

April 16, 1963

B. C. MALONE

3,085,628

INFLATABLE WELL TOOL

Filed Feb. 18, 1959

4 Sheets-Sheet 1

Fig. 1

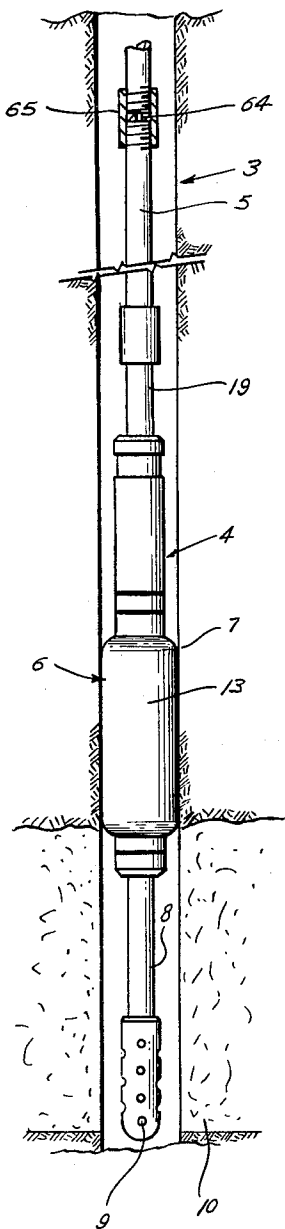


Fig. 6

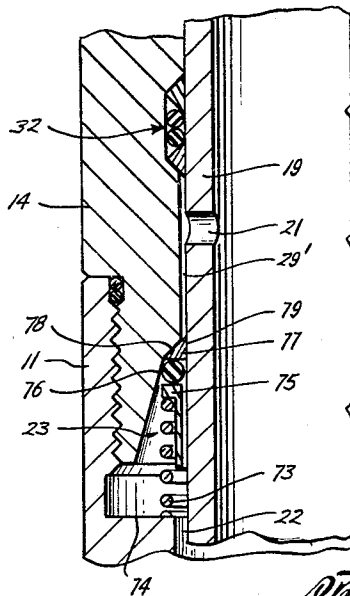
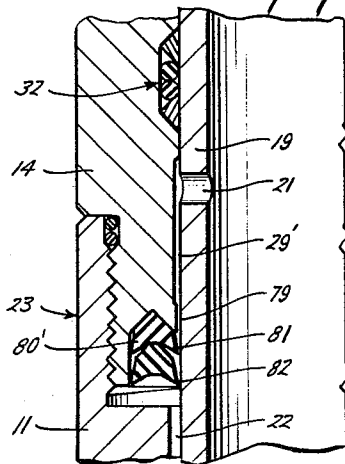


Fig. 7



Billy C. Malone
INVENTOR.

BY *Hayden & Pravel*

ATTORNEYS

April 16, 1963

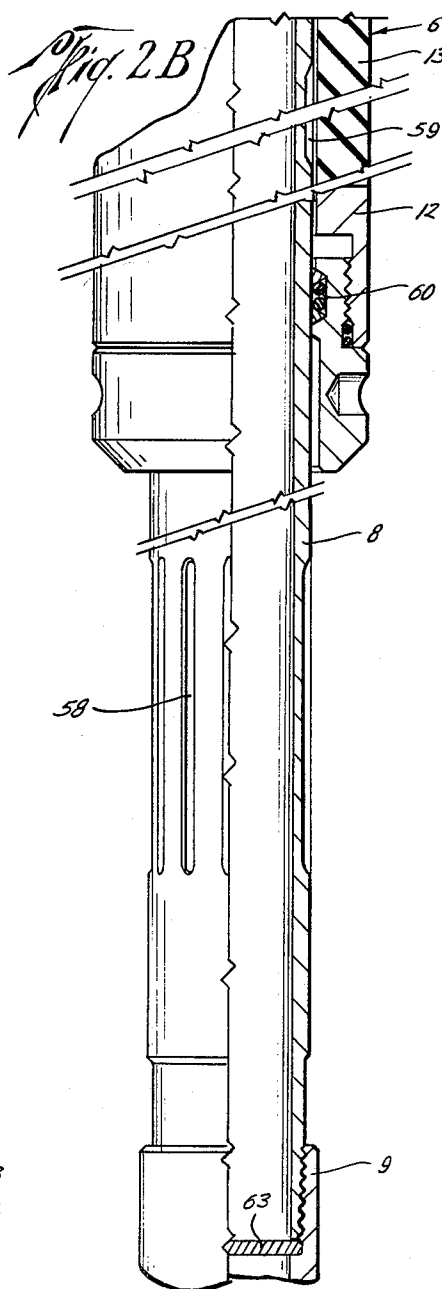
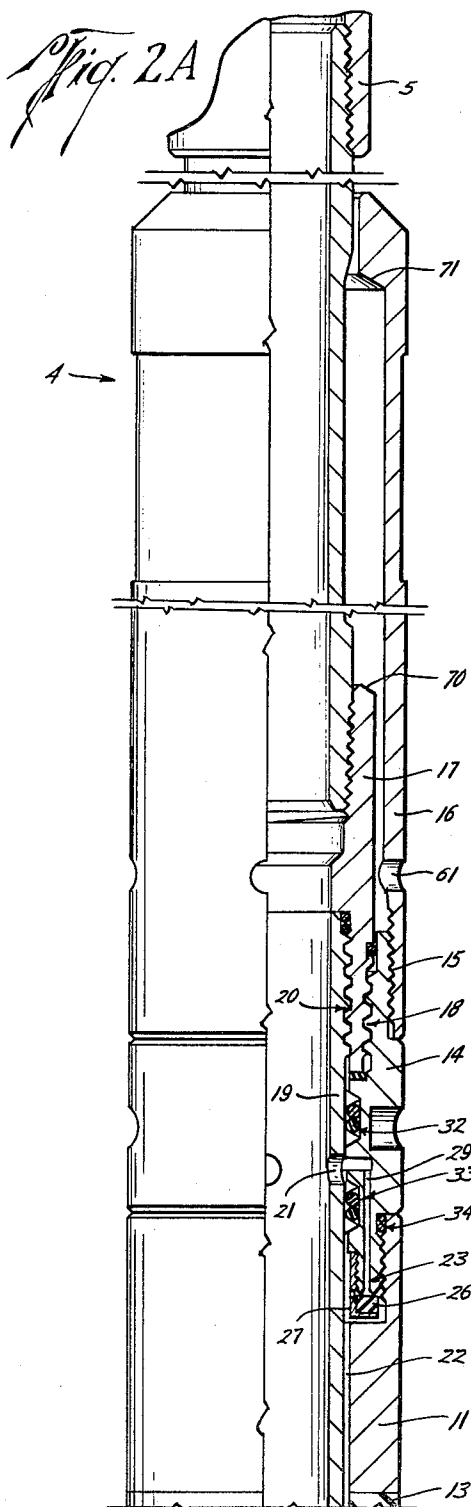
B. C. MALONE

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Billy C. Malone
INVENTOR.

BY *Hayden & Pravel*

ATTORNEYS

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B. C. MALONE
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Fig. 4

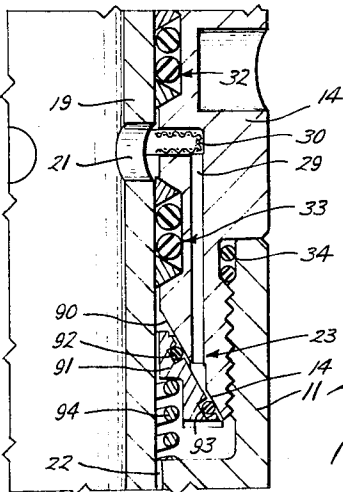
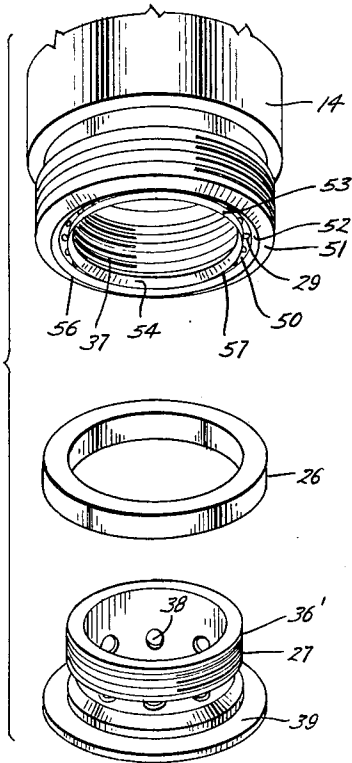
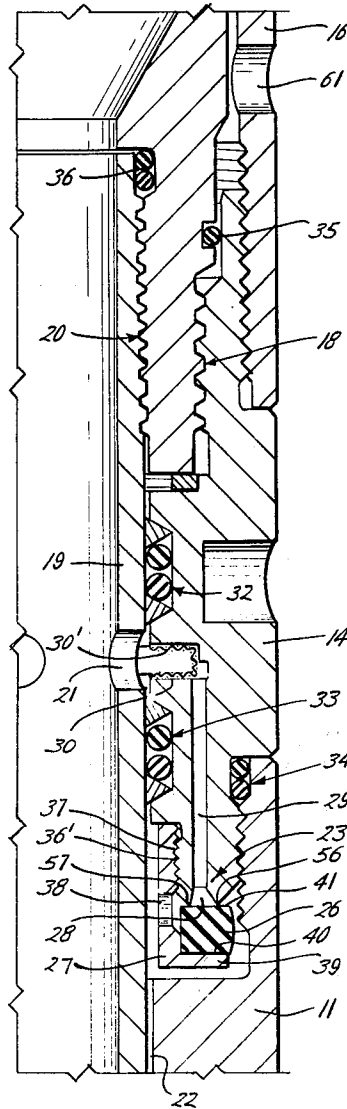


Fig. 3



Billy C. Malone
INVENTOR.

BY *Hayden & Prael*

ATTORNEYS

April 16, 1963

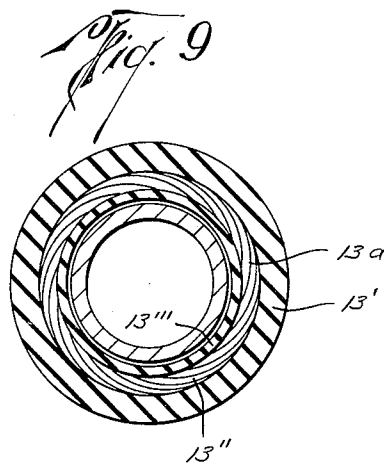
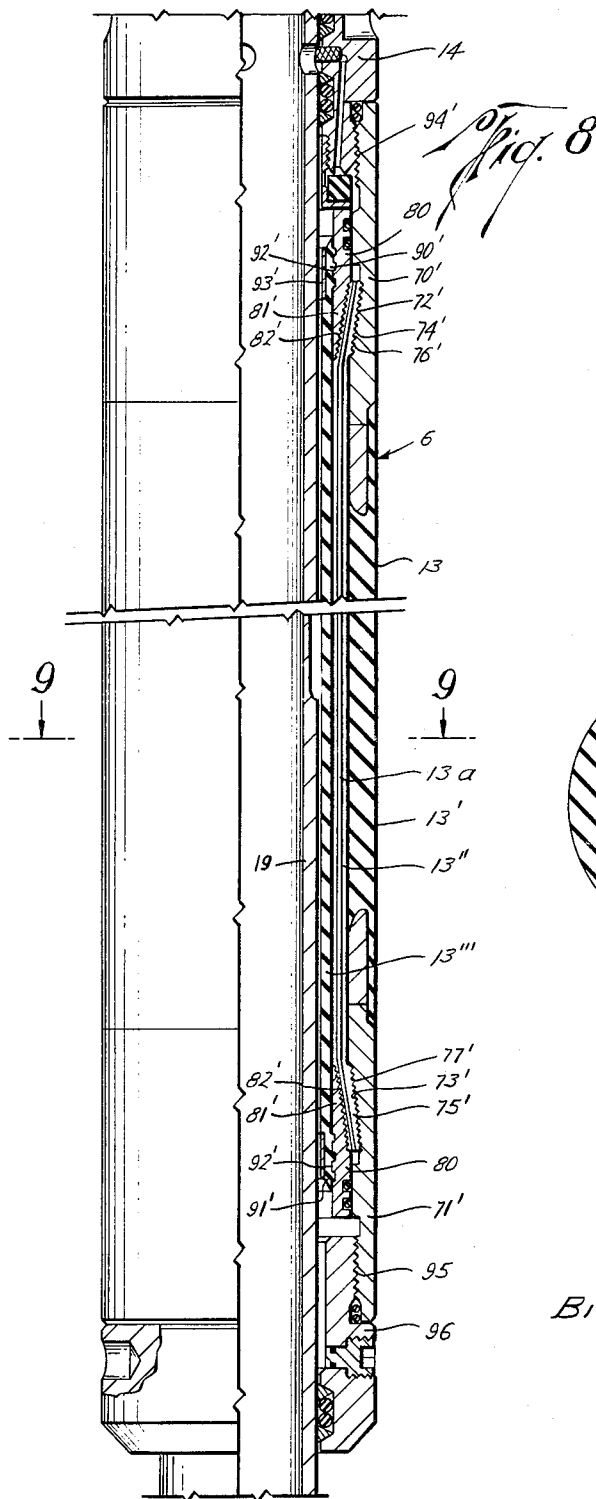
B. C. MALONE

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4 Sheets-Sheet 4



Billy C. Malone
INVENTOR.

BY *Hayden & Pravel*
ATTORNEYS

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3,085,628

INFLATABLE WELL TOOL

Billy C. Malone, Midland, Tex., assignor to

Lynes, Inc., a corporation of Texas

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9 Claims. (Cl. 166-187)

The present invention relates to an inflatable well tool, and more particularly to an improved form of packer and tool for wells.

Various forms of inflatable elements or packers and tools for manipulating and setting the inflatable elements in wells have been heretofore provided. In inflatable packer tool constructions heretofore used, the inflating of the elements is accomplished by manipulating pipe at the surface on which the element is supported in the well in order to inflate and deflate the packer, as desired, in the well. In some situations it may be more desirable to set an inflatable element of the packer tool or the like without manipulating it from the surface.

The present invention has for one of its objects, the provision of an inflatable packer element and packer tool which is relatively easy to set in a well without any manipulation of the support pipe at the earth's surface, and which may be unset or released from its expanded position in the well with a minimum of, or simple manipulation at the earth's surface of the pipe on which the packer is supported.

In other forms of packer tools or packer elements which are used at the present time, the setting of the tool is accomplished by means of some mechanical manipulation of the operating pipe at the earth's surface so that slips or other similar mechanisms are actuated to effect a squeezing action on the packer element in order to expand it into seating position in the well. In order to accomplish this function, there must be sufficient pipe in the well upon which the packer element is supported to provide the necessary weight for the setting of the slips or other mechanical mechanism associated with the packer tool.

Unfortunately, this form of packer tool is impractical for use in shallow wells, because the length of pipe in the well does not provide sufficient weight to effect the actuation of the mechanical setting and support mechanism. This form of packer is also objectionable in that there can only be a certain amount of radial expansion of the packer element when it is squeezed; therefore, the use of squeeze packers is restricted because it must be first of all, small enough to move through the well pipe, but large enough so that when the operating mechanism is actuated, it will expand radially sufficiently so as to engage with the well bore wall below the end of the well pipe.

The present invention is directed to a tool construction which does not depend upon weight to set the inflatable element carried by the tool, and the present invention does not have the restrictions as to space required by the squeeze type packer.

Still another object of the present invention is to provide an inflatable packer element tool which may be easily set in well pipe or in a well bore, without manipulating the well pipe at the surface to effect expansion of the inflatable element, or without relying upon the weight of the well string upon which the packer element is supported to operate any mechanical setting mechanism.

Still another object of the present invention is to provide a check valve in an inflatable element tool so as to maintain the element sealed off in relation to any fluid as it is being lowered into the well, which valve means opens upon the application of a predetermined amount of pressure to conduct fluid to the element to set it in the well bore.

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Still a further object of the present invention is to provide a valve means in an inflatable packer tool, whereby fluid may be sealed from the inflatable element until the pressure reaches a predetermined amount, whereupon fluid may thereafter be conducted to the inflatable element to expand it to engage in the well, said valve being constructed and arranged so that it is not sensitive, and will not become fouled by foreign matter in the inflating fluid.

Still a further object of the present invention is to provide a valve for use with a packer tool, wherein a predetermined amount of pressure is required to open the valve so that inflating fluid may be conducted to an inflatable element carried by the packer tool.

Still a further object of the present invention is to provide a packer which may be set in a well with a minimum amount of manipulation at the earth's surface.

Yet a further object of the present invention is to provide a well tool which incorporates an inflatable element thereon and a valve arrangement for controlling inflation of the element.

Another object of the present invention is to provide an improved form of well packer.

Still another object of the present invention is to provide a packer and tool whereby the packer may be expanded by liquid or by gas.

Still a further object of the present invention is to provide an inflatable packer tool having an inflatable element thereon which can be easily set in a well and which will remain permanently set over an extended period of time.

Yet a further object of the present invention is to provide a method of setting an inflatable packer tool in a well which overcomes the problems heretofore encountered with setting packer tools.

Other objects and advantages of the present invention will become more readily apparent from a consideration of the following description and drawings, wherein:

FIG. 1 is a vertical section of a well bore illustrating the present invention in elevation positioned therein;

FIG. 2A is an enlarged quarter-sectional view illustrating the upper part of the tool of the present invention;

FIG. 2B is a broken continuation of FIG. 2A and showing the lower portion of the tool;

FIG. 3 is an enlarged partial sectional view showing in greater detail the structural arrangement of the preferred form of the check valve means used with the present invention;

FIG. 4 is an exploded view illustrating the relationship of the check valve components;

FIG. 5 is a sectional view, somewhat similar to FIG. 3, illustrating still another form of a check valve construction which may be utilized with the present invention;

FIG. 6 is a sectional view, similar to FIG. 3, illustrating still another form of a check valve means;

FIG. 7 is an enlarged sectional view, somewhat similar to FIG. 3, illustrating yet a further form of a check valve means which may be utilized with the present invention;

FIG. 8 is a vertical quarter sectional view illustrating an embodiment of the packer construction of the present invention; and

FIG. 9 is a sectional view on the line 9-9 of FIG. 8 to illustrate further structural details of the packer.

In FIG. 1, a well bore is illustrated generally at 3, which well bore may be provided with pipe in some instances, and in other instances, it may be uncased leaving an open bore hole. The present invention is illustrated by the numeral 4 and is shown as being supported on pipe such as tubing 5 or the like, which extends to the earth's surface. The packer element designated generally at 6 is shown in FIG. 1 as being expanded to seal

with the sides 7 of the well bore shown at 3, whether the well bore is cased or uncased. The tubing 5 is connected to a pipe 19 which extends through the packer element 6 and terminates in the portion 8 below the packer element 6, with the perforated bull plug 9 connected thereto for receiving a flow from the formation 10.

While the present invention is described wherein only one packer element 6 is used on the tool, in some situations it may be desirable to use two or more elements, and it can be appreciated that the illustration of the present invention as shown in the drawings is by way of example only, and not by way of limitation. The present invention may be used equally well with a plurality of packers 6.

The invention 4 includes annular heads 11 and 12 which are spaced as illustrated in FIGS. 2A and 2B of the drawings, with the inflatable element body 13 extending therebetween and secured to each of the heads 11 and 12 in a manner well known in the art. The upper head 11 is connected to the sub 14, and the sub 14 is connected by any suitable means such as the threads 15 thereon to the housing 16 which extends upwardly from the sub 14 as shown in the drawings. The well pipe illustrated at 5 is extended downwardly into the housing 16 as shown in FIG. 2 of the drawings, and is connected to the coupling bumper sub 17. The coupling bumper sub 17 is connected by means of the engaging threaded area illustrated generally at 18 to the top sub 14 and is also connected to the tubular member 19 by means of the threaded connecting arrangement illustrated generally at 20. The tubular member 19 extends through the element 6 and terminates in the portion illustrated by the numeral 8 as shown in FIG. 2B of the drawings. The perforated plug 9 is connected by suitable means such as threads to the lower end 8 of the tubular member 19.

It will be noted that ports or openings 21 are provided in the tubular member 19, whereby fluid pressure may be communicated from the pipe to the annular space 22 between the member 19 and the resilient element body 13 so that the inflatable element 13 may be expanded into engagement with the well bore 3 as illustrated in FIG. 1 of the drawings. In order to control the inflation and deflation of the inflatable element 13, a check valve means illustrated generally by the numeral 23 is provided for closing off communication of the openings 21 in the pipe 19 relative to the annular space 22 to inhibit premature actuation or operation of the inflatable element 13.

The check valve means 23 is illustrated in greater detail in the enlarged drawings of FIG. 3 and is shown as including a resilient member 26 which is carried or supported by the ring 27 in a position so as to close off the lower end 28 of the passages 29 which communicate with the annular recess 30 in the sub 14, which recess is disposed adjacent the ports 21 in the tubular member 19 as shown in FIG. 3 of the drawings.

Suitable seals as illustrated at 32 and 33 span the recess 30 so as to prevent the improper passage of fluid during the use of the present invention. Similarly, seals are provided as illustrated at 34, 35 and 36 to seal between the various components of the well tool in order to prevent the leakage of fluid to or from the tool which might interfere with, or otherwise impair the operation or actuation of the tool.

In FIG. 4, it will be noted that the member 27 is shown as including the threaded area 36' which is adapted to engage with the threads 37 on the inner periphery of the lower end of sub 14 as shown in FIG. 3 of the drawings. Circumferentially spaced openings 38 are provided in the ring 27 for communicating fluid from the passages 29 when the resilient valve member 26 has been moved away from the lower end 28 of the passages 29. In order to properly seat the resilient member 26 adjacent the lower end 28 of the passages 29, a shoulder 39 is provided on the ring 27, which engages the lower end

40 of the member 26 and urges the upper surface 41 of the member 26 into engagement with the lower end 28 of the passages 29 as shown in the drawings.

The lower end 28 of the passages 29 is better illustrated in the exploded FIG. 4 view, and the arrangement of the passages 29 in the sub 14 are there better shown. In FIG. 4 it will be noted that the passages 29 are circumferentially spaced about the sub 14, and are arranged in a groove 50 in the lower end of the sub 14, which defines the flared lower end 28 of the passages 29. The outer edge 51 and the adjacent edge 52 of the groove 50 are annularly tapered as shown in FIGS. 3 and 4 of the drawings, and the edge 53 of the groove 50 and the inner edge 54 of the sub 14 adjacent the groove 50 are also tapered so that projections 56 and 57 are thereby formed which engage the top surface 41 of the member 26, and by reason of their configuration not only tend to depress the member 26 slightly, but also seat into the top surface 41 a predetermined amount when the member 27 is positioned on the threads 37 of the sub 14 as shown in FIG. 3 of the drawings.

A filter or screen 30' is provided in the recess 30 to aid in filtering any fluid which flows from the pipe 19 to the passages 29 so as to inhibit the settling of scale or other foreign matter on the surface 41 of the resilient member 26 which might otherwise tend to retain the valve in open position after it has been actuated. Additionally, the construction and arrangement of the valve is such that it inhibits the settling of foreign matter on the top surface 41, which settling would impair the closing of the valve. The construction of the annular projections 57 and 56 on each side of the groove 50 define substantially annular linear contacts with the top surface 41 of the member 26, thereby making it extremely difficult for foreign matter to settle at the proper place on surface 41 so as to inhibit the proper closing of the valve, when desired.

Circumferentially spaced and longitudinally extending grooves 58 and 59 are provided on the member 19, and when these grooves 58 and 59 are positioned so as to span the seal 60 in the lower head 12 and the seals 32, 33, in the sub 14 respectively, the inflatable element 13 is deflated by discharging any fluid therefrom externally through the grooves out the lower end of the packer and up above the packer through the ports 61 in the housing 16, as will be described in more detail hereinafter.

The present invention also contemplates a novel setting procedure, in that heretofore it has been customary to manipulate the pipe 5 which extends to the surface of the well bore in order to set packer tools. The present invention overcomes this difficulty in that no surface manipulation of the support pipe is required in order to set the inflatable element 13 in the well bore 3. When the tool is assembled as illustrated in FIGS. 2A and 2B of the drawings, clean fluid may be poured into the pipe 19 so as to completely fill the pipe 19 from the perforated nipple 9 for two or three joints above the tool as shown in FIG. 1 of the drawings. In order to accomplish this, a disc 63 may be inserted at the bottom of the tubular member 19 adjacent the top of the perforated plug 9 so as to close off communication through the lower end thereof, and the fluids may be thereafter inserted in the tubular member 19 when it is vertically positioned at the earth's surface for lowering into the well bore 3. Thereafter, as each length of pipe 5 is added, such pipe may be filled with the fluid until a desired amount has been added. Normally, two or three lengths of pipe filled with fluid will be sufficient for the operation of the present invention. By prefilling the pipes in the manner above described, the entrance of foreign matter into the tool is inhibited, because such fluid will permit the settling out of any scale or other foreign matter on the interior of the pipe onto the disc 63 by the time that the packer has been lowered into position in the well bore for operation.

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If desired, after the pipe 5 has been filled to a suitable height, such as two or three joints above the tool 4, a perforated member as shown at 64 in FIG. 1 may be inserted in a coupling 65, to catch any scale and foreign matter which may be present in the additional well fluids that are subsequently added to effect operation of the tool. The check valve means 23 inhibits actuation of the inflating element 13 by the fluid which is carried in the pipe 19 as the tool is lowered into the well, and will continue to prevent actuation of the inflatable element 13 until sufficient internal pressure has been supplied to depress the member 26 to move it away from the lower end 28 of passage 29 so that fluid may thereafter be conducted to the interior of the element 13.

When the packer has been lowered a sufficient amount, or to the desired elevation in the well, fluid may be pumped into the pipe 5 from the earth's surface, whereupon the internal pressure of the fluid in the member 19 is increased a sufficient amount so as to move the member 26 away from the projections 56 and 57 on the lower end 28 of the passages 29. As above noted, when this occurs, the fluid formerly carried in the member 19 will be permitted to pass through the annular space 22 to inflate or expand the element 13 into engagement with the wall of the well, as shown at 7 in FIG. 1 of the drawings. Thereafter, the disc 63 in the lower end 8 of the pipe 19 may be broken in any manner well known, such as by lowering a bar or weight or by breaking with fluid pressure, so that the formation 10 may communicate through the well pipe 5 to the surface, as desired.

The packer 6 will remain set in the well as long as desired, and when it is desired to unseat the packer or element for any reason, the surface pipe 5 may be rotated to the right and pulled upwardly which causes the right-hand releasing connection formed by the threaded arrangement 18 to disengage so that the pipe 5 disconnects from the sub 14, while remaining connected with the operating pipe 19 which extends through the inflated element 13. Thereafter, the tubular member 19 connected in the pipe 5 which pipe extends to the surface may be pulled upwardly so as to position the grooves 58 across the packing 60, and so as to position the grooves 59 across the packing 32 and 33 which communicates the interior of the packing with the well bore above and below the element 13 so as to discharge the fluid from the inflated element 13.

If the packer for any reason has become stuck to the wall of the well, the pipe 5 may be moved upwardly rapidly so as to deliver a jar to the housing 16 by reason of engagement of the surface 70 with the surface 71. Continued blows may be thus delivered to aid in pulling the packer from the well, if necessary.

In FIG. 5, an alternate form of the check valve is shown, wherein the check valve 23 is shown as being formed by the annular tapered surface 90 on the lower end of sub 14. A valve member 91 is formed to abut the taper 90 and carries seals 92 and 93 to span the lower end 28 of passages 29. A spring 94 rests on the head 11 and urges valve element 91 into seating and sealing position on tapered surface 90 to close off flow from opening 29 to annular space 22 which communicates internally to element 13.

In FIG. 6, another alternate form of the check valve 23 is shown wherein a spring 73 rests on the annular shoulder 74 of the head 11. The spring 73 engages the annular support 75 on which rests the O-ring 76. The O-ring, in turn, abuts the wedge shaped valve member 77, which seats against the taper 78 on sub 14 and the outer periphery 79 of the member 19 to aid in sealing off the annular space 22 therebelow from the port 21. In the FIG. 6 modification, it will be noted that the passage 29' is formed by the clearance between the operating pipe 19 and the sub 14 which surrounds the pipe 19. In the operation of the FIG. 6 modification,

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sufficient fluid pressure applied through the pipe 19 will act on the wedge shaped member 77 to move it downwardly against the tension of spring 73 and thereby move it away from the tapered surface 78 of sub 14 and the surface 79 of the member 19, whereupon fluid will pass into the annular space 22 to be conducted to the resilient member 13 of inflatable packer 6.

In the FIG. 7 modification, it will be noted that chevron packing as illustrated at 80' is arranged in the lower end of the sub 14, and resists the flow of fluid to the annular space 22 from the member 19 until the lips 81 and 82 have been moved away from the outer periphery 79 of the member 19. When the lips 81 and 82 have been moved away from the outer periphery 79 of the member 19, then fluid is free to flow from the member 19 through the port or opening 21 and into the space 22. Again, it will be noted that the passage 29' from the opening 21 to the valve 23 in the FIG. 7 modification is formed by the clearance between the outer periphery 79 of the member 19 and the inner periphery on the surrounding sub 14.

The FIG. 7 modification may be utilized in those situations where it is desirable to provide a smaller predetermined pressure before actuation of the valve 23 is effected.

With the valves illustrated in the various forms which may be with the invention, it will be noted that a predetermined amount of pressure must be applied before the valve member is moved away from the lower end of the passages 29 or 29', so as to permit fluid flow to the interior of inflatable element 13, and also, a minimum surface contact between the components of the valve is provided so that there is less likelihood of fouling of the valve by reason of foreign matter such as scale or the like which may be present in the fluid. The screen 30' aids in removing scale formation from the operating fluid to further inhibit fouling of the valve means 23 illustrated in the various figures of the drawings.

In FIG. 8, the details of a preferred embodiment of the packer construction forming a part of the present invention are illustrated. Spaced annular packer heads 70' and 71' are provided at each end of the packer and the inflatable element 13 extends between the packer heads 70 and 71 and is secured thereto by suitable means as illustrated in FIG. 8 of the drawings.

It will be noted that the inflatable element 13 includes the outer covering 13', a continuous layer of reinforcing 13'', and an inner layer 13''' which covers the inner periphery of the reinforcing 13''. The reinforcing layer 13'' may be formed of any suitable material which is sufficiently resilient so as to yield along with the coverings 13' and 13''' adjacent thereto as inflating fluid is passed into the packer 6, and which will assume its initial position after the inflating fluid is discharged from the packer. In FIGS. 8 and 9, the reinforcing layer 13'' is illustrated as comprising a plurality of longitudinally extending, circumferentially overlapping strips 13a which are adapted to be secured at each of their ends 72' and 73' in the heads 70' and 71' respectively. To this end, it will be noted that the heads 70' and 71' are provided with an inner tapered portion 74' and 75', respectively, which has serrations 76' and 77' on each portion 74' and 75' respectively, to aid in gripping and holding the ends 72' and 73' of the reinforcing strips 13a. An annular member 80 is adapted to be received within each of the heads 70' and 71' and is provided adjacent its lower end 81' with a tapered portion which conforms generally to the tapered portion 74' and 75' on each of the annular heads 70' and 71'. Also, serrations 82' are provided on each tapered portion of the annular members 80 for engaging the ends 72' and 73' of the reinforcing strips 13a to further aid in engaging and holding the reinforcing in position during expansion of the packer.

It will be noted that the member 80 extends downwardly into the inflatable element 13 between the rein-

forcing layer 13'' and the inner layer 13''' as more clearly illustrated in FIG. 8 of the drawings. Each end portion of the inner layer 13''' is telescopically received within the annular ring member 80 as illustrated at 90' and 91' in FIG. 8, and it will be noted that the ring member 80 is provided with a plurality of longitudinally spaced, circumferentially arranged grooves 92' so that when the ring seal member 93' is inserted into the end of the layer 13''' and expanded radially against the layer 13'', the layer 13''' will seat in the grooves 92' which aids in retaining the inner layer in position within each of the annular ring members 80.

It will be noted that each of the heads 70' and 71' is threaded as shown at 94' and 95, whereby the closure member 96 may be threadedly engaged with the head 71' and the sub 14 threadedly engaged with the head 70'. The operating pipe 19 extends through the sub 14 and lower closure member 96 as shown in the drawings.

With the present invention it can be noted from the foregoing description that the packer is set without requiring any manipulation of the pipe at the surface, and may be set independently of the weight or length of pipe above the tool and without providing a tail pipe below the tool. Also, the packer may be expanded to greater sizes than possible with squeeze packers.

The invention has been described as being set with liquid; however, it can be appreciated that inflation of the packer element can also be accomplished by gas pressure without departing from the scope of the invention.

Broadly the present invention relates to an inflatable packer tool, and particularly to an inflatable packer tool which overcomes the problems of setting and deflating heretofore encountered with various types of inflatable packer tools and elements.

What is claimed is:

1. In an inflatable well tool including an inflatable element, annular heads connected to each of said element, tubular means to support said inflatable element heads in a well bore, passage means in said tubular means and at least one of said heads to conduct fluid pressure to expand said element, a check valve closing off flow from said passage to prevent fluid pressure from acting on said element until the pressure fluid overcomes said check valve, said check valve including an annular resilient member surrounding said tubular means, a substantially continuous projection on each side of said passage means at the outlet end and engaging said annular member, and a support for maintaining said resilient member engaged with said surrounding opening projections whereby pressure fluid must first move said resilient member away from said projections before it can act to expand said element.

2. In a well tool adapted to be lowered on a well string including, an inflatable packer element, annular heads at each end of and anchored to said element, an operating pipe extending through said element and heads and connected to one of said heads and adapted to be connected to the well string, an opening in said operating pipe, and a fluid conducting passage in one of said heads, annular check valve means mounted in said one head and surrounding said pipe at the end of said passage for communicating fluid from the well string to inflate said element, said check valve including an annular resilient valve member, annular support means carried by said one head for holding said member abutted against the end of the head to seal said passage whereby fluid pressure must first move said member away from said passage end before entering said element.

3. In a well tool adapted to be lowered on a well string including, an inflatable packer element, annular heads at each end of and anchored to said element, an operating pipe extending through said element and heads and connected to one of said heads and adapted to be connected to the well string, an opening in said operating pipe, and a fluid conducting passage in one of said heads, a filtering

medium in said passage to filter fluid flowing into said element, annular check valve means mounted in said one head and surrounding said pipe at the end of said passage for communicating fluid from the well string into said element, said check valve including an annular resilient member, annular support means carried by said head for holding said member abutted against the end of the head to seal said passage whereby fluid pressure must first move said member away from said passage end before entering said element.

4. In an inflatable packer including spaced annular heads, an expandable element extending between and secured to each of said heads, said element including a continuous reinforcing layer and an outer and inner covering thereon, means engaging and holding said element within each of said heads, an annular sub secured to and forming an extension on one of said heads, said sub and at least one of said heads having fluid passage means for establishing fluid communication from the bore of said sub to the interior of said expandable element, and annular valve means in said passage means and carried by said sub for controlling fluid communication through said passage means to inflate and expand said element.

5. A well tool adapted to be lowered in the well on a well string comprising, a tubular member for connecting with the lower end of the well string, an inflatable means, annular heads secured at each end of said inflatable means, means connecting one of said heads to said tubular member, therebeing an opening in the well string and at least one of said heads for communicating fluid interiorly of said inflatable means from said well string, and check valve means surrounding said member and positioned in said opening to normally shut off flow between said tubular member and said inflatable means until the pressure in the well string exceeds a predetermined amount, said check valve means including annular chevron packing surrounding said tubular member and formed of resilient material which normally closes off said opening in said head until fluid pressure from the well string acts thereagainst to flow past said chevron packing, said packing acting to prevent flow in a reverse direction.

6. The invention recited in claim 2 wherein said support means includes spring means urging said valve member toward normally closed position.

7. The invention recited in claim 2 wherein said support means includes a ring, an annular shoulder thereon on which said resilient valve member is supported in engagement with said passage in said head to close off flow to said packer element, an annular projection at one end of said passage for forming an annular linear contact with said resilient valve member when engaged therewith.

8. The invention recited in claim 2 including a releasable connection between said operating pipe and said head whereby said operating pipe may be disconnected from said packer element after it has been expanded.

9. A well tool adapted to be lowered in a well comprising, a tubular member, inflatable means supported on said member to be expanded in the well, there being an opening in said member communicating with the interior of said inflatable means whereby fluid may be conducted to expand said inflatable means, and valve means surrounding said member for controlling the communication of fluid through said opening in said tubular member to said inflatable means, and releasable means connecting said tubular member and said inflatable means which permits said tubular member and inflatable means to be disconnected for relative movement therebetween, said releasable means including leak passage means on said tubular member which, upon relative movement between said tubular member and said inflatable means communicates the interior of said inflatable means with the well to discharge the expanding liquid from said means.

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