

Dec. 9, 1952

R. A. MUELLER ET AL
CASING COMPLETION AND METHOD

2,620,880

Filed Feb. 26, 1946

5 Sheets-Sheet 1

FIG. 1.

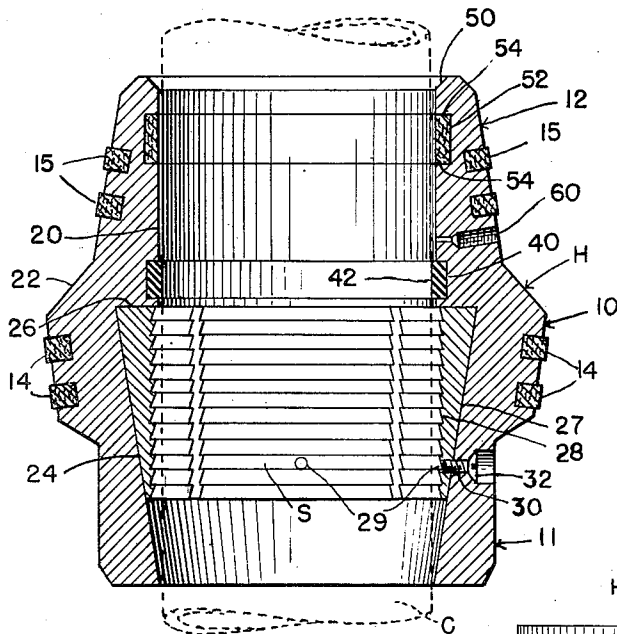


FIG. 3.

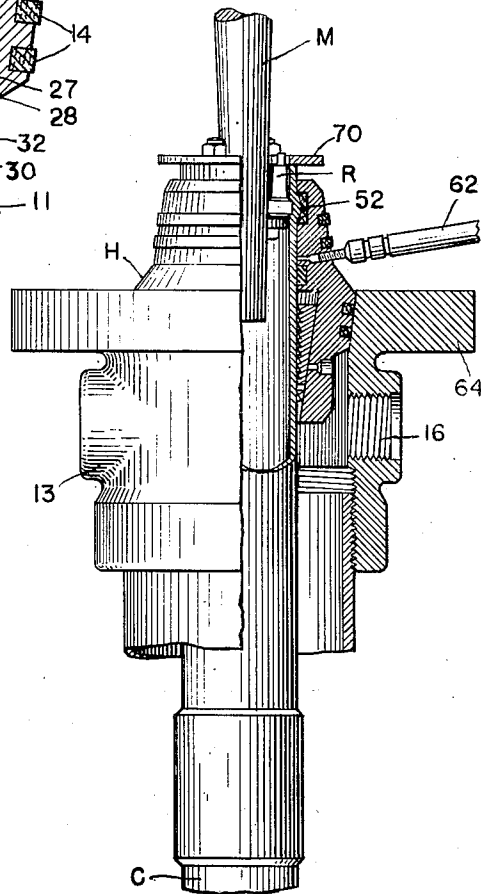
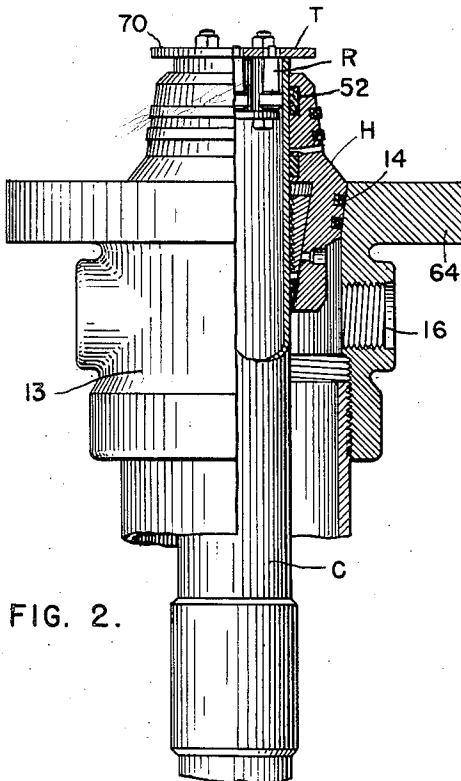


FIG. 2.

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FIG. 4.

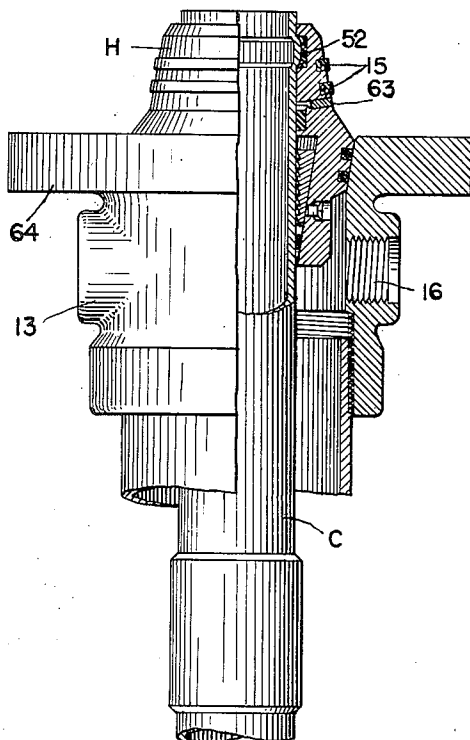


FIG. 6.

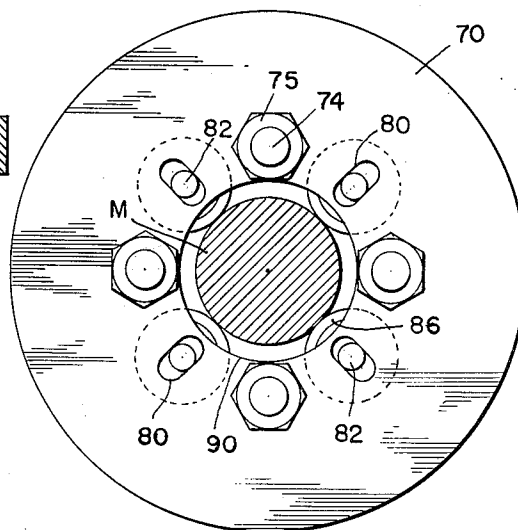


FIG. 5.

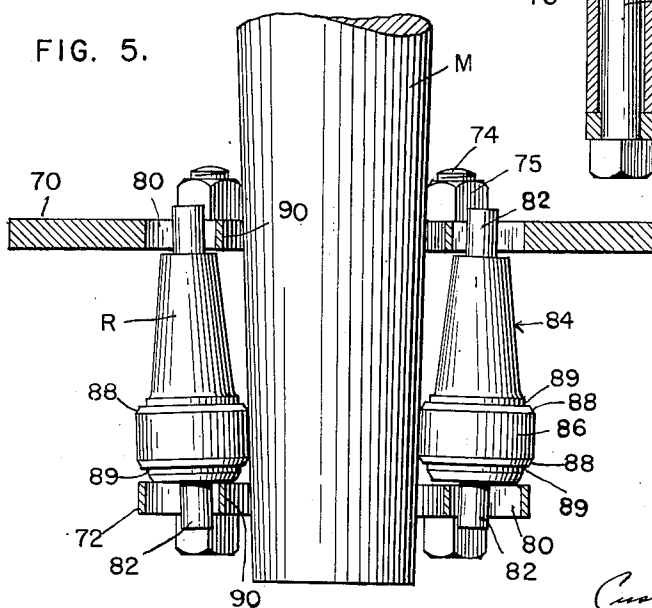
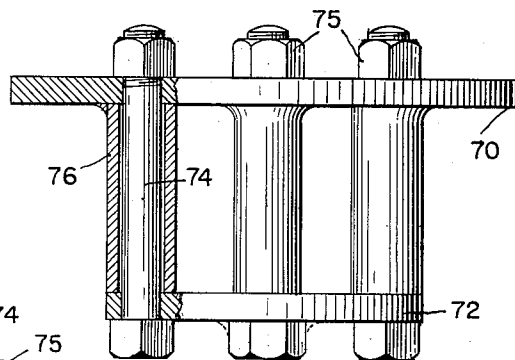


FIG. 7.

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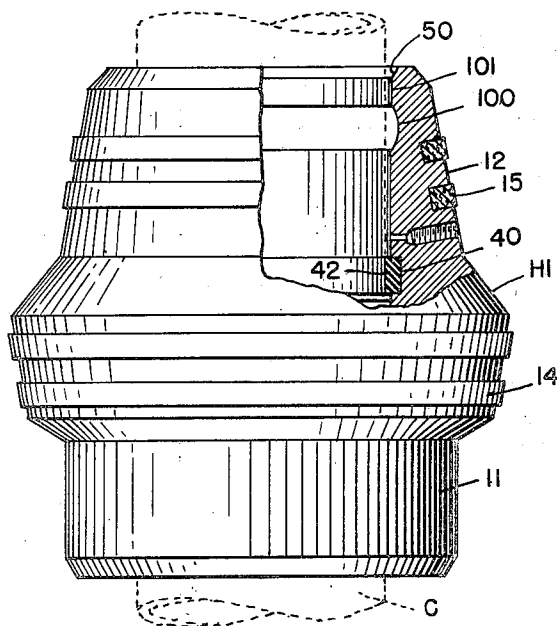


FIG. 8.

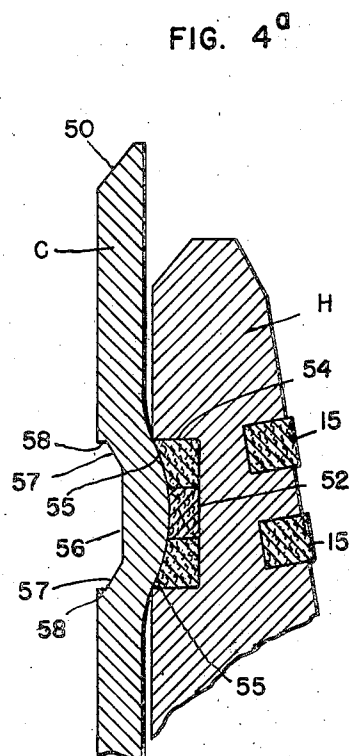


FIG. 4^a

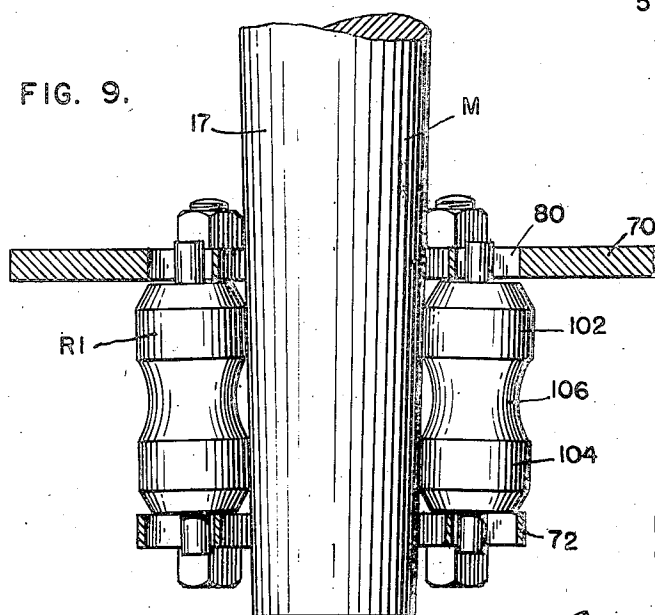


FIG. 9.

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FIG. 10.

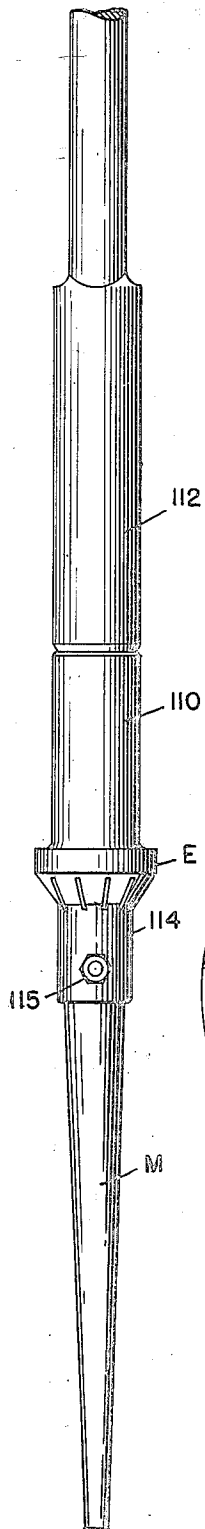


FIG. 13.

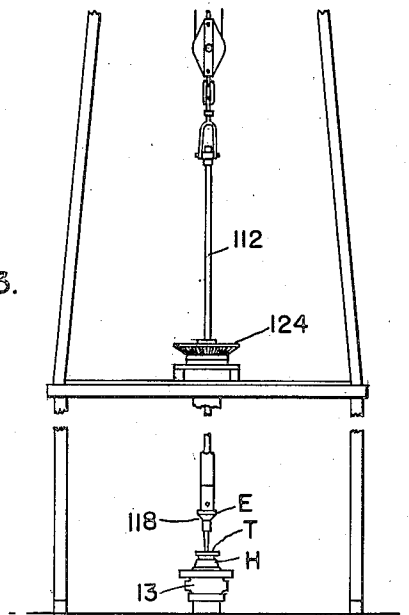


FIG. 11.

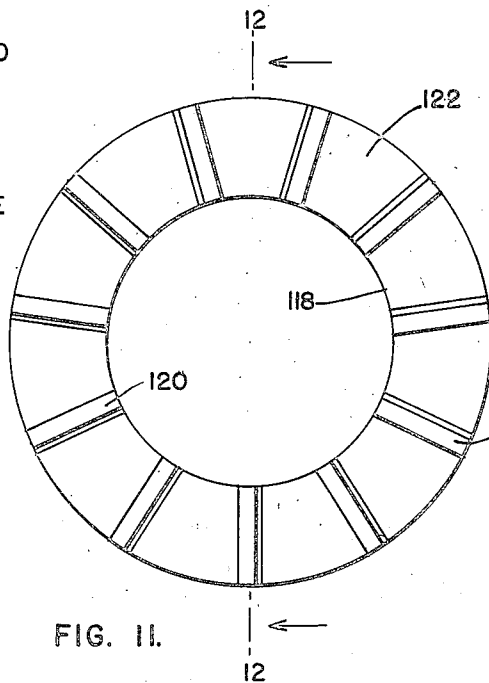
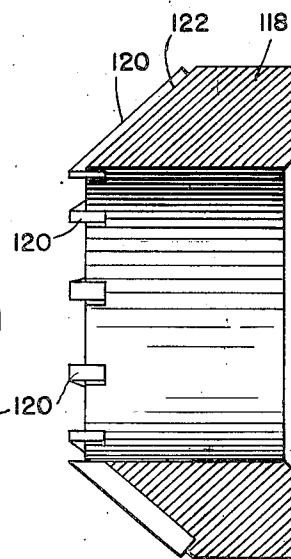


FIG. 12.



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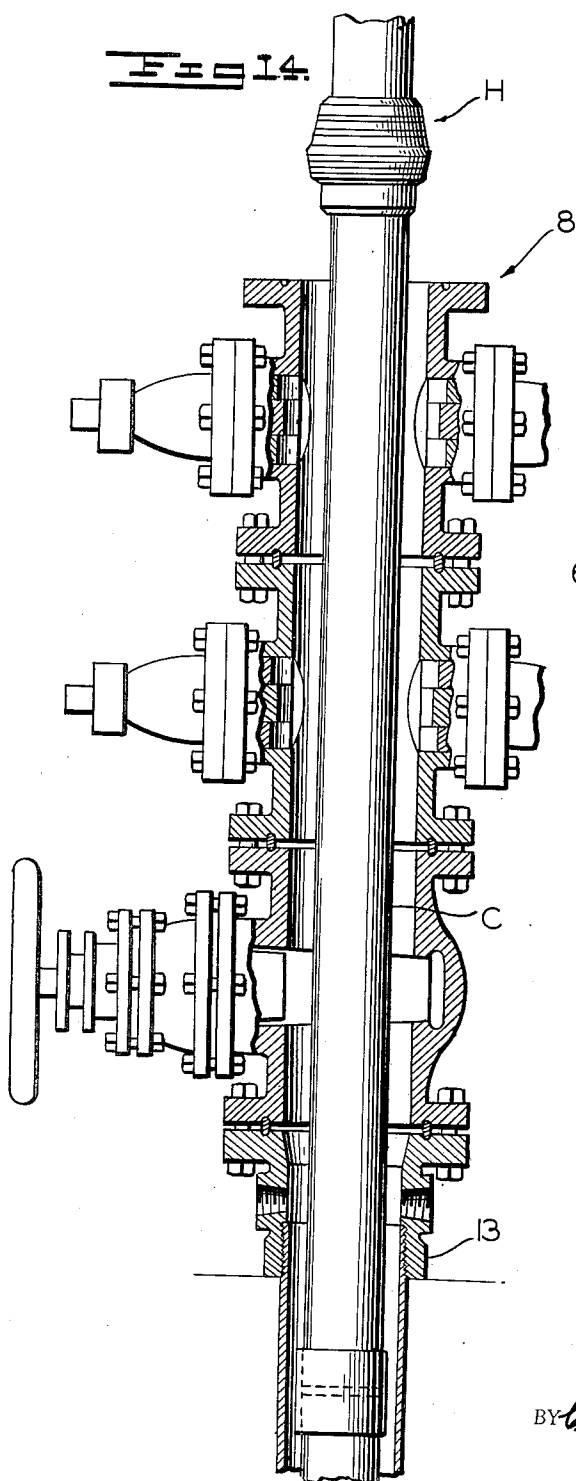
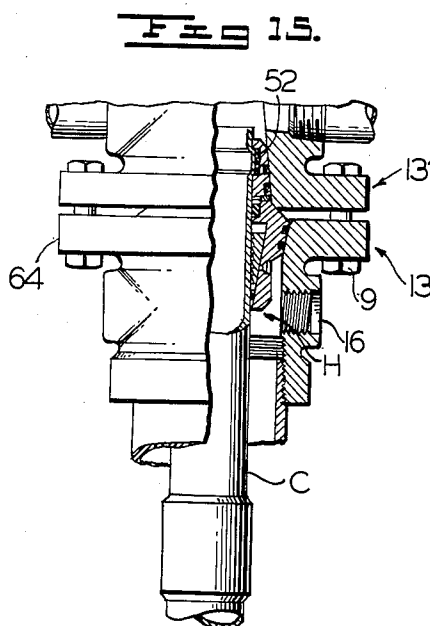
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,620,880

CASING COMPLETION AND METHOD

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Application February 26, 1946, Serial No. 650,272

6 Claims. (Cl. 166—14)

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The present invention relates to the building of oil wells, and is particularly applicable to apparatus and methods for running in casing and for hanging and sealing the same in the casing head while providing complete mechanical control of the well at all times.

The invention is concerned with such safe wells and methods of building same as are described in Patents 2,117,444, May 17, 1938, and 2,082,413, June 1, 1937, to Mueller and Yancey, while using a slip-type hanger of the type disclosed in the Patent to Roye 2,207,469, July 9, 1940. The description of applicable structure and steps in operation which appears in these patents is not repeated herein, it being understood that they are referred to as disclosing now well known equipment and methods which would be used with the present invention, and to that extent they form a part of the present disclosure.

As in the case of the Roye patent, the invention contemplates the use of a hanger which may be positioned intermediate the ends of the top joint of casing, and which permits the casing to be pulled upwardly therethrough to remove the slack, or to put a strain on the casing, the hanger having means associated therewith such as slips to support the casing while steps are being taken above the point of support for permanently sealing the hanger to the casing.

As illustrated in the drawings and as similarly shown in Figure 6 of the aforementioned Roye patent, the hanger of the present invention is adapted to be lowered through such control equipment as a drilling master valve and blow-out preventers, and is provided with means for forming a seal with the bowl of the casing head in which it is landed. The hanger likewise has means for sealing with a second casing head mounted above the same, this second casing head being applied to support an inner string of casing or tubing.

The application of the invention disclosed herein comprises a hanger which is positioned over the upper end of a string of casing at the time it is being landed, said hanger forming a seal with the seat of the casing head in which it is landed and also forming a temporary seal with the casing on which it is positioned, these seals being formed while the control equipment is still mounted on the casing head and available for use. Thereafter, a novel type of permanent seal is effected between the hanger and the casing above said temporary seal. When the permanent seal has thus been effected, an additional casing

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head may be mounted over the hanger, as described in the patents mentioned above, after which successive strings of casing may be run, landed, and sealed in the same fashion, and tubing may finally be landed in the last or tubing head.

It will be understood that the steps of cementing the casing with control, the circulation of fluid incident thereto, the sealing of the lower end of the casing and drilling out of cement blockades, as referred to in said patents, may be performed in connection with the present invention. Likewise, the steps involved in accurately positioning the casing, removing the slack therefrom, etc. may also be performed.

A principal object of the invention is to provide for effecting the permanent seal between the casing and the hanger by the regular well crew and with tools operable from the conventional derrick equipment, rather than requiring the presence of special workers such as welders and the like. As is well known, there is a high degree of human skill required in efficient welding, and it is not desirable to have the success of such an expensive and potentially dangerous structure as an oil well depend on the skill of one man. While the welding of hangers to casings has proved to be generally satisfactory, there have been failures in wells at this point. More recently there have been difficulties resulting from the use of higher alloys in the manufacture of casing, which alloys are more difficult to weld.

Another object of the invention is to provide a seal between the casing or other oil well pipe and the element which supports it in the casing or tubing head, by operating on or deforming the metal of the pipe in such manner as to improve rather than impair its physical characteristics.

In the drawings, which illustrate the methods involved, and forms of apparatus for carrying out the invention:

Figure 1 is a longitudinal vertical sectional view through a hanger of the present invention, showing the relation of the hanger to the casing.

Figure 2 is a partial vertical sectional view through equipment at the top of a well, showing the casing deforming tool in position prior to effecting the permanent seal between the casing and hanger.

Figure 3 is a view similar to Figure 2, indicating the manner in which conventional derrick equipment may be employed to accomplish the permanent sealing operation.

Figure 4 is a view similar to Figures 2 and 3,

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showing the condition of the casing and hanger after accomplishment of the permanent seal, and prior to the mounting of the next casing or tubing head above the casing head shown.

Figure 4(a) is an enlarged view showing details of the seal disclosed in Figure 4.

Figure 5 is a vertical sectional view through the casing deforming mechanism, showing the expanding mandrel positioned between the deforming rollers.

Figure 6 is a top plan view of the casing deforming mechanism showing the mandrel in section at the point where it engages the expanding rollers.

Figure 7 is a side elevational view of the housing of the deforming mechanism, partly in section, the expanding rollers not being indicated to simplify the view.

Figure 8 is a view similar to that of Figure 1, only partially in section, showing a modified form of hanger.

Figure 9 is a view similar to Figure 5, of a modified construction of the casing deforming mechanism.

Figure 10 is a side elevational view of the combined mandrel and expanding tool connected with the conventional drilling joint which is operable by the drilling rotary.

Figure 11 is a face view of the mandrel portion of the tool of Figure 10.

Figure 12 is a sectional view of the mandrel portion of Figure 11, taken along the line 12—12 of Figure 11.

Figure 13 is a diagrammatic view generally illustrating the derrick floor and rotary, and showing the expanding tool suspended in the derrick and operatively connected with the rotary.

Figure 14 is a vertical sectional view through the control equipment, showing the hanger being lowered around the oil well casing and through the sealed chamber of the control equipment in accordance with the present invention.

Figure 15 is a view similar to Figure 4 showing the condition of the casing and hanger after accomplishment of the permanent seal, and after the second casing head has been secured in place.

Referring to Figure 1, the hanger H is shown in embracing relation with respect to a casing C. Said hanger comprises a lower downwardly and inwardly converging conical portion 10, a substantially cylindrical collar portion 11 below the same, and an upwardly and inwardly converging conical portion 12 above the portion 10. The outer surface of the converging portion 10 is adapted to seat in the conical bowl of a casing head 13, and when seated therein, a seal is formed between the hanger and the casing head by circular strips of hydraulic packing 14 which are carried in grooves in the surface of the hanger, the packing strips or rings extending throughout the entire circumference of the hanger. The upper surface 12 is likewise provided with packing rings 15, which form a seal with the upper casing head as shown in the patents referred to above. The casing head is provided with conventional side outlets 16 below its seat, for purposes such as the circulation of fluid, as referred to in said patents.

The hanger has a central longitudinal bore 20 of such diameter that the hanger may slide freely over the casing which it is designed to fit. The bore 20 extends downwardly through the interior of the hanger to a point opposite the shoulder 22 between the upper and lower conical surfaces thereof, where it merges into an enlarged slip chamber defined by an upwardly diverging conical

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cal wall 24 which terminates in a shoulder 25 defining the top of the chamber. This chamber serves to retain any number of slip segments S, the general construction and manner of operation of which are well known in the art. They are shaped to fit within the slip chamber, having outer smooth conical walls 27 and inner walls 28 provided with upwardly directed teeth which are adapted under certain circumstances, to engage the casing C and support the same. Each slip section is provided with a threaded opening 29 adapted to be aligned with the corresponding opening 30 through the wall of the lower collar portion 11 of the hanger, and screws 32 are passed through the openings 30 and are threaded into the aligned threaded openings in the slip sections, to initially retain the slips in their upper or inoperative position as is now well known in the art.

In the bore 20 of the hanger immediately above the slip chamber and below the upper end of the bore is an annular groove 40 of substantially rectangular cross section which receives means 42 for forming a temporary seal with the casing, this means being shown in the form of a neoprene or rubber continuous circular ring in the groove, but having an inside diameter slightly less than that of the casing on which the hanger is fitted. The packing ring 42 may have a somewhat smaller outside diameter than that of the groove 40 and an axial thickness somewhat less than the axial thickness of the groove so that the ring is floatingly supported in the groove. The ring is by the above construction and arrangement adapted through its tension to circumferentially engage the casing extending through the hanger whereby to complete a seal against well pressure in conjunction with the seal provided by sealing members on the exterior of the hanger. The sealing ring will be expanded when passed over the casing to form a tight seal with the exterior wall thereof and with the walls of the annular groove 40 in the bore of the hanger, to temporarily prevent any flow of well pressure through the space between the hanger and the casing during the performance of operations described below. The material of the packing ring 42 is of the highly flowable short-lived classification which is satisfactory as a seal for a short period of time, but which could not be relied on as being permanent in nature.

The hanger described above is adapted to be slipped over a string of well casing incident to hanging the casing in the well in any of the various ways described in the said Royce patent. The hanger has all of the advantages as referred to in the patent, with the further provision that it provides a seal between the hanger and casing as soon as it is applied to the casing. When it is desired to form a permanent seal at the top of the hanger as by the welding operation disclosed in the said Royce patent, the control equipment may be disengaged from the casing head and elevated or entirely removed during the performance of the welding operation without danger of a blow-out, as a temporary seal is provided by the ring 42 between the hanger and the casing. The sealing rings 14 complete this seal by their engagement with the seat in the bowl of the casing head.

While we have illustrated and described the temporary seal between hanger and the casing as a continuous rubber ring 42, it will be understood that other forms of seals may be employed involving modifications in the hanger construction. We have in mind particularly the type of

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seal as disclosed in the application of John Lemley et al. Serial No. 569,863 filed December 26, 1944, now Patent No. 2,485,497, granted October 18, 1949. In this application a temporary seal is disclosed comprising a groove somewhat similar to the groove 40, but having an annular packing ring therein adapted to be expanded against the casing by fluid pressure applied to its outer wall to form a seal with the casing, the fluid under pressure being delivered through a passage extending from the outer wall of the hanger to its inner groove.

The upper end of the hanger is specially formed to provide for the formation of a novel type of permanent seal. As shown in Figure 1, the upper end of the bore 20 is flared or curved outwardly forming a depression as at 50, and spaced below the latter, the bore has a circular indentation or depression 52, shown as substantially rectangular in cross section. The edge of the indentation forms upper and lower shoulder portions, toward which the casing is expanded as hereinafter described. The indentation 52 is substantially filled with a ring of permanent sealing material such as hydraulic packing, metallic packing, or the like. By means described in detail below, the well casing is distorted by expansion outwardly into intimate engagement with the bore of the hanger adjacent the upper end thereof to form a permanent seal between the casing and the bore of the hanger, this sealing operation being substituted for the welding connection described in the said Roye patent.

As will be apparent from Figure 14 and from the specification of the Roye patent, the above described hanger may be slipped over the string of casing and through the sealed chamber of the control equipment 8 and positioned at the desired point thereon, either during the lowering of the casing into the well or after the casing has been run in and cemented. After the cement has set, the hanger is worked downwardly over the casing through the sealed chamber of the control equipment 8 into the bowl of the casing head and the casing is then pulled upwardly by conventional means in the derrick to remove the slack therefrom or to take a strain, as desired. It will be understood that before the hanger is disposed in the seat of the casing head, the screws 32 are removed to release the slips. When the strain taken by the derrick draw works is released, resulting downward movement of the casing moves the slips downwardly in their chamber causing their teeth to rigidly grip and support the casing.

At this time, the hanger forms a seal in the bowl of the casing head by its circumferential rings 14, and the inside temporary seal such as that provided by the ring 42 or other means mentioned forms a seal between the bore of the hanger and the outer wall of the casing. The control equipment 8 may now be removed with complete safety for the accomplishment of the permanent seal now to be described. It is most convenient to detach the control equipment from the flange 64 of the casing head, elevate the same a short distance, and by a suitable tool provided for this purpose, cut off the casing evenly at a proper selected point immediately above the hanger H. The upper end of the cut casing may now be beveled at its inner edge as hereinafter described.

Referring to Figures 2 and 3, a tool T for expanding the upper end of the casing is now positioned in the open end thereof. The tool T car-

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ries a plurality of expanding rollers which are rotated and forced outwardly by a tapered mandrel M adapted to be attached to the Kelly or grip joint suspended in the derrick from the traveling block and swivel, which joint extends through and is rotated by the rotary table on the derrick floor in a manner hereinafter described in detail. The tapered mandrel is lowered into engagement with the expanding rollers, and rotation of the mandrel and the tool T with its rollers deforms the casing into sealed engagement with the hanger, by spinning portions of the casing into the indentation 52 of the hanger and by bending adjacent portions of the casing toward the shoulders 54 of the hanger above and below the indentation 52, thus forming a fluid tight permanent seal with the hanger. It will be noted that a ring like bead is formed on the exterior of the casing, which bead enters the groove 52 and compresses the packing therein to form a tight and permanent seal.

As best shown in Figure 4a, the packing in the groove 52, when compressed outwardly, is also forced toward the shoulders 54 of the groove and toward the casing into the corners 55 to form a tight seal between the hanger and the casing. The depression in the inner wall of the casing takes the form of the deforming rollers, having a flat bottom surface 56 between short tapered surfaces 57, and top and bottom flat ledges 58, formed by grooves on the face of the mandrel provided to eliminate protruding burrs of metal, as hereinafter described.

Referring again to Figure 1, it will be noted that there is a radial threaded opening 60 leading from the exterior to the bore of the hanger between the temporary seal 42 and the means 52 and 54 for effecting the permanent seal as just described. When the permanent seal has been effected, fluid under pressure may be introduced into the bore of the hanger between the two seals and in the space surrounding the casing by connecting a conduit 62 (Figure 3) leading from a test pump into the opening 60 and applying pressure to the space referred to. If there is leakage of fluid past the seal at the upper end of the hanger, the expanding operation may be continued until a tight seal is assured. When a permanent seal has thus been effected and tested, the testing connection 62 may be removed from the threaded opening 60 and the latter may be closed with any suitable plug 63 (Figure 4) as is well known in the art, said plug being of such size as not to extend beyond the surface of the upper face of the hanger.

An additional casing head 13¹ may now be mounted on the flange 64 of the casing head 13 as shown in the patents mentioned above, and further casing may be run, hung, and sealed in a manner identical with that described above, until the well is completed.

Referring to Figures 5, 6, and 7, the casing expanding tool comprises a mandrel M and a housing including an upper plate 70 of diameter greater than the diameter of the casing being operated upon, and a lower plate 72 of somewhat less diameter to pass into the open end of the casing. These plates are rigidly held in spaced relation with respect to one another by bolts 74 having nuts 75 on opposite ends thereof, there being spacing sleeves 76 positioned between the inner faces of the plates 70 and 72 through which the bolts 74 pass. These sleeves are preferably welded or otherwise secured to the inner face of the plate 70, and the plate 72 is bolted

against the lower ends of the sleeves. As shown in Figure 6, there may be four of the bolts 74 circularly arranged a quadrants distance from one another. Intermediate the bolts 74, the plates 70 and 72 are provided with spaced and aligned openings 80, which are elongated in a radial direction. These openings are adapted to loosely receive stub shafts 82 which extend from opposite ends of the spools or rollers which accomplish the expanding operation.

Referring to Figure 5, each spool comprises a body portion 84, and a lower substantially cylindrical rolling portion 86, and inwardly tapered rolling portions 88 on each side of the portion 86. The surfaces 88 are cut away near their outer effective areas by grooves 89 to prevent the formation of burrs of metal on the edges of the indentation on the inner surface of the casing. Referring to Figure 4(a), these cut outs 89 form the ledges 50 in the indentations, thus eliminating burrs, while the tapered surfaces 57 are formed by the surfaces 88 of the rollers. It will be apparent that when the rollers are assembled in their housing, the elongated grooves 80 will permit some radial movement of their stub shafts 82. When properly assembled, the nuts 75 on the bolts 74 may be welded to their respective plates to complete a rigid tool assembly.

As indicated by comparison of Figures 2 and 3, the expanding tool is so designed, and the casing C is cut off so that the upper plate 70 of the tool will suspend the expanding rollers with their shoulder 86 in substantially horizontal alignment with the indentation 52 of the hanger. The top and bottom plates 70 and 72 of the housing have central aligned openings 90 therein, which define a passage through the housing for the mandrel M. The rollers R are so supported in the openings 80 that they partially extend into the passage defined by the openings 90. When the mandrel M is forced into this central passage in the expanding tool, it contacts the cylindrical portions 86 of the rollers and forces them outwardly into firm engagement with the interior of the wall of the casing. Upon rotation of the mandrel by the rotary and with further downward wedging pressure of the mandrel, resulting from the weight of the drilling Kelly joint, swivel and connected parts, the tool housing is rotated and the rollers are forced outwardly while being rotated to cold roll the adjacent portion of the pipe into the groove 52 in the bore of the hanger and toward the shoulders 54 of the bore thereof and the packing in the indentation 52 is tightly compressed. It will be understood that the action of the expanding rollers is not a mere bending of the pipe, but is a cold working of the metal which results in a permanent deformation of the casing.

I have found that this cold rolling operation improves the physical characteristics of the metal which has been deformed, as compared with the adjacent metal of the pipe which has not been so treated. It is well known that the metal immediately adjoining a weld is deleteriously affected thereby, and the utmost care must be exercised by the welder to restore the original physical properties of this metal.

Furthermore, the well head assembly in which this invention is best adapted to be used, is such that means are provided to constantly assist in maintaining the seal formed as described above. Referring to Figures 4 and 15, and to the earlier patents mentioned above (particularly Figure 9 of the Royce Patent 2,207,469), it will be under-

stood that once the seal has been formed, an additional casing head or tubing head 13¹ will be mounted on and above the flange 64 of the casing head 13. As shown in Figure 15 and said earlier patents, this additional casing or tubing head 13¹ has a bottom opening comprising an inwardly tapering bowl which engages the upper conical surface 12 of the hanger, and exerts inward pressure on this surface of degree depending on the tightness of the bolts 9 which connect the flanges of the two heads. Thus, the force exerted on the upper tapered surface of the hanger by the upper casing or tubing head is in a direction substantially inwardly toward the sealing groove 52, and this inward force tends to maintain the seal in tight engagement throughout the life of the well. Thus, when the entire head is assembled, there are two forces in effect, both of which tend to maintain the seal, these being the outward force against the bore of the hanger exerted by the bead spun in the outer wall of the casing, and the inward force on the hanger itself exerted by the bowl of the casing head mounted around and above said hanger. If occasions arise to tighten the bolts which connect the flanges of adjacent casing heads in order to tighten the seal on the outer packing rings 15, this tightening action would tend to improve the seal 52 by inward pressure on the hanger.

Thus, when the casing or tubing head next above that shown at 13 in Figure 4 is placed on the well, as described in said previous patents, any inward force exerted on the upper tapered surface of the hanger will tend to improve rather than impair the effectiveness of the seal. This may not be true in the case of hangers which are welded to the casing adjacent their upper ends, for, in the case of such hangers, any movement of the parts after the welding has been accomplished, may tend to fracture the union, welded connections being relatively inflexible.

The seal of the present invention is also superior in insuring against faults in the weld caused by heavy objects striking the pipe during subsequent operations within the casing. While a welded connection might be fractured by a sharp blow, the present seal is of sufficient flexibility to withstand such impact. It will be further apparent that the seal as described rigidly retains the casing against both upward and downward movement with respect to the hanger.

In Figure 8, a modified form of hanger H1 is disclosed, same being in all respects similar to the hanger of Figure 1 except that its sealing indentation 100 is somewhat more shallow than the indentation 52 of the preferred embodiment, and it has an arcuate rather than rectangular bottom surface as in the preferred embodiment. In the use of this modified type of hanger, it is preferred to insert a permanent sealing material comprising a thin sleeve of metal such as Monel, brass, bronze, or the like into the clearance space between the casing and the bore of the hanger, this sleeve extending from above the top edge of the hanger into and throughout the vertical dimension of the indentation 100. The upper end of the bore of the hanger may be slightly enlarged to receive this sleeve. As an alternative, a quantity of permanent hydraulic packing could be inserted into this clearance space. Upon the performance of a somewhat modified rolling operation, now to be described, this sealing material is compressed to insure a permanent tight seal between the casing and the hanger.

Referring to Figure 9, a modified expanding

tool is shown, differing from the preferred embodiment of Figure 5 substantially only in the design of the expanding rollers, which are designated R1. These rollers have upper and lower cylindrical surfaces 102 and 104, and between the same there is a longitudinally curved indented portion 106 forming a reduced central neck. This expanding tool may be so designed and the casing C may be cut off so that the upper plate 70 of the tool will suspend these expanding rollers with their reduced neck portions 106 in substantially horizontal alignment with the shoulder 101 of the hanger formed above the indentation 100. Upon rotation of the mandrel by the rotary, the rollers are forced outwardly while being rotated to deform the casing into the groove 100 of the bore of the hanger and around the shoulder formed above said groove and toward the flared portion 50 at the upper end of said bore. The upper cylindrical portions 102 of the rollers serve to bend the upper end of the casing outwardly toward the wall of the flared portion 50 of the hanger while the lower cylindrical portions 104 of the rollers force an annular ring of the casing into the indentation 100, the reduced necks 106 of the rollers in turn forcing the intermediate portion of the casing against the interior shoulder 101 in the bore of the hanger above said indentation. The thin sleeve of Monel, brass, or bronze previously inserted between the casing and the upper end of the bore of the hanger is tightly compressed between the distorted portions of the casing and the bore of the hanger. In all other respects, the sealing operation using the modified hanger H1 and the modified rollers R1 is similar to that described in connection with the preferred embodiment of the invention.

The portion of the casing expanding mechanism which is connected with and driven by the conventional derrick equipment is shown in Figure 10. The working parts of the mandrel assembly are connected with a tool joint 110 which is conventionally secured to the lower end 112 of a standard Kelly or grip joint. The lower end of the tool joint 110 is attached to a short section of drill pipe 114 in the conventional manner, and the elongated tapered steel mandrel M is inserted at its outer end into the pipe section 114 where it may be secured by a bolt 115 which extends through aligned openings in the drill pipe section and in the inner end of the mandrel. If it is desired to ream or bevel the open end of the casing after it is cut with the same tool assembly, a reaming tool E may likewise be suitably secured to the pipe section 114 and to the tool joint 110 as by welding.

The reaming portion of the tool comprises a collar-like body 118 (Figure 12) adapted to embrace the section of drill pipe 114 and to be welded thereto, this body being made of mild steel and being equipped with cutting or reaming blades 120 made of tool steel. These blades may be removably secured in any well known manner in the body 118 along an external tapered surface 122 thereof, so that they may be replaced when worn. The cutting blades are equally spaced around the tapered surface 122 of the body 118 and are ground by right-hand rotation of the tool.

Referring to Figure 13, it will be understood that the standard drilling joint 112 is provided with a conventional polygonal portion which passes through a similar opening in the drilling rotary table 124, by which it is driven in a man-

ner well known in the art. The rotary is geared to a suitable engine driven shaft forming part of the standard drilling equipment and turns the joint 112 while permitting the same to be moved vertically through the rotary as is also well known in the art. The drilling joint 112 is suspended from the conventional swivel and traveling block carried from the top of the derrick by wire lines, as is diagrammatically illustrated in Figure 13.

As is further apparent from Figure 13, the lower end of the tool can be inserted into the open end of the casing to ream or bevel the open end of the same after the casing has been cut, either before or after the mandrel M has been attached to the tool. This reaming operation is desirable in order to have full use of the entire width of the casing in subsequent operations, and to eliminate any sharp edges which might hang up tubing or tools being run through the casing in subsequent operations. With the mandrel attached, it can be inserted through the openings 90 of the casing expanding assembly to apply rotary force to the rollers R or R1 from the rotary drilling table 124 as will be apparent to one skilled in the art, and as has been previously described.

The operations involved in preparing the casing and then permanently sealing the same to the hanger are thus effected by power applied by conventional derrick equipment, and thus do not depend for their performance on the availability of special workers such as welders not ordinarily present as members of the derrick crew.

It will be evident that the expanding tool comprises the mandrel, housing, and rollers, as well as the drill joint which passes through and is engaged for rotation by the rotary table. The housing includes an upper plate which supports the rollers in proper position, and a depending portion terminating in the lower plate 72 of diameter to be capable of insertion into the casing. The rollers are of length slightly less than the distance between the plates of the housing, and being loosely mounted in the elongated opening 80, they are capable of being tilted during the expanding operation as shown in Figures 5 and 9, by the taper of the mandrel 17. This tilting position assists in properly expanding the casing into the depression in the bore of the hanger.

During the expanding operation, the downward thrust on the mandrel is controlled by the degree of tension or slackening of the supporting cables in the derrick between the crown and traveling blocks. The vertical thrust of the mandrel is supported by the deforming rollers which in turn are supported in the indented track they form in the well of the casing.

After the forming of the permanent seal as described, the function of the short-lived highly flowable temporary seal has been assumed by a more durable agency, and the deterioration which will ultimately take place in the temporary seal is not a problem, for it has satisfied its purpose.

It will be understood that the design of the tool and the manner of performing the cutting and expanding operations are such that any flaring of the upper end of the casing is not sufficient to interfere with an upper casing head mounted over and above the hanger, as described in the patents mentioned. It will also be evident that the permanent seal formed as described has a minimum area subject to pressure from within the well.

It will be obvious that changes in the structure and methods disclosed herein may be made without departing from the invention. Where use of the invention with "casing" is referred to, it is obvious that there is applicability to other oil well pipe, such as tubing, and the claims are intended to include practice of the invention with tubing, unless they specifically indicate otherwise.

We claim:

1. A hanger for oil well pipe having a longitudinal bore of diameter to slide over the pipe, said hanger having a lower downwardly and inwardly tapered exterior surface to seat in and seal with the bowl of a lower casing head and having a top upwardly and inwardly tapered exterior surface, said hanger being of size and shape for lowering through control equipment mounted on the lower casing head, said hanger having an annular depression in the wall of its bore adjacent the upper end thereof to facilitate expanding the wall of the pipe adjacent the upper end thereof into said depression and thereby into permanent sealing engagement with the bore of said hanger, said hanger having a second annular depression in the wall of its bore spaced beneath said first annular depression and having a temporary sealing ring positioned therein for temporary sealing engagement with the pipe, said hanger having an enlarged chamber in said bore below said first annular depression providing a slip compartment, and slips in said compartment which are completely enclosed within and carried by said hanger for engaging and supporting the pipe while its wall is being expanded into said depression.

2. An apparatus of claim 1, wherein said first annular depression is provided with a yieldable permanent hydraulic packing.

3. An apparatus of claim 1 wherein a radial opening in the wall of said hanger and having a removable plug therein is provided for testing the permanent seal between the expanded annular portion of the wall of said casing and the first annular depression in the wall of said bore.

4. An oil well completion assembly comprising lower and upper casing heads with a hanger for suspending the oil well casing secured between them, said hanger having a longitudinal bore of diameter to slide over the oil well casing, said hanger having a bottom portion surrounded by a downwardly and inwardly tapered exterior surface to seat in and seal with the bowl of said lower casing head and a top portion surrounded by an upwardly and inwardly tapered exterior surface to seal with a similarly tapered recess in said upper casing head, said hanger being of size and shape for lowering through control equipment mounted on said lower casing head, the top portion of said hanger having an annular depression in the wall of its bore to facilitate expanding the wall of the casing adjacent the upper end thereof into said depression and outwardly into permanent sealing engagement with the bore of said hanger, the bottom portion of said hanger having slip means in its bore for engaging and supporting the casing while its wall is being expanded into said depression, said hanger having a second annular depression in

the wall of its bore positioned below said first annular depression and having a temporary sealing ring positioned therein for temporary sealing engagement with the casing, and adjustable means for forcing said upper casing head downwardly toward said lower casing head to exert compression forces against said top portion of said hanger inwardly toward the seal formed in said first depression.

5. The method of completing a casing installation wherein a first temporary seal is provided by sealing off a chamber above the casing head and around the casing, comprising lowering a tubular hanger around the casing through the first temporary seal and seating the hanger in the casing head, providing a second temporary seal between the bore of the hanger and the casing, taking a strain on the casing and thereafter preliminarily suspending same from the hanger and thereby simultaneously forming a permanent seal between the hanger and the casing head, removing the first temporary seal and cutting off the casing immediately above the hanger, and thereafter permanently sealing to and suspending the casing from the hanger by cold rolling the casing adjacent the cut off open end thereof outwardly into sealing engagement with the bore of the hanger.

6. In an apparatus of the type described comprising in combination upper and lower casing heads, a hanger secured between said heads and supporting an oil well casing, said hanger having a bore extending therethrough of a diameter to slide over said oil well casing, an enlarged chamber in said bore adjacent the lower end of said hanger providing a slip compartment, slips carried in said compartment for preliminarily engaging and supporting said oil well casing, an annular depression in the wall of said bore adjacent the upper end of said hanger, said annular depression receiving an expanded annular portion of the wall of said casing and thereby permanently sealing and supporting said casing to the bore of said hanger, and a second annular depression in the wall of said bore and positioned between the first annular depression and the enlarged chamber of said bore, and an annular sealing ring having an inside diameter less than the diameter of said oil well casing positioned in said second annular depression for temporary sealing engagement between said bore and said casing.

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