Jan. 6, 1953 R. A. MUELLER ET AL 2,624,413

OIL WELL HANGER

Filed June 28, 1946 4 Sheets-Sheet 1

Fig. 1.

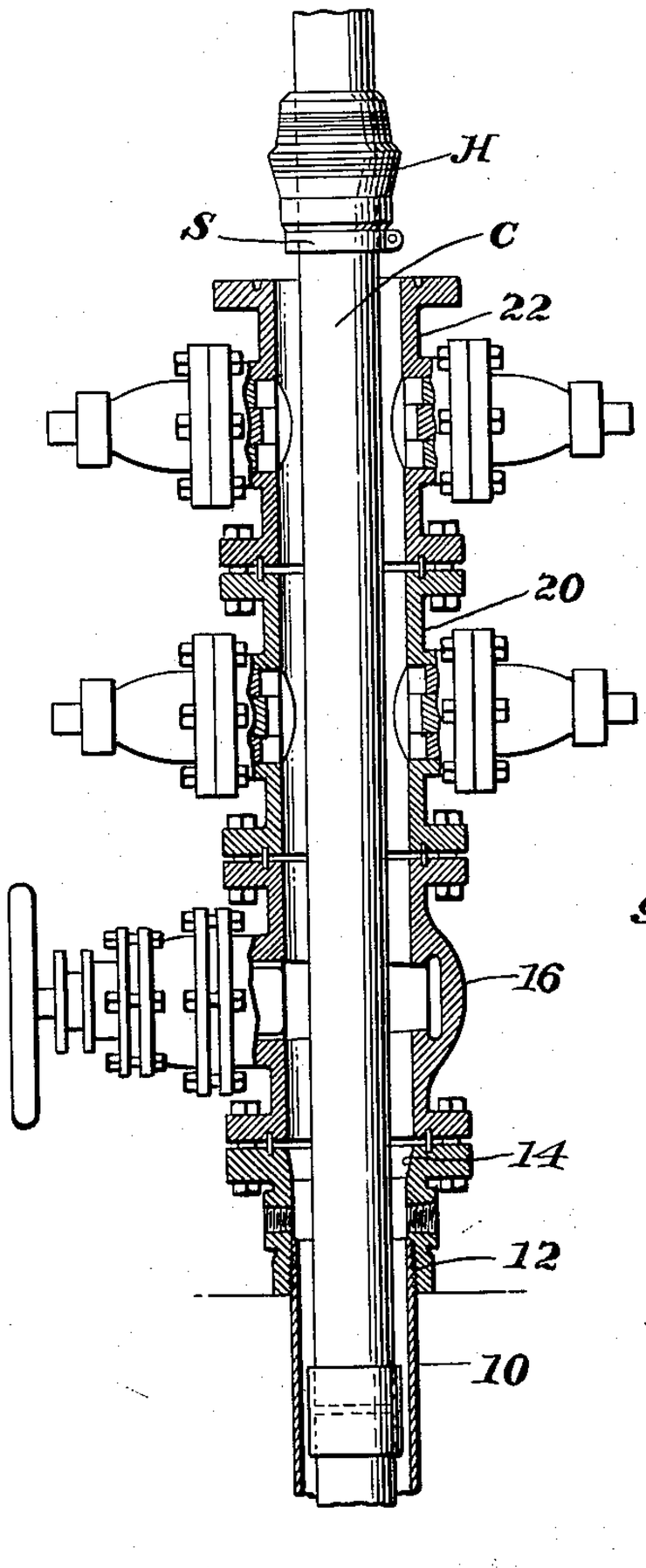

Fig. 11.

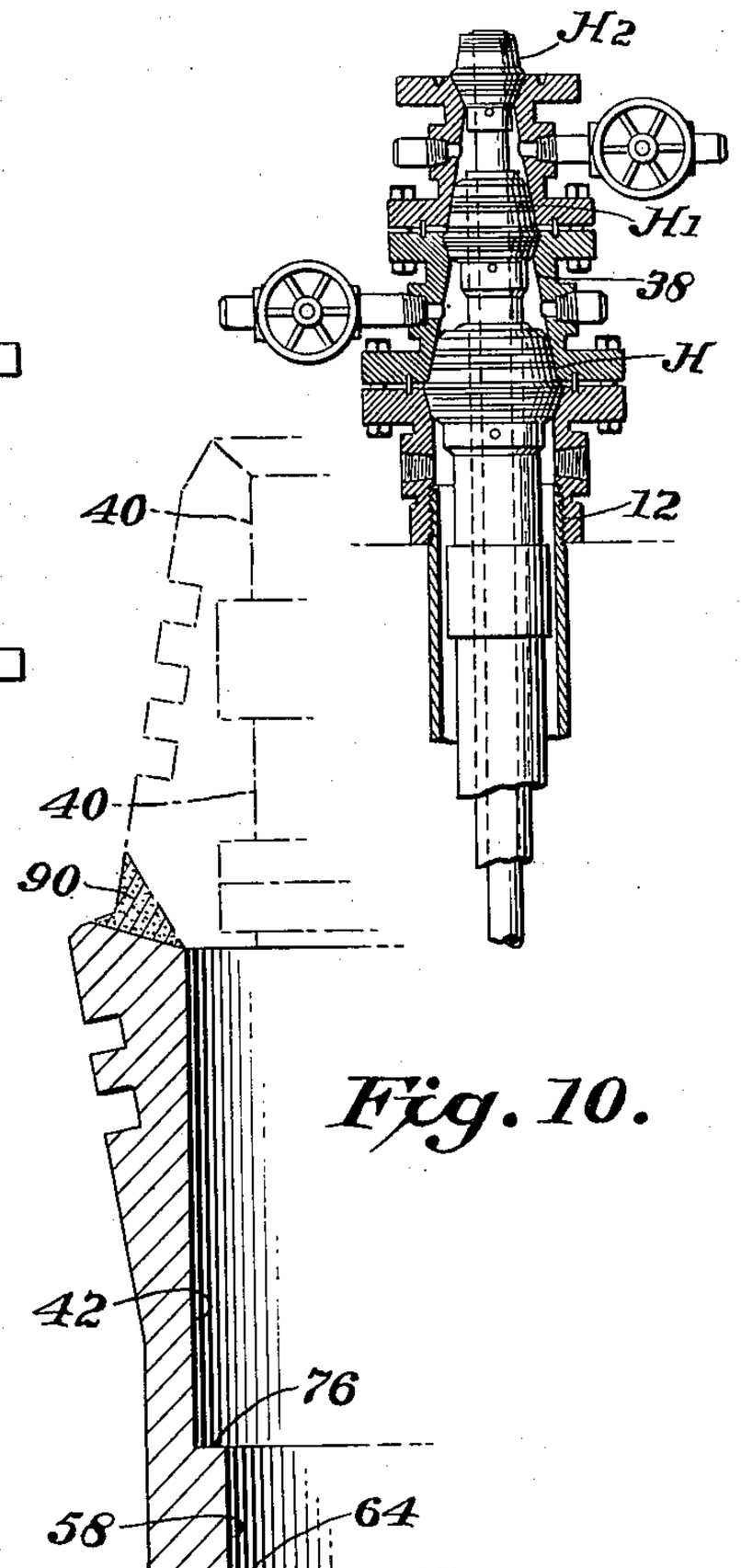

Fig. 10.

Fig. 12.

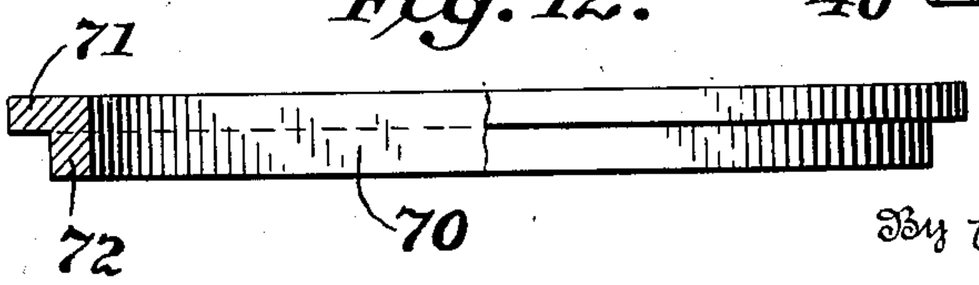

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Fig. 2.

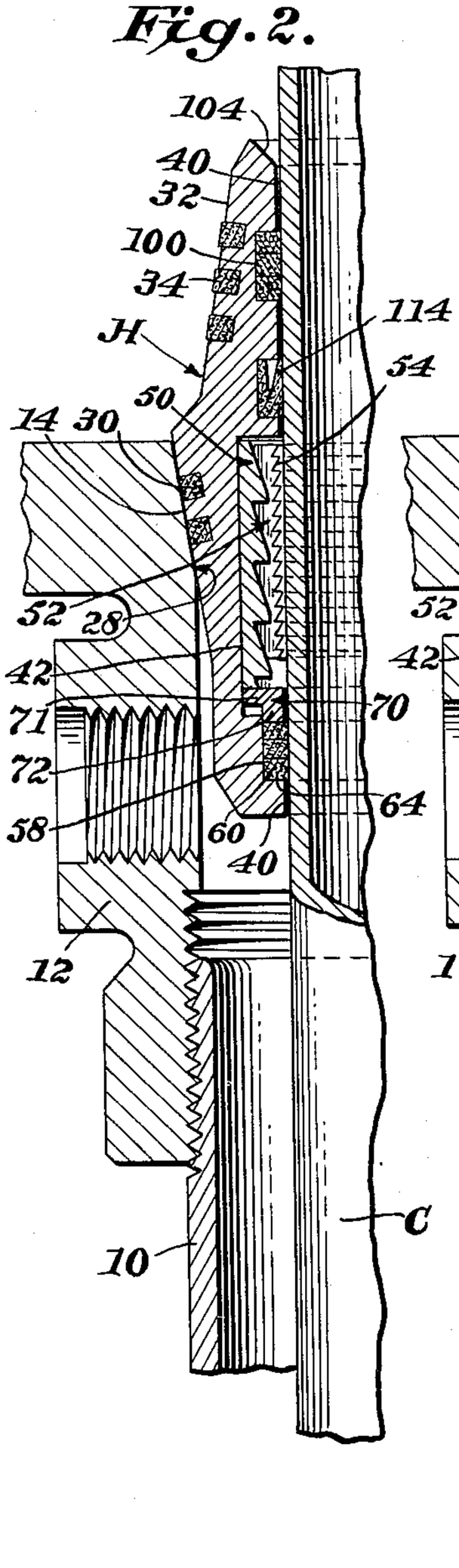
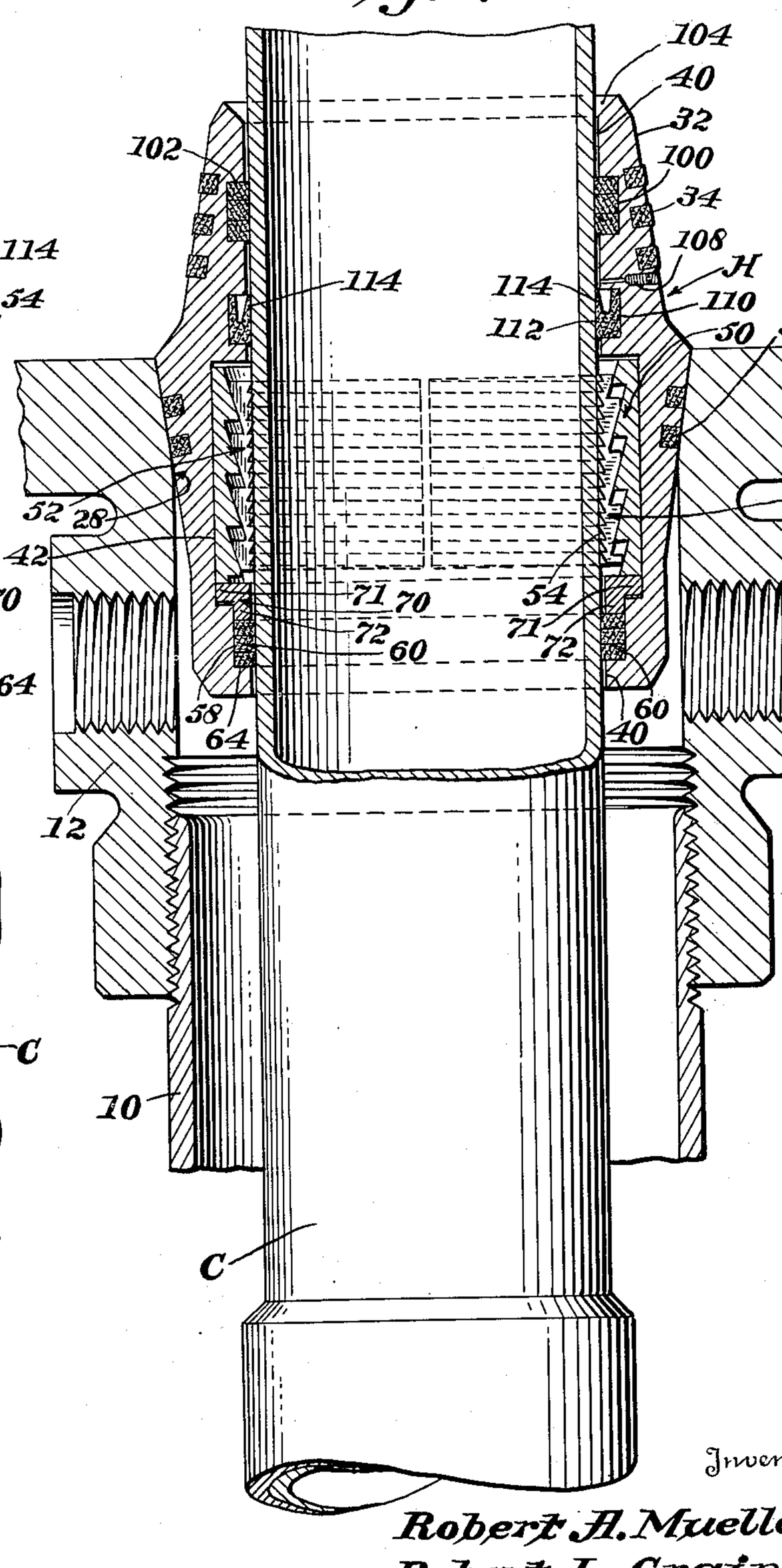


Fig. 3.



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OIL WELL HANGER

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Fig. 4.

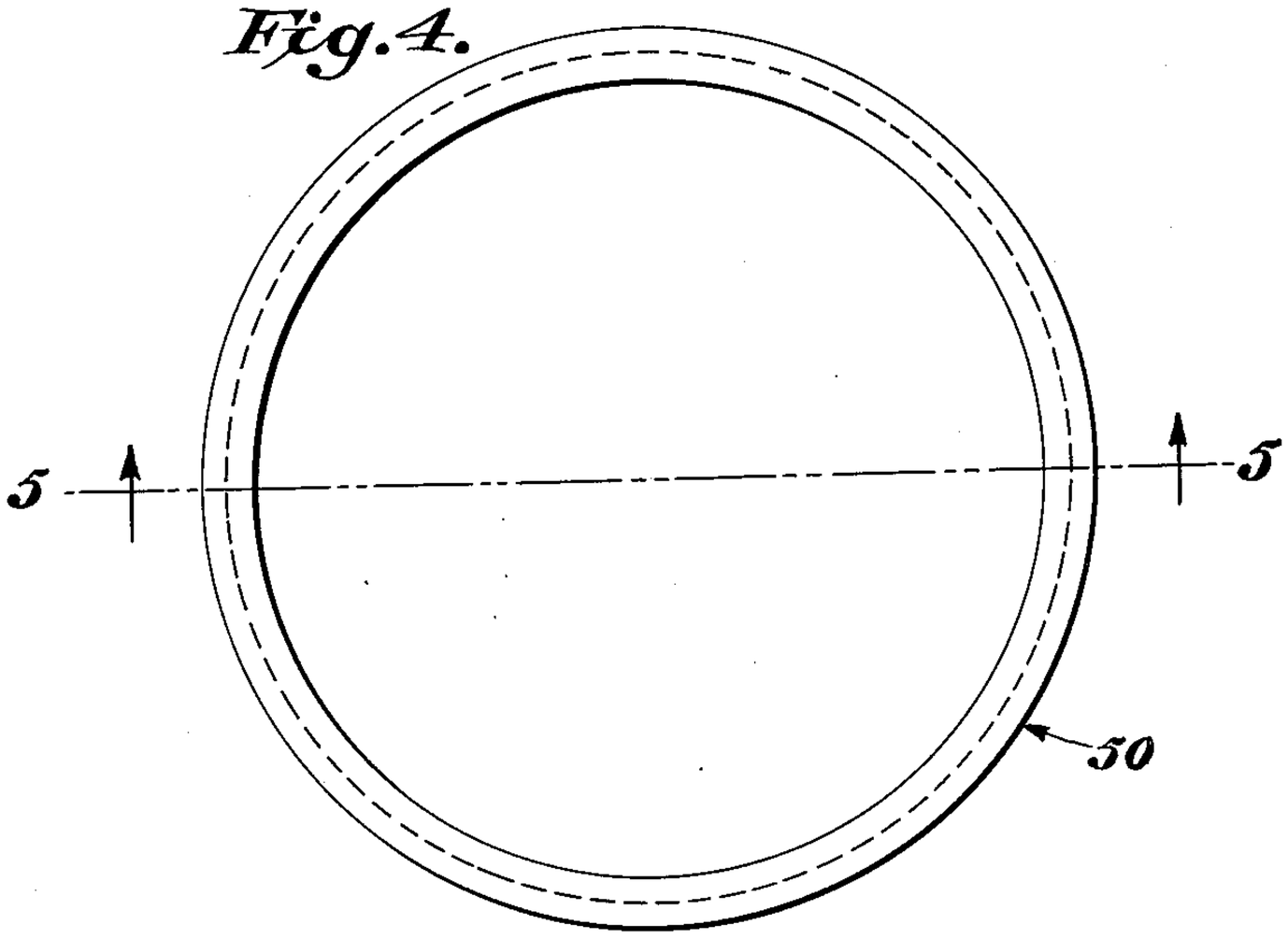


Fig. 5.

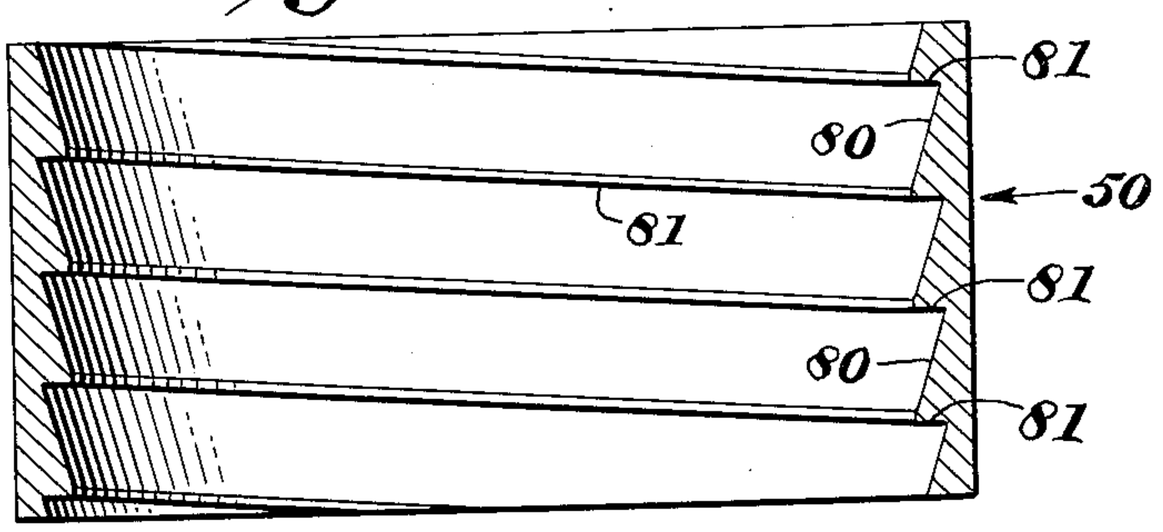
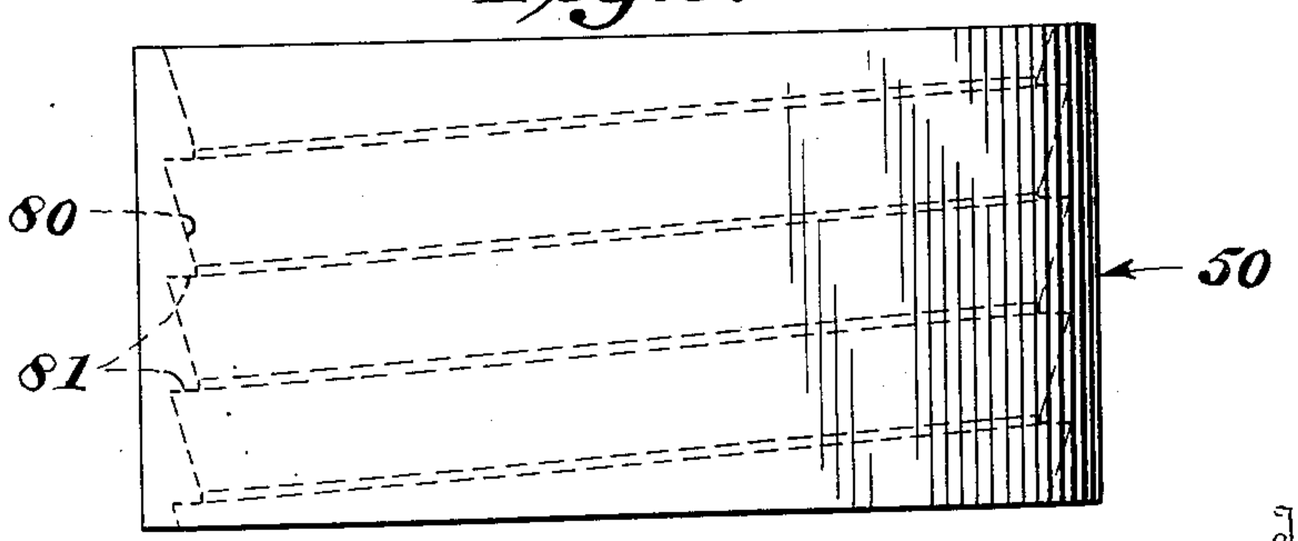


Fig. 6.



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OIL WELL HANGER

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Fig. 7.

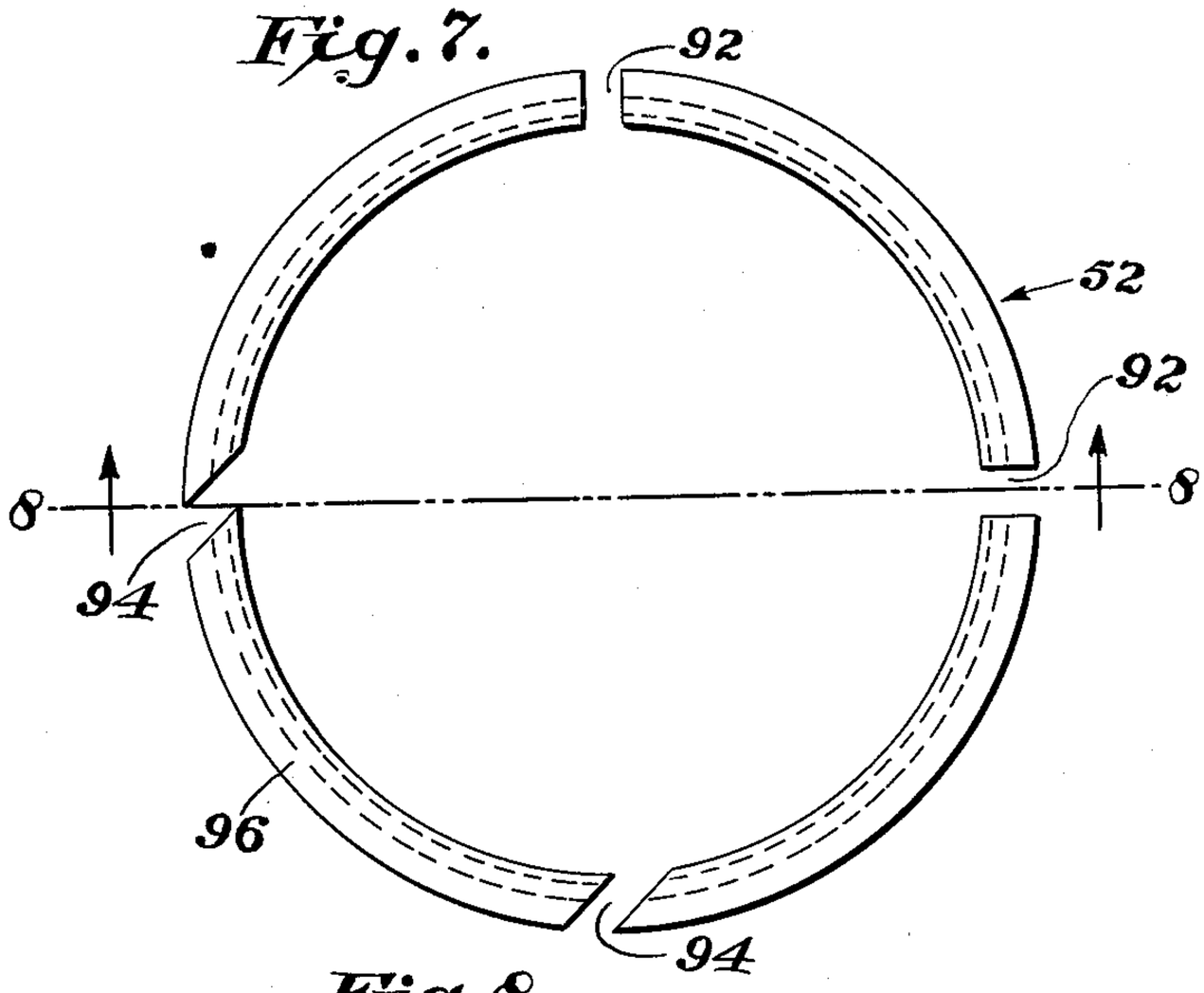


Fig. 8.

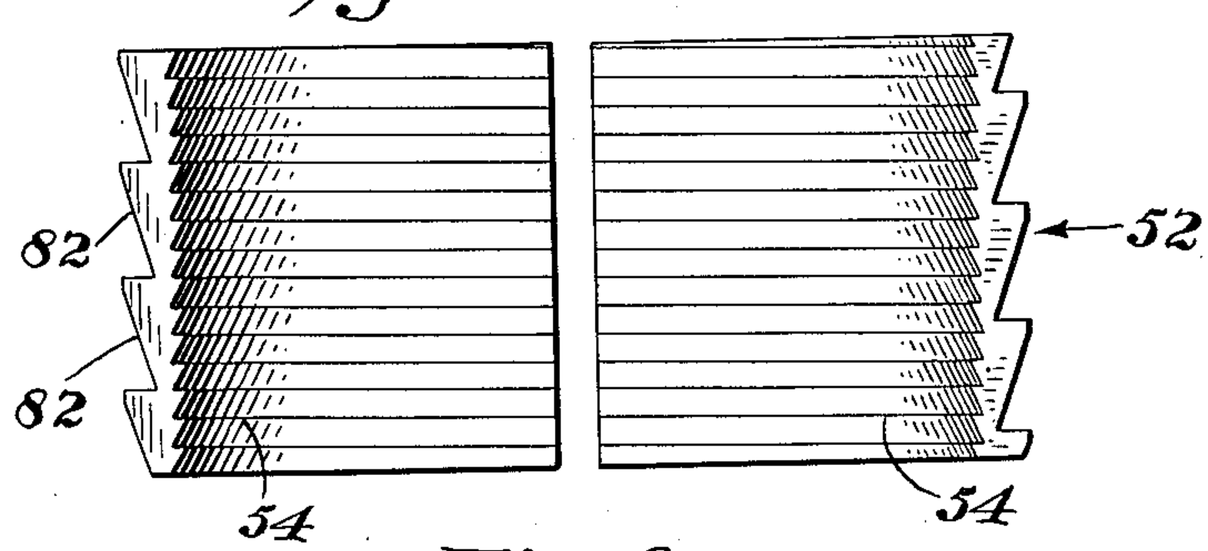
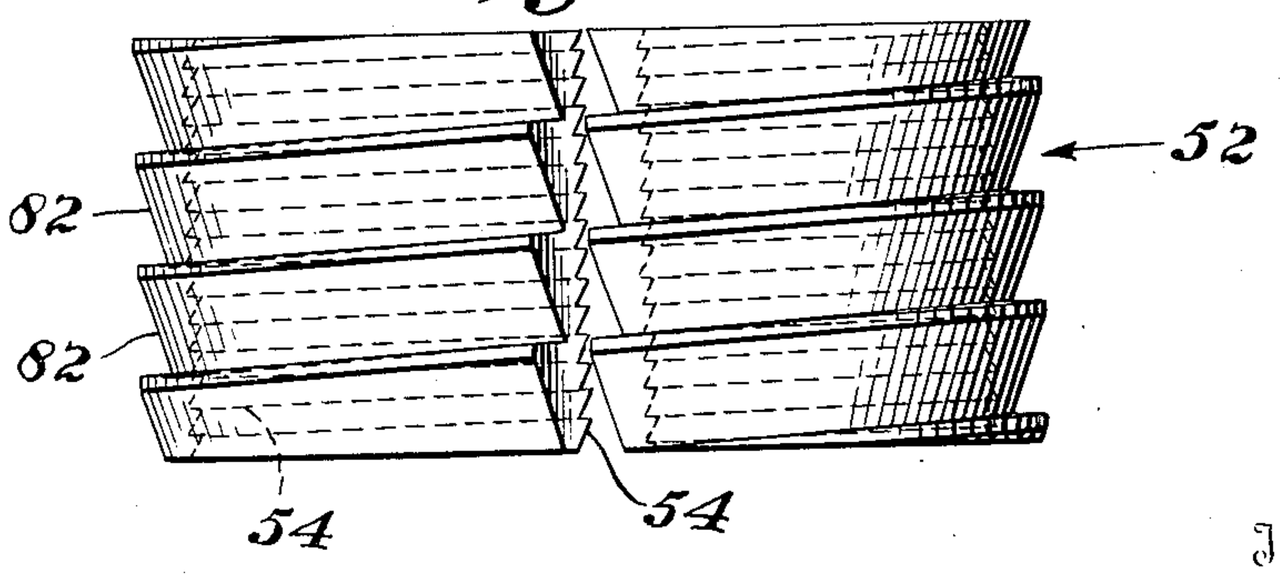


Fig. 9.



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Patented Jan. 6, 1953 2,624,413

UNITED STATES PATENT OFFICE

2,624,413

OIL WELL HANGER

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Application June 28, 1946, Serial No. 680,334

5 Claims. (Cl. 166—14)

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The present invention relates to hangers for use with oil well completion equipment. A principal object of the invention is to provide a hanger capable of being lowered through control equipment to its seat and which permits limited vertical movement of the pipe with respect to the hanger after seating, but which will establish a complete seal of the casing head at the time the hanger is landed by the weight of the pipe, both between the hanger and the pipe and between the hanger and the casing head.

In Patent No. 2,117,444, Mueller et al., May 17, 1938, a method of building oil wells by setting and cementing successive strings of casing is described. This method involves lowering the pipe and the hanger through appropriate control equipment mounted on the casing head while maintaining mechanical control of the well at all times. In this method, the hanger is lowered to its seat through the aforementioned control equipment to there form a permanent seal by the weight of the pipe, after which the cementing operation is performed and the control equipment may then be removed with safety.

In Patent No. 2,207,469, to Roye, July 9, 1940, a further practice analogous to the said Mueller et al. patent is described, but wherein provision is made for pulling the casing upwardly after the hanger is landed to remove the slack and to put a strain on the casing, slip means being provided in the hanger to support the pipe after the strain has been taken. In the said Roye patent, a practice of thereafter welding the casing to the hanger to permanently seal and support the casing in the hanger is suggested. In practical oil well operations, welding of the pipe to the hanger has not been found to be entirely satisfactory in all cases, as mentioned in a copending application of Mueller et al. Serial No. 650,272 filed February 26,1946. In that application, a further refinement of the practices under consideration herein is disclosed, wherein a hanger and associated means are provided to roll the casing into permanent sealing engagement with the hanger in order to form a permanent union between the casing and the hanger. The details of description of applicable structure and steps in operation which appear in the above-mentioned patents and application are not repeated wherein, it being understood that they are referred to as disclosing equipment and methods which would be used with the present invention, and to that extent they form a part of the present disclosure.

An object of the present invention is to provide a completion of the type referred to in the above-mentioned patents and application wherein an effective seal is had both between the pipe and the hanger, and between the hanger and the casing head at the time the hanger is landed. It is a further object of the invention to provide such sealing apparatus wherein strain may be taken on the casing, and wherein the slack taken up may be retained, while maintaining the effectiveness of the seals mentioned above at all times.

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Another object of the invention is to provide a completion wherein, at the time the hanger is landed, separate seals are simultaneously formed between the hanger and the casing head and between the hanger and the pipe, both by the weight of the pipe suspended by the hanger.

A further object of the invention is to provide a hanger, in the methods of operation therewith, the seal between the hanger and the pipe is made effective and maintained by the weight of the pipe, and which seal may be regarded as permanent in many cases. Ancillary to the preceding objective, it is a purpose of the invention to provide means for forming a permanent union by rolling the casing against the hanger above said seal which is maintained by the weight of the pipe, or, in the case of some practices, to form a permanent seal by welding the hanger to the pipe.

Another object of the invention is to accomplish the above purposes with a hanger capable of being lowered through conventional control equipment, so that the latter may be removed and replaced with other control equipment or with structure which form a permanent part of the well head, the latter being of the type disclosed in Patent 2,116,444 wherein additional casing or tubing heads may be mounted above and in sealing engagement with the hanger previously landed.

Another object of the invention is to provide a novel form of slip suspension means for the pipe within the hanger, whereby the metal of the hanger may be maintained at maximum strength and thickness. Similar to the preceding objectives, it is a purpose of the invention to provide a novel slip suspension means wherein a slip supporting cage and slips with accurately machined engaging surfaces are provided to insure even and accurate gripping of the pipe by the slips when the former is suspended in the hanger.

Various other objects and advantages of the invention will be apparent as the description herein progresses. In the drawings, which are

illustrative, and are not intended to restrict the invention except as defined in the appended claims:

Figure 1 is a vertical sectional view through now well known control equipment, showing pipe such as oil well casing being run in in accordance with the present invention.

Figure 2 is a partial vertical sectional view through the casing head of a well, showing the condition of same just prior to the time when the hanger is completely suspended and before the weight of the casing or pipe is taken by the hanger, the control equipment being omitted for simplification.

Figure 3 is a view similar to Figure 2, but showing both sides of the hanger after it has been landed in the casing head with the weight of the casing supported therefrom, the control equipment or additional casing or tubing heads above being omitted for simplification.

Figure 4 is a top plan view of the slip cage of the present invention.

Figure 5 is a vertical sectional view taken along the line 5—5 of Figure 4.

Figure 6 is a side elevational view of the slip cage of Figure 5.

Figure 7 is a top plan view of the four slip segments of the present hanger, showing their associated relation generally corresponding with the condition of the equipment illustrated in Figure 2.

Figure 8 is a vertical view taken substantially along the line 8—8 of Figure 7.

Figure 9 is a side elevational view of two of the slip segments, looking inwardly from a position below the view of Figure 7.

Figure 10 is a partial vertical sectional view of the hanger of the present invention, illustrating one manner in which the double tapered hanger might be manufactured in two parts to be welded together.

Figure 11 is a vertical sectional view through the equipment at the top of a well, showing a manner in which several casing heads and associated equipment of the present invention may be nested.

Figure 12 is a side elevational view, partly in section, of a packing follower employed in the hanger.

Referring to Figure 1, an oil well casing is shown at 10, same being connected in a well known manner to a now conventional casing head 12, the latter having an inside bore with a tapered hanger seat 14 and being flanged for removable attachment with a conventional piece of control equipment such as a drilling master valve 16 having a bore substantially as wide as the maximum diameter of the tapered seat 14. The control equipment may include one or more blowout preventers, as shown at 20 and 22, these pieces of control equipment likewise having the full bore previously referred to, and being removably mounted in sealing engagement with one another on the casing head 12.

The pipe being landed is shown as a casing C, and slidably positioned thereon is the hanger H, the construction of the latter being an important part of the invention. As described in the said Roye patent, the hanger H is slipped over the casing C between the collars thereof, just prior to the time when the casing is to be landed, and it may be temporarily supported by a removable strap S which is taken off at the time when the hanger is passed through the control equipment. As will be apparent from Figure 1, the hanger is of outside maximum diameter slightly less than the interior diameter of the control equipment

so that it may be lowered therethrough until the lower tapered surface of the hanger rests on and in sealing engagement with the tapered seat 14 of the casing head 12, all as is described in the aforementioned patents.

Referring to Figure 2, the lower tapered outside surface of the hanger is shown at 28, and this surface is equipped with one or more circular rings of packing 30 which form a seal when the hanger is seated in the casing head with the weight of the casing borne by the hanger as hereinafter described. The type of hanger which we preferably employ in connection with the present invention also has an upper tapered surface 32, and this surface is provided with one or more circular sealing rings 34 to seal with the next successively used casing head 38 as illustrated in Figure 11, the last-mentioned casing head having a lower upwardly and inwardly tapering sealing surface to engage the upper tapered surface of the hanger, all as described in the aforementioned patents. As referred to in these patents, when the hanger has been landed to support the casing, and when cementing or similar operations have been performed, the control equipment shown in Figure 1 may be safely removed, and substitute control equipment adapted for subsequent operations may be applied to the casing head 12, or, if the operations under discussion are concerned with a later stage of the building of the well, a tubing head and associated equipment may be attached for the completion and flowing of the well.

As shown in Figures 2 and 3, the smallest bore 40 of the hanger is of diameter slightly greater than the exterior diameter of the casing C, and the central part of the hanger is counter-bored as at 42 to form a somewhat wider cylindrical chamber to receive the slip means now to be described. However, it will be apparent from the description below, that the counter-bore 42 is not large enough to weaken the over-all strength of the hanger, the wall thickness of the lower part of the hanger being quite adequate to provide support for the casing and to withstand the high pressures involved in modern oil well completions.

Positioned for vertical sliding movement in the chamber 42 is a substantially cylindrical slip cage 50 (shown in detail in Figures 4 through 6). This slip cage is constructed to fit with and support a plurality of slip segments 52 (the details of which are shown in Figure 7 through 9). The slip segments 52 are provided with upwardly directed teeth 54 which are adapted to grip the pipe and support the same when the weight of the pipe is borne by the hanger, as will be understood by those skilled in the art.

Between the lower end of the chamber 42 and in the lower end of the hanger bore 40, there is a depression comprising a short counter-bore chamber 58 (Figure 10) of intermediate diameter, and this short chamber is of vertical dimension sufficient to receive several packing rings 60, the packing rings being of selected material depending on the degree of the pressures of the stratums which have been penetrated. We prefer to use packing rings of the hydraulic type, that is, packing rings of material which is considered to be of permanent nature in dealing with the pressures under consideration. The packing rings 60 are of outside diameter substantially as large as that of the chamber 58, and of inside diameter substantially equal to the outside diameter of the casing C, the said rings being of such nature as to be capable of expansion outwardly and in-

wardly under vertical pressure to form a tight seal with the wall of the chamber **58** and with the outer wall of the casing. The lowermost of the packing rings **60** rests on a shoulder **64** which forms the bottom of the chamber **58**.

An annular packing follower **70** is positioned in the lower part in the chamber **42**, said follower being substantially L-shaped in cross section, having a horizontal part **71** which supports the slip cage **50** and a vertical part **72** capable of movement in the upper end of the chamber **58**.

Depending on the weight of the casing, and the pressures being met, the packing **60** will be of such thickness and composition that when the weight of the casing is taken by the slips **52**, the downward movement of the cage **50** bearing on the follower ring **70** will be substantially sufficient to move said ring downwardly from the position of Figure 2 to the position shown in Figure 3, thus expanding the packing **60** into gas tight sealing engagement with the wall of the chamber **58**, with the horizontal ledge **64**, and similarly against the outer wall of the casing. It will be apparent that the area of the packing **60** subject to well pressure is minute, as the packing **60** is supported on all sides by steel. The lower surface of the horizontal portion **71** of the follower ring **70** provides a limitation on the extent of compression of the packing **60**, as said surface will engage the ledge **76** (Figure 10) of the hanger bore, in cases where the weight of the casing is sufficient to cause this degree of movement. The engagement of portion **71** with ledge **76** will prevent any injury to the casing by application of excessive pressure to the packing **60**.

Comparison of Figures 5, 6 with Figures 8, 9 clearly discloses the construction and operation of the slip mechanism, comprising the supporting cage **50** and the slip segments **52**. Referring to Figure 5, the slip cage has an interior continuous spiral cut which provides downward and inwardly inclined guiding surfaces **80** positioned one above the other in vertical alignment, and on which the similarly and exactly cut inclined exterior surfaces **82** of the slip segments are guided during vertical movements of the slips. The surfaces **80** are separated by continuous downwardly presented horizontal spirally cut ledges **81**, and the surfaces **82** are separated by similar upwardly presented ledges **83**, which abut the ledges **81** when the slips are disengaged from the pipe as in Figure 2, but which are spaced from ledges **81** when the slips engage the pipe as in Figure 3. In order to secure uniform bearing of the inclined surfaces **82** of the slip segments on the inclined surfaces **80** of the cage, it is necessary that each incline or stage be the same as every other incline or stage, both in shape and distance apart, both on the cage and on the slip segments. This is done by cutting the plane of the steps with an appropriate tool, as if it were a thread with a fixed lead, and results in a given point on one step or incline being exactly the same as a corresponding point on the following step. It will be understood that hangers of the larger sizes (such as for 10¾'' casing and larger) not requiring the temporary sealing feature within the hanger may be equipped with the slips machined as described, the cooperating supporting surfaces **80** being machined directly in the inner wall of the hanger. In such an arrangement, the cage **50** would be omitted as a separate element, and the metal shown in Figures 2 and 3 for the cage would be a part of the hanger body.

Referring to Figure 8, it will be also observed that the teeth **54** on the inner faces of the slip segments are likewise cut in the spiral thread fashion.

The slip cage **50** may be of one continuous circular piece as shown in Figure 4 if the hanger is constructed in such manner as to permit its insertion into the chamber **42**. In this connection, Figure 10 discloses a suggested arrangement wherein upper and lower parts of the hanger are separately fabricated, to be welded together as at **90** after the ring **70** and cage **50** have been inserted through the top of the lower part of the hanger, the packing **60** and slips **52** being inserted after the welding and finish machining have been performed. In modified types of hangers not having the upper tapered surface **32**, a unitary cage could be inserted and held in place against upward movement by any type of retaining ring. If necessary, the cage **50** could be made in two or more sections to facilitate insertion into the chamber **42**.

As will be apparent from Figures 7 through 9, the slip segments should be cut into several sections to facilitate their proper insertion into the slip cage as disclosed in Figures 2 and 3. In Figure 7, two radial cuts are shown as at **92**, and two non-radial cuts as at **94**, it being apparent that the segment **96** should be the last one to be inserted into the cage, this general construction having been previously disclosed in the said Roye patent. In making the cuts **92** and **94**, sufficient material may be removed to permit the edges of the slip segments to move toward one another as they grip the pipe (during movement from Figure 2 position to the position of Figure 3).

In operation, the hanger is threaded over the casing as in Figure 1, it being understood that any suitable means such as removable screws extending through the wall of the hanger above the packing **30** may be provided to retain the slips **52** in their uppermost or retracted position until just before the hanger is lowered through the control equipment, such means, for instance, being shown at **32** in Figure 1 of the said Roye patent. When the hanger is to be lowered through the control equipment, this means may be removed, and the strap S (Figure 1) may likewise be removed. The hanger is lowered through the control equipment until it engages the seat **14**, at which time the weight of the casing or other pipe is taken by the hanger causing the hanger to simultaneously seal in the seat **14** by the weight of the casing and seal with the casing likewise by the weight of the casing. When the hanger takes the weight of the casing, the slips **52** are pulled downwardly by the pipe, and they move downwardly and inwardly in an even manner by reason of the engagement of their inclined surfaces **82** with the inclined surfaces **80** of the cage **50**. Simultaneous with this movement, the cage **50** is pulled downwardly in the chamber **42**, and the follower ring compresses the packing **60** to form a seal between the bore of the hanger and the exterior wall of the casing, the ledge **71** of the follower engaging the ledge **76** in the bore of the hanger as a limitation on the extent of this downward movement.

Many operators, particularly in the case of wells where the pressure is not excessive, may regard this seal between the hanger and the casing as being permanent, particularly if hydraulic packing is employed and because the exposure of said packing is kept at a minimum, the packing being substantially surrounded on all four walls by steel.

It will be understood that the various steps such as taking a strain on the casing, removing the slack, etc., may be performed at this stage as described in the said Roye patent, while the above-mentioned seals are maintained. After cementing, the control equipment may be removed and an additional casing head or tubing head with associated control equipment of related size may be substituted for further drilling in operations, as described in the above-mentioned patents.

In the case of high pressure wells, or where a permanent union between the pipe and the hanger is desired by the operator, steps to effect this union may be taken, preferably after cementing, with the control equipment removed, yet with complete safety because of the effectiveness of the seals described above.

For example, and referring to the said application, Serial No. 650,272, the hanger has an extension above the bore 42, as shown in Figures 2 and 3, and this extension provides a bore of adequate surface to permit rolling the casing outwardly into a permanent union with the bore of the hanger. If found to be expedient, the casing may simply be rolled above the chamber 42 outwardly against a smooth cylindrical surface of the bore 40, but we prefer to provide special means to insure the success of this rolling operation by providing a groove or indentation 100 in the upper bore 40 of the hanger, preferably with hydraulic packing 102 therein, so that the bead of the casing may be rolled outwardly into said groove all as described in our co-pending application referred to above. Of course, if a particular operator should desire to weld the hanger to the casing as described in said Roye patent, the upper end of the bore 40 may be flared outwardly as at 104 for this purpose, and the welding may be performed with perfect safety at the stage of completion referred to, for both an inside and an outside seal (with respect to the hanger) has previously been provided below by the weight of the pipe.

After the casing has been cemented and the hanger installed supporting the pipe, then the pipe may be cut off above the hanger to permit the permanent seal by rolling or welding, or without either of these last two operations in the case of wells of lower pressure, as described in our co-pending application, and the next casing head is then mounted on and secured to the casing head as shown. Referring to Figure 11, these operations may be repeated, by landing and sealing successive hangers, and by mounting successive casing heads on the well, terminating in a tubing head as the final stage. When a tubing head is positioned, the invention may be practiced by lowering tubing equipped with a hanger having the essential features of the present invention, which hanger need not be provided with the upper tapered surface as no further casing or tubing heads are to be mounted above same. In this instance, the hanger, while having the slip and packing arrangements described herein, would be of such design as to be capable of being locked down by the now conventional locking screws which extend through tubing heads for this purpose, for example, as shown in Figure 3 of Patent 2,241,333 to Smith dated May 6, 1941. It will be understood therefore, that references to oil well pipe or casing are used in their broader sense, and this likewise applies to the descriptive use of the words casing head, as including in a special sense the elements more technically

known as tubing heads, although the invention is of most usefulness and effectiveness in its application to casing and casing hangers as such.

It has been brought out above that the inside seal provided by the packing 60 may be regarded as temporary or permanent, depending on the circumstances, and depending on whether the formation of a permanent union by rolling, or the performance of welding, is desired. In any case, the inside seal referred to is positive during the rolling, welding or similar operations.

As is mentioned in the said co-pending application, the rolled seal in the upper part of the bore of the hanger, or the weld may be tested through a threaded opening 108 extending into the bore of the hanger, which opening is adapted to receive a pressure gun or similar fitting. The hanger may be provided with a further annular inside groove 110 below the opening 108 with a rubber gasket or the like 112 therein having a suitable upwardly presented lip 114. This gasket will retain test fluid pumped in through the opening 108 during the testing of the more permanent union which was previously created above said gasket.

It will be apparent that we have provided a novel form of hanger capable of providing complete mechanical control during the landing of an oil well pipe such as the casing, by automatically providing simultaneous seals both within and around the hanger when the hanger is landed. By reason of the above, the control equipment can be safely removed after cementing, and various operations such as rolling or welding the casing, cutting off the same, and then securing additional equipment above the casing head in question, can be carried out in complete safety. Likewise, necessary manipulations of the pipe as particularly referred to in the said Roye patent may be made, without affecting the seals previously formed.

We claim:

1. A tubular hanger having a vertical bore therethrough to receive an end of an oil well pipe to be supported from the hanger, said hanger having an enlarged counter-bore and a slip cage therein comprising a cylindrical sleeve having in any vertical plane therethrough a series of inwardly presented vertically aligned, downwardly and inwardly inclined slip guiding areas formed on its interior wall, a plurality of slip segments comprising semi-cylindrical members having inner walls formed with pipe engaging teeth and having outer walls comprising in any vertical plane therethrough a plurality of cooperating outwardly presented vertically aligned downwardly and inwardly inclined guiding areas, said guiding areas being formed in a continuous spiral surface of fixed lead.

2. A tubular hanger having a vertical bore therethrough to receive an oil well pipe to be supported from the hanger, said hanger having a slip assembly therein to grip and support the pipe, said assembly comprising a plurality of slip segments and a surrounding supporting cylindrical wall for said segments, said wall having in any vertical plane therethrough a series of inwardly presented vertically aligned, downwardly and inwardly inclined slip guiding areas, said slip segments comprising semi-cylindrical members having inner walls formed with pipe engaging teeth and having outer walls comprising in any vertical plane therethrough a plurality of cooperating outwardly presented vertically aligned downwardly and inwardly inclined guiding areas,

said guiding areas being formed in a continuous spiral surface of fixed lead.

3. A unitary casing hanger of size and shape adapting it for lowering through control equipment as a unit for supporting a casing in the seat of a casing head, comprising a metal body having upper and lower exterior sealing surfaces with sealing rings carried therein, and a vertical bore to pass over the well casing, the bore of said hanger including an enlarged counter-bore therein which is closed at its upper and lower ends, slip means mounted in said counter-bore for movement by the relative downward passage of the casing therethrough to grip and suspend the casing at any point between the collars thereof, said slip means including a slip cage comprising a cylindrical sleeve having in any vertical plane therethrough a series of inwardly presented vertically aligned, downwardly and inwardly inclined slip guiding areas formed on its interior wall, a plurality of slip segments comprising semi-cylindrical members having inner walls formed with pipe engaging teeth and having outer walls comprising in any vertical plane therethrough a plurality of cooperating outwardly presented vertically aligned downwardly and inwardly inclined slip guiding areas, said guiding areas being formed in a continuous spiral surface of fixed lead, packing means in said bore below said slip means arranged for compression by said slip means to automatically form a seal between said bore and the outer wall of the casing when the lower exterior sealing surface of said hanger is seated and sealed in the casing head with the weight of the casing suspended from said hanger, the bore of said hanger above said counter-bore having a first circular groove with packing material therein to seal with the casing and a second circular groove above said first circular groove for forming a permanent seal with the casing.

4. Oil well completion equipment comprising a casing head having an upwardly presented inside seat and an unrestricted bore therethrough, a unitary casing hanger of size and shape adapting it for lowering through control equipment as a unit for supporting a casing in said seat, comprising a metal body having upper and lower exterior inwardly tapered sealing surfaces with sealing rings carried therein, and a vertical bore to pass over the well casing, the bore of said hanger including an enlarged counter-bore therein and means in said counter-bore automatically operable by downward movement of the casing therethrough to grip the pipe at any point between the collars thereof, said means including a slip cage comprising a cylindrical sleeve having in any vertical plane therethrough a series of inwardly presented vertically aligned, downwardly and inwardly inclined slip guiding areas formed on its interior wall, a plurality of slip segments comprising semi-cylindrical members having inner walls formed with pipe engaging teeth and having outer walls comprising in any vertical plane therethrough a plurality of cooperating outwardly presented vertically aligned downwardly and inwardly inclined guiding areas, said guiding areas being formed in a continuous spiral surface of fixed lead, said bore having means therein automatically operable by the weight of the casing to form a seal below said gripping means between said bore and the casing, and a circular groove in the bore of said hanger above said counter-bore in substantial alignment with the sealing rings on said upper

tapered exterior sealing surface to receive and seal with a bead on the casing, and a second casing head secured on said first named casing head having a downwardly presented tapered sealing surface to engage and seal with the upper tapered surface of said hanger.

5. Oil well completion equipment comprising a casing head having an uninterrupted downwardly and inwardly tapered inside seat and an unrestricted bore therethrough permitting operations in the well to the full width of the casing on which said head is mounted, a unitary casing hanger of size and shape adapting it for lowering through control equipment as a unit for supporting a casing in the seat of said casing head, said hanger comprising a metal body having upper and lower exterior inwardly tapered sealing surfaces with rings of sealing material permanently carried therein, said hanger having a vertical bore therethrough to pass over the well casing, the bore of said hanger including an enlarged counter-bore therein which is closed at its upper and lower ends, slip means mounted in said counter-bore for movement by the relative downward passage of the casing therethrough to grip and suspend the casing at any point between the collars thereof, said slip means including a slip cage comprising a cylindrical sleeve having in any vertical plane therethrough a series of inwardly presented vertically aligned, downwardly and inwardly inclined slip guiding areas formed on its interior wall, a plurality of slip segments comprising semi-cylindrical members having inner walls formed with pipe engaging teeth and having outer walls comprising in any vertical plane therethrough a plurality of cooperating outwardly presented vertically aligned downwardly and inwardly inclined guiding areas, said guiding areas being formed in a continuous spiral surface of fixed lead, packing means in said bore below said slip means arranged for compression by said slip means to automatically form a seal between said bore and the outer wall of the casing when said lower exterior sealing surface of said hanger seats and seals in the casing head with the weight of the casing suspended from said hanger, said hanger having means in its bore above said counter-bore for forming an additional seal with the casing, and a second casing head secured on said first-named casing head having a downwardly presented tapered sealing surface to engage and seal with the upper tapered surface of said hanger.

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