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[45] Patented **Aug. 24, 1971**
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[54] **WELL PRODUCTION APPARATUS WITH FLUID OPERATED VALVE**
3 Claims, 23 Drawing Figs.

[52] U.S. Cl. **166/85,**
166/87, 166/224

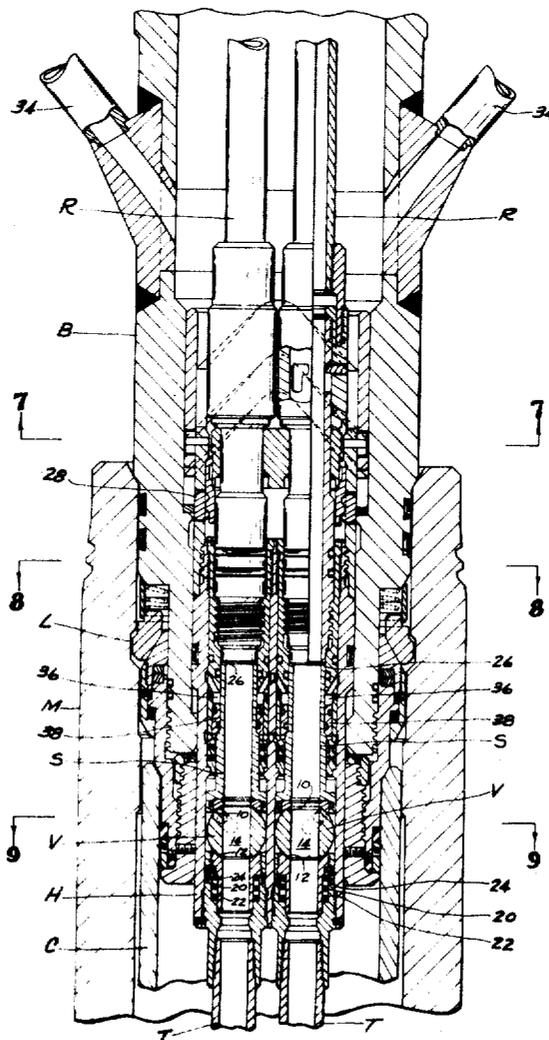
[51] Int. Cl. **E21b 33/04**

[50] Field of Search 166/.5, .6,
75, 85-87, 95, 97, 72, 224; 251/89

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ABSTRACT: A well production apparatus including an improved valve adapted to be positioned in a well production string and operated responsive to a pressure fluid from the wellhead to open and close flow through the production string. The valve is positioned in the tubing hanger and is retained in open position during running by engagement with the running string.



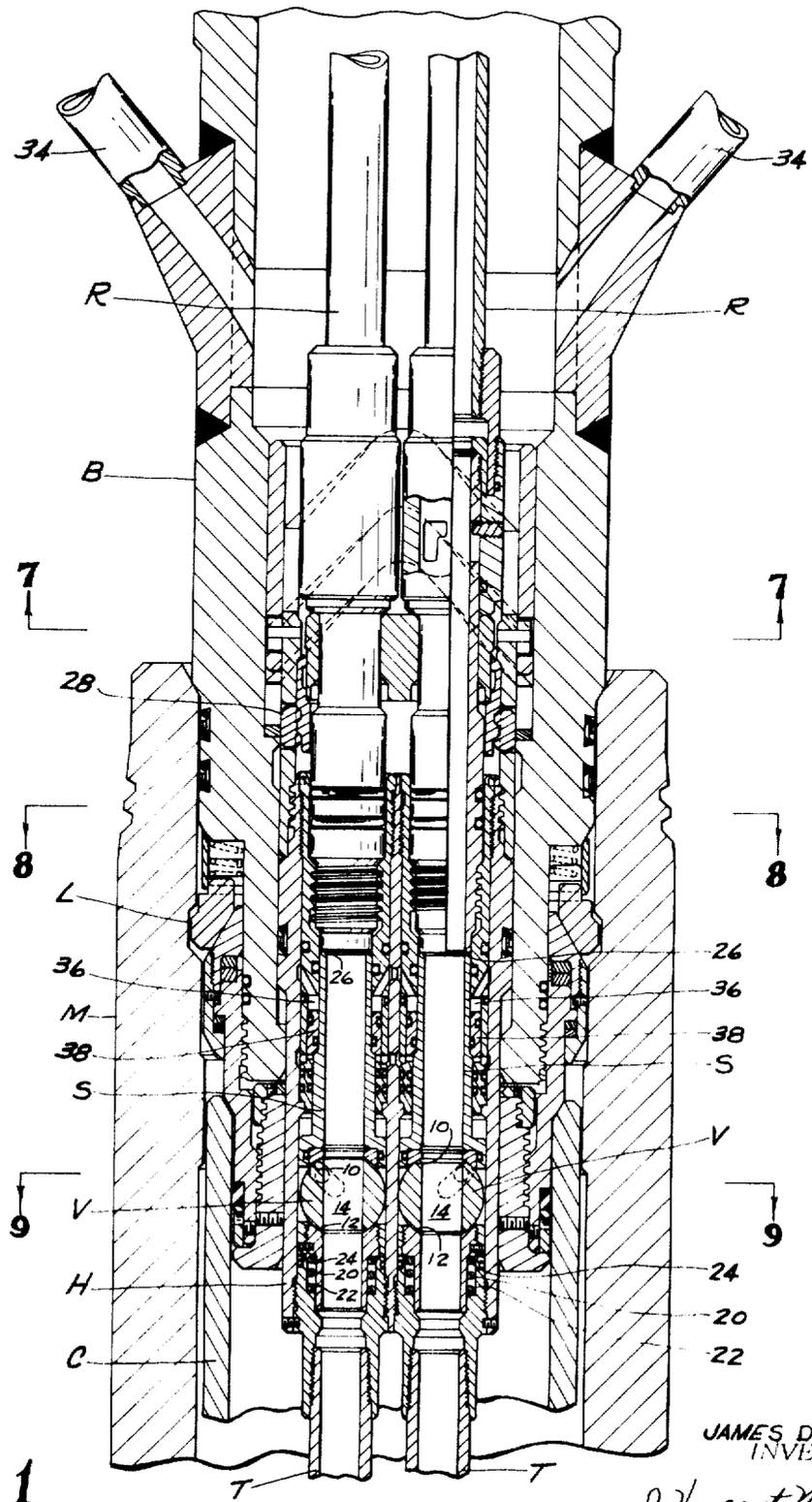


Fig. 1

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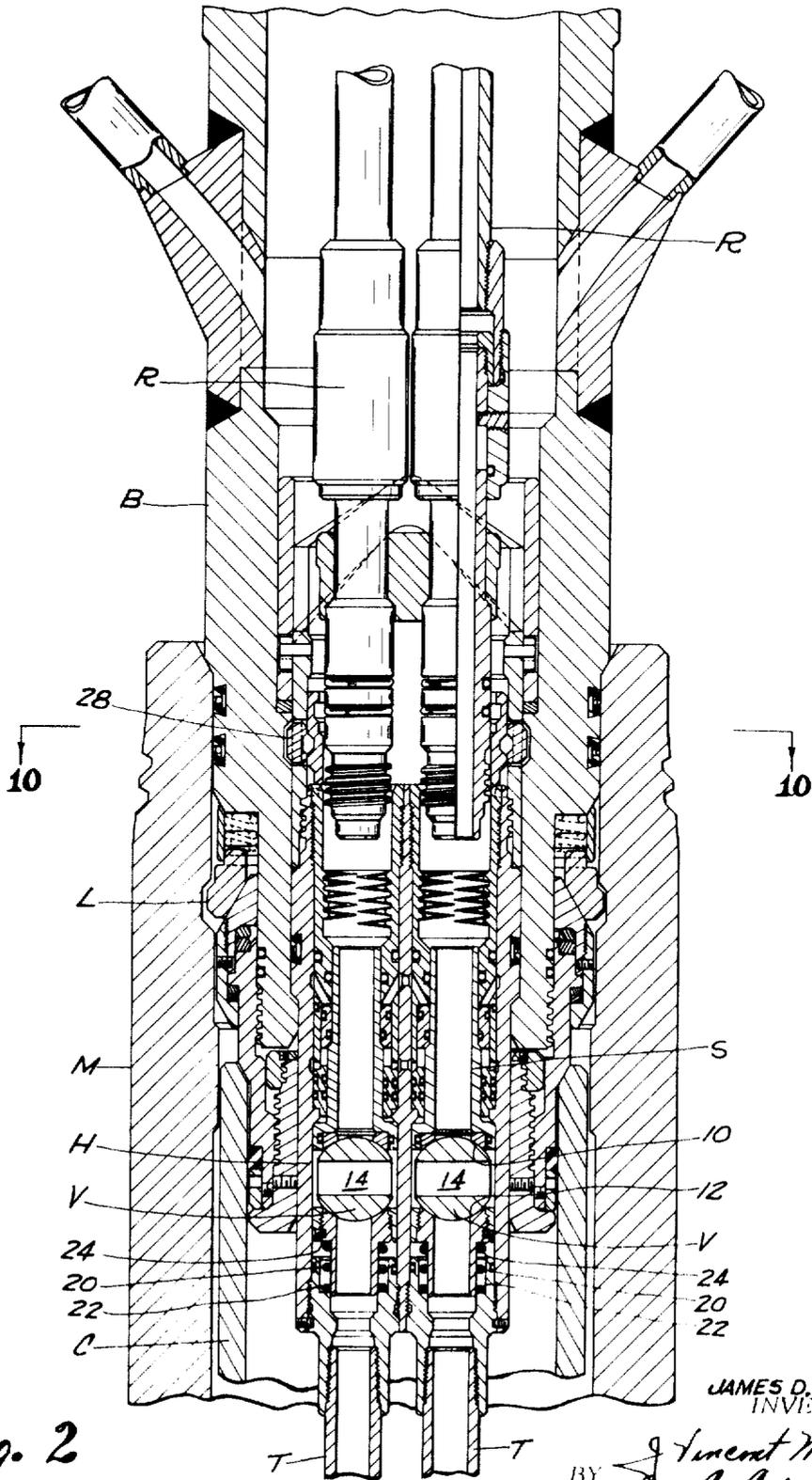


Fig. 2

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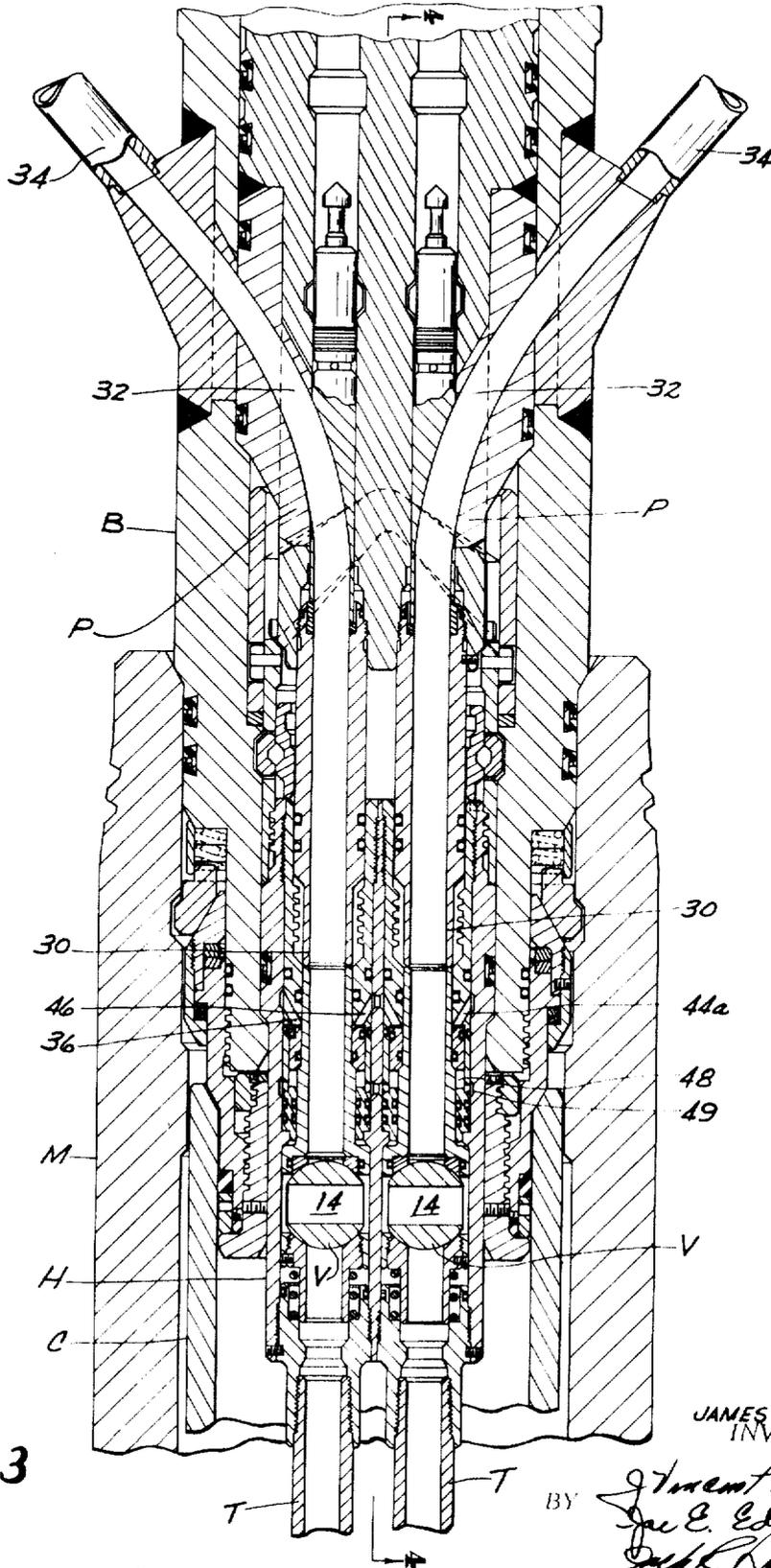


Fig. 3

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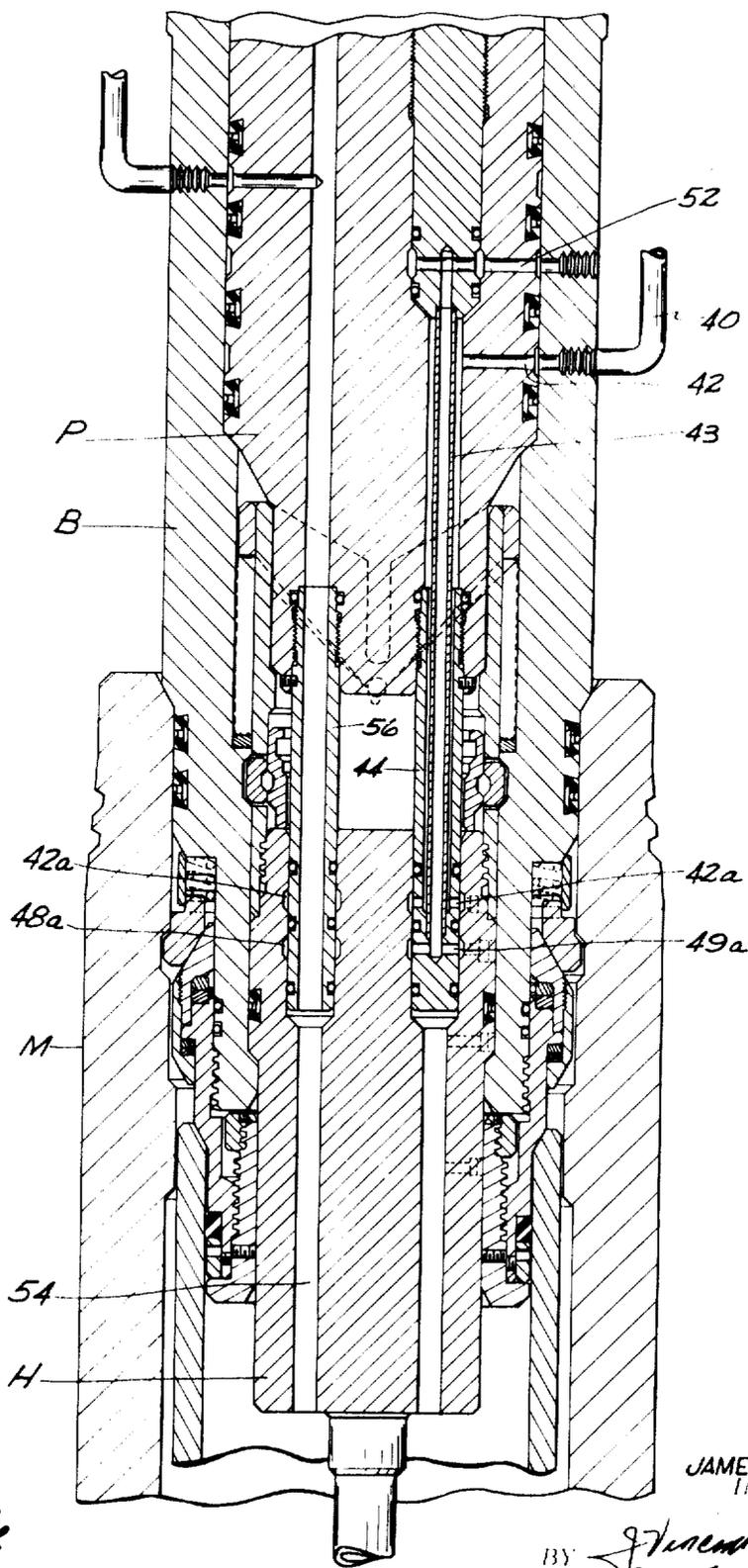


Fig. 4

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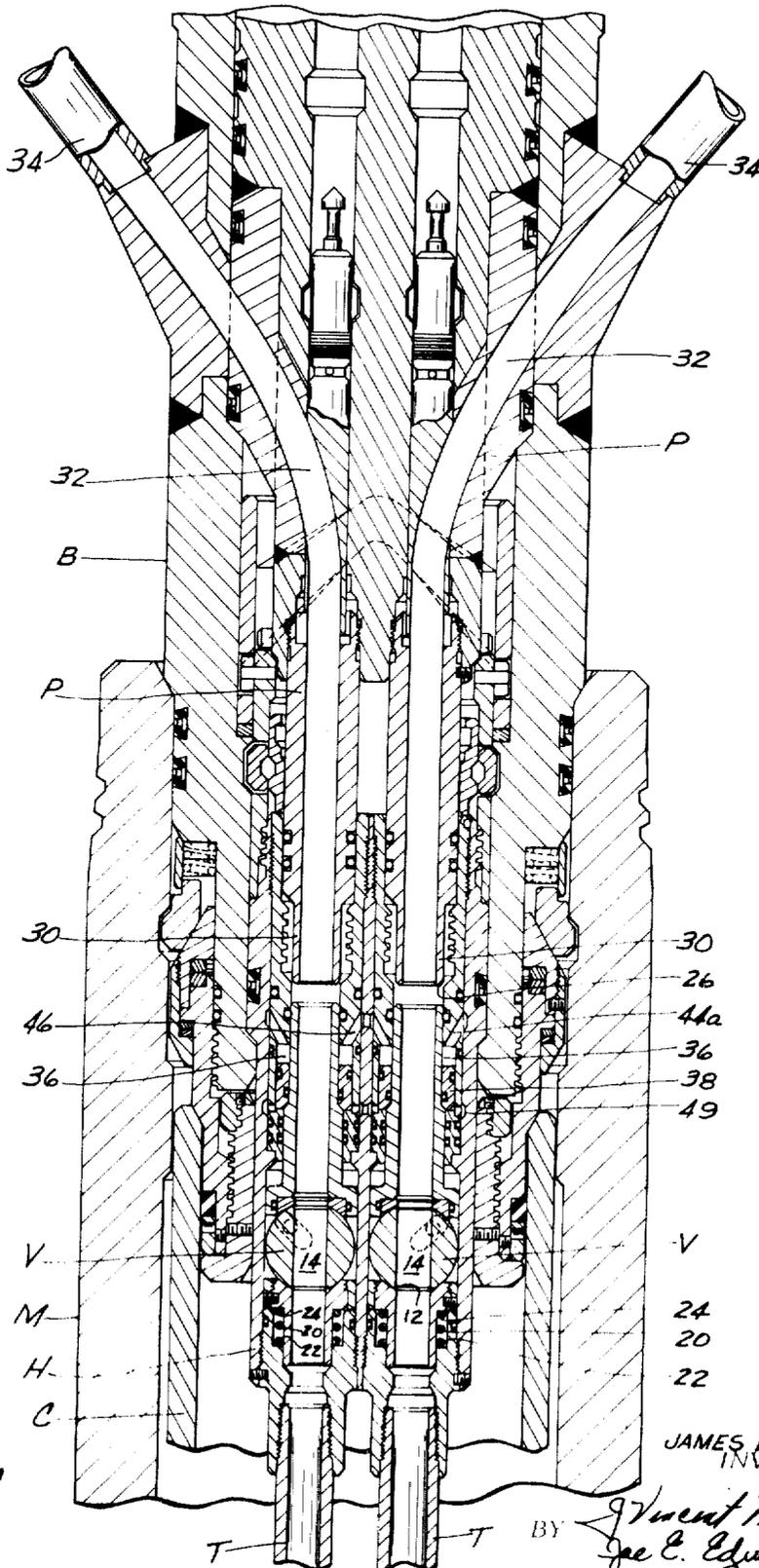
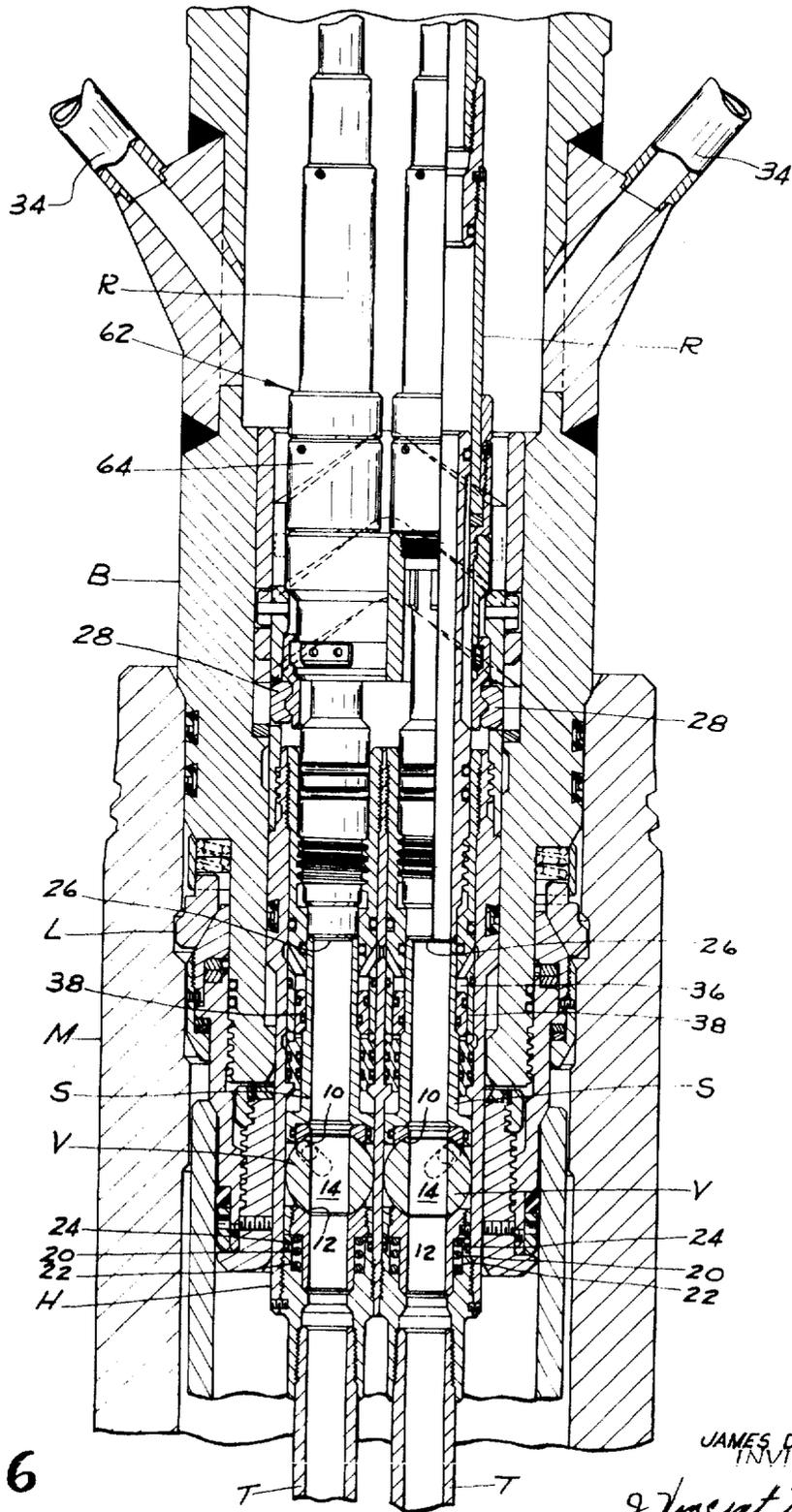


Fig. 5

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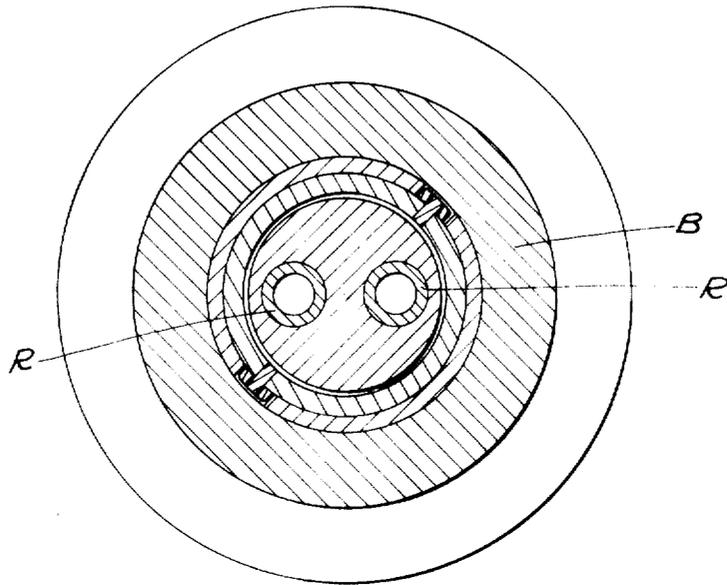


Fig. 7

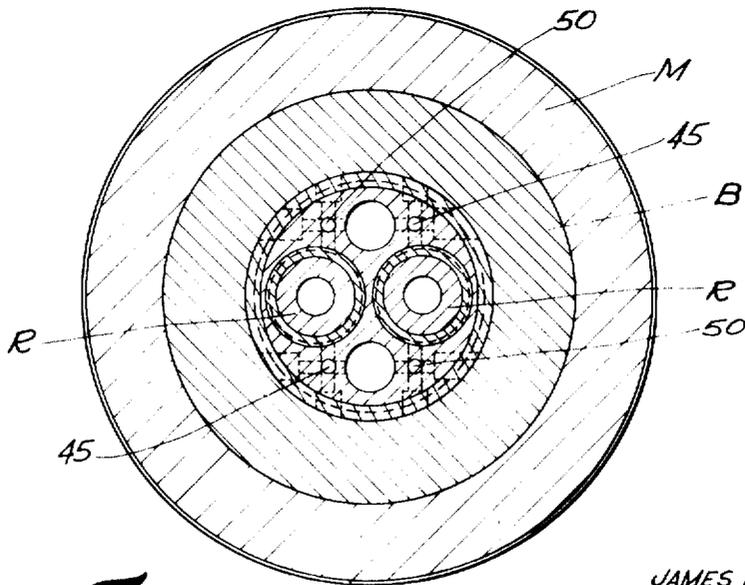


Fig. 8

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Fig. 9

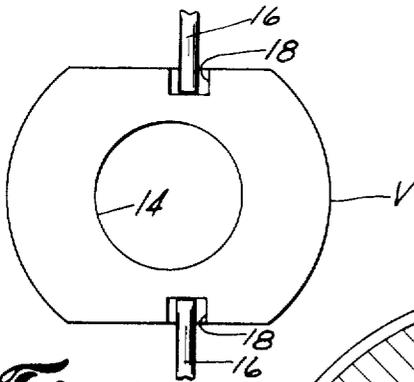
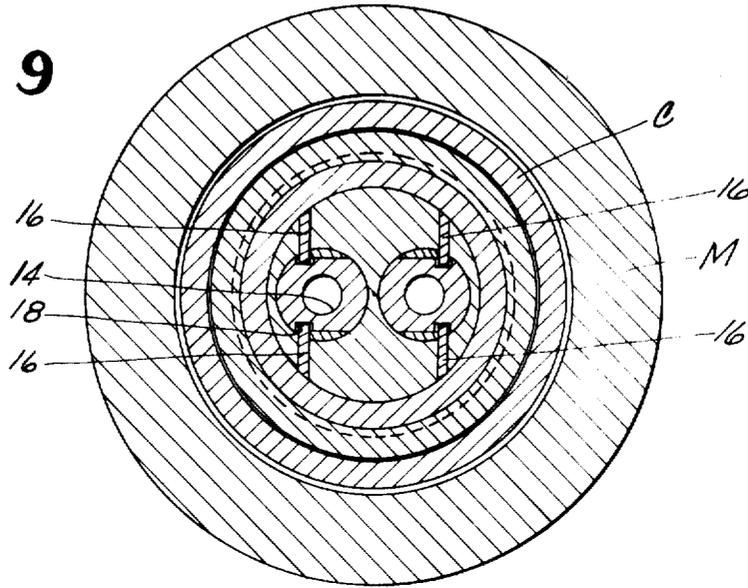


Fig. 12

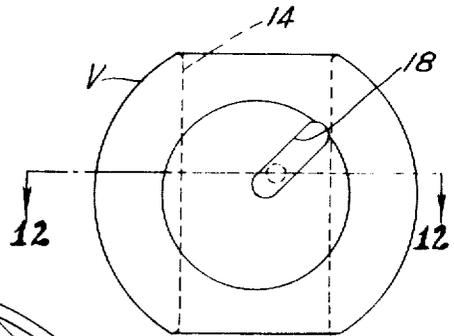


Fig. 11

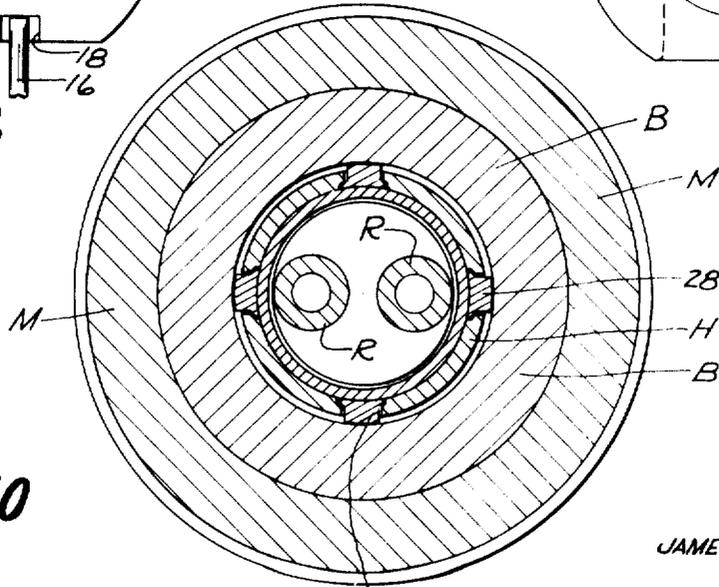


Fig. 10

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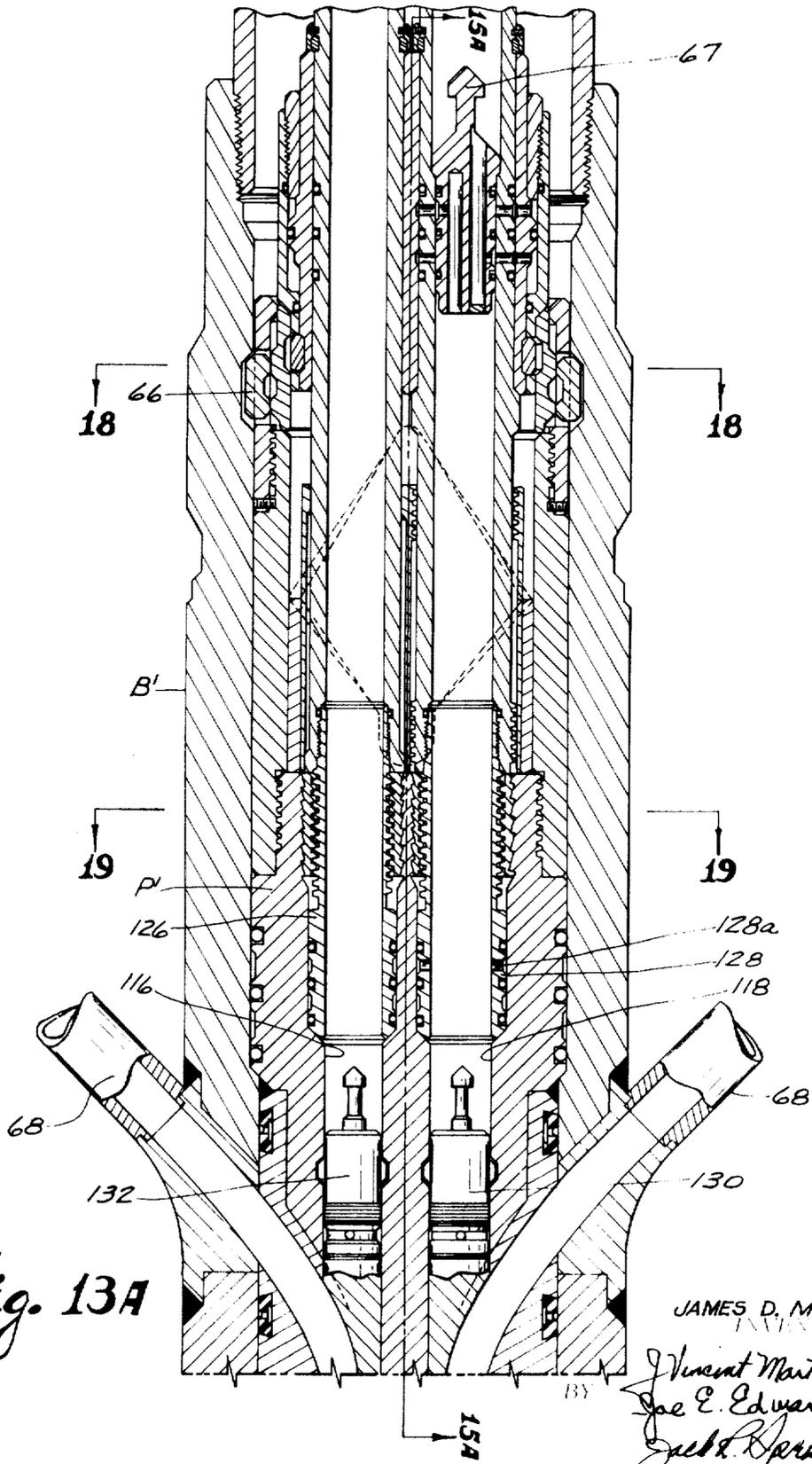


Fig. 13A

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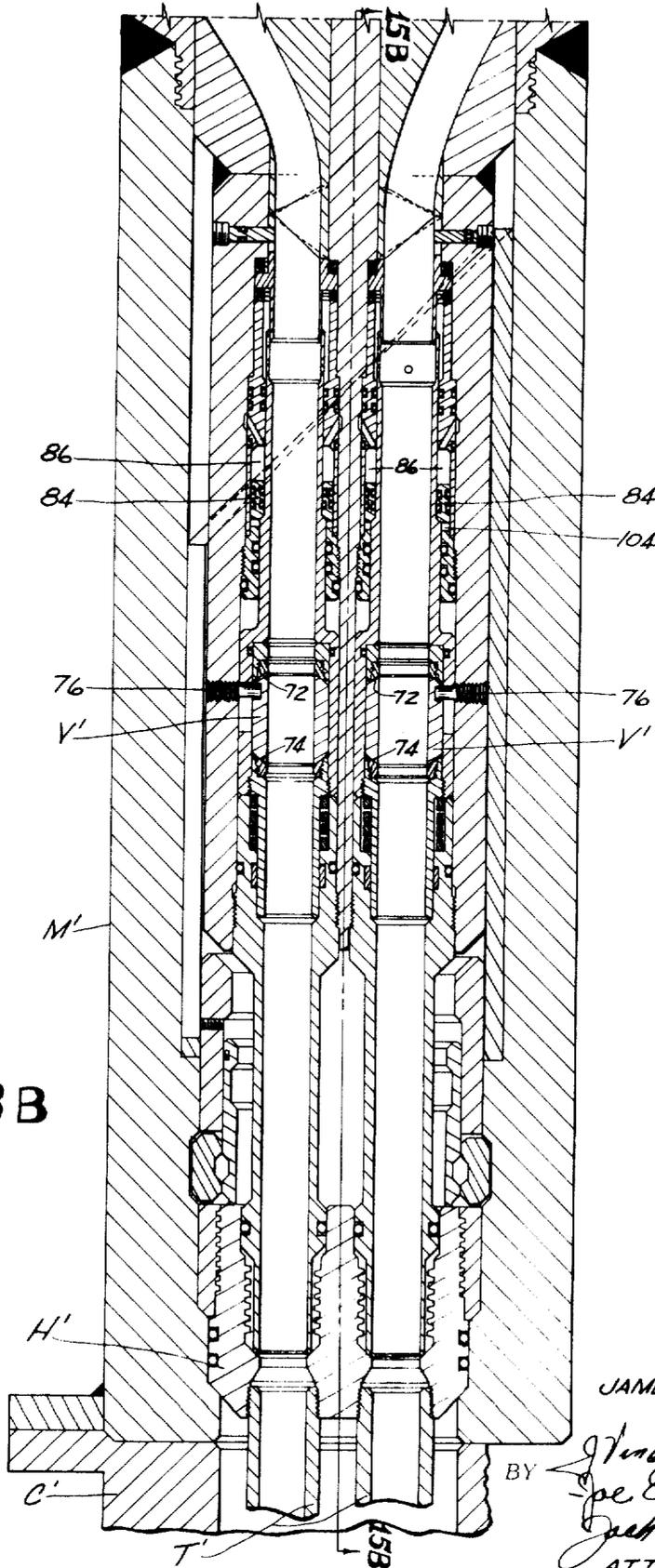


Fig. 13B

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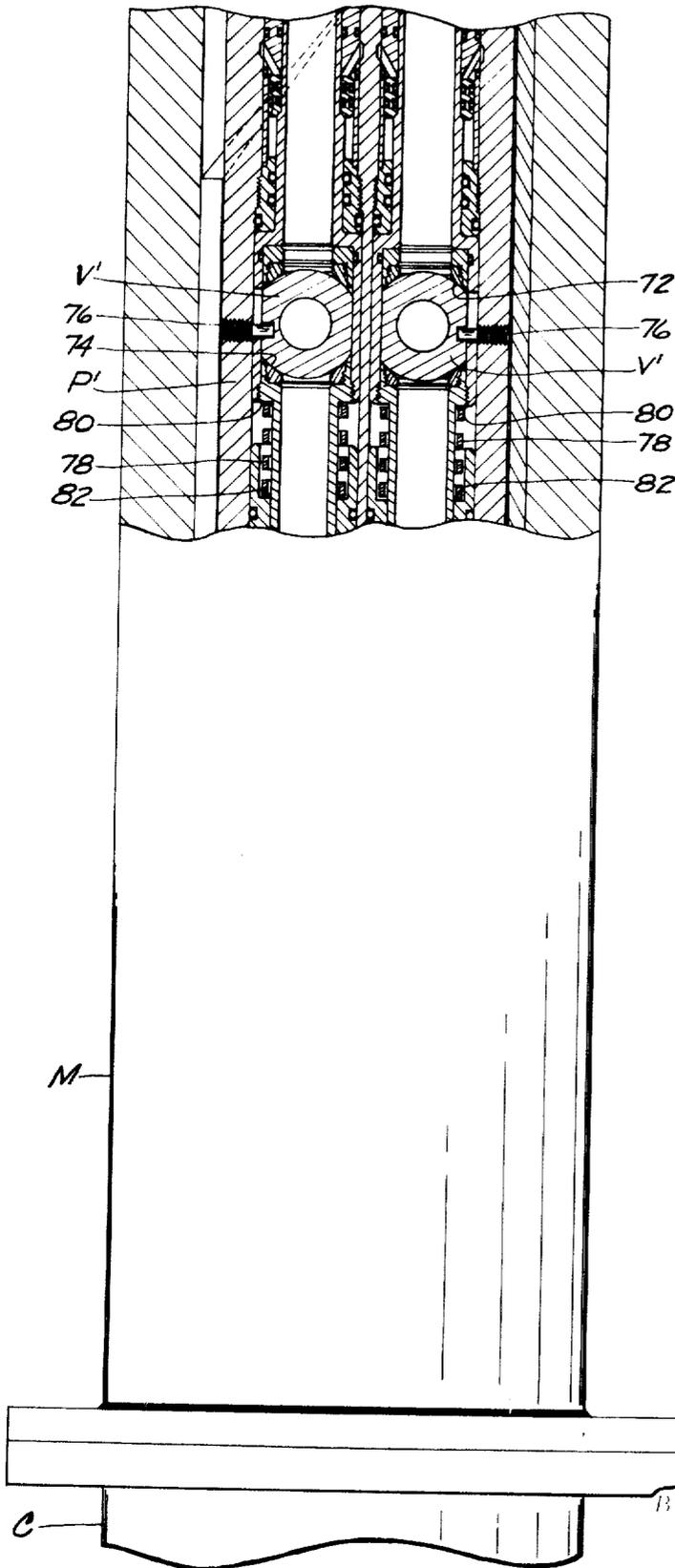


Fig. 14

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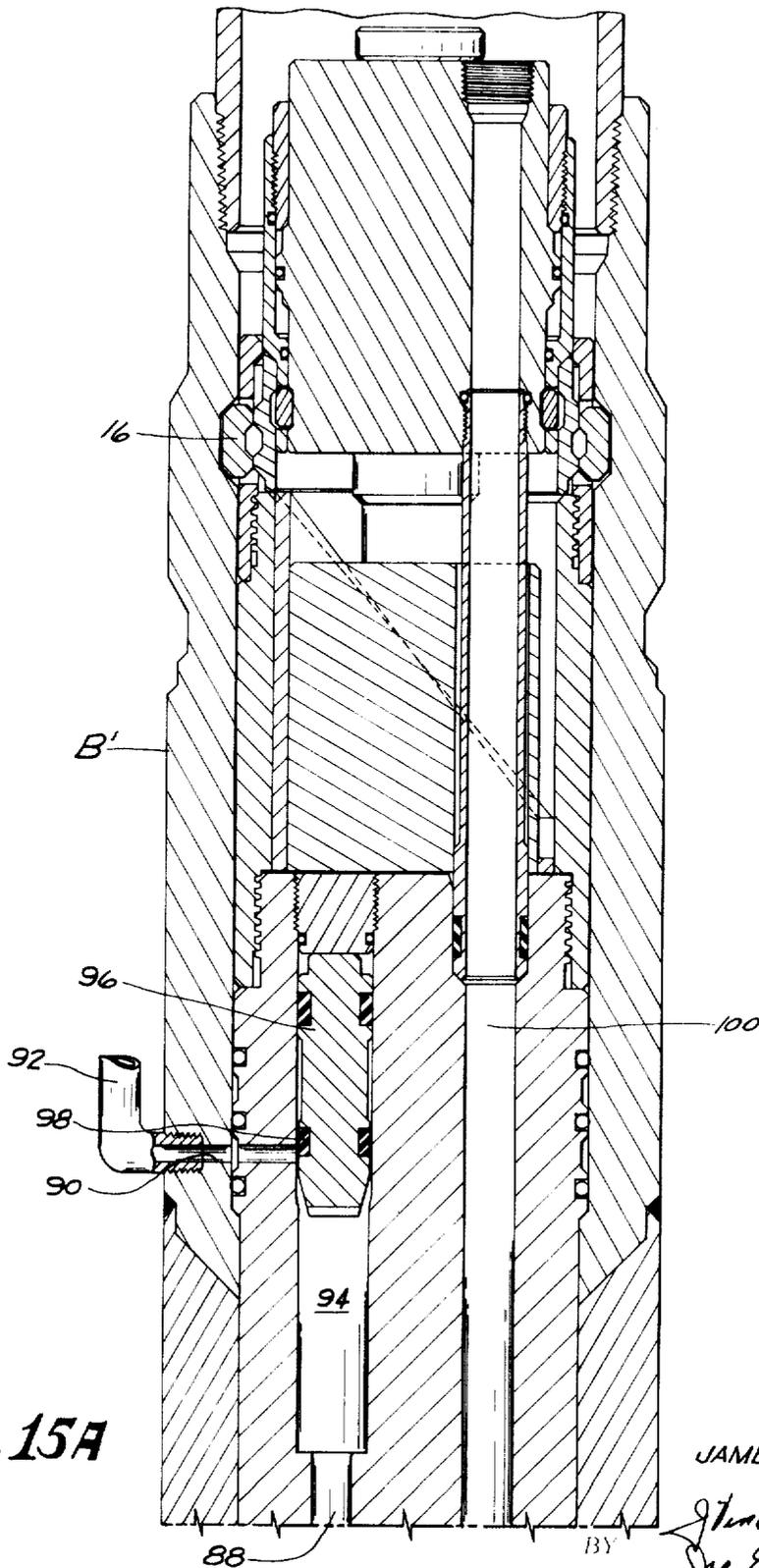


Fig. 15A

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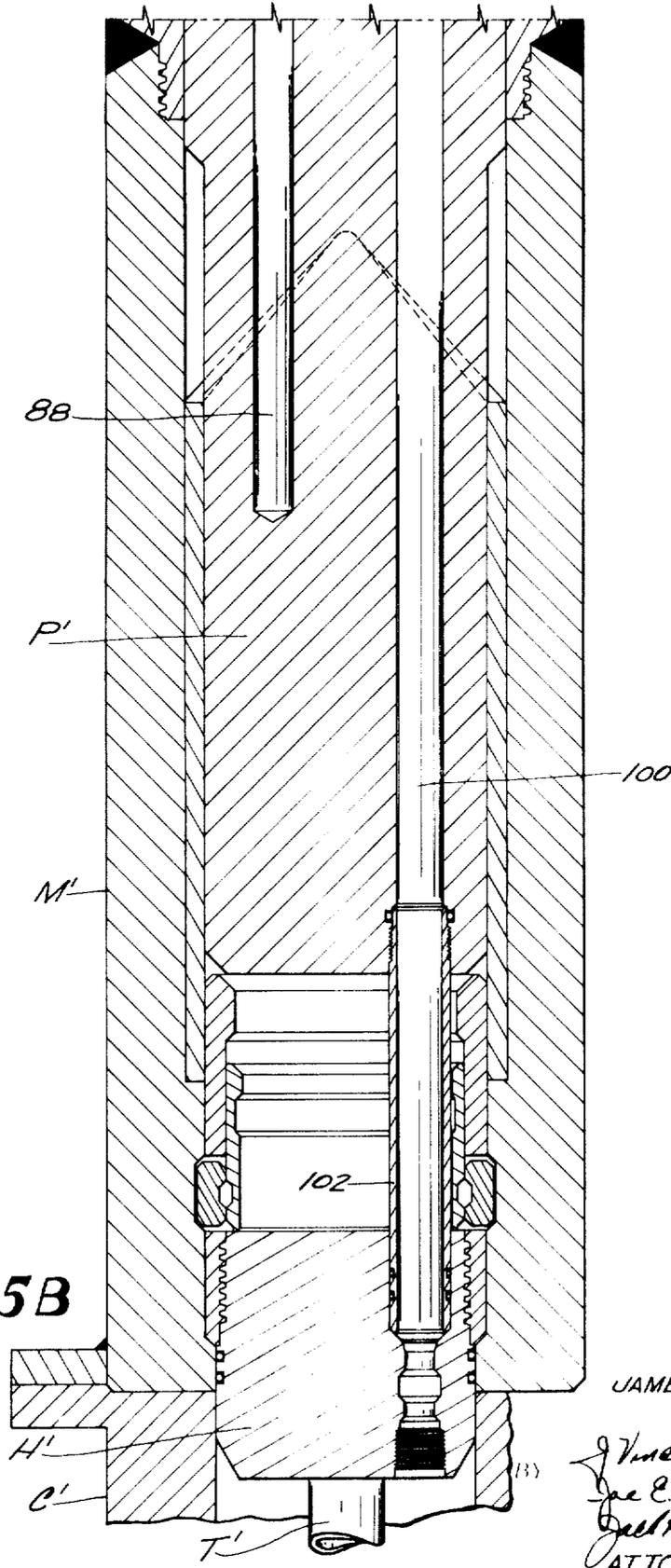


Fig. 15B

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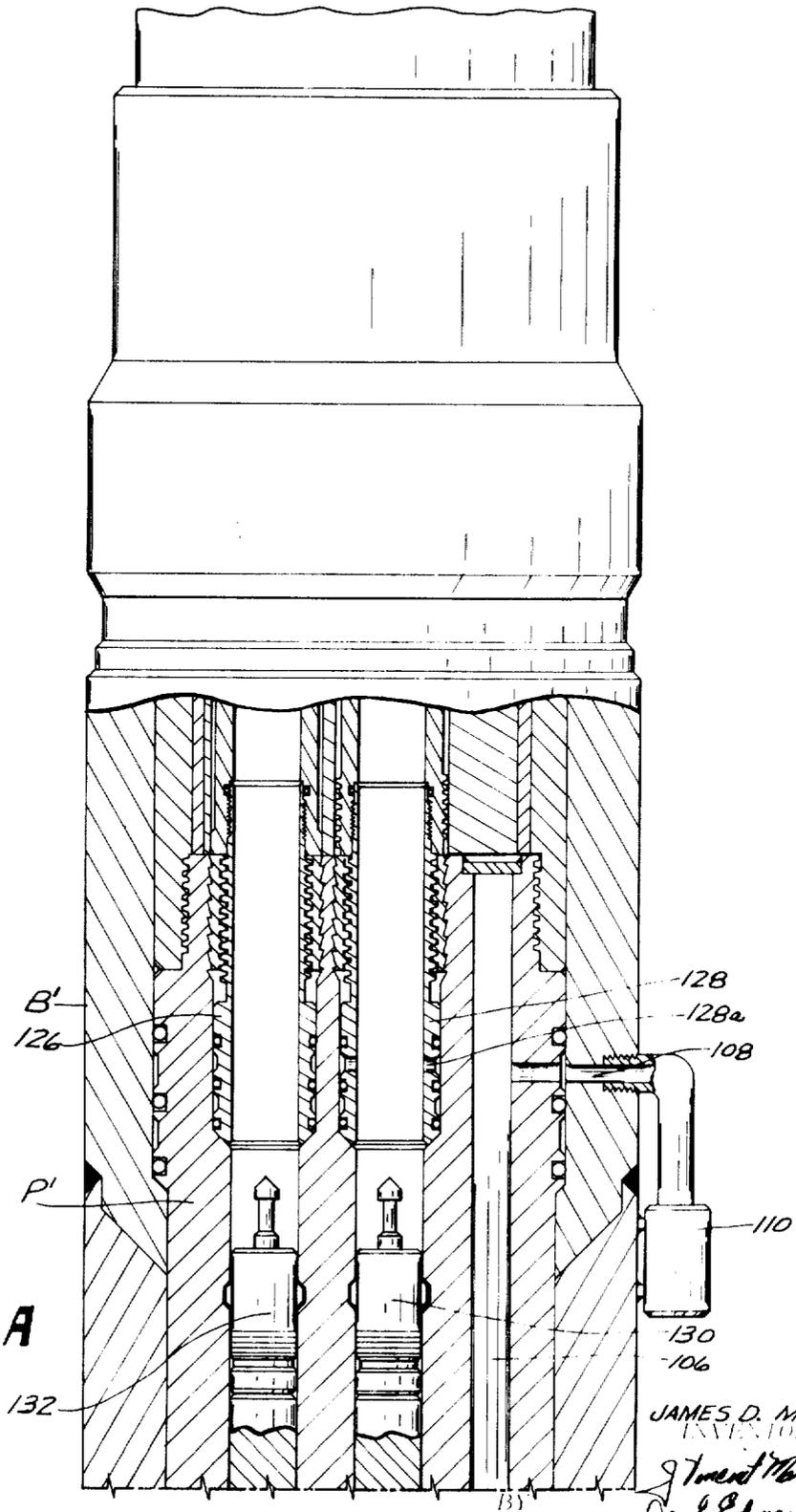


Fig. 16A

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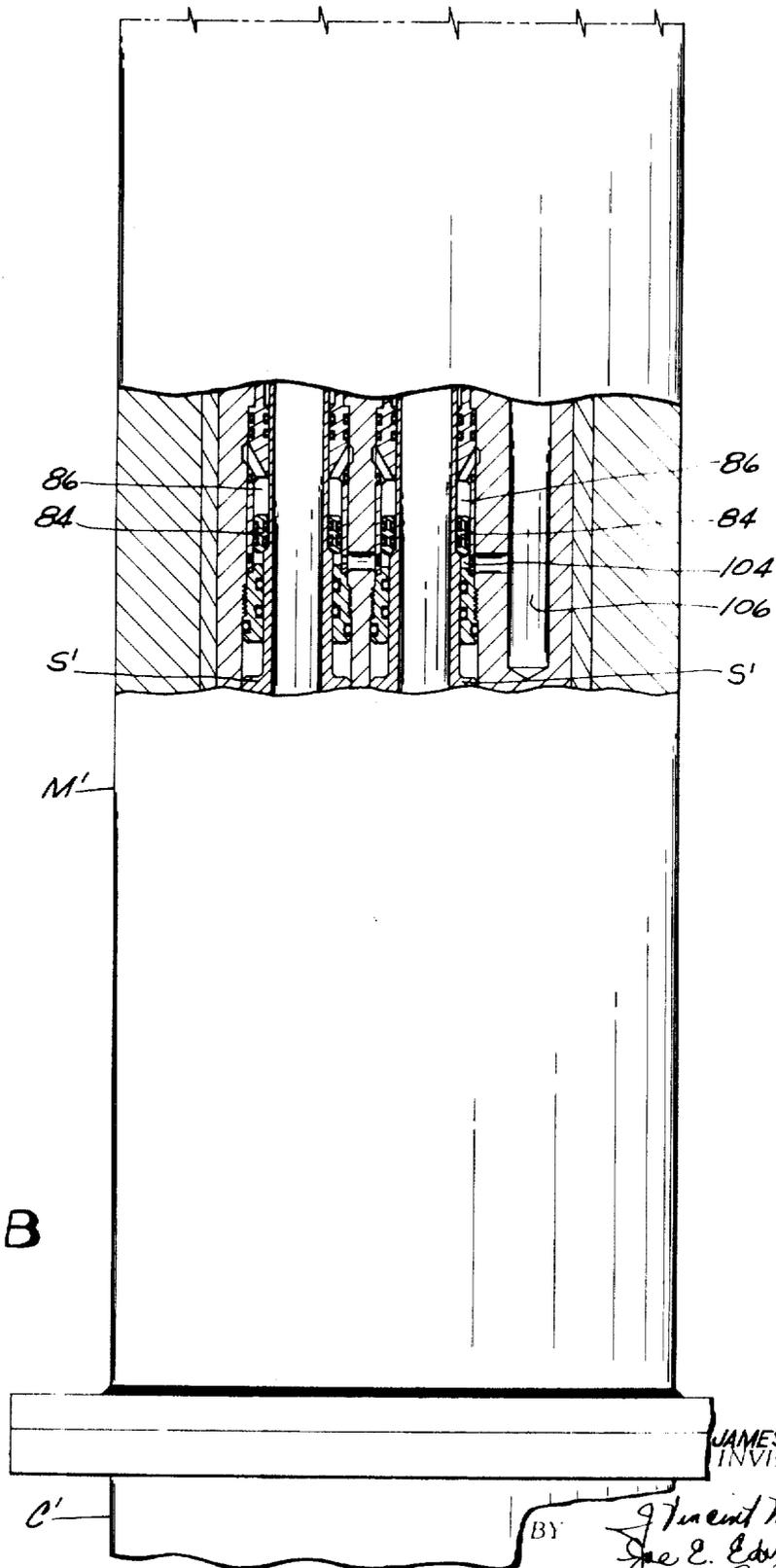


Fig. 16B

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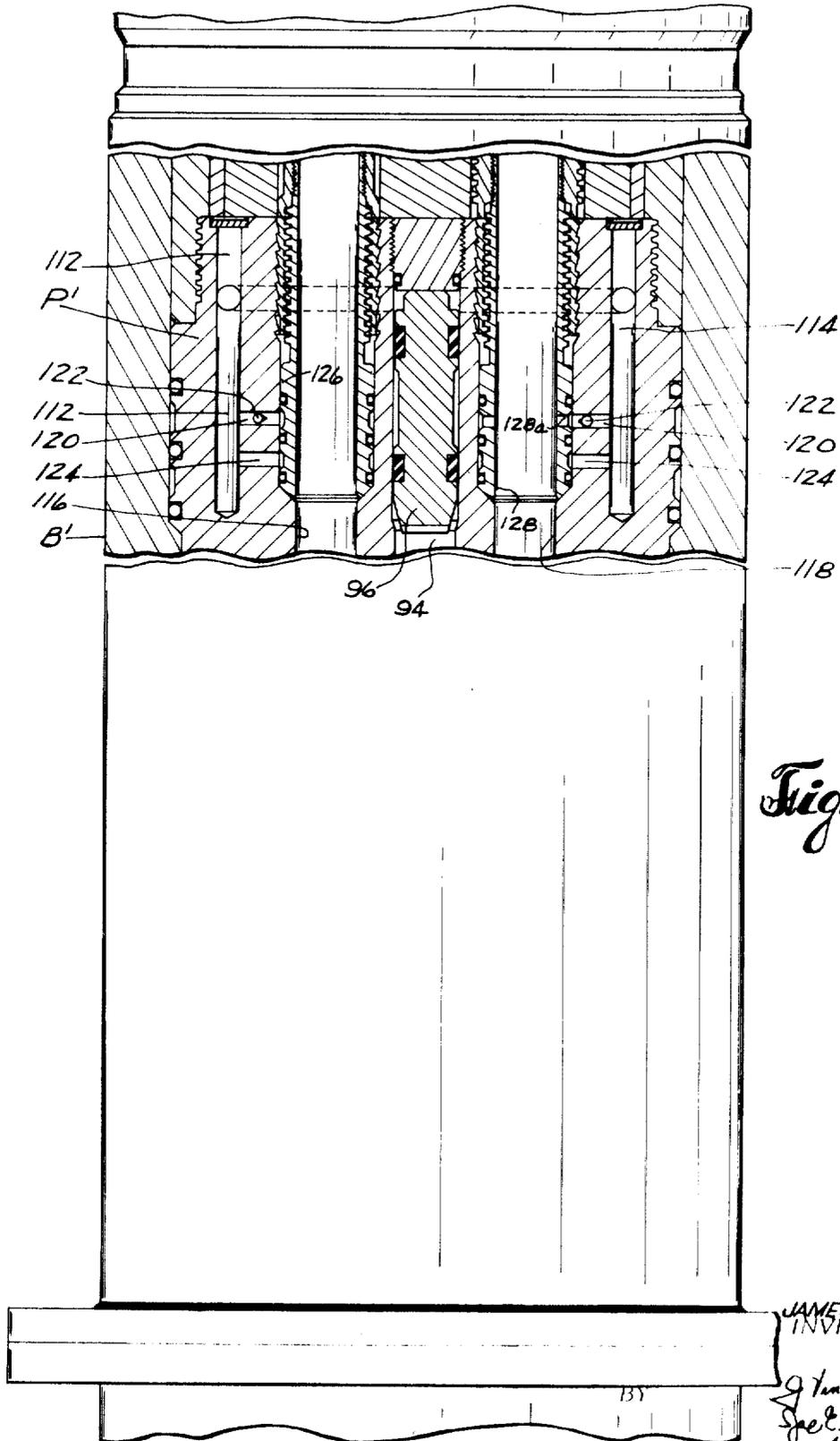


Fig. 17

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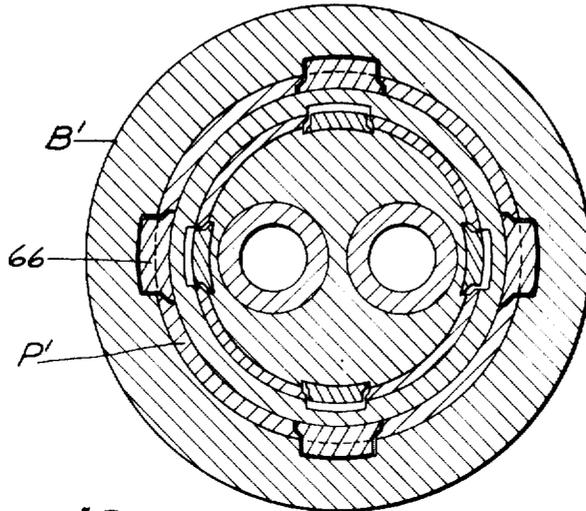


Fig. 18

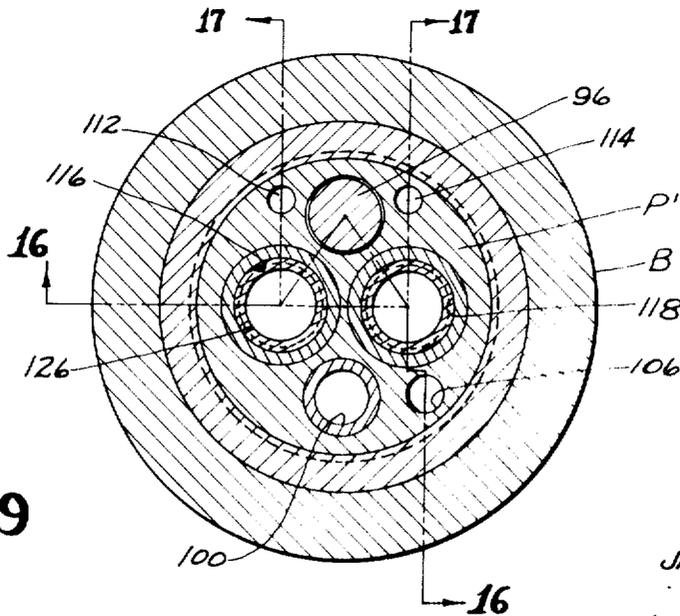


Fig. 19

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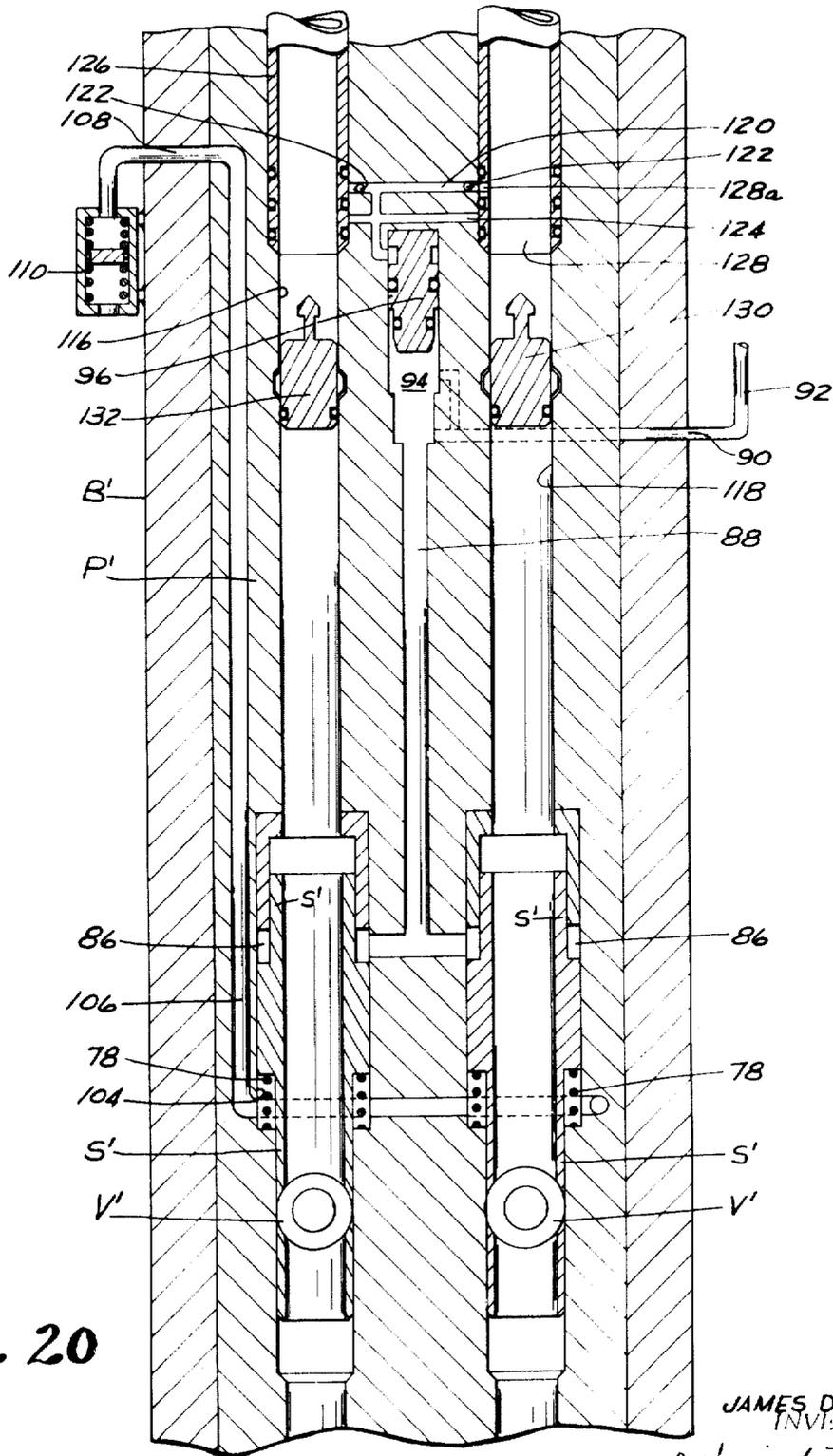


Fig. 20

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WELL PRODUCTION APPARATUS WITH FLUID OPERATED VALVE

SUMMARY

The present invention relates to a well production apparatus including an improved remotely operated valve.

An object of the present invention is to provide an improved valve for a production string which is easily and positively controlled from the wellhead.

Another object is to provide an improved well string in which the production flow may be controlled from a remote position.

Still another object is to provide an improved production well string which is suitable for an underwater well and which includes a remote controlled valve for controlling the production through the production string.

Still a further object is to provide an improved remotely controlled valve for a production string which may be pulled and replaced without pulling the production tubing.

A still further object of the present invention is to provide an improved remotely controlled valve structure which may be installed on each string of dual completion well production strings to control the production flow therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention are hereinafter set forth and explained with reference to the forms of the present invention illustrated in the drawings wherein:

FIG. 1 is a sectional view of the upper end of a dual production string well including the remote control tubing valve, with the strings and tubing hanger being run into a well on a running tool.

FIG. 2 is a sectional view of the structure shown in FIG. 1 illustrating the running tool being removed and showing the closing of the tubing valves.

FIG. 3 is another sectional view of the same structure illustrating the diverter plug in landed position and the tubing valves closed.

FIG. 4 is a longitudinal sectional view taken along lines 4—4 in FIG. 3 to show the control passages for the tubing valves.

FIG. 5 is a sectional view similar to FIG. 3 but showing the tubing valves in open position.

FIG. 6 is another sectional view of the well structure illustrating the removal of the tubing hanger and the tubing string.

FIG. 7 is a sectional view taken along line 7—7 in FIG. 1 illustrating the orienting of the tubing hanger in the body.

FIG. 8 is a sectional view taken along line 8—8 in FIG. 1 to illustrate the passages communicating to the tubing valves.

FIG. 9 is another sectional view taken along line 9—9 in FIG. 1 through the tubing valves.

FIG. 10 is a transverse sectional view taken along line 10—10 in FIG. 1 showing the latching means for the tubing hanger structure.

FIG. 11 is an elevation view of the ball valve used in the present invention.

FIG. 12 is a plan view of the ball valve shown in FIG. 11.

FIGS. 13A and 13B (13B being the lower extension of 13A) are sectional views of the preferred form of structure of the present invention with the tubing valves held open.

FIG. 14 is a partial sectional view of the structure shown in FIGS. 13A and 13B showing the tubing valves in closed position.

FIGS. 15A and 15B are sectional views taken along lines 15A—15A and 15B—15B in FIGS. 13A and 13B, respectively.

FIGS. 16A and 16B are partial sectional view of the structure of the preferred form of the present invention to illustrate the control passages for the tubing valves taken along line 16—16 in FIG. 19.

FIG. 17 is another sectional view to show the control passages for the tubing valves taken along line 17—17 in FIG. 19.

FIG. 18 is a transverse sectional view taken along line 18—18 in FIG. 13A.

FIG. 19 is a transverse sectional view taken along line 19—19 in FIG. 13A.

5 FIG. 20 is a schematic sectional view of the control system of the preferred form of the invention for the tubing valves.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 The structure illustrated in FIGS. 1 through 10 is a typical underwater well completion embodying the improved valve of the present invention in each of the dual production strings. This structure includes the mandrel M which supports the casing C, the dual string tubing hanger H which supports the tubing strings T, and the completion means, such as the diverter body B, which is suitably secured in the mandrel M by the latch L.

As shown in FIG. 1, the running strings R are running the tubing strings T and the tubing hanger H into position within the diverter body B. The remotely controlled ball valves V are mounted in the sleeves S which are slidably positioned within the bores through the tubing hanger H. The valves V are retained in open position by the running strings R during running as shown in FIG. 1 and hereinafter explained.

25 The ball valves V are retained between an upper seat 10 and a lower seat 12 defined in the sleeves S. The ball valves V have a generally spherical shape with a bore 14 extending through the ball valves and include a means for actuation between open and closed positions responsive to axial movement of the sleeves S. Such actuation means includes the pins 16 which are secured in the tubing hanger H and extend through slots in the sleeve S into the grooves 18 defined in the sides of the valves V. Thus, as sleeves S and valves V move axially of the hanger H, the engagement of the pins 16 in the grooves 18 causes the ball valves V to rotate. The open or closed positions of the valves V are thus determined by the position of the sleeves S in the hanger H.

30 The valves V are open, i.e., their bores 14 register with the bores of the sleeves S above and below the valves, when the sleeves S are in their lowermost position with respect to tubing hanger H. The sleeves S are also biased in an upward direction by a biasing means so that the valves V are biased toward their closed position. The biasing means includes the springs 20 which surround the lower portions of sleeves S and are confined between the upwardly facing internal shoulders 22 on the tubing hanger and the downwardly facing external shoulders 24 on the sleeves S.

45 In running tubing strings T, it is desired that the strings remain open. As previously mentioned, the running strings R retain the valves V in open position during running by the engagement of the lower end 26 of the running strings R with the upper ends of the sleeves S. Since the strings R thread into the hanger H above the sleeves S, the position of the lower end 26 of strings R is preselected to engage the sleeves S and retain the sleeves S in their lowermost position against the force of the springs 20. This is clearly illustrated in FIG. 1. When the tubing hanger has been landed and is latched into position in body B by the latch 28 which is seen in FIG. 10, then the running strings R are removed. The removal of the running strings R is shown in FIG. 2. As shown, the upward threading of the running strings R allows the sleeves S to move upwardly responsive to the force exerted by springs 20 closing the valves V.

50 Before production can be commenced, the diverter plug P is lowered into position within the diverter body B as shown in FIG. 3. The diverter plug P latches in seated position in body B and has the stingers 30 which engage within the upper end of the bores in the tubing hanger H. The lower end of the stingers 30 engage the upper end of sleeve S in its upper position but do not move the sleeve S downwardly. The diverter plug P defines the production passages 32 to the production lines 34. When the valves V are open, the production lines 34 are in communication with the interiors of their respective tubing strings T.

The valves V are positioned in the sleeves S to control the flow through the tubing strings T and are provided with a means of controlling flow by opening and closing the valves from a position remote from the tubing hanger H, such as at the surface in an underwater completion. Since the valves V open and close responsive to movement of the sleeves S, a means is needed to move the sleeves S downwardly against the forces developed by the springs 20. Such means is provided by making the sleeves S responsive to pressure. The pressure chambers 36 are defined within the tubing hanger H above the seal rings 38. Fluid pressure in the pressure chambers 36 is exerted on the seal rings 38 to urge the sleeves S downwardly. When the pressure is sufficient to overcome the force of the springs 20, the sleeve S moves downwardly to the position shown in FIG. 5, opening valves V.

In order to remotely control the position of the valves V, a fluid communication means is provided to the pressure chambers 36. Such fluid communication means is shown in FIG. 4 and includes the fluid line 40 which communicates through the passages 42 in the body B, the plug P and the space around tube 43 in the stinger 44, the groove 44a to the passages 45 and 46 in the tubing hanger H, which passages 46 are in communication with the pressure chambers 36. Communication between the groove 42a to the groove 44a is provided by one of the passages 45. Fluid pressure from the chambers 48 on the opposite side of the seal rings 38 is equalized with the pressure around body B through the groove 49, the passage 50 to groove 49a, through the interior of the tube 43 in stinger 44 and the passage 52 through plug P and body B. If desired, a line may be connected to the passage 52 to control the fluid pressure in the chambers 48. Also, both of the bores through tubing hanger H as shown are provided with grooves 42a and 48a. One each of the passages 45 and 50 provide communication to their respective grooves from 44a and 49 to the grooves 42a and 49a. In this way valves V may be remotely operated with the stinger 43 in either one of these bores through the tubing hanger H.

The fluid pressure in the casing annulus below tubing hanger H is conducted to a remote location by the passage 54 through hanger H, through stinger 56, the passages 58 in plug P and body B and the line 60. Normally line 60 is connected to a pressure gauge at the location of the controls for the valves V.

As shown in the drawings, all of the fluid passages are properly sealed so that when it is desired to open valves V, fluid pressure is supplied through line 40 and the remainder of the communication means to the chambers 36 causing the sleeves S to move downward thereby opening the valves V as shown in FIG. 5. When valves V are to be closed, fluid pressure is relieved from the chambers 36 allowing springs 20 to move the sleeves S upwardly to cause valves V to close. In the event that line 40 is broken or that the fluid pressure communication means should fail, the springs 20 cause the valves V to be closed. This provides a shutoff of production flow through the tubing strings T at any time control thereof cannot be remotely maintained.

The structure hereinbefore described has remotely controlled valves for controlling the flow through the production strings and such valves are positioned in the tubing hanger. It is often desirable that such valves be pulled for repair or checking and in such structure the whole production string would have to be lifted to retrieve the valves. In FIG. 6, the retrieving tool 64 is shown with its stingers 66 engaged in the hanger H and holding the sleeves S down so that the valves V remain open.

In the preferred form of the present invention illustrated in FIGS. 13 through 20, the remotely controlled valves for controlling flow through the production strings are so positioned that they may be removed without disturbing the production strings. As shown in FIGS. 13A and 13B, the mandrel M' is suitably secured to the upper end of the casing C', and provides a support for tubing hanger H' from which the tubing string T' depends. The diverter body B' is suitably secured to

the mandrel M' and the diverter plug P' is latched by latch 66 in body B' with the tubing strings T' in communication through the valves V' to the production lines 68. Plug 67 allows remote actuation of latch 66 and is retrievable. The diverter plug P' includes the stingers 70 which are adapted to engage in the hanger H' to communicate with the tubing strings T'.

Flow through the diverter plug P' to the production lines 68 is controlled by the valves V'. As shown in FIG. 13B, the valves V' are positioned between the upper and lower seats 72 and 74 in the sleeves S'. The sleeves S' are axially movable within the plug P' and such movement causes rotation of the valves V'. This rotation results from engagement of the pins 76 in grooves on the exterior of the valves V'. The pins 76 are secured in the diverter plug P' so that as sleeves S' move, the valves V' are rotated as previously explained with respect to the valves V.

During running of the plug P' the valves V' are held in the open position shown in FIG. 13B, as hereinafter described. When not retained in such open position, the valves V' are biased toward their closed position shown in FIG. 14. This biasing is accomplished by the springs 78 which urge the sleeves S' upwardly. Springs 78 are positioned around the lower portion of sleeves S' and coast between the external downwardly facing shoulders 80 on sleeves S' and the internal upward facing shoulders 82 on the plug P' to urge the sleeves S' upwardly.

With the sleeves S' biased upwardly a means is provided to move the sleeves S' downwardly. Such means includes the seal rings 84 which surround the sleeves S' and are exposed to pressure in the pressure chambers 86 so that when sufficient fluid pressure is delivered to chambers 86, sleeves S' are moved downward to cause valves V' to open. A communication means from a remote location to the pressure chambers 86 is included in the structure illustrated to remotely control the operation of valves V'.

This communication means includes passage 88, the passage 90 and the fluid line 92 as shown in FIGS. 15A and 15B. Passage 88 connects from pressure chambers 86, through the control chamber 94 to the passage 90. Piston 96 is slidable in chamber 94 as hereinafter explained. As shown, when piston 96 is in the upper end of chamber 94, passage 88 communicates through chamber 94 with passage 90. However, when piston 96 moves downwardly in chamber 94, its lower seal 98 seals against the wall of chamber 94 to isolate passage 88 and thus chamber 86 from passage 90 and line 92. The passage 100 in plug P', stinger 102 and hanger H' provide for the communication of casing annulus pressure below hanger H' to above plug P'. A suitable line (not shown) may be provided to connect with a remote location to indicate the casing annulus pressure at such location.

Since sleeves S' are to be moved downwardly by fluid pressure delivered to pressure chambers 86 above seal rings 84, it is preferred that the chambers 104 below seal rings 84 be suitably vented. The passage 106 shown in FIGS. 16A and 16B is in communication with the chambers 104 and through passage 108 in body B' with the pressure equalizing device 110. The upper end of passage 106 is suitably sealed off above its connection with passage 108 as shown in FIG. 16A.

The pressure in pressure chambers 86 is exerted in chamber 94 urging piston 96 upwardly. To provide a means retaining the valves V' open during running, the passage 112 and 114 (see FIGS. 17, 19 and 20) communicate with the upper end of the piston 96 so that a pressure might be applied to the top of piston 96 to hold it in the lower part of chamber 94 isolating passage 88 from passage 90 and thereby trapping any fluid under pressure which is within passage 88 and chamber 86 when piston 96 is moved downwardly. Both passages 112 and 114 communicate with the main bores 116 and 118 and such communication for each passage is provided through an upper passage 120 having check valves 122 therein to allow flow only from the bore to the passage and the lower passage 124.

As plug P' is lowered into body B', sleeve 126 is positioned in bore 116 and sleeve 126 closes the communication through passages 120 and 124 between bore 116 and passage 112. Sleeve 128 is positioned in bore 118 to close the communication into passage 124 but to allow communication from bore 118 through port 128a, passage 120 and passage 114. Thus, with sleeves 126 and 128 in position as shown in FIG. 17, fluid under pressure in bore 118 is conducted through passages 120 and 114 to the upper end of chamber 94. When sufficient pressure has been added to the upper end of chamber 94, piston 96 moves downwardly and traps fluid pressure in passage 88 and chamber 86. If this fluid pressure is sufficient to overcome the force of springs 78, the sleeves S' are held in their lower position without regard to pressure supplied through line 92. With the sleeves S' in their lower position the valves V' are retained in their open position.

The foregoing description is best understood by reference to the schematic illustration of the fluid passage and their relationships as shown in FIG. 20. As shown, the flow diverters 130 and 132 are latched into position in their respective bores 116 and 118, and they are sealed therein to prevent flow of production in the bores above the diverters.

Whenever the plug P' is run into the body B' with the piston 96 retained in its lower position to hold valves V' open, remote control of valves V' may be established by lifting sleeve 128 to open passage 124 into bore 118. The pressure trapped in passages 120 and 124 and in the upper end of chamber 94 is released through passage 124. The pressure trapped in chambers 86 forces plug 96 upwardly to the position shown in FIG. 20. Thereafter the movement of valves V' is controlled by the fluid pressure supplied through line 92. Plug 96 seals against the upper bore of chamber 94 to prevent leakage of fluid from line 92 into bore 118. Whenever the fluid pressure in the pressure chambers 86 is reduced, the springs 78 move the sleeves S' upwardly. This upward movement of sleeves S' causes valves V' to move to their closed position. When sufficient fluid pressure is supplied through line 92 to pressure chambers 86 to overcome the forces of springs 78, the sleeves S' move downwardly opening the valves V'.

From the foregoing it can be seen that the present invention provides an improved well string in which the production flow may be remotely controlled by improved remotely controlled valves. These improved remotely controlled valves control flow through the production strings and may be mounted in the production string hanger or separate therefrom. Further, these improved valves are biased toward their closed position and are provided with a means to retain them in their open position while being run into position. These valves may be installed in single, dual or multiple string completion wells.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What I claim is:

1. A well production apparatus, comprising
 - a pair of tubing strings,
 - a tubing string hanger for connecting to and supporting said tubing strings,
 - means for supporting said tubing hanger in a well bore of a producing well,
 - completion means connecting to said hanger and providing connections extending out of the well bore,
 - pressure responsive valve means mounted in one of said tubing hanger and said completion means and adapted to open and close flow through said tubing strings,
 - means supplying a fluid under pressure to said pressure responsive valve means to remotely actuate said pressure responsive valve means, and
 - means for retaining said valve means in open position during running of said valve means into said well bore which retaining means includes
 - a chamber defined in said completion means and having an inlet and an outlet,
 - the chamber inlet connecting to said supply means,
 - the chamber outlet connecting to said valve means,
 - a piston slidably positioned in said chamber and adapted in one extreme position to shut off communication through said chamber between said inlet and said outlet and in its other extreme position to establish communication between said inlet and said outlet,
 - said piston in said one position trapping fluid in said pressure responsive valve means to hold said valve means open, and
 - means for retaining said piston in said one extreme position and for moving said piston from said one extreme position to said other extreme position to allow said valve means to close.
2. An apparatus according to claim 1 wherein said piston retaining and moving means includes
 - means for trapping fluid pressure behind said piston to urge said piston to said one extreme position, and
 - means for relieving the fluid pressure from behind said piston whereby the pressure trapped by said piston in said pressure responsive valve means moves said piston to said other extreme position.
3. A well production apparatus, comprising a tubing string,
 - means supporting said tubing string within a well bore,
 - completion means connecting to said tubing string and extending out of said well bore,
 - pressure-responsive valve means mounted in one of said tubing string support means and said completion means to open and close flow from said tubing string,
 - means supplying a fluid under pressure to said pressure-responsive valve means whereby flow from said tubing string is remotely controlled,
 - means for retaining said valve means in open position while said valve means is being installed in the well bore, and
 - a running tool connecting to said completion means, said running tool when connected to said completion means engaging said valve means within said tubing string to maintain said valve means in open position.

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