

Sept. 22, 1970

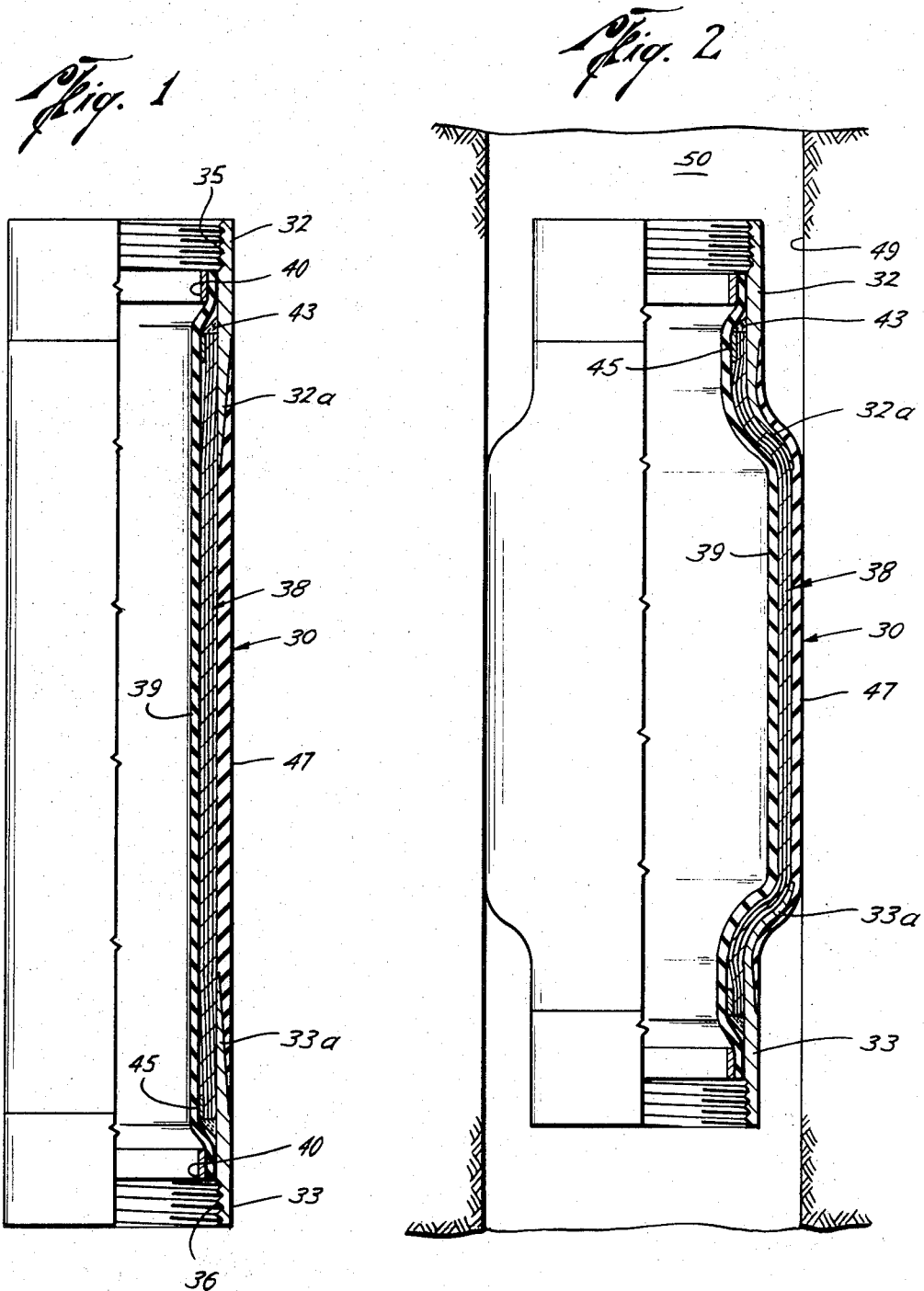
B. C. MALONE

3,529,667

INFLATABLE, PERMANENTLY SET, DRILLABLE ELEMENT

Filed Jan. 10, 1969

5 Sheets-Sheet 1



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INFLATABLE, PERMANENTLY SET, DRILLABLE ELEMENT

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Fig. 3

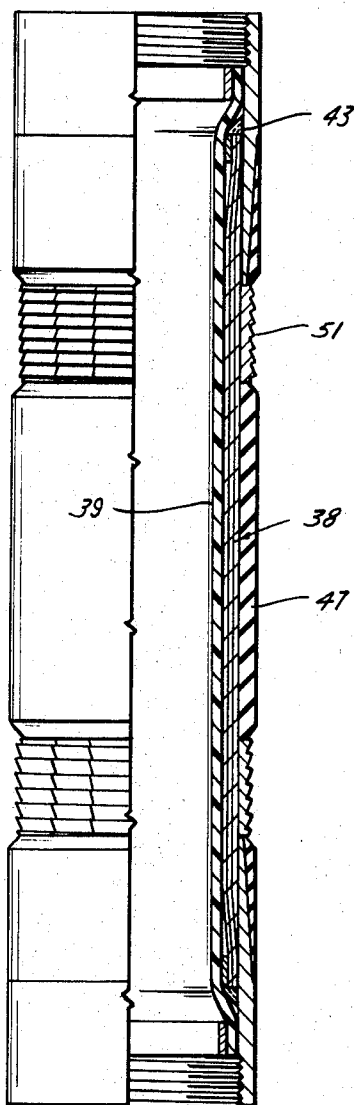
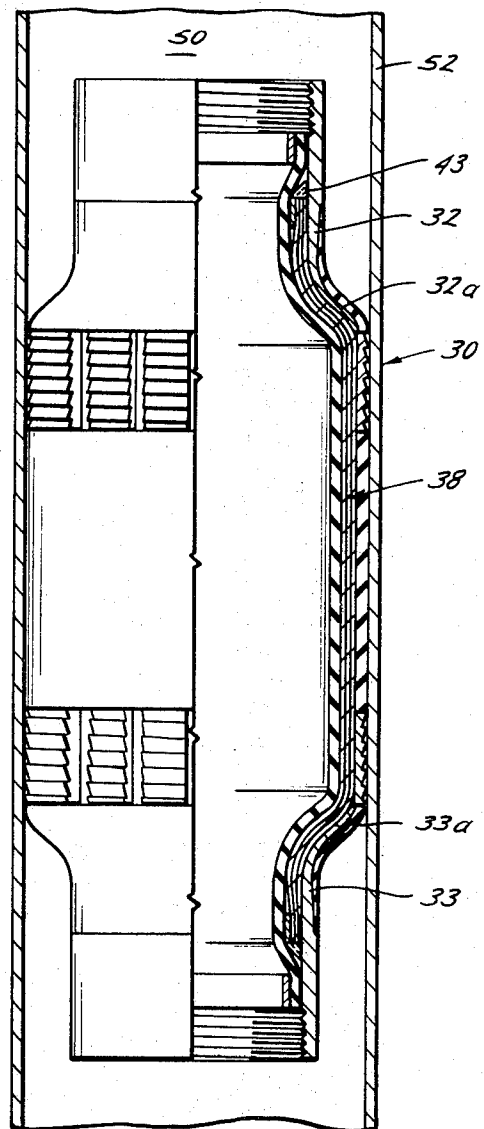


Fig. 4



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Fig. 6

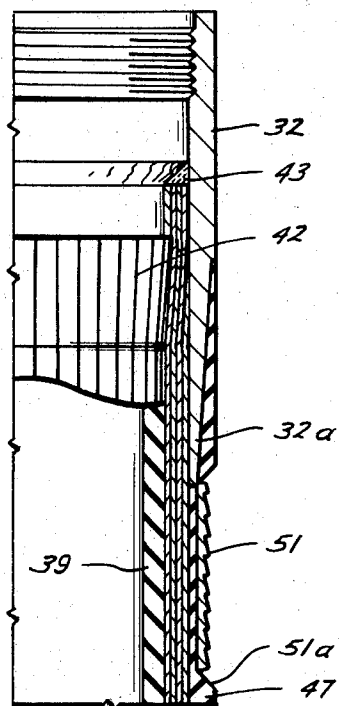


Fig. 5

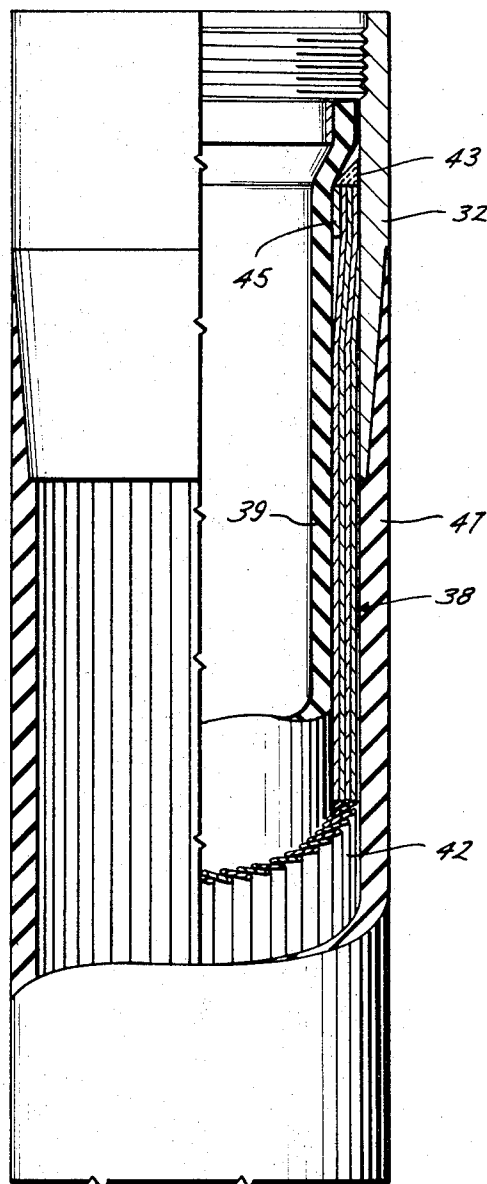
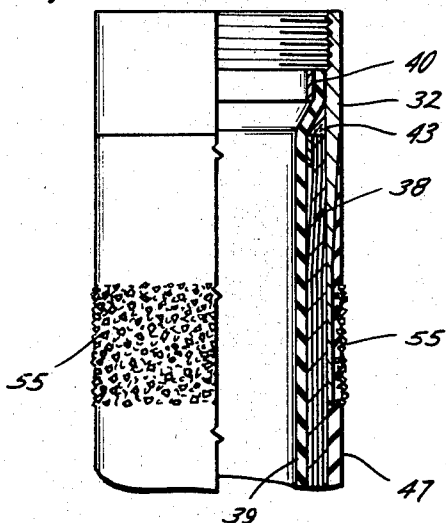


Fig. 7



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Fig. 8

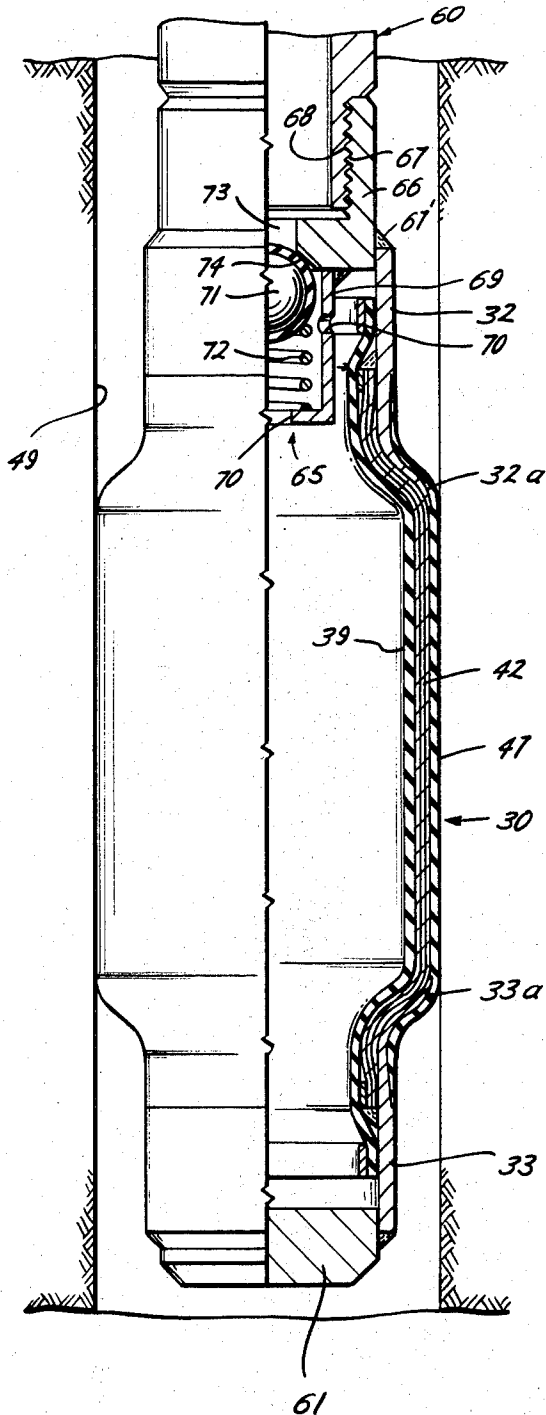
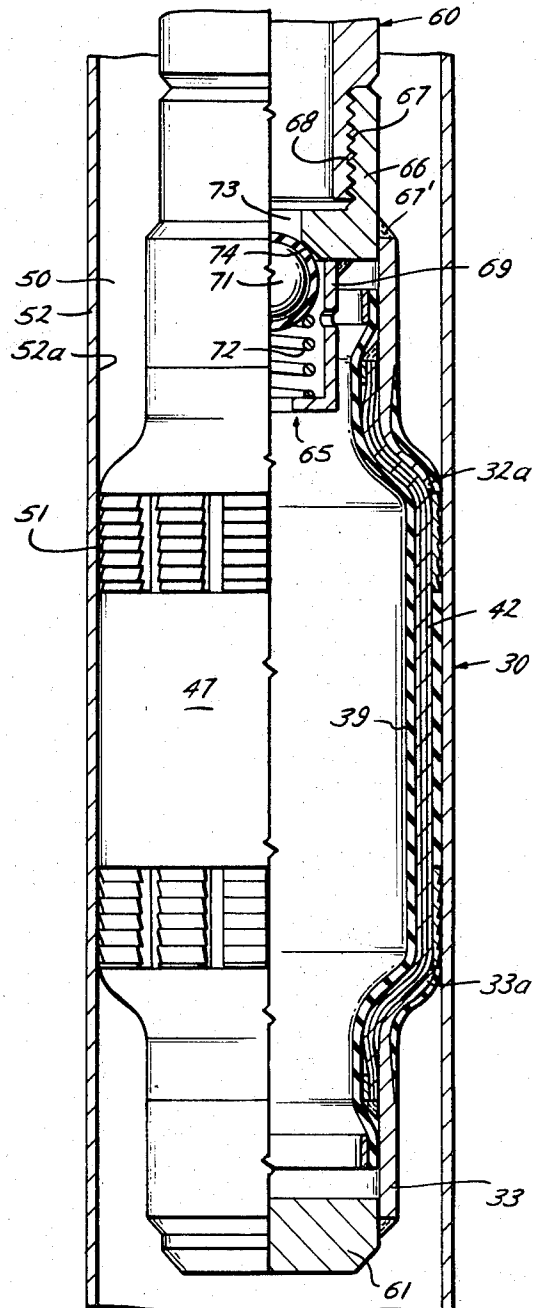


Fig. 9



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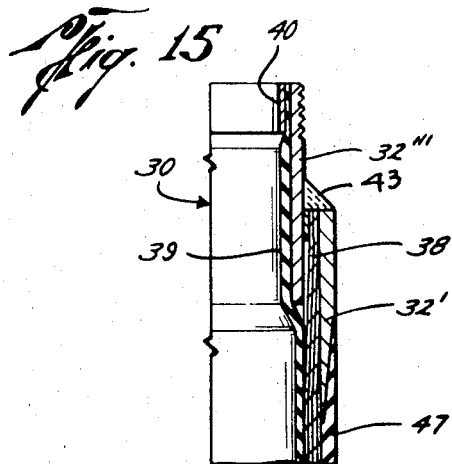
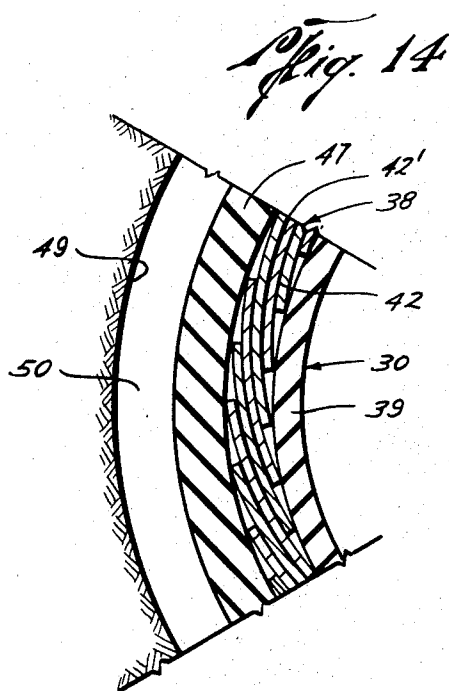
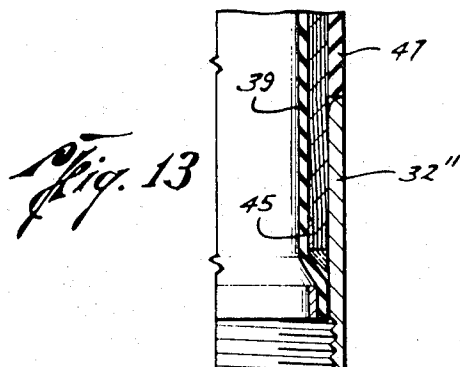
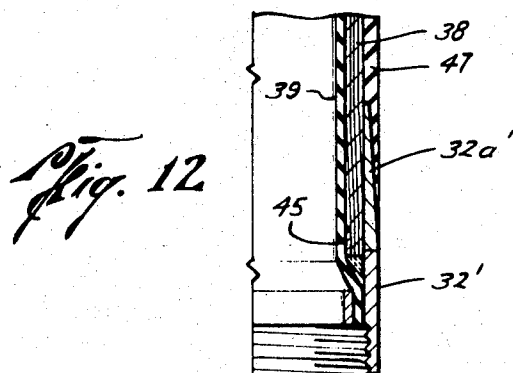
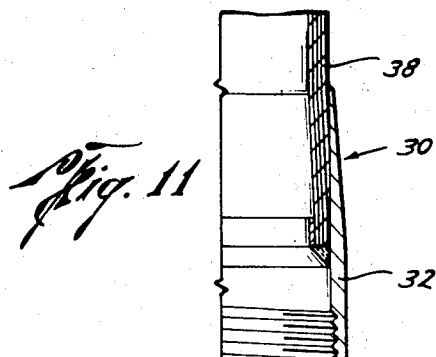
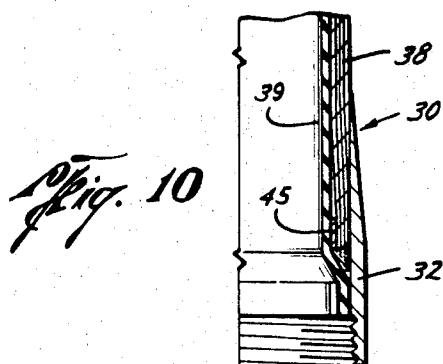
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5 Sheets-Sheet 5



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3,529,667
**INFLATABLE, PERMANENTLY SET,
DRILLABLE ELEMENT**
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Filed Jan. 10, 1969, Ser. No. 790,367
Int. Cl. E21b 33/12
U.S. Cl. 166—315 35 Claims

ABSTRACT OF THE DISCLOSURE

A reinforced, inflatable element, having annular end members and a reinforcing sheath extending therebetween and secured thereto, which, upon inflation of the element, deforms to form a permanent seal in an opening.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to the field of inflatable elements for use in well bores, mine shafts or in any other types of openings and, particularly relates to the field of reinforced inflatable elements, wherein the reinforcing and at least a portion of the end members with which the reinforcing is secured, may, upon inflation, be permanently deformed to seal in a well bore, mine shaft, or other opening in which the element is positioned.

Description of the prior art

The most pertinent prior art, with which applicant is familiar, consists of the patent to John Lynes No. 2,611,437; John Lynes Pat. No. 2,778,431; John Lynes et al. Pat. No. 2,643,722; and George H. Allen Pat. No. 2,778,432.

All of these references disclose a reinforced inflatable element; however, none of the elements disclose a construction which employ a reinforcing that is permanently deformable. Additionally, the type reinforcing employed in such prior art constructions does not lend itself to being drilled or milled out of the opening in which it is positioned, as readily as the present invention. Additionally, each of the references disclose a reinforcing of a specific nature, wherein the reinforcing is embedded in resilient material.

SUMMARY OF THE INVENTION

The present invention relates to an inflatable element, more particularly to a reinforced inflatable element, which is constructed and arranged so that it may be permanently inflated and deformed to seat in a well bore. The element includes a pair of annular end members, the annular end members having at least a part thereof, which is deformable when the element is inflated, with the reinforcing consisting essentially of a plurality of longitudinally extending and overlapping bands or strips formed of material which may be readily drilled or milled by conventional drilling and milling equipment. An inner tube of suitable material is positioned within the reinforcing and is surrounded by the reinforcing when deflated as well as in expanded position within the well bore, mine shaft or other opening. The inner tube is arranged to seal with the annular end members.

Under some circumstances, it may be desirable to provide an outer covering for the inflatable element which can be of and resilient or deformable material and secured to the annular end heads, such as by bonding or the like.

A particular advantage of the present invention is that it provides an inflatable element which may be positioned within a well bore, mine shaft or any other open-

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ing and thereafter inflated to deform it and to form a seal within the opening. In some circumstances it may be desirable at a later date to remove the element from its position within the opening and the present invention lends itself quite readily to being milled, or drilled out, when desired.

An object of the present invention is to provide a reinforced inflatable element, wherein the reinforcing consists essentially of longitudinally extending metal strips which overlap each other and which are welded or otherwise anchored or secured to an annular end member at each end.

An object of the present invention is to provide a reinforced inflatable element, wherein the reinforcing consists essentially of longitudinally extending metal strips which overlap each other and which are welded or otherwise anchored or secured to an annular end member at each end, there being a suitable lubricant and sealing material on the strips to aid in their relative movement and inhibit leakage of fluid between adjacent strips.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view illustrating one arrangement of the inflatable element of the present invention;

FIG. 2 illustrates the inflatable element of FIG. 1 inflated within an opening and deformed to seal or seat within the opening;

FIG. 3 is a sectional view similar to FIG. 1 but showing a suitable means for gripping the wall of the opening, such gripping means being in the form of slip segments;

FIG. 4 is a sectional view showing the element of FIG. 3 inflated within an opening with the slip segments embedded or engaged against the wall of the opening to aid in retaining the reinforced inflatable element position;

FIG. 5 is a sectional view with a portion of the inner tube, the reinforcing and the outer covering cut away to illustrate the overlapping relationship of the metal strips of reinforcing and the relationship of the inner tube which is surrounded by the reinforcing as well as the outer covering;

FIG. 6 is a partial sectional view of one end of the form of the element illustrated in FIGS. 3 and 4 and more particularly illustrates the relationship of the slip segments to the end portion and the means of securing the strips of reinforcing to the annular end portion with the inner tube surrounded thereby;

FIG. 7 is a partial sectional view of one end of an inflatable element illustrating another form of gripping means for aiding in seating the inflatable element within an opening wherein it may be desired to grip the wall of the opening;

FIG. 8 is a sectional view illustrating the present invention used as a drillable plug in the well bore and showing the element inflated and sealed against the wall of the well bore;

FIG. 9 is a sectional view showing an inflatable plug similar to that illustrated in FIG. 8 with slip segments embedded in the outer covering for engaging against the wall of the opening;

FIG. 10 is a sectional view of a portion of one end of another form of inflatable element, wherein the outer cover is omitted;

FIG. 11 is a sectional view similar to FIG. 10, but illustrates a form of inflatable element wherein the outer cover and inner tube is omitted;

FIG. 12 is a sectional view similar to FIG. 10, but illustrates the annular end member as being formed of two parts;

FIG. 13 is a sectional view similar to FIG. 10, but illustrates an alternate form of annular end member;

FIG. 14 is a sectional, diagrammatic representation of a form of inflatable element of the present invention to illustrate a sealing and lubricant on the metal strips in the reinforcing sheath; and

FIG. 15 is a sectional view similar to FIG. 10, but illustrating still another form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Attention is first directed to FIG. 1 of the drawings wherein one form of the inflatable element of the present invention is illustrated at 30. It comprises the annular end members 32 and 33 which may, if desired, be provided with suitable means such as the threaded portions 35 and 36 for engaging with threaded tubular members. It will be noted that the portions 32a and 33a of the annular end members is integral with each end member 32 and 33, and is tapered as shown in FIG. 1 of the drawings. In FIG. 12, the end member 32 is shown as being separate from the tapered portion 32a', while in FIG. 13 the end member 32'' is shown as being of uniform thickness throughout.

The reinforcing is referred to generally by the numeral 38 and an inner tube 39 may be provided which is sealingly secured within each annular head. The inner tube 39 may seal with the end member merely by the application of internal pressure as the element is inflated, or it may be secured to or anchored to each end member by any suitable means such as the ring 40 which may be expanded to seat against each end of the inner tube 39 to retain it in position within the annular end members 32 and 33. If desired, a suitable adhesive may be employed between each end member and the inner tube 39, or the inner tube may be bonded to each end member.

Attention is directed to FIG. 5 of the drawings wherein the reinforcing again referred to at 38 is shown as comprising a plurality of metal strips 42 which overlap each other circumferentially and extend longitudinally between each of the end members 32 and 33, and are secured thereto by suitable means such as the weld 43. It will be noted that the weld 43 not only engages the ends of the metal strips 42 to each other and to the annular end members 32 and 33, but the weld 43 also secures the retaining or anchor means 45 which abuts against the strips of reinforcing as illustrated in FIG. 5 of the drawings to the end members 32 and 33. It will be noted that the reinforcing strips 42 surround the inner tube 39 when it is deflated and similarly as the inner tube 39 is inflated the metal strips circumferentially slide over each other, but still surround the inner tube, even in expanded position.

Attention is directed to FIG. 14 wherein a part of an element is shown in enlarged section to diagrammatically illustrate one feature of the invention. The inner tube is shown at 39, the reinforcing at 38, and an outer cover at 47. The metal strips 42 of the reinforcing are coated with a highly viscous suitable lubricant 42' to more readily accommodate relative movement between the strips and also aid in inhibiting leakage between the strips.

In the form of the invention shown in FIGS. 1 through 9, 12, 13 and 15, an outer covering 47 is provided which extends between the annular end members and may be secured thereto by any suitable means such as bonding or the like, depending upon the type of material. As shown, the outer covering 47 is formed of a suitable elastomeric compound and can be bonded to the annular end portions in a manner well known in the art.

The inner tube 39 can be formed of any yieldable material such as lead or any other resilient or semi-resilient material such as Teflon, or elastomeric material which will yield when internal pressure is applied thereto. Also, it is desirable that the inner tube 39 as well as the reinforcing 38, be formed of material which can readily be cut, or milled, by milling or cutting tools of a conventional type presently employed for such purpose.

In FIG. 2, the reinforced, inflatable, deformable ele-

ment of the present invention is again illustrated and it will be noted that the tapered portions 32a and 33a of the end members 32 and 33 respectively are deformed or flared outwardly into the position as illustrated. Similarly, the reinforcing 38 is inflated and when so inflated becomes permanently deformed and takes a permanent configuration to seat the element against the wall 49 of the opening 50 in which the element is positioned.

In FIG. 3 of the drawings, it will be noted that suitable means for engaging the wall of the surrounding opening are provided, such engaging means in FIG. 3 being shown as slip segments 51 which are positioned in the surface of the outer covering 47. The reinforcing 38 is similar to that previously described as in the inner tube 39.

In FIG. 4 it will be noted that the opening 50 is provided with a conduit or metal tubular member 52 and when the inflatable element 30 of the present invention is inflated so as to permanently deform the tapered portions 32a and 33a of the end members 32 and 33 respectively, as well as permanently deform the reinforcing 38, the slip segments are expanded to engage and aid in locking or retaining the inflatable element 30 in its deformed position within the opening 50.

In FIG. 6 the arrangement of the slip segments 51 and their relationship to the end members 32 and 33 (only one end member is shown in FIG. 6) is illustrated in greater detail. It will be noted that the slip segments 51 are retained in the recesses 51a formed in the outer covering of 47. In FIG. 6 the inner tube 39 is cut away to illustrate the metal strips 42 forming the sheath of reinforcing for the tube 39.

All of the figures, except FIG. 14, illustrate the weld 43 as the means for securing the ends of the metal strips 42 in each annular end member 32 and 33 respectively; however, other suitable anchoring means may be employed such as some type of mechanical anchor or some suitable cement or adhesive such as epoxy resin.

FIG. 7 shows one of the end portions 32 and an alternate friction means for engaging the wall of an opening, such friction means comprising a plurality of abrasive particles 55 which are embedded in the outer covering 47 adjacent each end thereof. The arrangement of the inner tube 39 and the surrounding reinforcing 38 is similar to that previously described. The end member 32 is shown as comprising two cylindrical portions separated by a tapered surface. In this form the end cylindrical part of member 32 which underlies abrasive particles 55 and the tapered part flare outwardly as the element expands.

FIGS. 8 and 9 show the present invention employed in a drillable plug in a well string, the well string being referred to generally by the numeral 60 in each of FIGS. 8 and 9, and both figures being identical except that in FIG. 9 the slip segments 51 are provided in the outer covering 47.

It will be noted that the plug of FIGS. 8 and 9 is formed by closing off one end of the inflatable element 30 of the present invention by suitable means such as the closure or plug 61 which is secured to the annular end member 33 as shown in the drawings, by welding thereto. Spring loaded check valve means, referred to generally by the number 65, is secured to the member 32 as shown to permit flow into the element 30 and to the interior of the tube 39 and to retain the element 30 in inflated, deformed position. The check valve arrangement 65 may be of any suitable configuration but as illustrated is secured to the nipple 66 which is secured by welds 67' to the end member 32. The nipple 66 is provided with suitable thread means as illustrated at 67, for engaging with the threads 68 on the drill string 60.

A housing 69 is secured to the nipple 66 by any suitable means, such as welding as shown in each FIGS. 8 and 9, and includes openings 70 for the flow of fluid around the ball check valve 71 when it is unseated. The ball check valve is supported by the spring 72 in position, as previously mentioned, to permit flow from the drill string 60

through the opening 73 in the nipple 66 and through openings 70 into the interior of the inflatable element 30, and thereafter seat to retain the element 30 expanded or inflated. Cement, plastic or any other inflating fluid may be used to inflate and permanently set the element in position. Thereafter it may be drilled out, if desired.

When it is desired to inflate the drillable plug shown in FIGS. 8 and 9, pressure is increased within the conduit 60 to overcome the force of the spring 72 to unseat the ball 71 from the seat 74 formed on the inner end of opening 73 in nipple 66, whereupon fluid may flow into the interior of the element to expand it and force the tapered end portions 32a and 33a into permanently deformed position.

At the same time, the reinforcing strips 42 are expanded and deformed and the reseating of the ball check valve retains the inflating fluid in the element so that it takes a permanently deformed position to seal against the opening wall 49.

In FIG. 9 the slip segments 51 engage with the wall 52a of the metal member 52 to close off the opening 50 therein.

The threads 67 and 68 can be disconnected by right-hand rotation of the member 60, such threaded connection being a left-hand threaded arrangement to permit such disconnection whereupon the member 60 may be withdrawn from the well bore, mine shaft, or other opening, to leave the inflatable element in the form of the plug as shown in FIGS. 8 and 9 in position within the opening.

If at any time in the future it should become necessary or desirable to remove the element, it can be cut out by conventional milling or drilling tools.

In FIG. 10 a portion of one end of the element 30 is shown and in this view the outer cover 47 is shown as being omitted. The construction shown in FIG. 10 is otherwise similar to that shown in FIG. 1.

In FIG. 11, the reinforcing 38 is shown as being secured with the annular end members 32 and 33 (only 32 being shown in FIG. 11), and the inner tube 39 as well as outer cover 47 is omitted.

In FIG. 12, the construction is similar to that shown in FIG. 1, except the tapered portion is separated from the end member 32'. The member 32 is shown as being abutted against the end of 32a'.

In FIG. 13 the end member 32'' is shown as being of uniform thickness and the outer cover 47 bonded thereto. The member 32'' may be suitably heat treated or otherwise treated so that the portion adjacent its contact with the outer cover 47 will yield or flare outwardly when the element is inflated. Otherwise the construction is similar to that shown in FIG. 1.

In FIG. 14, an opening 50 is shown with the wall being represented at 49, with a section of an element being illustrated at 30' to illustrate the lubricant and sealing material represented by the numeral 42' on the metal strips 42, as previously described.

In FIG. 15, a pin, or male connection is provided on the end of the element 30 in lieu of the box or female element previously shown.

The annular end member 32''' receives the inner tube 39 and a ring 40 retains it in position. The member 32''' (and member 33''' which is not shown) are threaded for connection into a tubular string. The reinforcing 38 is secured by weld 43 to the end members and tapered deformable portion 32'. The outer cover 47 may be bonded to the members 32' (only one being shown), as previously mentioned with regard to FIG. 1.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A method of permanently setting and sealing an inflatable element in a well bore wherein the inflatable ele-

ment is provided with an inner tube, deformable reinforcing including expansible, permanently deformable metal strips surrounding the inner tube, spaced deformable end portions receiving the ends of the inner tube and metal strips and an outer sealing cover over the inner tube and reinforcing comprising the steps of:

- (a) positioning the inflatable, sealable element in a well bore at a predetermined location; and
- (b) injecting inflating fluid into the inner tube of the element to permanently deform the metal reinforcing strips and end portions and expand the outer cover to form a seal in the well bore.

2. In an inflatable element which permanently deforms upon deflation to maintain a seal in an opening comprising:

- (a) annular end members;
- (b) an expansible, permanently deformable reinforcing sheath including expansible, permanently deformable, overlapping metal strips extending longitudinally between each of said annular end members; and
- (c) anchor means for said sheath including means to secure said strips to said end members.

3. The invention of claim 2 including an expansible inner tube surrounded by said sheath and extending between and sealingly engaged with said annular end members.

4. The invention of claim 2 wherein said end members include portions which are permanently deformable as the element is inflated.

5. The invention of claim 4 wherein said permanently deformable portions are integral with said end members.

6. The invention of claim 4 wherein said permanently deformable portions are separate annular members abutted against said annular end members.

7. The invention of claim 3 wherein the inner tube is sealingly engaged with said annular end members by a seal ring within each end of the tube.

8. The invention of claim 3 wherein the inner tube is sealingly engaged with said annular end members by a suitable sealing material between the inner tube and each end member.

9. The invention of claim 3 wherein the inner tube is sealingly engaged with said annular end members by bonding the inner tube to each end member.

10. The invention of claim 2 wherein each of said strips circumferentially overlaps the next adjacent strip throughout its longitudinal extent.

11. The invention of claim 2 wherein each of said annular end members includes a tapered portion to aid in the deformation thereof.

12. The invention of claim 2 wherein said annular end members are of uniform thickness throughout.

13. The invention of claim 2 wherein said securing means connects said anchor means with said annular end members.

14. The invention of claim 2 including an outer covering extending between said annular end members and overlying said reinforcing sheath.

15. The invention of claim 14 wherein friction means are positioned in said outer covering for gripping the wall of the opening when said element is inflated.

16. The invention of claim 15 wherein said friction means comprises slip segments carried by said outer covering.

17. The invention of claim 16 wherein said slip segments are positioned in said outer covering adjacent said annular end members.

18. The invention of claim 15 wherein said friction means comprises abrasive particles bonded in said outer covering.

19. The invention of claim 2 wherein a lubricant is provided in the reinforcing sheath to aid in movement of said strips while maintaining a seal therebetween upon expansion of the element.

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20. The invention of claim 3 wherein said inner tube is formed of resilient material.

21. The invention of claim 3 wherein said inner tube is formed of permanently deformable material.

22. The invention of claim 3 wherein said inner tube is formed of elastomeric material.

23. The invention of claim 3 wherein said inner tube is formed of Teflon.

24. The invention of claim 2 wherein thread means are formed internally of each of said annular end members.

25. The invention of claim 2 wherein said securing means comprises a weld which connects said sheath with said annular end members.

26. A drillable plug for seating against the wall of an opening comprising:

(a) annular end members;

(b) an expansible, permanently deformable reinforcing sheath including expansible, permanently deformable overlapping metal strips extending longitudinally between each of said annular end members;

(c) anchor means for said sheath including means to secure said strips to said end members;

(d) a plug secured to one of said annular end members; and

(e) spring loaded check valve means secured to the other of said end members and yieldable in response to fluid pressure thereagainst to pass inflating fluid within said inner tube and retain it therein to deform said sheath and end members to form a plug in an opening.

27. The invention of claim 26 wherein said strips circumferentially overlap a next adjacent strip throughout its longitudinal extent.

28. The invention of claim 26 wherein each of said annular end members includes a tapered portion to aid in the deformation thereof.

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29. The invention of claim 26 including an expansible inner tube surrounded by said sheath and extending between and sealingly engaged with said annular end members.

30. The invention of claim 26 including an outer covering extending between said annular end members and overlying said reinforcing sheath.

31. The invention of claim 30 wherein friction means are positioned in said outer covering for gripping the wall of the opening when said element is inflated.

32. The invention of claim 31 wherein said friction means comprises slip segments carried by said outer covering.

33. The invention of claim 32 wherein said slip segments are positioned in said outer covering adjacent said annular end members.

34. The invention of claim 29 wherein said inner tube is formed of resilient material.

35. The invention of claim 26 wherein said securing means comprises a weld which connects said anchor means and sheath with said annular end portions.

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JAMES A. LEPPINK, Primary Examiner

U.S. Cl. X.R.

166—187

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,529,667 Dated September 22, 1970

Inventor(s) Billy C. Malone

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 67, change "and" to --any--.
Column 4, line 14, change "in" to --is--.

SIGNED AND
SEALED
DEC 8 - 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents