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B. Q. BARRINGTON

3,347,318

WELL TOOL WITH ROTARY VALVE

Filed Nov. 24, 1965

2 Sheets-Sheet 1

FIG. 1

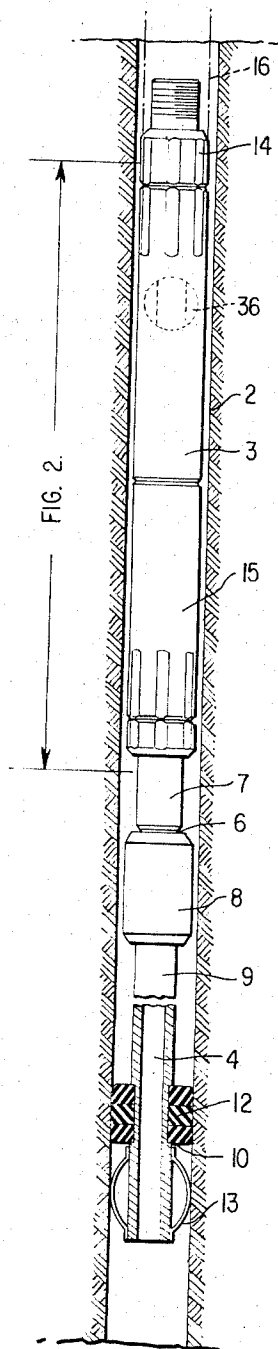


FIG. 2

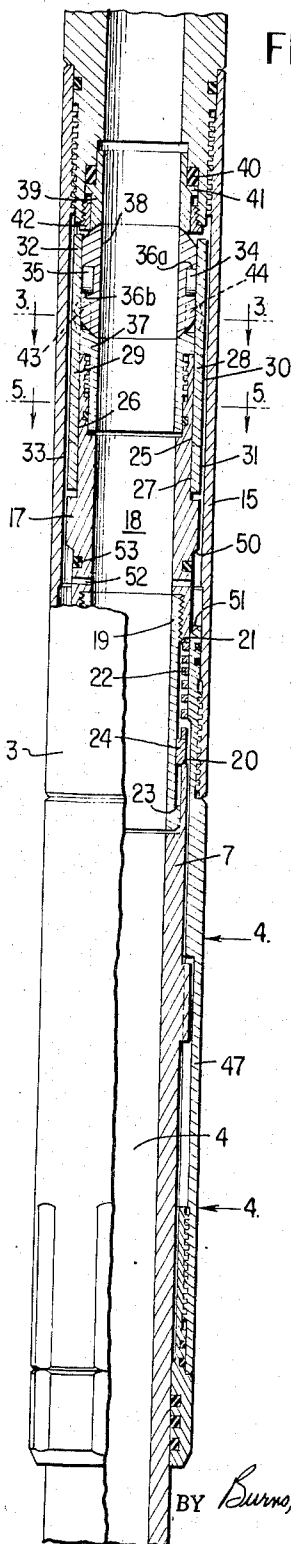


FIG. 3

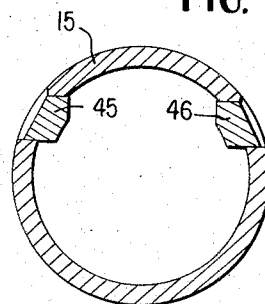


FIG. 5

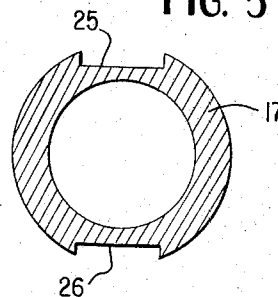
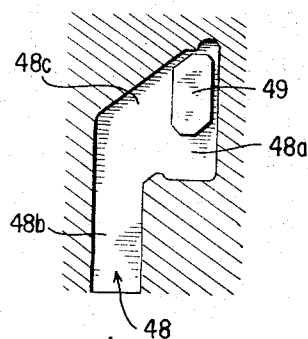


FIG. 4



INVENTOR
B. QUINTON BARRINGTON

BY *Burns, Roane, Benedict, Swecker & Mathis*

ATTORNEYS

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B. Q. BARRINGTON

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FIG. 6

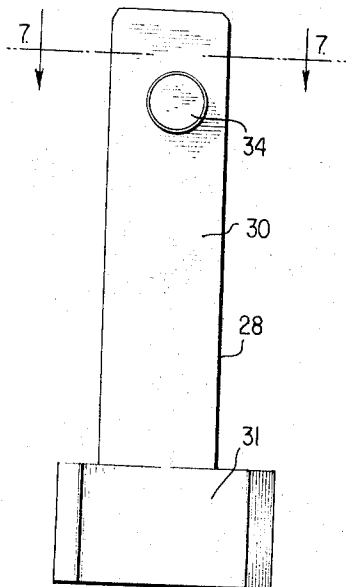


FIG. 7

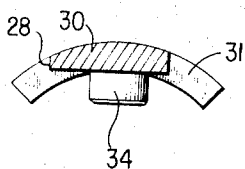


FIG. 9

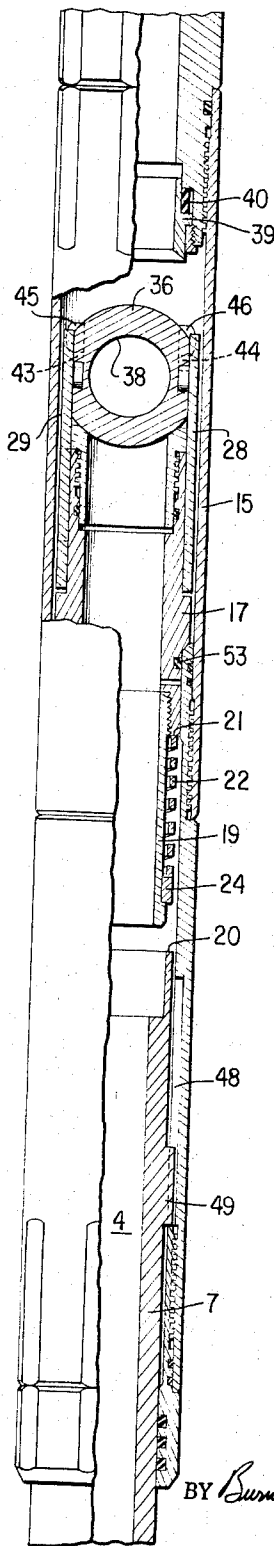


FIG. 8

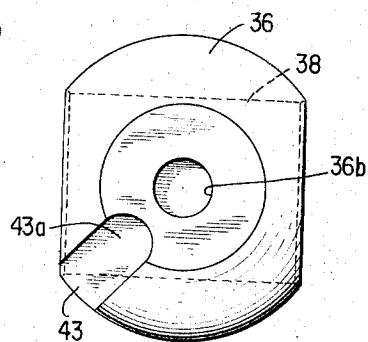
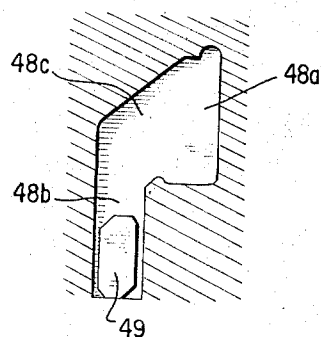


FIG. 10



INVENTOR
B. QUINTON BARRINGTON

BY *Burns, Davis, Benedict, Awecker & Mathis*

ATTORNEYS

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3,347,318

WELL TOOL WITH ROTARY VALVE

Burchus Q. Barrington, Duncan, Okla., assignor to Halliburton Company, Duncan, Okla., a corporation of Delaware

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4 Claims. (Cl. 166-226)

This invention relates to an apparatus for use in well bores. In particular it relates to apparatus for selectively controlling fluid flow through a passage in a well tool.

Many operations performed during the drilling and completion of wells require the transmittal of high pressure fluids through a conduit string which is disposed within a well bore. Complications and delays arise when conduits transmitting such high pressure fluids are not fluid tight and significant leakage occurs.

In order to minimize the possibility of excessive fluid leakage occurring during well completion or drilling operations, this invention contemplates the provision of an apparatus which enables conduit strings to be effectively leak tested.

It is a particular object of the invention to provide an apparatus which enables the pressure testing of conduits in response to reliable and controllable mechanical manipulations.

It is a further object of the invention to provide such an apparatus wherein shock resistance and a resilient holding action are simultaneously provided as a mechanism for controlling flow through a conduit passage is being manipulated or maintained in a particular position.

It is likewise an object of the invention to provide such an apparatus which is compatible with the utilization of a J-slot connecting mechanism joining and controlling relative axial movement between conduit portions.

It is also an object of the invention to provide such an apparatus which is characterized by unique structural simplicity, a high degree of operational reliability, and particular ease of assembly and maintenance.

The apparatus provided through this invention for accomplishing the foregoing objectives comprises conduit means adapted to be disposed within a well bore. The conduit means includes a first conduit portion and movement impeding means connected with the first conduit portion and engageable with a well portion to impede axial movement of the first conduit portion. The conduit means also includes a second conduit portion supported from a well head in a conventional fashion for axial movement relative to the first conduit portion. The apparatus additionally includes means defining a passage extending longitudinally of the conduit means, first abutment means mounted on the first conduit and second abutment means mounted for axial movement on the second conduit means. An axially and resiliently compressible means is interposed between the first and second abutment means. Valve operating means connected with the second abutment means operates in response to axial movement of the second conduit portion. Rotary valve means carried by the conduit means is operably connected with the valve operating means and adapted to control flow through the passage of the conduit means.

Particularly advantageous and significant features of the apparatus reside in structural characteristics of a mandrel, sleeve, coil spring, and valve supporting arms which comprise a novel, rotary valve carrying, assembly.

Of additional independent significance are the inter-related aspects of a J-slot connection and the previously noted coil spring which enable the rotary valve to be maintained in an open position even though valve operating elements are free to undergo relative axial movement to the extent necessary to accommodate operating characteristics of the J-slot connection.

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In describing the invention, reference will be made to a preferred embodiment illustrated in the accompanying drawings.

In these drawings:

FIGURE 1 is a fragmentary, schematic view of the interior of a well bore showing the lower end of a conduit string containing the passage control mechanism of the present invention;

FIGURE 2 is a schematic, fragmentary, enlarged and vertical sectioned view of the flow control portion of the FIGURE 1 assembly corresponding to the portion of FIGURE 1 associated with the reference indicator "FIGURE 2";

FIGURE 3 is a still further enlarged, horizontal and fragmentary, sectional view of an upper conduit portion of the FIGURE 2 assembly as viewed along the section line 3-3 of FIGURE 2;

FIGURE 4 is an enlarged, fragmentary, schematic, and vertical sectioned view of the flow control portion of the FIGURE 2 assembly, as viewed along a developed, cylindrical sectioning plane 4-4, and illustrating the J-slot elements as they are disposed when the rotary valve of the FIGURE 2 apparatus is in an open valve position;

FIGURE 5 is an enlarged, schematic, fragmentary and transverse sectional view of a mandrel portion of the FIGURE 2 assembly which serves to support a rotary valve, as viewed along the section line 5-5 of FIGURE 2;

FIGURE 6 is a still further enlarged view of one of the pair of valve supporting arms incorporated in the FIGURE 2 assembly and carried on the mandrel of that assembly;

FIGURE 7 is a transverse, sectional view of the FIGURE 6 arm as viewed along the section line 7-7 of FIGURE 6;

FIGURE 8 is an enlarged, external view of the rotary valve incorporated in the FIGURE 2 assembly and illustrating axle and cam sockets on one side of this valve;

FIGURE 9 schematically illustrates elements of the FIGURE 2 assembly as they are disposed when the rotary valve has been rotated to close and seal the conduit passage; and

FIGURE 10 schematically illustrates the components of the J-slot connection of the FIGURE 2 assembly as they are disposed when the tool elements are arranged as shown in FIGURE 9.

Structure

FIGURE 1 schematically illustrates the lower end of a conduit string 1 disposed within a well bore 2.

At the lower end of conduit string 1 is located a rotary valve mechanism 3 which serves to control the flow of fluid through a passage 4 extending longitudinally or axially of the conduit string 1. Passage 4, in the usual fashion, extends upwardly through the conduit string interior to a source of pressurized fluid at a well head, not shown.

In a conventional manner, the upper end of the conduit string 1 would be supported by hoisting equipment at the well head.

Conduit string 1 comprises a first or lower conduit portion 6 which includes a cylindrical component 7 of the valve assembly 3. Component 7 is connected by a conventional collar-like coupling 8 to a downwardly depending conduit section 9.

A conventional, and therefore only schematically shown, packer assembly 10 is mounted on the conduit section 9. Packer assembly 10 may include radially expandable packer elements 12 adapted to engage the inner periphery of the well bore 2. Packer 10 may include a conventional packer setting mechanism comprising the schematically illustrated drag springs 13 which frictionally engage the interior of the well bore 2.

Drag springs 13 frictionally engage the well bore 2 so as to impede axial and rotary movement of the first conduit portion 6. The impeding action of the drag springs 13 is sufficient to induce relative movement between portions of the conduit string so as to operate the valve assembly 3 in a manner hereinafter described. As will be understood, of course, when the packer 10 has been radially expanded into sealing and gripping engagement with the interior of the well bore 2, axial movement of the first conduit portion 6 will be even more positively impeded, i.e., from a practical standpoint, prevented.

Conduit string 1 includes a second conduit portion 14 comprising a cylinder-like upper component 15 of the valve assembly 3 and the portion 16 of the conduit string which is threadably connected with the cylinder 15 and extends upwardly to the previously described, well head located, hoisting equipment. Thus, as will be apparent, second conduit portion 14 is supported for axial movement relative to the first conduit portion 6 with the lower end 15 of the second conduit portion 14 being telescoped over the upper end 7 of the first conduit portion.

A mandrel 17 is supported within cylinder 15 for axial, slidable movement. Mandrel 17 has a central passage or opening 18 comprising a portion of the conduit string passage 4.

A generally cylindrical sleeve 19 is threadably connected with the lower end of the mandrel 17, as shown in FIGURE 2, and projects downwardly from the mandrel 17.

An annular shoulder 20 comprising first abutment means is formed by the upper end of the cylinder component 7 of the valve assembly 3. Annular shoulder 20 faces, and is generally aligned with, a superposed, downwardly facing, annular shoulder 21 comprising second abutment means. As illustrated, shoulder 21 is formed by the lowermost end of the mandrel 17.

A coil spring 22 is mounted on the outer periphery of the sleeve 19 and is retained on the sleeve between shoulder 21 and an annular sleeve rim 23. As illustrated, a spring ring 24 may be interposed between the lower end of the spring 22 and the sleeve shoulder 23. Spring 22 and ring 24, together, provide axially and resiliently compressible means.

As schematically shown in FIGURES 2 and 5, peripheral portions of the mandrel 17 define a pair of longitudinally extending slots 25 and 26 which extend upwardly from, and communicate with, an annular recess or slot 27. Longitudinal slots 25 and 26 are disposed on generally opposite sides of the mandrel 17 and project generally upwardly when the assembly 3 is disposed within a well bore.

Mandrel 17 and the interior of cylinder 15 cooperate to uniquely support a pair of rotary valve mounting arms 28 and 29. Arms 28 and 29 bear a mirror image relationship when disposed in the packer 2 assembly. Thus, it will suffice to describe the structural details of only one of these arms.

FIGURES 6 and 7 schematically illustrate structural details of representative arm 28. Arm 28 includes a longitudinal portion 30 which is disposed within the longitudinal mandrel slot 25 and projects upwardly beyond the upper end of the mandrel 17. Arm 28 includes, at its lower end, a generally transversely extending arcuate portion 31 which conforms to and is received within the arcuate mandrel slot 27. When the portions 30 and 31 of the arm 28 are received respectively within the slot portions 25 and 27 of the mandrel 17, radially outward movement of the arm 28 out of the mandrel slot portions is prevented by the restraining influence of the radially closely spaced, inner periphery of the cylinder 15. Similarly, the inner periphery of the cylinder 15 secures longitudinal and arcuate transverse portions 32 and 33, respectively, of the arm 29 within the slot portions 26 and 27 of the mandrel 17.

The arms 28 and 29 carry a pair of mutually facing and radially aligned stub axes 34 and 35. As illustrated, stub axle 34 projects radially inwardly from the upper end of the longitudinal portion 30 of the arm 28 while stub axle 35 projects inwardly from the longitudinal portion 32 of the arm 29.

A rotary valve 36 is journaled via axle sockets 36a and 36b on the stub axes 34 and 35 for rotation about an axis extending radially of the conduit axis 4. A conventional annular valve seat 37, threadably mounted on the upper end of the mandrel 17, wipingly engages the lower portion of the rotary valve 36.

As illustrated, rotary valve 36 includes a generally cylindrical inner wall 38 which defines a valve passage having a diameter substantially conforming to the identically sized inner diameters of the sleeve 19, mandrel 17 and valve seat 37.

An upper, annular valve seat 39 is supported within cylinder 15 above the rotary valve 36. Valve seat 39 has an inner diameter identical to that of seat 37 and is provided with a cushion mounting as schematically shown in FIGURES 2 and 9. This cushion mounting may be provided by resilient ring 40 which is disposed above a valve seat rim 41. A threaded ring 42, secures the valve seat 41 and the cushioning ring 40 within the cylinder 15 as generally shown in FIGURE 2. With this arrangement, the seat 39 resiliently resists upwardly movement of the valve 36.

FIGURES 2, 3, 8 and 9 schematically illustrate a camming arrangement which serves to rotate the ball valve 36 in response to axial movement of the second conduit portion 14 relative to the impeded or restrained first conduit portion 6.

This camming mechanism comprises a pair of parallel cam slots 43 and 44 formed on opposite sides of the outer periphery of the body of the ball valve 36. A pair of pin-like cam followers 45 and 46 project toward each other into the interior of the cylinder 15 as generally shown in FIGURE 3. Pins 45 and 46 are mounted in apertured wall portions of the cylinder 15, as schematically shown in FIGURE 3, and are secured by conventional fastening techniques such as welding.

Pin 45 projects into the cam slot 43, generally perpendicular to the base 43a of this slot. Similarly, pin 46 projects generally perpendicularly into the slot 44. As shown, camming pins 45 and 46 as well as cam slots 43 and 44 are disposed laterally of the axis of rotation of the valve 36 as defined by the axes of the stub axes 34 and 35.

With this arrangement, movement of the mandrel 17 and arms 28 and 29 will cause rotation of the valve body 36. This rotation results from the camming effect of the pins 45 and 46 on the cam slots 43 and 44.

Upper cylinder 15 is connected with the lower cylinder 7 through a J-slot connection 47 comprising a radially inwardly opening J-slot 48. Slot 48 is formed on the inner periphery of the cylinder 15 and a lug 49 projects radially outwardly from the inner cylinder 7 into this slot 48.

J-slot 48 includes a relatively short, longitudinally extending portion 48a, a relatively long and axially offset, longitudinally extending slot portion 48b, and a transversely extending slot portion 48c. Slot portion 48c serves to interconnect the two longitudinal portions 48a and 48b.

As shown in FIGURE 2, when the lug 49 is disposed in the slot portion 48a the rotary valve 36 is disposed such that the passage of valve 36 is axially aligned with the conduit string such that the passage 4 is open. When the lug 49 is disposed in the lower end of the slot portion 48b, as shown in FIGURE 9, the passage through the valve body 36 extends transversely of the conduit string such that the conduit string passage 4 is closed.

Camming cooperation between the pins 45 and 46 and the valve body cam slots 43 and 44 is maintained by a downwardly facing mandrel shoulder 50 which is

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superposed above and faces an upwardly facing annular shoulder 51 carried on the interior of the cylinder 15. During the raising of the cylinder 15, as when the J-slot 48 is being manipulated, engagement between the shoulders 50 and 51 serves to limit the rotation of the valve body 36 so as to maintain the pins 45 and 46 within their respective valve body cam slots.

When the valving assembly 3 is disposed as shown in FIGURE 2, i.e., with the valve body 36 rotated to an open valve or open passage position, the coil spring means, comprising spring 22 and spring ring 24, is compressibly engaged at opposite axial ends by first annular abutment 20 and second annular abutment 22. This compression of the spring 22 is maintained regardless of the position of the lug 49 within the slot portion 48a as a consequence of selecting an appropriate axial length for the spring 22. Thus, even though limited axial movement between the cylinders 15 and 7 is possible when the lug 49 is disposed in the slot 48a, such movement will not cause rotation of the valve body 36 owing to the biasing action of the coil spring 22. The coil spring 22, when the apparatus elements are disposed as shown in FIGURE 2, will exert an upward force on the mandrel 17 so as to hold the valve body 36 against the upper seat 39 and thus prevent rotation of the valve body 36.

In order to avoid obscuring the most significant features of the preferred tool embodiment, many conventional structural details of the tool have been simplified. However, it should be noted that the tool includes mandrel vents or radial ports 52 which serve to prevent fluid entrapment on the outside of the mandrel which might impede mandrel movement. The mandrel also is provided with an outwardly facing, annular seal 53. As shown in FIGURE 9, when the valve 36 is in the closed passage position, the seal 53 engages an inner wall portion of the cylinder 15 so as to effectively seal the mandrel and valve assembly to the cylinder 15. In this manner, fluid flow around the outside of the mandrel so as to bypass the valve 36 is effectively prevented.

As will be appreciated, cylindrical components of the assembly 3 may be fabricated from a plurality of threadably interconnected sections, as schematically shown in FIGURES 2 and 9.

Mode of operation

It is generally contemplated that the valve assembly shown in FIGURE 3 will be disposed on the lower end of a conduit string being assembled and lowered into a well bore.

As the string is being lowered, the valve assembly will be disposed as shown in FIGURE 2. After a string section has been lowered to the extent desired, it may then be pressure tested. Such pressure testing is effected merely by raising the second conduit portion 14 and rotating the conduit portion 14 counterclockwise. The first conduit portion 6 will be restrained against axial and rotational movement by the drag springs 13. Thus, the lifting and counterclockwise rotation of the conduit portion 14 will move the lug 49 into the lower end of the slot portion 48b as shown in FIGURE 10.

During the initial portion of this movement of the conduit portion 14, the compression in the spring 22 will be relieved. Once this compression is relieved, the remainder of the upward movement of the conduit portion 14 will cause the pins 45 and 46 to cooperate with the cam slots 43 and 44 and rotate the valve body 36 to the closed position shown in FIGURE 9. In this connection it should be understood that the weight of the mandrel 17, sleeve 19, coil spring 22, arms 28 and 29, valve seat 37, and valve body 36 will be sufficient to cause the camming of the valve body to take place. In other words, the weight of the valve and the assembly on which it is mounted is sufficient to hold the assembly in a lower position as the casing 15 is being raised such

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that the casing mounted pins 45 and 46 may cause the rotation of the valve 36.

As shown in FIGURE 9 when the valve 36 has rotated to a closed position, the seat 39 will have been raised above the rotated valve. As will be appreciated, the raising of the valve seat 39 away from the valve body 36 while it is being rotated facilitates the rotation of the valve.

After the valve has been positioned as shown in FIGURE 9, fluid within the conduit portion 14, as supplied from a well head source, may be pressurized so as to test the string for leaks.

After the testing operation has been completed, the conduit portion 14 may be lowered and turned clockwise to reverse the sequence of events previously described and restore the valve 36 to the open valve position shown in FIGURE 2. Additional sections of the string may then be added, the augmented string lowered, and again tested. As will be appreciated, this procedure may be repeated as often as desired.

Once the string has been completely assembled, tested and lowered the valve 36 may be opened, if desired, to facilitate the transmittal of fluid or the movement of equipment or tools through the conduit passage 4.

Advantages and scope of invention

In describing the structure and mode of operation of the preferred embodiment of the apparatus, several advantages of the invention have been demonstrated.

The mechanically induced mode of operation of the valve assembly 3 provides a uniquely positive, responsive, and predictable valve action. Operation of the valve is not dependent upon the flow of fluids which at times may be undesirable or difficult to effect.

Significantly, the valve assembly is cushioned at opposite axial ends by the seat cushion 40 and the mandrel spring 22. This tends to provide a resiliently secured and seated valve which prolongs the operating life of the tool components and minimizes the likelihood of breakage.

The coil spring associated with the mandrel is especially significant in that it tends to secure the valve in an open valve position even though limited axial movement of the valve movement inducing, upper conduit portion takes place.

The slotted mandrel and arm assembly provides a uniquely simplified but structurally rugged arrangement for effectively supporting a rotary valve and facilitating the mounting or removal of the valve.

In describing the invention, reference has been made to a preferred embodiment. However, those skilled in the art and familiar with the disclosure of the invention may well recognize addition, deletions, substitutions or other modifications which would fall within the purview of the invention as defined in the appended claims.

I claim:

1. An apparatus for controlling passage means in a well bore, said apparatus comprising:

conduit means adapted to be disposed within a well bore and including

a first conduit portion,

movement impeding means connected with said first conduit portion and engageable with a well portion to impede axial movement of said first conduit portion, and

a second conduit portion supported for axial movement relative to said first conduit portion;

means defining a passage extending longitudinally of said conduit means;

first abutment means mounted on said first conduit portion;

second abutment means mounted for axial movement within said second conduit means;

axially and resiliently compressible means between said first and second abutment means;

valve operating means connected with said second abutment means and operable in response to axial movement of said second conduit portion; and rotary valve means carried by said conduit means operably connected with said valve operating means, and adapted to control fluid flow through said passage. 5

2. An apparatus as described in claim 1 including: a mandrel mounted for axial movement within said second conduit portion, said mandrel having a longitudinally extending opening comprising a portion of said passage; 10

a sleeve connected with and projecting from said mandrel generally toward said first abutment means and defining a continuation of said opening;

an annular shoulder on said mandrel defining said second abutment means; 15

a coil spring mounted on said sleeve, extending axially from said annular shoulder toward said first abutment means, and defining said compressible means; portions of the outer periphery of said mandrel defining a pair of generally longitudinally extending slots extending from a generally annular slot; 20

a pair of arms, each arm having a longitudinal portion disposed in one of said longitudinal slots and extending generally longitudinally away from said coil spring and further having an arcuate portion extending transversely of said longitudinal portion and disposed in said annular slot, said arms being retained on said mandrel by said second conduit portion; and 25

a pair of mutually facing stub axles extending generally radially of said conduit means, each stub axle being carried by one of said arms; 30

said rotary valve means being journaled on said stub axles.

3. An apparatus as described in claim 2 including: 35

J-slot connecting means between said first and second conduit portions and including

a first, longitudinally extending slot portion on one of said conduit portions,

a second, longitudinally extending slot portion on said one of said conduit portions,

a generally laterally extending slot portion extending between and connecting said first and second slot portions and cooperating therewith to define a J-slot, and

a lug carried by the other of said conduit portions and projecting into said J-slot;

the longitudinal extent of said first slot portion being greater than the extent of axial movement of said second conduit portion required to cause said rotary valve means to rotate from a fully closed to a fully open condition; and

said coil spring, as a result of compressing engagement of said first abutment means with said coil spring, being operable to hold said rotary valve means in said fully open position when said lug of said J-slot connecting means is in any portion of said first portion of said J-slot.

4. An apparatus as described in claim 3 including: an annular valve seat adapted to engage said rotary valve means on the side of said valve axially opposite from the location of said mandrel; and resilient cushioning means engaging said valve seat so as to resiliently resist movement of said seat away from said rotary valve.

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JAMES A. LEPPINK, *Primary Examiner*.