

April 26, 1960

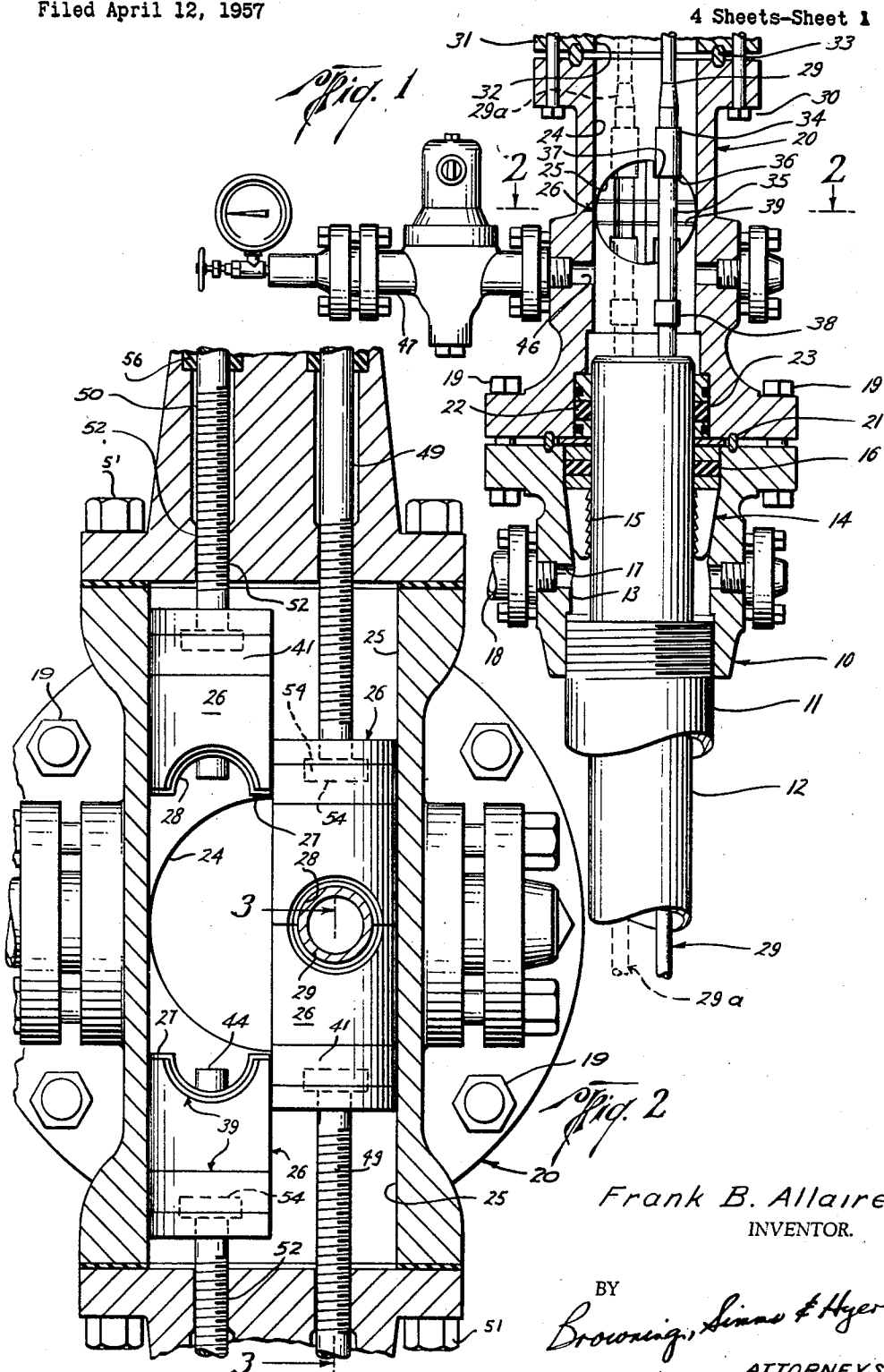
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2,934,148

MULTIPLE ZONE WELL COMPLETION

Filed April 12, 1957

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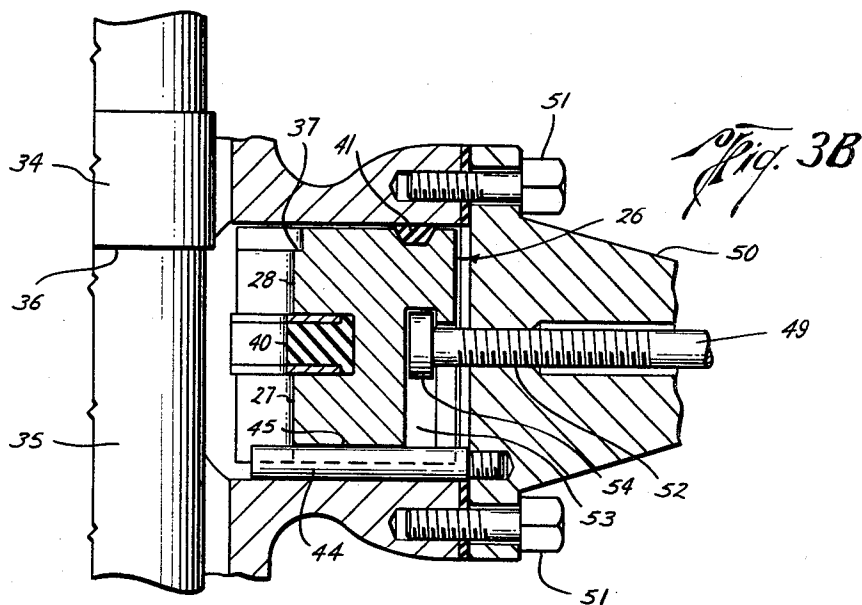
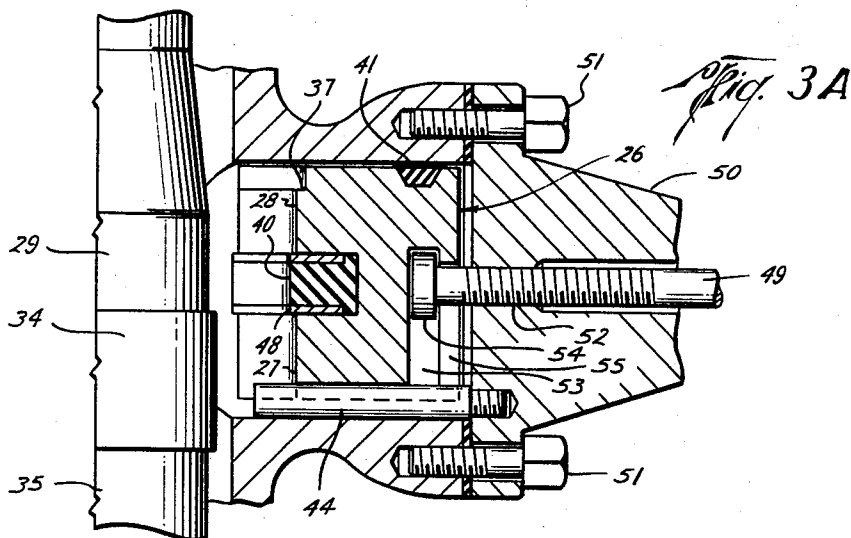
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4 Sheets-Sheet 2



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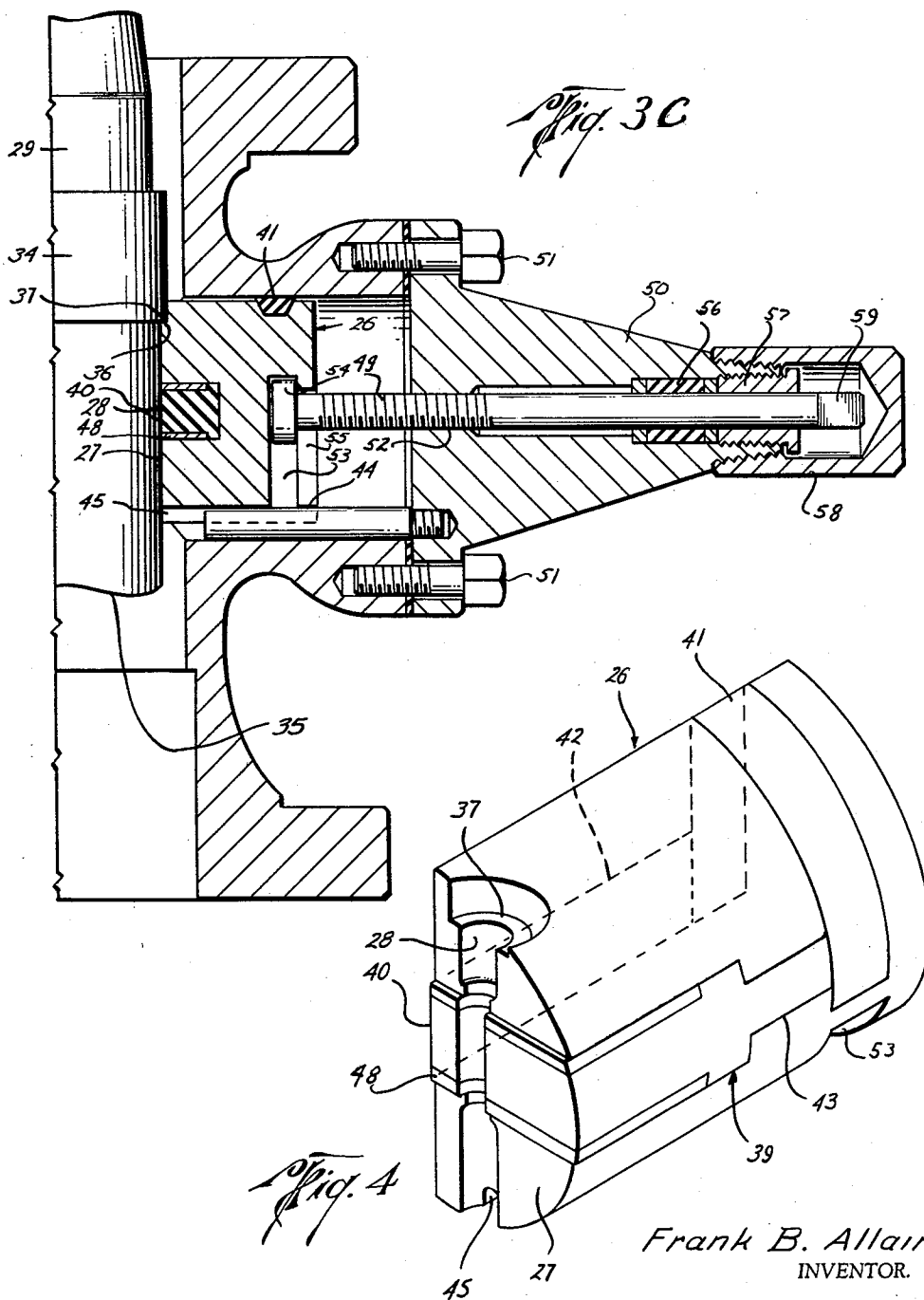
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MULTIPLE ZONE WELL COMPLETION

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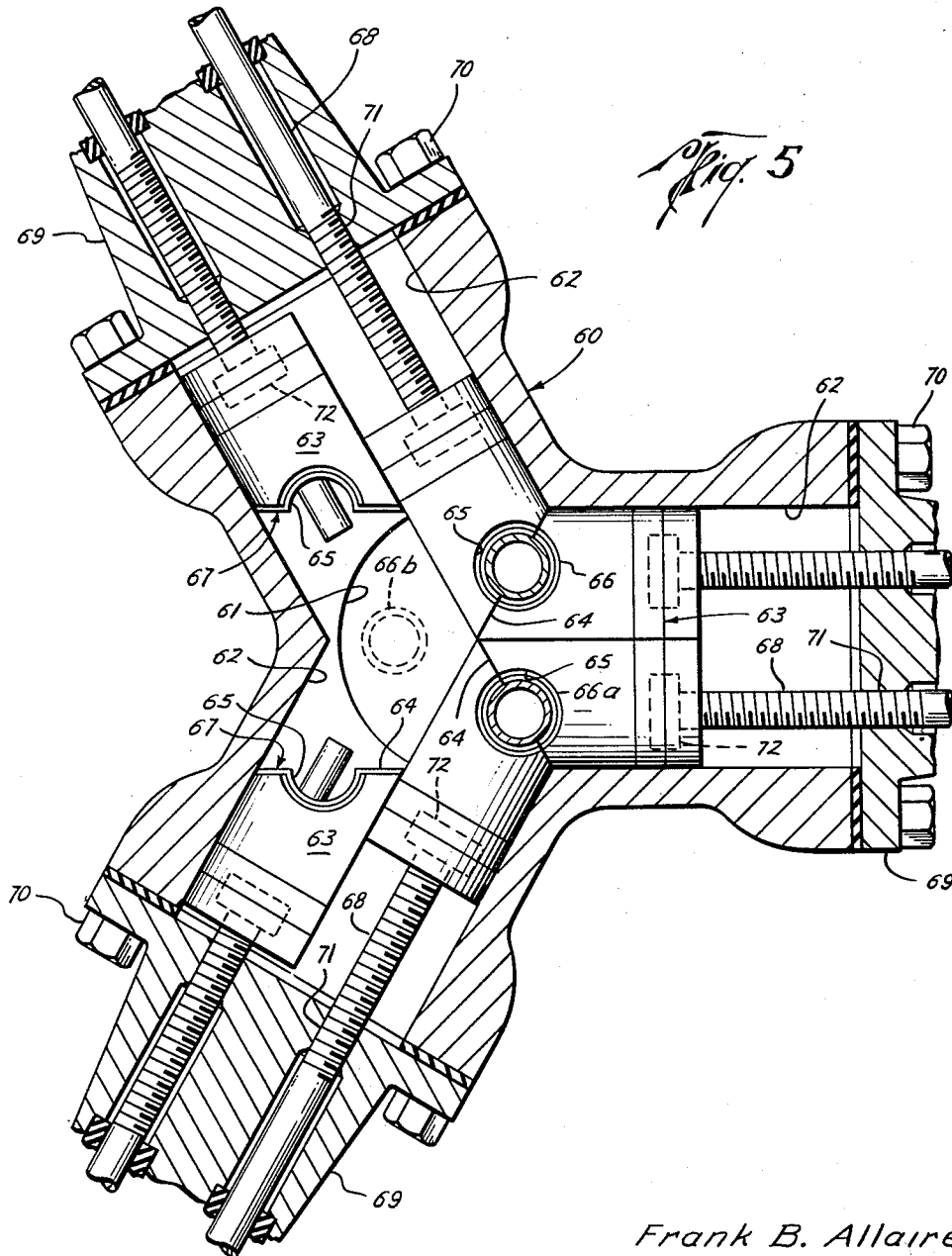
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MULTIPLE ZONE WELL COMPLETION

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4 Sheets-Sheet 4



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2,934,148

MULTIPLE ZONE WELL COMPLETION

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7 Claims. (Cl. 166—75)

This invention relates to improved apparatus for use in the completion of multiple zone wells in which production is flowed from the several zones through separate, side-by-side tubing strings. More particularly, it relates to novel well head apparatus for suspending and sealing about the strings.

In the completion of a well of this type, an inner casing or oil string communicating with the several zones is suspended from and sealed with respect to a casing head connected above an outer casing. Packers are set at levels within the inner casing for isolating the zones from one another, and the tubing strings are extended from the well head through the packers so that each communicates with one of the zones. The tubing strings are suspended from and sealed with respect to a tubing head connected above the casing head so as to isolate the space about the strings.

These strings are run into as well as pulled from the well through suitable pressure control equipment including a blowout preventer connected above the tubing head. When the strings are suspended and sealed in place, this equipment may be replaced for production purposes by the conventional "Christmas tree." During this change of equipment, back pressure valves may be installed within the tubing strings.

For reasons well known in the art, it may be desired to both run and pull one or more of the strings separately of the remainder. For this purpose, it has been proposed to suspend each string from a hanger which is supportable within the bore of the tubing head independently of the remainder, as shown, for example, in a copending application entitled, "Pipe Hanging Apparatus," Serial No. 575,079, filed November 4, 1955, by Herbert Allen, and now issued as patent No. 2,794,505, and assigned to the assignee of the present application. In this case, removal of the hangers provides a full opening through the tubing head bore for the passage of packers and other equipment therethrough.

An object of the present invention is to provide such apparatus which provides greater flexibility in suspending the strings by enabling each string to be suspended in tension.

Another object is to provide apparatus of this general type which also provides blowout preventer protection over the well during running of one of the strings while the remainder are suspended from the tubing head.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon a consideration of the written specification, the attached claims and the annexed drawings.

In accordance with the present invention, a tubing head is provided with guideways therein intersecting the bore, and a plurality of rams are mounted in side-by-side relation within each of the guideways. Means are provided for moving each ram between a position in which its inner end is retracted from the bore and another position in which said end is extended across the bore for engagement with the inner end of a ram extending from

another guideway. Registering recesses are formed on the inner ends of each pair of engageable rams for fitting about a tubing string within the bore.

Each string is provided with a collar or other suitable means for seating upon the rams. Thus, when a string is to be suspended from the tubing head, it is run into the well to a position in which its collar is just below the rams. Its lower end is then locked in place within the casing and a strain is taken thereon so as to raise the collar above the rams. The pair of rams fittable about the string are then extended across the bore and about the string, so that its collar may be seated thereon. Thus, in addition to suspending the string, the rams permit it to be suspended in tension. Each string is also provided with a collar or the like beneath and spaced from the first collar to limit raising of the string due to well pressures.

Obviously, when a string is to be pulled, the pair of rams which are fitted thereabout need only be retracted. When all the rams are retracted, and either prior to running of the strings or subsequent to pulling of same, the bore through the tubing head is fully open.

Means are provided for sealing between the tubing strings and tubing head when all of the rams are extended across the bore of the head and fitted about the strings. However, as distinguished from prior practices, this means is effective to provide such a seal and thus protect against blowouts at any time during running of the last string, when, for example, there is leakage through the preventer connected above the tubing head. For this purpose, the rams are provided with sealing strips so arranged thereon as to seal with respect to the strings about which they are fitted as well as with respect to each other and the guideways when in extended position.

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

Fig. 1 is a vertical sectional view of a dual zone well head installation including a tubing head having rams constructed and arranged in accordance with the present invention, and with one of the tubing strings suspended therefrom;

Fig. 2 is an enlarged horizontal sectional view of the tubing head and rams of the present invention, as seen along broken line 2—2 of Fig. 1;

Figs. 3A, 3B and 3C are vertical sectional views of a part of the tubing head, taken substantially along broken line 3—3 of Fig. 2, and illustrating the sequential steps for suspending a string within the bore therethrough;

Fig. 4 is an enlarged perspective view of one of the rams of Figs. 1 to 3; and

Fig. 5 is a horizontal sectional view of a tubing head and rams constructed, in accordance with the present invention, for use in triple zone completions, and showing a pair of strings suspended therefrom.

Turning now to a detailed description of the above described drawings, the dual zone well head installation shown in Fig. 1 includes a casing head 10 connected above an outer casing 11 and supporting an inner casing 12 within a bore 13 therethrough by means of a casing hanger 14, which may be similar in construction to the hanger of Patent No. 2,683,046 to Allen. As shown in Fig. 1, and described in detail in said patent, the hanger 14 may conventionally include slips 15 for gripping the inner casing 12 and a seal ring 16 of flowable material for sealing across the annulus between the outer casing and the casing head. The casing head 10 is also provided with an outlet 17 communicating the annulus between the inner and outer casings and below seal ring 16 with a flow wing 18.

Connected above the casing head 10, as by bolts 19, is a tubing head 20, the novel features of which will be described hereinafter. The opposite flanges of each of

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the tubing and casing head are provided with grooves therein for receiving an annular ring 21 therebetween which seals between the heads when they are connected together. Received within a counterbore portion 22 at the lower end of the tubing head in surrounding relation to the upper end of inner casing 12 is an annular seal member 23. Thus, each of the tubing and casing head is sealed with respect to the inner casing.

The above described apparatus is, of course, conventional and included herein merely for illustrating the usage of the novel apparatus to be described below.

The tubing head 20 is provided with a bore 24 there-through in substantial axial alignment with the bore of the casing head and of a diameter at least as large as the inner diameter of the inner casing 12. Mounted in side-by-side relation within each of guideways 25 intersecting opposite sides of the bore are a plurality of rams 26. In a manner to be described hereinafter, each ram is movable between a position in which its inner end 27 is retracted from the bore (see the leftmost pair of rams in Fig. 2) and another position in which said end is extended across the bore for engagement with the inner end of a ram extending from the opposite guideway (see the rightmost pair of rams in Fig. 2). Registering recesses 28 are formed on the inner ends 27 of each pair of engageable rams to form an opening for fitting about a tubing string disposed vertically within the bore 24, such as the string 29 shown in Figs. 1 and 2.

As can best be seen from Fig. 2, with the leftmost rams retracted from the bore, half of the bore is open so that gas lift valves or the like on the other string 29a (see Fig. 1) are easily passed therethrough as said other string is run into the well for suspension in side-by-side relation to string 29. As previously mentioned, the strings 29 and 29a, when suspended by the rams, extend through packers (not shown) within the inner casing 12 for communication with each production zone of the two-zone well.

Connected above the tubing head 20 as by bolts 30 is another well head member 31 which, according to the state of the completion process, may be a blowout preventer or a master valve. This well head member 31 is provided with a bore 32 therethrough for receiving the upper ends of the tubing strings and is sealed with respect to the tubing head by means of an annular seal ring 33 received between grooves in the flanges of said members.

During drilling of the well and running of the tubing strings, the well head member 31 will ordinarily comprise a blowout preventer for controlling the well pressure. The packers are run into the well through the preventer as well as the bore of the tubing head 20 from which rams 26 have been retracted. Obviously, the full opening so provided enables the tubing head to be constructed of a minimum size.

A collar 34 or other suitable means is provided about each string for seating upon the pair of rams extendable across the bore for fitting thereabout. Thus, upon lowering of the string 29 to a position such as shown in Fig. 3A, the mud in the string may be displaced and its packer tripped to lock the lower end of the string in place within the casing. A strain is then taken on the string to raise the collar 34 above the rams, as shown in Fig. 3B, and the rams are moved inwardly into fitted position about a portion 35 of the string beneath the collar. At this time, the string may be lowered to seat the lower edge 36 of the collar upon a seating surface 37 on the upper side of the rams, as shown in Fig. 3C.

The string may also be provided with a collar 38 spaced below the collar 34 an amount sufficient to provide a portion 35 of such length as to permit the rams to fit thereabout in the manner described. This collar 38 is seatable against the bottom of the rams to prevent the string from being blown out of the well.

When the tubing string 29a is also lowered into place,

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and the pair of rams shown retracted in Fig. 2 are extended across the bore for fitting thereabout, the bore 24 of the tubing head will be at least substantially closed. For the purpose of sealing between the tubing strings and the tubing head so as to prevent the escape of well pressure therepast, the rams 26 are each provided with a sealing strip 39 so arranged thereon as to seal with respect to the strings about which they are fitted as well as with respect to one another and the guideways when extended.

Referring now to a detailed description of the rams, it will be seen from Fig. 1 that each guideway 25 is cylindrical and of a diameter as large as that of the tubing head bore. Thus, each of the side-by-side rams is of semi-cylindrical shape, with its outer curved side slidable with respect to the guideway and its inner flat side slidable with respect to the inner flat side of its adjacent ram. Obviously, the guideway and rams may take other shapes.

Referring now particularly to Fig. 4, the strip 39 of flowable sealing material will be seen to include a first portion 40 extending laterally across the inner end 27 of the body transversely of the recess 28 therein, and a second portion 41 extending laterally about the curved side of the body rearwardly of the inner end 27 thereof. The strip 39 also includes portions 42 and 43 extending longitudinally along the flat and curved sides of the body, respectively, for connecting said laterally extending portions 40 and 41. As shown in Fig. 4, the portions 40, 42 and 43 of the strip may be integral with one another and separate from the portion 41.

The transversely extending portions 40 of the strips of each pair of engaging rams are abutable with one another when the rams are extended into engaging position so as to provide a seal therebetween as well as about the tubing string. The longitudinally extending portions 42 of the strips on adjacent rams in each guideway are disposable opposite one another so as to form a seal therebetween when said adjacent rams are extended. As best seen from Fig. 4, the strip portion 41 on each ram is spaced rearwardly of the inner end thereof an amount sufficient to seal with its guideway when the ram is extended. The outer strip portion 43 on each ram seals with respect to the guideway in the tubing head.

From the foregoing, it is obvious that the rams seal about the tubing strings and across the tubing head bore. Well fluid about the strings and beneath the rams may be diverted through an outlet 46 (Fig. 1) from the tubing head and into a flow wing 47. If desired, however, this outlet may be provided above the rams.

Inasmuch as the sealing strips 39 do not extend entirely around the rams, the rear or outer end of each ram will be subjected to well pressure so as to urge the inner ends of the rams into tight sealing engagement with one another and about the tubing strings. Disposed longitudinally along the curved side of each ram beneath the sealing strip 39 is a groove 45 slidable over a guide member 44 on the lower side of the guideway for preventing rotation of the ram as it is moved longitudinally within the guideway.

As can be seen from Fig. 4, all but the portion 40 of the sealing strip is substantially flush with the body of the ram. The portion 40 projects outwardly of the inner end 27 of the ram body so that the flowable material of the strip is substantially confined before the engagement of the front body faces on the inner ends of each pair of rams. This construction permits the strip to be compressed, as desired. The portion 40 of each strip is confined against flowing across the front face of the ram body by means of retainer plates 48 held in floating position between the top and bottom of this strip portion and the ram body. Reference is made to Patent No. 2,322,269 to Allen for a more detailed description of a sealing strip and retainer plate assembly of this type. Obviously, the seal may be established in accordance with other well known practices.

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As shown in Figs. 2 and 3A to 3C, each of the rams 26 is releasably connected to the inner end of a screw 49 supported within a bonnet 50 bolted as at 51 to the outer end of a guideway. This screw is threadedly connected to the bonnet at 52 for movement longitudinally of the guideway for moving the ram to which it is connected between retracted and extended positions. As shown in Fig. 2, the screws for both of the side-by-side rams in each guideway are supported by a single bonnet.

The aforementioned releasable connection between each ram and its screw comprises a slot 53 opening onto the lower side of the ram body and an enlargement 54 on the inner end of the screw removably received within the slot. During connection or disconnection of the ram and screw, the screw is passed through a reduced slot 55 connecting the slot 54 with the outer end of the ram.

Packing 56 is carried within the bonnet 50 for surrounding and sealing about the outer end of each screw. A gland 57 for the packing is threaded into the outer end of the bonnet, and a cap 58 is releasably secured about said outer end and over a part 59 for actuating the screw.

Obviously, if desired, each pair of engaging rams may be operated simultaneously or relative to one another. However, for reasons apparent from the foregoing description, it is essential that each pair of engaging rams be operable independently of the other pair.

As previously mentioned, the apparatus shown in Fig. 5 is provided for use in triple zone completions, and comprises a tubing head 60 having a bore 61 therethrough which, when the head is assembled in a well head installation in the manner described with respect to the apparatus of Figs. 1 to 4, is adapted to be in substantial axial alignment with the bore of the casing head of such installation and of a diameter at least as large as the inner diameter of the inner casing of such installation. Mounted in side-by-side relation within each of guideways 62 intersecting the bore are a plurality of rams 63. As distinguished from the apparatus of Figs. 1 to 4, there are three guideways 62 which intersect one another at angles of 120 degrees. Each of the rams 63 is movable between a position in which its inner end 64 is retracted from the bore (see the two leftmost rams of Fig. 5) and another position in which said end is extended across the bore for engagement with the inner end of a ram extending from another guideway (see the remaining rams of Fig. 5). Registering recesses 65 are formed on the inner end 64 of each pair of engageable rams to form an opening for fitting about a tubing string disposed vertically within the bore, such as the strings 66 and 66a of Fig. 5. As indicated by broken lines, a third string 66b may be inserted into the bore of the tubing head in position for suspension by the retracted pair of rams.

As can be seen from Fig. 5, with the leftmost pair of rams retracted from the bore, one-third thereof is open so that gas lift valves or the like on the string 66b are easily passed therethrough as said string is run into the well for suspension in side-by-side relation with the strings 66 and 66a. Of course, when all of the rams are retracted, the space through the bore 61 of the tubing head is full opening so as to accommodate the passage of packers or the like.

In view of the above described arrangement of the guideways 62, it will be understood that the inner end 64 of each of the rams will, as distinguished from the inner end 27 of each of the rams 26, be disposed in a plane forming an angle of 30 degrees with a plane perpendicular to the longitudinal axis of the ram. In other respects, however, it is contemplated that the construction of the rams 63 may be similar to that of the rams 26 so that further description thereof is unnecessary. Thus, for example, each ram 63 may be provided with a sealing strip 67 so arranged thereon as to seal with respect to the strings about which they are fitted as well as with respect to one another and the guideways when said rams are in

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extended position across the bore. Thus, as in the case of the apparatus of Figs. 1 to 4, these rams enable the bore to be sealed off as well as providing blowout protection for the last string to be run, such as the string 66b.

It is also contemplated that the rams 63 may be moved between retracted and extended positions by apparatus similar to that employed in connection with the rams 26. Thus, as shown in Fig. 5, each of the rams is releasably connected to the inner end of a screw 68 supported within a bonnet 69 bolted as at 70 to the outer end of a guideway. As in the case of the screws 49 of the apparatus of Figs. 1 to 4, each of the screws 68 is threadedly connected, as at 71, to a bonnet 69 for movement longitudinally of the guideway for moving the ram to which it is releasably connected between retracted and extended positions. As indicated in broken lines, this releasable connection comprises an enlargement 72 on the inner end of each ram removably received within a slot (not shown) in the ram body.

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

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

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

The invention having been described, what is claimed is:

1. Apparatus for use in suspending a plurality of tubing strings in side-by-side relation within a well, comprising a well head member having a bore therethrough to receive the strings and guideways therein intersecting the bore, a plurality of rams mounted in side-by-side relation within each of said guideways, and means for moving the rams in each guideway independently of one another and between a position in which the inner end of each is retracted from the bore and another position in which said end is extended into the bore for engagement with the inner end of a ram extended from another guideway, each pair of engageable rams having registering recesses formed on the inner ends thereof for fitting about a different one of said tubing strings.

2. Apparatus of the character defined in claim 1, including means for sealing between the tubing strings and said well head member when all of said rams are extended into the bore therethrough for fitting about said tubing strings.

3. Apparatus of the character defined in claim 1, wherein said rams are slidable within the guideways and with respect to one another, and each ram is provided with a strip of flowable material thereon including a portion across its inner end and extending transversely of the recess therein for sealing with a tubing string about which it is fitted as well as a portion of a strip across the inner end of the ram with which it engages, said strip also including portions extending from said first-mentioned portion along both sides of the ram and laterally thereacross to seal with the guideway in the extended position thereof.

4. Apparatus of the character defined in claim 1, including cooperable parts on the rams and guideways preventing rotation of the rams during movement longitudinally within the guideways.

5. Apparatus for use in completing a multiple zone well, comprising a tubing head connected above a casing head and having a bore therethrough, guideways in the tubing head intersecting the bore, a plurality of rams mounted in side-by-side relation within each of said guideways, each ram extending into the bore to en-

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gage at its inner end with the inner end of a ram extending from another guideway and having a recess on its inner end registering with a recess on the inner end of said last-mentioned ram to form an opening therebetween, a plurality of tubing strings extending vertically within the bore, each string being received within an opening and having a pair of spaced collars thereon to limit upward and downward movement within said opening, and means for retracting each of said rams out of the bore.

6. Apparatus of the character defined in claim 5, including means on said rams sealing between said strings and said tubing head.

7. A ram, comprising a rigid body of substantially semi-cylindrical shape having a flat side opposite a curved side and a recess formed in one end thereof and disposed parallel to its flat side, and a strip of flowable sealing ma-

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terial on the body, said strip including a first laterally extending portion across the end of the body transversely of the recess and a second laterally extending portion about the curved and flat sides of the body and spaced from said end of the body, and longitudinally extending portions on the flat and curved sides of the body connecting said laterally extending portions.

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