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PIPE HOLDING APPARATUS

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Fig. 1

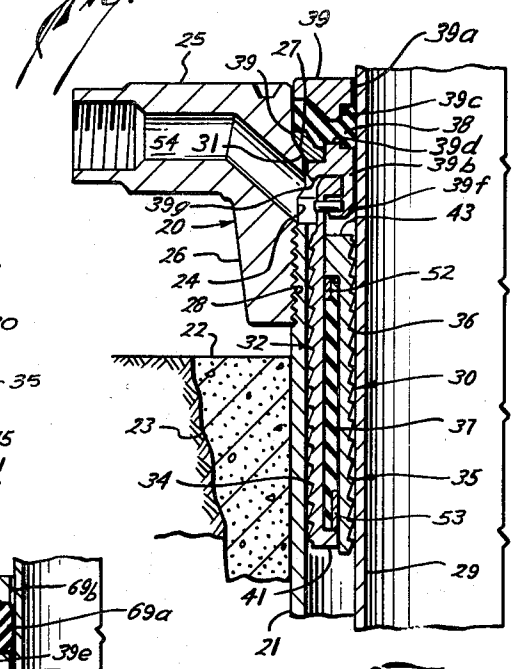

Fig. 5

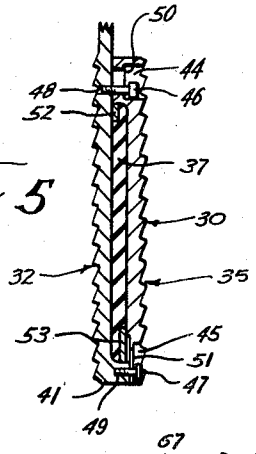

Fig. 2

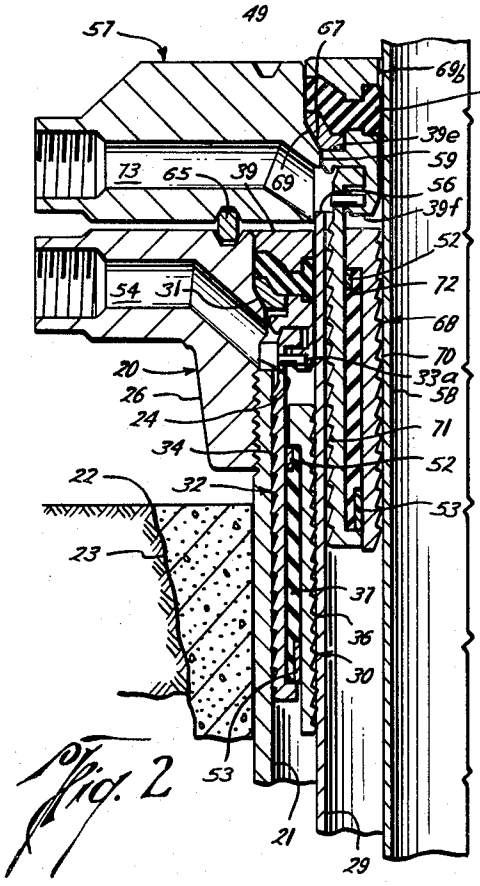

Fig. 6

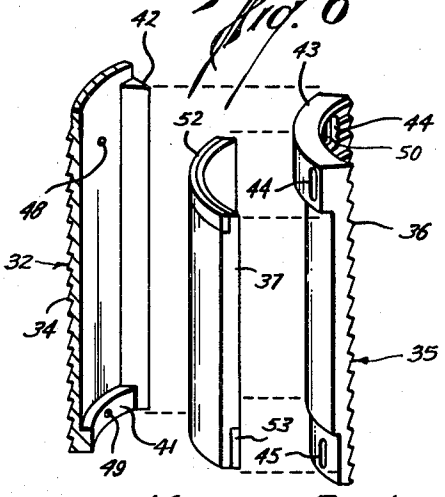

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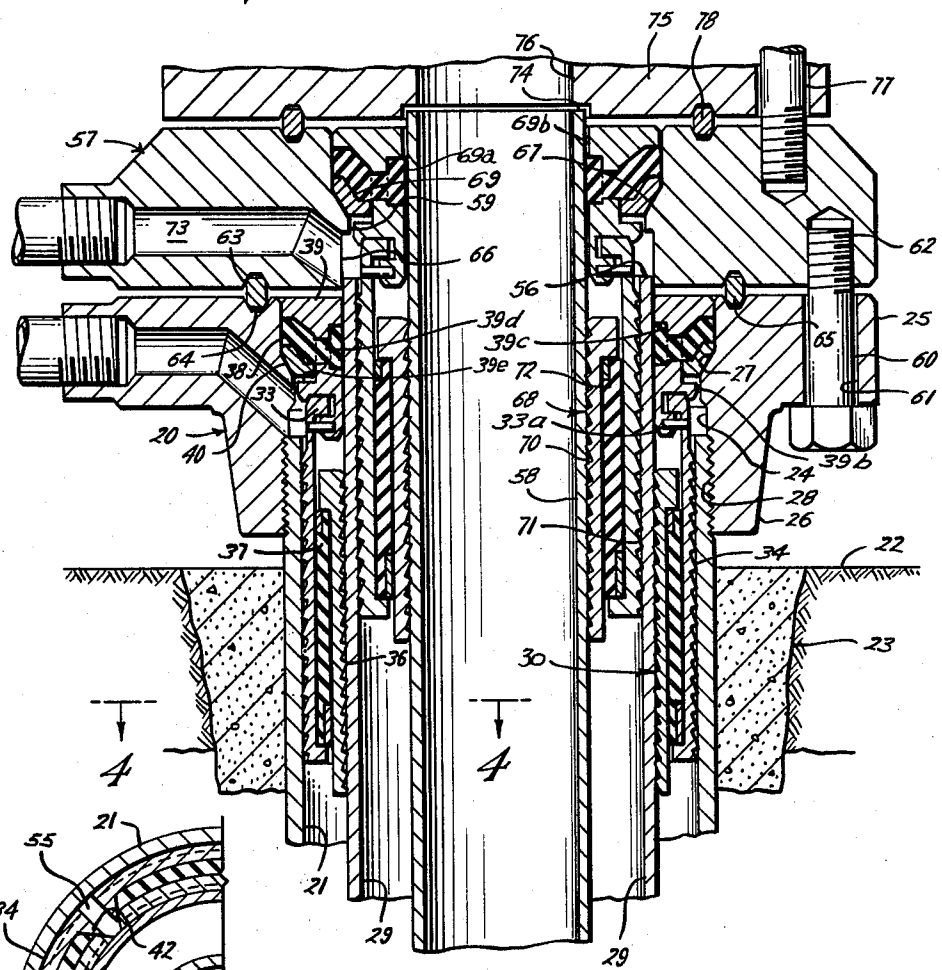
Fig. 3



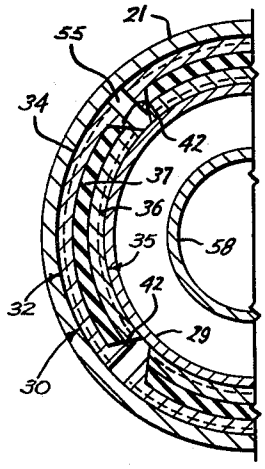


Fig. 4

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Fig. 7

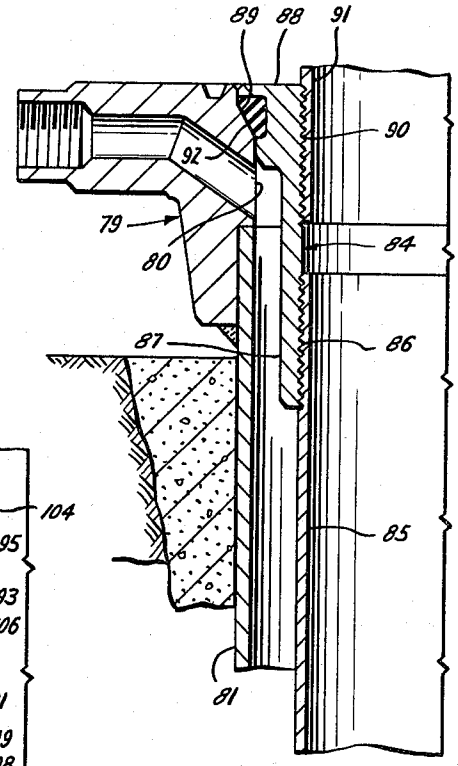

Fig. 8

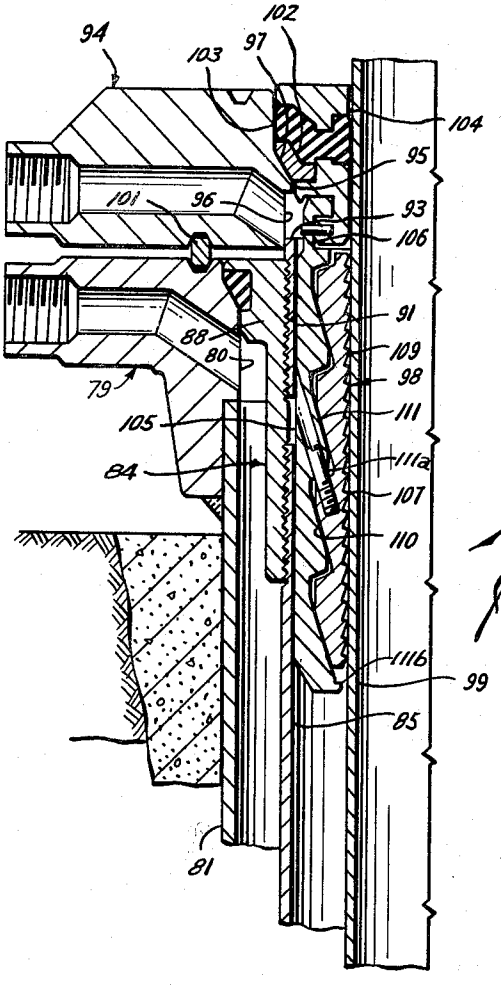

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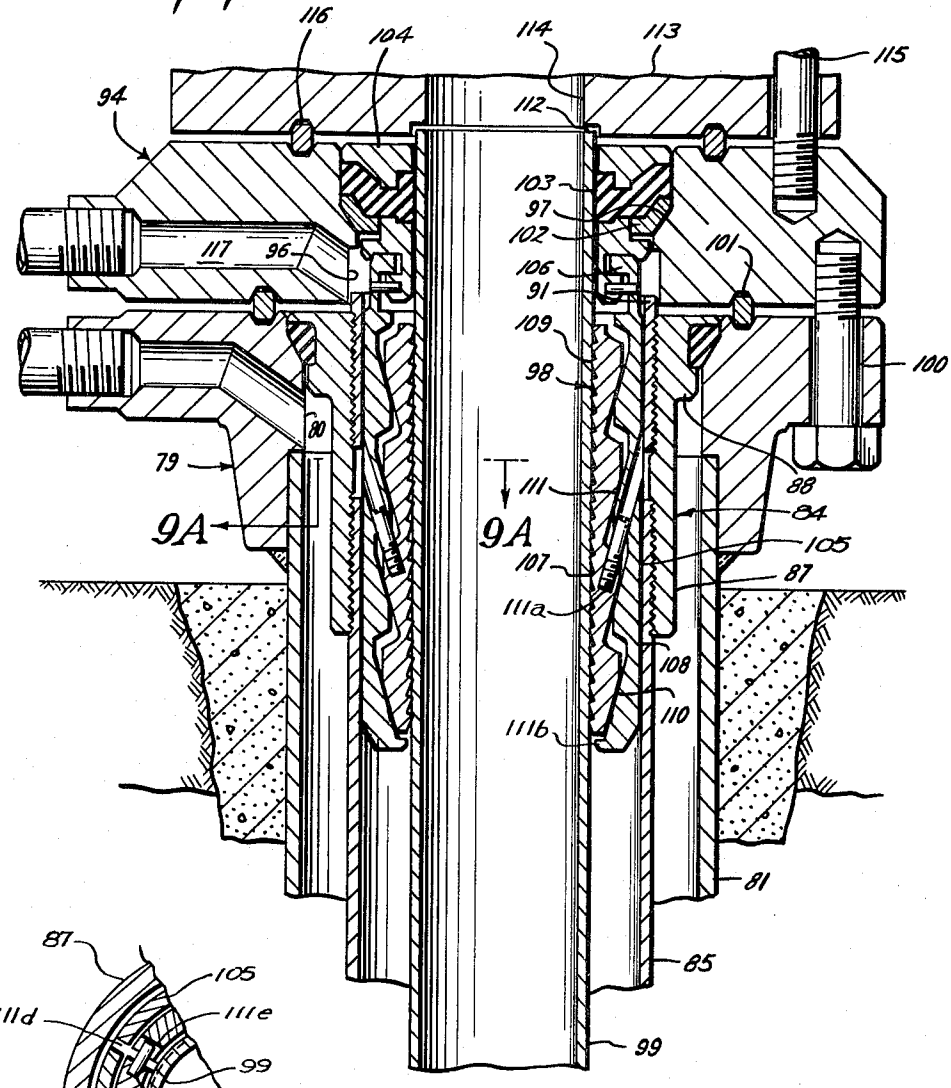
Fig. 9



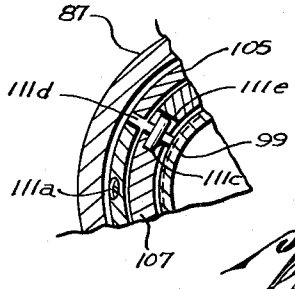


Fig. 9A

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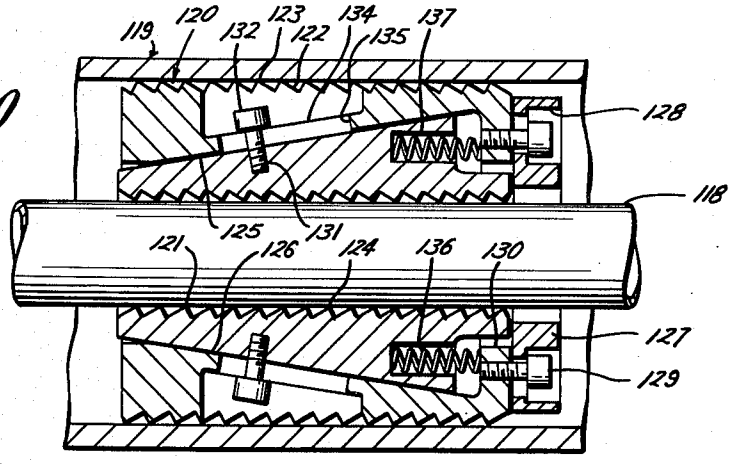
Fig. 10



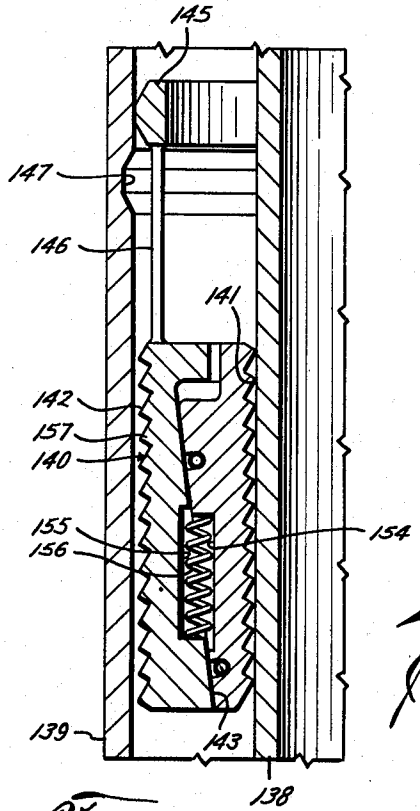
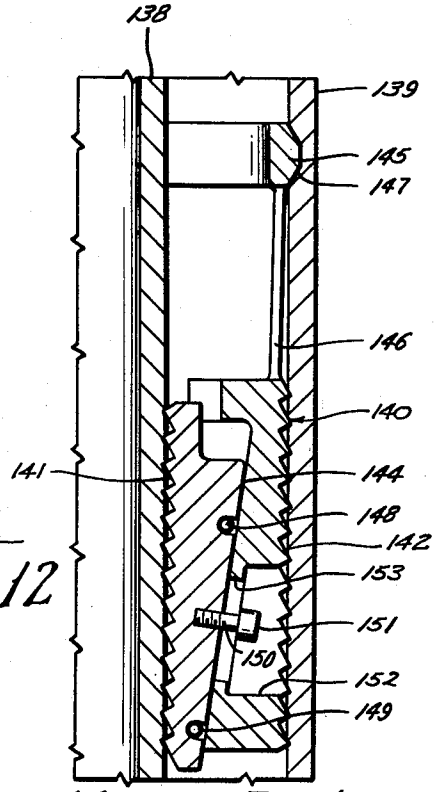


Fig. 11

Fig. 12



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United States Patent Office 3,188,118 Patented June 8, 1965

3,188,118

PIPE HOLDING APPARATUS

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Continuation of application Ser. No. 18,628, May 30, 1960. This application May 27, 1963, Ser. No. 284,289
7 Claims. (Cl. 285—133)

This application is a continuation of my copending application, Serial No. 18,628, filed May 30, 1960, and entitled "Pipe Holding Apparatus." This invention relates generally to improved apparatus for holding one pipe against movement in one axial direction with respect to another. In one of its aspects, it relates to such apparatus for supporting the one pipe against downward movement with respect to the other; and, more particularly, to equipment for suspending concentric strings of pipe from a wellhead.

In a typical installation of equipment of this type, a first casing head is connected to the upper end of an outer casing string and suspends an inner casing string within the outer string by means of a hanger which seats in the bore of the casing head. A second casing head connected above the first casing head suspends an oil string within the inner casing string by means of a similar type of hanger, and a tubing string is suspended within the oil string by a hanger seated in a tubing head connected above the second casing head. The heads are generally sealed to one another by means of a gasket which surrounds their bores. Conventionally, each casing hanger includes slips which slide down a tapered surface in the bore of the casing head to grip the string to be suspended.

In an "automatic" hanger of this general type, an annular seal is supported on a ring seatable on a seat in the casing head and slips are suspended by bolts from a follower ring above the seal for sliding downwardly and inwardly along a tapered surface within the head beneath the seat. Thus, upon seating of the ring and placing of the load of the casing on the slips, such slips are caused to grip the casing and the follower ring is pulled downwardly with respect to the seated ring to deform the seal.

Increasingly limited space beneath the derrick from which the well is drilled has made it desirable to reduce the over-all height of the wellhead. However, increases in the depths of the wells and the weight of the casing to be suspended from the wellheads dictate longer hangers to provide additional slip area for distributing the load on the casing without swaging. Also, during drilling operations, the gasket type seals between the casing heads and the threaded connection of the lowermost casing head to the outer casing string are subjected to intermittent compressive loads. When all of the load of the pipe being suspended is transmitted through these connections and added to the intermittent loads, the total may exceed the yield strength of the connections.

An object of this invention is to solve both of the apparently irreconcilable problems of limited space and increased hanger length by providing wellhead equipment which is shorter than conventional equipment of this type but which, at the same time, enables the hangers to be of any desired length.

A more particular object is to provide equipment of the type above described wherein there is relatively little pipe load transmitted through either the gasket between the casing heads or the threaded connection between the casing head and he outer casing string.

A further object is to provide such equipment in which the slip loads on an inner casing string are at least partially balanced.

Still another object is to provide apparatus operable to hold one pipe against axial movement in one direction with respect to another pipe automatically in response to such movement between the pipes, whether such apparatus is used for the above or other purposes.

A still more specific object is to provide such apparatus for supporting the one pipe from the other in response to receiving the load of the one string; and, particularly in the case of wellhead equipment, to provide a casing hanger for suspending a casing string from an outer casing string in response to landing of the hanger in the bowl of a casing head.

Another object is to provide an "automatic" casing hanger which is particularly well suited for the purposes of this invention, and, more particularly, which is of such construction as to suspend one casing from another concentrically arranged casing.

These and other objects are accomplished, in accordance with an illustrated embodiment of the present invention, by means of a wellhead assembly in which one or both of the oil string and inner casing string are suspended from the inner casing and outer casing, respectively. More particularly, there is provided a hanger adapted to be supported on the seat or the bowl in each head and having slip means suspended therefrom for disposal between and gripping engagement with both the suspended and suspending strings.

With the slip means disposed beneath the bowl in the head, the latter need only be of a height necessary to support a ring from which the slip means is suspended, which height is, of course, considerably less than the height necessary to support the entire hanger, particularly when the depth of the well and the weight of the casing require long slips. On the other hand, there is no practical limit to the length of the slip means which may be extended downwardly between the strings in order to avoid swaging of the suspended string.

Also, the suspension of the one string from the string about it reduces the pipe load on the head, which would ordinarily be transmitted through the ring gasket or connecting threads above mentioned, to a relatively small amount. That is, the only load on the head results from that transmitted thereto through the support ring by the weight of the slip means before the load of the pipe to be suspended is placed on it. Furthermore, the slip means between the concentric casings overlap longitudinally of one another so as to balance the slip loads over a portion of an intermediate casing.

In accordance with a preferred embodiment of the invention, the hanger or other apparatus for holding the one pipe against relative axial movement with respect to the other pipe, which movement would be downward in the case of a casing hanger, comprises a plurality of slip assemblies disposable between the pipes in circumferentially separated relation. Each such assembly includes inner and outer slips disposed about one another and having exterior cylindrical pipe gripping surfaces, and means are provided intermediate the inner and outer slip of each assembly for urging them in opposite radial directions upon the relative movement of the slips in said one direction. In one form of the invention, this means comprises a body of rubber-like material at least substantially confined between the inner and outer slips of each assembly. In another alternative form, such means comprises interengaging wedges on such slips.

The slip assemblies are preferably connected for disposal as a unit between the pipes in their circumferentially separated relation. When such apparatus is used for supporting one pipe against downward movement with respect to the other, as in the case of a wellhead assembly, this connecting means comprises a support ring sus-

pending either the inner or outer slips of each assembly. This ring may be split for passage in a retracted state through the suspending pipe and expansion into locking relation within a recessed portion thereof. On the other hand, in the case of wellhead equipment including a casing head having an upwardly facing seat in its bore, the ring is in effect solid for seating upon the seat as the slip assemblies are lowered into the bore.

In either case, the ring thus supports one slip of each assembly against movement with the slip suspended therefrom, so that the other slip will move further downwardly and the slips will be urged radially away from one another by means previously mentioned and into initial engagement with the pipes. However, in the case of apparatus which is used merely to hold one pipe with respect to one another, a means is provided for initially urging the inner and outer slips into engagement with the pipes prior to their relative axial movement in said one direction.

Thus, as the preferred embodiment of the casing hanger contemplated by the present invention is lowered between concentric strings, the ring thereof seats upon the seat in the bore of the head to locate and suspend the slip assemblies between the suspended string and the string to be suspended from the head. The weight of the inner slip of each assembly causes them to move downwardly and inwardly with respect to the outer slips to grip the inner casing. Then, as the weight of the casing string to be suspended is lowered onto the inner slips, the inner and outer slips are moved radially apart to grip both strings and thereby securely support the string to be suspended from the suspended string.

In the improved "automatic" type casing hanger contemplated by this invention, there is a seal ring above the support ring and the outer slip of each assembly is connected to a follower ring above the seal ring for radial sliding inwardly and outwardly thereof. Thus, as the inner slip moves downwardly and inwardly to grip the inner casing to be suspended, the outer slip is free to move outwardly to grip the outer casing. Since the extent of such movement is dependent upon the inner diameter of the particular weight of the outer casing, the freedom thus provided insures a tight gripping of the outer casing by the outer slip. Also, in keeping with the limited space between the casings, and as distinguished from the bolt type slip suspension employed in ordinary automatic casing hangers, the connection of each outer slip to the follower ring comprises a portion on the follower ring which extends downwardly beneath and inwardly of the support ring and has an outwardly projecting flange on its inner end, and an inwardly projecting flange on the upper end of the outer slip which slides radially over this follower ring flange.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a half sectional view of one embodiment of a casing head and casing hanger constructed in accordance with the present invention, with an inner casing string in position to be supported by means of the hanger from an outer casing string threadedly connected to the head;

FIG. 2 is a view similar to FIG. 1, but in which the weight of the inner casing string has been placed on the hanger and in which a second casing head and hanger constructed in accordance with this invention has been installed and the oil string has been positioned for support from the second hanger;

FIG. 3 is a view similar to FIG. 2, except that it is a full section and shows the weight of the oil string lowered onto the second casing hanger and a tubing head or other wellhead member connected above;

FIG. 4 is a cross-sectional view of one half of the casing hanger, as seen along broken line 4—4 of FIG. 3;

FIG. 5 is a vertical sectional view of the casing hanger in a position prior to loading;

FIG. 6 is a view similar to FIG. 5, but in which the parts of the hanger have been separated from one another;

FIGS. 7, 8, 9 and 9A show another embodiment of a casing head and hanger constructed in accordance with this invention and corresponding to FIGS. 1, 2 and 3, FIG. 9A being a partial cross-sectional view of the hanger, as seen along broken line 9A—9A of FIG. 9;

FIG. 10 is a sectional view of apparatus constructed in accordance with this invention and in position between two pipes for holding the inner one against axial movement in a direction to the left with respect to the outer one; and

FIGS. 11 and 12 are half sectional views of another form of apparatus constructed in accordance with this invention for supporting an inner pipe from an outer one, and showing, respectively, the apparatus prior to and upon landing in position between the pipes for so supporting the inner one.

In the embodiment of the invention illustrated in FIGS. 1 to 6, a casing head **20** is threadedly connected to the upper end of an outer casing **21** which extends downwardly below the surface level **22** and is anchored in cement **23**, as well known in the art. As best shown in FIG. 3, the casing head **20** comprises a tubular body having a bore **24** extending centrally through an upper, substantially flat flange portion **25** and a lower portion **26** depending coaxially from the upper portion. A conical seat or bowl **27** is formed in the upper portion **25**, while the lower portion **26** is threaded at **28** about the bore for connection with threads on the upper end of the outer casing string **21**.

As best shown in FIG. 1, an inner string of casing **29** has been lowered into a position substantially concentrically within the outer casing string **21**, and a casing hanger **30** has been lowered into the annular space between the inner casing string **29** and the bore **24** of the casing head and inside of the outer casing string **21**. This hanger includes a support ring **31** having a seat **40** on its outer periphery adapted to seat upon the seat **27** in the bore of the casing head; a ring **38** of rubber or like sealing material above the support ring and having inner and outer peripheries adjacent the bore **24** of the head and the casing **29**; and a follower ring **39** having an upper portion **39***a* above the seal ring **38** and movable downwardly with respect to the support ring **31**. Although each of these rings may be hinged at one point and split at another point about their circumference to facilitate wrapping of the hanger about the inner casing, they generally will form a complete circle when in place, as shown in the drawings.

The lower portion **39***b* of the follower rings extends downwardly from the upper portion radially inwardly of and below the support ring **31**. The inner periphery of the seal ring **38** is received within an inner recess **39***c* on the follower ring and is connected to its outer periphery through a series of holes **39***d*. More particularly, the upper portion **39***a* of the follower ring is at least substantially coextensive of the seal ring in a lateral direction, and the inner periphery of the support ring **31** is closely adjacent the lower portion **39***b* of said ring so as to at least substantially confine the seal ring therebetween. Thus, when the ring **31** is seated and the follower ring is moved downwardly, as shown in FIG. 2 and in a manner to be described hereinafter, the outer periphery of the seal ring is deformed into sealing engagement with the bore **24** of the head **20** above the seat **27**. Similarly, the deformation of the outer periphery of the seal ring is transmitted through the sealing material within the holes **39***d* to cause its inner periphery to sealingly engage the inner casing **29**.

The outer side of the lower portion of the follower ring has a shoulder **39***e* thereabout which supports the support ring **31** during handling of the hanger. The lower

end of the lower portion has an outwardly extending flange 39*f* which supports an inwardly extending flange 39 of the upper ends of circumferentially spaced-apart slips 32. The upper and lower sides of the flanges 33 fit closely between the flange 39*f* and the underside of the follower ring, and radially extending pins 33*a* connect the flange 39*f* to the upper end of the slips to align the slips vertically with respect to the follower ring, and particularly with respect to the separation between the support, seal and follower rings, so that the slip assemblies can be wrapped around the casing with such rings.

Thus, the slips 32 are freely movable radially outwardly from the position of FIG. 1 to that of FIG. 2 a distance sufficient to tightly grip the outer casing, and the follower ring 39 is free to move downwardly to fully deform the seal ring, as will be described below. A shoulder 39*g* on the underside of the follower ring is engageable with the outer side of the flanges 33 on the slips 32 to limit their outward movement during handling.

The first set of slips 32 have teeth 34 on their outer cylindrical surfaces for disposal adjacent the inner diameter of the outer casing string 21 when they are suspended from the support ring in the manner above described. A second set of slips 35 are arranged in circumferentially spaced-apart relation concentrically within the first set 32, and have teeth 36 on their inner cylindrical surfaces for disposal adjacent the outer diameter of the inner casing string 29. More particularly, the first and second slips are arranged in pairs to form a plurality of circumferentially spaced-apart slip assemblies, as best shown in FIG. 4.

Thus, as can be seen from the drawings, the casing head 20 is relatively short since only the support, seal and follower rings of the hanger 30 need be supported within the bore. It will also be seen that the slip assemblies suspended from the support ring are of relatively large longitudinal extent to provide the desired bearing surface for gripping the strings, in a manner to be described below, without swaging.

In this particular embodiment of the invention, a body 37 of rubber or other deformable material is at least substantially confined longitudinally as well as laterally between the slips 32 and 35 of each assembly so as to support the second or inner slips from the first or outer slips and move the two slips of each assembly away from one another, as previously described. Thus, longitudinal movement of the inner slips 35 downwardly with respect to the outer slips 32 will lessen the longitudinal extent and increase the radial extent of the body 37, as can be seen from a comparison of FIGS. 1 and 2, to force the slips of each assembly radially away from one another and into gripping engagement with the inside of the string 21 and outside of the string 29. More particularly, the teeth 34 are directed downwardly to support the outer slips from the outer casing string 21 when they are forced into gripping engagement therewith, while the teeth 36 on the inner slips 35 are directed upwardly to support the inner casing string 29 when they are forced into gripping engagement therewith, whereby the load of the inner string 29 is carried by the outer string 21. As previously mentioned, this is to be distinguished from the conventional installation in which the ordinary hanger is seated upon the head so as to transmit the load of the suspended pipe through the sealing threads 28 which connect the head to the outer string of casing.

Turning now to FIGS. 4, 5 and 6 for a more detailed description of the construction of each slip assembly and its operation in suspending the inner string 29 from the outer string 21, each outer slip has a lower flange 41 and two side flanges 42 projecting inwardly from the lower and opposite side edges, respectively, of the inner surface thereof. Each inner slip 35, on the other hand, has an upper flange 43 projecting outwardly from the upper edge of its outer surface to fit within the side flanges 42 of the outer slip to provide an arcuate space which at least substantially confines the body 37 of rubber during its deformation.

When the hanger 30 is first disposed between the strings 21 and 29, and prior to placement of the load of the string 29 upon the inner slips, there will be enough downward movement of the inner slips 35 with respect to the outer slips to partially deform the body of rubber, as shown in FIG. 1, whereby the teeth 34 and 36 on the slips are moved radially away from one another into initial engagement with the two strings. That is, although there may be a small amount of downward movement of the outer slips, and thus the follower ring 39, with respect to the support ring 31, the outer slips are, at this stage, at least substantially restrained from downward movement by landing of the support ring 31, so that the inner slips are free to move under their own weight a distance downwardly sufficient to longitudinally compress and radially expand the rubber body 37 until the slip teeth engage the two strings. This will enable the teeth 36 to take an initial bite on the inner casing 29 as the load of the latter is transferred from the means (not shown) by which it is suspended from the derrick onto the slip assembly. Then, as previously described, when more of the load of the string 29 is placed upon the slip assembly, the body of rubber is further deformed to move the inner slips further downwardly with respect to the outer slips and both sets of slips radially away from one another into gripping engagement with the strings 21 and 29.

This loading of the slip assemblies will also move the follower ring 39 downwardly from its elevated position of FIG. 1 to the position of FIGS. 2 and 3 so as to deform the seal ring 38 into sealing engagement with the string 29 and the bore 24 in the manner previously described. However, as has also been described, the connection of the follower ring to the slips 32 of each assembly permits a complete deformation of the seal ring as well as a penetration of the casing 21 by the slip teeth 34 sufficient to suspend the inner casing 29 therefrom.

In order to facilitate this automatic deformation of the sealing elements, the teeth 34 on the outer slips may be initially less effective than the teeth on the inner slips in gripping its respective pipe surface. In this manner, there will always be an initial downward movement of the outer slips, as the load of the inner pipe is placed on the inner slips, sufficient to insure full deformation of the seal rings. This may be accomplished, for example, by relatively dull teeth on the outer slips.

With further reference to FIGS. 4, 5 and 6, the inner and outer slips of each assembly are connected to one another in such a manner as to maintain them in assembled relation while at the same time enabling the above-described longitudinal and radial movement with respect to one another. More particularly, the inner slips are provided with elongated slots 44 and 45 to receive cap screws 46 and 47 for threaded connection within sockets 48 and 49, respectively, in the outer slips. As shown in FIG. 6, the slots 44 and 45 are reduced toward their inner ends to provide shoulders 50 and 51 for engagement with the heads of the screws 46 and 47, respectively, to prevent the inner slips from becoming detached from the outer slips. Also, the upper and lower corners of the body of rubber 37 are provided with metal reinforcements 52 and 53, respectively, adjacent the separation between the inner and outer slips to prevent flowing of the rubber during deformation.

The casing head 20 is provided with one or more radial passages 54 connecting its exterior with the bore 24 therethrough, and the spaces 55 between adjacent slip assemblies (FIG. 4) communicate between the annular space between strings 21 and 29 below the slip assemblies and the bore 24. Thus for purpose will known in the art, there is a flow path between such annular spaces and the exterior of the head.

Upon suspension of the inner casing string 29 in the

manner described, its upper end is cut off at 56 on a level just above the top surface of the casing head 20, as shown in FIGS. 2 and 3. Another casing head 57 is then connected above the casing head 20 preparatory to suspension of another casing string 58, known as the "oil string," from the inner string 29 in a manner described below. This second casing head 57, which has a bore 59 therethrough of substantially the same diameter as the inner diameter of the casing string 29, is connected above the first casing head with their bores substantially axially aligned. For this purpose, bolts 60 are received through openings 61 in the upper flange portion 25 of the casing head 20 and threadedly connected within sockets 62 in the casing 57, as shown in FIG. 3.

Annular grooves 63 and 64 in the adjacent lower and upper surfaces of the casing heads receive a metal ring gasket 65 or other sealing element therebetween for sealing between the heads in surrounding relation to their bores as the bolts 60 are tightened up. As can be seen from FIGS. 2 and 3, the lower end of the bore 59 through the second casing head is recessed at 66 so that it fits over the upper end of the inner casing string 29, and the upper end of the bore 59 is provided with a conical bore 67, similarly to the bowl 27 in the first casing head.

Another casing hanger 68 substantially identical with the other casing hanger 30 is suspended between the oil string 58 and the bore through the head and the inner casing string 29 for supporting the oil string from the inner casing string, in a manner similar to that above described with regard to supporting of the inner string from the outer string 21. Thus, the hanger 68 also comprises a support ring 69 which seats in the bowl 67 of the casing head, and a slip means suspended from the ring for disposal between the inner casing string and the oil string so as to support the latter from the former.

This support of the oil string also enables the second casing head to be of substantially short construction since it need only support the ring 69 as well as seal and follower rings 69*a* and 69*b* associated therewith similarly to that above described. As distinguished from the first casing head 20, the entire casing head 57 is substantially flat since it does not require a depending portion for supporting the inner string 29, which is instead supported from the outer casing string 21 in the manner previously described. Also, this support of the oil string 58 enables the assemblies of circumferentially spaced-apart inner and outer slips 70 and 71, respectively, to be disposed between the suspended string and the string to be suspended without transmitting the load of the tubing string through the gasket 65. Thus, as the load of the oil string 58 is placed upon the inner slips 70, the teeth on the inner and outer slips are moved radially away from one another to firmly grip the oil string and inner casing string, while at the same time causing the sealing ring 69*a* to seal between the oil string and the bowl of casing head 57, in a manner obvious from the foregoing description. When the teeth of the slips have fully set, the load of the oil string is transmitted through the body 72 of rubber of the hanger 68 to the outer slips and thus to the inner casing string 29.

It is important to note that the lower ends of the slip assemblies of the hanger 68 overlap with the upper ends of the slip assemblies of the hanger 30. Thus, the forces with which the teeth of the slips 71 and 35 engage opposite sides of the inner casing string 29 will tend to offset one another such that there is less opportunity for the string to be swaged.

Similarly to the first casing head, the second casing head is provided with one or more radial passages 73 connecting the exterior of the head with the bore 59 therethrough, and the slip assemblies of hanger 68 are spaced apart in a manner similarly to that shown in FIG. 4, so as to provide a continuous flow passage between the annular space between strings 29 and 58 below the hanger and the exterior of the second casing head.

When the oil string has thus been supported from the inner casing string, its upper end 74 is cut off, as indicated in FIG. 3, and another wellhead member 75, which may be a tubing head and which has a bore 76 therethrough of a diameter substantially the same as the inner diameter of the tubing string, is connected above the second casing head by means of bolts 77 and sealed with respect thereto by means of a gasket 78. Although other preparations may be necessary to complete the wellhead for production of the well, they are well known in the art. While three strings of casing, 21, 29 and 58 have been shown, it will be understood that a fourth and even more strings of casing may similarly be suspended within casing string 58.

In the embodiment of the invention shown in FIGS. 7, 8 and 9, there is shown a conventional casing head 79 of a construction in most respects similar to that of casing head 20 and a casing hanger 84 seated in the casing head 79 which is also of more or less conventional construction. That is, as distinguished from the casing hanger 30, the hanger 84 supports the inner casing string 85 by means of a threaded connection 86 along a lower tubular end 87 of the hanger which is suspended from a ring 88 at its upper end. Thus, in this embodiment of the invention, the load of the inner casing string 85 is transmitted through the hanger 84 directly to the casing head 79.

Similarly to the support ring 31 of the casing hanger 30, the ring 88 is adapted to seat about its outer surface upon a conical bowl 89 in the bore of the upper flanged portion of the casing head. Its inner surface is threaded to sealably connect at 90 to the lower end of an upper joint 91 of the inner casing string 85. The ring 88 is also recessed about its outer periphery to receive a sealing element 92 which protrudes outwardly from the outer surface of the ring prior to its engagement with the seat 89 and then is deformed inwardly upon loading of the hanger to form a seal between the ring and the seat 89, as shown in FIG. 7. The lower end 87 of the casing hanger 84 depends downwardly from the bowl 89 for disposal between the outer casing string 81 and the inner casing string 85.

Upon running of the inner casing string 85, the upper end of joint 91 is cut off at 93, as shown in FIGS. 8 and 9, and a second casing head 94 constructed substantially similarly to the casing head 57 of the first embodiment is disposed over the first casing head with its bore 95 in substantial registry with the inner diameter of inner casing string 85. More particularly, and similarly to the bore of the tubing head 57, the bore 95 through the casing head 94 is recessed at 96 to fit over the upper end of joint 91 and is provided with a conical bowl 97 at its upper end to provide a seat for a casing hanger 98 which supports the oil string 99 from the inner casing string 85. As shown in FIG. 9, the casing head 94 is connected above the casing head 79 by means of bolts 100 and is sealed with respect thereto in surrounding relation to the bores through the heads by means of a gasket 101 in substantially the same manner as described in connection with the first embodiment of the invention.

A support ring 102 at the upper end of the hanger 98 also corresponds substantially to the rings 31 and 69 of the casing hangers 30 and 68 of the first embodiment in that it seats upon the conical bowl 97. The hanger 98 also includes a seal ring 103 and a follower ring 104 for sealing between the casing head 94 and the oil string 99 when the load of the oil string is placed upon the slip means of the hanger, in a manner described particularly in connection with hanger 30. Also, the hanger 98 comprises, similarly to the hangers 30 and 68, circumferentially spaced-apart slip assemblies which include outer slips 105 suspended from the support ring and inner slips 107 which are supported from the outer slips. Furthermore, these slip assemblies are disposed between the oil string 99 and the inner casing string 85, including the joint 91, for gripping engagement therewitth to support the oil string from the inner casing string. In this man-

ner, the load of the oil string is not transmitted through the gasket **101** and the slip assemblies are enabled to be of whatever length is deemed desirable under the circumstances while, at the same time, the casing head **94** is of short construction.

Although the inner cylindrical surfaces of the inner slips are provided with upwardly directed teeth **109** similarly to the inner slips of the other hangers, the outer surfaces **108** of the outer slips are relatively smooth. Thus, as the slips are moved radially away from one another, in a manner to be described below, the surfaces **108** tightly engage the inside of casing **85** and the teeth **109** bite into the outside of the oil string **99** so as to support the load of the oil string from the inner casing string. In this connection, it will be noted that the aforementioned connection of the outer slips **105** to the support ring **102** enable such slips to move freely in an outward direction so as to grip the casing **85** with sufficient force to suspend the oil string **99** therefrom. It will also be appreciated that the substantially smooth exterior surface **108** on the outer slips **105** function, similarly to relatively dull teeth on the outside of the outer slips of the hangers **30** and **68**, to insure sufficient downward movement of the outer slips for fully deforming the seal ring.

The means for supporting the inner slips from the outer ones and moving the inner and outer slips radially away from one another in response to downward movement of the inner slips relative to the outer slips comprises downwardly and inwardly tapered wedges on the inner and outer slips having interengaging surfaces **110** and **111**, respectively. Thus, as will be understood from a comparison from FIGS. 8 and 9, when the hanger **98** is disposed between the oil string and casing head **94** and the inner casing string, and the support ring **102** is landed upon the conical seat **97**, the inner slips **107** will move downwardly over the tapered surfaces **111** to force the slips radially away from one another into initial engagement with the strings **85** and **99**. Then, as the load of the string **99** is placed upon the inner slips, they move further downwardly so as to force the inner and outer slip segments further radially away from one another into tight gripping engagement with strings **85** and **99**. As will be understood from the previous description, this loading of the slip assemblies is transmitted to the follower ring **104** so as to lower same and thereby deform the seal rings **103** into sealing engagement between the pipes, as shown in FIG. 9.

As shown in the drawings, there are a plurality of wedges between the inner and outer slips of each assembly to provide a desired angle of taper without increasing the width of the hanger. Obviously, more or less wedges may be used, depending upon the taper desired and the length of the hanger. Aligned holes are drilled in the slips of each assembly to receive pins **111***a* threaded to the inner slip and extending into the outer slip for sliding therein. More particularly, the axes of the holes are parallel to the wedge surfaces **110** and **111**, and the pins maintain the inner slips in a fixed path as they slide downwardly along the outer slips. A flange **111***b* on the lower end of the outer slips limits this guided downward movement of the inner slips and thereby maintains the slips in assembled relation during handling. As shown in FIG. 9A, pins **111***c* are fitted within one side edge of each inner slip and span the space **111***d* between such slip and an adjacent inner slip for reception loosely within a radial slot **111***e* in the adjacent side edge of the adjacent inner slip, thereby maintaining the slip assemblies in fixed vertical positions with respect to one another, while at the same time enabling some radial play between adjacent assemblies.

As in the case of the head **57** of the first embodiment, casing head **94** is provided with one or more radial passages **117** therethrough which form continuations of spaces between the slip assemblies similarly to those shown in FIG. 4, so as to provide a flow passage between the space between strings **85** and **99** below the hanger **98** and the exterior of the casing head.

When the casing string **99** has been suspended in the manner above described, its upper end **112** is cut off, as shown in FIG. 9, and a wellhead member **113** having a bore **114** therethrough is connected above the casing head by means of bolts **115** and sealed with respect thereto by means of gasket **116**. Thus, the well is completed in the manner described in connection with the first embodiment of the invention.

With reference now to FIG. 10, a first pipe **118** is arranged concentrically within a second pipe **119**, and an apparatus, designated in its entirety by reference character **120** and constructed in accordance with the present invention, is disposed between the two pipes for holding the inner pipe against movement with respect to the outer pipe in a leftward direction, or in the alternative, for holding the outer pipe against movement with respect to the inner pipe in a rightward direction. This apparatus comprises a plurality of circumferentially spaced-apart slip assemblies, each of which includes inner and outer slips **121** and **122** disposed about one another. As shown in FIG. 10, the outer slips have teeth **123** on their exterior cylindrical surfaces directed in a leftward direction, while the inner slips **121** have teeth **124** on their exterior cylindrical surfaces directed in the opposite direction or to the right. The slips of each assembly have wedges on their interiors which provide tapering surfaces **125** and **126** engageable with and slidable over one another. More particularly, these surfaces are tapered convergently toward the left such that upon the aforementioned relative axial movement between the pipes, the teeth on the inner and outer slips of each assembly are urged radially away from one another.

A ring **127**, which may be split for disposal about the inner pipe **118**, connects the assemblies in spaced-apart relation and facilitates their handling during disposal into a desired position between the two pipes. As shown in FIG. 10, this ring is provided with radially elongated slots **128** which receive the heads of cap screws **129** threadedly connected to an inwardly extending flange portion **130** on the end of the outer slips **122** of each assembly. This construction enables the radial movement of the outer slips with respect to the ring **27**, which in effect forms a full circle.

The inner slips **121** are guidably carried by the outer slips **122** by means of cap screws **131** threadedly connected to the inner slips and having heads **132** received for longitudinal movement within a recessed portion **134** of each outer slip. More particularly, the recessed portion **134** on each outer slip is provided with a longitudinal slot **135** opening onto the tapered surface **125** of the outer slip such that the screw **131** is guidably slidable therein during relative axial movement between the inner and outer slips.

The inner and outer slips of each slip assembly are urged in opposite axial directions by means of a coil spring **136** acting therebetween. More particularly, each inner slip **121** is provided with a bore **137** for receiving one end of the spring, while the other end of the spring bears against the flanged end **130** of the outer slip. This slip normally urges the inner slip in a leftward direction with respect to the outer slip, so that it is caused to move along the tapered surface **125** of the outer slip and thereby urge the slip segments into initial engagement with the inner and outer pipes as the apparatus **120** is disposed therebetween. Then, as the pipes are moved relatively to one another in the manner previously mentioned, the slips of each assembly are moved further radially away from one another so that their teeth bite into the respective pipes until they hold the pipes against further relative movement when firmly gripped therewith. Upon movement of the pipes in the opposite axial direction relative to one another, the slips of each assembly slide along

one another in opposite radial directions to release the pipes.

With reference to the embodiment of the invention shown in FIGS. 11 and 12, a pipe 138 is disposed concentrically within a pipe 139 for support against downward movement with respect thereto by means of an apparatus designated in its entirety by reference character 140. Similarly to the apparatus described in connection with FIG. 10, the apparatus 140 comprises a plurality of circumferentially spaced-apart slip assemblies, each of which comprises an inner slip 141 disposed within an outer slip 142. Also, the slips of each assembly have interior wedges which provide downwardly and inwardly tapered surfaces 143 and 144 on the outer and inner slips, respectively, for moving the slips radially away from one another upon downward movement of the inner slips with respect to the outer slips.

Furthermore, this apparatus includes a ring 145 having connectors 146 extending downwardly therefrom for connection to each of the outer slips 142. More particularly, the ring is split to permit its radial contraction and expansion for landing within and removal from a detent 147 in the outer pipe 139. The outer periphery of the ring 145 and the detent 147 may be specially formed for locking engagement with one another as shown; or, if desired, the detent may comprise merely a collar in a string of tubing onto which the outer periphery on the ring 145 may be landed.

As shown in FIG. 11, as the apparatus 140 is moved downwardly between the pipes, the ring 145 is contracted for sliding within the inner diameter of the outer pipe 139. Then, when the apparatus reaches a level between the pipes at which the ring is opposite the detent 147, such ring is automatically expandable outwardly into locking engagement with the detent. This supports the outer slip 142 of each slip assembly against further downward movement such that continued downward movement of the inner slip 141 with respect thereto will cause the slips of each assembly to move radially away from one another.

In this apparatus, the inner slips of the several assemblies are surrounded by garter springs 148 and 149 which normally urge the inner slips inwardly an amount sufficient to cause the teeth on the exterior cylindrical surface of the inner slips to initially engage the inner pipe with a force sufficient to enable the inner pipe to be gripped as it moves downwardly with respect to the inner slips. However, the gripping force provided by the springs 148 and 149 is not so great as to prevent the inner pipe from being released from the apparatus when it is moved upwardly with respect thereto.

As shown in FIG. 12, the inner slip of each assembly is guidably movable along the tapered surface 143 of the outer slip thereof by means of cap screws 150 threadedly connected at their inner ends to the inner slips and having heads 151 received within a recessed portion 152 on the back of the outer slips. As in the case of the embodiment of the invention described in FIG. 10, the recess is slotted at 153 to connect with the tapered surfaces on the outer slips for guidably receiving the intermediate portions of the screws 150.

The inner and outer segment of each slip assembly are also provided with registering recesses at 154 and 155, respectively, to receive a coil spring 156 which acts between the two slips to urge the outer slips downwardly with respect to the inner slips and thereby hold the downwardly facing teeth 157 on the exterior cylindrical surface of each outer slip out of engagement with the inside diameter of the outer pipe 139 until the apparatus has reached the position determined by landing of the ring 145 in the detent 147. However, when the ring is so landed, the force of the spring 156 is overcome by the downward pull of the inner pipe 138 on the inner slip so that the latter moves downwardly with respect to the outer slip for urging the slips radially away from one another. As a result, the teeth 157 on the outer slips are urged into gripping engagement with the outer pipe so as as firmly support the inner pipe therefrom.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A casing hanger, comprising a support ring having a seating surface thereon, a ring of resilient sealing material seated on the support ring, a follower ring having an upper portion supported on the sealing ring and a lower portion below the sealing ring, means connecting the lower portion of the follower ring to the upper portion thereof, and a plurality of circumferentially separated slip assemblies suspended from the follower ring beneath the support ring, each assembly comprising an outer slip, means connecting the outer slip to the lower portion of the follower ring for radial sliding movement inwardly and outwardly thereof, an inner slip, and means supporting the inner slip on the inner surface of the outer slip, said supporting means permitting movement of the inner slip longitudinally downwardly and radially inwardly with respect to the outer slip, whereby load carried by the inner slip is transmitted from said inner slip to the outer slip and then to the lower portion of the follower ring for lowering the upper portion of said ring with respect to the seating surface of the support ring for deforming the seal ring.

2. A casing hanger of the character defined in claim 1, wherein each of said inner and outer slips of each slip assembly has an exterior surface with pipe gripping teeth having their points lying on a cylindrical surface.

3. Apparatus for holding one cylindrical pipe against relative movement with respect to another cylindrical pipe in one axial direction, comprising a plurality of slip assemblies disposable between the pipes in circumferentially separated relation and retaining said pipes in radially spaced-apart relation, each assembly having an inner and outer slip each of which has an exterior surface with pipe gripping teeth having their points lying on a cylindrical surface, means connecting the inner and outer slips of each assembly together for relative axial and radial movement, and means on the inner and outer slips of each assembly forming a substantially confined space therebetween which is at least substantially filled with a body of deformable material, whereby the slips of each assembly are urged in opposite radial directions upon relative movement of said slips in said one axial direction.

4. In a wellhead assembly, an outer casing string, a lower head having a bore therethrough, means connecting the head to the upper end of the outer casing string, an intermediate casing string, a hanger suspending the intermediate casing string within the outer casing string, an upper head having a bore therethrough, means connecting the upper head above the lower head with their bores substantially aligned, an annular seal ring compressed between the upper and lower heads, an inner casing string, and another hanger including a pipe gripping means, at least a portion of the pipe gripping means extending downwardly between and directly engaging the intermediate casing string and the inner casing string to suspend

said inner casing string from said intermediate casing string, so that at least a substantial portion of the load of said inner string is transmitted directly to said intermediate string without transmission through said seal ring.

5. In a wellhead assembly of the character defined in claim 4, wherein the first-mentioned hanger includes a pipe gripping means, and at least a portion of the pipe gripping means extends downwardly between and directly engages the outer casing string and the intermediate casing string to suspend said intermediate string from said outer string, so that at least a substantial portion of the load of said intermediate string is transmitted directly to said outer string without transmission through said connecting means.

6. In a wellhead assembly, a first casing string, a lower head having a bore therethrough, means connecting the bore of the head to the upper end of the first casing string, a second casing string extending downwardly within the first casing string, and a hanger including a pipe gripping means, at least a portion of the pipe gripping means extending downwardly between and directly engaging the second casing string and the first casing string to suspend said second string from said first string, so that at least a substantial portion of the load of said second string is transmitted directly to said first string without transmission through said connecting means.

7. In a wellhead assembly, a first casing string, a lower head having a bore therethrough and a seat about the

bore, means on the bore of the head below the seat connecting said head to the first casing string, a second casing string extending downwardly within the first casing string, and a hanger supported on the seat of the head and including a pipe gripping means, at least a portion of the pipe gripping means extending downwardly between and directly engaging the first and second casing strings to suspend said second string from said first string, so that at least a substantial portion of the load of said second string is transmitted directly to said first string without transmission through said connecting means.

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