Nov. 6, 1962 C. C. BROWN 3,062,291

PERMANENT-TYPE WELL PACKER

Filed May 11, 1959 3 Sheets-Sheet 1

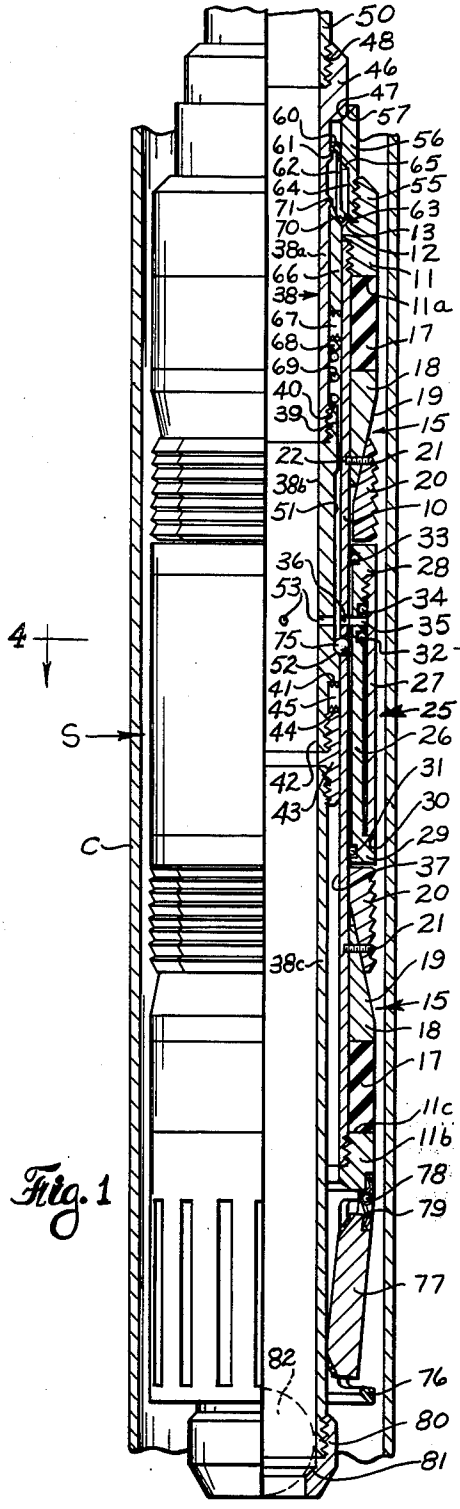

Fig. 1

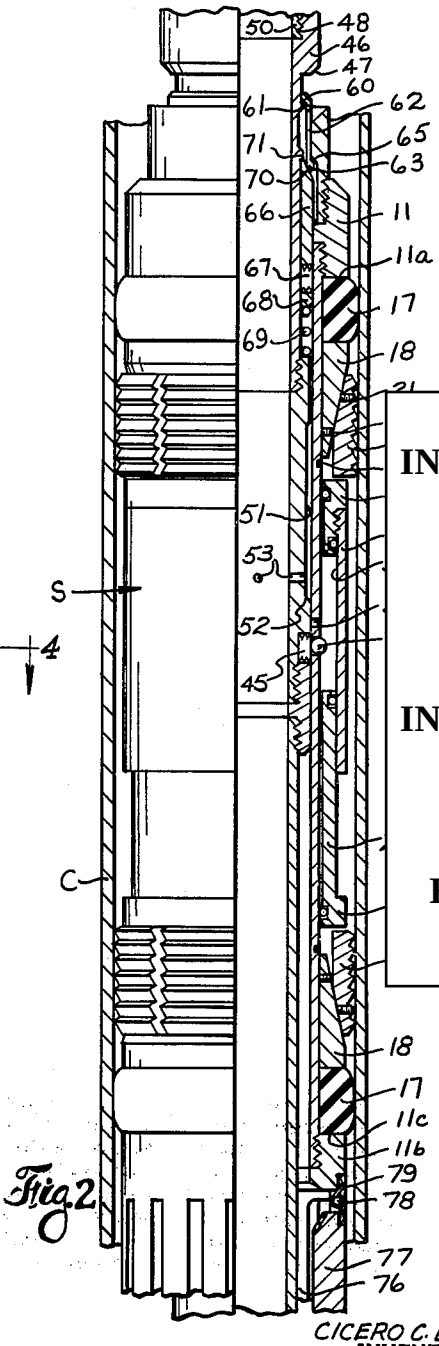

Fig. 2

CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

WEATHERFORD INTERNATIONAL, LLC, et al.

EXHIBIT 1016

WEATHERFORD INTERNATIONAL, LLC, et al.
v.
PACKERS PLUS ENERGY SERVICES, INC.

Nov. 6, 1962 C. C. BROWN 3,062,291

PERMANENT-TYPE WELL PACKER

Filed May 11, 1959 3 Sheets-Sheet 2

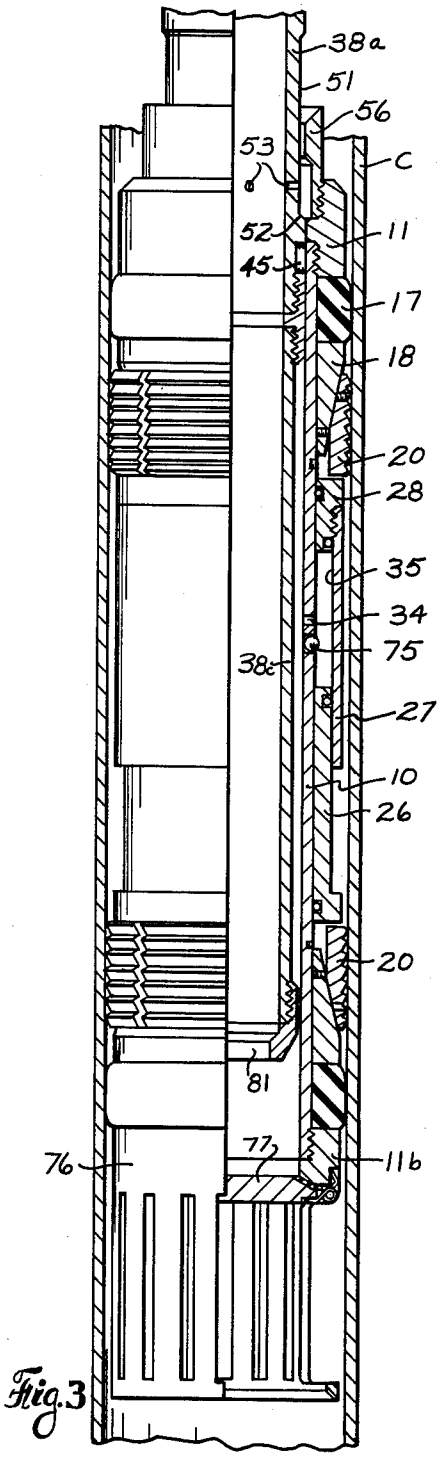

Fig. 3

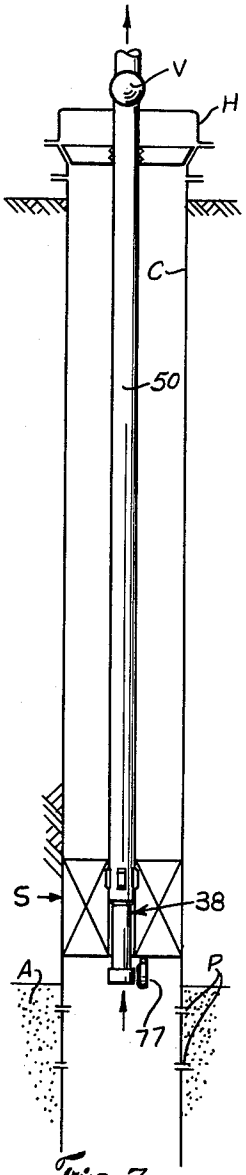

Fig. 7

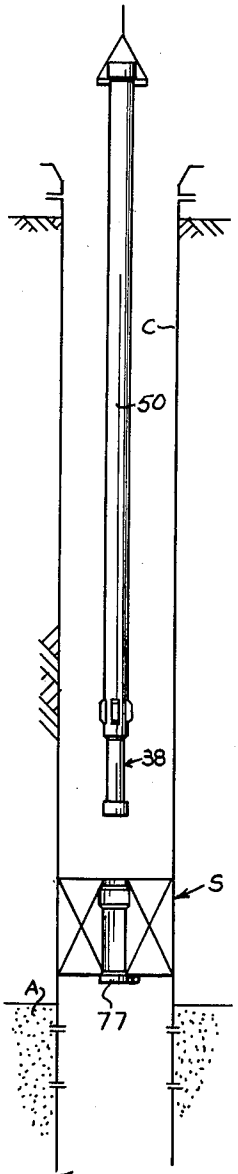

Fig. 8

CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

Nov. 6, 1962 C. C. BROWN 3,062,291

PERMANENT-TYPE WELL PACKER

Filed May 11, 1959 3 Sheets-Sheet 3

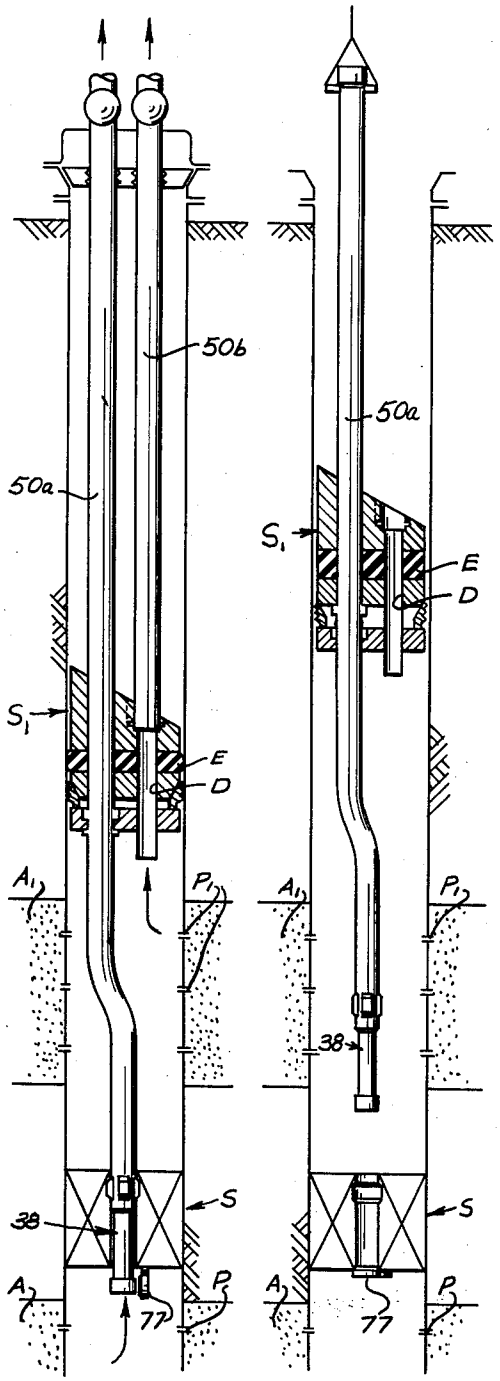

Fig. 9

Fig. 10

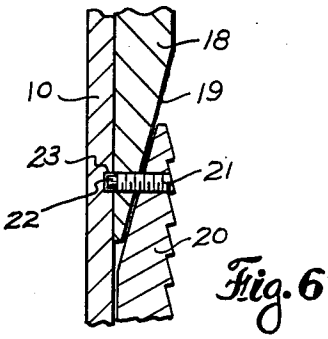

Fig. 6

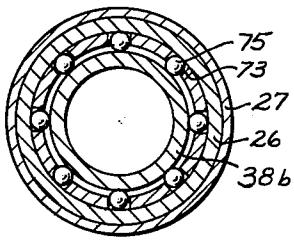

Fig. 4

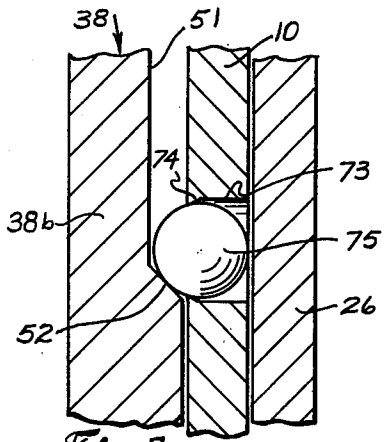

Fig. 5

CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

United States Patent Office

3,062,291
Patented Nov. 6, 1962

3,062,291

PERMANENT-TYPE WELL PACKER

Cicero C. Brown, Houston, Tex., assignor to Brown Oil Tools, Inc., Houston, Tex., a corporation of Texas

Filed May 11, 1959, Ser. No. 812,263
9 Claims. (Cl. 166—119)

This invention relates to well packers and particularly to well packers of the so-called "permanent-type" packers. These packers are designed, when once set in the well, to remain permanently, but are ordinarily constructed of materials such that they may be readily destroyed by drilling tools when necessary or desirable to remove them.

More conventional types of packers of the general character described are designed to be run either on wire line setting strings or on tubing strings. In both cases, however, these conventional packers require that the setting strings and setting tools, whether a wire line or tubing string is employed, must be removed from the well before the string of production tubing is run into the well and connected to the packer. These more conventional types of packers, therefore, require a multiplicity of operations before the well is equipped for production, and in these operations, control of the well is not feasible or as complete as is desirable, particularly when high pressures are present in the formations penetrated by the well bore.

The present invention has for its principal object the provision of a permanent-type drillable packer which overcomes the major disadvantages of existing designs, such as are noted above, in that it may be run on the production tubing string itself, and before any circulation operations or manipulation operations to set the packer, may be placed in final position in the Christmas tree and thereby permit the blowout preventers to be removed. This permits maintaining the well under complete control throughout the subsequent operations of preparing the well for production and setting the packer; that is, the mud materials may be circulated out of the well and the face of the sand or other producing formation washed to the point at which it is ready to flow before the packer is even set. No setting tools are required to be removed and the entire setting operation is greatly simplified and conducted under secure well control conditions.

An important object of the present invention is to provide a form of packer of the type described in which the packer is set hydraulically, thereby minimizing the mechanical manipulations which are frequently troublesome in setting packers.

Another important object resides in the employment of a packer structure having oppositely acting anchor and seal assemblies operable to anchor the structure in the well casing against movement in either direction while sealing with the well casing, and employing a hydraulically-actuated piston and cylinder arrangement for setting the anchor and seal elements of the assemblies.

Still another object is the provision of a hydraulically-actuated packer structure of the type described, having a valve member for closure the bore of the packer structure upon withdrawal of the operating stem in order to prevent back-flow of pressure fluid from below the packer when the operating stem is out of the packer.

A more specific object is the provision of two longitudinally spaced releasable latch mechanisms for releasably securing the operating stem in the packer body and which will prevent premature setting of the packer.

Other and more specific objects and advantages of this invention will become more readily apparent from the

with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIGS. 1 and 2 are longitudinal, partly sectional, views, showing the packer structure positioned in a well casing and illustrating two stages in the operation of the packer;

FIG. 3 is a view generally similar to FIG. 2, but showing the operating stem withdrawn and the back pressure valve in the closed position;

FIG. 4 is a cross-sectional view along line 4—4 of FIG. 1;

FIGS. 5 and 6 are enlarged fragmentary views illustrating some of the details of the packer structure;

FIGS. 7 and 8 are schematic views illustrating the packer employed with a single string of tubing, FIG. 8 showing the tubing string being withdrawn from the packer; and

FIGS. 9 and 10 are schematic views, generally similar to FIGS. 7 and 8, illustrating the present invention employed in conjunction with an additional packer in multiple well completions.

Referring to the drawing, and more particularly to FIGS. 1 and 2, the packer structure S comprises a generally tubular body 10 having its upper end threadedly received in the bore of an upper collar 11 provided with a lip 12 which extends inwardly over the upper end of body 10 and forms a short flush extension thereof. The upper end of lip 12 is chambered to provide a seat 13, for purposes to be described subsequently. The lower end of body 10 is threadedly received in a lower collar 11*b*. Collars 11 and 11*b* define external longitudinally spaced opposed shoulders 11*a* and 11*c*, respectively, about the exterior of body 10 against which are seated a pair of longitudinally spaced upper and lower anchor-and-seal assemblies of identical form, each designated generally by the numeral 15.

Each of the assemblies 15 comprises the following successively arranged elements: an annular resilient seal element 17 constructed of rubber or other flexible resilient composition material abutting shoulders 11*a* and 11*c*; an expander 18 having one end abutting seal element 17 and having a conical surface 19 tapering inwardly toward body 10; a set of wedge-shape pipe-gripping slips 20 which are secured to the expander in longitudinally retracted position by means of a shear screw 21 which extends through registering openings in the adjacent tip portions of slips 20 and expander 18. The inner faces of slips 20 have outwardly tapering surfaces complementing the taper of surface 19. The inner end of shear screw 21 is reduced in diameter to form the end portion 22 which extends into a recess 23 provided in the exterior of body 10 (FIG. 6).

End portions 22 of the shear screws 21 will be dimensioned to have substantially lesser breaking strength than the bodies of shear screws 21. As an example of the relative strengths which will function satisfactorily for the purposes of this invention, portions 22 may be made to have a breaking strength such that it will shear when the pressure in the hydraulic cylinder, to be described later, attains about 1000 lbs. per square inch, while the larger portions of the shear screws will be made to break when said pressure attains about 3000 lbs. per square inch. These values may, of course, be varied depending on the service conditions obtaining in each instance. By this arrangement, it will be seen that shear screw 21 secures the slips 20 to expander 18 against relative movement therebetween and also simultaneously secures both of these elements to body 10, also against movement relative thereto, the slip expander being thereby initially held in retracted or non-setting position. It will be seen that the upper and lower anchor-and-seal

other, are arranged to act in opposite directions so that actuation of the assemblies will anchor the packer structure against movement in either direction when the structure has been set in a well casing, as will be subsequently described.

Positioned concentrically about the exterior of body **10**, between the upper and lower anchor-and-seal assemblies **15**, is an actuating assembly, designated generally by the numeral **25**, which comprises a tubular cylinder **27** concentrically surrounding a piston **26** and secured at its upper end to an annular head **28** forming a closure for the upper end of the cylinder. Cylinder **27** is longitudinally slidable relative to piston **26**. The latter is provided, at its lower end, with an annularly enlarged head **29** defining an upwardly facing annular shoulder **30** forming a limit stop for the lower end of cylinder **27**. The lower end of head **29** abuts against the base of lower slips **20**, while the upper end of head **28** similarly abuts against the base of upper slips **20**. Piston **26** is provided with an internal seal **31** to form a fluid-tight seal between the piston and the exterior of body **10** and is provided, near its upper end, with an external seal **32** to seal between the exterior of the piston and cylinder **27**. Head **28** of the cylinder is similarly provided with an internal seal **33** for sealing between body **10** and head **28** and an external seal **34** for sealing between the head **28** and cylinder **27**. In the fully telescoped position, illustrated in FIG. 1, a space is provided between piston **26** and head **28** defining a piston chamber **35**. One or more radial ports **36** are provided through the wall of body **10** communicating with chamber **35** for admission thereto of pressure fluid, as will be subsequently described.

Body **10** has an axial bore **37** into which extends a tubular operating stem or mandrel, designated generally by the numeral **38**. Mandrel **38** comprises co-axially connected upper, intermediate, and lower sections **38***a*, **38***b* and **38***c*, respectively. The external diameters of upper sections **38***a* is somewhat smaller than that of intermediate section **38***b* and is threaded at its lower end for threaded reception in an internally threaded socket **39** formed in the upper end of intermediate section **38***b*. The larger external diameter of the latter defines an annular upwardly facing shoulder **40** about the lower end of the upper section **38***a*. The lower end of intermediate section **38***b* is reduced in diameter to define the downwardly facing shoulder **41** about the lower end of intermediate section **38***b* and the reduced lower end portion of the latter is externally threaded to form the pin connection **42** for reception in a coupling collar **43**, the lower end of which threadedly receives the upper end of lower mandrel section **38***c* to complete the connections between the mandrel sections. The upper end of collar **43** forms an upwardly facing shoulder **44** spaced from shoulder **41** and a packing **45** is mounted about pin connection **42** in the space between these shoulders for compression therebetween when the pin connection is screwed into collar **43** whereby to cause packing **45** to form a fluid-tight slidable seal between mandrel **38** and body **10**.

At its upper end, upper mandrel section **38***a* is externally enlarged forming the head **46** and defining the downwardly facing external shoulder **47**. Head **46** is provided with the internally threaded socket **48** by which the mandrel **38** may be secured to the lower end of a tubing string **50**. The latter (FIG. 7) extends upwardly through a well casing C and a wellhead H at the surface. A valve V controls flow through the tubing string.

The exterior of intermediate mandrel section **38***b* is reduced somewhat in diameter over a portion of its length to form the annular chamber **51** between intermediate section **38***b* and the interior wall of body **10**. The reduction in diameter of section **38***b* defines at its lower end the downwardly and outwardly tapering annular shoulder **52**. One or more radial ports **53** are provided through the wall of section **38***b* above shoulder **52** to provide fluid ber **51**. It will be seen from the arrangement of these parts that when mandrel **38** is in the fully telescoped position, illustrated in FIG. 1, chamber **51** will be in communication with ports **36** and thence with piston chamber **35**, while the seal formed by packing **45** will be positioned below ports **36** and **53**.

Upper collar **11** is counter-bored above the lip **12** to form the internally threaded socket **55** into which is screwed a short tubular extension **56** having at its upper end the inwardly bevelled seat **57** adapted to be engaged by shoulder **47** when mandrel **38** is fully telescoped into body **10**. Extension **56** forms part of an upper latch mechanism by which the upper end portion of mandrel **38** may be releasably secured to the packer body and which permits the mandrel to be withdrawn from the body, after the packer is set, by application of a straight upward pull to the mandrel. This latch mechanism is disclosed and described in greater detail in my co-pending application Serial No. 756,522, filed August 28, 1958 for a "Coupling Device."

This latch mechanism comprises a ring **60** which is supported on upper mandrel section **38***a* on a narrow ledge **61** spaced a slight distance below shoulder **47**. Ring **60** has formed integrally therewith a plurality of angularly spaced depending fingers **62** of resilient construction and having pawls or dogs **63** on their lower ends which project radially into a counter-bore **64** in the lower end of extension **56**, the upper end of the counter-bore terminates at the downwardly bevelled shoulder **13**. Dogs **63** have their upper and lower ends tapered to complement shoulders **65** and **70**, respectively.

A keeper sleeve **66** is slidably mounted on mandrel section **38***a* between the latter and the upper end of body **10**, the keeper sleeve being positioned above shoulder **40**. A packing **67** is mounted about mandrel section **38***a* below keeper sleeve **66**, and a thrust ring **68** is positioned below packing **67** and urged thereagainst by a coil spring **69** disposed between shoulder **40** and ring **68**. Spring **69** not only compresses packing **67**, thereby forming a slidable seal between mandrel section **38***a* and body **10**, but also urges keeper sleeve **66** upwardly. The upper end of keeper sleeve **66** has a downwardly and outwardly and bevelled end face **70** adapted to engage a similarly sloping end face on dogs **63**, thereby being operable to urge the dogs outwardly into counterbore **64**, and to cause the dogs to engage shoulder **65** when the keeper sleeve moves upwardly to the position shown in FIG. 2, in a manner to be subsequently described. A narrow shoulder **71** limits the upward movement of keeper sleeve **66** on mandrel section **38***a* to prevent keeper sleeve **66** from attaining a point above dogs **63**. The operation of the latch mechanism will be described more fully hereinafter.

Body **10** is provided with a plurality of circumferentially spaced radial openings **73** which are constricted slightly at their outer ends at **74** to define sockets for the reception of ball-shaped latches **75** which project outwardly through the constricted end **74** into engagement with shoulder **52** when the mandrel member is fully telescoped in body **10**, as illustrated in FIGS. 1 and 5. In its fully retracted position, piston member **26** will extend upwardly past ball latches **75**, the clearance between piston **26** and body **10** being such that the outer surface of the piston will hold the balls in engagement with shoulder **52**, thereby providing a latching arrangement by which mandrel **38** cannot be drawn upwardly relative to body **10** while the ball latches are engaged with shoulder **52**. When piston member **26** has moved downwardly in response to hydraulic pressure, as best seen in FIGS. 2 and 3, ball latches **75** will be released for movement outwardly of openings **73** into chamber **35** and when so released, it will be seen that the mandrel may be drawn upwardly relative to body **10**.

Lower collar **11***b* has a longitudinally slotted tubular extension **76** which is commonly termed a "junk pusher"

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