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[54] **TRAVELING CRANE HEAD SUBASSEMBLY FOR ATOMIC REACTOR FUEL CELLS**

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[52] **U.S. Cl.** **294/88,** 212/129, 214/1, 294/110

[51] **Int. Cl.** **B25j 3/04,** B66c 1/10, B66c 19/00

[58] **Field of Search** ....294/88, 110; 214/1 CM; 212/127, 129

[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

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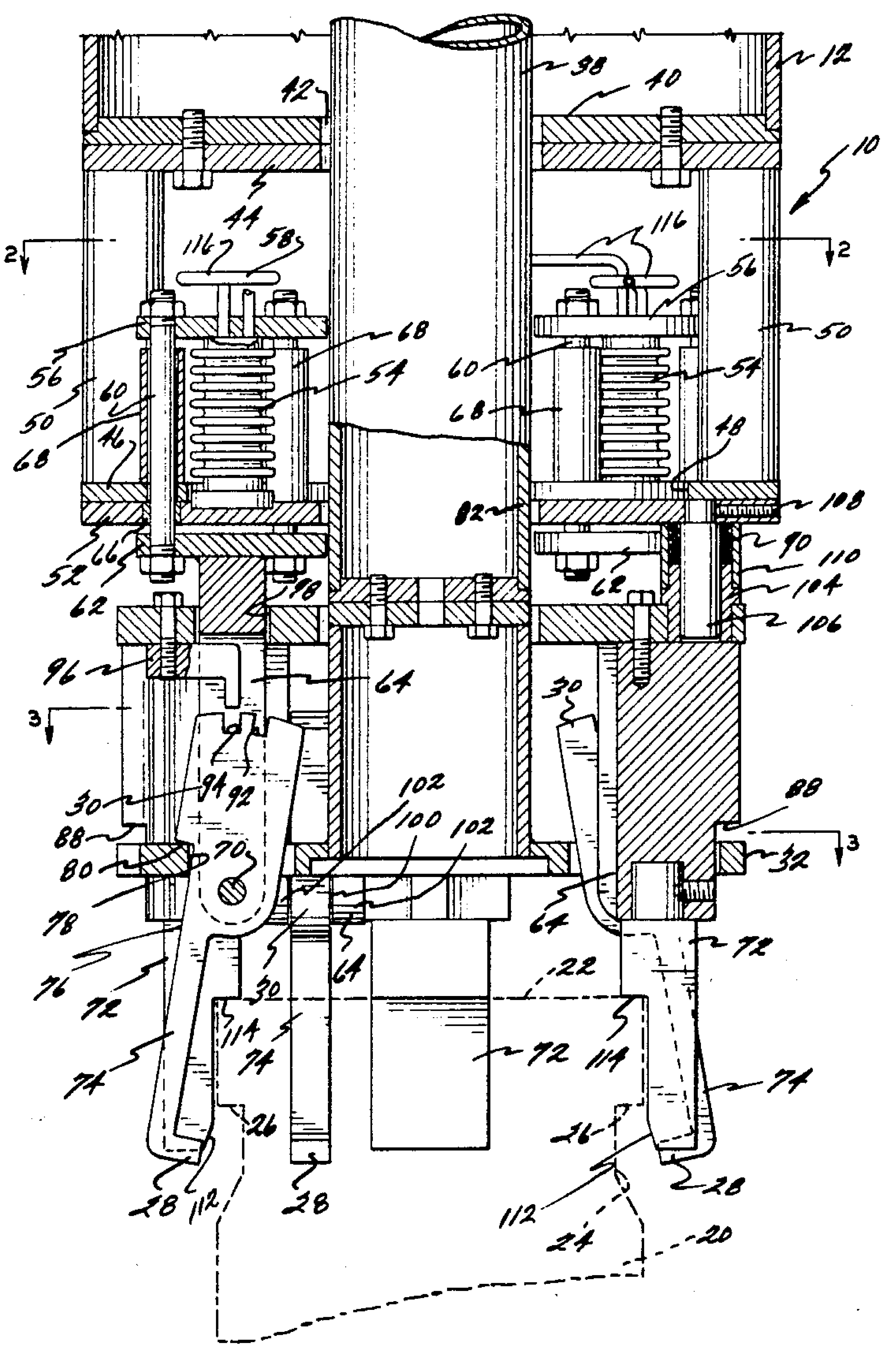
[57] **ABSTRACT**

This invention relates to a head subassembly for changing fuel cells in an atomic reactor that includes a plurality of hook-like fingers pivotally movable from a released into an engaged position locked beneath a downwardly-facing shoulder around the top of the cell. These fingers are cammed between their released and engaged positions by a pneumatic-servo-motor actuated cam plate. Each of the fingers is suspended from a separate sealed fluid chamber of variable volume and the several chambers are, in turn, serially interconnected to form a self-equalizing hydraulic system wherein the load is evenly distributed to maintain the cell in plumb relation.

10 Claims, 5 Drawing Figures



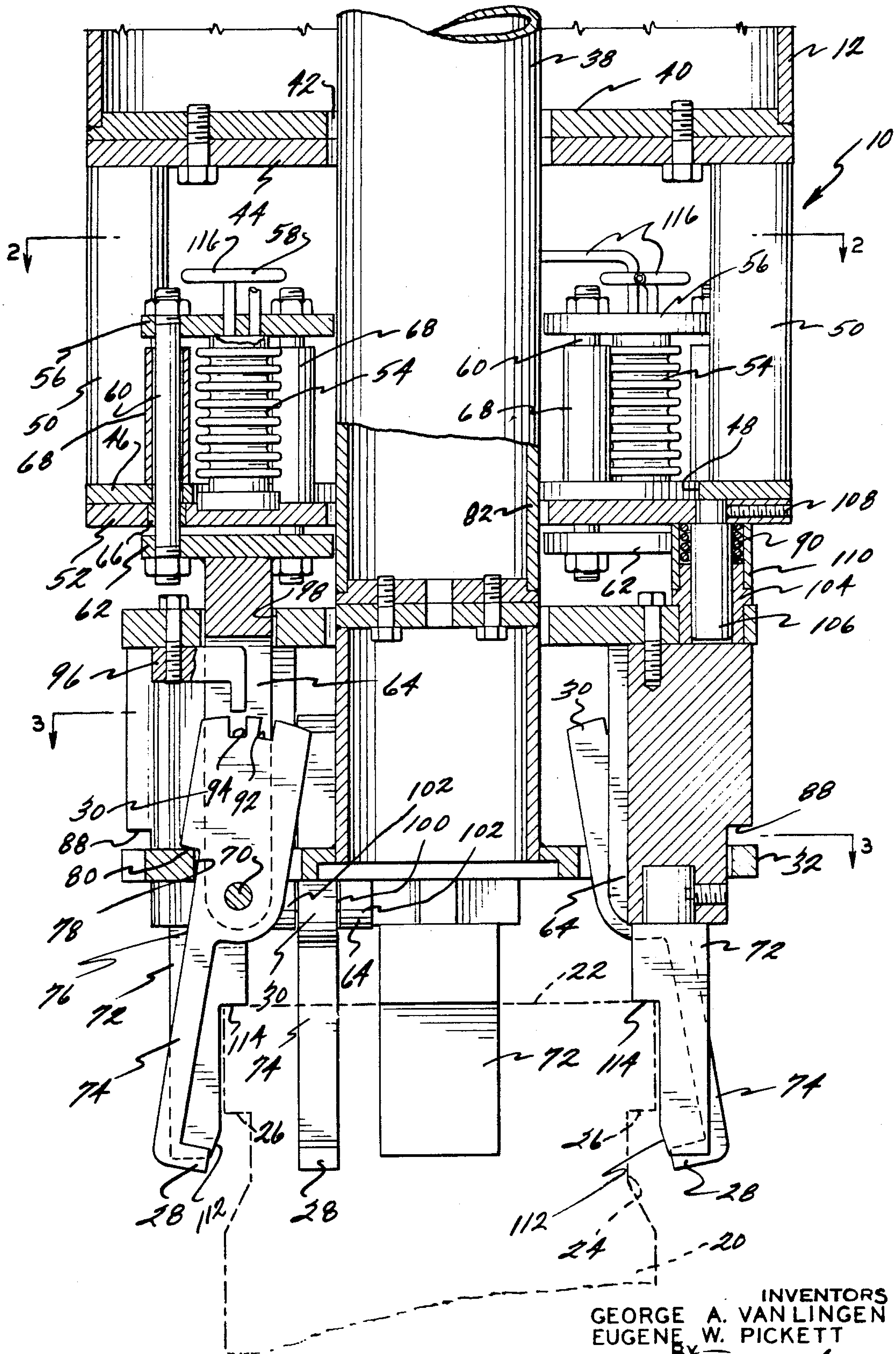


FIG. 1.

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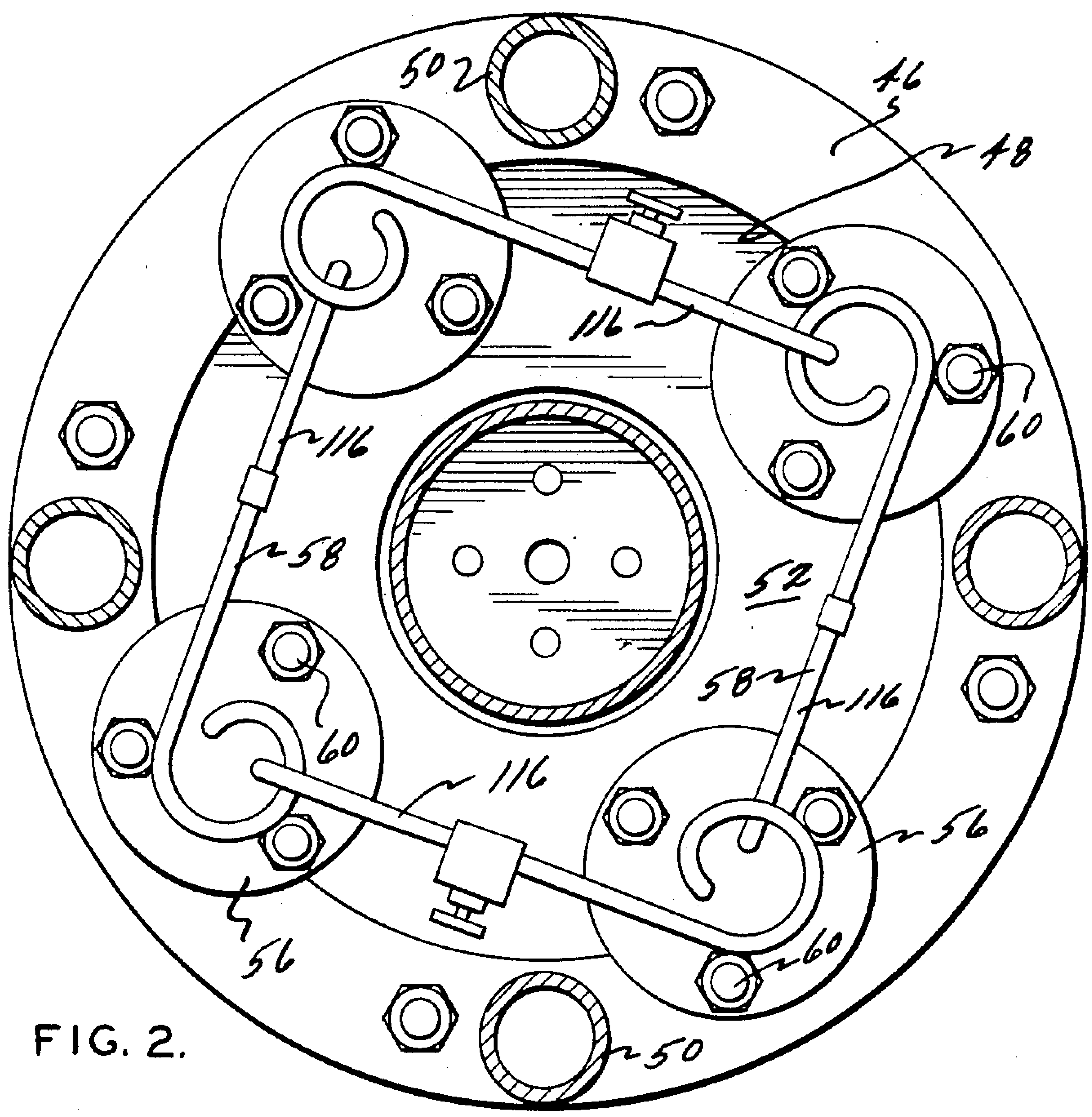

FIG. 2.

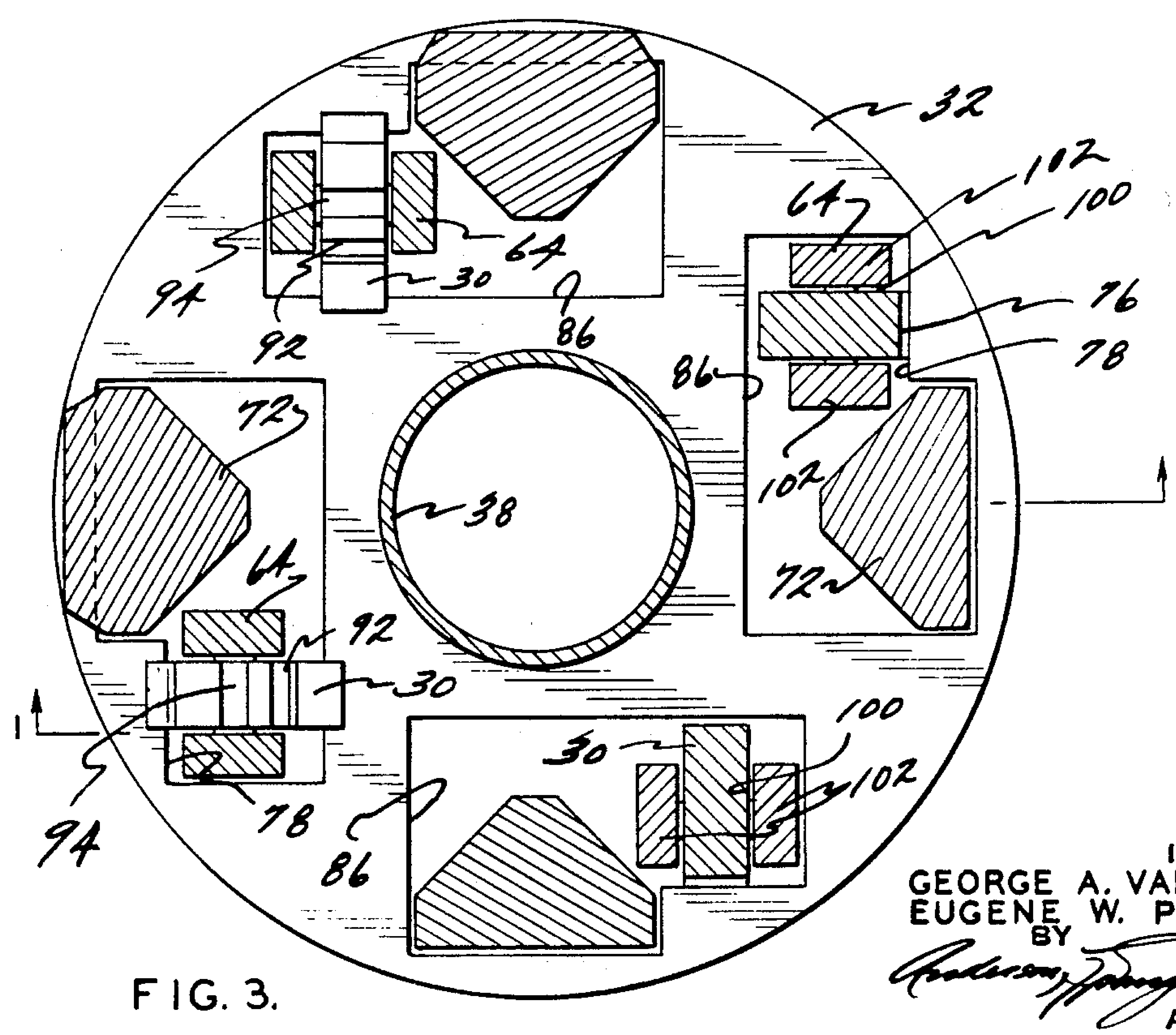

FIG. 3.

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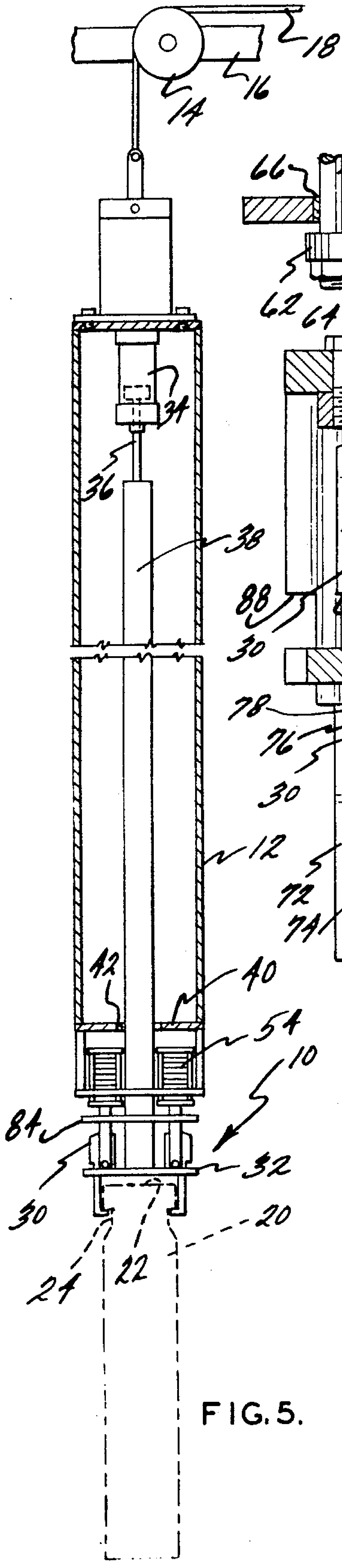

FIG. 5.

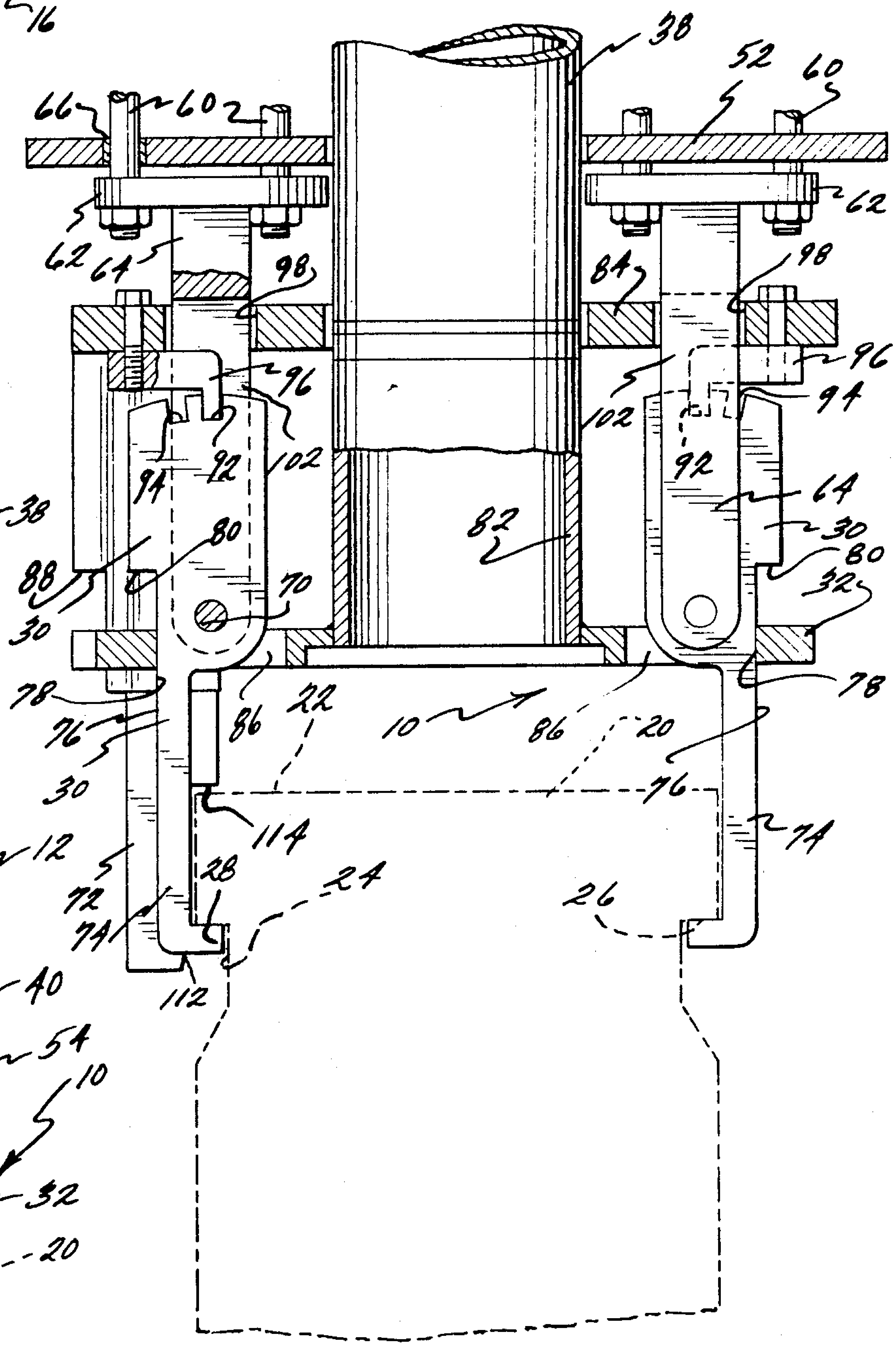

FIG. 4.

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TRAVELING CRANE HEAD SUBASSEMBLY FOR ATOMIC REACTOR FUEL CELLS

On occasion, it becomes necessary to relocate certain fuel cells in an atomic reactor as well as replace those that are spent. These fuel cells are housed in the reactor core such that a space of ± one thirty-second inch is all gap that is left therebetween.

The highly radioactive nature of the cells demands that they be handled mechanically with an overhead traveling crane from a remote operating station. This fact, in itself, is enough to create serious problems in connection with relocation and replacement of the fuel cells. Add to this, however, the fact that these cells are nearly 14 feet long and the magnitude of the problem becomes even more apparent.

It can be shown that an out-of-plumb condition of only one thirty-second inch at the top of a cell will result in a deflection of ± five-eighths inches at the bottom which is responsible for the rather obvious difficulties realized when attempting to insert same into a core having only a ± one thirty-second inch clearance. In an attempt to eliminate this misaligned condition, the prior art practice has been to carefully machine the downwardly-facing shoulder on the fuel cell and the lifting surfaces of the fingers to very close tolerances so that they all lie in an essentially common plane. Even the slightest imperfection in the mating surfaces on the fingers or shoulder will cause the load to be distributed unevenly resulting in an exaggerated tilt to cell that makes it most difficult to align with the reactor core.

It has now been found in accordance with the teaching of the instant invention that these and other difficulties can be eliminated through the simple, but unobvious, expedient of suspending each of the grapple fingers from a sealed fluid chamber of variable volume and then interconnecting the several sealed chambers together to form a unitary system at the same, though variable, pressure. In so doing, each finger will move up or down as needed independently of the others until the load shared by them is equalized and the fluid pressure throughout the system is constant. Obviously, as the load changes, the fluid will shift among the chambers and the volume therein will vary until the fluid pressure throughout the system is balanced and assumes an equilibrium condition.

A novel pneumatic servo-motor actuated cam is used to pivot the grapple fingers simultaneously between their released and engaged positions beneath the downwardly-facing shoulder on the fuel cell. Each finger is securely latched in each of these positions by a floating latch mechanism which activates to disengage from the fingers as the overhanging ledges carried by its cell-centering arms strike the top of the cell. Similarly, the latch mechanism disengages from the fingers in engaged position as it is raised free of the top of the fuel cell.

It is, therefore, the principal object of the present invention to provide a novel and improved head subassembly for reactor fuel cell cranes.

A second objective is the provision of a device of the type aforementioned that automatically maintains the fuel cell carried thereby in plumb condition well within the tolerances permitted by the reactor core.

Another object of the invention herein disclosed and claimed is to provide a head having a plurality of grapple fingers suspended from a self-equalizing hydraulic system for independent movement.

Still another object is to provide a fuel cell pick-up head having an automatic latch mechanism that locks the grapple fingers in both their released and engaged positions.

An additional objective is the provision of a pneumatic servo-motor actuated cam for simultaneously moving the grapple fingers between their operative and inoperative positions from a remote personnel station.

Further objects of the invention are to provide a fuel cell gripper that is simple, reliable, rugged, easy to operate, safe, relatively inexpensive, compact, safe and even somewhat decorative.

Other objects will be in part apparent and in part pointed out specifically hereinafter in connection with the description of the drawings that follows, and in which:

FIG. 1 is fragmentary diametrical section through the head subassembly showing the centering fingers of the latch mechanism in engagement with the fuel cell, the grapple fingers in released position and the latches disengaged therefrom;

FIG. 2 is a diametrical section taken along line 2—2 of FIG. 1;

FIG. 3 is a diametrical section taken along line 3—3 of FIG. 1;

FIG. 4 is a fragmentary diametrical section similar to FIG. 1 except that the fingers are shown latched in engaged position beneath the downwardly facing shoulder of the fuel cell; and

FIG. 5 is a diametrical section to a reduced scale showing the head subassembly as a part of the traveling crane, portions of the latter having been broken away to conserve space.

Referring now to the drawings for a detailed description of the present invention and, initially, to FIG. 5 for this purpose, reference numeral **10** has been selected to designate the head subassembly in a general way which will be seen to be suspended from the lower end of an outer tubular member **12** that comprises the mast of an overhead traveling crane **14** that includes a trolley track **16** for positioning it in a horizontal plane as well as a hoist mechanism **18** for raising and lowering same relative to the nuclear reactor (not shown). The various elements of the crane, the track therefor, the hoist mechanism, air supply hose reels and the guidance system are quite complex and, for this reason, have either been eliminated from the drawings altogether or shown schematically as the means for supporting and moving the head subassembly.

The fuel cells **20** (broken lines in FIGS. **1**, **4** and **5**) are substantially identical, each being about 8 ½ x 8 ½ inches in lateral dimension and some 13 feet 10 inches long. Spaced down from the top **22** is a horizontal groove **24** that defines a downwardly-facing pick-up shoulder **26** beneath which the inturned hooks **28** on the lower ends of the grapple fingers **30**. These fingers are a part of the head subassembly **10** as is the cam plate **32** that actuates them between the released position of FIG. **1** and the engaged position of FIG. **4**. A pneumatic servo-motor of the double-acting piston-cylinder type **34** has its piston rod **36** connected to reciprocate inner tubular member **38** within outer tube **12** where it is guided by trunnions (not shown) for axial movement. Suitable air intake and exhaust lines are, of course, connected into the servo-motor although they have not been illustrated.

FIGS. 1–4, inclusive, of the drawings, to which reference will now be made, show the details of the head subassembly **10**. The lower end of the tubular mast **12** has an endplate **40** fastened thereto that contains a central opening **42** through which the inner tubular element **38** extends and reciprocates. The head subassembly is bolted or otherwise fastened to the underside of the aforementioned plate.

An upper centrally-apertured plate **44** similar to plate **40** bolts to the underside thereof and functions to suspend the head subassembly therebeneath. A ring **46** of approximately the same diameter but having a much larger central opening **48** therein is attached to the upper plate and maintained in fixed-spaced parallel relation thereto by a plurality of angularly-spaced tubular spacers **50**. A third centrally-apertured plate **52** is fastened to the underside of ring **46** and provides the base upon which the sealed fluid chambers **54** rest. In the particular form shown, these fluid chambers comprise metal bellows having their lower ends seated and sealed against plate **52** and their upper ends closed by discs **56** except for the fluid manifold **58** connected therein. As will be described in more detail presently, the load comprising the fuel cell is shared equally among these fluid chambers as it hangs from the peripheral margins of the discs **56** that rest on top thereof. These discs, of course, transfer the load to the bellows which foreshorten or elongate as needed until an equilibrium condition of balanced fluid pressure is present. It should, perhaps, be mentioned at this point that the bellows units illustrated are but one type of sealed fluid chamber that can be used and the same result could be achieved, for example, by a simple hydraulic cylinder containing a floating piston connected to disc **56** in supporting relation.

Hanging down from the peripheral margins of the discs **56** are three or more equiangularly-spaced hanger rods **60** that pass through registering openings in both ring **46** and lower plate **52** before being connected to the flange **62** bordering the bifurcated grapple finger mounting member **64**. A bushing **66** in each rod-receiving opening in the lower plate **52** journals the hanger rods for reciprocating motion while tubular elements **68** resting atop ring **46** in concentric relation to the rod openings therein provide guides therefor. A transversely-extending pivot pin **70** bridging the gap in the bifurcated mounting member carries the grapple fingers **30** for essentially vertical tilting movement about a horizontal axis between the released position of FIG. **1** and the engaged position of FIGS. **4** and **5**. Note in FIG. **1** that, in the particular form illustrated, the grapple fingers are laterally offset to one side of guideposts **72** that form a part of the grapple finger latch mechanism.

Each grapple finger **30** of which there are four, one for each face of the fuel cell that has a square cross section, includes an elongate stem portion **74** carrying the inturned hook **28** on its lower end. The outside surface of the aforementioned stem portion **74** constitutes a cam surface **76** adapted to be engaged by a corresponding cam surface **78** on the camplate as it moves down from the FIG. **1** position to a location below the pivot pin so as to swing the hooks **28** inward into engagement. The portion of the grapple finger above the pivot pin includes a shoulder **80** adapted for engagement by the same cam surface **78** of the camplate upon upward movement of the latter so as to swing the grapple fingers out and thus release the hooks.

The camplate **32** is most clearly revealed in FIG. **3** and will be seen to comprise a circular metal disc having a central opening therein, the border of which is welded or otherwise permanently fastened to extension **82** of the inner tubular element **38** for reciprocating motion therewith in spaced parallel relation to plate **52** and plate **84** of the latch mechanism which is located therebetween. Large generally L-shaped apertures **86** pass the bifurcated grapple finger mounts as well as the fingers themselves and the guideposts **72** of the latch mechanism. As seen in FIGS. **1** and **3**, each of these guideposts includes a shoulder **88** formed on the outside thereof that is biased down toward the camplate by compression springs **90** (FIG. **1**) that act upon the latch mechanism as will be be explained presently. The top edge of each grapple finger is curved about its pivot pin **70** and includes a pair of notches **92** and **94** adapted to receive the L-shaped latch element **96** of the latch mechanism. With the latch elements engaged within the inner notches **92** as in FIG. **4**, the grapple fingers are locked in engaged position; whereas, when seated in the outer notches, said fingers are latched in released position.

The latch mechanism is most clearly revealed in FIGS. **1**, **3** and **4** to which specific reference will now be made. Plate **84** of the latch mechanism, which has already been mentioned briefly, is located between the camplate **32** and plate **52** and contains a central opening sized to freely pass the inner tubular element **38** as well as an opening **98** positioned and adapted to loosely pass each of the bifurcated grapple finger mounting brackets **64**. Thus, plate **84** is free to move up or down independent of both the grapple finger subassembly and the actuating mechanism therefor. The L-shaped latch elements **96** are bolted or otherwise fastened to the underside of plate **84** so as to extend into the gap **100** left between the arms **102** of the grapple finger mount in position to move into the notches **92** and **94**.

As seen in FIG. **1**, a hollow cylindrical guide member **104** fits into an aperture provided therefor in the plate **84** and projects upwardly therefrom in position to telescopically receive guide rod **106** extending down therein from the underside of plate **52** where it is fastened by a set screw **108**. These telescoping elements cooperate to prevent relative rotational movement of the latch mechanism and also to guide same vertically. The compression spring **90** slips onto the exposed portion of post **106** resting atop the guide member which provides the movable rest therefor while the underside of plate **52** acts as its fixed rest. A sleeve **110** projects above the upper extremity of the guide member and encases the lower portion of the spring except when the latter is entirely compressed therein as illustrated. Four such spring-biased guide subassemblies are provided atop the latch mechanism, one corresponding to each guide post, although but one can be seen in FIG. **1**.

Next, with regard to operation of the head subassembly, the latch mechanism and grapple finger actuating mechanism normally occupy the full line position of FIG. **4** while the grapple fingers occupy the released position of Figure **1** (broken line position of FIG. **4**) where the L-shaped latch elements will be locked within the outer notches **94**. As soon as the overhead traveling crane has positioned the head directly above the fuel cell to be picked up, it is lowered until the chamfered ends **112** of the guide posts engage the upper edge of the cell and guide it into centered position therebetween. The entire unit continues to drop down onto the fuel cell until the overhanging stops **114** on the inside edges thereof engage the top thereof thus preventing further relative movement between said cell and latch subassembly while allowing the rest of the crane and head subassembly to continue their downward motion relative thereto. As soon as the downward progress of the latch mechanism is halted by its engagement with the fuel cell, the continued downward movement of the grapple finger subassembly relative thereto will soon disengage latch elements **96** from notches **94** in the grapple fingers themselves and free the latter as shown in FIG. **1** for movement from disengaged into engaged position. The relative movement between the latch mechanism and the plate **52** thereabove will cease when the compression springs **90** are fully compressed inside sleeves **110** and the latter impinge against the underside of the plate.

With the grapple fingers released, they are in position to be moved into engaged position where the hooks or inturned ends **28** thereof move into groove **24** in the fuel cell. This is accomplished from a remote position by an operator who actuates the double-acting pneumatic servo-motor **34** in a direction to extend inner tubular member **38** so as to lower the camplate **32** causing the cam surface **78** thereof to slide down along the mating cam surface **76** on the outside of the grapple finger stem thus swinging the latter inwardly into engaged position. At this point, the hooks on the ends of the grapple fingers will be in the grooves in the fuel cell; however, their lifting surfaces will still lie in spaced relation beneath downwardly-facing shoulder **26**. Also, while the inner grapple finger notches **92** will be in vertical alignment with the latch elements, they will remain disengaged from one another.

The direction of movement of the crane is now reversed so that it begins to move upwardly. As it does, the hooks will start to move up toward shoulders **26** of the fuel cell which is not yet being lifted; but, compression springs **90** are biasing the latch mechanism downwardly so that the stops **114** on the guide posts continue to rest on the top of the cell. This relative motion between the latch mechanism and grapple finger subassembly raises the grapple fingers until the inner notches **92** thereof engage the latch element locking the fingers in engaged position ready to lift.

Ultimately, one or more of the four grapple finger hooks will engage shoulder **26** of the fuel cell groove so as to pull down on the grapple finger associated therewith. The load carried by the engaged grapple fingers will immediately be transferred through the bifurcated mount **64**, hanger rods **60** and disc **56** to the bellows units **54** which will foreshorten slightly and expell fluid therefrom through the fluid lines **116** of the manifold to the other fluid chambers connected in series therewith. These chambers will, in turn, elongate and raise the grapple fingers connected thereto until all are engaged against shoulder **26** so as to share the load equally and the hydraulic system is in a state of equilibrium Obviously, this equal distribution of the load among the four grapple fingers causes the fuel cell to be lifted in plumb aligned relation to the reactor core.

To return a fuel cell to its place in the reactor core, the steps of the above-described procedure are merely performed in reverse order. The positive mechanical latch of the grapple fingers in engaged position insures against the accidental release of the cell. Note in FIG. **4** that actuating the servo-motor to raise the cam plate will not release the grapple fingers which remain latched in engaged position and the only way that the latch mechanism can be released is by pushing it down on top of the fuel cell while the latter is itself resting on a support so that the necessary relative movement between the grapple finger subassembly and latch mechanism can take place. In other words, it is only when the elements of the head occupy the relative positions shown in FIG. **1** that the grapple fingers are free for movement between their engaged and disengaged positions.

What is claimed is:

1. In an overhead traveling hoist for use in changing fuel cells of the type having a peripheral groove defining a downwardly-facing lifting surface in the core of an atomic reactor, the head subassembly which comprises: platform means attached in substantially horizontal position on the lower end of the hoist; at least three sealed fluid chambers of variable volume resting atop the platform means arranged in equi-angularly spaced relation to one another; manifold means serially interconnecting the fluid chambers adapted to maintain a balanced though variable fluid pressure throughout the hydraulic system defined thereby; hanger means suspended from the top of each fluid chamber operative under load to reduce the volume and increase the fluid pressure in the latter; hook means mounted on each hanger means for pivotal movement about a horizontal axis between a released position and an engaged position hooked beneath the downwardly-facing lifting surface of a fuel cell, each of said hook means in engaged position being adapted to independently coact with its hanger means and fluid chamber to assume a position relative to the other of said hook means such that the load is shared equally therebetween; actuating means connected to the hook means operative upon actuation from a remote control station to shift said hook means between its engaged and released positions; and, latch means responsive to relative movement between it and the hook means occasioned by said latch means contacting the fuel cell operative to releasably lock said hook means in at least its engaged position.

2. The head subassembly as set forth in claim **1** in which: the fluid chambers comprise upstanding collapsible bellows elements.

3. The head subassembly as set forth in claim **1** in which: the actuating means includes cam means encircling the hook means for vertical movement relative thereto between an upper and lower position, said cam means in its lower position being operative to engage the hook means and simultaneously shift same from their released into their engaged positions, and said cam means in its upper position being operative to engage said hook means and simultaneously return same to their released positions; and, servo-motor means connected to the cam means operative upon actuation in one mode to shift the latter into its lower position and in a second mode to raise same.

4. The head subassembly as set forth in claim **1** in which: the latch means includes a latch element corresponding to each hook means mounted on the underside of the platform for movement relative thereto and relative to said hook means between a latched position in engagement with the latter and a released position disengaged therefrom, and stop-carrying means movable with said latch elements positioned to engage the top of a fuel cell as the head subassembly is lowered thereon with the hook means in their released positions, said stop-carrying means being operative when in engagement with the fuel cell to raise the latch elements into their disengaged position upon further downward relative movement of the head subassembly, and said stop-carrying means being operative to release said latch elements into latched position following movement of the hook means into their engaged position when the head subassembly is returned to an elevated position.

5. The head subassembly as set forth in claim **1** in which: the hanger means comprise a plate resting atop each fluid chamber vertically movable in response to changes in the volume thereof, bracket means supporting each hook means for pivotal movement located beneath the platform in substantial vertical alignment with one of said fluid chambers, and link means interconnecting said plate and bracket means for conjoint vertical movement independent of said platform.

6. The head subassembly as set forth in claim **4** in which: the latch means is operative in latched position to lock the hook means in either its released or engaged positions.

7. The head subassembly as set forth in claim **4** in which: spring means located between the platform and latch means normally bias the latter into latched position.

8. The head subassembly as set forth in claim **4** in which: the stop-carrying means each include projections positioned and adapted to move down alongside the fuel cell, said projections cooperating with one another to center same therebetween.

9. The head subassembly as set forth in claim **4** in which: the latch elements include vertically-disposed ears; and in which the hook means include a pair of notches in the upper edges thereof positioned to receive the ears in both the engaged and released positions of the latter upon movement of the latch means into latched position.

10. The head subassembly as set forth in claim **8** in which: the projections each include inwardly-chamfered lower end portions adapted to engage the top of the fuel cell and guide same into centered position therebetween.

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