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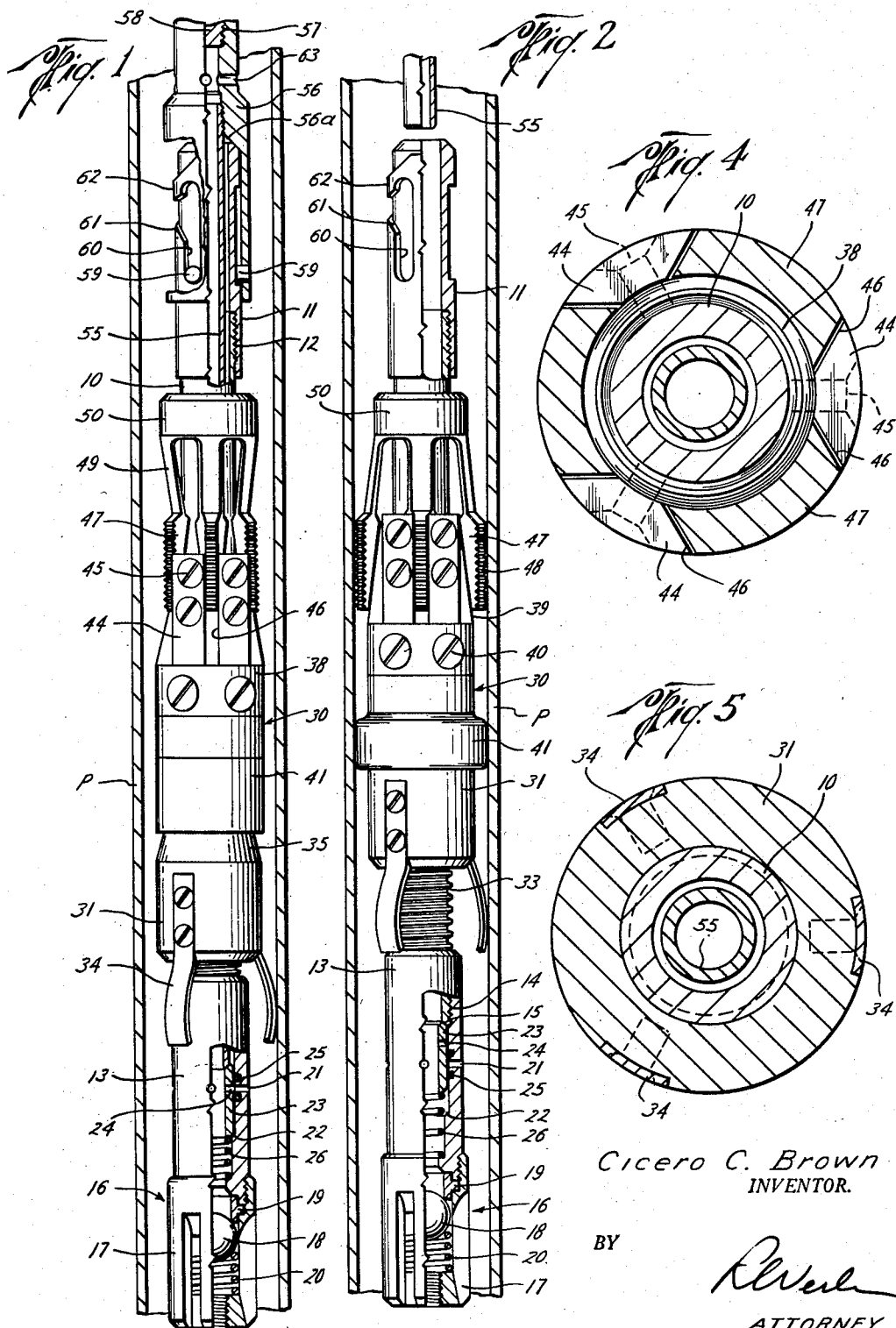
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SAFETY VALVE FOR WELL PIPES

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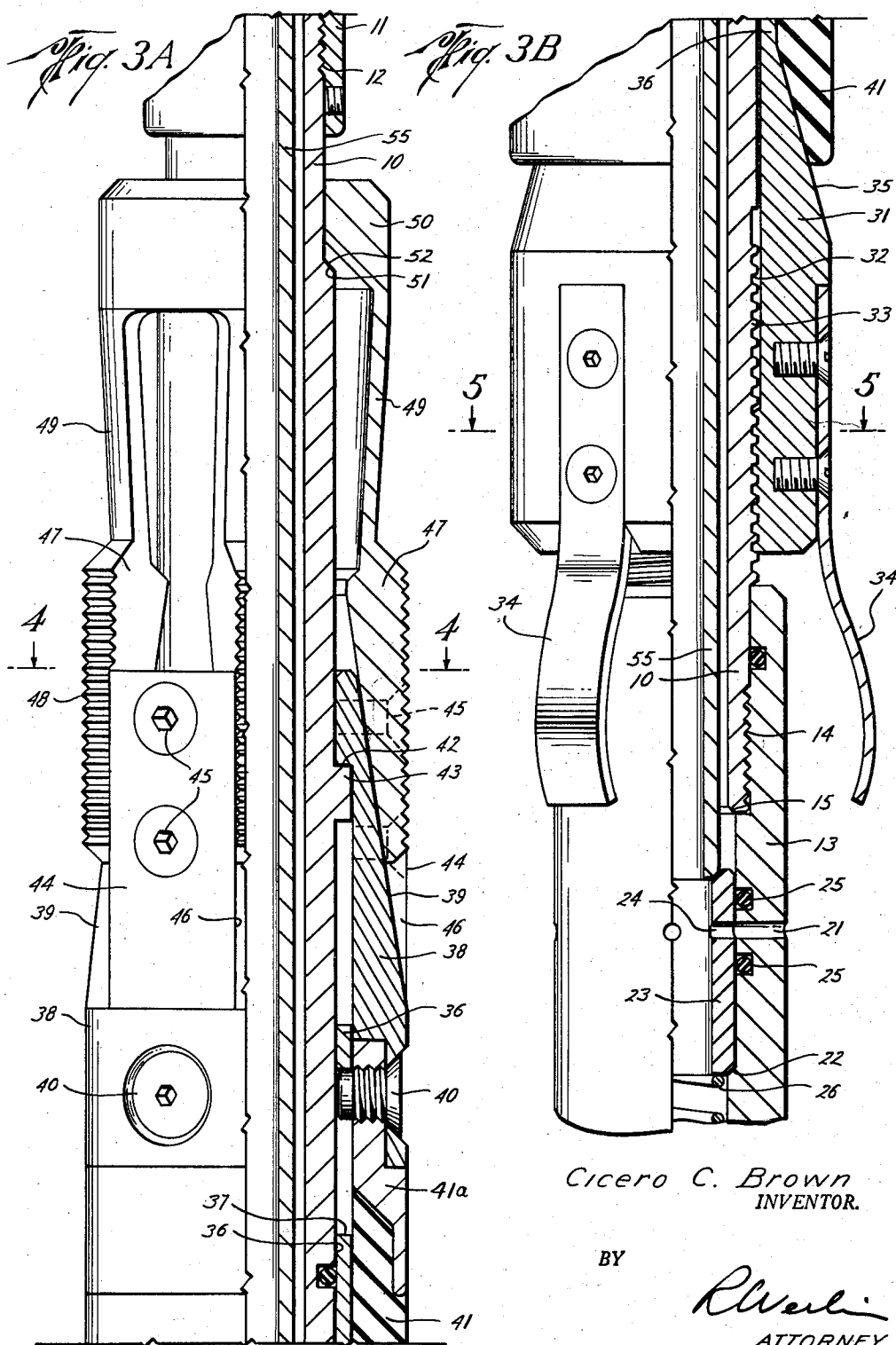
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SAFETY VALVE FOR WELL PIPES

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6 Claims. (Cl. 166—139)

This invention relates to a safety valve for plugging the bore of a pipe such as the tubing of an oil or gas well.

In the operation of oil and gas wells, it is often necessary or desirable to close-off the flow of well fluid through a production pipe string in order to repair or replace the surface or wellhead equipment. In such cases, closure of the production pipe must be effected below the wellhead since the latter ordinarily contains the flow control devices which are necessarily rendered inoperative during repair or replacement of the wellhead equipment.

One common expedient for controlling the flow while the repair work is underway is to "kill" the well by pumping sufficient mud or other hydrostatic fluid into the production pipe string to overbalance the pressure of the well fluids. This method of killing the well has many disadvantages well-known to those experienced in the production of oil and gas and its avoidance is highly desirable.

The present invention has for its primary object the provision of a valve mechanism, termed a "safety valve," which may be inserted into the bore of the production pipe string and releasably anchored therein to effectively plug the bore thereof, and which may be readily removed when it is desired to return the well to production.

Another object is to provide a safety valve which includes a tubular body insertible in a pipe string, said body carrying sealing and anchoring means for anchoring the body to the wall of the pipe string and for forming a fluid-tight seal with the latter, and means for setting and releasing the anchoring and sealing elements of the valve.

A further object is to provide a safety valve of the type described wherein the body is provided with fluid circulation ports controlled by a sleeve valve operable by means of a tubular mandrel removably insertible in the bore of the body.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing illustrative of one useful embodiment of this invention.

In the drawing:

Fig. 1 is an elevational view, partly in section, of the safety valve showing the parts in the inactive position, as when running into a well pipe;

Fig. 2 is a view similar to Fig. 1 showing the parts set in position to plug a well pipe;

Figs. 3A and 3B, together, constitute an enlarged longitudinal quarter-sectional view of the valve with the parts thereof in the positions corresponding to those of Fig. 1;

Fig. 4 is a cross-sectional view taken along line 4—4 of Fig. 3A; and

Fig. 5 is a cross-sectional view taken along line 5—5 of Fig. 3B.

Referring to the drawing, the safety valve comprises a generally tubular body 10 including the tubular head sec-

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tion 11 threadedly connected at 12 to the upper end of the body and the tubular foot section 13 threadedly secured at 14 to the lower end of the body, the latter defining a downwardly facing internal shoulder 15 in the bore of foot section 13 (Figs. 2 and 3B). A downwardly opening check valve, designated generally by the numeral 16, is threadedly secured to the lower end of foot section 13 to normally close the lower end of body 10. Check valve 16 includes a cage 17 containing a ball check valve 18 which is resiliently biased upwardly to the closed position on a valve seat 19 by means of a coil spring 20 mounted in cage 17 below the ball valve, as best seen in Figs. 1 and 2. Check valve 18 thereby serves to prevent upward flow of fluid into body 10 while permitting downward flow therethrough.

Foot section 13 is provided at a point below shoulder 15 with a plurality of circumferentially spaced radial ports 21 providing communication between the interior and exterior of the foot section, to serve as fluid circulation or equalizing ports for the valve body. An upwardly facing internal shoulder 22 is provided in the bore of foot section 13 below the ports 21. A sleeve valve 23 is slidably mounted in the bore of foot section 13 between shoulders 15 and 22 which serve as limit stops for the sleeve valve whose length is less than the spacing between the shoulders. Sleeve valve 23 is provided with one or more radial passages 24 which are positioned in the sleeve valve so as to register with ports 21 when the sleeve valve is moved downwardly to the position where its lower end is seated against shoulder 22 and which will be out of registration with ports 21 when the sleeve valve is moved to its uppermost position engaging shoulder 15. When ports 21 and passages 24 are out of registration, fluid communication between the interior and exterior of body 10 through ports 21 will be cut off. Annular seal rings 25—25 are positioned in the wall of section 13 above and below the ring of ports 21 to form fluid-tight seals slidably engaged with the outer surface of sleeve valve 23. A coil spring 26 is mounted in the bore of foot section 13 below sleeve valve 23 to resiliently urge the latter upwardly against shoulder 15 whereby to resiliently bias the sleeve valve to the position closing ports 21.

An anchoring and sealing assembly, designated generally by the numeral 30, is mounted for longitudinal movement on body 10 between head and foot sections 11 and 13. Assembly 30 includes a lower expander member 31, internally threaded at 32 to threadedly engage a section of complementary external threads 33 provided on the lower end portion of body 10 just above foot section 13, whereby relative rotation between expander member 31 and body 10 will produce relative longitudinal movement between these parts.

A plurality of angularly spaced, outwardly-bowed drag springs 34 are mounted on the exterior of lower expander member 31 to frictionally engage the wall of a surrounding pipe in which the valve is installed. The upper portion of expander member 31 is provided with an upwardly and inwardly tapering, generally conical expander surface 35 which terminates at its upper end in an upwardly extending tubular extension 36 slidably surrounding body 10 and provided near its upper end portion with a plurality (one shown) of elongate closed-end slots 37 (Fig. 3A).

An upper expander member 38 is slidably mounted on body 10 above lower expander member 31, and its upper end portion is upwardly and inwardly tapered to form the conical expander surface 39. The lower end portion of upper expander member 38 is telescoped over extension 36 and is secured thereto by means of threaded pins 40 which are screwed through the wall of upper expander member 38 to project radially into slots 37,

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thereby permitting relative longitudinal movement between the upper and lower expander members, the extent of this relative movement being limited by the length of slots 37, while preventing relative rotation between the upper and lower expander members.

A flexible resilient sealing sleeve 41 has its upper end secured to a metal end ring 41a which is secured to the lower end of upper expansion member 38 by means of the pins 40. Sleeve 41 extends downwardly about extension 36 and about the upper portion of expander surface 35, being thereby positioned to be radially expanded by longitudinal movement of sealing sleeve 41 and expander surface 35 toward each other.

The bore of upper expander member 38 is reduced near its upper end (see Fig. 3A) to provide a downwardly facing internal shoulder 42 abutable against an annular shoulder 43 formed on the exterior of body 10 whereby to limit downward movement of upper expander member 38 on body 10. A series of elongate separators 44 are secured in angularly spaced apart relation to the exterior of expander surface 39 by means of screws 45 to provide between them guide slots 46 of dove-tail configuration adapted to slidably receive slips 47 having external teeth 48 adapted for gripping a surrounding pipe, the cross-sectional configuration of the slips complementing that of guide slots 46 (Fig. 4), to hold the slips in place on expander surface 39. The inner faces of the slips are tapered to complement the taper of expander surface 39 and it will be understood that relative longitudinal movement between the slips and expander surface 39 will effect radial expansion and contraction of the slips. Slips 47 are carried by the lower ends of arms 49 which depend from a collar 50 slidably mounted on the upper portion of body 10 between head section 11 and an upwardly facing external shoulder 51 provided on body 10 a short distance below head section 11, as best seen in Fig. 3A, collar 50 having an internal downwardly facing shoulder 52 abutable with shoulder 51 to limit downward movement of collar 50 on body 10, while the lower end of head section 11 forms an upper stop or abutment to limit upward movement of collar 50 on body 10.

Collar 50, arms 49 and slips 47, which are constructed of steel, are preferably integrally formed so that arms 49 form comparatively resilient connections between the slips and the supporting collar. By this construction the natural resilience of arms 49 will permit the slips to be radially expanded and will automatically retract them when the expansive force on the slips is withdrawn, as illustrated in Figs. 1 and 2.

A tubular "stinger" or mandrel 55 is employed in setting, releasing and retrieving the valve, and is adapted to be removably inserted in the bore of body 10. The stinger will have such a length that when fully inserted in body 10 its lower end will engage the upper end of sleeve valve 23 and push the latter downwardly against shoulder 22 to place passages 24 in communication with ports 21. The upper end of stinger 55 is threadedly connected to a tubular cap 56 which extends downwardly about the outside of the upper end of the stinger in circumferentially spaced relation thereto to provide an annular space 56a in which the upper end of upper section 11 may be telescopically received (Fig. 1). The upper end of cap 56 is internally threaded to provide a socket 57 for attachment to an operating rod string 58 by which the stinger and the valve structure may be inserted, withdrawn and otherwise manipulated with respect to the pipe in which the valve is to be used. Cap 56 carries near its lower end internally projecting lugs 59 which are adapted to cooperate with bayonet or J-slots provided on the exterior of upper body section 11 (Figs. 1 and 2). By this arrangement, the upper portion of the stinger may be locked to upper body section 11. These J-slots include the vertical legs 60, the upper portions of which communicate with the laterally extending legs 61, the latter, in turn, opening to the upper end of body

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section 11 through conventional J-slot passages (not shown) but defined by side edge 62. With the described construction of the J-slots and cooperating lugs, it will be seen that the stinger may be inserted into and withdrawn from the bore of body 10, and when lugs 59 are seated in the lower portions of vertical legs 60, the stinger may be employed to rotate or otherwise manipulate the parts of the valve structure. Upper circulation ports 63 are provided through the wall of cap 56 at points between the lower end of operating rod 58 and the upper end of stinger 55.

The safety valve, above described, is operated in the following manner: The structure is assembled with the parts in the position shown in Figs. 1, 3A and 3B in which it will be seen stinger 55 is inserted into the bore of body 10 and locked into the J-slot on upper body section 11. In this position, stinger 55 will hold sleeve valve 23 in the downward position, opening the circulation ports between the exterior of the valve and the bore thereof. The anchor and seal assembly 30 will be screwed down on threads 33 to a position such that the sealing sleeve 41 and slips 47 are in retracted positions. The threaded engagement of lower expander member 31 with body 10 will hold the parts in their relatively inactive position until appropriate rotation of the threadedly engaged parts is effected. The upper end of cap 56 will then be secured to the end of operating rod 58 and the string of tools carried on the operating rod will be inserted into the well production pipe P, which may be the well tubing. The valve structure, ordinarily, will be inserted through a conventional stuffing box mounted on the wellhead (not shown) in order to insert the structure into the well pipe while the latter is under well pressure. By means of the operating rod, the valve structure will be positioned a short distance below the wellhead, as it will ordinarily be unnecessary to run the valve to any great depth in the pipe. The form and operation of stuffing boxes or lubricators commonly used for running tools into and out of wells while under pressure are well understood by those skilled in petroleum production and are not, therefore, illustrated or described in detail herein.

As the valve structure is run into the well pipe, any fluid in the pipe will be displaced through circulation ports 21 and 24 and thence upwardly through the bore of the stinger 55 and will discharge therefrom through the ports 63.

When the valve has been inserted to the desired position in the well pipe, the operating rod will be rotated in a direction to rotate body 10 relative to the anchor and seal assembly 30, the latter being held relatively stationary by the frictional engagement of drag springs 34 with the wall of the well pipe. This rotation of the operating rod will be transmitted to body 10 through the interlocked engagement of lugs 59 with the lower end portions of legs 60 of the J-slots. This relative rotation will cause upward movement of lower expander member 31 on body 10 relative to sealing sleeve 41. Conical surface 35 will act against sleeve 41, urging the latter in the upward direction which will, of course, apply upward thrust on upper expander member 38, which will thereby be moved upwardly along body 10 forcing slips 47 outwardly until they engage the wall of pipe P. When this occurs, further upward movement of upper expander member 38 will be stopped and the further upper movement of lower expander member 31 will act to expand sleeve 41, this additional upward movement of lower expander member 31 relative to sleeve 41 being permitted by the slidable connection formed by means of pins 40 and slots 37. As rotation of body 10 continues, sleeve 41 will be urged into tight sealing engagement with the wall of pipe P, while the slips 47 become even more tightly set in the pipe wall to thereby effectively anchor the valve structure in the pipe.

When the valve structure has thus been effectively

anchored and sealed in the bore of pipe P, the operating rod is withdrawn sufficiently to place lugs 59 in registration with legs 61 of the J-slots and then turned in a direction to permit the lugs 59 to be withdrawn from the J-slots through openings 62. Whereupon the stinger may be withdrawn from the bore of body 10 releasing sleeve valve 23, which will then be moved upwardly by the thrust of spring 26 to the position at which passages 24 will be out of registration with ports 21, thereby closing the circulation passages between the exterior and interior of the valve structure.

Check valve 16 will form the desired closure at the lower end of the valve structure to prevent escape of fluid from pipe P through the valve structure when it has been set as described. When the stinger has been withdrawn from the valve structure, it will be withdrawn by means of the operating rod through the lubricator and removed completely from the wellhead. The production pipe now being plugged by means of the above described valve, the wellhead fittings may be removed or replaced, or otherwise worked-over, while the well remains entirely under control by reason of the plugging function of the described valve.

When the work on the wellhead structure has been completed and it is desired to remove the valve structure, the operating rod carrying the stinger will be re-inserted through the lubricator and wellhead and stinger 55 will be re-inserted in the bore of body 10 and the J-connection between cap 56 and the body reengaged. Thereupon by rotating the operating rod in the direction opposite that employed to set the valve structure, relative movement between body 10 and the sealing and anchoring assembly will be produced, which will retract the lower and upper expander members 31 and 38, respectively, which will, in turn, cause sealing sleeve 41 and slips 47 to be retracted to their inactive positions. At the same time, of course, the re-insertion of stinger 55 will re-open the circulation ports and when the slips have been retracted, the valve structure may be withdrawn bodily through the wellhead and the lubricator, and the well will then be returned to control by the usual wellhead fittings.

With the valve structure, as above described, it will be seen that a highly effective, readily insertible and removable plugging device is provided to close in a production pipe which is under well pressure, without having to "kill" the well with mud or heavy fluid as is more conventional practice. It will be evident that the plugging structure may be employed to plug a well pipe at any desired depth.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiment 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. A safety valve for pipe strings, comprising, a tubular body insertible in the bore of a pipe string, means closing the lower end of the body, and a seal-and-anchor assembly mounted about the exterior of the body including radially movable anchor elements, a resilient seal element and having an expander portion threadably connected to the body operable by relative rotation of said body for expanding said anchor elements to secure the body to the wall of the pipe string and to expand said seal element in fluid-tight engagement therewith, said seal-and-anchor assembly including means frictionally engageable with the wall of said pipe string to hold said assembly stationary therein while permitting said relative rotation of said body, said body having fluid passages through the wall thereof below said assembly, sleeve valve means axially slidable in the bore of the body and having ports therein movable therewith between positions opening and closing said passages, resilient means biasing said sleeve valve means to the passage-closing position, and operating means releasably connectible to said body for

rotating the same, said operating means comprising a tubular mandrel removably extendible into the bore of said body and having releasable connection thereto, the inner end of the inserted mandrel being engageable with said sleeve valve means to maintain the latter in the passage-opening position.

2. A safety valve for pipe strings, comprising, a tubular body insertible in the bore of a pipe string, means closing the lower end of the body, and a seal-and-anchor assembly mounted about the exterior of the body including radially movable anchor elements, a resilient seal element and having an expander portion threadably connected to the body operable by relative rotation of said body for expanding said anchor elements to secure the body to the wall of the pipe string and to expand said seal element in fluid-tight engagement therewith, said seal-and-anchor assembly including means frictionally engageable with the wall of said pipe string to hold said assembly stationary therein while permitting said relative rotation of said body, said body having fluid passages through the wall thereof below said assembly, sleeve valve means axially slidable in the bore of the body and having portions therein movable therewith between positions opening and closing said passages, resilient means biasing said sleeve valve means to the passage-closing position, and operating means releasably connectible to said body for rotating the same, said operating means comprising a tubular mandrel removably extendible into the bore of said body and having releasable connection thereto, the inner end of the inserted mandrel being engageable with said sleeve valve means to maintain the latter in the passage-opening position, and said mandrel having ports through the wall thereof above said assembly.

3. A safety valve for pipe strings, comprising, a tubular body insertible in the bore of a pipe string, means closing the lower end of the body, and a seal-and-anchor assembly mounted about the exterior of the body for securing the body to the wall of the pipe string and in fluid-tight engagement therewith, said assembly comprising upper and lower upwardly tapering conical expanders longitudinally slidable on said body, connection means between the expanders permitting non-rotative limited relative longitudinal movement between them, an annular resilient seal member secured to the lower end of the upper expander and extending into operative expandible relation to said lower expander, a collar member slidably surrounding the body above the upper expander, pipe-gripping slips pendently supported from said collar member in operative relation to said upper expander, longitudinally spaced shoulder means on the body positioned to limit upward and downward movement of the collar member on the body, expander having threaded connection to said body and carrying means for frictionally engaging the surrounding pipe wall, whereby rotation of said body relative to the lower expander will be operative to produce longitudinal movement of both expanders into and out of expansive engagement with the respectively associated slips and seal member in accordance with the direction of said relative rotation, and means releasably connectible to said body for rotating the same.

4. A safety valve for pipe strings, comprising, a tubular body insertible in the bore of a pipe string, means closing the lower end of the body, and a seal-and-anchor assembly mounted about the exterior of the body for securing the body to the wall of the pipe string and in fluid-tight engagement therewith, said assembly comprising upper and lower upwardly tapering conical expanders longitudinally slidable on said body, an annular resilient seal member secured to the lower end of the upper expander and extending into operative expandible relation to said lower expander, a collar member slidably surrounding the body above the upper expander, pipe-gripping slips pendently supported from the collar member in operative relation to said upper expander, longitudinally spaced shoulder means on the body positioned to limit upward

and downward movement of the collar member on the body, expander having threaded connection to said body and carrying means for frictionally engaging the surrounding pipe wall, and connection means between the expanders positioned interiorly of the seal member and arranged to permit non-rotative limited relative longitudinal movement between the expanders, whereby rotation of said body relative to the lower expander is operative to produce longitudinal movement of both expanders into and out of expansive engagement with the respectively associated slips and seal member in accordance with the direction of said relative rotation, and means releasably connectible to said body for rotating the same.

5 5. A safety valve for pipe strings according to claim 4 wherein said means closing the lower end of the body is a downwardly opening check valve.

6. A safety valve for pipe strings, comprising, a tubular body insertible in the bore of a pipe string, means closing the lower end of the body, and a seal-and-anchor assembly mounted about the exterior of the body for securing the body to the wall of the pipe string and in fluid-tight engagement therewith, said assembly comprising upper and lower upwardly tapering conical expanders longitudinally slidable on said body, connection means between the expanders permitting non-rotative limited relative longitudinal movement between them, an annular resilient seal member secured to the lower end of the upper expander and extending into operative expandible relation to said lower expander, pipe gripping slips and support means therefor positioned on the body above the upper expander and in operative relation thereto, lon-

itudinally spaced stop means on the body positioned to limit upward and downward movement of said support means on the body, said lower expander having threaded connection to said body and carrying means for frictionally engaging the surrounding pipe wall, whereby rotation of said body relative to the lower expander will produce longitudinal movement of both expanders into and out of expansive engagement with the respectively associated slips and seal member in accordance with the direction of said relative rotation, circulation passages through the wall of the body above and below said assembly, sleeve valve means slidable in the bore of the body to control the lower passages, spring means resiliently biasing the sleeve valve means to the passage-closing position, and means releasably connectible to said body for rotating the same, said last-mentioned means including a tubular mandrel extendible into the bore of said body into engagement with said sleeve valve means to maintain the sleeve valve means in the passage-opening position.

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