

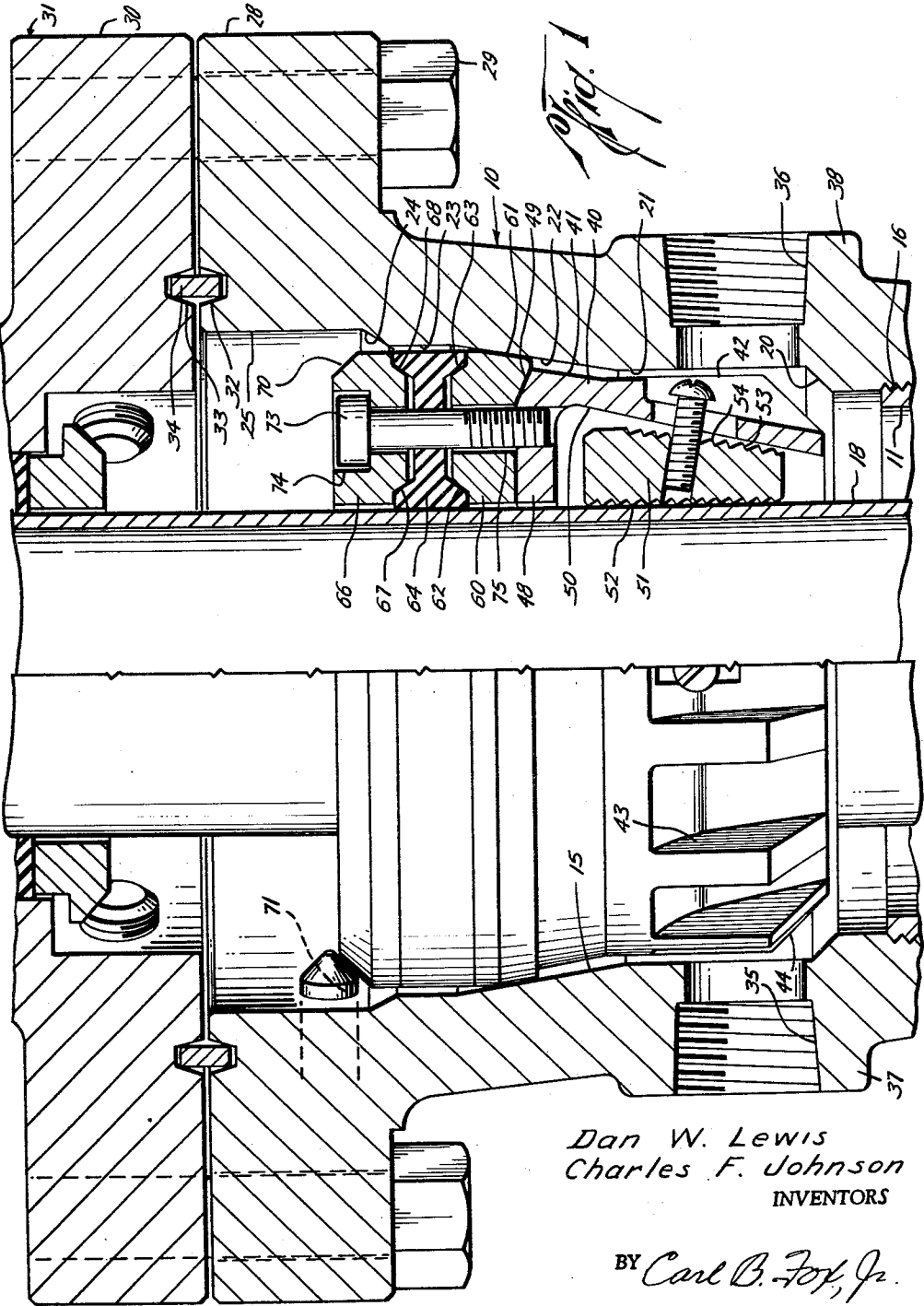
Dec. 11, 1962

D. W. LEWIS ET AL
SUPPORTING APPARATUS

3,068,027

Filed Oct. 13, 1958

3 Sheets-Sheet 1



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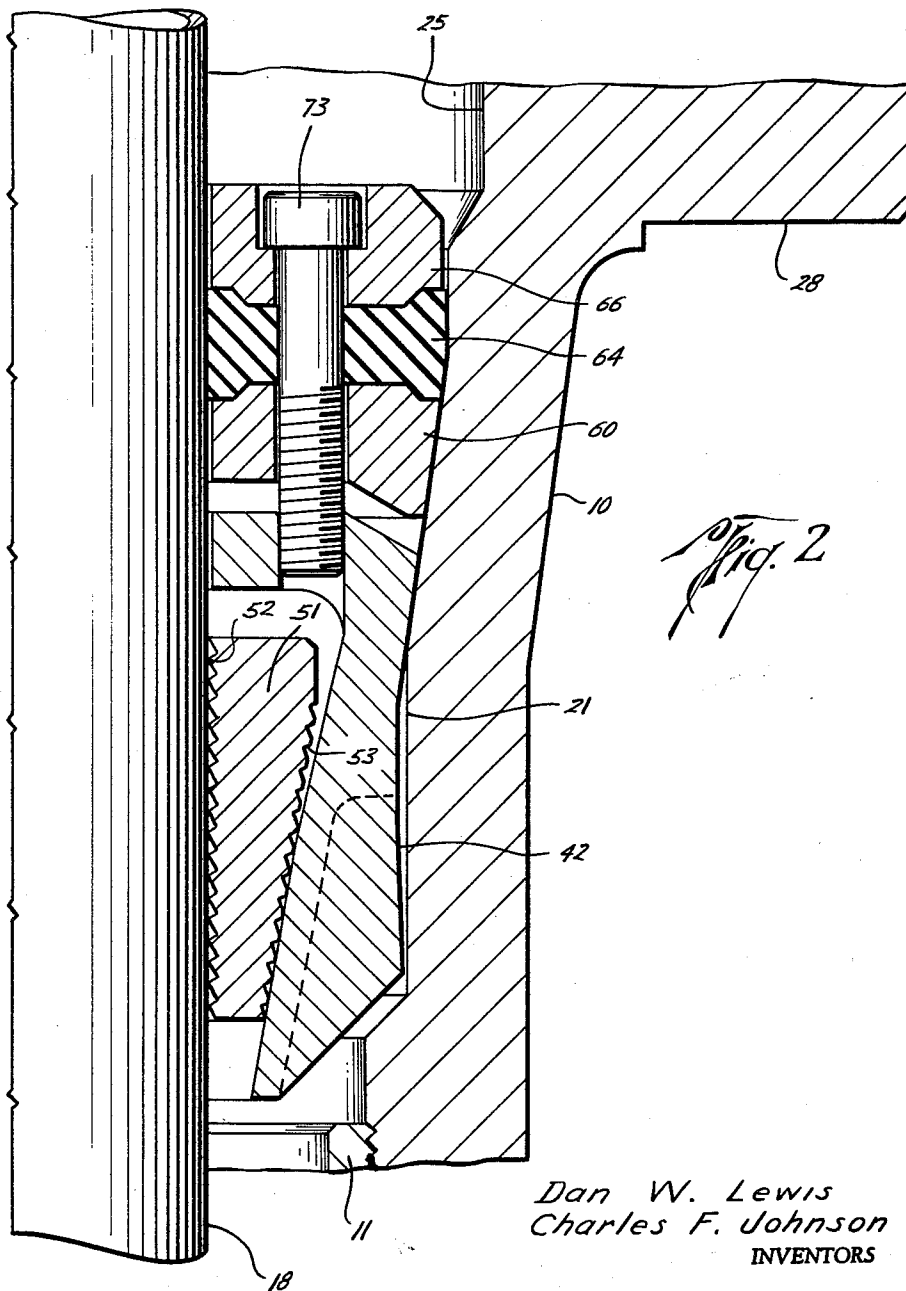
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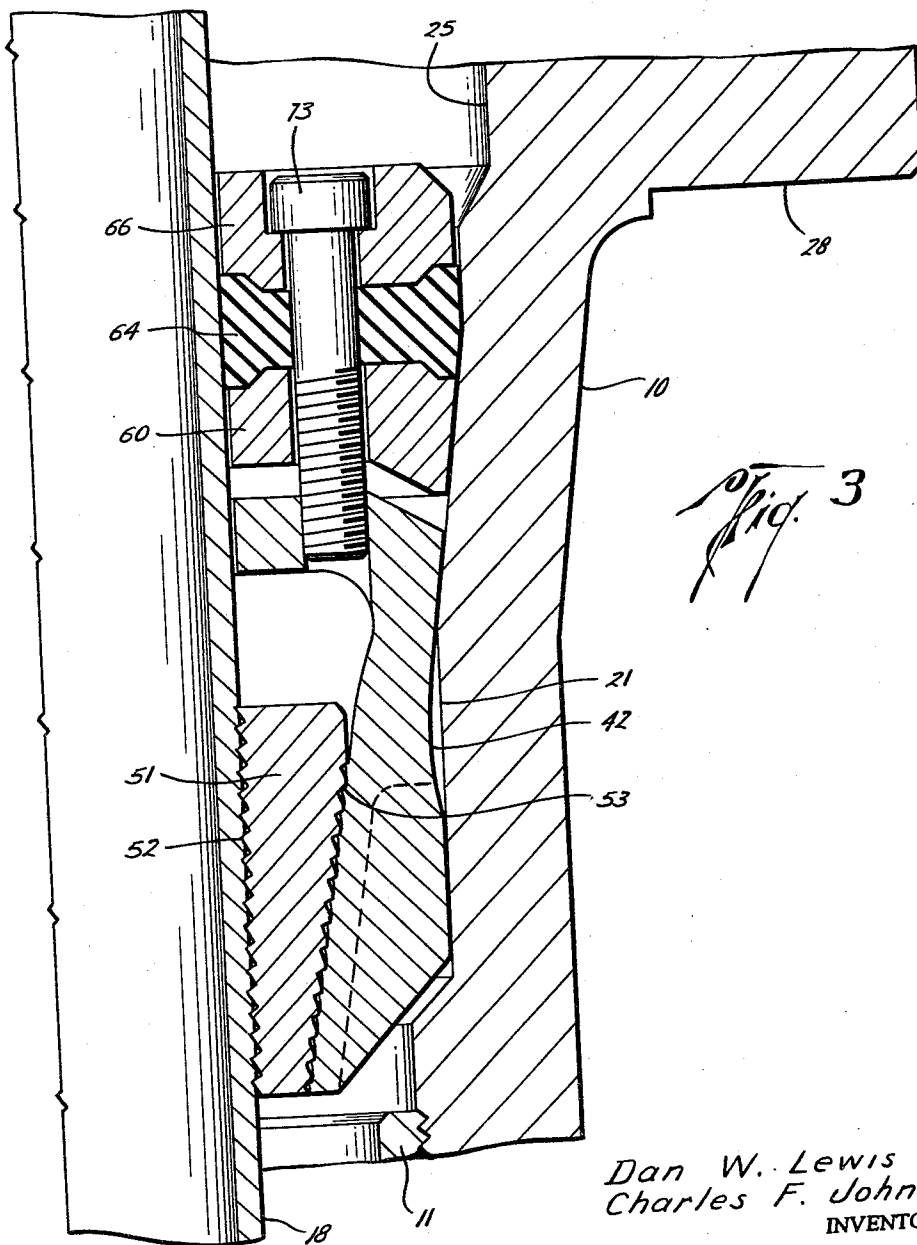
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SUPPORTING APPARATUS

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2 Claims. (Cl. 285-144)

This application pertains to apparatus for hanging pipe in a vertical axial position, and more particularly to such apparatus as it is used in the completion of petroleum wells for suspension of the casings and tubings in the well bore. The apparatus here contemplated utilizes slip means for engaging and supporting the pipe, it being an advance in the art in that it contributes to efficiency, dependability, and safety of such apparatus.

A principal object of the invention is to provide pipe hanging apparatus which will support strings of pipe without bottle necking, crimping, and like failures of the pipe.

Another object of the invention is to provide such apparatus wherein the load on the hanger resulting from the pipe weight and/or the weights of fluids within and acting on the pipe is evenly distributed at the hanger.

A further object of the invention is to provide such apparatus wherein said load is evenly distributed at the hanger when the load is being borne by the hanger.

In pipe hanging apparatus of the type herein described and referred to, the loads borne by the hanger are of great magnitude, it being invariably the case that many thousands of feet of pipe must be supported in the well by the hanger, and the loads are thus concentrated at the well head at a relatively small hanger structure area. With the load thus concentrated, the hanger elements which bear the load are subject to considerable distortion upon application of the load, and misfitting and misalignment of the load-bearing hanger elements results. In other words, although the slips may bear equally area by area on the pipe and hanger before the weight of the pipe is assumed thereby, the hanger elements are distorted by the load once assumed so that only a part of the slip area is effective. Consequently, it is another principal object of the invention to provide slip-type pipe hanger apparatus wherein the entire slip area is effective in supporting load after the load is applied thereto.

The distortion occurs in several elements of the hanger assembly. The slip bowl tends to expand at its lower portions when placed under load, and the slip segments themselves are subjected to unequal pressures the flex or distort in response thereto.

The invention is generally applicable where slip means are used to support a load.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment thereof, reference being made to the accompanying drawings, of which:

FIGURE 1 is a vertical quarter sectional view of the preferred embodiment, some being in the "unloaded" condition;

FIGURE 2 is an enlarged partial vertical section of the apparatus shown in FIGURE 1, showing the "intermediate loading" condition of the slips; and,

FIGURE 3 is like FIGURE 2, showing the slips in "loaded" condition.

In the drawings, the differential taper of slips and hanger and the downward slip travel have been exaggerated to clearly present the invention.

Referring now to the drawings in detail, and first to FIGURE 1, a casing head 10 is screwed onto the upper end of a well casing 11 which extends downwardly from the casing head into a well bore (not shown). As is customary, the casing extends somewhat above the earth's

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surface (not shown) so that the casing head is above the earth's surface. Casing head 10 has an axially vertical generally cylindrical opening 15 therethrough at the lower end of which are provided the internal threads 16 for threaded engagement of the casing head 10 with the threaded upper end of casing 11. Casing 11 is often referred to as the surface casing of the well.

A second casing 18 is disposed concentrically through opening 15 of casing head 10 and also concentrically through the outer casing 11. Opening 15 of casing head 10 has, above lower threads 16, an upwardly facing conical annular shoulder 20 therearound, and above shoulder 20, a cylindrical section 21. A second conical shoulder 22, of small angle or taper with the axis of the head, is provided above opening section 21 as seat means for supporting a hanger body and seal within opening 15. Above seat 22, there is a short straight bore section 23 and a conical enlargement 24 to an upper straight bore section 25 at the upper end of opening 15. Shoulder 20 is not used as a seat, but as an entering guide surface into casing 11.

A connecting flange 28 surrounds the upper end of the casing head whereby the casing head is connected by bolting, by a plurality of the bolts 29, to a flange 30 of surmounting well head equipment 31. Circular grooves 32, 33 in the faces of flanges 28, 30 surrounding the upper end of the opening 15 receive a circular steel ring gasket 34 which assures a fluid-tight connection between the flanges. Casing head 10 also has a pair of side outlet ports 35, 36 from opening 15 a portion 21 thereof, these being internally threaded for connection of flow receiving or delivering means (not shown), as, for example, a valve or pipe. The wall of the casing head 10 is thickened outwardly around the ports 35, 36 at 37, 38, respectively.

The hanger body or bowl 40 has conical surface 41 around its upper side which corresponds in taper with seat 22 upon which it is supported when a load is placed on the hanger. Below surface 41, the side 42 of hanger body 40 is parallel to the axis of the casing head, but a plurality of the evenly spaced separate recesses 43 are provided therearound so that the hanger body will not close the ports 35, 36. A chamfered lower edge 44 of the hanger body permits the hanger body to be easily entered into the well head.

A ring shaped flange 48 at the upper end of body 40 extends radially inwardly thereof to substantially fill the annular space between casing head 10 and casing 18. The outer portion of the upper flange surface is conically beveled at 49. The hanger body inner surface 50 is conical and downwardly converging to provide a tapered seat for the slip segments 51. A plurality of the slip segments are provided about the hanger, these being separated at vertical radial divisions. The slip segments are vertically wedge shaped, as is shown in FIGURES 1-3, so that they can assume wedged positions when set between the outer surface of casing 18 and surface 50 to support casing 18 in the well.

The inner surface of each slip 51 is provided with a plurality of circumferential teeth 52 which are horizontal or substantially horizontal. Teeth 52 are of semibut-tress form and are upwardly pointing or directed. The outer tapered surface 53 of each slip 51 is provided with a plurality of circumferential teeth 54 which are horizontal or substantially horizontal. Teeth 54 are downwardly pointing. Slips 51 may be conveniently made by fabricating all of the slip segments as one piece in ring form, forming teeth 52, 54 at the inner and outer ring surfaces, and then cutting the ring into arcuate segments.

The conically tapered surface 53 has a different taper than does conically tapered surface 50 of hanger body 40, as can be best seen in FIGURE 1, showing the hanger

in the unset condition with no casing load supported thereby. Surface 53 is more steeply tapered vertically so that, when the hanger is put around casing 18 and lowered into opening 15, the first contact of slips 51 with casing 18 and with surface 50 is at the lower ends of the slips as shown in FIGURE 1. The unequal tapers, or intentionally mis-matched tapers, of surfaces 50, 53 provides angular wedge-shaped gaps between the upper portions of surface 53 and surface 50, the apex of the gaps being at the lower ends of the slip segments, the gaps widening upwardly as shown in the drawing.

Thus, when only a small load, or no load, is carried by the slips, only a few of the lowermost teeth 54 of each slip are disposed to carry or support load (in contact with load-bearing slip seat surface 50). As will be more fully described, as load is added to the hanger, the teeth above the lowermost teeth progressively take the load.

Above flange 48 of hanger 40, there is provided a means for sealing off the annulus between casing 18 and the casing head 10 within opening 15. An annular support ring 60 has a lower surface substantially conforming to the upper surface of flange 48, including bevel 49. The peripheral outer surface of ring 60 has a conically tapered portion 61 at the same bevel as seat surface 22 of the hanger body, and seats on an upper part of the seat surface to be supported thereby. Ring 60 has inner and outer upper recesses 62, 63 conforming generally to the lower surface of a sealing ring 64, or pack-off, which rests upon the upper surface of ring 60 and substantially closes the annulus when not axially compressed. A follower or compression ring 66 is disposed above the sealing ring, and the compression ring has inner and outer lower recesses 67, 68 and has upper outer bevel surface 70 for engagement by each of a plurality of lock screws 71 radially through flange 28 of the casing head.

Each of the support ring 60, sealing ring 64 and compression ring 66 has a plurality of azimuthally spaced registering or vertically aligned perforations therethrough, through which a plurality of the screws 73 are received. The heads of the screws fit within counterbores 74 of the compression ring perforations to be held therein against downward movement of the screws. Flange 48 has a plurality of tapped perforations 75 therethrough each in axial alignment below a set of the seal member perforations, and the screws 73 are screwed into the perforations 75. The screws 73 are freely movable through the sealing element perforations to that flange 48 and compression ring 66 are held to a predetermined maximum axial spacing.

The conical surface 41 of hanger 40 is held spaced above the lower part of seat 22 by screws 73 when there is no casing load on the slips of the hanger. Support ring 60 is seated on the upper part of seat 22. This no-load condition of the hanger is shown in FIGURE 1. When load is put on the hanger, hanger body 40 is moved downwardly by the load, drawing compression ring 66 down to compress sealing ring 64 between support ring 60 and compression ring 66. If the load is of great enough magnitude, surface 41 is seated on the lower part of seat 22. The axial compression of sealing ring 64 causes a fluid-tight seal to be formed in the annulus space between casing 18 and the sides of opening 15. The degree of axial compression of the sealing ring may be adjusted, before or after the seal is formed, by adjustment of the extent to which the screws 73 are screwed into flange 48.

When load is put on a hanger having slip type load transferring means to transmit or transfer the casing weight to the hanger body, the slip tapers and the hanger seat or bowl tapers being equal, it has been found that the slip segments are caused to "rock." The slip segments, because of the casing weight imposed in a downward direction at their inner surfaces, and because of their en-

gagement with the hanger seat at their outer surfaces, are subjected to a twisting force which causes the upper ends of the slips to move radially inwardly relative to the lower ends of the slips. The wall of hanger body 40 is usually of less radial thickness at its lower slip-engaging parts than at its upper slip-engaging parts, because of the necessity for providing downwardly-converging exterior conical surfaces on hanger body 40 to facilitate guidance and movement of the hanger body through blowout preventers and other equipment and into the casing head, and because of the necessity in some hangers for providing clearance space for flow of fluids between the interior of the casing head and lateral outlets from the casing head. The clearance space described is well exemplified by the recesses 43 of hanger body 40, which prevent closure of ports 35, 36 by the hanger body. The recesses must be provided all around the outer periphery of the hanger body so that the necessary clearance will result regardless of the ultimate azimuthal position of the hanger body 40 in the casing head. The hanger body 40 must always have some peripheral clearance therearound within the casing head so that it can be easily moved thereinto, and it therefore results that the hanger body is not radially supported by the casing head at all portions of its exterior sides when it is seated in the casing head. Thinner walled portions of the hanger body have less strength to support radial outward components of the load on the hanger, and therefore any outward deformation of hanger body 40 caused by such outward load components is maximum at the thinnest wall section and decreases as the wall thickness increases.

Referring now more particularly to FIGURES 1-3, FIGURE 1 shows the hanger in the unset condition, with no casing load supported thereby. The seal ring is not compressed, and the weight of the hanger and seal is supported by the support ring 60 seated upon the upper part of seat 22. Surface 41 of the hanger body is spaced above the lower part of seat 22, being held in that position by the screws 73. Only the lowermost few of the teeth 54 are in contact with surface 50.

Proceeding to FIGURE 2, a part of the weight of casing 18 has been put on the slips, so that a greater number of rows of the teeth 54, proceeding upwardly from the lowermost rows of such teeth, are now engaged with surface 50 to support the casing load. The thinner lower part of the hanger body 40 has been distorted, about a flexure area of the hanger bowl immediately below the vertically intermediate zone of the hanger bowl at the lower end of seat or shoulder 22, outwardly by the horizontal component of the casing weight, to bring teeth 54 higher upon the slips into contact with surface 50.

When the load on the slips becomes great enough, the condition shown in FIGURE 3 prevails. All of the slip teeth 54 are now engaged with surface 50, and all are active in carrying the load represented by the weight of casing 18. The lower portions of the hanger body have been distorted or moved radially outwardly to close the gap between the upper slip areas and surface 50.

The amount of "differential taper" between outer slip surfaces 53 and hanger body surface 50 that is required depends on the design of the apparatus, including such factors as downward thinning of the hanger body, vertical length of the slips, taper of the seat 50, and the like. The angle of gap increases as the load-bearing strength of the lower part of the hanger body decreases. But the weakening of the lower parts of the hanger body (thinning of the hanger body wall at its lower parts) cannot be avoided altogether in the design of such equipment, because of the compelled overall shape of the hanger body to provide entrance taper of the hanger body and to avoid closing the lateral ports of the casing head. Therefore, some necessity for "differential taper" will always be encountered for slip-type casing hangers which are designed to support long lengths of

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casing in a well in order to make it apparent what occurs during loading of the hanger. The initial angular gap between surfaces 50, 53 will generally be of the order of a few degrees, usually about one degree.

The slips are always fully backed up by the hanger when carrying load because of the upward progressive contact of the slips with the hanger as additional load is applied to the hanger.

As has already been mentioned, it has been determined for slip-type casing hangers otherwise of the usual form, that a "differential taper," i.e. a difference in taper between the outer slip surfaces and the surface on which the slips seat of about 1°, is satisfactory, and results in an increase in load-bearing capacity of the hanger of about 30 percent, or more. In other words, a hanger without mis-matched or "differential taper" fit between slips and seat when unloaded, would have its capacity under load increased by 30 percent or more were the slip-seat tapers intentionally mis-matched or differentially tapered by only 1°, the angle of slip taper from vertical being less than the angle of hanger slip seat taper from vertical by that amount.

An additional advantage of "differential taper," as herein described, is that it affords "line contact" of the slips with the casing when the slips are first set to begin supporting the casing. Referring to FIGURE 1, the slips are, under no-load condition, in contact between the casing 18 and surface 50 only at their lower ends. Only the lowermost of teeth 52 are disposed to bite into or "grab" casing 18, and only the lowermost of teeth 54 are disposed to bite into or "grab" surface 50. Were all of teeth 52 or all of teeth 54 disposed to initially bite into or "grab" the respective surfaces, the biting action would be spread over large areas (the entire slip areas) and initial slippage would be expected and does occur. But, with only a small vertical length of teeth effective on initial setting of the slips, an intensified biting action at small areas is obtained, thereby eliminating substantially the initial slippage. Once the initial biting contact of the slips inwardly and outwardly has occurred, the teeth toward the upper slip ends come progressively into play as the loading of the hanger is increased.

The directed buttress forms of the threads, threads 52 being "upwardly pointing" and threads 54 being "downwardly pointing," provide that each type of threads is strongest in the direction that load is to be imposed. Threads 52 primarily resist downward movement of the casing, while threads 54 primarily resist downward movement of the slips on surface 50. Thus, each type of thread is pointed to resist sliding of the surface to be supported thereover.

While a preferred embodiment of the invention has been shown and described, modification thereof may be made by a person skilled in the art without departing from the spirit of the invention, and it is intended to protect by Letters Patent all forms of the invention falling within the scope of the following claims.

We claim:

1. Apparatus for supporting a well pipe disposed vertically in a well, comprising a well head disposed at the upper end of the well having a vertical passageway therethrough to the well and having a seat means in said pas-

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sageway for supporting a hanger bowl, a hanger bowl within said passageway supported by said seat means against downward movement, said hanger bowl having a vertical opening therethrough through which the well pipe to be supported is disposed, said hanger bowl having about a lower portion thereof an inwardly facing downwardly converging conically tapered slip seat, slip means having inner surface means engaging the well pipe and having outwardly facing downwardly converging conically tapered surface means for engaging said slip seat to support the well pipe, the taper of said outwardly facing slip surface means being steeper with respect to the axis of said hanger bowl opening than the taper of said slip seat, said hanger bowl having contact with and being fully supported outwardly by said well head from a vertically intermediate zone of said hanger bowl to the upper end of said hanger bowl, said hanger bowl being spaced inwardly from said well head from said vertically intermediate zone to the lower end of said hanger bowl, said hanger bowl having a flexible portion immediately below said intermediate zone permitting progressive pivotal outward movement of the part of said hanger bowl below said intermediate zone when well pipe load is transferred thereto by said slips, said part of said hanger bowl moving into contact with said well head when full well pipe load is transferred thereto by said slips and moving only partially toward said well head when partial well pipe load is transferred thereto by said slips, said movement fully aligning said outwardly facing slip surface and said slip seat when said part of said hanger bowl below said intermediate zone is moved to contact said well head, and decreasing the difference in the tapers of said outwardly facing slip surface and said slip seat when said part of said larger bowl below said intermediate zone is moved only partially toward said well head, whereby when no weight of the well pipe is being supported by the slips only the lower end of the outwardly facing slip surfaces engages the slip seat, and whereby when part of the weight of the well pipe is being supported by the slips there is outwardly facing slip surface-slip seat contact at a portion of the outwardly facing slip surface extending upward from its lower end, and whereby when the full weight of the well pipe is being supported by the slips there is full outwardly facing slip surface-slip seat contact.

2. The combination of claim 1, said outwardly facing slip surface and said inner slip surface means each having a plurality of spaced substantially horizontal tooth formations thereover, whereby when pipe load is first placed on said slips such of said tooth formations as are near the lower end of said slips will bite into said casing and into said slip seat to decrease initial slippage at the inner outer surfaces of said slips.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,068,027

December 11, 1962

Dan W. Lewis et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 52, after "inner" insert -- and --.

Signed and sealed this 4th day of June 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents