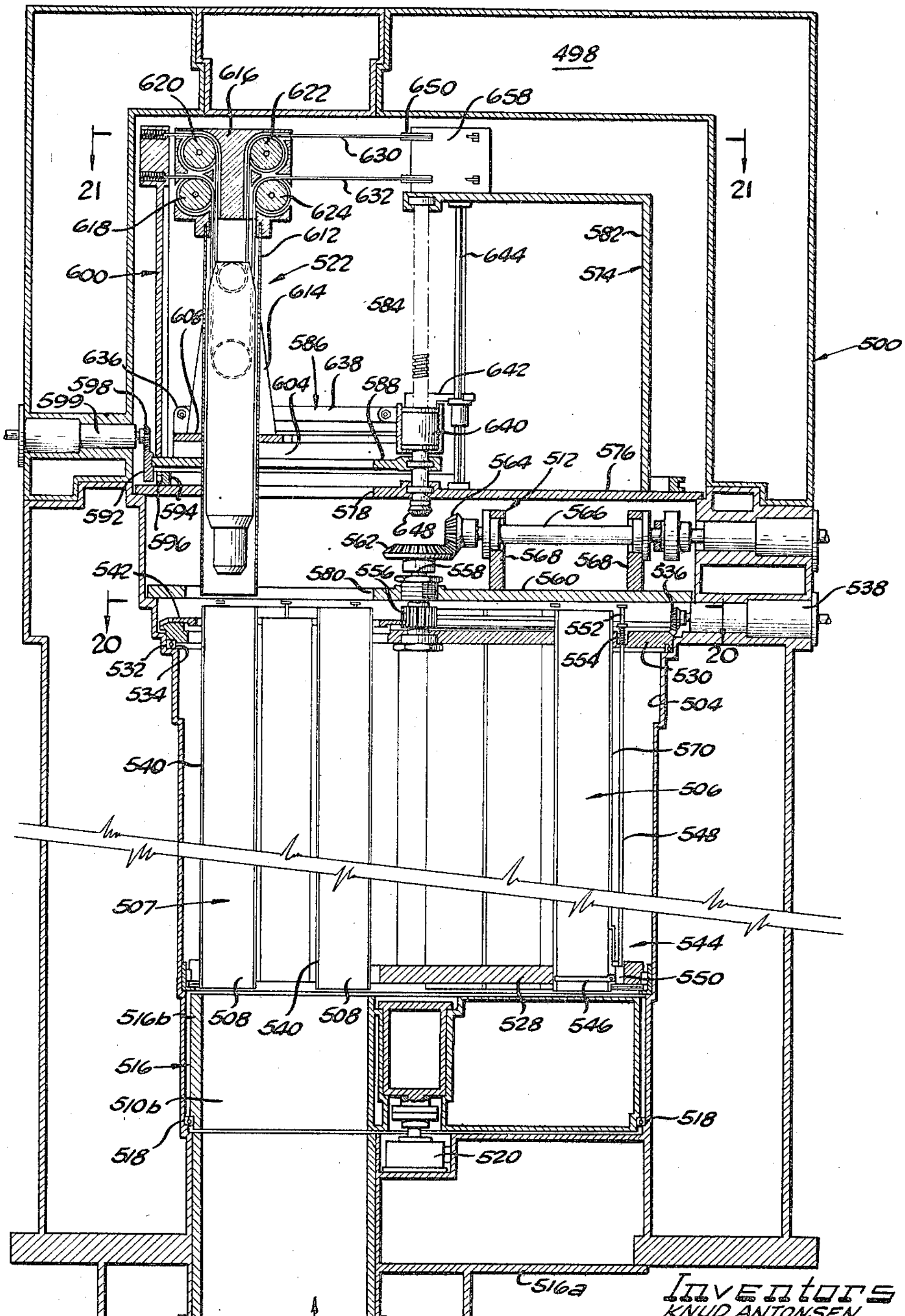


Fig 19

Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin, Atty's

SHIELDED CASK FOR RADIOACTIVE MATERIAL

Filed April 9, 1965 10 Sheets-Sheet 10

Fig 21

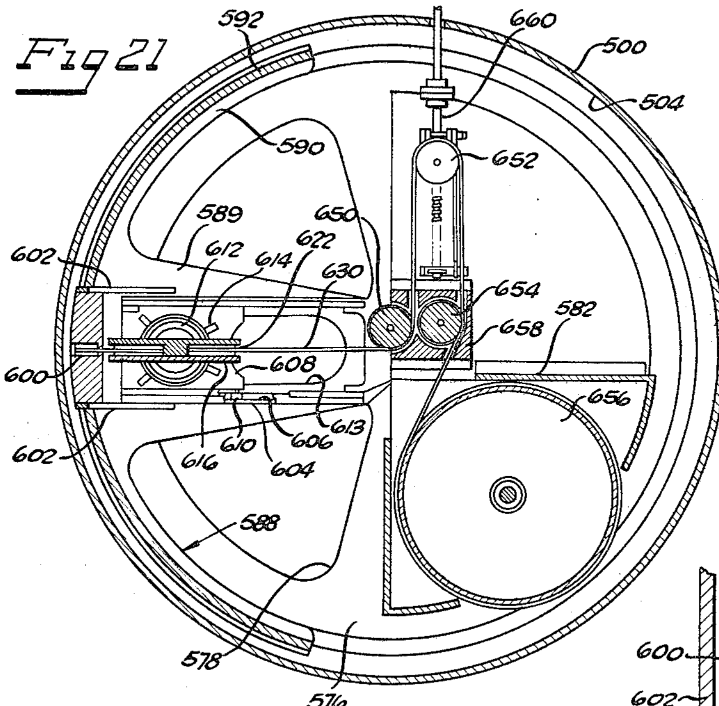


Fig 22

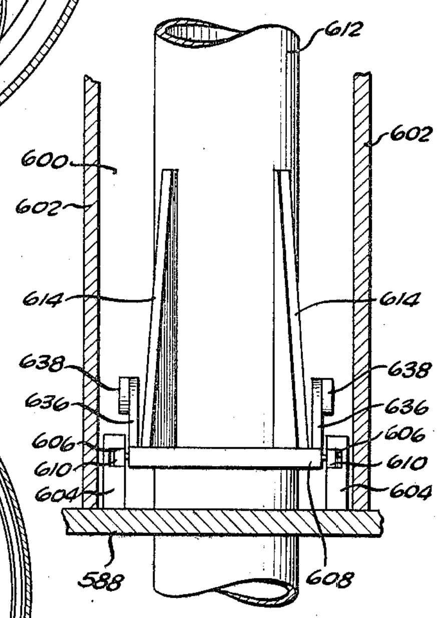
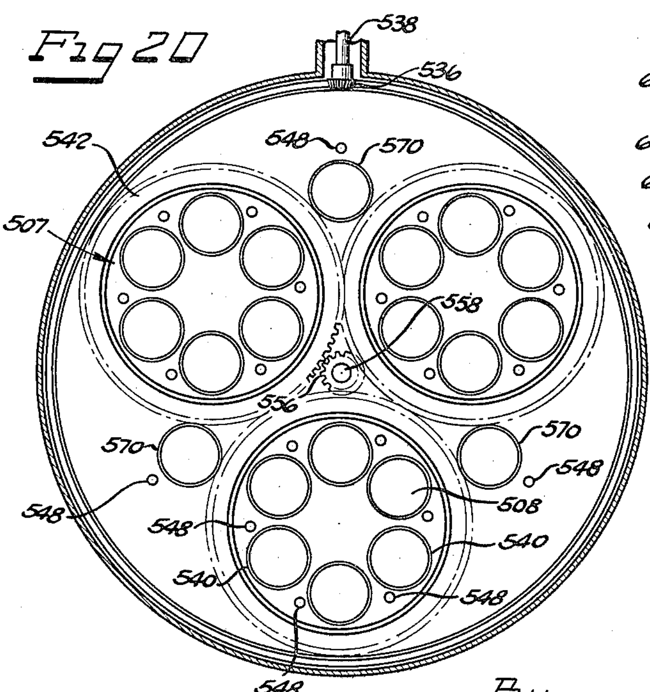


Fig 20



Inventors
KNUD ANTONSEN
RICHARD ROSENBERG
HADLEY K. WIARD

By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

3,483,380
SHIELDED CASK FOR RADIOACTIVE MATERIAL
Knud Antonsen and Richard Rosenberg, San Diego, and Hadley K. Wiard, La Mesa, Calif., assignors, by mesne assignments, to Gulf General Atomic Incorporated, San Diego, Calif., a corporation of California
Filed Apr. 9, 1965, Ser. No. 447,003
Int. Cl. G21f 7/00
U.S. Cl. 250—108 21 Claims

ABSTRACT OF THE DISCLOSURE

A shielded cask particularly adapted to receive radioactive elements, such as nuclear fuel cells, including a housing having an access passageway at one end, a rack rotatably mounted in the housing and defining a plurality of compartments each adapted to receive an element. In certain specific embodiments, means are provided for varying the position of the access passageway relative to the housing, to maintain the elements in compartments, and to shift the rack within the housing to enable it to be supported by an interior wall of the housing for shipment.

The present invention relates to a shielded cask for receiving, storing, transporting and delivering radioactive elements of a nuclear reactor.

It is a necessary incident to the operation of a nuclear reactor system to periodically remove radioactive elements, such as spent fuel elements, from the nuclear reactor and to transport such radioactive elements to various places in the nuclear plant or other installations. It also may be necessary to transport and replace in the reactor radioactive elements such as fresh fuel elements. It is also necessary that radioactive reactor elements be shipped to and from the plant. During the handling of such elements, it is very important that personnel are adequately shielded from the radioactive elements themselves and from equipment which may be exposed to, and thereby contaminated by, the elements. Other primary considerations are the time required for the operation, and the cost of the equipment and/or plant structure required.

In presently known systems, handling and transportation of reactive elements, such as nuclear fuel elements, by a movable shielded cask with a high element capacity frequently requires an overhead bridge or trolley system and submergence in water unless very large isolation valves are employed. Such plant construction and/or equipment is costly. In dry reactor systems, such as gas-cooled reactor systems, installation of such reactive elements in a high load capacity movable cask, which does not include a movable rack arrangement such as is incorporated in the cask of the invention, would require either a seal-tight canning of each of the elements and subsequent wet installation in the cask in a separate water-filled facility, or some type of very large isolation valve or other heavy equipment for dry installation. Again large costs are involved.

The present invention has the advantage that it provides a high capacity, shielded cask from which elements may be rapidly loaded or unloaded through an isolation valve which is small relative to the cross sectional area of the cask while personnel and other equipment are adequately protected from radiation from the elements. The operation is fast, easy and safe, and the required plant structure and equipment are relatively inexpensive.

It is a broad object of the present invention to provide a novel and improved apparatus for handling a plurality of radio active elements.

It is another object of the present invention to provide a novel and improved shielded cask for handling a plurality of radioactive elements.

It is a more specific object of the invention to provide such a cask for receiving, storing, transporting, and/or delivering radioactive elements of a nuclear reactor.

It is another object of the present invention to provide such a cask wherein radioactive elements may be loaded and unloaded through a relatively small passageway and through relatively small and less costly isolation valve equipment while personnel and other equipment are adequately protected from radiation from the elements.

Another object is to provide such a cask into which a plurality of radioactive elements may be loaded, or from which a plurality of elements may be unloaded, in a minimum of time.

A more specific object of the present invention is to provide such a cask which is operable to selectively position at least one compartment of a multi-compartment element-receiving rack within the cask in alignment with an access passageway of the cask.

It is another more specific object of the present invention to provide such a multi-compartment cask in an alternative form where compound movement is utilized to afford access to a large number of compartments.

It is another object of the invention to provide such a cask capable of receiving and delivering elements from different spaced locations while the cask itself is in a fixed position.

It is another object of the invention to provide such a cask that incorporates particularly suitable handling means for positioning the elements relative to the cask.

It is another object of the invention to provide such a cask that includes particularly suitable means for supporting the elements in the cask.

It is also an object of the present invention to provide a novel and improved cask in a form particularly adapted for shipment of a plurality of elements.

It is a more specific object to provide such a shipping cask which incorporates means for readily radially repositioning a centered rotatable element-holding arrangement to an eccentric, non-rotatable, supported position for shipment of the elements.

It is also an object of the present invention to provide such a shielded cask which is simple, durable, and relatively economical to produce and maintain.

Other objects and advantages of the present invention will become more apparent from the following description and the accompanying drawings, wherein:

FIGURE 1 is a partially broken away, fragmentary elevational view, partially in section, of a nuclear power plant illustrating in particular the reactor of the plant, a fuel transfer cask, and a fuel shipping cask, embodying various features of the present invention;

FIGURE 2 is an enlarged side view of the fuel shipping cask shown in FIGURE 1;

FIGURE 3 is an enlarged plan view of the fuel shipping cask of FIGURE 2;

FIGURE 4 is an enlarged sectional plan view taken generally along line 4—4 of FIGURE 2;

FIGURE 5 is an enlarged partially broken-away sectional plan view taken along line 5—5 of FIGURE 2;

FIGURE 6 is an enlarged fragmentary sectional elevational elevational view taken along line 6—6 of FIGURE 3;

FIGURE 7 is an enlarged fragmentary sectional plan view taken generally along line 7—7 of FIGURE 6;

FIGURE 8 is an enlarged side sectional view of the fuel transfer cask shown in FIGURE 1, said cask having a rotary support rack arrangement and presenting a preferred form of transfer cask which embodies various features of the invention;

FIGURE 9 is a fragmentary sectional plan view on a reduced scale taken generally along line **9—9** of FIGURE 8;

FIGURES 10 and 11 are enlarged plan sectional views taken generally along lines **10—10** and **11—11**, respectively, of FIGURE 8;

FIGURE 12 is an enlarged fragmentary partially broken away side sectional view of portions of the cask shown in FIGURES 8 through 11, showing in particular the supporting and retaining structure of the cask;

FIGURES 13 and 14 are enlarged side sectional views of portions of the structure shown in FIGURE 12;

FIGURE 15 is an enlarged side sectional view of the grappler of the cask shown in FIGURES 8 through 14;

FIGURES 16 through 18 are sectional plan views taken generally along lines **16—16**, **17—17**, and **18—18**, respectively, of FIGURE 15;

FIGURE 19 is a fragmentary side sectional view of a modified form of fuel transfer cask having a compound-movement rack arrangement;

FIGURES 20 and 21 are enlarged plan sectional views taken generally along lines **20—20** and **21—21**, respectively, of FIGURE 19; and

FIGURE 22 is an enlarged side view of a portion of the positionable grappler carrier for the cask shown in FIGURES 19 through 21.

Briefly, a shielded cask, in accordance with the invention, for receiving, storing, transporting, or delivering a plurality of elongated radioactive elements of a nuclear reactor includes a closed, shielded housing having at least one openable access opening or passageway. Within the housing a support rack arrangement is mounted for movement relative to the access passageway. The rack arrangement defines at least two elongated compartments or channels each adapted to receive and support one of the elements. The rack arrangement is movable to align any selected one of the compartments with an access passageway so that an element can be moved through the passageway into or out of that compartment.

The cask can be operated remotely and the access opening may be small in size compared with the size of the storage area of the cask. Such a cask affords positive positioning of elements in the cask, requires a minimum of shielding material and a minimum of additional equipment, and serves to minimize radiation exposure to personnel and equipment. Further, the use of such a cask for refueling a nuclear reactor substantially reduces refueling time.

NUCLEAR POWER PLANT

As shown in FIGURE 1, which discloses a portion of a nuclear power plant, a gas-cooled nuclear reactor **30** which includes a primary containment vessel **32** and a secondary containment vessel **34** is housed within the lower level of a reactor building **36**. The reactor building **36** includes an intermediate wall **38** which overlies the reactor **30** and is provided with an access opening **40** above the reactor vessels. A bridge **42** is movably supported over the opening **40** generally level with the wall **38**. The bridge **42** includes tracks **44** which extend transversely to the direction of movement of the bridge and which may be aligned with other tracks (not shown) of a track or rail system which extends to other portions of the reactor building **36** and to other portions of the power plant. In particular, the rail or track system leads to a fuel storage vault (not shown) and a shipping cask loading area or installation **48**, both of which are positioned like the reactor, below the level of the tracks. The shipping cask loading area **48** has an access opening **49** above it extending through the intermediate wall **38**.

The track system has a centrally open construction to afford extension of equipment and passage of material or elements through the tracks and openings **40** and **45** in the wall **38**. A self-propelled wheeled fuel transfer cask **50**, hereinafter described in detail, is movable along the tracks **44** from the reactor **30** to the fuel storage vault (not shown) and to the shipping cask loading area **48**. The lower portion of the cask **50** extends, as shown in FIGURE 1, through the open track construction to communicate with the reactor and other equipment in the lower level.

The combined movement of the bridge **42** relative to the opening **40**, and the fuel transfer cask **50** relative to the bridge, serve to position the cask over a preselected one of a plurality of control rod nozzles or special refueling nozzles **51** of the reactor. The nozzles **51** extend upwardly from the primary containment vessel **32** and are in communication with the reactor core **52** which is housed within the vessel **32**. The core **52** is a generally cylindrical package or bundle of elongated upright core elements which include control rod guide tube elements **53**, control rod elements, and fuel rod elements **54**. The core may also be surrounded by suitable reflector elements (not shown). Preparatory to refueling, either the control rod drive mechanism with its two associated control rod elements, or, in the case of a special refueling nozzle, the shielding plug, in the pre-selected nozzle is removed from the reactor. In brief, the fuel transfer cask **50** is then positioned over and connected to the selected nozzle **51**. Spent elements are transferred from the reactor through the nozzle and into the transfer cask. The cask is also used to transfer fresh elements into the reactor.

The cask **50** transports spent radioactive elements to a fuel storage vault (not shown) in which they are stored for a "cooling" period. The "cooled" elements are subsequently taken by the fuel transfer cask **50** and delivered to a fuel shipping cask **60** (FIGURES 1 to 7), disposed in the lower level loading area **48**, as shown in FIGURE 1. More specifically, the fuel transfer cask **50** is moved along the tracks **44** to a position over the opening **49** leading to the area **48** from which position the cask **50** delivers the spent elements to the fuel shipping cask **60**. The fuel transfer cask **50** is also used to transfer fresh elements from the shipping cask **60** to the reactor.

FUEL SHIPPING CASK

The fuel shipping cask **60** is shown in FIGURES 2 through 7. In general, the illustrated cask **60** includes an elongated generally cylindrical closed shielded housing or casing **62** positionable for loading and unloading with its longitudinal axis vertical. For convenience, the cask and its components will be described in terms of its vertically extending operational position. The casing **62** defines a closed cavity **65** within which a rack or support arrangement **66** (FIGS. 6 and 7) is supported for rotation about the vertical central axis of the casing. The rack arrangement **66** defines a plurality of elongated vertically extending channels or compartments **68** which are each adapted to receive one of the reactor elements. As shown particularly in FIGURE 7, the illustrated rack arrangement **66** provides four concentric rings or loops of compartments **68**, and there are four relatively small openable access openings or passageways **70** in the upper end of the casing **62** (FIG. 3) which are each radially aligned with one of the rings of compartments. The cask **60** further includes driving means **72** (FIG. 6) which is operable to rotate the rack arrangement **66** to align a pre-selected compartment **68** with an access opening **70**.

Now referring more specifically to the fuel shipping cask **60** illustrated in FIGURES 2 through 7, the generally cylindrical shielded housing or casing **62** for the cask is positioned in vertically extending position, as shown in FIGURES 2 and 6, for loading and unloading, and, in this regard, is provided with a pair of opposed trunnions **73** and a second pair of trunnions **73***b*, the latter of which provide suitable attachments for raising and lowering apparatus, such as a pair of hydraulically operated cylinders (not shown). For shipment, the cask is mounted on its side in horizontally extending position (not shown) on a heavy duty railroad flatcar **74** with the trunnions **73** received in suitable mating supports **73***a* on the railroad car. Other external equipment (not shown) is used to complete the supporting and securing of the cask for shipment. Referring to FIGURE 1, the railroad car **74** is moved along suitable tracks **75** into the loading area **48** and the cask is pivoted about the pair of trunnions **73** at its lower end to the upright position where the access passageways **70** are uppermost. The railroad car is positioned so that the access passageways **70** are aligned below the opening **49** above the loading area. The casing **62** includes generally a receptacle or base section **76** and a cover or lid section **78**.

The illustrated base section **76** includes an exterior shell **76***a* and an interior shell **76***b* (FIG. 6). The shells **76***a* and **76***b* are generally cylindrical vertically-extending containers open at their upper ends and closed at their lower ends. The interior shell **76***b* is somewhat smaller than the exterior shell **76***a* being located centrally of and spaced from the cylindrical wall of the exterior shell by three elongated, vertically extending, semicircular pipe sections **79** (FIG. 4) equally spaced circumferentially around the interior shell. The lower walls of the shells are also spaced from each other, and the space between the shells as well as the cavities of the three semicircular pipes **79**, an filled with lead FIGS. 5 and 7). The upper edges of the shell are generally level and connected together by a generally horizontal, annular, interconnecting ring structure **82** (FIG. 6) which defines an internal annular recess **84** extending around the inside of the upper edge of the base section **76**.

The illustrated cover or lid section **78** (FIGS. 2, 3 and 6) is in the form of a generally flat circular disk or plate that is secured over the open upper end of the base section **76** to complete the shielded casing **62**. The underside of the cover section **78** is formed with a downwardly extending centrally located cylindrical portion **86** which is adapted to mate with the annular recess **84** at the upper edge of the base section **76** when the cover section **78** is positioned on the base section as illustrated in FIGURE 6. The cover section **78** is secured in place by a plurality of screws **88** disposed circumferentially adjacent the edge of the cover section (FIGS. 2 and 3).

When the cover section **78** is secured on the base section **76** to provide the shielded casing **62**, the two sections define internally thereof the generally cylindrical upright cavity **64**. The rack or support arrangement **66** is rotatably supported within the cavity **64**, as hereinafter described.

As best shown in FIGURES 6 and 7, the illustrated rack arrangement **66** includes a generally circular horizontal lower support plate **102** having a somewhat smaller diameter than the casing interior. The support plate **102** is supported generally coaxially within the casing and spaced a short distance above the lower end wall of the casing. Secured upon and supported by the support plate **102** are five generally cylindrical tubes or barrels **104** which are secured with their axes generally vertical and concentric with the vertical axis of the casing. The cylindrical barrels **104** are generally of equal height with their upper edges spaced a short distance below the cover section **78**, but vary in diameter from the largest outermost barrel **104***a*, which is approximately the diameter of the plate **102**, through intermediate barrels **104***b*, **104***c* and **104***d*, to the smaller and innermost barrel **104***e*. Thus, the barrels **104** are in generally concentric telescoped relation, secured at their lower edges to the horizontal plate **102**, and define four generally cylindrically or annular spaces between adjacent barrels. The annular spaces are designated *a*, *b*, *c* and *d*, with largest annular space *a* being defined inwardly of barrel **104***a* and outwardly of barrel **104***b*, with space *b* defined inwardly of barrel **104***b*, with space *c* defined inwardly of barrel **104***c*, and with space *d* defined inwardly of barrel **104***d*. It may also be noted that the spacing between the adjacent barrels **104** is approximately equal so that the radial widths of the various annular or ring-like spaces are approximately equal to one another.

Each of the annular spaces is subdivided into the individual element-containing channels or compartments **68** of the rack arrangement. More particularly, each of the annular spaces is provided with a plurality of generally vertical radially extending dividers **106** which are secured in position between adjacent barrels **104**. The dividers **106** in adjacent annular spaces are generally offset or staggered to provide stability to the rack arrangement. As shown in FIGURE 7, the rack arrangement **66** of the illustrated cask **60** provides six elongated vertical channels or compartments **68** around the innermost space *d*, twelve such compartments around the next intermediate annular space *c*, eighteen such compartments around the next intermediate annular space *b*, and twenty-four such compartments around the outermost annular space *a* for a total of sixty compartments.

As shown in FIGURE 7, there is secured in a corner of each compartment **68** of the intermediate annular space *c* an elongated vertically disposed absorber rod **110** which serves, in case of an emergency as where the cask becomes flooded by a moderating material such as water, to absorb neutrons and thereby ensure that the fuel in the cask **60** does not become critical. Each of the illustrated rods **110** is in the form of a hollow tube capped with steel end plugs and filled with a suitable neutron absorbing material such as boron carbide granules.

As shown in FIGURE 6, a generally circular upper bearing race or ring **112** is secured to the underside of the horizontal support plate **102** in inwardly spaced relation to the edge of the plate approximately half the distance to the center thereof. Secured directly beneath the bearing race **112** is a generally circular bearing cage or ring **114**. The race **112** and the cage **114** are secured to the plate **102** as by means of screws **116**. The illustrated bearing cage **114** is provided with a plurality of circumferentially spaced-apart recesses in each of which is partially received a bearing-ball **118**. Disposed immediately below the cage or ring **114** is a generally circular lower bearing race or ring **120** which is secured to the horizontal lower end wall of the interior shell **76***b* as by means of screws **121**. The bearing-balls **118** abut the lower race **120** to vertically support the rack arrangement **66** while permitting it to rotate with a minimum of friction between the rack arrangement and the supporting parts.

The illustrated rack arrangement includes a generally tubular upper collar or bushing **122** which is mechanically secured in the upper end of the innermost and smallest barrel **104***e*. A generally tubular lower collar or bushing **124** is secured in the lower end of the barrel **104***e*. The horizontal support plate **102** is provided with a central opening or aperture through which the lower end of the bushing **124** extends downwardly. The lower end of the bushing **124** is provided with an outwardly extending flange which is secured to the underside of the plate **102** as by means of screws **126**. The illustrated bushings **122** and **124** are both generally cylindrical externally to mate with the respective ends of the cylindrical barrel **104***e*, while the central opening through each of them is enlarged at either end to provide a narrowed or restricted intermediate annular contact area or zone **122***a* and **124***a*, respectively, for each bushing.

Received in, and extending through, the upper bushing **122** is an elongated vertically extending upper cam **128** which includes a generally cylindrically lower portion, an irregularly shaped upper portion, and an upper extension. The upper portion of the cam **128** is cut away to form a recess on the left, as viewed in FIGURE 6, and is provided with an upwardly outwardly enlarging wedge or projection **128***a* on the right. The upper end of the cylindrical lower portion is recessed inwardly to meet the lower inward end of the wedge **128***a*. When the cask is in operating position, the lower portion is received in the bushing **122**, as shown in FIGURE 6, with that lower portion engaging the contact zone **122***a* of the bushing. The upper extension of the cam **128** is connected to the casing **62** in a manner permitting vertical movement but preventing rotation of the cam. More particularly, the upper extension is received in a recess in the undersurface of the cover section **78**. A pair of keys **130** are arranged between the extension and the cover section **78** to prevent relative rotation between the cam and the casing while permitting vertical movement of the cam.

An elongated generally tubular vertically extending lower cam **132** is received by the lower bushing **134**. The lower cam **132** is somewhat similar in construction to the upper cam **128**, having a generally cylindrical lower end portion adjacent an irregularly shaped upper portion formed to provide a recess at the left and a wedge or projection **132***a* at the right. The lower cam **132** is connected through a pair of keys **134** and a housing **135** to the base section **76** of the casing in a manner permitting vertical movement but preventing rotation of the lower cam.

The lower cam **132** is provided with a generally cylindrical vertically-extending threaded central aperture through which a generally cylindrical threaded lower center shaft **136** is rotatably disposed. The lower end of the shaft **136** is rotatably mounted in the housing **135** which is supported in the lower end wall of the base section **76**. The upper end of the shaft **136** is secured to the lower end of a cylindrical vertically-extending tube or hollow rod **140**. The tube **140** extends upwardly through the center of the rack within the innermost barrel **104***e*. The upper end of the tube **140** is secured to the lower end of a generally cylindrical vertically extending threaded upper center shaft **142**. The shafts **136** and **142** and the center tube **140** thus comprise a unitary center shaft construction. The upper end of the shaft **142** is rotatably threaded into a threaded central aperture or recess **144** in the lower end of the upper cam **128**.

Thus, when the cask is in its vertically extending operational position and the parts are in the respective positions shown in FIGURE 6, the rack arrangement **66** is rotatable about the central axle assembly which comprises the cams **128** and **132** as well as the rotatable center shaft construction. When the cask is in this operational centered position, the central axle assembly is rotationally fixed as will be understood from the further description. The rotational engagement between the rack arrangement and the center axle assembly is between the upper and lower contact zones **122***a* and **124***a* of the bushings and the cylindrical lower portions of the cams **128** and **132**. The rack arrangement **66**, as noted above, is supported vertically by the bearing-balls **118** for low-friction rotational movement.

As shown in FIGURES 5 and 6, the lower end wall of the interior shell **76***b* defines a generally rectangular well or recess **146** located centrally of the casing. The well **146** is adapted to receive the rectangular housing **135**, within which the lower shaft **136** is rotatably supported, and to restrict rotational movement of the housing. The illustrated housing **135** includes a generally rectangular upwardly-open body portion **135***a* and a horizontal cover or lid portion **135***b*. The lower portion of the shaft **136** extends downwardly through a suitable bearing in the cover portion **135***b* with the lower end of the shaft rotatably supported in a suitable bearing in the lower wall of the base portion **135***a*. The cover portion **135***b* includes a generally central, upwardly-open, recessed area or cavity around the shaft **136** where the lower end of the cam **132** is received and is secured against rotation by the keys **134**.

As shown in FIGURE 6, within the housing **135** and fixed on the lower portion of the shaft **136**, is a centering worm gear **150** which engages a centering worm **152** fixed to a horizontal shaft **154** rotationally supported in the housing **135**. The shaft **154** is adapted to operatively connect to suitable motor means (not shown) through a closable passageway **156** which, as shown in FIGURE 5, extends from the recess **146** to the exterior of the casing. When the cask is positioned in a suitable installation such as the loading area **48**, the shaft **154** is operatively connected to motor means of the installation. When the cask is being shipped, the passageway **156** will be sealed.

Rotation of the centering worm **152** rotates the worm gear **150** and the center shaft construction to move the cams **128** and **132** vertically. More specifically, the rotation of the threaded shafts **142** and **136**, which comprise the center shaft construction, move the threaded cams **128** and **132** either both upwardly or both downwardly due to the fact that both are threadedly engaged with the shafts but are keyed to prevent their rotation. The cams **128** and **132** are shown in FIGURE 6 in their elevated or uppermost positions where the cylindrical lower portions extend through the contact areas **122***a* and **124***a* of the bushings to center the rack arrangement **66** in its operating rotational position.

Suitable rotation of the center shaft construction moves or shifts the rack arrangement laterally of its center position, as shown in FIGURE 6, to the right to an offset or eccentric position. More specifically, the cams **128** and **132** are moved downwardly by the rotation of the center shaft construction. The downward movement of the projections **128***a* and **132***a* of the respective cams **128** and **132** shift or move the rack arrangement to the right and maintain it in that position. Then, when the entire cask is tilted or pivoted toward the right and onto its side for shipment, the rack arrangement will rest against and be supported by the casing rather than being suspended on the central axle assembly. This is desirable since it provides more uniform support of the rack arrangement.

A lock screw **157** is provided in the center of the cover section **78** for abutting the upper end of the cam **128** and locking the central axle assembly and the rack arrangement against linear movement. The lock screw **157** is operated through an aligned closable port **158** in the cover section **78**.

When the cask is again pivoted to the upright position for loading or unloading, the rack arrangement is laterally shifted by rotation of the center shaft construction back to its centered position (FIGURE 6) to permit rotational positioning of the rack arrangement.

The rack driving means, designated generally **72**, is illustrated best in FIGURE 6 within a driving means housing **160** disposed adjacent one side of the lower end of the casing. More particularly, the housing **160** is disposed in an upwardly open cavity or well **161** (FIGURE 5) in the horizontal lower wall portion of the interior shell **76***b*. The housing **160**, as viewed in plan, is generally rectangular, with one end being semi-circular and conforms to the shape of the well **161** which is of similar configuration, the semicircular end of the housing being directed radially outwardly to a point immediately adjacent the cylindrical wall of the casing. Extending from the radially inward end of the well **161** to the exterior of the casing is a generally tubular closable passageway **162**. The passageway **162** extends generally parallel to the passageway **156**, and its outer end is spaced relatively closely to the outer end of the passageway **156** at one side of the cask.

The illustrated housing **160** includes an upwardly open base portion **160***a* and an overlying horizontal cover or lid portion **160***b*. A vertical shaft **163** is rotatably supported in suitable bearings in the bottom wall of the housing base portion **160***a* and in the cover portion **160***b*. A drive worm gear **164** is fixedly secured to the shaft **163** and is meshed with a drive worm **166**. The worm **166** is fixedly secured to a horizontal shaft **168** rotatably supported by the housing **160**. The horizontal shaft **168** is aligned with the passageway **162**, through which it is operatively connected to motor means (not shown) of the installation, when the cask **60** is supported in operative upright position in a suitable installation such as the loading area **48**.

The upper end of the vertical shaft **163** extends outwardly of the housing **160** and has fixed to it a spur gear **170**. When the rack arrangement **66** is in its centered operative position, the gear **170** meshes with a generally circular internal ring gear **172** secured as by means of screws **174** to the underside of the horizontal plate **102** of the rotary rack arrangement at the periphery of that plate. The selective operation of the associated motor means serves to rotate the rack arrangement. The matching configuration of the housing **160** and its well **161** prevents rotation of the housing.

An access, service or emergency port **176** is provided at the lower end of the side wall of the casing opposite the ring gear **172** and radially outwardly of the rack driving means **72** to permit manual rotation of the rack arrangement. As illustrated in FIGURE 6, a shielding or sealing plug **178** is normally removably disposed in the port **176** to close the port. An outer or exterior port cover **180** is removably secured over the outside of the port **176**.

FIGURE 6 also illustrates indicating means **182** for the cask (located in the left side of the bottom of the cask as viewed in the drawing) which includes a micro-switch **184** and a box receptacle **185** that is secured as by means of screws **186** in a port **188** through the horizontal bottom wall of the casing. The switch **184** is positioned to be actuated by cam **190** secured to the underside of the horizontal support plate **102** of the rack arrangement **66** intermediate the outer edge of the plate and the ring of supporting bearing-balls **118**. The rotation of the rack arangement serves to operate the switch **184** to indicate the rotational position of the rack arrangement.

As noted above, the fuel rod elements **54** and control rod guide tube elements **53** are inserted and removed from the cask **60** through the access openings or passageways **70** in the cover section **78** of the cask. Each of the illustrated access passageways **70** is generally cylindrical and vertically extending, having a larger diameter portion at its upper end to provide a support shoulder **192**. As shown in FIGURES 3 and 6, the access passageways **70** are arranged along the centerline of the cover section **78** with one passageway radially aligned over each annular or ring-like space *a–d* of the rack arrangement **66**. Because of space and shielding requirements, two of the access passageways **70** are located on one side of the cask, while the other two passageways are on the other side of the cask: one access passageway is over the outermost annular space *a*, while the other passageway on that side of center is over the alternately inward space *c*; on the other side of center, one passageway is over the innermost space *d*, and another passageway is over the alternate space *b*. As shown best in FIGURE 3, the size of each passageway is small relative to the storage area of the cask in plan so that the isolation valve required for moving an element into or out of the cask is quite small in comparison to the cross section of storage space in the cask.

The illustrated access passageways **70** are normally closed and sealed, each receiving a generally cylindrical shielding plug or insert **194**. The lower end of each of the plugs **194** is provided with a reduced diameter whereby each plug is supported within a passageway **70** by the annular shoulder **192** of that passageway. The uppermost end of each of the passageways **70** is threaded to receive a mated locking or securing nut **196** which serves to maintain the shielding plug **194** in the passageway.

The rack arrangement **66** may be rotated by means of the gears **170** and **172** to position any preselected channel or compartment **68** below the access opening **70** associated with the annular space of that compartment to permit a fuel rod element **54** (or a control rod guide tube element **53**) to be placed into or removed from that compartment. The rack may be repeatedly rotated to provide access to successive compartments until the cask is fully or partially filled or emptied. For shipment, the rack arrangement is shifted, as noted above, so that its weight is directly supported by the casing when the cask is tilted onto its side into shipping position.

The illustrated cask **60** may be handled or shipped as a shielded, sealed self-contained integral unit. The illustrated cask provides adequate shielding for personnel and handling equipment during loading, unloading, shipment and storage for indefinite periods of time.

FUEL TRANSFER CASK WITH SINGLE MOVEMENT ROTARY RACK ARRANGEMENT

The shielded fuel transfer cask **50**, which has a single motion rotary rack arrangement, is shown generally in FIGURE 1 and in further detail in FIGURES 8 through 18. The cask **50** illustrates a preferred form of fuel transfer cask and is illustrative of a reactor-element receiving, transporting, and delivering cask of the present invention.

Broadly, the operation of the fuel transfer cask **50** is to receive or deliver—one at a time—a supply of fuel rod elements **54** and/or control rod guide tube elements **53**, and to transport a number of such elements between the reactor, storage facilities, and shipping facilities.

Briefly, the illustrated fuel transfer cask **50** includes a generally cylindrical, upright, closed, shielded casing or housing **200** which is mounted on a wheeled carriage **202** (FIGURE 1) movable along the rail or track system **44** of the nuclear power plant. The casing **200** defines an internal cavity **204** (FIGURE 8) within which a generally cylindrical rack arrangement **206** is supported for rotation about the vertical central axis of the cask. The rack arrangement **206** defines a plurality of elongated vertically extending compartments or channels **208** (FIGURE 10), each of which is adapted to receive one of the reactor elements **53** or **54**. The illustrated casing **200** also includes a relatively small openable access passageway **210** in its lower end (FIGURE 8) with which each of the compartments **208** of the rack arrangement is adapted to vertically align incident to the rotation of the rack arrangement. Suitable rack driving means **212** are provided on the cask for selectively rotating the rack arrangement to align determined compartments with the access passageway. A grappler **214** for releasably connecting to an element and moving it into or out of a compartment is disposed in the upper end of the casing **200** above the rotary rack arrangement.

For refueling of the reactor **30**, the fuel transfer cask **50** is fixedly positioned over the reactor **30**, as shown in FIGURE 1, and in conjunction with the operation of an isolation valve (not shown), the access passageway **210** of the cask is put into communication with the interior of the reactor through a selected empty control rod or refueling nozzle **51** which serves as an access port or passageway to the reactor interior. The selected control rod or refueling nozzle **51** is prepared for this use by the prior removal of the control rod drive mechanism or shielding plug which the nozzle ordinarily contains. The positioning of the fuel transfer cask **50** over the selected nozzle is achieved by the combination movement, as described above, of the cask itself and of the bridge **42**. Once the cask is connected to the reactor, the cask is in a fixed position laterally or in horizontal directions, and it is not moved until the loading or unloading of the cask is completed.

The unloading and loading of radioactive elements from and to the portion of the reactor core serviced by each nozzle involves two distinct phases or steps. For unloading, first, the seven center elements, i.e., the elements directly below the selected nozzle, are lifted from the reactor into the fuel transfer cask **50** by the direct action of the grappler **214** of the cask. Second, the cask **50** is removed, a fuel transfer machine (not shown) is inserted into the selected nozzle, and the cask **50** is replaced over the nozzle. Additional or outer elements which are laterally displaced from positions directly below that nozzle are individually removed from the reactor core by the fuel transfer machine. The fuel transfer machine delivers each element to the grappler **214** of the fuel transfer cask which lifts the element into the cask. For loading, the steps or phases are reversed.

While the fuel transfer machine delivers all outer elements to the grappler in a single "delivery" position, the center elements are each in a different lateral position. Inasmuch as the cask is laterally fixed in position once it is connected to a reactor nozzle, but the center elements are located in various positions, the access passageway **210** and the grappler **214** of the illustrated cask are laterally movable or positionable so that they can be aligned with each of the center elements. The alternative of repositioning of the cask **50** for each center element is undesirable since it would involve appreciable time. Similarly, the provision of a large passageway with only the grappler being laterally movable is undesirable as requiring at least a larger and more expensive door arrangement on the cask to deal with the increased escape outlet for radioactivity.

After the cask **50** has been loaded with radioactive elements from the core, the elements are transported to a storage vault into which they are transfererd from the cask and retained for a "cooling" period of some months.

The fuel transfer cask **50** is used subsequently to take "cooled" elements from the storage facility, transport them to a fuel shipping cask, and load them into the shipping cask for shipment to a suitable fuel reprocessing plant.

While fresh fuel elements made from new fuel may not require such shielding as in the case of spent fuel elements, the cask **50** is used to transport fresh but radioactive fuel elements made from reprocessed fuel from a storage facility or directly from a shipping cask to the reactor, and to load the reactor with the elements.

When elements are being transferred between a shipping cask, such as the illustrated cask **60**, and the transfer cask **50**, the shipping cask **60** is supported in the lower-level loading area **48** and the transfer cask **50** is positioned directly above it. The respective rack arrangements of the two casks are independently rotated to successively index or align the compartment containing the element to be transferred with the empty compartment of the other cask into which the element is to be loaded. This transfer operation between casks **50** and **60** is facilitated with adequate protection against radiation exposure to personnel and other equipment by a relatively small isolation valve that affords passage of the elements through the passageway **49** of the shipping cask loading area or installation **48**.

Casing

Now considering the fuel transfer cask **50** in further detail, as shown best in FIGURE 8, the generally cylindrical upright closed shielded casing or housing **200** defines therein the generally cylindrical internal cavity **204**. The walls of the illustrated casing or housing **200** may be of a suitable shielding construction, as by including an inner and outer shell or layer of a material such as steel with an intermediate layer of a shielding material such as lead.

The illustrated cask is provided with a door arrangement **216** at its lower end operable to provide the openable and positionable access passageway or opening **210** of the cask. The illustrated door arrangement **216** comprises two sections: a smaller inner section **216*a*** and a larger outer section **216*b***. The sections **216*a*** and **216*b*** are each provided with an aperture **210*a*** and **210*b***, respectively. The apertures **210*a*** and **210*b*** are moved relative to one another by the relative movement of the two door sections **216*a*** and **216*b*** to either align with one another to provide the access passageway **210** or to be out of alignment with one another to provide a sealed closure to the interior of the cask.

More particularly, as shown in FIGURES 8 and 9, the short, generally cylindrical, outer door section **216*b*** is supported generally centrally in the open lower end of the casing with its axis vertical. The section **216*b*** includes the aperture **210*b*** which extends vertically through the section, but which is also of oval configuration in plan cross section (FIGURE 9) and is positioned with one of its ends located cenatrally of the section and with the remainder thereof extending radially of the section. The hole **210*a*** of the section **216*a*** is of similar configuration but is offset relative to the axis of the section with its longitudinal or principal axis lying on a non-diametrical chord of the section when viewed in plan (FIGURE 9). A generally circular horizontal internal ring gear **220** is rotatably supported from the underside of the outer section **216*b***. The gear **220** is generally coaxial with the outer section **216*b*** and is rotatable about the axis of the section. The outer section **216*b*** is provided with a generally cylindrical vertical cavity or recess in its undersurface in which the mating generally cylindrical inner section **216*a*** is received. The recess is positioned eccentrically of the outer section **216*b***, and while it is generally below the aperture **210*b*** and in communication therewith, it is positioned with its center or axis **221** (FIGURE 9) angularly offset from the aperture **210*b***.

The inner section **216*a*** is supported in the recess by suitable bearings for rotation about its own axis and includes the aperture **210*a*** which is elongated and extends transversely across the cylindrical section **216*a*** offset to one side of its axis. A small external ring gear **222** is secured to the underside of the inner section **216*a*** and engages the larger internal ring gear **220**. Rotation of the larger ring gear **220**, by suitable selectively-operable door-opening driving means **224** on the casing (FIGURE 9), rotates the smaller ring gear **222** and the inner section **216*a*** relative to the outer section **216*b*** to position the apertures **210*a*** and **210*b*** into and out of vertical alignment.

More particularly, the apertures **210*a*** and **210*b*** are shown in full alignment in FIGURES 8 and 9 to provide the fully open access passageway **210**. The passageway **210** is thus formed by the aperture **210*a*** aligning with the aperture **210*b***, with the upper aperture **210*b*** defining the position of the passageway. As shown best in FIGURE 9, the fully open passageway **210** extends radially outward from the center of the cask, and as will be seen, when fully open, it can afford access to a center channel or compartment **208** as well as to one outer compartment. When the inner section **216*a*** is rotated about its axis, which coincides with the center **221** of the mating recess, the aperture **210*a*** can be brought to the position shown in broken line in FIGURE 9 to completely close the cask, or can be rotated to an intermediate position (not shown) where only portions of the apertures **210*a*** and **210*b*** are aligned to provide a smaller access passageway to either the center compartment of the cask or an outer compartment. It should be noted that even the fully open passageway **210** is relatively small compared to the cross section of the storage area of the cask and that the partially aligned apertures provide an even smaller passageway.

The outer section **216*b*** is supported for rotation about the vertical center axis of the casing by an annular bearing **226** between the lower edge of the cylindrical wall of the section **216*b*** and the casing. The upper portion of the section **216*b*** has a reduced diameter to provide an annular horizontal ledge **228** on which a circular ring bevel gear **230** is mounted. The ring gear **230** is engaged by a bevel gear **232** which is secured on the end of a horizontal shaft structure **233** that extends outwardly through and is rotatably supported in the adjacent casing wall. The shaft structure **233** is in driving connection with a selectively-operable door-positioning driving means **234** mounted on the outside of the casing. Operation of this driving means **234** serves to rotate both door sections as a unit to selectively position the passageway **210** laterally of the casing to facilitate handling of the center elements which, as explained above, must each be handled directly by the cask **50** in laterally different positions.

A generally cylindrical annular shield skirt **235** is disposed externally around the lower end of the casing **200.** A generally horizontal annular flange **236** is fixed to the casing wall above the skirt **235.** The flange **236** supports a selectively operable jack mechanism including a worm gear rack **238**, a flexible drive shaft **238***a* and a gear motor **239** (FIG. 9) which is operatively connected to the skirt **235** and which functions to raise and lower the skirt incident to connecting the cask to other equipment such as an isolation valve for transfer of elements to or from the cask.

Rack arrangement

The rack arrangement or means **206** for the illustrated fuel transfer cask **50** is disposed in the cavity **204** above the door arrangement **216.** The illustrated rack arrangement **206** is a generally cylindrical, vertically extending, open structure supported for rotation about the central axis of the casing. The rack arrangement **206** includes a horizontal, generally circular, upper rack plate **240** which extends across the cavity **204** intermediate its height and is supported for rotation by a suitable annular bearing **242** between the outer edge of the plate **240** and the adjacent inner wall of the casing. Suspended from the plate **240** are a plurality of downwardly extending vertical support and guide rods **244.** Supported at spaced intervals along the rods **244** are a plurality of horizontal, generally circular channel-defining plates **246.** Suspended from the lowermost plate **246** are a plurality of spaced vertical bars **247** which support at their lower ends a generally circular, horizontal lower rack plate **248** (FIGURE 11) that extends across the cavity **204** just above the door arrangement **216.** An annular lower flange structure **249** between the lower rack plate **248** and the adjacent casing wall laterally positions and maintains the lower end of the rack arrangement, particularly incident to its rotation. A generally tubular vertical shell structure **250** is supported in the cavity **204** around the rack arrangement and spaced from the casing inner wall.

The channel-forming plates **246** and the lower rack plate **248** are each formed to provide seven generally circular apertures **251** which are vertically aligned to define the seven elongated vertical compartments, channels or racks **208** of the illustrated rack arrangement **206.** As shown best in FIGURE 10, the vertical rods **244** are disposed around the periphery of the channel-forming apertures **251** to partially define the channels and maintain the reactor elements moving through the channels in proper vertical alignment. The illustrated rack arrangement **206** is provided with a center compartment and six outer compartments annularly arranged around the center compartment. These seven compartments are relatively disposed in positions corresponding to the positions of the seven center fuel elements in the core.

A circular ring gear **252** is secured to the upper surface of the upper rack plate **240** and is engaged by a gear **254** secured on the end of a radially extending horizontal shaft structure **256.** The shaft structure **256** extends outwardly through and is rotatably supported in the casing wall and is in driving engagement with the selectively-operable rack driving means **212** mounted on the outside of the casing. The operation of the rack driving means **212** serves to rotate the rack arrangement **206** to any desired position.

The illustrated fuel transfer cask **50** includes a retaining mechanism **260** that is operable to selectively support and maintain reactor elements within channels **208** into which they have been positioned.

As shown best in FIGURES 11, 12 and 14, an elongated normally horizontally disposed support bar or platform **262** is provided at the lower end of each channel **208.** Each bar **262** is pivotally supported at one end by the lower rack plate **248** adjacent to one of the channel-forming apertures **251** in the plate for rotation about a horizontally disposed pin **264** (FIG. 14) so as to permit its movement between a vertical, raised, open position (shown in broken line) and a horizontal, lowered, or closed, supporting position (shown in full line). When a bar **262** is raised, it is positioned sufficiently out of the associated channel or compartment **208** so that it will not obstruct movement of an element or handling means through the channel. When a bar is lowered, it extends horizontally transversely across the associated channel with its free outer end resting on a block **265** mounted on the plate **248** across the aperture **251** from where the bar **262** is supported, to thereby support the element **54** in the channel (FIG. 12). The pivoted end of each bar **262** is formed with teeth and engages a toothed block **266** that is secured to the lower end of a vertically extending rod **268.** Each rod **268** is supported by the plates **246** for vertical movement and is connected at its upper end, through a compression spring **270**, to an actuator pin **272** that is supported by the upper rack plate **240** for vertical movement.

More particularly, each actuator pin **272** is supported in a generally tubular, vertical, pin housing **275** for vertical movement. The housings **275** are supported by and extend downwardly from the upper rack plate **240.** A biasing spring **276** in each housing **275** urges the associated pin **272** upwardly to a raised position where its upper end extends above the plate **240** as shown in FIGURE 14. Suspended from the lower end of each pin **272** is a generally tubular vertical, connector housing **278.** Each housing **278** is open at its lower end to receive the spring **270** and a guide member **279** that is secured to the upper end of the associated vertical rod **268.** When a pin **272** and its rod **268** are so raised, the associated support bar **262** is in its horizontal closed position as shown in FIGURE 14.

The pins **272** are actuated to open the channels by a horizontal actuating plate **280** supported across the cavity **204** above the rack arrangement for vertical movement. More specifically a plurality of spaced studs **281** that are secured to the actuating plate **280** each extend downwardly through a suitable aperture in the upper rack plate **240** into a tubular, vertical, cushion housing **282** secured to the plate **240** and extending downwardly therefrom. The lower end of each housing **282** is closed and a compression spring **283** is disposed in each housing to resiliently support the actuating plate **280** and permit its downward movement.

Driving means **283** and jack mechanisms **285** are supported by suitable brackets on the casing inner wall above the actuator plate **280.** The driving means **284** operates the jack mechanisms **285** to lower the plate **280** against the springs **283.** In particular, the lower ends of vertically movable shafts or pins **286** of the jack mechanisms **285** are received in an upwardly open annular slot or trough **287** formed in the upper surface of the plate **280.** This construction permits the plate **280** which is mounted on the rack arrangement to rotate with the latter while a driving engagement is maintained between the plate **280** and the fixed jack mechanisms **285.**

When the actuating plate **280** is lowered to depress the pins **272**, the support bars **262** are pivoted upwardly to their vertical open positions. With regard to a compartment already containing an element, the assocated bar **262** is held down by the element and the associated rod **268** remains stationary, the downward movement of the associated actuator pin **272** being absorbed by its compression spring **270.** When an element is in place and it is desired to close the compartment, the actuating plate **280** is elevated to release the pins **272** and the bar associated with that channel or compartment is allowed to tilt back to its lowered closed position. Of course, the reactor element initially is raised far enough in the compartment to permit the downward swing of the bar; then the element may be lowered onto the bar and deposited there. The bar, as noted above, will support the element in the compartment.

As shown best in FIGURE 8 a grappler or handling mechanism or means **290** is disposed in the upper end of the cavity **204**. It is thus positioned above the rack arrangement **206** and operates in general to selectively position the grappler **214** in any desired position laterally of the rack arrangement as well as to raise, lower and operate the grappler.

A generally circular, horizontal transverse plate **291** is secured across the cavity **204** above the rack arrangement **206**. The transverse plate **291** is provided with a large central irregularly-shaped aperture **292**.

A grappler carrier **293** which includes an elongated horizontal carrier plate **294** is mounted for pivotal movement on the transverse plate **291**. More particularly, a short vertical post or shaft **295** is secured at one side of the plate **291** adjacent the central aperture **292**. The post **295** extends upwardly from the plate and pivotally supports one inner end of the elongated carrier plate **294**, with the remainder of carrier plate **294** extending across to the other side of the aperture **292**. The carrier plate **294** is supported in spaced relation above the transverse plate **291**. An elongated horizontally extending shaft structure **296** is rotatably supported below the carrier plate **294**, extending generally longitudinally and centrally of the elongated carrier plate. The shaft structure **296** is supported for rotation by three vertical support plates **297, 298, 299** which are secured to, and extend downwardly from, the underside of the carrier plate **294**. The support plates each extend transversely of the elongated carrier plate **294** and are positioned at spaced-apart intervals along the carrier plate. One of the support plates **297** is secured at the outer end of the carrier plate with an intermediate plate **298** and an inner plate **299** being progressively spaced inwardly from the outer support plate **297**. The intermediate support plate **298** has a greater height than the other two support plates and is provided with roller means along its lower edge. The roller means rest upon an upper surface of the transverse plate **291** to thereby support the outer end of the elongated carrier plate **294** while permitting its rotation.

A gear **300** is secured on the shaft structure **296** between the outer support plate **297** and the intermediate support plate **298** and is thereby positioned to engage a segment of a circular ring gear **302** which is secured to the upper surface of the transverse plate **291**.

A large intermediate bevel gear **304** is rotatably disposed on the pivot post **295**. A two-part connector mechanism **306** provides a driving rotational connection between the intermediate gear **304** and the inner end of the shaft structure **296**. One part **306*a*** of the connector mechanism **306** is secured to the underside of the carrier plate **294**. The other part **306*b*** of the connector mechanism **306**, which includes a small bevel gear **306*c*** that engages the intermediate gear **304**, is fixed to the upper surface of the transverse plate **291**. The two parts **306*a*** and **306*b*** are movable relative to one another about a vertical joining axis so that the driving connection between the gear **304** and the shaft structure **296** will be maintained regardless of the rotational position of the carrier plate **294** about the pivot post **295**. The large intermediate gear **304** is also engaged by a bevel gear **308** which is fixedly secured on the inner end of a horizontal shaft structure **310** rotatably supported in the adjacent wall of the casing. The shaft structure **310** is drivingly engaged to a suitable driving means **312** which is mounted on the outside of the casing and which is selectively operable to rotate the gear **300** and thereby cause the carrier plate **294** and the grappler **214** which it supports, as will be described below, to assume any desired azimuth position.

The illustrated fuel transfer cask **50** is also provided with means for positioning the grappler **214** radially with respect to the pivot post **295**. A generally rectangular, horizontal, movable platform **320** is supported on the elongated carrier plate **294** for movement longitudinally of that plate. The platform **320** is supported between a spaced-apart parallel pair of track members **322** which are supported on and extend longitudinally of the plate **294**. Each of the track members **322** is provided with an elongated horizontal groove **323** in its opposed or inwardly directed vertical surface. Guide rollers (not shown) mounted on the opposite longitudinal edges of the platform **320** are received in the respective grooves **323** to support the platform for movement.

The elongated carrier plate **294** is provided with an elongated, central, longitudinally extending aperture **325**, and a generally cylindrical, hollow, vertical, grappler guide cylinder **326**, which extends through and is supported intermediate its height by the movable platform **320**, extends downwardly through the carrier plate aperture **325**. The downwardly extending portion of the guide cylinder **326** also passes downwardly through the aperture **292** of the transverse plate **291**. The lower end of the guide cylinder **326** is disposed a short distance above the actuating plate **280** of the retaining mechanism. The upwardly extending portion of the guide cylinder **326** has mounted on its upper end a pulley support block **328**. The block **328** is a generally flat structure disposed in a vertical plane that extends in general alignment with the elongated carrier plate **296**. As will be described more fully, pulleys supported by the block **328** maintain and guide cables, and the cables support and operate the grappler **214** for vertical movement through and below the guide cylinder **326**.

The means for moving the platform **320** and the supported grappler **214** radially toward and away from the pivot post **295** includes an elongated, horizontal, threaded shaft **334** which is rotatably supported above the carrier plate **294** between a vertical post structure **335** extending upwardly from the outer end of that plate and a vertical support plate **336** extending upwardly from the inner portion of that plate. An internally threaded follower member **337** is disposed on the threaded shaft **334** for movement longitudinally of the shaft as the shaft is rotated. The follower member **337** is secured to the movable platform **320** so that the movement of the follower produces like movement of the platform. The inner end of the shaft **334** is connected by a two-part pivotal connector mechanism **338** to a horizontal shaft structure **340** extending through and rotatably supported in the casing wall. The shaft structure **340** is in driving engagement with radial positioning drive means **342** mounted on the outside of the casing. The connector mechanism **338** is generally similar in construction to the two-part connector mechanism **306**, having one part **338*a*** supported by the vertical plate **336** and operatively connected to the shaft **334**. The second part **338*b***, which is pivotally connected to the first part **338*a*** about a vertical axis, is mounted by a bracket **344** to the wall of the casing and operatively connected to the shaft structure **340**. Selective operation of the drive means **342** serves to move the follower **337** longitudinally of the carrier plate **294** to thereby move the platform **320** and the grappler **214** toward or away from the pivot post **295**. This radial movement, coupled with the azimuth movement afforded by the rotation of the carrier plate about the pivot post **295**, permits selective positioning of the grappler **214** over an infinite number of positions relative to the underlying rack arrangement, and in particular permits the grappler **214** to be vertically aligned above any selected reaction element.

In general, the grappler **214** is supported, vertically moved, and actuated by the selective operation of a pair of flexible cables: a lower lift or hoist cable **348** and an upper actuator cable **350**.

The lower lift cable **348** is secured at one end to a block **352** supported at the upper end of the vertical post **335**. The cable **348** then passes over a vertically extending lower outer pulley **354** supported for free rotation about a horizontal axis in the pulley block **328**. The lift cable **348** then extends vertically downwardly into the guide cylinder **326**, passes through the grappler itself **214**, and returns vertically upwardly where it passes over and around a vertically extending lower inner pulley **356**, also supported for free rotation in the pulley block **328**. The lift cable **348** then extends generally horizontally to a pulley **357** mounted for free rotation about a vertical axis in a pulley block **358** secured to the casing wall by a bracket **359**. The blocks **352**, **328** and **358** generally lie in a common vertical plane and consequently the cable **348** to this point has been confined to that common vertical plane. However, from the horizontal pulley **357** the lift cable **348** extends generally horizontally out of the plane, passing under and around a vertically extending lower offset pulley **360** mounted for free rotation by suitable means on the casing. The cable **348** extends vertically upwardly from the pulley **360**, passing through a narrow aperture through the upper end wall of the casing. Finally, the cable **348** is wound about a suitable lifting drum or reel **362** rotatably supported in a housing **364** mounted atop the casing. The drum **362** is in driving engagement through a clutch-brake connector with and selectively rotatably by suitable motor means **366** also mounted atop the casing.

The upper or actuator cable **350** is similarly supported and guided. One end of the actuator cable **350** is fixed to the block **352**, from whence the cable extends around a vertical upper outer pulley **370** supported in the block **328** into the guide cylinder **326**, where it passes through the grappler **214**, and upwardly to an upper inner pulley **372**, also mounted on the block **328**. The actuator cable **350** then extends horizontally to a pulley **374** mounted in the block **358**, around an offset vertical pulley **375**, and upwardly through a suitable aperture or passageway in the upper end wall of the casing into the housing **364**. Finally, the actuator cable **350** is secured to and wound around a suitable actuator drum or reel **376** rotatably supported in the housing **364**. The actuator reel **376** is in direct driving engagement with the motor means **368**.

To raise or lower the grappler **214**, the cables **350** and **348** are both moved at the same rate by the motor means **368**, which is operated to rotate both reels **362** and **376**. To actuate or operate the grappler **214**, the connector **366** is operated to release the clutch and to apply the brake to the lift cable drum or reel **362** while the actuator cable reel **376** continues to rotate. The actuator cable **350** is thereby moved to cause relative movement of the parts of the grappler to cause engagement or disengagement by the fingers of the grappler with the element being handled.

It may be noted that the cables **348** and **350** in essence pivot around the vertical axis of the pulleys **357** and **374**, which is in general alignment with the vertical pivot post **295**. The portions of the cables between the pulleys **357** and **374** at one end and the block **352** at the other are disposed in a common vertical plane and these portions of the cable remain generally in this plane incident to the pivoting movement of the carrier plate **294** about the pivot post **295**. In this connection, the block **352** is fixedly secured to the carrier plate **294** through the vertical post **335** and the block **328** is also mounted on the carrier plate **294** through the movable platform **320** and the guiding cylinder **326**. While the platform **320** is movable toward and away from the axis of the pivot post **295** (which generally coincides with the axis of the horizontal pulleys **357** and **374**), the platform **320** is not capable of rotational or azimuth movement around that axis other than as a unit with the carrier plate **294** and associated parts. Thus, the platform **320** and the guide cylinder **326** and the block **328**, define a common vertical plane with the vertical post **335** and the block **352**. The platform **320** and the parts it supports are movable only in that plane. The noted portions of the cables **348** and **350** are likewise maintained in this pivoting common vertical plane, with the flexible cable arrangement also affording ready movement of the platform **320** and the grappler **214** toward and away from the axis of pivot. Movement of the platform, guide cylinder, and block **328** toward the pivot merely causes rotation of the various pulleys and a repositioning of these parts, including the grappler **214**, at more inwardly located portions of the respective cables. It may particularly be noted that the height of the grappler **214** remains unaffected by its radial movement.

The illustrated grappler **214**, shown generally in FIGURE 8, is shown in further detail in FIGURES 15 through 18. As seen in FIGURE 15, the grappler includes a generally cylindrical vertically extending hollow grappler housing **378** which is open at its lower end and has a transverse wall at its upper end. The housing **378** forms a generally cylindrical vertical central cavity **379**. A pulley **380** for the lift cable **348** of the grappler mechanism is mounted at an intermediate point within the cavity **379** in such a manner that an open actuator assembly **381** is disposed in the cavity around the pulley and vertically movable relative to the pulley.

The lift cable pulley **380** is positioned in the cavity **379** centered between opposite sides of the cavity, and is supported on a short shaft **382** for free rotation about a horizontal axis. The shaft **382** is supported by a hoist or lift pulley support block **383** which is fixedly mounted by means of a transverse support member **384** within the cavity. The lift pulley **380** and the associated supporting parts thus extend transversely of the cavity **379** in general alignment with the plane of that pulley, being secured in position at opposed sides of the housing, with a space being left at either face side of the pulley **380**. The lower lift cable **348** extends down into the grappler, is looped under the pulley **380**, and passes back upwardly. The cable passes through appropriate openings or apertures in the upper end wall of the grappler housing. The lift cable **348** is wound on to or unwound from its reel **362** by the drive means **368** to selectively raise or lower the grappler housing which carries with it the other parts of the grappler.

As noted above, the actuator assembly **381** is vertically movable within the cavity **379**. The illustrated actuator assembly **381** includes a pair of elongated vertically disposed, opposed bands or strips **386** which extend down the sides of the generally cylindrical cavity **379** at opposite face sides of the lift cable pulley **380** and associated mounting parts. Each of the band **386** is curved or formed about a longitudinal vertical axis to generally conform to the contour of the housing cavity. The bands **386** are secured at their upper ends to a transversely extending support member **387** on which a pulley block **388** is mounted. An actuator cable pulley **389**, which is smaller than the pulley **380**, is mounted in the block **388** on a short shaft **390** for free rotation about a horizontal axis. As shown in FIGURE 15, the pulleys **380** and **389** are disposed in a generally common vertically extending plane which generally bisects the grappler. The upper actuator cable **350** extends down into the grappler, is looped under the actuator cable pulley **389**, and passes back upwardly. The cable **350** passes through a pair of suitable apertures or openings in the upper end wall of the grappler housing.

The lower ends of the vertical bands **386** are secured to the upper end of a generally cylindrically vertically extending weighted actuator element **392** which is disposed below the lift cable pulley **380** and associated support parts. An irregularly-shaped generally annular actuator block **393** is secured around the lower end of the element **392**. The illustrated actuator block **393** includes a set of three horizontally extending upper actuator pins **394** and a set of three horizontally extending lower actuator pins **395** (FIGURE 18).

The grappler **214** is provided with means to engage either a fuel rod element **54** or a control rod guide tube element **53**. More particularly, mounted in the lower end of the grappler housing **378** are two sets of elongated vertically extending circumferentially-equally-spaced arms, hooks or members, one set of three, long, first, fuel-rod-element-engaging arms **396** and one set of three, alernately-spaced, shorter, second, guide-tube-element-engaging arms **397**. The arms **396** and **397** extend downwardly from the open lower end of the grappler housing **378**, as shown generally in FIGURE 15. The arms **396** and **397** are pivotally supported at their upper ends on pins **398** and **399**, respectively, in a manner permitting the lower ends of the arms to pivot radially toward and away from the vertical center line of the grappler. Each of the three arms **396** is provided with a formed elongated vertical slot **400** in which one of the actuator pins **395** of the actuator assembly is received. Similarly, each of the arms **399** is provided with an elongated formed vertical slot **401** in which one of the actuator pins **394** is received. In general, the vertical movement of the actuator assembly **381** relative to the grappler housing **379** causes the arms **396** and **397** to open and close.

More particularly, each of the three fuel-rod-element-engaging arms **396** is provided with a radially-inwardly-directed circumferentially-enlarged projection or finger **402** (FIGURE 16) and the vertical slot **400** of each of these arms **396** is provided with a radially inwardly offset portion **403** at the lower end of the slot. Thus, when the actuator assembly **381** is lowered relative to the grappler housing **378**, the fuel-rod-element-engaging arms **396** are spread open or outwardly by the action of the actuator pins **395** moving into the offset lower end portion **403** of their respective slots. When the actuator assembly **381** is raised relative to the grappler housing, the arms **396** are pivoted or drawn radially inwardly. This causes the enlarged fingers **402** to set under an annular lip or ledge **54*a*** provided by the head at the upper end of a fuel rod element **54**. As shown best in FIGURE 16, the fingers **402** are circumferentially equally spaced and provide firm three-point engagement of the fuel rod element to prevent its slippage or misalignment. While the weight of the fuel rod element **54** would tend to maintain the aforesaid connection, positive vertical location of the grappler relative to the fuel rod element is provided by an engaging and positioning plug **404** secured to the grappler and extending downwardly from the center thereof through the open lower end of the housing. The plug **404** is provided with a flared central recess **405** which engages the generally conical upper end of the fuel rod element **54** and ensures maintenance of the positive connection between the grappler and the fuel rod element.

Each of the control-rod-guide-tube-element-engaging arms **397** is provided with an outwardly extending circumferentially enlarged finger or projection **406** (FIGURE 16 at its lower end and the vertical slot **401** of each arm is provided with a radially outwardly offset portion **407** at the lower end of the slot. When the actuator assembly **381** is lowered relative to the grappler housing, the arms **397** are pivoted or drawn inwardly by the action of the actuator pins **394** entering the lower portions **407** of their respective slots. When the actuator assembly is raised relative to the grappler housing, the arms **397** are pivoted radially outwardly, causing the enlarged fingers **406** to seat in an annular groove or recess **53*a*** that extends around the inside of the control rod guide tube element adjacent its upper end. The proper height of the grappler relative to the control rod guide tube element **53** is defined by the engagement of the lower end of the grappler housing **378** with the upper end of the guide tube element. This also ensures that the positive connection between the grappler and the guide tube element is maintained.

It will of course be understood that while the movement of the actuator assembly **381** operates all of the arms **396** and **397**, at any given time the grappler **214** will only be operated with respect to one of the elements, i.e., either a fuel rod element **54** or a control rod guide tube element **53**. Both of the types of elements **54** and **53** are illustrated in FIGURE 15 in broken line merely to illustrate the alternate functions or uses of the grappler.

Thus, with the grappler actuator assembly **381** lowered, the entire grappler **214** is lowered to position the appropriate arms in proper position relative to the element to be handled. The grappler is lowered by the drive means **368** operating both reels **376** and **362** at the same rate to unwind both cables **350** and **348** at the same rate. Then the grappler actuator assembly **381** is raised relative to the grappler housing and other grappler parts to a position such as shown in FIGURE 15 to cause the grappler fingers to engage the element being handled. This relative movement of the actuator assembly **381** is achieved by releasing the clutch and engaging the brake between the lift cable reel **348** and the drive means **368**. Then the drive means **368** will only function to rotate the actuator cable reel **376** and not the lift cable reel **362**. When it is desired to raise or lower the element being held, both of the cables **350** and **348** are again operated at the same rate so that the actuator assembly **381** is maintained in raised, locking position relative to the grappler housing **378**.

To release the element, the aforesaid action is reversed, i.e., the actuator assembly **381** is lowered relative to the grappler housing to move the fingers **402** and **406** out of engagement with the element being handled.

Suitable locks and safety features may be incorporated to prevent improper, dangerous or hazardous operation of the grappler mechanism.

Thus, the same compact, relatively simple, yet sure and effective mechanism or arrangement which serves to raise and lower the grappler also serves to operate the grasping or connecting fingers.

The operation of the fuel transfer cask **50** may now be more readily understood.

To remove elements from the reactor **30**, the empty cask **50** is positioned over a selected empty nozzle **51**, fixedly connected to that nozzle by an isolation valve, and is operated to remove the seven center elements from directly below the nozzle. In this connection, the rack arrangement **206** is rotated to vertically align **208** with a selected one of the center elements. The grappler mechanism **290** is operated to position the grappler **214** directly above the selected center element. The inner door section **216*a*** is rotated to align at least partially its aperture **210*a*** with the aperture **210*b*** of outer door section **216*b*** and the door sections are rotated as a unit to vertically align the small access pasageway **210** with the selected center element. The isolation valve is also opened. The retaining mechanism **260** is operated to open or raise the platforms or bars **262** of the empty compartments and the grappler **214** is lowered through the selected compartments with which the grappler is aligned, through the underlying access passageway **210**, through the isolation valve and nozzle **51**, into the primary reactor vessel **32** (FIGURE 1). The grappler engages the selected center element, is actuated by the cables to connect to that element, and lifts the element essentially straight upwardly through the nozzle and the isolation valve into the aligned compartment. The element is raised sufficiently in the compartment to clear the platform **262** and the platforms are then caused to pivot or swing down to their closed or horizontally extending position across the bottom of the compartment. The element is lowered to its platform, the grappler is actuated to disconnect from the element, and the grappler is raised clear of the rack arrangement.

Then the procedure is repeated for another center element. The grappler and the access passageway **210** are repositioned laterally to vertically align with another of the center elements. The latch mechanism is operated to raise the platforms of the empty compartments to their open positions and the grappler is lowered, connected to the center element and raised to position the element in the aligned compartment. The platforms are lowered, the element is deposited in the compartment on the platform, and the grappler is again raised above the rack arrangement. This procedure is repeated for each of the seven center elements.

As noted above, inasmuch as each of the center elements is in a different lateral location, the access passageway **210** and the grappler **214**, are selectively laterally positionable. This ability of the grappler and the access passageway to be laterally moved to a position above the element being handled is preferable to repositioning the cask itself over each of the center elements. In addition to time and effort required to move the cask and the bridge **42** to reposition the cask, maintaining a sealed connection between the cask and the nozzle would create added problems. The illustrated structure permits the cask to be rigidly connected to the nozzle by the simple isolation valve while all of the center elements are removed.

After the seven center elements are transferred to the cask **50**, the isolation valve and the door arrangement **216** are closed and the cask is disconnected from the reactor. The cask then transports the elements to a suitable facility such as a fuel storage vault where the radioactive elements may be deposited for a "cooling" period.

To continue removal of elements from the reactor, an element transfer machine is placed in the selected nozzle and extends down into the area of the core vacated by the seven center elements. The machine operates generally to grasp an outer element, i.e., one laterally displaced from directly below the nozzle, to move that outer element essentially laterally only to a position directly below the nozzle, and to raise the element through the machine itself to a "delivery" position where the upper end of the element can be grasped from above. The emptied fuel transfer cask **50** is again placed over and sealed to the nozzle, and the isolation valve and the access passageway **210** are opened. The grappler **214**, a selected outer compartment, and the access passageway **210** are vertically aligned with the "delivery" position of elements removed from the reactor core by the element handling machine. Since all outer elements removed by the machine are positioned in the same "delivery" position, the grappler and the access passageway need not be repositioned for subsequent elements. In receiving the outer elements, the rack arrangement merely rotates to successively index empty outer compartments with the passageway, with the grappler raising and lowering the latch mechanism operating to place outer elements in the six outer compartments. Since the element transfer machine places the elements in only the one delivery position, the center compartment of the cask is not used for this phase of the operation.

The shielded cask **50** is also used to transport and deliver elements that are radioactive, such as fresh fuel elements made from reprocessed fuel material, to the reactor and to load such elements into the reactor by a general reverse of the described unloading operations.

Thus, a relatively simple and effective shielded fuel transfer cask **50** is provided, affording rapid remote control operation to selectively position one after another of its compartments **208** in vertical alignment with the access passageway **210**, the grappler **214** and the element to be handled to load or unload the reactor.

COMBINATION MOVEMENT FUEL TRANSFER CASK

A modified form of fuel transfer cask which includes a multiple or combination movement rack arrangement is designated **498** and is best illustrated in FIGURES 19 through 22. The cask **498** is similar in various respects to the fuel transfer cask **50** but is provided with a larger storage capacity. In general, the illustrated cask **498** includes a generally cylindrical, upright, closed, shielded housing or casing **500** which is mounted on a movable carriage or carrier (not shown) for movement of the cask along the track or rail system of the nuclear power plant. As explained with regard to cask **50**, the rail system of the reactor plant construction with which the transfer cask **498** is used permits the cask **498** to be selectively positioned over and moved between the nuclear reactor, the storage vault and the loading area **48**, or a fuel shipping cask such as cask **60**, heretofore described and illustrated. The casing or housing **500** of the fuel transfer cask **498** defines a cavity **504** in which a rack arrangement **506** is rotatably mounted. The illustrated rack arrangement **506** is comprised of three separate rack, support, or cluster units **507** that are each rotatable relative to the remainder of the rack arrangement. Each of the illustrated units **507** defines six individual compartments or channels **508** which each are adapted to receive and support therein one of the reactor elements. The cask **498** also includes a relatively small openable access passageway **510**, means **512** for driving the rack arrangement, and a grappler **514**.

Now considering the cask **498** in further detail, as shown best in FIGURE 19, the casing **500** is a generally double-walled steel structure with an intermediate layer of a shielding material such as lead. A door arrangement **516**, which is provided at the lower end of the casing **500**, forms the openable access passageway or opening **510** of the cask **498**. The illustrated door arrangement **516** includes a lower section **516*a*** and an upper section **516*b*** which in general are movable relative to one another to align apertures **510*a*** and **510*b*** in the respective sections to provide the passageway **510**. When the apertures **510*a*** and **510*b*** are out of alignment, a suitable closure is thereby provided for the casing **500**.

More particularly, the sections **516*a*** and **516*b*** are disposed generally centrally at the bottom of the casing **500**, with the apertures **510*a*** and **510*b*** both located eccentrically or off-center of the respective sections. The lower section **516*a*** is permanently fixed in position while the upper section **516*b*** is mounted to the inside of the casing wall on suitable annular bearings **518** for rotational movement about a vertical central axis generally coincident with the axis of the casing **500**. The rotation of the upper section **516*b*** serves to move the aperture **510*b*** of that section into and out of vertical alignment with the aperture **510*a*** of the lower section. FIGURE 19 shows the apertures **510*a*** and **510*b*** in vertical alignment to provide a passageway for reactor elements into and out of the cask **498**. Suitable door-operating motor means **520** is mounted in a recess in the upper surface of the lower fixed section **516*a*** generally centrally of the casing. The motor means **520** is disposed with its rotatable driving shaft extending vertically upward and generally aligned with the vertical axis upper section. The motor means **520** is in driving connection with means on the rotatable upper door section **516*b*** so that operation of the motor means **520** serves to rotate the section **516*b*** about its axis to open and close the door arrangement **516**.

The passageway **510** is about the size in plan of one of the six-element cluster or support units **507**, and thus is able to receive center elements from the different lateral positions. All of the center elements for a given core zone will pass directly through the passageway **510**. This eliminates the need for the passageway to be laterally positionable, it being sufficient for purposes of handling the center elements that the rack arrangement **506** and the grappler **514** are laterally positionable. While the passageway **510** is thus considerably larger than the passageway **210** of cask **50**, the passageway **510** is still relatively small in relation to the larger storage cross sectional area of the cask **498**.

As illustrated best in FIGURES 19 and 20, the generally cylindrical rack or support arrangement **506** is disposed within the casing **500** with its axis vertical and generally coincident with the central axis of the casing. The illustrated rack arrangement **506** occupies the intermediate portion of the generally cylindrical cavity defined by the casing **500**, being positioned immediately above the door structure **516** and extending upwardly through the casing to a position spaced below the upper end of the casing. The uppermost end of the casing is occupied by a grappler mechanism **522** which includes the grappler **514** and will be described hereinafter.

The illustrated rack arrangement **506** includes a pair of generally circular horizontal end plates, including a lower rack plate **528** and an upper rack or support plate or frame **530**. As shown in FIGURE 19, the periphery or edge of the upper plate or frame **530** is supported for rotation, as by means of suitable bearings **532**, on a generally circular or annular internal ledge **534** in the casing **500**. The outer edge or periphery of the upper support plate **530** is formed to provide an external bevel ring gear that engages a bevel gear **536** fixed to horizontal shaft structure **538** extending outwardly through and rotatably supported in the adjacent wall of the casing. The shaft structure **538** is selectively rotated by rack rotating drive means (not shown) supported on the outside of the casing.

The illustrated rack arrangement **506** includes the three eccentrically positioned generally cylindrical upright cluster or support units or sub-arrangements **507**. Each of the cluster units **507** is supported for rotation about its vertical center axis. The cluster units **507** are generally circumferentially equally spaced around the center of the casing, as shown best in FIGURE 20.

Each of the cluster units **507** includes six elongated cylindrical vertically extending tubes or sheaths **540** which are disposed in a circular or annular array about the vertical axis of the unit. Each of the tubes **540** provides one of the elongated vertical channels or compartments **508** for receiving a reactor element. The tubes **540** of each unit are connected together at their upper ends by a horizontal circular connector plate **542** through which the upper ends of the tubes extend.

The upper plate **530** of the rack arrangement **506** is provided with three generally circular apertures arranged around the center of the plate to each receive one of the cluster units **507**. As shown best in FIGURE 19, the edge of the connector plate **542** of a unit overlies the portion of the upper rack plate **530** adjacent one of the apertures, while the tubes **540** of the unit extend downwardly through the aperture and the rack arrangement to the lower plate **528**. The lower ends of the tubes **540** extend through the lower plate **528** so that each of the tubes **540** in itself provides an unobstructed vertical conduit extending completely down through the rack arrangement. Elements are maintained in the tubes by operation of retaining means or mechanisms **544**.

Each retaining mechanism **544** operates to position a support platform **546** across the lower end of an associated tube **540** to support and maintain the element in the tube once it has been positioned therein. More particularly, each mechanism **544**, as shown best in FIGURE 19, includes a vertical rod **548** supported adjacent the associated tube for vertical movement. At the lower end of the rod **548** a toothed block **550** is secured. The block **550** engages a toothed portion of the pivotally mounted associated support platform **546**. An actuator pin **552** is connected, through a compression spring **554** to the upper end of the rod **548** and extends above the upper plate **530**. Vertically movable means (not shown) are operable to depress and release the pins **552**. When the pins **552** are released, the platforms **546** extend horizontally across the lower ends of their associated tubes as shown in FIGURE 19 to provide support for the elements in the tubes. When the rods **548** are depressed, the platforms of all unoccupied tubes are each tilted to a generally vertical position, leaving the associated tubes unobstructed and permitting free passage of reactor elements and/or the grappler, With regard to the occupied tubes, the elements maintain the platforms in horizontal position and the depression of the associated pins **552** is absorbed by their springs **554**. This construction and operation is similar to that previously described with reference to FIGURES 11 and 12.

In addition to the overall rotation of the rack arrangement **506** which thereby serves also to rotate the cluster units **507** about the center of the casing, each of the cluster units is also individually rotatable about its own axis. The edge or periphery of each cluster connector plate **542** is formed with gear teeth (FIGURE 20) and the cluster units are arranged and proportioned so that the teeth of each of the plates **542** engages a central gear **556**. The gear **556** is fixed to a vertically extending shaft structure **558** disposed generally centrally of the casing and the rack arrangement. The shaft structure **558** is rotatably supported between the upper support plate **530** of the rack arrangement and a generally horizontal transverse or cross plate **560** supported in transversely extending position within the casing **500** just above the rack arrangement. A first bevel gear **562** is secured to the upper end of the vertical center shaft structure **558** and this gear **562** engages a second bevel gear **564** which is secured to a horizontal shaft structure **566**. The horizontal shaft structure **566** is rotatably supported on a pair of spaced vertical plates **568** mounted on the transverse plate **560** and extends outwardly through the side of the casing **500** where it is drivingly engaged by a cluster-rotating drive means (not shown) secured to the outside of the casing. The rotation of the center drive gear **556** serves to rotate the cluster units **507** relative to the rack arrangement **506**.

The rotation of the rack arrangement **506**, together with the rotation of the individual cluster units **507**, permits a preselected compartment **508** to be located precisely in a desired vertical alignment, particularly with respect to the access passageway **510** and a selected reactor element.

In addition to the cluster units **507**, the illustrated rack arrangement **506** includes three additional generally cylindrical vertically extending supplemental tubes **570** (FIGURE 20) supported between the plates **528** and **530** and each defining one of the elongated vertically extending compartments **508** for one of the reactor elements. Each of the tubes **570** is also provided with a suitable associated retaining mechanism **544** to support the element in position within the tube.

When a tube **540** or **570** and the passageway **510** are vertically aligned with a reactor element and the door structure **516** is operated to open the passageway, the element may be moved into or out of the aligned compartment **508** provided by the tube by means of the grappler mechanism **522** described hereinafter.

Grappler mechanism

As shown best in FIGURE 19, the grappler or handling mechanism or means **522** is disposed in the upper end of the casing **500**. In general, the grappler **514** is raised and lowered by a cable arrangement which functions to also operate the fingers of the grappler. The mechanism **522** is also operable to achieve any desired transverse or lateral positioning of the grappler where it is desired to directly connect to various reactor elements without the necessity of relocating the entire cask.

The illustrated grappler mechanism **522** includes a grappler frame **574** comprising a horizontal, circular, lower frame plate **576** which is supported on an annular internal ledge of the casing and extends across the casing a short distance above the rack arrangement. The lower frame plate **576** is provided with a large generally semi-circular-shaped aperture **578** (FIGURE 21) which is vertically aligned above the access passageway **510**. Also vertically aligned with the passageway **510** and the aperture **578** is an aperture **580** in the transverse plate **560** which immediately overlies the rack arrangement.

The grappler frame **574** also includes a tower or support section **582** of generally box-like construction secured atop one quadrant of the circular frame plate **576**.

Centrally of the casing, a vertical shaft **584** is rotatably supported between the upper wall of the frame support section **582** and the lower frame plate **576**. The shaft **584** is threaded for a reason to be described. Supported by the vertical shaft **584** and the lower frame plate **576** for pivotal movement around the shaft is a grappler carrier or holder **586**.

The illustrated grappler carrier **586** includes an irregularly-shaped horizontal carrier or base plate **588**, the shape of which is best shown in FIGURE 21. The carrier plate **588** includes a radially extending center section **589** which is pivotally mounted at its inner end on the shaft **584**, and a circumferentially extending outer or rim section **590** at the outer end of the center section **589**. The rim section **590** follows a generally circular path extending well beyond the center section at either side thereof to provide a substantially semicircular outer edge for the carrier plate **588**. Secured along that outer edge of the carrier plate is a semicircularly-formed thin vertically disposed gear plate **592** which extends both upwardly and downwardly from the plane of the carrier plate **588**. The downwardly extending portion of the semicircular gear plate **592** extends around and immediately outside a circular ring or guide block **594** (FIGURE 19) secured to the upper surface of the frame plate **576**. The circular guide block **594** is provided with an external annular groove or track **596** which receives suitable guide means such as rollers secured to the inside of the downwardly extending portion of the gear plate **592**. The carrier plate **588** is thus mounted for ready rotation about the shaft **584**. The upwardly extending portion of the semi-circular gear plate **592** is provided with radially-outwardly directed bevelled gear teeth. As shown in FIGURE 19, the teeth of the semicircular rack **592** engage those of a bevel gear **598** secured to a horizontal shaft structure **599**. The shaft structure **599** extends outwardly through and is rotatably supported in the wall of the casing. The shaft structure **599** is drivingly connected to the grappler azimuth drive motor means (not shown) supported on the outside of the casing.

The illustrated grappler carrier **586** also includes a vertical post **600** secured to and extending upwardly from the carrier plate **588** adjacent the radially outward end of the center section **589**. A vertical support or web **602** for the post **600** is mounted on the carrier plate **588** at either side of the post.

Secured to the upper side of the center section **589** of the carrier plate **588** and extending radially are a pair of elongated, spaced-apart, parallel guide or track members **604**. Each of the track members **604** is a short vertical wall having an elongated horizontal groove or recess **606** facing the opposite track member and located adjacent the upper edge of the track member (FIGURE 22).

In general, means which carries the grappler **514** is mounted between the track members **604** for radial movement. More particularly, a horizontal, generally rectangular, support plate or platform **608** (FIGURES 21 and 22) is supported for horizontal movement in the radial direction by means of a spaced-apart pair of rollers **610** mounted at either side of the platform **608** and extending into the adjacent horizontal groove **606**. A vertical guiding cylinder **612** extends through the platform **608** to which it is secured intermediate its height. The lower end of the guiding cylinder **612** extends through a raidally extending slot or aperture **613** in the center section **589** of the carrier plate and through apertures **578** and **580** in the frame plate **576** and transverse plate **560**, respectively.

The upper portion of the guiding cylinder **612** is reinforced in its vertically extending position by circumferentially-spaced, vertically extending support webs **614** between the platform **608** and the cylinder. Secured at the upper end of the guiding cylinder **612** is a generally flat pulley block or support **616** (FIGURE 19). The block **616** is disposed in a vertical plane extending radially of the cask. The block **616** supports a lower outer pulley **618**, an upper outer pulley **620**, an upper inner pulley **622**, and a lower inner pulley **624**. The pulleys **618**, **620**, **622** and **624** are disposed in the plane of the block **616**, and are freely rotatable about horizontal axes. The block **616** is positioned immediately radially inwardly of the upper end of the post **600** of the grappler carrier **586**.

An upper grappler actuator cable **630**, which is secured at one end to the upper end of the post **600**, extends over the upper outer pulley **620**, down to the grappler **514**, and up over the upper inner pulley **622** from where it extends radially inwardly, as will be more fully explained. Similarly, a lower grappler lift cable **632** is secured at one end to the post **600** at a point just below the connection of the upper cable **630**. The lower cable **632** then extends over the lower outer pulley **618**, down to the grappler **514**, up over the lower inner pulley **624** and then radially inwardly.

Secured to the upper surface of the platform **608** at either side of the guiding cylinder **612** is an upwardly extending ear **636**. Pivotally connected to each ear **636** is one end of a generally radially extending link **638** which is pivotally connected at its other end to an internally threaded follower **640**. The follower **640** is disposed on the threaded vertical shaft **584** in meshing engagement so that the rotation of the shaft **584** serves to raise or lower the follower. The elevation of the follower acts through the links **638** to define the radial position of the platform **608** and thereby the positions of the guide cylinder **612**, the pulley housing block **616**, and the grappler **514** which is supported within the guide cylinder.

The position of the follower **640** rotationally of the vertical shaft **584** is maintained by an extension or arm **642** of the follower which is movably connected to a vertical rod **644** supported by the frame **574**. A sliding engagement between the arm **642** and the rod **644** permits vertical movement of the follower and the connected links **638**, but maintains the follower in the desired position rotationally of the shaft **584**.

The lower end of the vertical shaft **584** extends below the frame plate **576** and has fixed to it a bevelled gear **648** which engages suitable grappler radial drive means (not shown) which is mounted on the cask.

Thus, the carrier plate **588** is rotated to provide azimuth positioning of the grappler **514**, while the platform **608** is moved toward and away from the shaft **584** to provide radial positioning of the grappler.

Referring further to the cables **630** and **632**, the portions heretofore described and illustrated in FIGURE 19 of the drawings lie in a common vertical radially extending plane. The drive mechanism or means for the cables causes the remainder of each of the cables to be turned, wound and stored in a generally horizontal plane, as illustrated in FIGURE 21.

Referring particularly to the upper actuator cable **630** as shown in FIGURE 21, this cable extends radially inwardly from the upper inner pulley **622** and is then turned or wound around a horizontally extending centrally-located pulley **650** that is freely rotatable about a vertical axis. The cable **630** then extends radially outwardly and is wound around a horizontally disposed positionable pulley **652**, from whence it extends radially inwardly to a second central horizontal pulley **654**. Finally the cable **630** passes around the pulley **654** and is wound around a large cylindrical actuator cable drum or reel **656**. The pulleys **650**, **652**, **654** and the drum **656** are all mounted for rotation about vertical axes and the path defined by the cable **630** around them extends, as noted above, in a generally common horizontal plane. The pulleys **650** and **654** are rotatably supported in a pulley block **658** mounted on an upper wall portion of the frame structure **574**. The pulley **652** is positionable generally radially of the cask by drive means **660**.

The lower hoist or lift cable **632** is similarly disposed about suitable pulleys and a storage drum or reel (not shown).

Sutable drive means (not shown) mounted on the casing is directly connected to the actuator cable reel **656** and connected through a clutch and brake arrangement to the lift cable reel. This permits the lift cable to be stopped by the action of the brake while the actuator cable is moved, resulting in actuation of the grappler **514**.

The grappler **514** is generally similar to the grappler **214** of the cask **50** and operates in a similar manner.

Various other modifications or changes may be made in the illustrated structure without departing from the spirit and scope of the present invention.

Various features of the present invention are set forth in the following claims.

What is claimed is:

1. A shielded cask for use with a nuclear reactor, said cask comprising a sealed shielded housing adapted to receive therein a plurality of elongated radioactive nuclear reactor elements, said housing being generally tubular and closed at both ends, access means on said housing defining a selectively openable access passageway at one end of said housing, element-supporting means in said housing mounted for movement laterally of the axis of said housing, said supporting means defining a plurality of elongated channels that extend generally parallel to the axis of said housing and are arranged to each register with said access passageway incident to the lateral movement of said supporting means, said supporting means being adapted to receive and support an element in longitudinal alignment in each of said channels, driving means on said housing for selectively moving said supporting means to register a determined channel with said passageway, and handling means in said housing for releasably engaging an element to axially move the element through said passageway into or out of the channel registered with said passageway.

2. A shielded cask for use with a nuclear reactor, said cask comprising a movable housing including an elongated, sealed, tubular, closed-ended, upright, shielded section, said section being adapted to receive a plurality of elongated radioactive nuclear reactor elements, said housing being movable to a position adjacent to the reactor, access means on said housing defining an openable access passageway at one end of said tubular section, said access means being adapted to releasably connect to the reactor to place said passageway in communication with the interior of the reactor, an element-supporting rack arrangement in said tubular section laterally movable relative to said section, said rack arrangement defining a group of elongated vertically extending channels each adapted to receive and support a vertically disposed element therein, said channels being generally parallel to the axis of said section and being arranged to vertically align with said passageway incident to the movement of said rack arrangement, and driving means on said housing for selectively moving said rack arrangement to register a determined channel with said passageway, whereby an element may be moved into or out of any of said channels through said access passageway.

3. A shielded cask as called for in claim **1** wherein said element-handling means is laterally positionable relative to said housing and to said element-supporting means, and said housing is adapted to releasably connect to the reactor in a manner preventing any substantial lateral movement between said housing and the reactor.

4. A cask for use with a nuclear reactor, said cask comprising a sealed, shielded, walled housing positionable above an access port of the reactor and adapted to receive a plurality of elongated radioactive nuclear reactor elements, access means on said housing defining an openable access passageway in a lower wall of said housing adapted to be placed in releasable sealed communication with the access port of the reactor, laterally movable support means in said housing, said support means defining at least two elongated, vertical, generally open channels that are each adapted to receive and support a vertically disposed element therein, each of said channels being adapted to be vertically aligned with said access passageway by the lateral movement of said support means, and a straight-lift element-handling means supported in said housing above said support means in vertical alignment with said access passageway, said element-handling means being operable to releasably connect to an element and to raise or lower it through an aligned channel, said access passageway, and the access port of the reactor to move it between the reactor and said cask.

5. A shielded cask for use with a nuclear reactor, said cask comprising a sealed, shielded, walled housing adapted to receive a plurality of elongated radioactive nuclear reactor elements, said housing being positionable above an access port of the reactor and adapted to releasably connect to the reactor in a location laterally fixed relative to that port, the access port being large enough laterally to accommodate movement therethrough of elements in different lateral positions, access means on said housing defining an openable and laterally movable access passageway in a lower wall of said housing adapted to be placed in releasably sealed communication with that access port and to vertically align with different lateral element-positions, a laterally-movable element-supporting rack arrangement in said housing, said rack arrangement defining at least two elongated vertical generally open channels that are each adapted to receive and support a vertically disposed element therein, each of said channels being arranged so as to be vertically aligned with said access passageway by the lateral movement between said rack arrangement and said access passageway, and a laterally-movable straight-lift element-handling means supported in said housing above said rack arrangement, said element-handling means being adapted to vertically align with said access passageway and to pass through the vertically aligned channel to connect to an element and to raise or lower it between the reactor and said cask through the access port of the reactor.

6. A shielded cask for use with a nuclear reactor in which elongated elements are supported in parallel relation to one another, said cask comprising a sealed, shielded, walled housing adapted to receive therein a plurality of the elongated radioactive nuclear reactor elements, said housing being adapted to be releasably connected to the reactor so as to be fixed against movement relative to the reactor laterally of the axis of the parallel elements, an element-supporting rack arrangement supported in said housing for movement laterally with respect to the elements in the reactor, said rack arrangement defining a plurality of elongated channels that extend generally parallel to the axis of the elements in the reactor, each of said channels being adapted to receive and support one of the elements therein, access means on said housing defining an openable and laterally moveable access passageway in the wall of said housing that is adjacent to said reactor when said housing is connected to the reactor, said passageway being adapted to be placed in communication with the interior of the reactor when said housing and the reactor are connected, laterally movable element-handling means in said housing for releasably engaging and axially moving a reactor element, said rack arrangement, access means and handling means being constructed and arranged so that a selected channel, said access passageway, and said handling means can be axially aligned to move an element between that selected channel and the reactor.

7. A cask for use with a nuclear reactor, said cask comprising a sealed, shielded generally tubular elongated housing that is closed at each end and is adapted to receive a plurality of elongated radioactive nuclear reactor elements, access means defining at least one openable access passageway at one end of said housing, a rack arrangement disposed in said housing, said rack arrangement comprising a frame supported in said housing for movement in a plane generally transverse to the longitudinal axis of said housing, at least two support units mounted on said frame for movement relative to said frame in a plane generally transverse to the longitudinal axis of said housing, each of said support units defining at least two elongated channels that extend generally parallel to the longitudinal axis of said housing and are each adapted to receive and support one of the elements longitudinally disposed therein, each of said channels being adapted to be aligned with said access passageway by the movement of said frame and said support units, and driving means on said housing operable to selectively move said frame and said support units of said rack arrangement to align a determined channel with said access passageway.

8. A shielded cask for receiving, storing, transporting and delivering a plurality of elongated radioactive elements of a nuclear reactor, said cask comprising a sealed, shielded housing that is generally tubular and closed at both ends, said housing being adapted to be movably supported with its axis generally vertical and including at least one openable access passageway at one end thereof, said housing being movable to a position where said access passageway is vertically aligned with an access port of the reactor, a rack arrangement disposed in said housing and comprising a frame supported in said housing for rotational movement about a generally vertical axis, and at least two support units mounted on said frame for rotational movement relative to said frame about an axis generally parallel to the axis of rotation of said frame, each of said support units defining at least two elongated vertically extending channels that are each adapted to receive and support therein a reactor element in a generally vertical disposition, each of said channels being adapted to be vertically aligned with said access passageway by the movement of said frame and said support units, and driving means on said housing operable to selectively move said frame and said support units to position a determined channel in vertical alignment with said access passageway.

9. A shielded cask for receiving, storing, transporting and delivering a plurality of elongated radioactive elements from a nuclear reactor, said cask comprising a sealed shielded housing that is generally tubular and closed at both ends, said housing being disposed with its axis generally vertical, access means on said housing defining at least one openable access passageway at one end of said housing, a rack arrangement disposed in said housing and comprising a frame supported generally centrally in said housing for rotation about the vertical axis of said housing, and at least two support units each mounted eccentrically on said frame for rotation about a vertical axis, each of said support units defining at least two elongated vertically extending channels that are each adapted to receive and support therein one of the reactor elements in a generally vertical disposition, each of said channels being adapted to be vertically aligned with said access passageway by the movement of said frame and said support units, driving means on said casing operable to selectively rotate said frame and said support units to position a determined channel in vertical alignment with said access passageway.

10. A shielded cask for receiving, storing, transporting and delivering elongated radioactive elements of a nuclear reactor, said cask comprising a sealed shielded housing that is generally tubular and is closed at both ends, said housing being adapted to receive a plurality of the elements therein, access means defining at least one openable access passageway in the lower end of said housing, a rack arrangement disposed in said housing and comprising a frame supported in said housing for generally horizontal movement relative to said housing, at least two support units mounted on said frame for generally horizontal movement relative to said frame, each of said support units defining at least two elongated vertically extending generally open channels that are each adapted to receive and support one of the elements vertically disposed therein, each of said channels being adapted to be vertically aligned with said access passageway by the movement of said frame and said support units, driving means in said housing operable to selectively move said frame relative to said housing and said support units relative to said frame to position a determined channel in vertical alignment with said access passageway, and a straight-lift element-handling means in said housing above said rack arrangement operable to releasably connect to an element and move it through said access passageway into or out of the aligned channel.

11. A shielded cask for receiving, storing, transporting and delivering elongated radioactive elements of a nuclear reactor, said cask comprising a sealed shielded housing that is generally tubular and is closed at both ends, said housing being adapted to receive a plurality of the elements therein, access means defining a fixed-location openable access passageway in the lower end of said housing, said passageway being sufficiently large to permit straight vertical movement therethrough of at least two horizontally spaced elements, a rack arrangement disposed in said housing and comprising a frame supported in said housing for generally horizontal movement relative to said housing, at least two support units mounted on said frame for generally horizontal movement relative to said frame, each of said support units defining at least two elongated vertically extending generally open channels that are each adapted to receive and support one of the elements vertically disposed therein, each of said channels being arranged to be vertically aligned with a selected portion of said access passageway by the movement of said frame and said support units, driving means in said housing operable to selectively move said frame relative to said housing and said support units relative to said frame to so position a determined channel relative to said access passageway, and a laterally positionable straight-lift element-handling means in said housing above said rack arrangement operable to releasably connect to an element and move it through a selected portion of said access passageway into or out of a channel.

12. A cask for use with a nuclear reactor, said cask comprising a sealed, shielded housing adapted to receive therein a plurality of elongated, radioactive elements of the nuclear reactor, access means on said housing defining at least one openable access passageway, rack means supported within said housing, said rack means defining at least two elongated generally open channels that are each adapted to receive an element therein, said rack means being selectively movable to align a determined channel with said access passageway, element-handling means on said housing adapted to releasably connect to an element to move it in and relative to a channel, and a retaining mechanism in said housing associated with each of said channels, each of said retaining mechanisms being normally positioned outside of the associated channel to afford free movement of the element and the element-handling means through said channel and being selectively movable into that channel to support and maintain an element therein.

13. A shielded cask for elongated radioactive elements of a nuclear reactor, said cask comprising a sealed, generally tubular, close-ended, vertical shielded housing, means defining at least one openable access passageway in the lower end of said housing, a laterally movable rack arrangement disposed within said housing above said access passageway, said rack arrangement defining

at least two elongated generally open, vertically extending channels that are each adapted to receive an element therein, said rack arrangement being movable to selectively align a determined channel with said access passageway, element-handling means mounted within said housing above said rack means for generally straight-line movement, said element-handling means being operable to releasably connect to an element and to raise or lower it in or relative to a channel, and a retaining mechanism in said housing associated with each of said channels, each of said retaining mechanisms including a platform that is normally positioned outside of the associated channel to afford free movement of the element and said grappler through said channel, each of said retaining mechanism being operable to position said platform across the lower end of the channel to support an element thereon.

14. A shipping cask for use with a nuclear reactor, said cask comprising a generally tubular closed-ended walled housing adapted to contain a plurality of elongated nuclear reactor elements, said housing including an access passageway at one end thereof, said housing being adapted for loading and unloading in a generally vertical position and for shipment in a generally horizontal position, an element-supporting rack arrangement mounted within said housing for rotation about the axis of said housing, said rack arrangement defining a plurality of elongated channels that extend generally parallel to the axis of said housing and are each adapted to receive and support a reactor element therein, each of said channels being arranged to align with said access opening incident to the rotation of said rack arrangement, and shifting means in said housing for shifting said rack arrangement laterally to a position substantially abutting a portion of the side wall of said housing so that the rack arrangement will be supported by that wall portion when the housing is tilted to the horizontal shipping position with that wall portion downward.

15. A shielded cask in accordance with claim **14** wherein said element supporting rack is provided with a bushing at each end, wherein a shaft segment is provided within said bushing defining the axis of rotation of said rack, wherein said shaft segment includes a cam engageable with said bushing when said segment is moved axially to urge said rack laterally, and wherein means are provided to move said shaft segment axially.

16. A shielded cask comprising an elongated sealed shielded housing adapted to receive therein a plurality of elongated radioactive nuclear reactor elements, means within said housing defining channels for receiving elongated nuclear reactor elements arranged within said housing in a predetermined array with their longitudinal axes parallel to the longitudinal axis of said housing, means at one end of said housing defining a selectively openable access passageway disposed with its longitudinal axis generally parallel to the longitudinal axis of said housing, said passageway defining means being shiftable relative to said housing so as to permit said access passageway and any one of said channels to be placed in alignment for the passage of nuclear reactor elements into and out of said cask.

17. A shielded cask in accordance with claim **16**, wherein said passageway is defined by a cylindrical door mounted for rotation about the central longitudinal axis of said cask.

18. A shielded cask in accordance with claim **17**, wherein said passageway is of oval configuration and is arranged relative to the cask such that the intersection of the major and a minor axis of the passageway as viewed in transverse cross section lies on the axis of rotation of the door.

19. A shielded cask in accordance with claim **18**, wherein the widest dimension of the passageway is at least as great as twice the transverse diameter of one of nuclear reactor elements.

20. A shielded cask in accordance with claim **17**, wherein an inner generally cylindrical plug is mounted within said door for rotation about its central longitudinal axis, wherein the axis of rotation of said plug is displaced laterally from the axis of rotation of said door, and wherein said plug is provided with a longitudinally extending passageway displaced laterally from its axis of rotation.

21. A shielded cask in accordance with claim **20**, wherein said plug is rotatable relative to said door so as to bring the passageway of said plug into and out of alignment with the passageway of said door.

References Cited

UNITED STATES PATENTS

2,514,909	7/1950	Strickland	250—108
3,038,999	6/1962	Loos et al.	250—108 X
3,179,243	4/1965	Ashcroft	250—108 X

ARCHIE R. BORCHELT, Primary Examiner

U.S. Cl. X.R.

250—106