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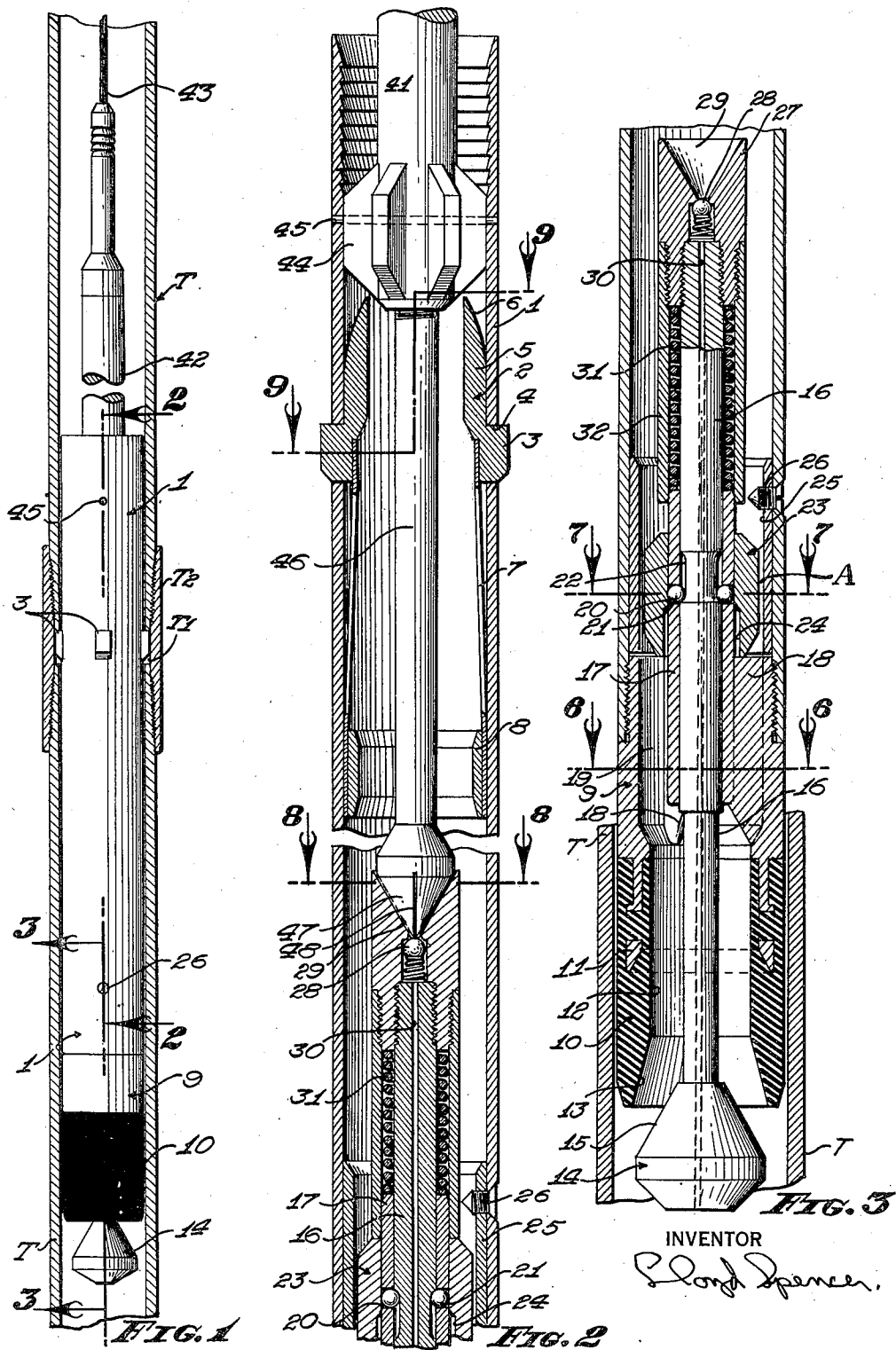
L. SPENCER

2,447,546

AUTOMATIC SHUTOFF APPARATUS FOR OIL WELLS

Filed March 30, 1942

2 Sheets-Sheet 1



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AUTOMATIC SHUTOFF APPARATUS FOR OIL WELLS

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2 Sheets-Sheet 2

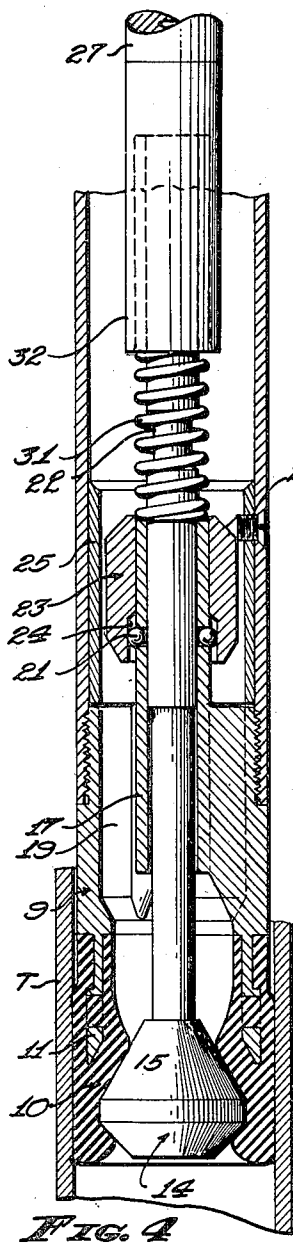


FIG. 4

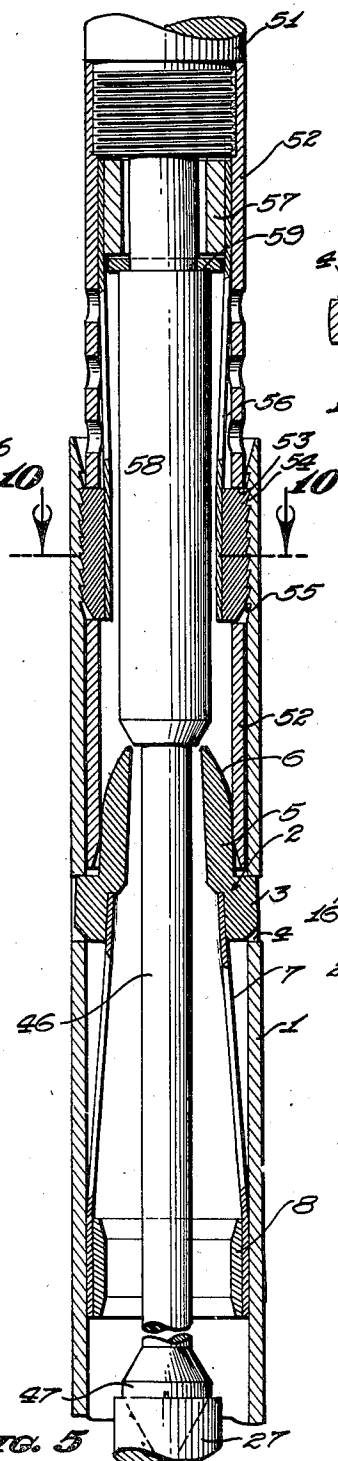


FIG. 5

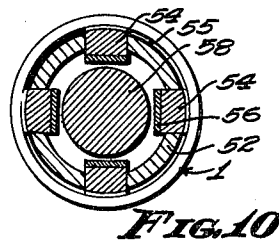


FIG. 10

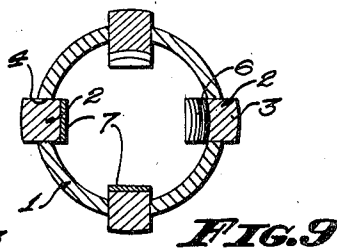


FIG. 9

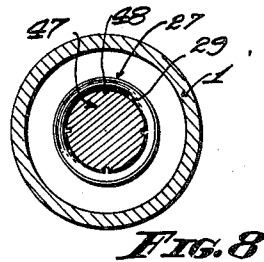


FIG. 8

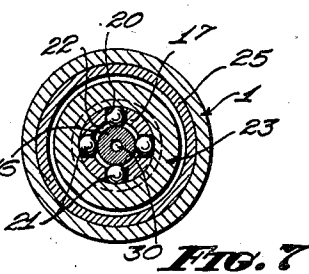


FIG. 7

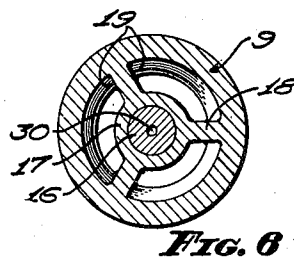


FIG. 6

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UNITED STATES PATENT OFFICE

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AUTOMATIC SHUTOFF APPARATUS FOR OIL WELLS

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14 Claims. (Cl. 166—2)

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My invention relates to automatic shut-off apparatus for oil wells; that is, to apparatus adapted to be placed within the upper portion of a tubing string for the purpose of closing the tubing string in the event the surface connections to the well should be broken. Among the objects of my invention are:

First, to provide an automatic shut-off apparatus for oil wells which may be lowered to position or removed without shutting off production, that is, the well may continue to produce under control while the apparatus is lowered into position and thereby avoid the difficulties sometimes involved in re-establishing production after the production has been shut off or "killed";

Second, to provide an automatic shut-off apparatus which permits a predetermined normal rate of flow from the well but closes when such predetermined rate of flow is exceeded;

Third, to provide a shut-off apparatus which incorporates a novel valve arrangement that simultaneously seals the annular clearance space between the apparatus and the well tubing in addition to the control passage through the apparatus;

Fourth, to provide a shut-off apparatus which incorporates a novel locking means for securing the apparatus in a well tubing by engagement with an internal channel formed by a collar which connects sections of the well tubing;

Fifth, to provide an automatic shut-off apparatus which, after operation, may be readily reopened and reset for further operations or removal; and

Sixth, to provide an automatic shut-off apparatus which is capable of remaining exposed to the flow of well fluids for long periods of time without attention and with the assurance that it will function should the need arise.

With the above and other objects in view, as may appear hereinafter, reference is directed to the accompanying drawings, in which:

Figure 1 is an elevational view of my apparatus as it appears when lowered to position but before removal of the setting tool;

Figure 2 is an enlarged fragmentary longitudinal sectional view through 2—2 of Figure 1 showing the upper portion of the apparatus in the position assumed while being lowered into the well bore and indicating by elevation the setting tool in position;

Figure 3 is an enlarged fragmentary longitudinal sectional view with the lower portion of the apparatus taken through 3—3 of Figure 1 and

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showing the parts in their normal position after the setting tool has been removed;

Figure 4 is a longitudinal sectional view similar to Figure 3 showing the parts in the positions assumed when the apparatus has operated and the valve closed;

Figure 5 is a fragmentary longitudinal sectional view similar to Figure 2 showing, partially by section and partially by elevation, the retrieving tool in engagement with the apparatus;

Figures 6 and 7 are transverse sectional views taken through 6—6 and 7—7, respectively, of Figure 3;

Figures 8 and 9 are transverse sectional views taken through 8—8 and 9—9, respectively, of Figure 2; and

Figure 10 is a transverse sectional view taken through 10—10 of Figure 5.

My automatic shut-off apparatus includes a tubular shell 1 capable of passing through a well tubing designated T. The upper portion of the shell 1 is provided with several retainer bars 2 which have outwardly directed lugs 3 adapted to extend radially through slots 4 provided in the walls of the shell 1. The retainer bars are also provided with upwardly extending tongues 5 having inwardly beveled portions 6 at their upper ends, so that they curve inwardly from the inner walls of the shell 1 to form cam faces engageable by a retrieving tool as described hereinafter for the purpose of moving the lugs 3 inwardly. The retainer bars 2 are connected by reins 7 which extend downwardly within the shell 1 to a band 8 which may float within the shell 1 or be secured thereto as desired. The lugs 3 extend outwardly through their slots 4 and are adapted to ride against the interior of the tubing T and spring outwardly by reason of the reins 7 into annular internal channels T₁ formed by the collars T₂ which connect sections of the tubing string together. The lower sides of the lugs 3 are beveled so that the apparatus may move downwardly in the tubing, but will not permit upward movement of the apparatus. The reins 7 urge the lugs 3 outwardly with sufficient force that the apparatus will not drop down the well bore by its down weight, but must be urged downwardly by additional weight, particularly past the internal channels T₁.

The lower end of the shell 1 is internally threaded to receive the externally threaded upper end of a coupling 9. The lower end of the coupling forms an abutment and an attachment for a packing sleeve 10 which extends axially therefrom. Reinforcing elements 11, which are in-

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tegral with the coupling 9, extend downwardly into the packing sleeve for firmly bonding the sleeve to the coupling. The packing sleeve is formed of rubber, or preferably so-called synthetic rubber, which is impervious to well fluid. The outside diameter of the packing sleeve is as large as possible and yet permit ready downward movement of the sleeve through the tubing. The wall thickness of the packing sleeve is somewhat greater than the shell 1 and is preferably equal to the thickness of the lower end of the coupling 9. The packing sleeve is provided with a bore 12 which communicates with the bore of the coupling 9 to form a flow passage for fluid. The lower end of the bore 12 is preferably flared, or tapered to form a valve seat 13. The packing sleeve 10 is adapted to be closed by a valve member 14 having an upwardly converging conical valve face 15. The valve seat 13 and valve member 14 comprise the elements of a main valve for control or shut-off of fluid flow through the device. The valve member 14 is sufficiently larger than the bore and valve seat of the packing sleeve so that when forced upwardly therein the packing sleeve is expanded outwardly into sealing contact with the surrounding tubing, as shown in Figure 4, so that the valve member not only closes the bore 12 but also effects a seal between the packing sleeve and tubing.

The valve member 14 is provided with a stem 16 which extends upwardly through the packing sleeve 10 and into a supporting structure comprising a guide sleeve 17 centered in the coupling 9 and preferably formed integrally therewith by radiating webs 18 which define therebetween passages 19. The sleeve 17 continues above the upper end of the coupling 9 and is provided with equally spaced key ball holes 20 which receive key balls 21. The stem 16 extends upwardly beyond the sleeve 17 and is provided opposite the key balls 21 with an annular keyway or channel 22. The key balls are adapted to fit into the keyway 22 and bear against the lower shoulder of said keyway to comprise a latching means to prevent upward movement of the stem 16 and its valve member 14. Surrounding the upper portion of the stem 16 and normally resting upon the upper edges of the webs 18 is a keeper ring or latch control sleeve 23. The keeper ring normally covers the key ball holes 20 and prevents outward movement of the key balls from their latched position in key way 22. The lower portion of the keeper ring, however, is counterbored, as indicated by 24, to slightly larger diameter than the sleeve 17 so that upon upward movement of the keeper ring 23, in response to fluid flow as hereinafter more fully described the counterbored portion 24 permits sufficient outward movement of the key balls 21 within the hole 20 to clear the key way recess 22 and thereby release the stem 16. However, the outward movement of the balls 21 permitted by the keeper ring is insufficient to release them from their key holes 20.

Surrounding the keeper ring 23 is a liner 25 fitting the shell 1 and secured thereto by screw-threaded pins 26. These pins may serve also as stops for limiting upward movement of the keeper ring 23 so that the key balls cannot fall out of the key ball holes.

The upper end of the stem 16 is provided with an enlarged head 27 which forms the housing for a small fail check valve 28 which is employed as a pressure equalizer valve as hereinafter described in connection with the operation of the device. The upper end of the head 27 is

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provided with a conical recess 29 which exposes the upper end of the check valve. The check valve controls a passage 30 extending downwardly through the stem 16 and valve member 14. The check valve prevents upward flow of fluid through this passage, but is engageable through the recess 29 to open the passage for the purpose of equalizing the pressure in the tubing above and below the packing sleeve.

Between the head 27 and the upper end of the sleeve 17 there is interposed a coil spring 31 which tends to raise the valve stem and valve member. A skirt 32 is secured to the head 27 and extends downwardly over the spring 31. The lower end of the skirt is so arranged in relation to the keyway 22 that when the spring 31 is compressed by downward force applied on the stem 16 the lower end of the skirt 32 engages the keeper ring. The skirt however is normally clear of the keeper ring to permit the desired upward movement as shown in Figure 3.

Reference is now directed particularly to Figures 1, 2, 8 and 9, in which is illustrated the setting tool employed to position the shut-off apparatus in the well bore. The setting tool includes a mandrel 41 which may form the lower end of a weight bar 42 attached to a cable 43. The mandrel is provided at its lower end with a suitable spacer 44 which fits snugly within the shell 1, but is provided with passages for the flow of fluid through the shell. A shear pin 45 extends through the spacer 44 and into the shell 1. A stem 46 extends downwardly from the mandrel 41 and is provided at its lower end with a conical head 47 adapted to fit in the conical recess 29 of the head 27 and engage the pressure equalizer check valve 28 to hold it open. Suitable bleeder slots 48 are provided in the head 47.

Reference is now directed particularly to Figures 5 and 10: The retrieving tool comprises a body 51 suitably attached to a cable (not shown) and incorporating a weight bar of sufficient mass to provide the necessary downward force, or the body member may be secured to the lower end of a tubing or sucker rod string capable of fitting within the tubing string T. The lower end of the body 51 receives a tubular housing 52 adapted to slip within the shell 1 and engage the tongues 5 of the retainer bars 2, the lower end of the housing bearing against the beveled portions 6 to urge the tongues inwardly and thereby withdraw the lugs 3 from the channel T1. The housing 52 is provided with slots 53 through which extend dogs 54 adapted to engage annular wicker grooves 55 formed within the upper end of the shell 1. The dogs 54 are connected by spring reins 56 to a collar 57 positioned within the housing 52 below the body 51. Attached to the body 51 and extending downwardly through the housing 52 is an extension rod 58 which forms at its upper portion a shoulder 59 arranged to retain loosely the collar 57. The lower end of the extension rod 58 receives the stem 46 and head 47 of the setting tool; the stem and lead being interchangeable between the setting tool and receiving tool.

Operation of my apparatus is as follows: The shell 1 is attached to the setting tool by the shear pin 45. When thus assembled the head 47 engages the head 27, holding the equalizer check valve 28 open and also holding the valve member 14 clear of the packing sleeve 10. The apparatus is then lowered on the cable 43 to the position in the tubing string below the collar in which it is desired to lock the tool. The cable is then

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drawn upwardly carrying the apparatus upward therewith until the lugs 3 snap into the channel T₁ formed by the collar T₂. The device is thus locked in the tubing and further upward tension on the cable shears the pin 45. The setting tool is then removed and the apparatus appears supported in the tubing in the position shown in Figure 3, in which the key balls 21 hold the valve member 14 open.

A predetermined annular clearance space or passage A is formed between the outer surface of keeper ring 23 and the inner surface of the liner 25. The area of this space is so predetermined that as long as the well flows at its normal rate no appreciable pressure differential will develop between the upper and lower ends of the keeper ring. Thus the keeper ring normally stays in the lower position shown in Figure 3 and the valve remains locked in its open position under normal flow conditions. Should the velocity increase materially, as might be the case should the surface connection to the well be broken and the well allowed to run wild, the pressure differential between the extremities of the keeper ring due to the pressure drop through the narrow annular flow passage between the keeper ring and the tubing becomes sufficient to cause the keeper ring to rise and release the key balls 21 from the annular keyway or recess 22 of the stem into the counterbored portion 24 of the keeper ring. The spring 31 thereupon urges the valve member upwardly into initial contact with the valve seat 13 of the packing sleeve 10. As this space is closed a material pressure differential builds up between the upper and lower sides of the valve 14 which jams the valve upwardly as shown in Figure 4, expanding the packing sleeve and thereby completely sealing the bore 12 as well as causing the sleeve to seal against the surrounding tubing.

When it is desired to reset the valve the setting tool, with or without the spacers 44, is again lowered until the head 47 engages the head 27 in a manner to open the by-pass or pressure equalizer check valve 28. This permits the pressure above and below the valve member 14 to equalize, assuming of course that the upper end of the well tubing is under control and has preferably packed against fluid pressure, so that there will be no tendency for fluid to flow past the valve until it is released. By pushing downwardly on the head 27 the spring 31 is compressed, moving the keyway 22 again in position opposite the key holes. Continued downward pressure causes the skirt 32 to engage the upper end of the keeper ring, forcing it downwardly and thereby urging the key balls from the position shown in Figure 4 into the position shown in Figure 2. The setting tool is again removed and the stem moves upwardly within the limits of the keyway to the position shown in Figure 3, returning the parts to position for repeated operation.

If it is desired to remove the shut-off apparatus the retrieving tool is lowered until the lower end of the housing 52 engages the tongues 5 of the retainer bars to withdraw the lugs 3, at which time the dogs 54 are in position for engagement with the wickers 55 and the head 47 has engaged the head 27 and urged the valve member 14 to an open position so that fluid may flow through the shell 1 as the apparatus is removed.

It should be noted that the effective clearance through the apparatus is the clearance between the packing sleeve 10 and the tubing, as well as the annular clearance between the keeper ring

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23 and the inner surface of the adjacent liner 25, but in spite of the bypassing of some fluid between the packing sleeve 10 and the tubing string, the desired pressure differential is readily developed through the restriction formed by the keeper ring should the flow become excessive.

Various changes and alternate arrangements may be made within the scope of the appended claims, in which it is my intention to claim all novelty inherent in the invention.

I claim:

1. A shut-off apparatus comprising: a supporting structure; a sealing element depending from said supporting structure defining a passageway adapted to be closed and having walls expansible into sealing engagement with a surrounding tubing; a valve member positioned below said sealing member and movable upwardly to seal said passageway and expand said sealing element into sealing engagement with said tubing; a stem for said valve member extending into said supporting structure; means for locking said stem relative to said supporting structure to hold said valve member open; and a slidable keeper for maintaining said locking means in locked condition, said keeper defining with said supporting structure a flow passage of reduced area whereby, upon flow of fluids above a predetermined velocity, a pressure differential is created tending to move said keeper to free said locking means.

2. In a shut-off device adapted to be employed in a tubing string having sections joined by collars which define internal annular channels, apparatus comprising: a supporting sleeve; lugs mounted within said sleeve and movable outwardly through openings in the walls of said sleeve into such an internal channel; a yieldable tubular packing element depending from said supporting sleeve; a movable valve member associated with said sleeve and adapted to be moved from an open position to close the bore of said packing element and spread the packing element into sealing engagement with the surrounding tubing; a retrieving tool, including means for attachment to said sleeve, means for retracting said lugs, and means for opening said valve member.

3. A shut-off apparatus comprising: an expansible, tubular packing element slidable through a tubing string and having a bore forming at one end a valve seat; a valve member movably supported adjacent said packing element, said valve member being adapted to be moved into said valve seat to seal said bore, and expand said packing element into sealing engagement with a surrounding tubing; a supporting structure for said packing element and valve member; latch means associated with said supporting structure for holding said movable valve member clear of said valve seat under normal fluid flow, and operative in response to excessive fluid flow through said apparatus to release said valve member for movement into said valve seat.

4. A shut-off apparatus comprising: an expansible, tubular packing element slidable through a tubing string and having a bore forming at its lower end a valve seat; a valve member movably supported below said packing element, said valve member being adapted to be moved upwardly into said valve seat to seal said bore and expand said packing element into sealing engagement with a surrounding tubing; a supporting structure for said packing element and valve member; means associated with said supporting structure for holding said movable valve member

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down, clear of said valve seat, under normal fluid flow, and operative in response to excessive fluid flow through said apparatus to release said valve member for movement into said valve seat.

5. An automatic shut-off device comprising: a tubular flow passage; a valve head; a unitary valve stem coaxially extending from said head; a valve seat for said valve head formed in an adjacent end of said tubular flow passage; a guide coaxially positioned within said passage for movably supporting said valve stem and head; a latch associated with said guide and valve stem and having a first position locking said valve stem in said guide in a position in which said head is in an open position with respect to said valve seat and a second position freeing said stem for axial movement in said guide sufficient to permit closure of said valve head upon said valve seat; an axially movable sleeve member surrounding said valve stem and defining in part the said flow passage through the device, said sleeve being associated with said latch and axially movable in response to forces resulting from fluid flow through said passage from a normal position in which the latch is retained thereby in its said first position, to an actuating position to effect movement of said latch from said first position to said second position when said fluid flow exceeds a predetermined value.

6. A shut-off device adapted to be movable through and secured within a tubing comprising: an expansible valve sleeve having a flow passage therethrough; a valve member associated with said valve sleeve and adapted to move between an open and a closed position with respect to said valve sleeve and said flow passage and in the closed position to expand said valve sleeve into sealing engagement with a surrounding tubing; and means operative initially during fluid flow through said flow passage at less than a predetermined rate to maintain said valve member in the open position, and operative in response to fluid flow exceeding said pre-determined rate to release said valve member for movement into said closed position.

7. A shut-off device adapted to be movable through and secured within a tubing and comprising: an expansible valve sleeve; a valve member associated with said valve sleeve and adapted to move between an open and a closed position, with respect to said valve sleeve and in the closed position to expand said valve sleeve into sealing engagement with surrounding tubing; means for urging said valve member toward the closed position; and means operative initially during fluid flow through the tubing at less than a predetermined rate to restrain said valve member in the open position and operative in response to fluid flow exceeding said pre-determined rate in the tubing to release said valve member for movement into the said closed position.

8. A shut-off device adapted to be movable through and secured within a tubing and comprising: an expansible valve sleeve; a valve member associated with said valve sleeve and adapted to move between an open and a closed position with respect to said valve sleeve and in the closed position to expand said valve sleeve into sealing engagement with a surrounding tubing; a latch means having a first position locking said valve member in the open position and a second position in which said valve member is free for movement to the closed position, and means operative initially during flow through the tubing at less than a predetermined rate to maintain said latch

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in said first position and operative in response to fluid flow exceeding said pre-determined rate in the tubing for releasing said latch means for movement from said first position to said second position.

9. A shut-off device adapted to be movable through and secured within a tubing and comprising: an expansible valve sleeve; a valve member associated with said valve sleeve and adapted to move between an open and a closed position with respect to said valve sleeve and in the closed position to expand said valve sleeve into sealing engagement with a surrounding tubing; a latch means having a first position locking said valve member in the open position and a second position in which said valve member is free for movement to the closed position, and means operative initially during fluid flow through the tubing at less than a predetermined rate to maintain said latch in said first position and operative in response to fluid flow exceeding said pre-determined rate in the tubing for releasing said latch means for movement from said first position to said second position, and means for urging said valve member into the closed position.

10. A shut-off apparatus comprising: a supporting structure; a hollow sealing element depending from said supporting structure defining a passageway adapted to be closed and having walls expansible into sealing engagement with a surrounding tubing; a valve member positioned below said sealing member and movable upwardly to seal said passageway and expand said sealing element into sealing engagement with said tubing; a stem for said valve member extending into said supporting structure; means for locking said stem relative to said supporting structure to hold said valve member open; and an element of said locking means actuated by the flow of fluid above a predetermined velocity relative to said supporting structure to unlock said locking means and release said valve member for upward movement.

11. A shut-off device adapted to be movable through and secured within a tubing comprising: a tubular shell; an expansible valve sleeve secured to one end of said shell, said shell and valve sleeve forming a flow passage, said valve sleeve having a valve seat adjacent one end thereof; a valve member associated with said valve sleeve and adapted to move axially between an open position away from said valve seat and a closed position upon said valve seat; a valve stem extending from said valve member; a tubular guide within said flow passage for axially movably supporting said stem and said valve member; a latch means associated with said guide and said valve stem and arranged to occupy a first position locking said valve stem in said guide against axial motion with said valve member in an open position away from said valve seat, said latching means being movable to a second position releasing said valve stem for movement in said guide and thereby permitting movement of said valve member to a closed position seating on said valve seat; a control ring surrounding said guide and valve stem within said flow passage and supported on said guide for axial sliding movement thereon, said control ring forming a restriction in said flow passage and being positioned, during fluid flow through said flow passage at less than a predetermined rate, to retain said latch in said first position and being movable axially in response to fluid flow in

said flow passage exceeding said pre-determined rate and adapted to effect, by such movement, the movement of said latch means from said first position to said second position.

12. A well shut-off apparatus for controlling flow of fluid through a tubing comprising: a supporting structure adapted to be anchored in a tubing string; valve means including a valve member and valve seat for said valve member carried by said supporting structure and arranged for controlling flow of fluid through said tubing when said supporting structure is anchored therein; a stem extending from said valve member; a guide for said stem carried by said supporting structure; key and keyway means incorporated in said guide and stem for holding, by means of said stem, said valve member in an open position away from said seat; a keeper for said key normally holding said key in said keyway, said keeper defining with said supporting structure a flow passage of reduced area and said keeper being movable in response to a pressure differential created by the flow of fluid above a predetermined velocity through said passage of reduced area to effect release of said key from said keyway, thereby freeing said valve member for movement to a closed position on said valve seat.

13. A well shut-off apparatus comprising: a supporting structure adapted to be anchored in a tubing string; valve means including a valve member and valve seat for said valve member and adapted to control flow of fluid through said tubing when said supporting structure is anchored therein; a stem extending from said valve member; a guide for said stem carried by said supporting structure; key and keyway means incorporated in said guide and stem for holding, by means of said stem, said valve member in an open position off said valve seat; a keeper for holding said key in said keyway to maintain said valve member in said open position, said keeper also forming a constriction in the flow passage through said tubing and operable by a pressure differential created by the flow of fluid above a pre-determined velocity through said constriction to release said key from said keyway, thereby permitting said valve member to close on said seat; and a spring positioned between said sup-

porting structure and valve member and adapted to urge said valve member when thus released toward a closed position on said seat.

14. A well shut-off apparatus comprising: a sleeve member; a valve associated with said sleeve, said sleeve member and valve member being adapted to be moved down and positioned in a tubing string to close the tubing string against flow of fluid upwardly therethrough; a latch means in said sleeve for holding said valve open to permit flow of fluid through said tubing string; a keeper means in said sleeve for actuation of said latch means, said keeper means forming together with said sleeve a constriction through which fluid flowing through said tubing must pass and whereby a pressure differential may be created on opposite sides of said constriction upon flow of fluid therethrough, said keeper means being movable in response to said pressure differential when the flow of fluid through said constriction is excessive, to release said latch, thereby to free said valve member for movement to a closed position.

LLOYD SPENCER.

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Certificate of Correction

Patent No. 2,447,546.

August 24, 1948.

LLOYD SPENCER

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 47, for the words "its down" read *its own*; column 3, line 72, for "fall" read *ball*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of December, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.