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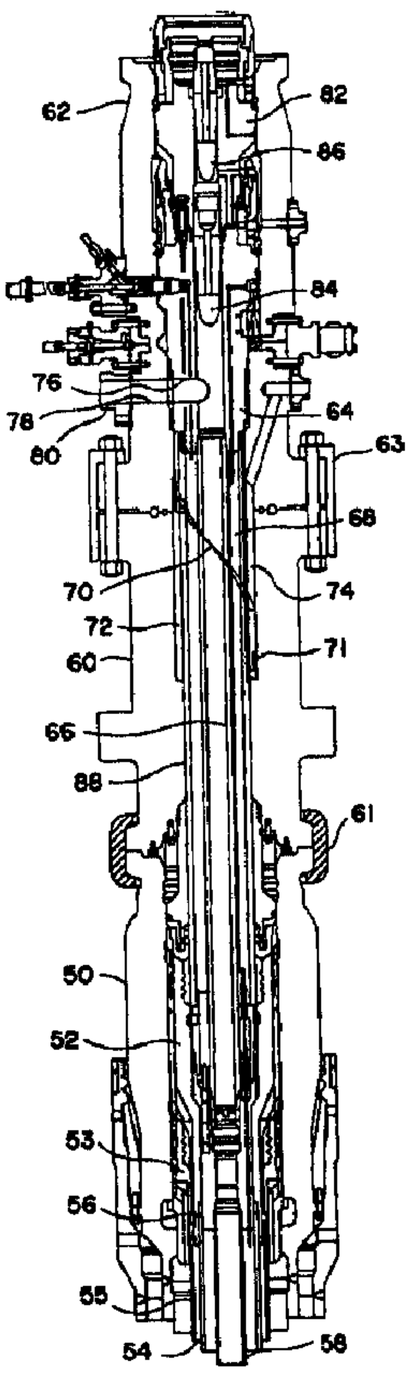
(54) Title: SUBSEA WELLHEAD



(57) Abrégé/Abstract:
The present invention relates to an improved subsea wellhead and to the method of retrieving the production string from the wellhead and the method of retrieving the tree from the wellhead. The wellhead includes a lower tubing hanger landing within the wellhead housing and an upper false tubing hangar landed within the tree. The upper false tubing hanger includes preps for receiving two plugs within its central bore above the radial bore through the upper tubing hanger which communicates with the radial bore through the tree through which production fluids flow from the well. A tubular member extends from the upper false

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(57) Abrégé(suite)/Abstract(continued):
tubing hanger to the lower tubing hanger and defines the flow passage through which production fluids flow between the two hangers. A sleeve surrounds the exterior of the tubular member and contains fluids communicated to the interior of the sleeve from the annulus surrounding the tubing string. Orienting means is provided to orient the upper false tubing hanger as it is being landed within the tree so that the radial passages in the upper false tubing hanger and the tree are in registry.

Abstract of the Disclosure

The present invention relates to an improved subsea wellhead and to the method of retrieving the production string from the wellhead and the method of retrieving the tree from the wellhead. The wellhead includes a lower tubing hanger landing within the wellhead housing and an upper false tubing hanger landed within the tree. The upper false tubing hanger includes preps for receiving two plugs within its central bore above the radial bore through the upper tubing hanger which communicates with the radial bore through the tree through which production fluids flow from the well. A tubular member extends from the upper false tubing hanger to the lower tubing hanger and defines the flow passage through which production fluids flow between the two hangers. A sleeve surrounds the exterior of the tubular member and contains fluids communicated to the interior of the sleeve from the annulus surrounding the tubing string. Orienting means is provided to orient the upper false tubing hanger as it is being landed within the tree so that the radial passages in the upper false tubing hanger and the tree are in registry.

SUBSEA WELLHEAD

The present invention relates to an improved subsea wellhead in which either the production string or the production tree may be easily and quickly recovered from their subsea location and readily reinstalled without the excessive loss of downtime normally associated with such operations.

Prior to the present invention, the removal of either of the production tubing or the production tree from a subsea well could only be accomplished by utilizing the steps of their installation in the reverse order for recovery. This entails substantial equipment for the removal of the tree and for the removal of the tubing string. None of the known prior art allowed the easy removal of the production tree in any manner.

One of the closest known prior art is the European Patent No. 0572732, filed by Cooper Industries, Inc. on Jun. 1, 1992, having inventors named: Thomas Gus Cassity and Hans Paul Hopper and entitled "Wellhead." This application discloses an improved wellhead in which the production tubing and tubing hanger can be retrieved without pulling the production tree. This art, however, requires that the production tubing be pulled prior to pulling the tree. There is no suggested structure or steps by which the tree can be removed, without first removing the production tubing, other than by the extended procedure which reverses its installation process.

The present invention relates to an improved subsea wellhead in which the production string may be quickly and easily removed, or the production tree may be quickly and easily removed, each independent of the other. The

structure includes the wellhead housing with the casing hangers supporting the casing strings landed in the housing, a tree connected to the upper end of the wellhead housing, an upper false tubing hanger landed in the tree and having communication with the production line extending radially out of the tree, a tubular member extending downwardly therefrom, an orienting lip extending downwardly therefrom and a sleeve extending downwardly around the exterior of the orienting lip and tubular member, and a lower tubing hanger landed within the inner casing hanger and having the production tubing string extending downwardly therefrom and an internal preparation for a sealing plug and any other downhole devices desired. With the two casing hangers, the production string can still be sealed with a plug when the upper hanger is removed and the tree is removed. In addition with this structure the complete production tubing string including both tubing hangers may be quickly and easily retrieved from the well and replaced therein.

An object of the present invention is to provide an improved subsea wellhead in which either the production string or the production tree may be easily and quickly removed.

A further object is to provide an improved method of retrieving a tree from a subsea well without having to remove the production tubing.

Still another object is to provide an improved method of retrieving the production string and/or the production tubing from a subsea well quickly and easily with only a blowout preventer, and without having to remove the tree.

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

FIGURE 1 is a schematic illustration of the prior art subsea wellhead structure with the production tree

installed thereon and the production string installed therein.

FIGURE 2 is a vertical sectional view of the wellhead housing with the improved production tree and production string installed therein.

FIGURE 3 is a series of vertical sectional views of the wellhead housing with a hanger cap installed therein above the production tubing and tubing hanger. FIGURE 3A is the upper portion of the structure, FIGURE 3B is the intermediate portion of the structure and FIGURE 3C is the lower portion of the structure.

FIGURE 4 is a sectional view of the wellhead with a wellhead seal cap installed.

As shown in FIGURE 1, the subsea wellhead of the prior art includes housing 10 having casing hanger 12 landed therein and supporting casing string 14 extending downwardly from hanger 12. Tree 16 is suitably connected to the upper end of housing 10 by remote operated connector 17 and production tubing hanger 18 is landed therein with production tubing 20 extending downwardly therefrom. Locating member 22 is supported within tree housing 10 and engages casing hanger 12 and has an upper helix surface 24 which coacts with lower helix surface 26 on tubular member 28 extending downward from tubing hanger 18 to ensure the proper orientation of tubing hanger 18 within tree 16 so that port 30 through the side of tubing hanger 18 registers with port 32 which extends through tree 16 and communicates with external production connection 34 which is under the control of valve 36. Isolation cap 38 is landed within tree 16, plug 40 is landed in hanger 18 immediately above port 30 and plug 42 is landed in isolation cap 38 so that production is directed out through ports 30 and 32 and through connection 34 and valve 36.

With the components positioned as shown in FIGURE 1, production through tubing string 20 is under the control

of valve 36 and the annulus pressure is under control of isolation cap 38 which is sealed within tree 16. In order to pull the production string, it is only necessary to lower and secure a suitable blowout preventer to the upper end of tree 16 and then remove isolation cap 38 and tubing hanger 18 with tubing string 20 secured thereto from the well. During these operations the well is under the control of the blowout preventer. Since the subsea apparatus shown in FIGURE 1 does not include a separate tubing hanger supported within the well at a point below the tree, the recovery of the tree from the subsea well is only possible with the extended and complicated procedures of the prior art which are necessary to maintain control of the well during these operations.

Wellhead housing 50, as shown in FIGURE 2, has casing hangers 52 and 53 landed therein with the casing strings 54 and 55 extending down into the well from the hangers 52 and 53. Lower tubing hanger 56 is landed within casing hanger 52 and supports tubing string 58 which extends downwardly from the lower end thereof.

Tree sub 60 is landed and secured by clamp 61 to the upper end of housing 50 and tree 62 is landed on and secured to the upper end of tree sub 60 by clamp 63. Clamp 61 is a remotely operated clamp so that it may be released when tree 62 is to be removed. Upper false tubing hanger 64 is landed within tree 62 as shown and includes tubular member 66 threaded into its lower opening and sleeve 88 attached to the exterior of its lower end having orienting key 71 mounted to its exterior surface. Tubular member 66 extends downwardly and seals within lower tubing hanger 56. Tubular orienting member 72 is mounted within tree sub 60 and includes upper helix surface 74 which receives key 71 to cause the upper hanger 64 to rotate so that port 76 in upper hanger 64 registers with port 78 in tree 62 allowing production flow from tubing string 58 to flow therethrough into suitable production lines 80 with suitable valving (not shown). When ready for production, upper cap 82 is

secured and sealed within the upper end of tree 62 and includes a central bore registering with the central bore of upper tubing hanger 64 and having a configuration to allow lower plug 84 to be seated and sealed within upper tubing hanger 64 and to allow upper plug 86 to be seated and sealed within the central bore of upper cap 82. Lower tubing hanger 56 includes optional electrical connector 89 for use in communicating with a downhole electrical device, such as a pressure transducer. A hydraulic control line coupling 92 is provided to allow communication to a downhole safety valve. Tubing hanger 56 also includes an orienting pin (not shown) located approximately 90° from control line coupling 92 and pointing vertically upward to engage the lower end of hanger cap 90 to ensure proper axial alignment of the entire assembly when it is returned to the wellhead after having ben removed.

When it is desired to recover the production tubing string 58, any suitable blowout preventer may be installed on the upper end of tree 62 to place the well under control and then upper cap 82 is released and recovered through the blowout preventer. With upper cap 82 removed a suitable tool is run to engage and recover upper tubing hanger 64 including tubular member 66 and sleeve 88 with orienting key 71 attached thereto. Thereafter, a tool is run into engagement with lower tubing hanger 56, which has tubing string 58 suspended therefrom, and it is recovered from the wellhead housing 50. With the production tubing and tubing hangers removed from the wellhead housing 50 any desired work or change in equipment may be performed in the well and then the production tubing and tubing hangers are again set in the wellhead housing 50.

In the event that it is desired that tree 62 be removed from the wellhead without removing the production tubing, a suitable blowout preventer is connected to the upper end of tree 62. With the blowout preventer in place, upper cap 82 is engaged and retrieved. Then upper tubing hanger 64 with upper tubular member 66, sleeve 88 and

hanger cap 90 attached thereto, is engaged and retrieved. As shown in FIGURE 4, a suitable wellhead seal cap 190 is secured within lower tubing hanger 56 to control the production string and the casing annulus. If desired, a wireline plug may be seated within the wireline prep 91 in the production bore of tubing hanger 56. This seals the production bore and annulus. With the well under control, the blowout preventer can be removed and then tree 62 is removed. After all operations planned for the well while tree 62 is removed, tree 62 is returned and connected to the upper end of tree sub 60 and after the blowout preventer has been connected to the upper end of tree 62. The wellhead seal cap 190 is recovered and then the remainder of the production equipment is reinstalled.

In the event that both the tree 62 and the production tubing string 58 are to be retrieved, then its is suggested that the tubing string 58 should be recovered as set forth above and a suitable plug is set in the inner casing hanger to close the well and thereafter, the tree 62 and tree 60 can be released and retrieved by remotely releasing clamp 61 and recovering them to the surface.

It should be noted that tree sub 60 is used primarily only in subsea guidelineless completions where it is desirable to elevate tree 62 above the upwardly facing funnel typically installed about the wellhead housing 50 and thereby, gain clearance for the production flowlines. In a typical guideline completion, tree sub 60 and clamp 63 would not be used. The lower end of tree 62 would be slightly longer and connected directly to the upper end of housing 50 by claim 61. Tubular member 66 and sleeve 88 would both be substantially shorter.

From the foregoing, it can be seen that the present invention provides an improved subsea wellhead in which either the production equipment within the well may be safely and quickly removed from within the tree or the production equipment may remain in the well bore and the tree retrieved from the wellhead housing. Maintenance to

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either the downhole production equipment or the seabed tree can be performed independently without the requirement to retrieve both.

CLAIMS

What is claimed is:

1. A subsea wellhead completion system comprising

a wellhead housing having an internal bore,

a lower tubing hanger with a production tubing string extending downwardly therefrom and supported within said internal bore of the wellhead housing,

an upper false tubing hanger having a production bore therethrough,

said lower tubing hanger having a central production bore therethrough with a wireline plug profile therein for receiving a wireline plug to close the production bore below said upper tubing hanger,

a tree having a radial production port connecting to production lines and production control means,

means for connecting said tree to said wellhead housing,

means connecting said production bores of said upper hanger and said lower hanger,

orienting means to orient said upper tubing hanger to its desired position within said tree to allow radial flow of production fluids from said production bore of said upper tubing hanger through said tree,

means in said upper tubing hanger above said radial port to receive an upper bore plug and a lower bore plug, and

means in said tree for receiving an upper cap.

2. The subsea wellhead according to claim 1 including

casing hangers supported within the internal bore of said wellhead housing, and

means on the interior of the inner casing hanger for supporting said lower tubing hanger.

3. The subsea wellhead according to claim 1 including

a radial port in said upper hanger,

a radial port in said tree,

said orienting means causing rotation of said upper tubing hanger within said tree as it is lowered therein to bring the radial port in the upper tubing hanger into registry with the radial port in said tree.

4. The subsea wellhead according to claim 1 wherein the production tree and the production tubing each may be removed individually without removal of the other.

5. A method of servicing a subsea well which has a wellhead housing, a tree secured to the upper end of the wellhead housing, a lower production tubing hanger landed within said wellhead housing, an upper false tubing hanger landed within said tree, and radial passage means extending through said upper tubing hanger and said tree which method includes the steps of

setting a blowout preventer on the upper end of the tree,

removing the upper tubing hanger from within the tree,

closing and sealing the production bore through the lower tubing hanger within said lower tubing hanger,

removing said blowout preventer from the tree, and

removing the tree from the wellhead housing.

6. The method according to claim 5 including the steps of

lowering and connecting the tree to the upper end of the wellhead housing,

lowering and connecting a blowout preventer to the upper end of the tree,

retrieving from the production bore the closing and seal element,

lowering and landing the upper hanger in the tree with the radial passage means of said upper hanger and said tree being in registry,

closing the production bore through said upper hanger above said radial passage means, and

retrieving said blowout preventer.

7. The method according to claim 6 wherein the blowout preventer used to maintain control of the well during the removal and resetting of the tree may be a wireline blowout preventer.

8. A method of servicing a subsea well which has a wellhead housing, a tree

secured to the upper end of the wellhead housing, a lower production tubing hanger landed within said wellhead housing, an upper false tubing hanger landed within said tree, and radial passage means extending through said upper tubing hanger and said tree which method includes the steps of

setting a blowout preventer on the upper end of the tree,

removing the upper tubing hanger from within the tree, and

removing the lower tubing hanger and the tubing string from within the wellhead housing and retrieving the lower tubing hanger and the tubing string from the subsea well.

9. The method according to claim 8 wherein said tree includes a top cap closing the upper end of its bore and including the step of

removing the top cap from said tree.

10. The method according to claim 8 including the steps of

lowering and landing the lower tubing hanger with the production tubing extending downwardly therefrom into the interior of the wellhead housing,

lowering and landing the upper tubing hanger with a means to connect the production bores of the upper and lower tubing hangers,

setting tubing plugs in the upper tubing hanger, and

lowering and setting a top cap on the upper end of the tree.

11. A subsea wellhead assembly, including a wellhead housing having a wellhead internal bore and a tree connected to said wellhead housing and having a tree internal bore such that said tree internal bore communicates with said wellhead internal bore, said tree including a radial production port, characterized by:

a first hanger disposed in said tree internal bore and having a first production bore extending through said first hanger; and

a second hanger disposed in said wellhead internal bore below said first hanger and having a production tubing string extending downwardly therefrom, said second hanger having a second production bore extending therethrough, said second production bore communicating with said production tubing string and with said first production bore whereby said first production bore communicates with said production tubing string.

12. The subsea wellhead assembly according to claim 11 further characterized by a plug in said first hanger closing said first production bore at a location above said radial production port and a cap in said second hanger closing said second production bore.

13. The subsea wellhead assembly according to claim 12 including a blowout preventer having a BOP bore further characterized by said plug and cap being retrievable through the BOP bore.

14. The subsea wellhead assembly according to claim 12 further characterized by a removable cap closing an end of said tree internal bore.

15. The subsea wellhead assembly according to claim 14 further characterized by said first hanger being movable vertically relative to said second hanger and being removable from said tree internal bore when said cap is removed and when said cap closes said second production bore, to enable said tree to be disconnected from said wellhead housing.

16. The subsea wellhead assembly according to claim 14 further characterized by said first and second hangers being movable vertically through said tree internal bore and out of said tree when said cap is removed.

17. The subsea wellhead assembly according to claim 11 further characterized by

said first and second hangers being movable vertically through said tree internal bore and out of said tree.

18. The subsea wellhead assembly according to claim 11 further characterized by said first hanger having a lateral production port and orienting means orienting said first hanger to a pre-selected position communicating said lateral production port with said radial production port.

19. The subsea wellhead assembly according to claim 11 further characterized by said first hanger being movable vertically relative to said second hanger and being removable from said tree internal bore.

20. The subsea wellhead assembly according to claim 11 further characterized by radially inner and outer casing hangers supported within said wellhead internal bore, said second hanger being supported on said radially inner casing hanger.

21. The subsea wellhead assembly according to claim 20 further characterized by a tubular member extending from said first hanger to said inner casing hanger.

22. The subsea wellhead assembly according to claim 11 further characterized by:

said tree having a wall forming at least a portion of said tree internal bore;

said first and second hangers forming an annulus bore communicating with an annulus formed by said production tubing string;

said wall of said tree including said radial production port in fluid communication with a lateral production port in said first hanger, an annulus passageway in fluid communication with said annulus bore and annulus, and a workover passageway in fluid communication with said tree internal bore above said lateral production port; and

said annulus passageway and said workover passageway being in fluid communication externally of said tree internal bore.

23. The subsea wellhead assembly according to claim 11 further characterized by:

said tree being fixed and sealed to said wellhead housing, said radial production port being connected to a production line, said tree internal bore having an internal surface;

said first hanger landed and sealed within said tree internal bore at a predetermined angular position at which a lateral production port in said first hanger is in alignment with said radial production port in said tree;

said first production bore in said first hanger being sealed above said lateral production port by a plug, and said tree internal bore being sealed above said first hanger by a cap;

a workover passageway extending through said wall of said tree for fluid communication with said tree internal bore above said first hanger; and

an annulus passageway extending through said wall of said tree for fluid communication with an annulus around the production tubing string.

24. The subsea wellhead assembly according to claim 11 further characterized by said second production bore of said second hanger having a wireline plug profile therein adapted for receiving a wireline plug.

25. The subsea wellhead assembly according to claim 11 further characterized by said radial production port being connected to production lines and production control means.

26. The subsea wellhead assembly according to claim 11 further characterized by means for connecting said tree to said wellhead.

27. The subsea wellhead assembly according to claim 11 further characterized by means for connecting said first and second production bores.

28. The subsea wellhead assembly according to claim 11 further characterized by orienting means to orient said first hanger to its desired position within said tree to allow radial flow of production fluids from said first production bore of said first hanger through said tree.

29. The subsea wellhead assembly according to claim 28 further characterized by said orienting means causing rotation of said first hanger within said tree as it is lowered therein to bring a lateral production port in said first hanger into registry with said radial port in said tree.

30. The subsea wellhead assembly according to claim 11 further characterized by

means in said first hanger above a lateral production port to receive a first bore plug and a second bore plug.

31. The subsea wellhead assembly according to claim 11 further characterized by means in said tree internal bore of said tree for receiving a cap.

32. The subsea wellhead assembly according to claim 11 further characterized by

casing hangers supported within said wellhead internal bore of said wellhead housing; and

means on the interior of said inner casing hanger for supporting said second hanger.

33. The subsea wellhead assembly according to claim 11 further characterized by said tree and said production tubing string each being removable individually without removal of the other.

34. The subsea wellhead assembly according to claim 11 further characterized by a tubular member extending from said first hanger to said second hanger and forming said first production bore.

35. The subsea wellhead assembly according to claim 34 further characterized by a tubular sleeve extending from said first hanger to said second hanger around said tubular member and forming a flow passage therebetween communicating with an annulus formed by said production tubing string.

36. The subsea wellhead assembly according to claim 11 further characterized by

said first hanger including first closing means for closing said first production bore;

said second hanger including second closing means for closing said second production bore; and

a removable plug closing said tree internal bore above said first hanger.

37. The subsea wellhead assembly according to claim 36 further characterized by said first hanger being movable vertically relative to said second hanger and being removable from said tree internal bore when said removable plug is removed and when said second closing means closes said second production bore to enable said tree to be

disconnected from said wellhead housing.

38. The subsea wellhead assembly according to claim 36 further characterized by said first and second hangers being movable vertically through said tree internal bore and out of said tree when said cap is removed.

39. The subsea wellhead assembly according to claim 11 further characterized by said first and second hangers being movable vertically through said tree internal bore and out of said tree when said cap is removed.

40. A method of servicing a subsea well, including a wellhead housing removably connected to a tree disposed on said wellhead housing, a first hanger landed within said tree and a second hanger landed within said wellhead housing, said first hanger including a first production bore extending therethrough and said second hanger including a second production bore extending therethrough, said first production bore communicating with said second production bore, said tree including a radial passage communicating with said first production bore, said method characterized by:

setting a blowout preventer on said tree; and

removing said first hanger from within said tree.

41. The method according to claim 40 further characterized by:

closing said second production bore;

removing said blowout preventer from said tree; and

removing said tree from said wellhead housing.

42. The method according to claim 41 further characterized by:

re-connecting said tree to said wellhead housing;

connecting a blowout preventer to said tree;

opening said second production bore;

landing said first hanger in said tree with said radial passage communicating with said first production bore;

closing said first production bore at a location above said radial passage; and

retrieving said blowout preventer.

43. The method according to claim 42 wherein the blowout preventer used to

maintain control of the well during the removal and resetting of the tree may be a wireline blowout preventer.

44. The method of servicing a subsea well according to claim 40 including a tubing string extending downwardly from said second hanger further characterized by removing said second hanger and said tubing string from both said wellhead housing and said tree.

45. The method according to claim 44 further characterized by:

landing said second hanger in said wellhead housing, with said tubing string extending downwardly from said lower hanger;

landing said first hanger in said tree to communicate said first production bore with said second production bore;

setting a plug in said first production bore to close said first production bore at a location above said radial passage; and

setting a cap on an end of said tree.

46. The method according to claim 40 further characterized by prior to removing said first hanger, removing a cap from an end of said tree to permit said first and second hangers to be removed from said tree.

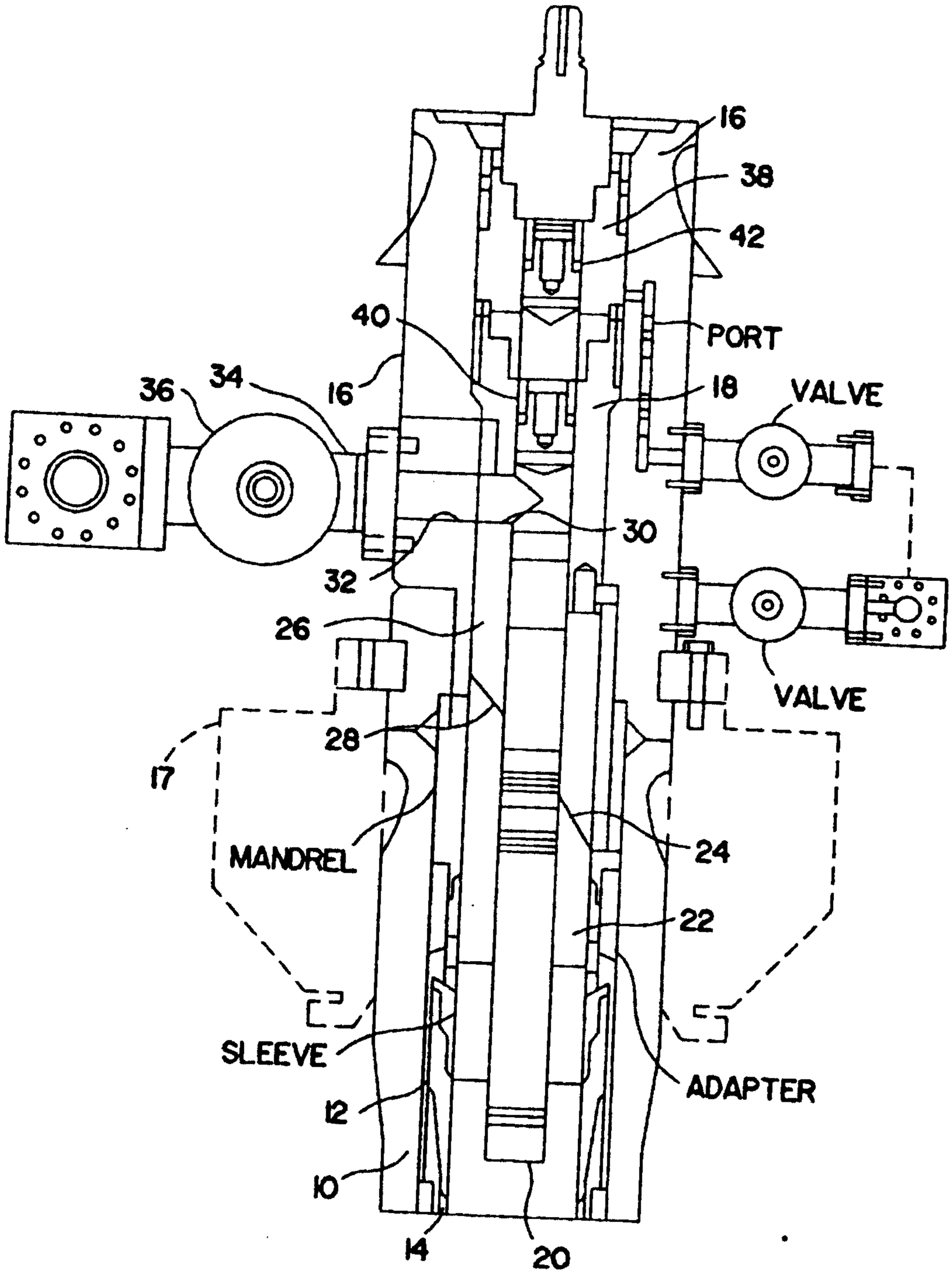

FIG. 1
PRIOR ART

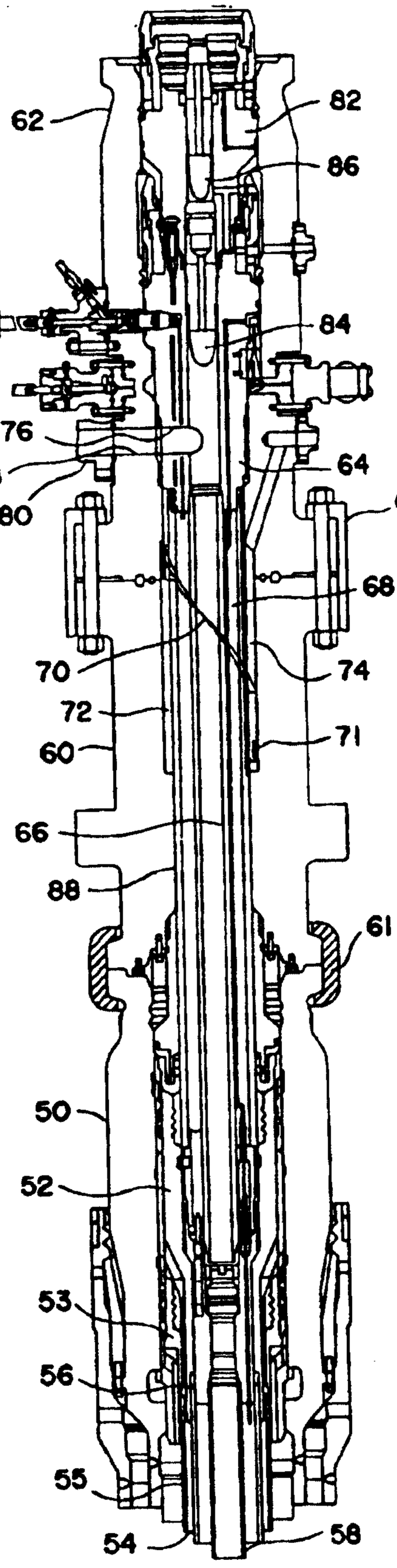
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FIG. 2

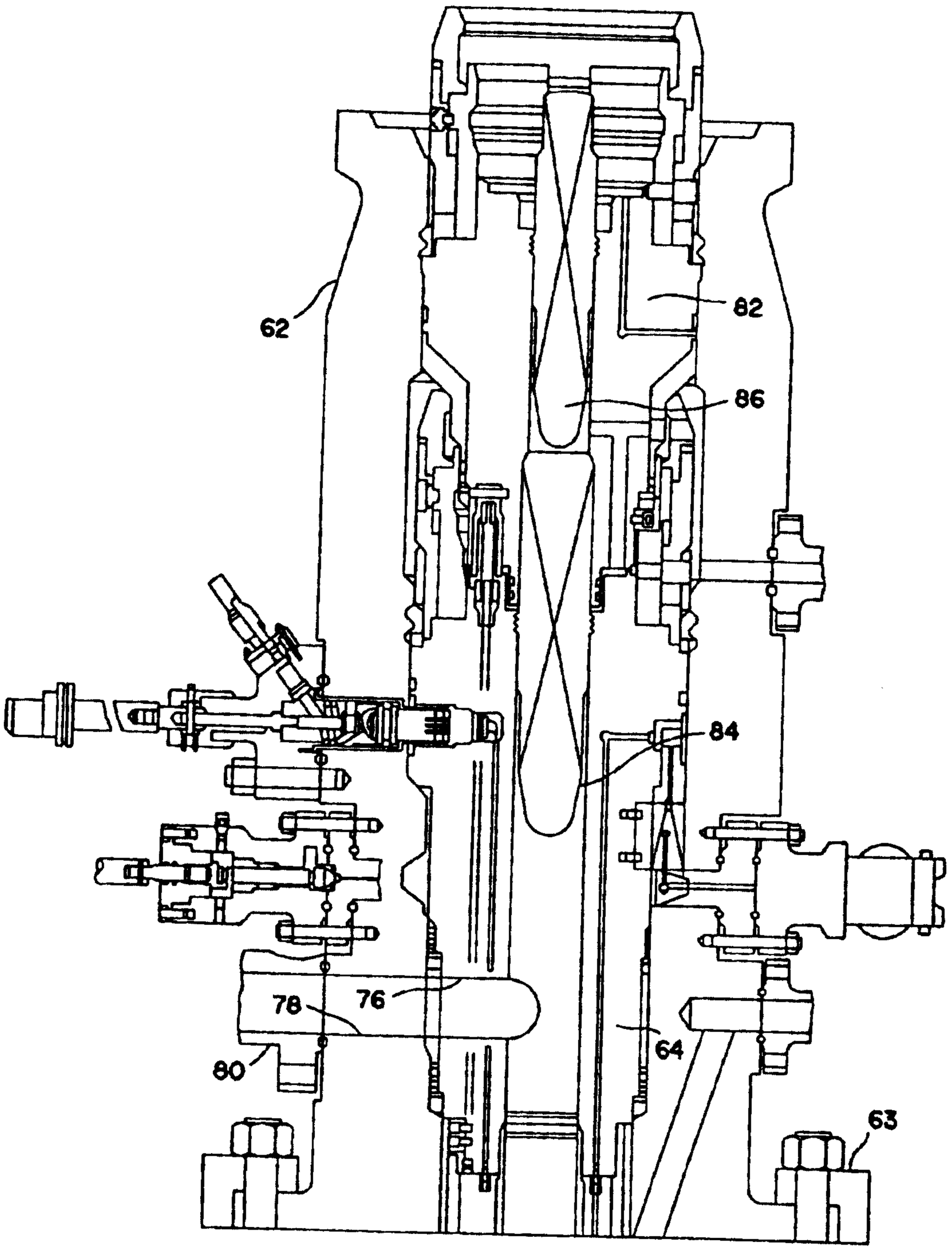


FIG. 3A

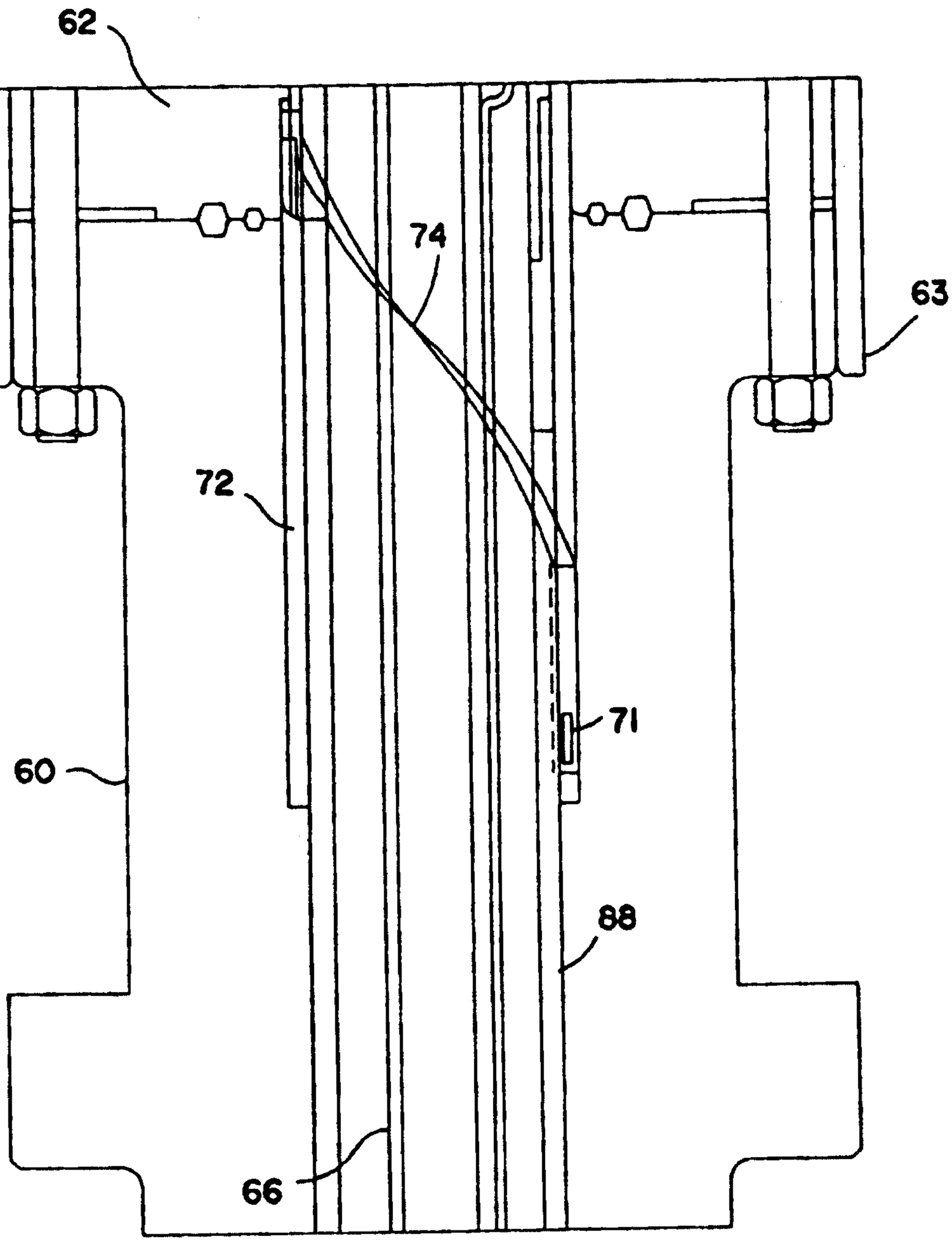


FIG. 3B

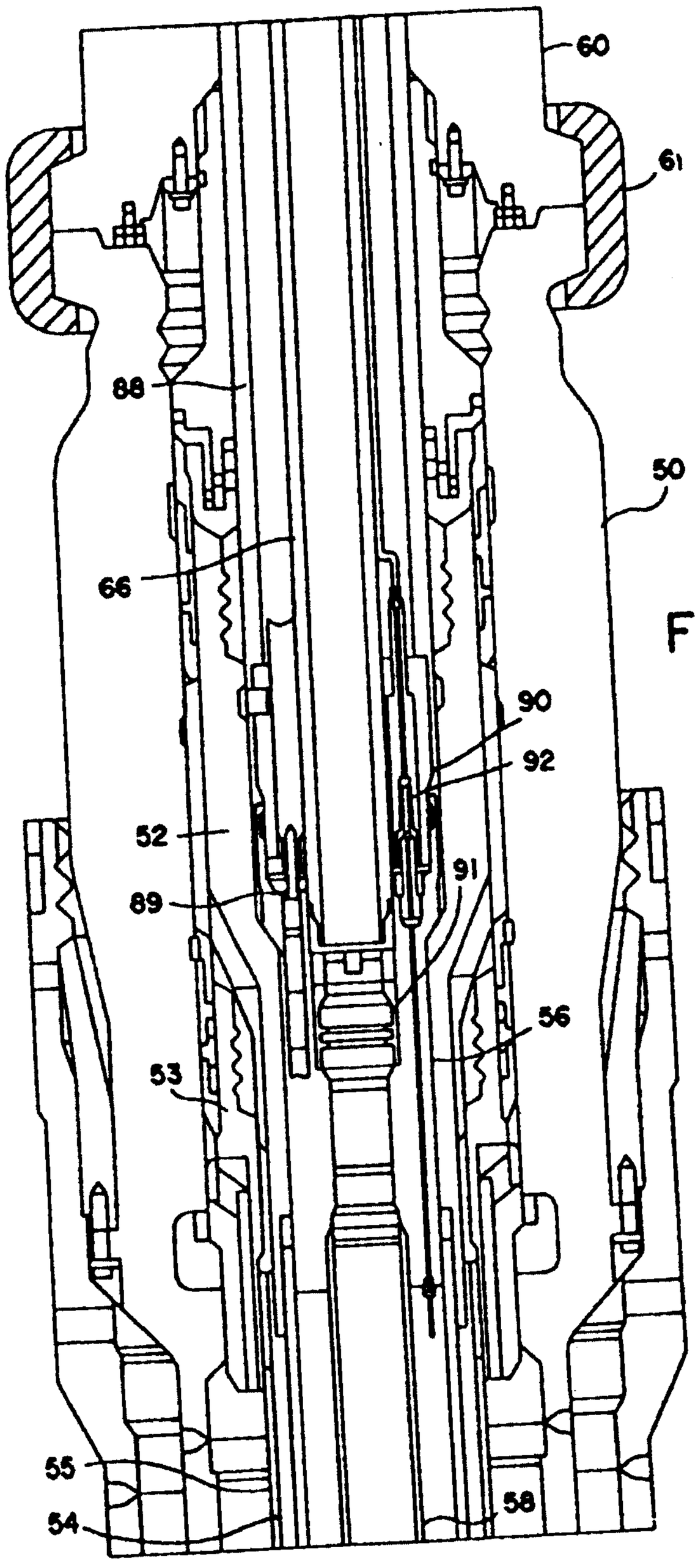


FIG. 3C

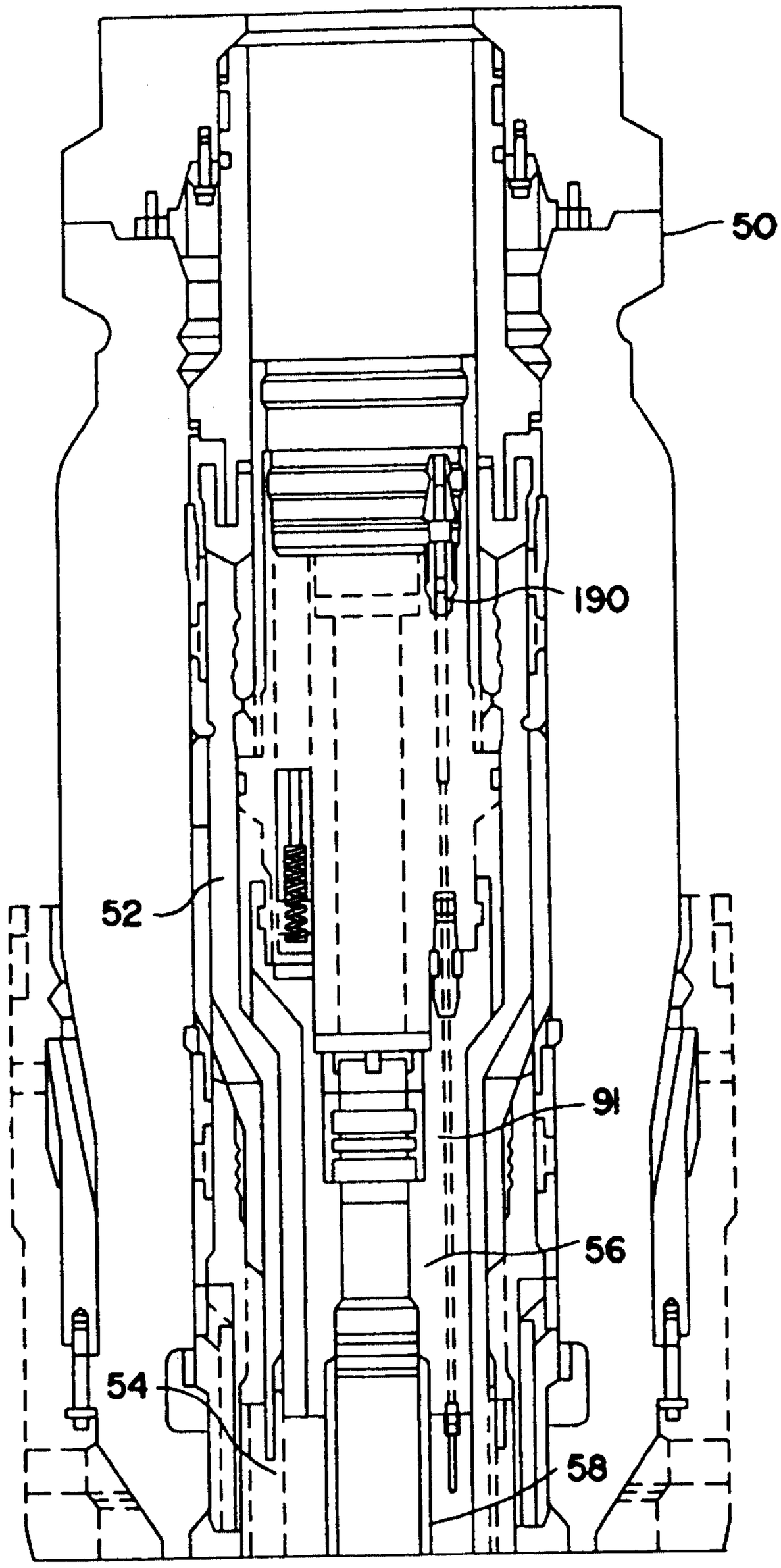
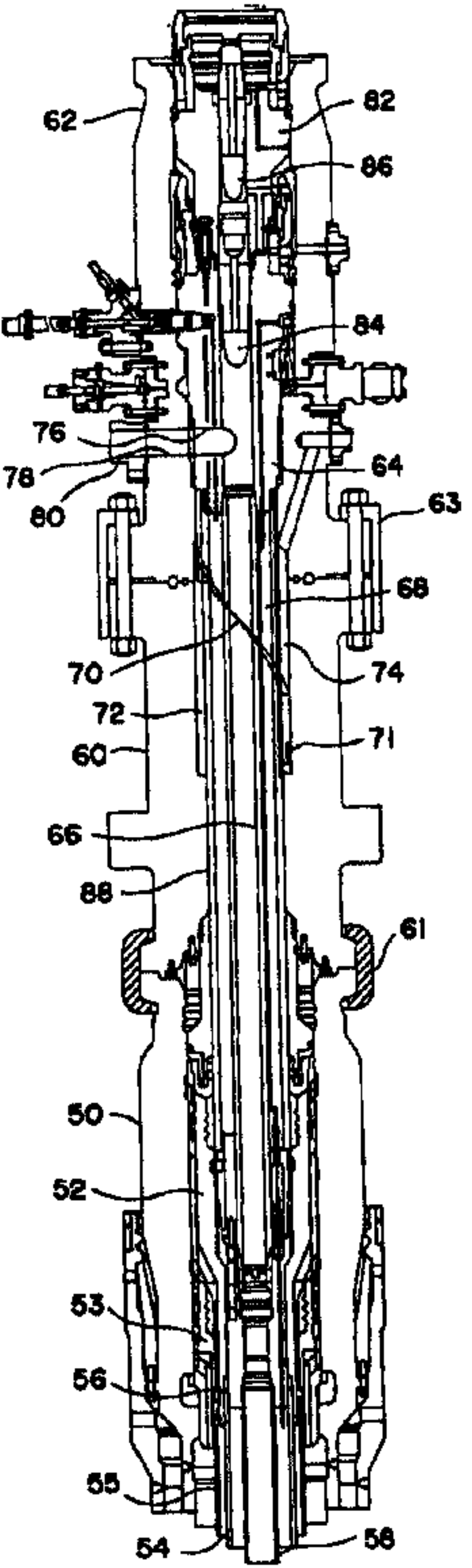


FIG. 4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