Nov. 19, 1968 J. W. E. HANES 3,411,588

HANGER APPARATUS FOR WELL PIPE

Filed Dec. 28, 1966 2 Sheets-Sheet 1

FIG. 1.

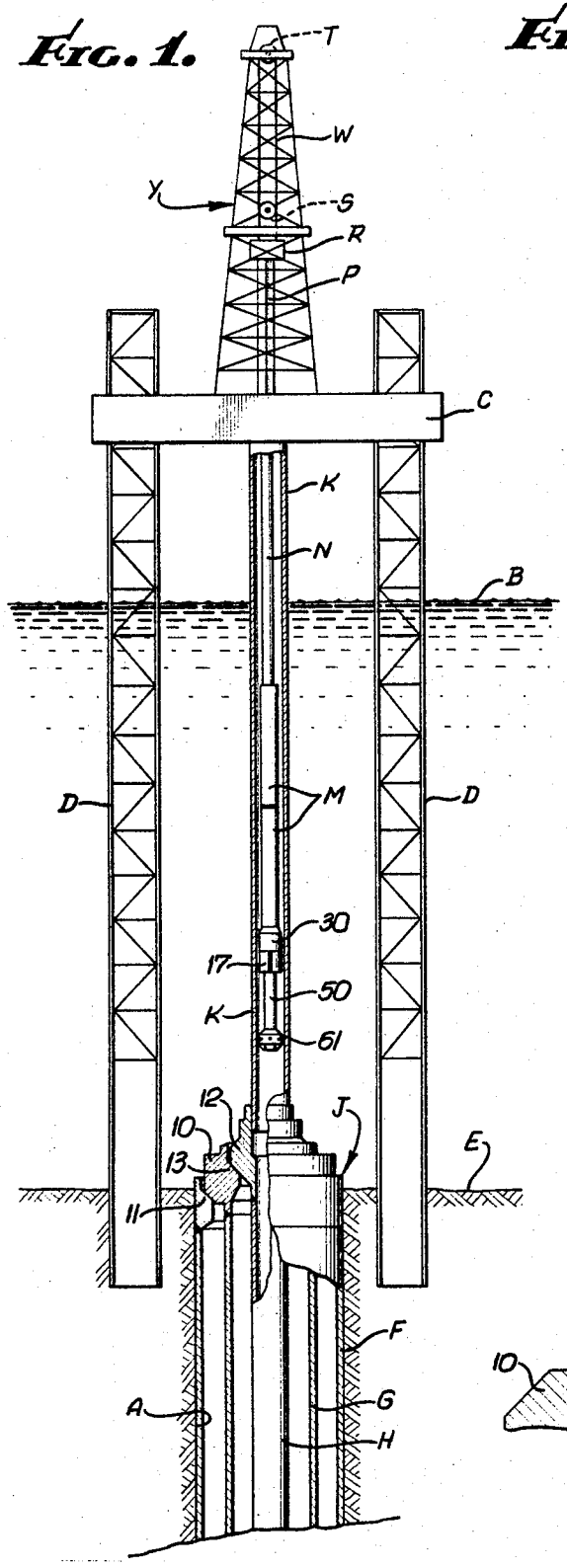
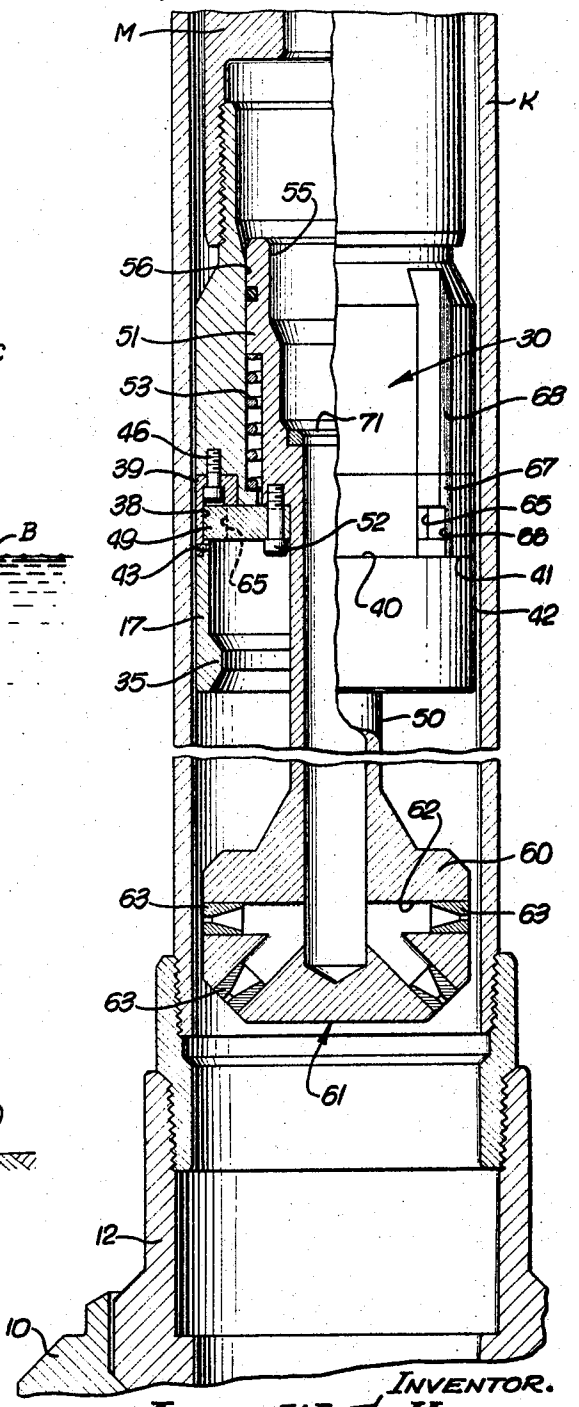


FIG. 2.



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HANGER APPARATUS FOR WELL PIPE

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FIG. 4.

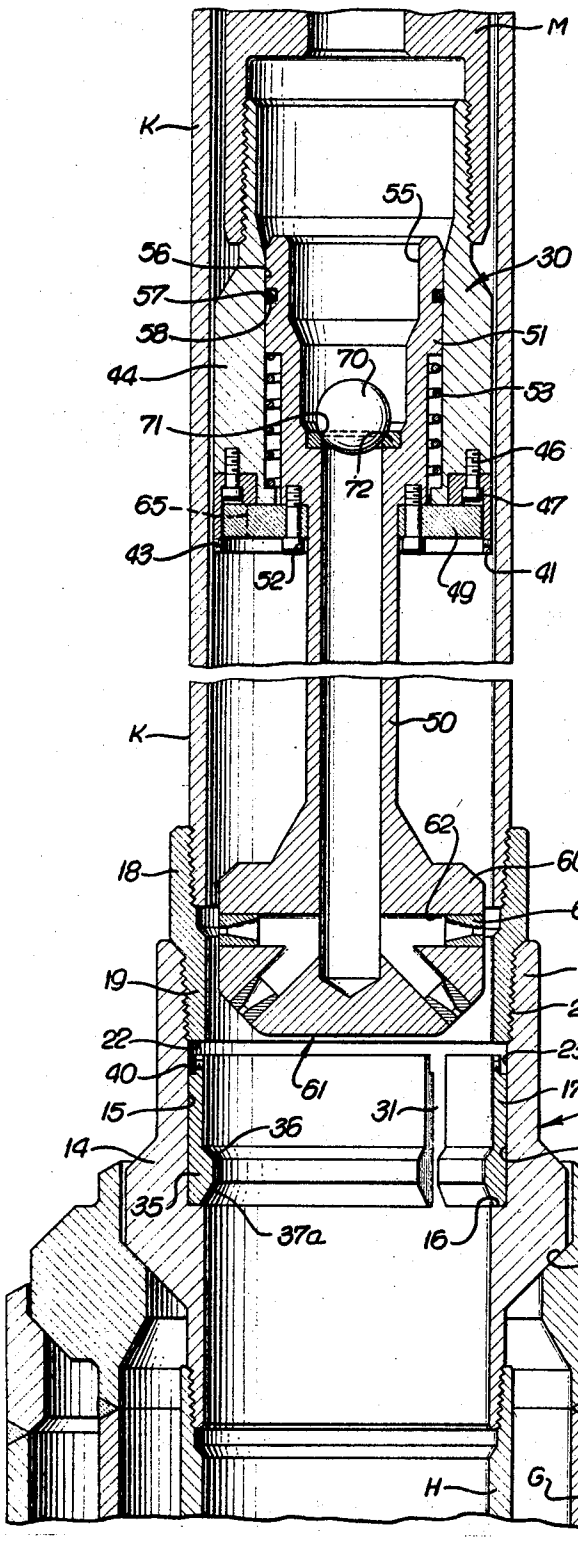
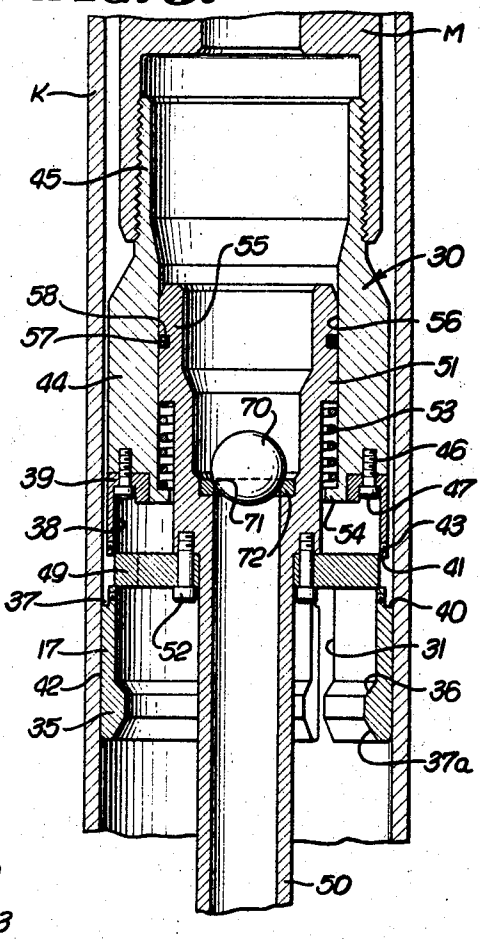


FIG. 3.



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HANGER APPARATUS FOR WELL PIPE

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22 Claims. (Cl. 166—208)

The present invention relates to casing systems for underwater or subsea well bores, and more particularly to apparatus for hanging casing or tubing in a casing system.

In the drilling of underwater wells, a drilling platform is used. Instead of supporting the several concentric strings of casing from the floor of the platform, it is desirable to effect their support or hanging at or near the mudline where the casing strings are interconnected by the casing head system. Risers extend from the casing head system to the platform, there being blowout preventer equipment attached to the casing head system. Upon completion and successful testing of the well, the riser section of each string of casing (including the blowout preventer equipment) is "backed off" where it is supported, or at the mudline, and the well is capped.

Following capping of the well, the relatively heavy and large capacity drilling platform is removed from the well location, and a light production platform installed in its place. The last casing string, or perhaps the last two casing strings, that had been run in the well are extended to the production platform by securing risers to them. An outer casing is stripped over the smaller riser or risers, and cement poured in the annulus between the riser and outer casing to form a column. Since the weight of the several casing strings disposed in the well are carried at the mudline, the production platform need only be of sufficient capacity to support the load of the risers extending from the mudline to the platform, plus the weight of tubing hung from a casing head at the top of the aforementioned column and other production equipment required to produce the well.

Heretofore, a casing has been hung at or near the mudline by ues of slips. Where the casing load is great, serious design problems are encountered in developing a slip type hanger of sufficient strength to carry the load. In addition, the inside diameter of the string of casing previously installed in the well becomes restricted, reducing the size of drilling bit that can be run through the casing string already in the well bore, for the purpose of continuing the drilling of the well bore to the desired depth.

An object of the present invention is to provide casing hanger apparatus that does not impose restrictions on the inside diameter of a previously installed casing string, so that a drilling bit of large or maximum size can be run through it to drill an optimum size well bore, and thereby permit a larger size casing to be run subsequently in such well bore.

Another object of the invention is to provide casing hanger apparatus embodying a hanger of unrestricted inside diameter into which a hanger seat of an appropriate size can be set after the well bore has been drilled. An inner casing string may then be run in the well and supported from the hanger seat.

A further object of the invention is to provide a hanger seat and running tool apparatus for lowering the seat within a casing string or riser to a casing hanger head, and for setting the seat in the casing hanger head.

An additional object of the invention is to provide a simple, strong and sturdy casing hanger head and hanger seat to be set therein, in which the bore through the casing hanger head is initially unrestricted, the seat being subsequently installed in the hanger head to provide a support for an inner casing string.

Yet another object of the invention is to provide an expansible hanger seat and running tool combination, in which the hanger seat is initially in retracted position and is easily released from the running tool for expansion and movement into coupling relation to a casing hanger head.

Still a further object of the invention is to provide an expansible hanger seat and running tool combination, in which the seat is initially releasably secured to the running tool in retracted position, and in which release of the seat from the running tool is effected hydraulically, enabling the running tool to move the seat into position for expansion into its associated casing hanger head.

Another object of the invention is to provide an expansible hanger seat and running tool therefor, in which the running tool initially maintains the seat in retracted condition, release of the seat from the running tool being effected hydraulically to allow expansion of the seat into an associated casing hanger head, the running tool embodying a cleaning tool for insuring a clean condition of the casing hanger head for appropriate reception of the hanger seat.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a diagrammatic view, parts being disclosed in section, of an underwater or subsea well, with associated equipment used in drilling the well from a drilling platform;

FIG. 2 is an enlarged longitudinal section, with a portion thereof disclosed in side elevation, of a running tool and hanger seat being lowered to a casing hanger head in which the seat is to be installed;

FIG. 3 is a view similar to FIG. 2 disclosing the hanger seat released from the running tool;

FIG. 4 is a view similar to FIG. 3 disclosing the hanger seat installed in the casing hanger head, and the running tool in condition to be removed to the drilling platform.

As disclosed in the drawings, a well bore A has been drilled below a body of water B from a drilling platform C, which is suitably supported on a plurality of leg structures D driven into the ocean or subsea floor E. As disclosed, a plurality of concentric casing strings F, G, H have been installed in the well bore A and are supported from a suitable structure or base J resting on the subsea floor E, or at the mudline. Three concentric casing strings are disclosed in the drawings, but their number can be varied, if desired. The outermost casing string F is suitably carried at or near the mudline, the intermediate casing string G being secured to a hanger **10** resting upon an appropriate hanger seat **11** connected to the outermost casing string F. The inner casing string H is connected to a casing hanger head **12** resting upon an appropriate seat **13** of the intermediate hanger **10**. It is desired to run yet another smaller diameter string of casing (not shown) through the inner casing string H and to be carried from the casing hanger head **12**, after the well bore has been drilled to the required depth.

As specifically disclosed in the drawings, the casing hanger **12** includes a main body section **14** having a counterbore **15**, the base **16** of the counterbore providing a support or upwardly facing shoulder against which a hanger seat **17** is to bear, as described hereinbelow. The casing hanger head further includes a coupling section **18**,

including a pin **19** threadedly secured to a companion upper box **20** on the main body section, the threads **21** preferably being left-hand threads. The coupling section **18**, in turn, is threadedly attached to a marine conductor pipe or riser K that extends upwardly through the body of water B to the drilling platform C. Although not disclosed in the drawings, a blowout preventer or a series of blowout preventers are disposed between the casing hanger body **12** and the riser K. Such blowout preventer or preventers are not shown since they form no part of the present invention.

The lower end **22** of the coupling section **18** is longitudinally spaced from the upwardly facing shoulder **16** of the main body section, such lower end and shoulder forming upper and lower sides of a circumferential groove **23** provided in the head **12**, and into which the hanger seat **17** is adapted to expand for installation therein. This hanger seat is installed after the well has been drilled to the required depth, and in its absence, a suitable drill bit (not shown) may be connected to the lower end of a series of drill collars M, the upper end of which is connected to drill pipe N terminating in an upper kelly P supported from the usual swivel R carried by the travelling hook and block S, crown block T, and intervening cable W, mounted on the usual derrick Y forming part of the drilling rig on the drilling platform C. The drill bit can be of a maximum size for passing downwardly through the marine conductor pipe or riser K, casing hanger head **12** and the casing H suspended therefrom, so as to be capable of drilling a maximum size of well bore below the inner casing string H.

After the well bore has been drilled by the drilling bit, or a plurality of drilling bits, the drilling string and the last bit are elevated from the well bore, and through the casing H and riser K to the drilling platform C. Thereafter, a hanger seat **17** of required size to expand outwardly into the casing hanger groove **23** is detachably secured to a running tool **30** secured to the lower end of the drill collars M. This combination is run from the drilling platform through the riser toward the casing hanger head **12** by means of the drill pipe N connected to the drill collars M.

As specifically disclosed in the drawings, the hanger seat **17** comprises a sleeve or ring having a longitudinal split **31** extending completely therethrough, the hanger seat tending inherently to expand to a diameter that will bring it into snug engagement with the base **23***a* of the groove **23**. In making the hanger seat, a solid sleeve having an outside diameter slightly greater than the diameter of the base **23***a* of the groove may be provided, and this sleeve or ring is cut longitudinally throughout its length to provide the split or gap **31**. It is then contracted to a diameter slightly less than the inside diameter of the marine conductor pipe or riser K. This sleeve or ring **17** has a length which is greater than the length of the coupling spaces usually present between adjacent sections of the riser K. It will only fit within a groove or gap having a length slightly exceeding its length, which is the casing hanger groove **23**. The groove **23** has a length substantially greater than the length of any groove or gap in the riser K and other equipment thereabove.

The casing hanger sleeve **17** has an inwardly projecting seating portion **35** constituted by an inwardly directed flange having an upper downwardly tapering seat **36** and a lower downwardly flaring surface **37***a* opening through the lower end of the seat. The seat **17** also has an upper reduced diameter portion **37** adapted to fit within a restraining skirt **38** of a body adapter **39** forming part of the running tool **30**. When the reduced diameter upper portion **37** of the seat is disposed in the adapter **39**, an upwardly facing shoulder **40** on the hanger seat engages the lower end **41** of the adapter, the retracted outside diameter **42** of the hanger seat **17** then preferably being no greater than the outside diameter of the body adapter **39** of the running tool. The hanger seat **17** is releasably

secured to the body adapter **39** by a plurality of shear screws **43**.

The running tool **30** further includes a main body **44** having an upper threaded pin **45** threadedly secured to the lower section of the string of drill collars M, or a drill collar adapter connected to the lowermost section of the drill collar and forming the lower portion of the drilling string that extends upwardly to the drilling platform C. The body adapter **39** is secured to the lower portion of the body **44** by a plurality of longitudinally extending cap screws **46** projecting through the upper portion of the body adaper, the heads **47** of the screws being received within a recess **48** in such upper portion. Initially disposed above the hanger seat **17** and in close proximity thereto, and initially engaging the body **44** and the body adapter **39**, is a seat ejector plate or release member **49** which surrounds a hollow piston rod or conductor tube **50** secured to or integral with an actuator or actuating piston **51** slidably mounted within the body **44** of the running tool. The seat ejector plate **49** is secured to the piston **51** by a plurality of longitudinally extending cap screws **52**.

Initially, the piston **51** and plate **49** are held in an upper position within the body **44** and adapter **39** of the running tool **30** by a helical compression spring **53** surrounding a lower portion of the piston, its lower end bearing against an inwardly directed body flange **54**, its upper end engaging the lower end of a hollow piston head portion **55** of the actuating piston, which is slidable within a cylinder **56** provided by the running tool body **44**. Leakage of fluid between the cylinder wall and the piston head is prevented by a suitable seal ring **57**, such as a rubber or rubber-like "O" ring, mounted in a peripheral piston groove **58** and slidably and sealingly engaging the wall of the cylinder.

As disclosed in the drawings, the conductor tube or pipe **50** is secured to the main body portion **60** of a cleaning tool **61**, which is specifically illustrated as being a hydraulic cleaning tool, in which fluid will flow through the conductor tube or pipe **50** and laterally through passages **62** in the body of the cleaning tool, discharging through nozzles **63** that will eject high velocity streams of fluid against the wall of the riser pipe K and against portions of the casing hanger body **12** to clean the parts, and thereby offer assurance that the running tool **30** and casing hanger seat **17** can be lowered to the groove **23** in the casing hanger body **12**, and can expand outwardly thereinto to its final seating position. Although a hydraulic or jet type of cleaning tool **61** is disclosed for purpose of illustration, a drill bit (not shown) can be used in its place, rotation of the drill bit effecting a cleaning action, as well as the fluid jets emanating from the usual drill bit nozzles. The fluid discharged from the nozzles **63** passes upwardly around the cleaning tool **61**, flowing around the exterior of the retracted hanger seat **17**, or into its interior, and through passages **65** in the seat ejector plate **49** that communicate with openings **66** in the body adapter, which, in turn, communicate with grooves **67** extending from the openings **66** into aligned circulation grooves **68** formed in the exterior of the body **44** of the running tool, the circulating fluid continuing upwardly around the drill collars M and drill pipe N back to the drilling platform C.

In connection with the installation of the hanger seat **17** in the casing hanger head **12**, the hanger seat is contracted and is mounted within the restraining skirt **38** of the body adapter **39**. The shear screws **43** are then applied to releasably secure the seat to the adapter, the running tool **30** and hanger seat **17** then being in the relative condition illustrated in FIG. 2, in which the hanger seat has clearance with the inner wall of the riser K. This combination of apparatus is lowered from the drilling platform C by means of the drill string N, M through the riser toward the casing hanger head **12**. Circulating fluid may be pumped down through the drill string while it is being rotated to rotate the running tool **30**, hanger seat **17** and the cleaning tool **61**, the fluid jetting against the

wall of the riser. As the apparatus is lowered through the riser, the cleaning tool **61** will also move downwardly past the casing hanger head **12**, the fluid jetting into the groove **23** and insuring that such groove is or becomes clean. The lowering action is stopped before the hanger seat **17** is located in the casing hanger head **12**, and preferably when it is positioned above the coupling section **18** of the casing hanger head.

After the cleaning action has been completed, a tripping member **70**, such as a valve ball member, is dropped into the drilling string, gravitating or being pumped downwardly therethrough until it engages a valve seat **71** within the hollow piston **51** formed on a seat insert **72** secured within the piston **51**. Pressure can now be built up in the fluid within the string of drill pipe M, N, exerting a downward force on the piston **51** and on the seat ejector plate or release member **49**, the latter bearing against the upper end of the hanger seat **17**. When the pressure has increased sufficiently to overcome the shear strength of the screws **43**, the latter are disrupted and the piston **51** and plate **49** moved downwardly to shift or eject the hanger seat **17** from the restraining skirt **38** of the body adapter **39**, the hanger seat then expanding inherently outwardly into frictional engagement with the wall of the riser K.

The extent of expansion may be such that the plate **49** will still be engaged with the upper end of the hanger seat **17**, as disclosed in FIG. 3. The running string M, N can now be lowered to cause corresponding lowering of the running tool **30**, the plate forcing the hanger seat **17** downwardly within the riser so long as pump pressure is being applied to the fluid in the string of drill pipe. However, such pump pressure can be discontinued, allowing the spring **53** to elevate the piston **51** and plate **49** and move the plate back within the restraining skirt **38** of the body adapter. The lowering of the drill string M, N and running tool **30** will cause the plate **49** to still engage the upper end of the hanger seat **17**, or, if the latter has expanded outwardly beyond the diameter of the hanger plate, the lower end **41** of the restraining skirt **38** will then engage the upper end of the hanger seat to push the latter downwardly in the marine conductor pipe or riser. Downward sliding of the hanger seat in this manner continues until it slides along the wall of the coupling section **18** and becomes disposed opposite the circumferential groove **23** in the casing hanger, at which location it will snap outwardly inherently into the groove and come to rest with its lower end engaging the lower side **16** of the groove, as disclosed in FIG. 4. The string of drill pipe and collars M, N and running tool **30** can now be elevated through the riser K and removed entirely therefrom.

An inner string of casing or pipe (not shown) can now be lowered from the drilling platform C through the riser K, and an upper head (not shown) on such string of pipe will come to rest upon the upper seat **36** of the casing hanger. Such head will preferably also be connected through a left-hand thread to a riser that extends through the riser K to the drilling platform.

As stated above, following the suspension of the casing or pipe from the casing hanger **17**, and upon completion of the well in a required manner and its successful testing, the riser of each string of casing, such as the riser K, is backed off by rotating each riser to the right, the disconnection being effective at their left-hand threads (as at the threads **21**), and the well is capped. Thereafter, the drilling platform C is removed and a light production platform installed in its place, the well then being completed in the manner described above or other desired manner.

I claim:

1. In apparatus for suspending pipe in a well bore: a head having a circumferential recess therein; an inherently expandable hanger seat adapted to expand into said recess to provide a seat for supporting a string of pipe in the well bore; a running tool connectible to a tubular running-in string for lowering toward said head; means releasably connecting said hanger seat in retracted condition to said running tool; and means for releasing said hanger seat from said running tool to enable said hanger seat to expand inherently into said recess upon being lowered into transverse alignment therewith.

2. In apparatus as defined in claim **1**; wherein said means for releasing said hanger seat comprises hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string.

3. In apparatus as defined in claim **1**; wherein said means releasably connecting said hanger seat in retracted condition to said running tool comprises means on said running tool encompassing said hanger seat; said means for releasing said hanger seat ejecting said hanger seat from encompassing relation by said means on said running tool to permit said hanger seat to expand.

4. In apparatus as defined in claim **1**; and a cleaning tool connected to and depending from said running tool for conditioning said recess for the reception of said hanger seat therein.

5. In apparatus as defined in claim **1**; wherein said means releasably connecting said hanger seat in retracted condition to said running tool comprises means on said running tool encompassing said hanger seat; said means for releasing said hanger seat comprising hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string for ejecting said hanger seat from encompassing relation by said means on said running tool to permit said hanger seat to expand.

6. In apparatus as defined in claim **1**; wherein said means releasably connecting said hanger seat in retracted condition to said running tool comprises means on said running tool encompassing said hanger seat; said means for releasing said hanger seat comprising hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string for ejecting said hanger seat from encompassing relation by said means on said running tool to permit said hanger seat to expand; and a cleaning tool connected to and depending from said running tool and adapted to discharge fluid pumped down the running-in string to condition said recess for the reception of said hanger seat therein.

7. In apparatus for suspending pipe in a well bore: a head having a circumferential recess therein; a split, inherently expandable hanger seat adapted to expand into said recess to provide a seat for supporting a string of pipe in the well bore; a running tool comprising body means connectible to a tubular running-in string for lowering toward said head; means releasably connecting said hanger seat in retracted condition to said body means; and means engageable with said hanger seat and shiftable relative to said body means for releasing said hanger seat from said body means to enable said hanger seat to expand inherently into said recess upon being lowered into transverse alignment therewith.

8. In apparatus as defined in claim **7**; wherein said means for releasing said hanger seat comprises hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string for shifting said hanger seat downwardly of said body means to released condition.

9. In apparatus as defined in claim **7**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; said means for releasing said hanger seat ejecting said hanger seat from encompassing relation by said skirt to permit said hanger seat to expand.

10. In apparatus as defined in claim **7**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; said means for releasing said hanger seat comprising hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in

string for ejecting said hanger seat from encompassing relation by said skirt to permit said hanger seat to expand.

11. In apparatus as defined in claim **7**; cylinder means in said body means; said releasing means comprising piston means in said cylinder means responsive to the pressure of fluid in the tubular running-in string for shifting said hanger seat downwardly of said body means to released condition.

12. In apparatus as defined in claim **7**; cylinder means in said body means; said releasable means comprising tubular piston means in said cylinder means; and means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be built up in the tubular running-in string and cylinder means to shift said piston means downwardly in said cylinder means to shift said hanger seat downwardly of said body means to released condition.

13. In apparatus as defined in claim **7**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; cylinder means in said body means; said releasing means comprising piston means in said cylinder means responsive to the pressure of fluid in the tubular running-in string for ejecting said hanger seat downwardly from encompassing relation by said skirt to permit said hanger seat to expand.

14. In apparatus as defined in claim **7**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; cylinder means in said body means; said releasing means comprising tubular piston means in said cylinder means; and means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be built up in the tubular running-in string and cylinder means to shift said piston means downwardly in said cylinder means and eject said hanger seat downwardly from encompassing relation by said skirt to permit said hanger seat to expand.

15. In apparatus as defined in claim **7**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; cylinder means in said body means; said releasing means comprising tubular piston means in said cylinder means; means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be built up in the tubular running-in string and cylinder means to shift said piston means downwardly in said cylinder means and eject said hanger seat downwardly from encompassing relation by said skirt to permit said hanger seat to expand; and a cleaning tool connected to and depending from said tubular piston means and adapted to discharge fluid pumped down the running-in string and tubular piston means to condition said recess for the reception of said hanger seat therein.

16. In apparatus for suspending pipe in a well bore from a head having a recess therein: a split, inherently expandable hanger seat adapted to expand into the recess to provide a seat for supporting a string of pipe in the well bore; a running tool comprising body means connectible to a tubular running-in string for lowering toward the head; means releasably connecting said hanger seat in retracted condition to said body means; and means engageable with said hanger seat and shiftable relative to said body means for releasing said hanger seat from said body means to enable said hanger seat to expand inherently into the recess upon being lowered into transverse alignment therewith.

17. In apparatus as defined in claim **16**; wherein said means for releasing said hanger seat comprises hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string for shifting said hanger downwardly of said body means to released condition.

18. In apparatus as defined in claim **16**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; said means for releasing said hanger seat ejecting said hanger seat from encompassing relation by said skirt to permit said hanger seat to expand.

19. In apparatus as defined in claim **16**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; said means for releasing said hanger seat comprising hydraulically actuatable means responsive to the pressure of fluid in the tubular running-in string for ejecting said hanger seat from encompassing relation by said skirt to permit said hanger seat to expand.

20. In apparatus as defined in claim **16**; cylinder means in said body means; said releasing means comprising tubular piston means in said cylinder means; and means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be built up in the tubular running-in string and cylinder means to shift said piston means downwardly in said cylinder means and shift said hanger seat downwardly of said body means to released condition.

21. In apparatus as defined in claim **16**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; cylinder means in said body means; said releasable means comprising tubular piston means in said cylinder means; and means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be built up in the tubular running-in string and cyilnder means to shift said piston means downwardly in said cylinder means and eject said hanger seat downwardly from encompassing relation by said skirt to permit said hanger seat to expand.

22. In apparatus as defined in claim **16**; wherein said means releasably connecting said hanger seat to said body means comprises a skirt on said body means encompassing said hanger seat; cylinder means in said body means; said releasable means comprising tubular piston means in said cylinder means; means adapted to be lowered through the tubular running-in string into engagement with said piston means to restrict the flow of fluid therethrough and allow fluid pressure to be biult up in the tubular running-in string and cylinder means to shift said piston means downwardly in said cylinder means and eject said hanger seat downwardly from encompassing relation by said skirt to permit said hanger seat to expand; and a cleaning tool connectible to and depending from said tubular piston means and adapted to discharge fluid pumped down the running-in string and tubular piston means to condition the recess of the head for the reception of said hanger seat therein.

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