July 7, 1953 C. C. BROWN 2,644,523

METHOD AND APPARATUS FOR CONNECTING WELL CASINGS TO LINERS

Filed March 12, 1949 2 Sheets-Sheet 1

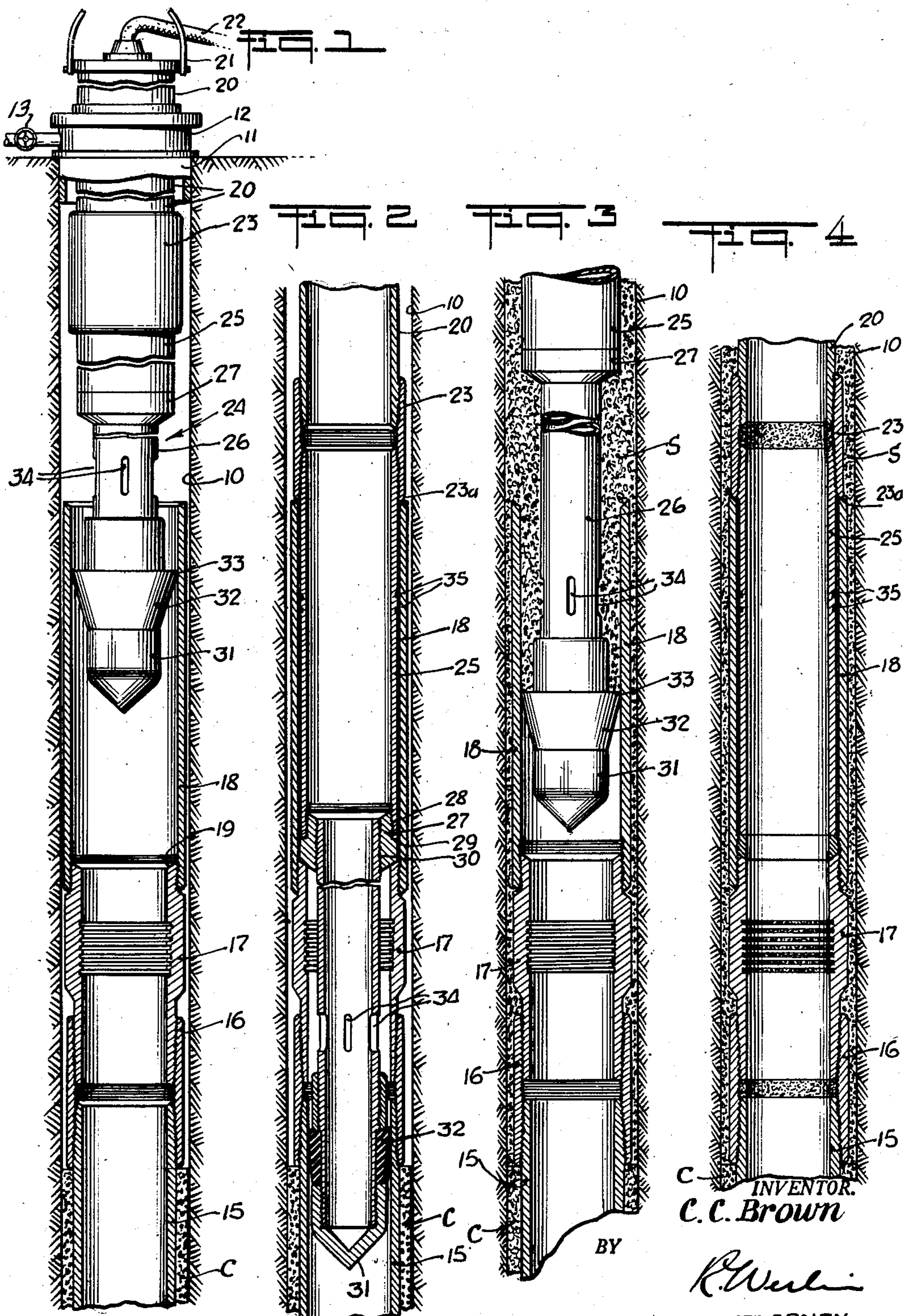

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FIG. 5

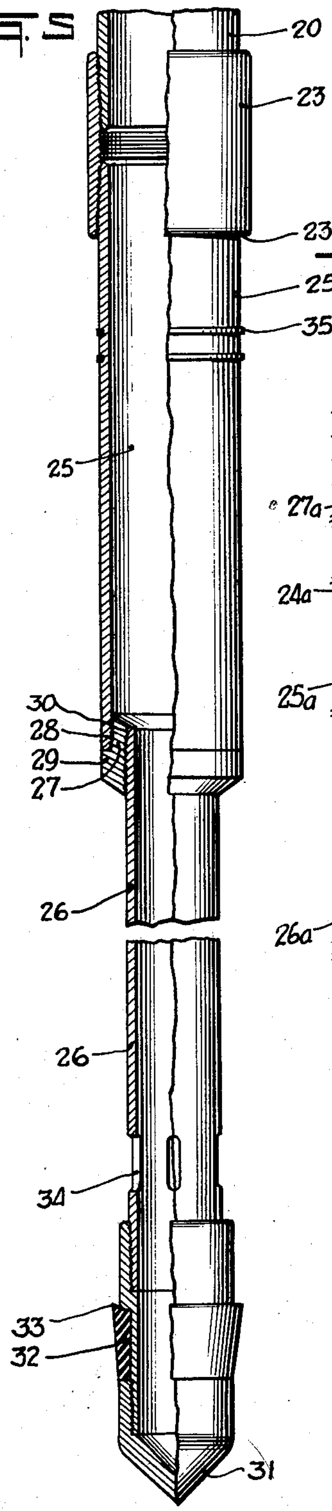


FIG. 6

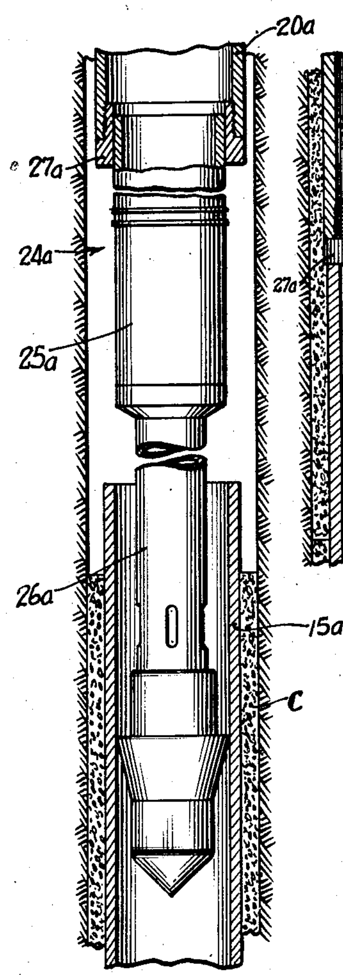


FIG. 7

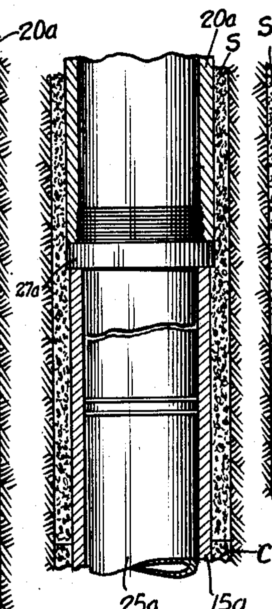
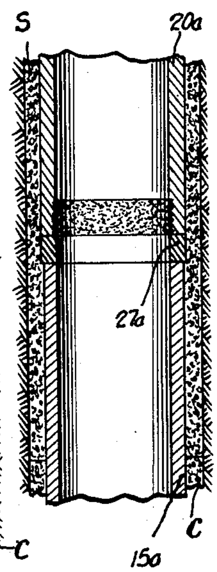


FIG. 8



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METHOD AND APPARATUS FOR CONNECTING WELL CASINGS TO LINERS

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4 Claims. (Cl. 166—1)

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This invention relates to a method and apparatus for connecting well casings to liners.

In the drilling and completion of wells by the rotary method, the well bore is normally drilled to a selected depth without lining the bore with a metal casing, except for the usual surface pipe, the drilling fluid being employed to form a plastic lining to support the wall of the bore during the drilling. When a formation is encountered which it is desired to test for production possibilities, various conventional methods may be employed to prepare the portion of the well bore traversing that formation for testing the latter. In accordance with one of the more common of these methods, a string of casing of sufficient length to extend all the way from the surface to or through the formation to be tested is set in the well and cemented therein by conventional methods. One of the several types of production tests is then made of the formation and, if found productive, the casing is left in the well and the well is equipped in the usual manner for production. However, if the formation is found to be non-productive, a quite frequent occurrence, it then becomes necessary to cut the casing at some point above the cemented portion and withdraw it from the well in order to salvage it. This generally results in the loss of a substantial section of the casing and in considerable expense of cutting and salvaging the severed portion.

In accordance with another generally conventional method, a relatively short section of casing, commonly termed a "liner," is run into the well bore and cemented at an appropriate depth in the well. Such liners may be of variable length, but being in every case less than the full length of the well bore. Such liners are run into the well bore on a releasable liner setting tool which is released from the liner and withdrawn from the well, leaving the liner in place for subsequent testing of the surrounding formations. If the latter prove to be dry or commercially non-productive, the liner may be left in the well and abandoned. This type of testing is favored because of the saving in casing and other costs if the well is found to be unproductive. On the other hand, if the formations are found to be productive, then a full string of casing must be set in the well. Because the liner is already in place and cemented, it has heretofore been deemed necessary to set the production string through the liner and cement it in place, after which both the casing and liner and the surrounding and intervening cement bodies must be perforated to provide communication between the formation and the interior of the casing string. This operation necessarily requires the use of a casing string of smaller diameter than the liner, which undesirably restricts the diameter of the well, and requires the use of an extra length of casing which substantially duplicates the length of the previously set liner.

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The present invention is directed to, and has for its principal object, the provision of a method and apparatus by which a casing may be connected directly to the upper end of a pre-set liner so as to form the liner and casing into one continuous string which may be of uniform internal diameter from top to bottom of the well. By means of this invention, the advantage of the use of relatively short liners for testing purposes is retained and when production is found, a full diameter casing may then be set in the well, and substantial savings in casing and operating costs may be effected.

Still another important advantage of this invention is that since the production casing does not have to be set inside and through the liner, the expense and difficulties of re-cementing between the liner and casing and re-perforating both strings to bring the well into production is avoided.

Various other objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate useful embodiments in accordance with this invention.

In the drawings:

Figs. 1, 2, 3, and 4 illustrate apparatus used in performing the method, in accordance with one embodiment of this invention, for connecting a casing to a liner, the several figures illustrating several stages of operation;

Fig. 5 is a longitudinal quarter-sectional view of the aligning or guide member employed in effecting the connection between the casing and a liner; and

Figs. 6, 7 and 8 illustrate a slightly modified form of apparatus, showing relative positions thereof at several stages of operation.

Referring first to Fig. 1, there is shown a well bore **10**, provided with the usual surface casing **11**, fitted at its upper end with a conventional well head **12**, having a valved outlet connection **13** communicating therethrough with the well bore. A liner **15** is shown installed in the well bore at some previously determined depth, the liner being cemented in place by a body of cement C filling the annular space between the liner and the wall of the well bore to a suitable height along the exterior of the liner. These liners may ordinarily vary in length from less than 100 feet to even several thousand feet but, in any event, are shorter than the full length of the well bore, as previously noted. It will be understood that liner 15 will previously have been put in place and cemented in accordance with conventional procedures. The bore of the liner will have been cleared of cement preparatory to testing of the surrounding formations and may be filled with well fluid, drilling mud or other fluid at the time of initiation of the operations which are to be performed in accordance with the method of this invention.

The upper end of liner 15 will ordinarily be fitted with the usual screw collar 16 to which is connected a conventional liner setting sleeve 17 having a tubular skirt 18 screwed down over its upper end. Liner setting sleeve 17 and skirt 18 are parts which are conventionally employed for releasably connecting a conventional setting tool (not shown) employed in setting the liner in the well and will normally remain in the well when the setting tool has been withdrawn following cementing of the liner. In accordance with usual practice, the bore of setting sleeve 17 will have the same diameter as that of liner 15 so as to be flush therewith. Skirt 18 will ordinarily have a bore of somewhat larger diameter than that of sleeve 17 and liner 15 and the upper end of sleeve 17 will be inserted into the bore of skirt 18 and threadedly connected thereto, as illustrated. The upper end of sleeve 17 will thus form an internal shoulder 19 in the bore of skirt 18 which may be employed in the subsequent casing-connecting operations, but is not essential thereto, as will be evident from the subsequent description. For the purposes of this description, liner 15, setting sleeve 17 and skirt 18 is termed the "liner string."

A string of casing 20 is shown inserted into well bore 10 through well head 12 and connected at its upper end to the usual hollow swivel 21 adapted to be suspended from the conventional hoisting mechanism of a derrick (not shown), whereby the casing string may be raised or lowered in the well bore, as required. Swivel 21 is provided with a hose connection 22 through which cement slurry, drilling mud, or other fluid may be introduced into the interior of casing 20 by means of conventional slush pumps (not shown).

Casing 20 will preferably, although not necessarily, be of the same internal and external diameter as liner 15 and will ordinarily be provided at its lower end with the usual screw collar 23, forming an enlargement thereon to provide an abutment 23*a* which is adapted to engage and rest on the upper end of skirt 18 when the casing is lowered into the well bore sufficiently to bring the lower edge of collar 23 into contact with the upper end of the skirt.

Connected to collar 23 and forming an extension of casing 20, is an aligning or guide member, indicated generally by the numeral 24, which is adapted to enter the bore of skirt 18 and effect axial alignment of casing 20 with liner 15. Guide member 24 (see Fig. 5) includes a tubular body 25, externally threaded at its upper end for connection to collar 23. Body 25 will ordinarily have the same external and internal diameters as casing 20 and liner 15, its external diameter being, therefore, slightly smaller than the internal diameter of skirt 18 whereby body 25 will be slidable inside skirt 18 in accordance with the movements of casing 20. Connected to the lower end of body 25 is a tubular extension 26 of substantially smaller external diameter than body 25. Extension 26 may be connected, as shown, to the lower end of body 25 by means of a tubular bushing 27 externally threaded about its upper end at 28 for threaded insertion into the bore of body 25 and provided with a laterally extending flange 29 forming a shoulder against which the lower end of body 25 is seated. The outer diameter of flange 29 is made flush with the exterior of body 25. The bore of bushing 27 is internally threaded at 30 to receive the upper end of extension 26.

The lower end of extension 26 is provided with cap 31 adapted to form a closure for the end of the extension. An annular packer or sealing ring 32, constructed of compressible, resilient material such as rubber or the like, is mounted about the lower end portion of extension 26 and provided with an upwardly and outwardly flaring flexible lip 33 adapted to form a fluid-tight seal for the annular space between the exterior of extension 26 and the bores of liner 15, sleeve 17 and skirt 18, as the case may be, flexible lip 33 being adapted to accommodate the sealing ring to any of the diameters of these elements. A plurality of radial openings 34 is provided in the wall of extension 26 somewhat above sealing ring 32 to provide communication between the bore of extension 26 and the exterior thereof. A pair of axially spaced sealing rings 35 are seated in circumferential grooves in the exterior of body 25 below its point of connection to casing 20 and may be of any suitable or conventional form adapted to form a fluid-tight seal between body 25 and skirt 18 when the former is inserted into the latter.

The above-described apparatus may be employed for connecting casing 20 to liner 15 in the following manner, reference being had particularly to Figs. 1 to 4, inclusive:

Guide member 24 will be connected to the lower end of casing 20 and lowered thereon into well bore 10 as the casing string is made up to the length necessary to extend from the surface to the upper end of the liner string. When the casing string has been made up to the proper length, it will be lowered from the surface sufficiently to cause guide member 24 to enter skirt 18 (Fig. 1). The casing string will then be further lowered until either flange 29 contacts shoulder 19 or abutment 23*a* contacts the upper end of skirt 18, either contact serving to stop the further downward movement of the casing and guide member relative to the liner string (Fig. 2). At this stage of operations, body 25 will be enclosed within skirt 18 and spaced seals will be formed between the exterior of guide member 24 and the adjacent portions of the liner string by means of sealing rings 32 and 35. At this stage of operations, the pumps at the surface will be started pumping a suitable hydraulic fluid, which may be mud, water, or cement slurry, through the interior of casing 20, thence through the registering bores of body 25 and extension 26, the fluid passing out of opening 34 into the annular space between guide member 24 and the bore of the liner string. Since this annular space is sealed at spaced points above and below opening 34 this space will be quickly filled with fluid and back-pressure will promptly develop against the pumps and will be evidenced by stoppage of the pumps or a sharp increase in gauge pressure on the pump discharge. In either event, this back pressure will serve as an indication to the operator that guide member **24** has been properly inserted in the liner string and that the casing string is properly aligned with the liner string. The casing string will then be lifted at the surface a sufficient distance to raise body **25** out of the upper end of skirt **18** and thereby open communication between the guide member and the well bore. It will be understood that the distance which the string should be raised for this purpose, while keeping the lower end of extension **26** and packing ring **32** within the bore of skirt **18**, may be readily determined from the known length of guide member **24**. This position of the parts of the apparatus is illustrated in Fig. 3. Cement slurry S will now be pumped through the casing string and out openings **34** into the well bore. Cap **31** and sealing ring **32** will prevent entrance of cement or other fluid into the liner thus keeping it clear. The slurry will, of course, fill the annular space between extension **26** and skirt **18** above sealing ring **32** and will also fill the annular space between the liner string and the wall of the well bore above the previously placed body of cement C. A sufficient quantity of cement slurry will be thus introduced into the well bore to fill the annular space between the wall of the well bore and the exterior of casing string **20** to the desired height, conventional cementing methods being used for this purpose. When the cement slurry has all been introduced and displaced in the usual manner from the interior of the casing string, the latter will again be lowered until shoulder **23a** again rests on the upper end of skirt **18**, or flange **29** contacts shoulder **19**, as the case may be, this position of the parts of the apparatus again corresponding to that shown in Fig. 2. The cement will now be allowed to harden, thus firmly cementing the casing in the well bore and joining it with the liner string, both by the continuous cement body formed with cement C and by the telescopic connection through member **24**. After the cement has hardened, a conventional drill will be run through the bore of casing **20** and will be employed to drill out cap **31** and all metal parts or cement inside guide member **24** to a diameter which will be flush with the bores of casing **20** and liner **15**, as illustrated particularly in Fig. 4. In this illustrative embodiment, it will be evident that the drill will be required to remove only extension **26** and the portion of bushing **27** which extends inwardly from the inner wall of body **25**. It will be understood that the metal parts to be removed will preferably be constructed of easily drillable metal, such as brass, bronze or a suitable aluminum alloy such as are commonly used in the well tool art.

As illustrated in Fig. 4 particularly, it will be seen that when extension **26** has been drilled out, a flush bore will be provided throughout the liner and casing string. The wall of body **25** forms with the enclosing skirt **18** a double walled section which will substantially strengthen the inter-connected portions of the liner and casing strings. Also sealing rings **35** will remain in place between the body **25** and skirt **18** and thereby prevent leakage of fluids between these members from the interior of the casing.

Figs. 6, 7 and 8 illustrate a modification of the connecting apparatus wherein the lower end of a casing **20a** is aligned with the end of a liner **15a** without the intervention of elements such as setting sleeve **17** and skirt **18** of the previously described embodiment. In this instance, a guide member **24a** has the upper end of its body **25a** connected into the end of casing **20a** by means of a bushing **27a**, similar in construction to bushing **27**, which is inserted into the end of casing **20a**, body **25a** being dimensioned to slide inside the bore of liner **15a**. In all other respects the construction of guide member **24a** is identical with guide member **24**. The aligning and connecting operations are also conducted in the same manner as previously described. Fig. 6 shows the guide member partially inserted in liner **15a** at a stage preparatory to the introduction of cement slurry. Fig. 7 shows the casing and liner connected following the introduction of the cement, and Fig. 8 shows the casing and liner connected with the entire guide member **24a** bored out to provide the flush bore through the casing and liner.

In accordance with the foregoing, it will be evident that methods and apparatus are provided for readily connecting well casings to liners which are already in place in a well and to thereby provide a continuous well lining of uniform bore which includes the liner as a part thereof. It will be understood, of course, that casing strings of smaller or larger diameter than the liner may be connected thereto by suitable modification of the inter-connecting parts.

The herein described method and apparatus may be employed to provide full length cemented casings for very deep wells by connecting together a series of liners which are adapted to form a continuous casing of the desired length. By this method, the undesirable high hydrostatic pressures commonly occurring in conventional full string cementing in deep wells may be avoided without the relatively complicated apparatus and procedures of conventional stage cementing.

Various alterations and changes may be made in the details of the illustrative embodiments within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. The method of connecting a well casing to a liner previously installed in a well bore, comprising, lowering a casing into the well bore into axial alignment with said liner and axially spaced from the upper end thereof, sealing the upper end of the bore of said liner against the entrance of fluids, introducing cement slurry into the well bore surrounding the adjacent ends of said liner and casing, lowering said casing into end-abutting engagement with said liner, allowing said cement slurry to harden to form a continuous cement sheath about the engaged ends of said liner and casing, and removing said seal to provide a continuous bore connecting said liner and casing.

2. Apparatus for connecting a well casing to a liner which is in place in a well bore, comprising, an upwardly facing internal annular shoulder in the bore of said liner below the upper end of said liner, a tubular connection member closed at its lower end and connected to the lower end of said casing and insertible into said liner, a downwardly facing external annular shoulder on said connection member intermediate its ends adapted to seat on said internal shoulder, a sealing element mounted on said connection member below said external shoulder and adapted to form

a fluid-tight seal between said member and said liner below said internal shoulder, and openings in the wall of said member between said sealing element and said external shoulder.

3. Apparatus for connecting a well casing to a liner which is in place in a well bore, comprising, an upwardly facing internal annular shoulder in the bore of said liner below the upper end of said liner, a tubular connection member closed at its lower end connected to the lower end of said casing and insertible into said liner, a downwardly facing annular external shoulder on said connection member intermediate its ends adapted to seat on said internal shoulder, a pair of circumferential sealing elements mounted at spaced points along said connection member above and below said external shoulder adapted to form axially spaced fluid-tight seals between said connection member and said liner above and below said internal shoulder, and openings in the wall of said member between the lower one of said sealing elements and said external shoulder.

4. Apparatus for connecting a well casing to a liner which is in place in a well bore, comprising, an upwardly facing internal annular shoulder in the bore of said liner below the upper end of said liner, a tubular connection member connected to the lower end of said casing, said connection member being insertible into said liner and including an upper portion adapted to form a close sliding fit in the bore of said liner and a lower portion of reduced diameter closed at its lower end, the juncture of said portions forming a downwardly facing annular external shoulder adapted to seat on said internal shoulder, circumferential sealing elements mounted on said upper and lower portions of said member adapted to form axially spaced fluid-tight seals between said portions and said liner above and below said internal shoulder, and openings in the wall of said lower portion between the lower one of said sealing elements and said external shoulder.

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