United States Patent [19]

Owen et al.

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[45] **Jan. 23, 1973**

[54] **CONDUIT LINER FOR WELLBORE AND METHOD AND APPARATUS FOR SETTING SAME**

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[73] Assignee: **Gearhart-Owen Industries, Inc.,** Forth Worth, Tex.

[22] Filed: **July 26, 1971**

[21] Appl. No.: **166,066**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 878,108, Nov. 19, 1969, abandoned.

[52] **U.S. Cl.** **166/277,** 166/63, 166/315, 166/297

[51] **Int. Cl.**.....**E21b 23/04,** E21b 43/10

[58] **Field of Search**.....166/277, 315, 63, 206, 207, 166/297; 29/522, 523

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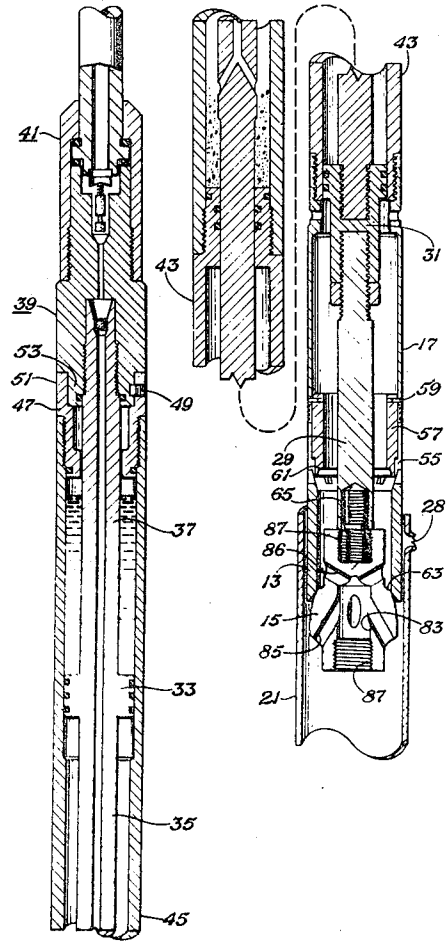
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Attorney—Wm. T. Wofford et al.

[57] **ABSTRACT**

A method of emplacing a liner in a conduit in a well penetrating subterranean formations characterized by positioning with a wire line a cylindrical annular liner at a given depth in the well, the liner being disposed adjacent a swaging mandrel and a setting sleeve, both being connected with a setting tool; actuating the charge in the setting tool to force the swaging mandrel through the liner and to oppose movement of the liner by a reactive force on the setting sleeve, thereby expanding the liner outwardly into tight frictional engagement with the conduit without requiring an anchor or supplemental support; and removing the other apparatus from the well. Also disclosed are specific arrangements and combinations of respective embodiments and some of the uses of the liner.

39 Claims, 21 Drawing Figures



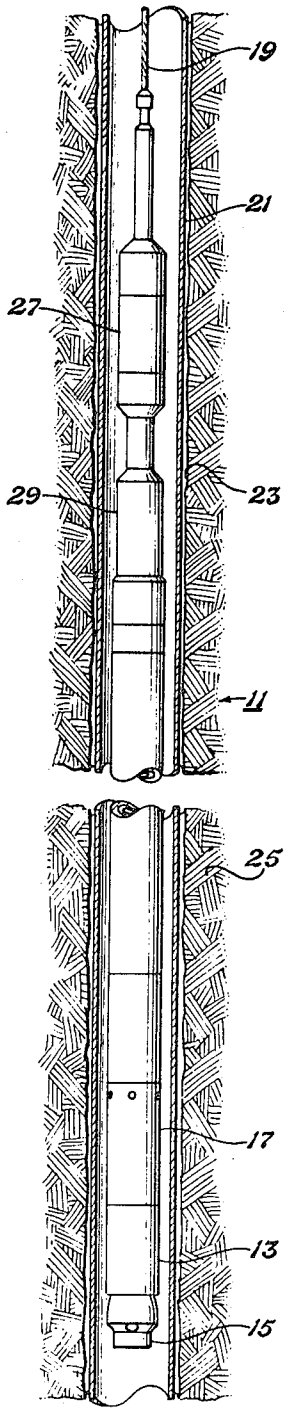


Fig. 1

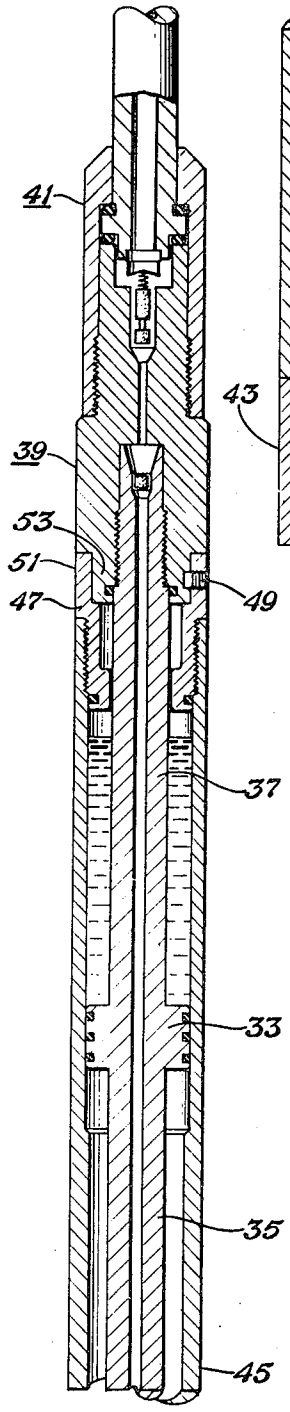


Fig. 2

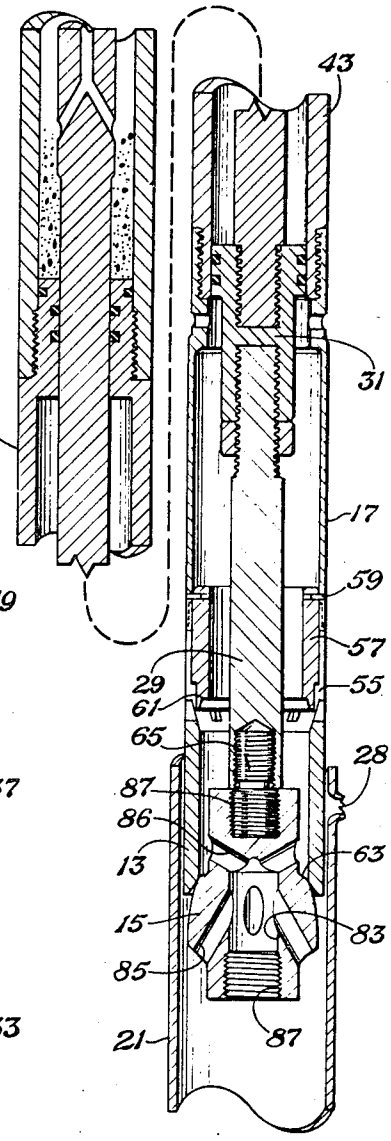


Fig. 3

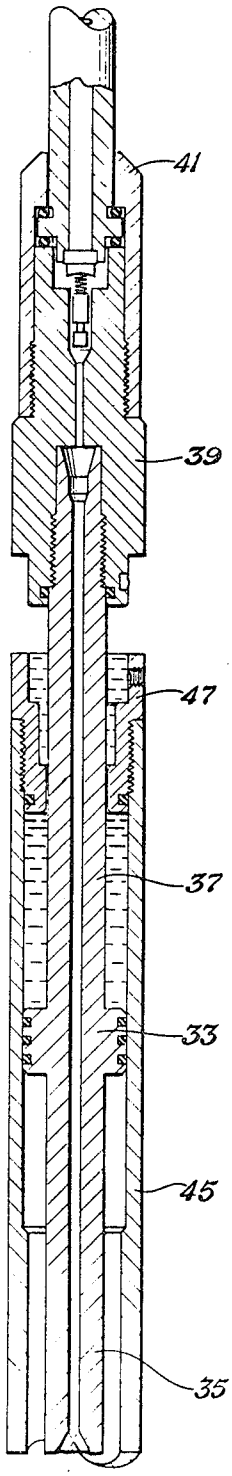


Fig.4

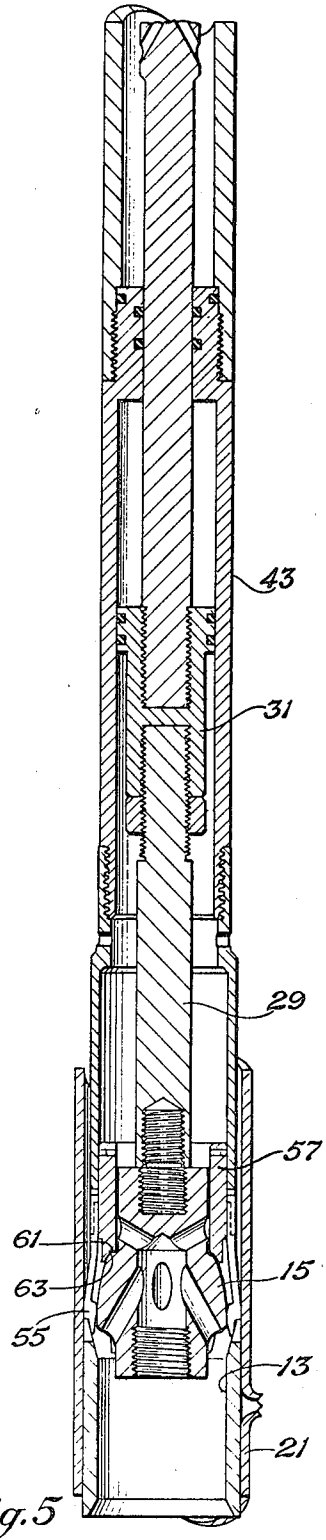


Fig.5

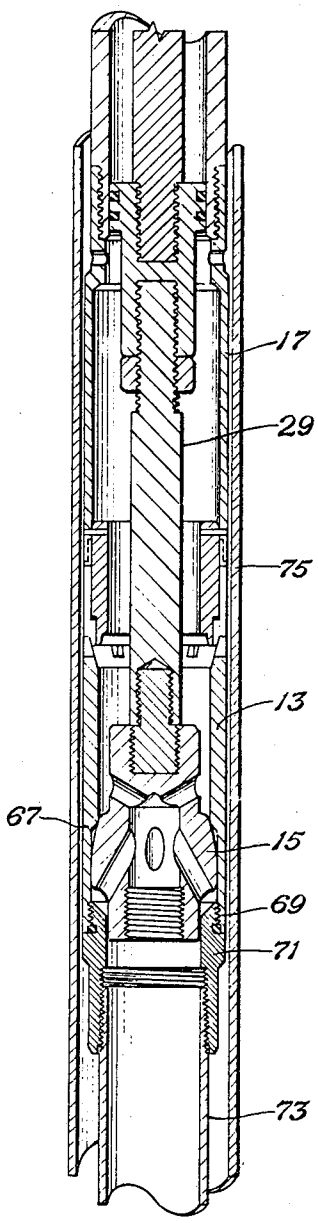


Fig.6

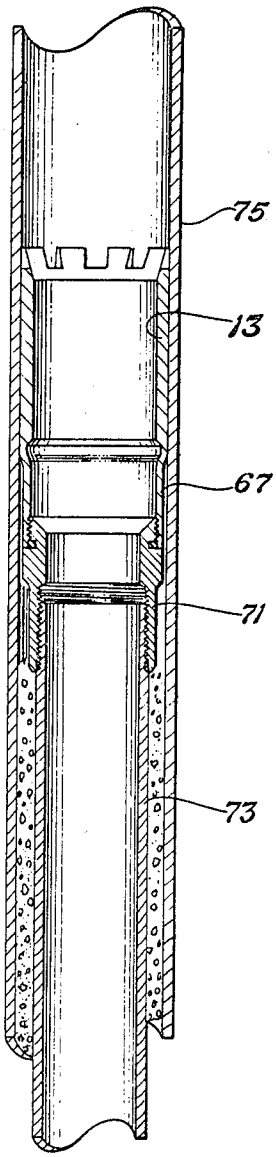


Fig. 7

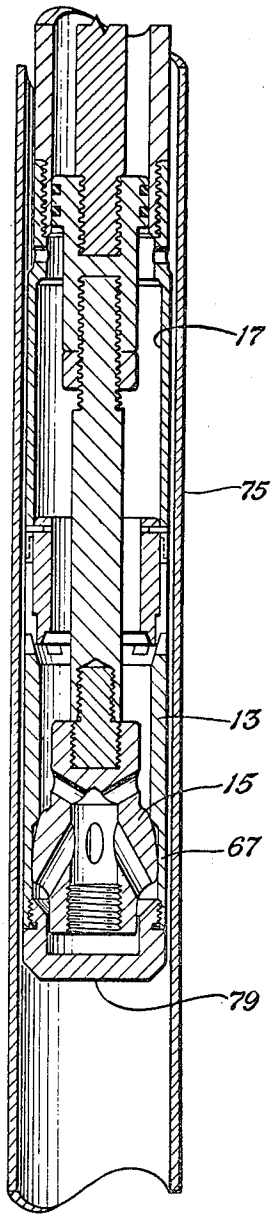


Fig. 8

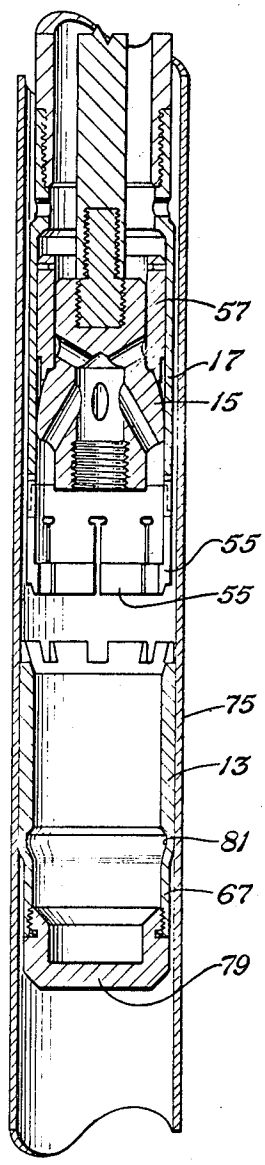


Fig. 9

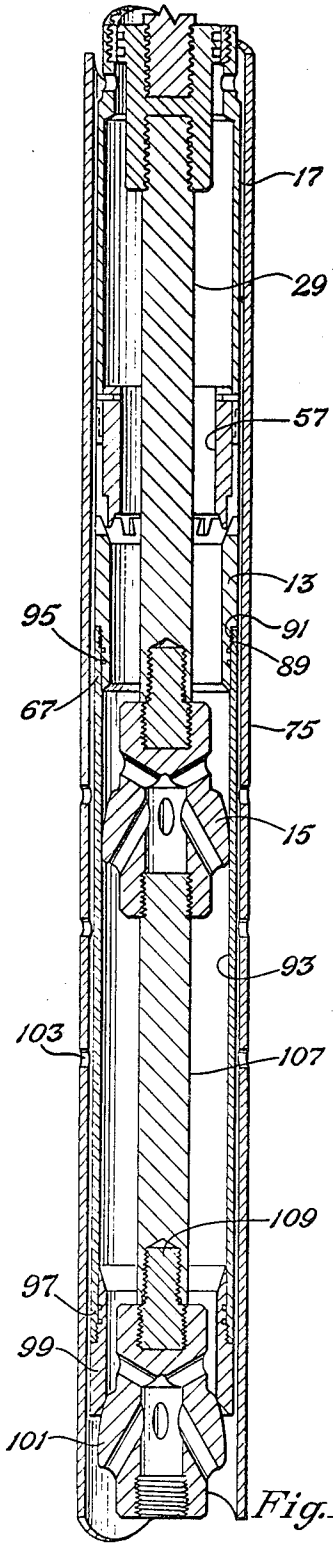


Fig. 10

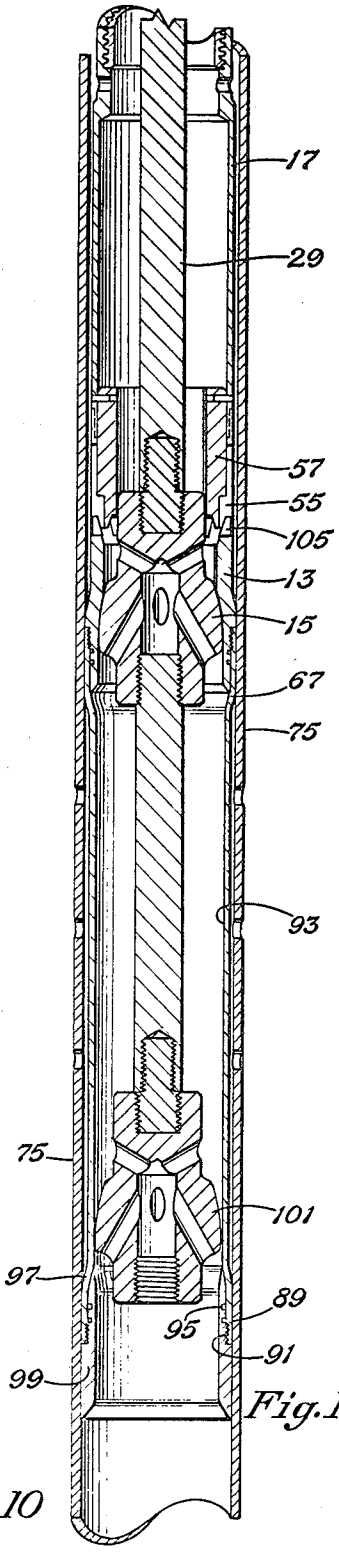


Fig. 11

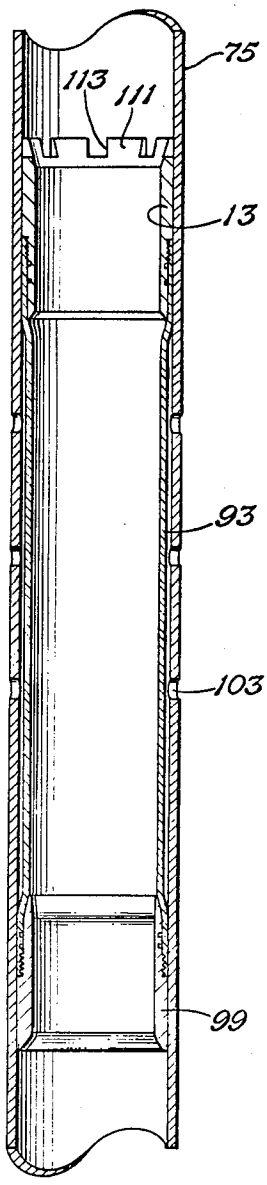


Fig. 12

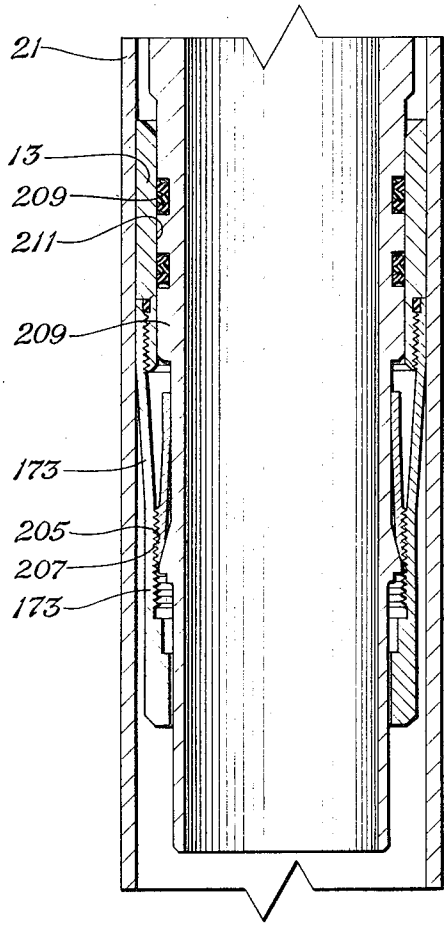


Fig. 18

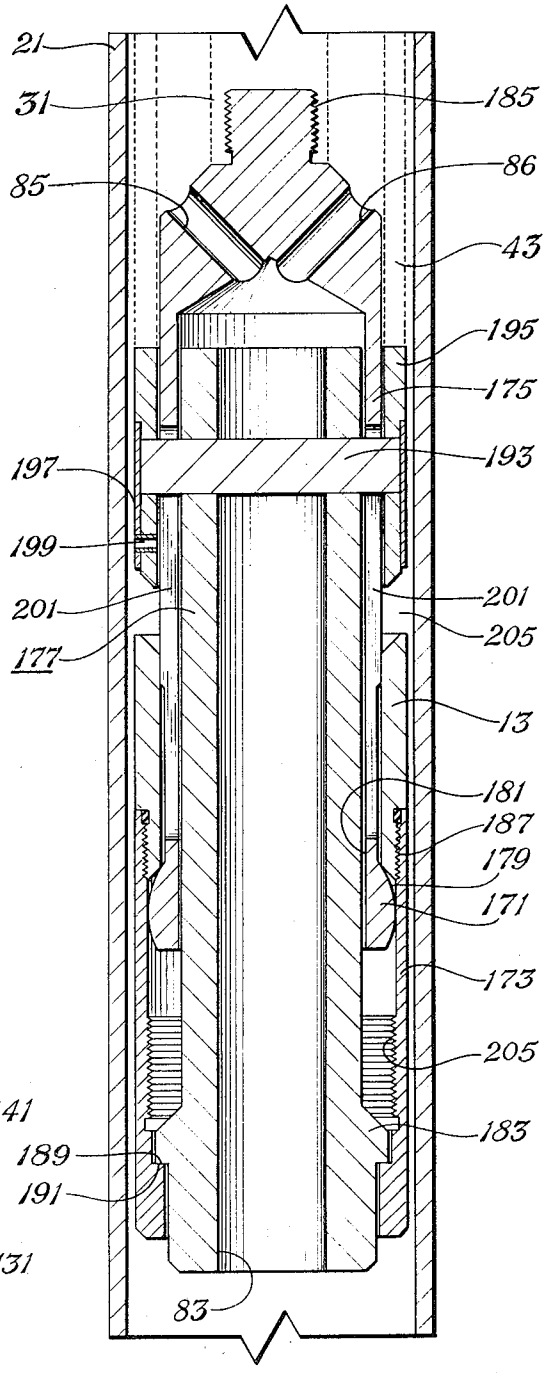


Fig. 17

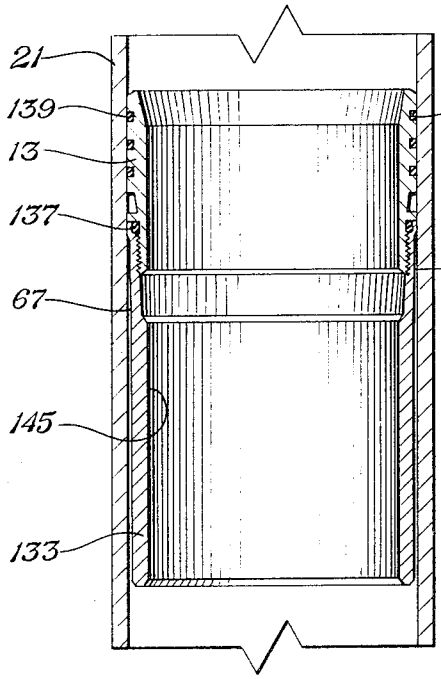


Fig. 13

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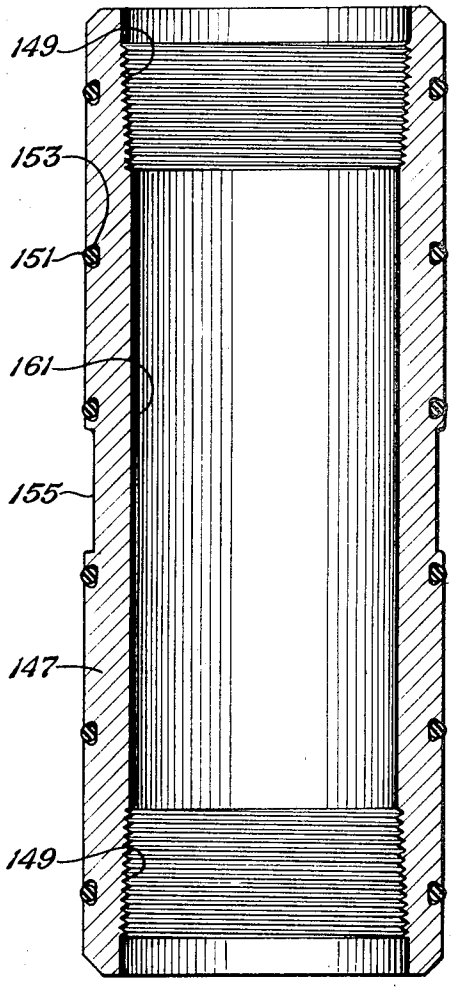


Fig. 14

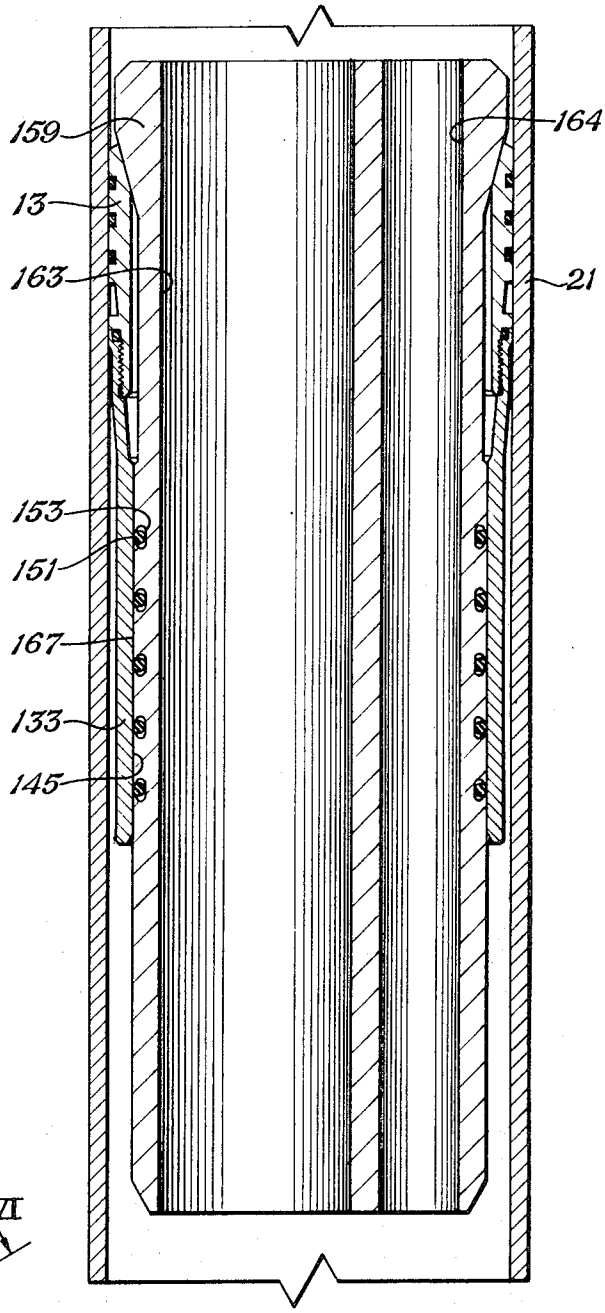


Fig. 16

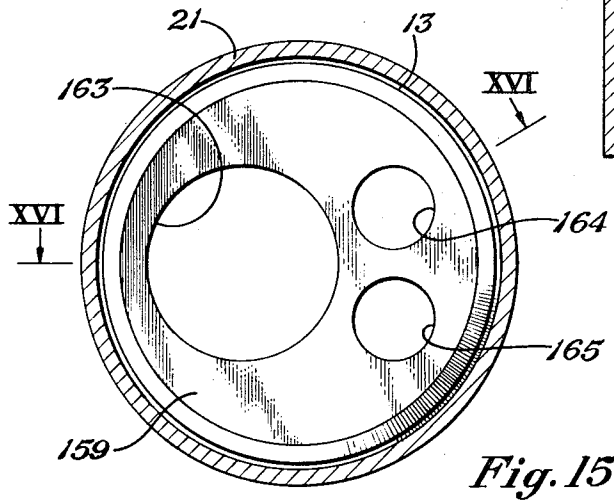


Fig. 15

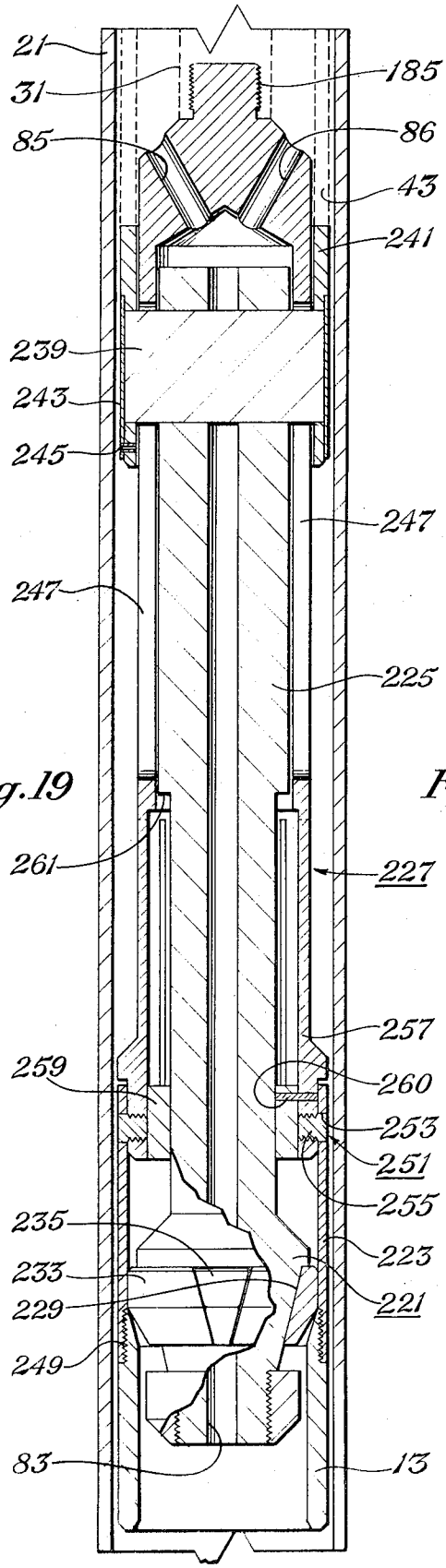


Fig.19

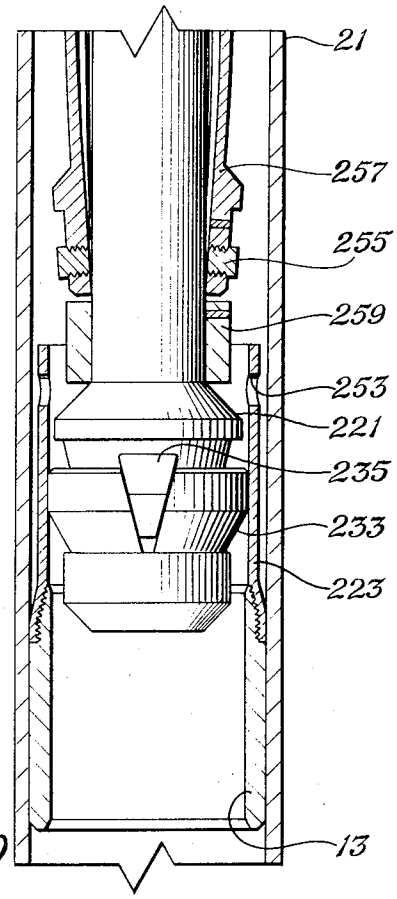


Fig.20

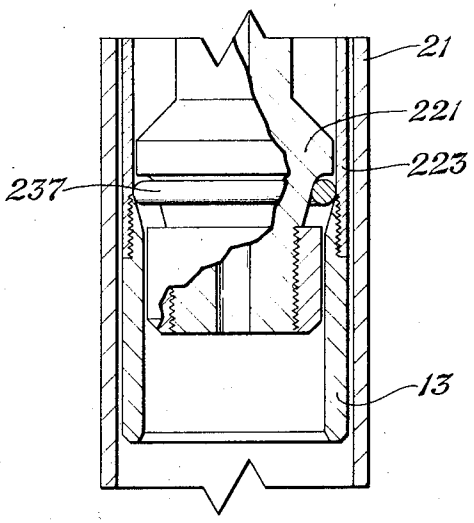


Fig.21

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CONDUIT LINER FOR WELLBORE AND METHOD AND APPARATUS FOR SETTING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 878,108, filed Nov. 19, 1969, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods and apparatus for use in a well penetrating subterranean formations. More particularly, it relates to methods, liners and combinations of apparatus employing a liner in casing or tubing in an oil well or the like.

2. Description of the Prior Art

The prior art is replete with practical and impractical liners, and methods and apparatus for setting the liners in the casing or tubing in a well. As is well known, the liners are ordinarily set by being expanded outwardly into tight frictional engagement with the conduit; such as, the casing or the tubing. The degree and type of tight frictional engagement depends, of course, on the use, or application, for which the liners are intended. For most applications, the liners are set with a tightness that prevents unwanted movement longitudinally of the conduit. Frequently, the liners are set with both tight frictional and sealing engagement, as will be apparent from a description of specific embodiments hereinafter. The tight frictional engagement provides a finite force that is designed for retaining the liner in place to do its job. Obviously, forces larger than design can be generated that are large enough to move the set liner longitudinally of its conduit. Liners or plugs have been set in a well by detonation of explosives within an enclosed chamber, or about a mandrel within a conduit; bridge plugs have been set by drawing a mandrel up within an expansible annular body and leaving the mandrel emplaced within the annular body, and by driving an expanding body upwardly or downwardly into and through an expansible body retained in position by a supplemental anchor or support means; such as, a tubing stop or a string of conduit supported on a bottom of the well. Liners have been set by hydraulically forcing a swaging mandrel, or swage means, upwardly through corrugated liners held in place by the tubing string. Liners have also been set by jarring by repeated firing of an explosive jar brought to the surface and reloaded between firings and by explosively driving a swage means upwardly or downwardly through a corrugated liner held in place by a frangible member with a second explosive charge within the frangible member to destroy it. While some of the prior art devices have been useful, they have suffered from one or more of the following disadvantages:

1. they depended upon a separate supplemental support which had to engage the conduit and had to be individually set in the well for satisfactory operation, the supplemental supports were often unreliable and even if successful effected a surface discontinuity that created corrosion problems later;

2. they depended upon an outside coating of resilient material for effecting the sealing;

3. they required two parts; such as, an inner mandrel for setting and retaining in place;

4. they were limited to thin walls because of the relatively large flexure of certain corrugations in the walls;

5. they had regions of relatively low yield strength because of the large amount of flexure induced by corrugations;

6. the resulting structure emplaced in the well-bore had a restricted aperture that was not as smooth as desired therethrough;

7. if they formed seats with a smooth internal diameter they were limited to seating at joints;

8. they required a separate string of pipe for operation; for example, either for rotating or jarring a tool or for conveying a high pressure fluid thereto;

9. they required a plurality of trips into the well to effect passage of the swage means completely through the liner;

10. they destroyed a portion of the equipment and sometimes damaged other equipment in the well by an uncontained explosion; or

11. they employed in the liner materials that were objectionable because of their physical, chemical, or electrochemical properties; for example, they formed galvanic, or electrolytic, cells with the conduit, thereby causing localized corrosion.

It is a primary object of this invention to provide an improved method of and combinations of apparatus for setting a liner in a conduit in a wellbore penetrating subterranen formations that alleviate the disadvantages of the prior art devices and methods, as enumerated hereinbefore.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic elevational view of the liner and apparatus for setting it in a casing in a well penetrating subterranean formations, in accordance with one embodiment of the invention.

FIGS. 2 and 3 are fragmentary longitudinal sectional views of, respectively, the upper and lower parts of the device of FIG. 1, showing the device in one operative position.

FIGS. 4 and 5 are fragmentary longitudinal sectional views of, respectively, the upper and lower parts of the device of FIG. 1, showing the device in another operative position.

FIGS. 6 and 7 are fragmentary longitudinal sectional views illustrating another embodiment of the invention employed in hanging a production liner within a casing in a well.

FIGS. 8 and 9 are fragmentary longitudinal sectional views of another embodiment of the invention employed in emplacing a bull plug seal means in a casing in a well.

FIGS. 10, 11 and 12 are fragmentary longitudinal sectional views illustrating another embodiment of the invention employed in emplacing a straddle patch in a casing in a well.

FIG. 13 is a fragmentary longitudinal sectional view of another embodiment of this invention employed in emplacing a seal sub in a casing in a well.

FIG. 14 is an elevational cross sectional view of a seal nipple for emplacing in the seal sub of FIG. 13.

FIG. 15 is a cross sectional view of a multiple bore packer emplaced in the embodiment of FIG. 13.

FIG. 16 is a fragmentary longitudinal sectional view taken along the line XVI — XVI of FIG. 15.

FIG. 17 is a fragmentary longitudinal sectional view illustrating another embodiment of this invention wherein the liner is disposed above both the swage means and the setting sleeve means.

FIG. 18 is a fragmentary longitudinal sectional view of the embodiment of FIG. 17 containing a seal unit and emplaced in the conduit in the well.

FIG. 19 is a fragmentary longitudinal sectional view illustrating another embodiment of this invention wherein the liner is disposed below both the swage means and the setting sleeve means.

FIG. 20 is a fragmentary longitudinal sectional view of the embodiment of FIG. 19 after the liner has been expanded into tight frictional engagement with the conduit in the well.

FIG. 21 is a fragmentary longitudinal sectional view illustrating another construction of the swage means of the embodiment of FIG. 19.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, FIG. 1 illustrates a setting tool device 11, having liner 13 disposed between swage means 15 and setting sleeve means 17, all suspended from a wire line 19 at a given depth in a section of casing 21 in wellbore 23 penetrating subterranean formations 25. A collar locator and cable head assembly 27 is ordinarily included to facilitate accurate emplacement of the liner and withdrawal of the setting tool device.

The setting tool device which is illustrated in cross section in FIGS. 2 and 3 is described in detail in U. S. Pat. No. 3,186,485, "Setting Tool Devices," Harrold D. Owen. Reference is made to that patent for a detailed description of the operation of the setting tool. Broadly, the setting tool is a type of force generating means wherein a piston assembly and a cylinder assembly are powered for movement relative to each other by an ignitable charge in the tool. Briefly, setting tool device 11 includes fluid actuated means comprising a head assembly including igniter means, a cylinder assembly and a piston assembly within the cylinder assembly, with the piston assembly being slideable relative to the cylinder assembly; and means including a combustion chamber adapted for receiving a combustible material power charge and disposed within the cylinder assembly for imparting motion to the cylinder assembly relative to the piston assembly to move the swage means upwardly through the liner, movement of which is opposed by the setting sleeve means. For ease of explanation the setting tool is illustrated herein as having its piston assembly connected with the swage means and its cylinder assembly connected with the setting sleeve means. Adapter means are available to effect the converse connection in which the cylinder assembly is connected with the swage means and the piston assembly is connected with the setting sleeve means if desired.

Referring to FIGS. 2 and 3, liner 13 is accurately positioned at a given depth; for example, by use of collar locator 27. The given depth may include a section of casing 21 having a leak such as formed by an aperture 28 therein. Liner 13 includes an annular body portion having interior and exterior surfaces that define cylinders that are at least partially coextensive. The body portion has an outside diameter less than the diameter of the casing, or conduit; has sufficient malleability for and is adapted for being expanded to conformingly engage the casing; and has a wall thickness sufficient to effect a wall after expansion capable of withstanding differential pressure between the inside and outside of the casing. The body portion of the liner has a modulus of elasticity in compression sufficient to retain tight frictional engagement with the conduit after being expanded thereagainst and prevent being displaced upwardly or downwardly by forces normally expected to be imposed on the liner. The liner 13 is disposed adjacent a swage means 15 for being expanded outwardly into tight frictional engagement with the conduit such as the casing in the well; and is disposed adjacent a setting sleeve means 17 for holding the liner at the desired setting depth against the force of the swage means 15 as the swage means 15 is forced through the liner. As illustrated, the liner 13 is disposed between swage means 15 and setting sleeve means 17. Expressed otherwise, swage means 15 is disposed below liner 13 for moving through and expanding the liner outwardly and into contact with the casing, the external dimensions of the swage means having been preselected in accordance with the internal dimensions of the casing and the diameters and wall thickness of the liner to effect the necessary frictional engagement and the necessary thickness of the wall after expansion into engagement with the casing.

An adapter rod means such as adapter rod 29, FIG. 3, is provided for connecting the swage means 15 with a force generating means such as the setting tool device 11. As illustrated in FIG. 3, adapter rod 29 passes through the liner 13, is connected at one end portion with swage means 15 and is adapted for connection at the other end with a force generating means for subjecting the swage means to a force acting upwardly for pulling the swage means upwardly through the liner.

Setting sleeve means 17 is disposed radially of the central axis of the adapter rod 29. As illustrated, the setting sleeve means 17 encircles the adapter rod 29 and has its lower end portion engaging the top of the liner and being adapted at its upper end portion for connection with the force generating means for opposing upward movement of the liner by transmission of a downwardly acting reactive force from the force generating means.

When setting tool device 11 is employed as the force generating means, adapter rod 29 is connected at its upper end with bottom piston 31 of the piston assembly of setting tool device 11. Setting tool device 11 also includes a top piston 33, a top piston connecting rod 35, a top piston extension rod 37, and a firing head 39 surmounted by a quick change assembly 41. Setting sleeve means 17 is connected with bottom cylinder 43 of the cylinder assembly of setting tool device 11. The cylinder assembly also includes top cylinder 45 and top sub 47.

A shear plug 49, having a predetermined shear value, is threadedly inserted into matched holes in the upper cylindrical portion 51 and lower body portion 53. Upon ignition of the ignitible charge in the setting tool, shear plug 49 is sheared and a force generated to pull swage means 15 through liner 13. Movement of liner 13 is opposed by the downwardly acting reactive force via the cylinder assembly and setting sleeve means 17 and

another operative position, illustrated in FIGS. 4 and 5, is assumed as the swage means 15 is pulled through liner 13 to expand it out into frictional and sealing engagement with casing 21.

Specifically, setting sleeve means 17 expandibly engages the top of the liner via expander means; such as, flexible spring fingers 55. The flexible spring fingers 55 are ordinarily of steel. The flexible spring fingers 55 retain the liner in place during setting but are adapted to flex outwardly to allow passage of the swage means therethrough, as illustrated in FIG. 5 and spring back into position after the swage means has passed therethrough.

To allow the flexible spring fingers to transmit the reactive force and oppose the force pulling swage means 15 through liner 13, an expander support ring 57 is employed in the setting sleeve means 17 and is held in place adjacent liner 13 and within the flexible spring fingers with a shearable means; such as, shear pins 59; for supporting the fingers during the interaction of the large force and reactive force pulling the swage means through the liner. Expander support ring 57 has an annular shoulder 61 for conformingly engaging a shoulder portion 63 of the swage means after the swage means has passed through the liner for moving the expander support ring upwardly as the swage means passes upwardly out of the liner.

The swage means is connected with the adapter rod by a tension release portion 65 having a weak point to facilitate removal of the setting tool device in the event malfunction occurs to prevent removal of the liner and the swage means.

Swage means 15 is illustrated as a ball swage in which the exterior surfaces form a circle such that upon being pulled through liner 13 an interior cylindrical surface is generated. Any other swage means capable of generating a smooth, cylindrical interior surface and having the requisite strength to expand liner 13 out against the conduit with the force available in the force generating means can be employed.

Swage means 15 contains a central passageway 83 and branch passageways 85 and 86 to facilitate flow of fluids therethrough. In this way the liner and the setting apparatus can be run rapidly down casing 21 to reach the proper depth more quickly. Swage means 15 contains threaded apertures 87 at each end for receiving a tension release portion 65 and allow interconnecting it with adapter rod 29, as well as other adapter rods. Threaded aperture 87 is merely illustrative of a satisfactory interconnection means. Any other interconnection means can be employed if desired.

As can be seen in FIGS. 4 and 5, when the combustible charge is nearly spent, the piston assembly including bottom piston 31, top piston 33, top piston connecting rod 35, and top piston extension rod 37; firing head 39, and quick change assembly 41 will have moved upwardly with respect to the cylinder assembly including bottom cylinder 43, top cylinder 45 and top sub 47. As swage means 15 moves out of the top portion of liner 13, its shoulder portion 63 engages annular shoulder 61 of expander support ring 57, shearing shear pins 59 and moving expander support ring 57 upwardly. Spring fingers 55 move outwardly to allow swage means 15 to pass therethrough, retaining engagement with the top edge of liner 13.

The liner is placed in the well by the following procedure. The liner and its setting apparatus, setting tool and any accessory equipment are inserted through conventional wellhead and lubricator equipment; and lowered to the desired depth on wire line 19. As indicated hereinbefore, once the liner is accurately positioned at the desired depth in the conduit in the well the force generating means comprising an ignitable charge in the setting tool is actuated, thereby, normally in a single stroke, pulling the swage means upwardly through the liner and expanding the liner outwardly into physical contact with the conduit with sufficient force to retain it in place. In detailed operation, as relative longitudinal movement starts to occur between the liner 13 and the swage means 15 in response to the upwardly and downwardly acting forces from the force generating means, the liner is forced outwardly to engage the casing 21. The engagement of the liner 13 with the casing 21 stops downward movement of the liner, obviating the need for an anchor of any sort. Thereafter, for all practical purposes, the force of the setting tool is directed to pulling the swage means 15 upwardly through the liner 13 which has been immobilized in tight frictional engagement with the casing 21. Following the setting operation, the setting tool, the swage means and the setting sleeve means and accessories are removed from the well, leaving the liner in place having an unusually large aperture penetrating longitudinally therethrough.

The liner remaining emplaced in the casing has uniform crystallographic structure since it has been substantially uniformly expanded outwardly to engage the casing, or other conduit, into which it is emplaced. The liner has a smooth bore which will serve as a seat against which to seal other elements.

The liner may be formed of any material having the requisite malleability and modulus of elasticity in compression after expansion against the conduit. Ordinarily, the liner will be a metallic liner. For example, alloys of copper, magnesium, aluminum or iron may be employed. The soft steels form satisfactory liners, since they have the requisite properties and do not set up any galvanic cells, regardless of the fluid in the conduit or outside the conduit in the well. A surprising and particularly preferred material of construction is commercially pure iron such as is employed in magnetic ingots for making iron cores of electromagnets, relays, and the like. The commercially pure iron is a highly refined open hearth grade of low-carbon, low-manganese iron. It has less than one percent by weight of alloy constituents, or other elements, and is described in detail in our co-pending application Ser. No. 166,032 entitled "-Conduit Liner for Wellbore," filed July 26, 1971.

When softer metals; such as, aluminum, magnesium, or alloys of copper; are employed as the body portion of the liner, it is preferable to include a top portion integrally connected with the body portion. The top portion should have a plurality of notches in its top edge to afford niches into which the metal can extrude when the swage means is pulled upwardly through the body portion of the liner. In this way, the metal does not extrude between the spring fingers of the setting sleeve.

When the liner is to be employed as other than a patch for the conduit, it is preferable to include integrally connected with the body portion of the liner a

top portion that has an inner inverted frusto-conical section to form a stabbing section to facilitate entry of other elements into the liner once emplaced in the well.

If desired, a coating of a supplementary material may be employed on the exterior surface of the liner to facilitate effecting a seal with the conduit into which the liner is emplaced. When such an external coating is employed, care should be taken that the material of which the coating is made does not extrude from between the liner and the conduit under the differential pressures that may exist thereacross and that the material is not soluble in fluid in contact with it so as to be dissolved from between the liner and the conduit.

In other embodiments, the liner can be employed with a connector means for connecting with a terminal element. The connector means is connected at one of its ends with the body portion of the liner and at the other of its ends with the terminal element. The terminal element may comprise conventional or newly developed downhole equipment; and, typically, includes equipment such as a production liner; a bull plug seal means; a seal sub for a seal nipple or packer; or an intermediate conduit of a straddle patch. Preferably for most downhole applications, the connector means is sealingly connected with the liner and with the terminal element; and has an expansible portion for retaining the sealing interconnection after the body portion of the liner has been expanded outwardly into tight frictional engagement with the conduit in the well. The connector means may be connected with either the top or the bottom of the respective liner, as most expeditious in connecting with the terminal element. The connector means may be connected with the terminal element by conventional means; such as, a threaded connection; or by an expansible portion, depending upon the nature of the terminal element. The connector means may be integral with or carried by either the terminal element or the liner, or it may be detachably connected with either or both, as by threaded connection. A variety of typical connector means are illustrated in the figures hereinafter referred to and the accompanying descriptive matter.

Referring to FIG. **6**, liner **13** is connected at its lower extremity with connector means **67**. The expansible connector portion of the connector means **67** is illustrated as being integrally formed with liner **13**. If desired, and as implied hereinbefore, it may be affixed by any suitable expansible joint; for example, it may be thermally joined thereto; as by welding, or silver soldering. At its other end, or lower end portion **69**, connector means **67** may be threaded to facilitate joining with sub **71** onto which at least a section **73** of a production liner is affixed. While threaded connections between connector means **67**, sub **71** and production liner **73** are illustrated, any suitable means can be employed for such interconnection.

The liner **13** of FIG. **6** is arranged and emplaced similarly as described hereinbefore. Specifically, the liner **13** is disposed between swage means **15** and setting sleeve means **17** for accurate placement within the conduit when swage means **15** is pulled through liner **13**. The adapter rod **29** is connected with a force generating means for pulling swage means **15** through liner **13** and setting sleeve means **17** is connected with the force generating means for imparting an opposing, or reactive, force to retain the liner accurately positioned and oppose its being displaced upwardly by the movement of swage means **15** therethrough. The force generating means is actuated to pull swage means **15** through liner **13** and expand it out into frictional and sealing engagement with conduit **75** which may be the same as casing **21**. The force generating means pulls swage means **15** through liner **13**, effecting simple, rapid, long lasting emplacement of the liner. Thereafter, the force generating means, swage means **15**, and setting sleeve means **17**, as well as the intermediate connections, are removed from the well.

FIG. **7** illustrates the liner **13** expanded into place against conduit **75**, the connector means **67** with its upper expansible portion expanded with liner **13**, the sub **71**, and the production liner **73** emplaced in a conduit **75** in the well-bore. The production liner may be employed as a sand screen, or in connection with a gravel pack. Such production liners are frequently employed in wells operating under secondary recovery techniques; such as, flooding or thermal recovery. While the liners are ordinarily of steel, in certain instances, such as thermal recovery, they may be of stainless steel, titanium or other oxidation resistant metals or metallic alloys. The tough metals such as titanium require greater forces in setting, however, when they are employed in liner **13**. Production liners are well known in the technology of producing oil from subterranean formations and need not be described in great detail herein.

When emplaced with liner **13**, the production liner does not move downwardly from its own weight. Neither is it moved upwardly by any pressure differential. Ordinarily, there is relatively small differential pressure between the inside and the outside of a production liner.

FIG. **8** illustrates liner **13** and connector means **67** employed to support a bull plug seal means **79** within conduit **75** inside a wellbore. In this embodiment of the invention, the liner is run downwardly through conduit **75** relatively slowly to allow fluids within the conduit to flow past the bull plug seal means **79** and liner **13**. Threaded connections are illustrated as the means by which bull plug seal means **79** is connected with the connector means **67**. Any other suitable means may be employed to interconnect the two.

After the desired depth has been achieved in the wellbore, operation of the setting apparatus is effected by actuation of the force generating means as described hereinbefore. Upon actuation of the force generating means, swage means **15** is pulled upwardly through liner **13**, expanding the liner outwardly and into frictional and sealing engagement with conduit **75**. Setting sleeve means **17** is also connected with the force generating means for opposing the relatively upward movement of swage means **15** with downwardly acting reactive force to retain liner **13** at the desired depth in conduit **75** for emplacement.

FIG. **9** illustrates the liner **13** emplaced in conduit **75**, the upper, or expansible, portion **81** of connector means **67** being expanded outwardly to accommodate the increased diameter of liner **13**, and the lower portion retaining the original diameter and threadedly and sealingly connected with bull plug seal means **79**.

In FIG. 9 spring fingers 55 are seen clearly after swage means 15 has passed upwardly therethrough, moving expander support ring 57 upwardly from within fingers 55. Setting sleeve means 17, swage means 15, as well as the remainder of the force generating means are removed from conduit 75 to leave bull plug seal means 79 firmly emplaced via liner 13 in conduit 75. Liner 13 sealingly and frictionally engages conduit 75 with sufficient force to prevent movement of bull plug seal means 79 upwardly or downwardly by the force of any differential pressure across it normally expected to be encountered. Such differential pressure may be appreciable since the purpose of the bull plug seal means is for isolating a zone of a particular fluid pressure from the remainder of conduit 75. For example, the differential pressure may run as high as 1000 to 3000 pounds per square inch, or higher. It is apparent, therefore, that the frictional engagement of liner 13 with conduit 75 must resist displacement with a large frictional force. In some instances where a large differential pressure is expected, the force generating means may generate a force sufficient to expand the liner outwardly to the extent that conduit 75 is also distorted slightly to increase the force resisting movement upwardly or downwardly.

FIG. 10 illustrates another embodiment of the invention in which the connector means 67 is sealingly connected with liner 13, includes an elongate sleeve portion 93, and is sealingly connected at its other end with the annular body portion of a second liner 99 to form a straddle patch for emplacing in the conduit for blocking a communicating passageway between the interior of the conduit 75 and the exterior of the conduit 75.

Specifically, liner 13 is threadedly connected with the connector means 67 via an expansible portion comprising conforming threaded section 89 and 91, and sealing means; such as, O-rings 95; that are employed to ensure that liner 13 is sealingly connected with connector means 67 after expansion.

Similarly, the lower end portion 97 incorporates threaded sections 89 and 91 with O-rings 95 to form a second expansible portion 97 that sealingly connects the connector means 67 with the second liner 99. As illustrated, the connector means 67, incorporating its elongate sleeve portion 93 and two expansible portions, is connected with the bottom of the top liner 13 and the top of the bottom liner 99 to form the straddle patch.

Swage means 15 is connected with a second swage means 101 below second liner 99. Second swage means 101 has a diameter slightly less than the diameter of swage means 15 so that it will freely pass through the aperture left in liner 13 by the passage of swage means 15 therethrough. Moreover, the diameter of the second swage means 101 and the diameters and wall thickness of second liner 99 are selected so that they cooperate to effect sealing engagement of second liner 99 with conduit 75 when second swage means 101 is drawn upwardly through second liner 99 expanding it outwardly into sealing and frictional engagement with conduit 75.

It is important that the swage means pass through the associated liners to expand them outwardly into engagement with conduit 75 singly rather than simultaneously. In this way, setting sleeve means 17 is not required to supply the large force that would be required by simultaneous passage of both swaging means through both liners. It is not critical which swage means is pulled through its associated liner first.

As illustrated, second swage means 101 is immediately below and contiguous with second liner 99 and swage means 15 is spaced a distance below liner 13 sufficient to enable second swage means 101 to transverse through second liner 99 before swage means 15 starts its traverse of liner 13.

Swage means 15 is connected via adapter rod 29 with the force generating means and setting sleeve means 17 is connected with the force generating means as described hereinbefore.

Swage means 15 is connected with second swage means 101 by a second adapter rod 107 and a second tension release means 109. Second tension release means 109 enables removal of the portion of the apparatus thereabove in the event there is a malfunction which prevents removal of the second swage means from the conduit 75 within the well.

The straddle patch formed by the two liners and the intermediate second conduit will straddle passageways 103 communicating with an undesired strata by emplacing the straddle patch at the appropriate depth in conduit 75.

The force generating means is actuated to pull second swage means 101 through second liner 99 and swage means 15 through liner 13.

An intermediate position in which second swage means 101 has passed through second liner 99 and in which swage means 15 is in the process of being passed upwardly through liner 13, is illustrated in FIG. 11. Therein, second liner 99 has been expanded outwardly to sealingly and frictionally engage conduit 75. Lower expansible end portion 97 of connector means 67 has been expanded with the body portion of second liner 99. The conforming threaded sections 89 and 91 are expanded outwardly to retain sealing engagement. O-rings 95 also retain sealing engagement and ensure there is no leakage.

It may be advantageous to employ a connector means wherein the elongate sleeve portion 93 is threadedly and sealingly connected at each end portion to the respective expansible portions, in the manner as sub 71 was engaged in FIG. 6. In this way, the threaded sealed portions of the connector means are not expanded, thus lessening the chances of a leak.

As swage means 15 is pulled upwardly through liner 13, spring fingers 55 engage the top portion 105 of the liner and resist its being displaced upwardly. Moreover, as swage means 15 passes through the lower portion of the liner 13 and the upper portion of connector means 67, they are expanded outwardly to frictionally and sealingly engage a portion of conduit 75, and help to retain the liner in place. Expander support ring enables spring fingers 55 to withstand the large force engendered by the interaction between the upward acting force on adapter rod 29 and the downward acting reactive force on setting sleeve means 17 without bowing or otherwise distoring.

FIG. 12 illustrates the straddle patch emplaced within conduit 75. Therein, liner 13 and second liner 99 are sealingly and frictionally emplaced in conduit 75 and co-act with connector means 67 to effect a straddle patch which isolates passageway 103 from the interior

of conduit **75**. Liner **13** has a stabbing section **111** comprising an inverted frusto-conical section. As illustrated, top portion **111** has notches **113** to allow room for extrusion of metal thereinto during the passage of the swage means through liner **13**. Notches **113** are not ordinarily necessary in second liner **99** since there are no adjacent spring fingers **55** into which metal will extrude. Moreover, extrusion of metal in second liner **99** by passage of second swage means **101** therethrough, is of less significance than at the top of liner **13**.

A variety of other applications, or uses, of the liner **13** will be apparent once this invention becomes known. Illustrative of such other uses is the use of a seal sub as the terminal element, the seal sub being used to sealingly receive a "large bore packer," or the like. The term "large bore packer" is used in its broad sense to include single bore packers and similar devices such as seal nipples, as well as packers having a plurality of bores. The liner **13** connected via connector means **67** having an expansible portion **131** with a seal sub **133** is illustrated emplaced in casing **21** in FIG. **13**. The connector means is connected with the body portion of the liner **13** via threaded connection **135** and suitable sealing means **137**; such as, an O-ring in an annular recess. On the other hand, the connector means **67** is integrally formed with the seal sub **133**. As illustrated, the liner **13** contains suitable seal means **139** for ensuring a fluid impermeable interconnection between it and the casing **21**. For example, the seal means **139** may comprise a plurality of O-ring type seals disposed in grooves **141** extending peripherally around the liner **13**. The seal sub **133** has a seal surface **145** defining an internal bore and extending longitudinally thereof. The seal surface **145** is provided with a smooth finish for sealing engagement with the seal nipple, packer, or the like, that it is to sealingly receive.

A seal nipple **147** suitable for emplacing within the seal sub **133** is illustrated in FIG. **14**. The seal nipple **147** is provided with a top and bottom connection means such as female threads **149** for sealingly receiving male threads on a compatible element; such as, a joint of pipe in a string of conduit. In this way, the joint of pipe, or conduit, may be screwed into the seal nipple **147** and lowered until the seal nipple **147** is emplaced within the seal sub **133**. If desired, suitable seal means **151** such as O-ring type seals may be emplaced in grooves **153** extending peripherally around the seal nipple **147**. An undercut portion **155** is provided for being gripped with a wrench or the like in order to hold the seal nipple **147** while screwing the respective joints of pipe into the threads **149**, or for other purposes.

A packer **159** emplaced in the seal sub **133** is illustrated in FIGS. **15** and **16**. Whereas the seal nipple **147**, FIG. **14**, had a single aperture **161**, the packer **159** has a plurality of apertures **163–165** for receiving respective strings of conduit such as tubing and spaghetti strings. Such supplemental strings of conduit may be necessary in the production of a plurality of zones or in operating supplemental downhole equipment such as gas lift valves or gas operated devices in which the gas is injected through the spaghetti strings. On the other hand, the spaghetti strings may be employed for injection of chemicals; such as, corrosion inhibitors; paraffin deposition suppression chemicals; or the like. In any event, the packer has a sealing surface **167** for being disposed adjacent the seal surface **145** of the seal sub **133**. If desired, suitable seal means **151** may be provided also in the body of the packer **159**. The seal means **151** may be disposed in suitable grooves **153** extending peripherally around the body of the packer **159**, similarly as described with respect to the seal nipple **147**.

In operation, the liner **13** is set in the casing **21** as described hereinbefore. Specifically, the liner is emplaced at the desired depth and the setting tool activated to pull the swage means upwardly through the liner to expand it out into tight frictional engagement with the casing **21**. The expansible portion of the connector means **67** expands outwardly to retain sealing engagement with the liner **13** as it is expanded. Consequently, the seal sub **133** is sealingly connected with the liner **13**. When the respective elements such as the seal nipple **147** or the packer **159** is thereafter emplaced sealingly within the seal surface **145** of the seal sub **133**, there is a fluid impermeable block formed; although fluid may flow through the bores of the respective apertures within the element so emplaced. The bores **163–165** may have conduits sealingly emplaced within them so that the conduits define the flow passageways, whereas the single aperture **161** of the seal nipple **147** may define the flow passageway therethrough.

While the straddle patch illustrated in FIGS. **10–12** employed a unitary elongate sleeve portion **93**, the sleeve portion may comprise a plurality of joined sections, if desired.

In the embodiments illustrated and described hereinbefore, the liner has been shown above the swage means and below the setting sleeve means to facilitate expansion of liner outwardly into the conduit by drawing the swage means upwardly therethrough. If desired, the liner may be disposed either above both the swage means and the setting sleeve means or below both the swage means and setting sleeve means.

For example, FIGS. **17** and **18** illustrate an embodiment in which the liner **13** is disposed above both swage means **171** and setting sleeve means **173**. In FIG. **17** the combination comprises, in addition to the swage means **171** and the setting sleeve means **173**, adapter rod means **175** and thrust means **177** for effecting the desired interconnection between the respective elements of a force generating means such as setting tool device **11** and the swage means **171** and setting sleeve means **173**.

The swage means **171** has its external dimensions sized, as described hereinbefore with respect to swage means **15**, to effect expansion of the liner **13** into tight frictional engagement with the conduit, such as the casing **21**, in the wellbore. The swage means **171** has a spherical exterior surface **179** for effecting a smooth internal bore in the liner after it has been expanded. The swage means **171** has a cylindrical interior **181** and is movable longitudinally with respect to thrust member **183** of the thrust means **177**. The swage means **171** is structurally strong so as to expand the liner **13** outwardly into tight frictional engagement with the casing **21** without being compressed inwardly enough to bind on thrust member **183** as the swage means **171** passes upwardly through the liner **13**.

The adapter rod means 175 is connected at one end portion with the swage means 171 and has, at its other end portion, means 185 for connection with a portion of a force generating means; such as, the bottom piston 31 of the piston assembly of the setting tool device 11; for pulling the swage means 171 upwardly through the liner 13. The adapter rod means 175, as illustrated, comprises a generally cylindrical member that is disposed exteriorly radially of the thrust member 183 and has slots 201 for accommodating movement of a crossover pin longitudinally thereof. The adapter rod means 175 extends downwardly through liner 13.

The setting sleeve means 173 has its upper end portion connected with the liner 13, as by threaded connection 187. Setting sleeve means 173 has a first shoulder portion 189 that removably abuts a second shoulder portion 191 of the thrust member 183. Thus, the setting sleeve means 173 is adapted for transmitting a tensile force to hold downwardly on the liner 13 to prevent its movement upwardly as the swage means 171 is drawn upwardly therethrough. Space 205 is provided above the top of the annular body of the liner 13 to allow the swage means 171 to pass completely out of the top of the annular body while the reaction force from the force generating means is still being applied to the setting sleeve means via thrust member 183. The setting sleeve means 173 has connection means 205 for connection with a supplemental element emplaced therewith after liner 13 has been expanded into tight frictional engagement with the casing 21 and the remainder of the setting tool device 11, swage means 171, and the thrust member 183 have been removed from the casing 21. Such an arrangement, with the connection means 205 engaging second mating connection means 207 of a seal unit 209 emplaced within the liner 13 and the setting sleeve means 173, is illustrated in FIG. 18.

The thrust means 177 comprises an adapter means including a crossover pin 193, skirt 195, and thrust member 183. The crossover pin 193 is retained in skirt 195 by annular ring 197 which is held in place by suitable means such as shear pin 199. The crossover pin 193 traverses longitudinally in slots 201 in adapter rod means 175, as indicated hereinbefore. The skirt 295 engages, as by threaded connection or abutting engagement, the other portion of a force generating means; for example, the bottom cylinder 43 of setting tool device 11; for transmission of the reaction force opposing movement of the liner 13 as the swage means 171 is pulled upwardly therethrough.

Central passageway 83 and branch passageways 85 and 86 are provided, as described hereinbefore, for allowing fluid flow therethrough, facilitating rapidly changing depths in the borehole without creating pressure surges.

In operation, the adapter rod means is connected with the bottom piston 31 of the setting tool device 11, and the sleeve 195 abuts the bottom end of cylinder 43 of setting tool device 11. The liner 13 has its bottom interior shoulder bearing on swage means 171 and setting sleeve means 173 has its shoulder portion 189 bearing on the second shoulder portion 191 of thrust member 183. The assembled combination is lowered to the desired depth in the well bore where the liner 13 is to be set. Thereafter, the setting tool device 11 is actuated, as described hereinbefore. Setting sleeve means 173 and the liner 11 are initially moved downwardly as the swage means 71 is moved upwardly. The liner 13 is expanded outwardly into engagement with the casing 121, however, to stop movement of the liner, as described more fully hereinbefore. Thereafter, the swage means 171 is moved upwardly completely out of the top of the liner 13 to complete the swaging operation.

After the liner 13 has been expanded outwardly into tight frictional engagement with the casing 21, the thrust member 183, the swage member 171, and the setting tool device 11 may be moved upwardly out of the wellbore leaving the setting sleeve means 173 emplaced with the liner 13. Subsequently, any suitable device may be installed in the liner. For example, as illustrated in FIG. 18, a seal unit 209 may be lowered into place, and its mating connection means 207 engaged with connection means 205 such that resilient seals 209 engage the interior surface 211 of liner 13.

FIGS. 19–21 illustrate another embodiment in which the liner 13 is disposed below both swage means 221 and setting sleeve means 223. In FIG. 19, the combination comprises, in addition to the swage means 221 and setting sleeve means 223, adapter rod means 225 connecting the swage means with the force generating means, and tensile means 227 for transmitting a tensile reaction force upwardly for opposing movement of the liner 13 as the swage means 221 is pushed downwardly therethrough.

The swage means 221 has external dimensions sized as described hereinbefore to effect expansion of the liner 13 into tight frictional engagement with the casing 21. Swage means 221 has a frusto-conical section 229. A sectioned ring means such as sectioned ring 231 is provided for defining the cylindrical exterior having the desired outside diameter. The sectioned ring 231 is disposed peripherally of the frusto-conical section 229 and is movable longitudinally thereof. Preferably, the sectioned ring 231 has a plurality of sections such as section 233 and V-shaped section 235 to facilitate withdrawal of the swage means 221 upwardly through the liner after the liner has been set. Sections 233 and 235 are coupled together to effect the desired uniform outside diameter when positioned at the largest portion of the frusto-conical section 229. The sections join smoothly together to effect the desired external dimensions delineated hereinbefore and to form a continuous surface for effecting a smooth bore in the expanded liner. Sections 233 and 235 are displacable sectionally; for example, vertically; to effect a reduced outside diameter that can be readily withdrawn upwardly through the liner after the latter's expansion. If desired, other forms of the sectioned ring; such as ring 237, FIG. 21; can be employed.

The adapter rod means 225 comprises a strong rod-like member with a relatively large diameter so as to be able to push the swage means 221 downwardly through the liner 13. The adapter rod means 225 is connected with an adapter means, which includes cross link 239 and skirt 241. The cross link 239 is retained in suitable apertures in adapter rod means 225 and skirt 241 by an annular ring 243 that is held in place by shear pin 245. The cross link 239 traverses longitudinally in slots 247 in the tensile means 227. The skirt 241 engages, as by

threaded connection or abutting engagement, the bottom cylinder **43** of the setting tool device **11** for transmission of the requisite downward force to push the swage means **221** through the liner **13**.

The setting sleeve means **223** has its lower end portion connected with the liner **13** as by threaded connection **249**. The setting sleeve means **223** is connected with the tensile means **227**. As illustrated, setting sleeve means **223** is connected with the tensile means **227** by a detachable connector means **251** for being detached from the tensile means **227** and left in place with the liner **13**. The detachable connector means **251** comprises a plurality of paired, mating, tension-sustaining connectors; such as, apertures **253** and protrusions, or pins, **255**; that are separable by lateral movement. One portion of the connector; for example, the apertures **253**; are carried by the setting sleeve means **223** and the other portion; such as, the protrusions **255**; are carried by a biased portion; such as, collet fingers **257**; of the tensile means **251**. The biased portion is biased for lateral movement so as to disengage the tensile means from the setting sleeve means when not restrained. Specifically, the collet fingers **257** are biased so as to move their ends and the protrusions **255** inwardly to disengage the apertures **253**. A restraining means; such as, restraining ring **259**; is disposed adjacent the collet fingers **257** for maintaining connection with the setting sleeve means until the swage means has passed completely out of the annular body of the liner **13**. The restaining ring **259** is maintained in place by shear pin **260**. A shoulder portion **261** on the adapter rod **225** is moved downwardly to shear the shear pin **260** and move the restaining ring **259** from beneath the ends of the collet fingers **257** after the swage means **221** has moved downwardly out of the end of the annular body of liner **13**. Thus, as illustrated in FIG. **20**, the liner **13** may be left emplaced in tight frictional engagement with the casing **21** and the setting sleeve means **223** connected with the top of liner **13**. Space is provided below the bottom of the annular body of the liner **13** so as to allow the swage means **221** to pass completely out of the bottom of the annular body while the reaction force is still being applied to the setting sleeve means.

The tensile means **227**, containing its collet fingers **257** and slots **247**, connects the setting sleeve means **223** with an upper means **185** for connection with a bottom piston **31** of the piston assembly of the setting tool device **11** for pulling upwardly on the setting sleeve means **223** to oppose downward movement of the liner **13** as the swage means **221** is pushed downwardly therethrough. The tensile means **227** comprises a cylindrical member which is disposed exteriorly radially of the adapter rod means **225** and is movable longitudinally with respect thereto.

In operation, combination is assembled with the tensile means **227** and the setting sleeve means **223**. connected with the bottom piston **31** of the setting tool device **11**; whereas the bottom cylinder **43** of setting tool device **11** is connected by the adapter means with the adapter rod means **225** so as to push the swage means **221** downwardly through the liner **13**. The liner **13** is connected with the setting sleeve means **223**, which is connected by the detachable connectors **251** with the tensile means **227**. With the assemblage complete, the combination is lowered to the desired depth in the casing **21** of the wellbore and the setting tool device **11** actuated. The bottom cylinder **43** of setting tool device **11** will push the swage means **221** downwardly through the liner while the reaction force is being supplied by the piston assembly of the setting tool device to pull upwardly via the detachable connector means **251** on the setting sleeve means **223**. After a small amount of initial movement, the liner **13** is expanded into tight frictional engagement with the casing **21** to constrain the liner to the desired depth. Thereafter, the force generated by the setting tool device **11** pushes the swage means **221** downwardly through the liner **13** to complete the emplacement by expanding the liner outwardly into tight frictional engagement with the casing. After the liner is set by the swage means **221** moving out of the lower end of the liner **13**, the releasing shoulder portion **261** moves downwardly to shear the shear pin **260** and push the restraining ring **259** from under the collet fingers **257**. The collet fingers **257** spring inwardly, moving the protrusions **255** out of the apertures **253** and releasing the tensile means **227** from the setting sleeve means **233**. Thereafter, the swage means, the tensile means, and the setting tool device **11** are removed from the well. To facilitate removal from the wellbore, as the swage means **221** is moved upwardly through the liner, the sectional ring **231** will be moved to effect a reduced diameter if it encounters the set liner **13**.

Except for the liner **13**, the materials of construction of the respective elements employed in the invention are well known to those skilled in wire line operations and need not be described in detail herein.

The setting sleeve means has been illustrated and described herein as being primarily cylindrical in shape. It has been described in detail in specific embodiments; such as, having expansible fingers for allowing passage of the swage means therethrough, being connected with the setting tool so that it is removed with the setting tool, and being connected with the liner for being left in the conduit with the set liner. The setting sleeve means may take any other structure, or form, of setting means as long as it provides the two functions described hereinbefore; namely, (1) transmitting the reaction force from the force generating means to the liner, and (2) allowing passage of the swage means completely out of the end of the liner; thereby obviating the need for an anchor means in setting the liner in the conduit.

Also, the liner **13** has been described as having interior and exterior surfaces that define cylinders. The cylinders so defined need not be perfect cylinders in the mathematical sense. It is deemed within the scope of this invention if the interior and exterior surfaces define cylinders having small irregularities, or grooves, whether accidentally or deliberately induced, as long as the irregularities are not as severe as the corrugations of the prior art; and are not sufficient to produce the nonuniform crystallographic structure or result in a tight frictional engagement with the conduit that is unsatisfactory for the application for which the liner is emplaced.

It is apparent from the foregoing drawings and description that the invention accomplishes its objects of providing an improved method of setting a liner in a conduit in a wellbore penetrating subterranean formations, and providing combinations of apparatus that:

1. employ a cylindrical liner,
2. do not depend upon a separate supplemental support, or anchor, to hold the liner in place for setting in the conduit,
3. do not depend on an outside coating of resilient material for sealing,
4. do not require additional pieces to be retained in the well to retain the liner in place in the conduit,
5. are not limited to thin walled sections,
6. effect a more nearly uniform crystallo-graphic structure at the metallurgical crystalline structure level without regions of low yield strength caused by large flexure such as corrugations,
7. have a large smooth internal bore that forms a uniform internal diameter for seating additional elements thereon,
8. may be emplaced at any point without being restricted to joints,
9. are operable by means of a wire line without requiring an additional string of pipe,
10. do not require a plurality of trips into the well to effect passage of the swage means completely through the liner,
11. do not destroy equipment by an uncontained explosion in the well; and
12. in a particular embodiment, leave a liner that is physically, chemically, and electrochemically, compatible with the conduit in the well and the job the liner is required to do.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention.

What is claimed is:

1. A method of emplacing a liner in a conduit in a well penetrating subterranean formations comprising:

a. positioning via a wire line at a given depth in said conduit an annular liner having substantially cylindrical interior and exterior surfaces that are at least partially coextensive, having an outside diameter less than the internal diameter of said conduit, having sufficient malleability for and being adapted for being expanded to conformingly engage said conduit, having a thickness sufficient to effect a wall after expansion capable of withstanding the pressure within or outside said conduit, and heaving a modulus of elasticity in compression sufficient to retain tight frictional engagement with said conduit after expansion thereagainst; said liner being disposed adjacent a swage means for expanding said liner outwardly into said tight frictional engagement with said conduit and adjacent a setting sleeve means for holding said liner at the desired setting depth against the force of said swage means as said swage means is forced through said liner; said swage means engaging a force generating means suspended on said wire line for subjecting said swage means to a force acting to force said swage through said liner; and said setting sleeve means engaging said force generating means for subjecting said setting sleeve means to a reaction force opposing movement of said liner as said swage means is forced therethrough;

b. actuating said force generating means and applying said force to said swage means and said reaction force to said setting sleeve means, thereby forcing said swage means completely through and out of said liner while said reaction force is still acting on said liner, and expanding said liner outwardly into tight frictional engagement with said conduit; and thereafter;

c. removing said force generating means and said swage means from said well, leaving said liner expanded into said tight frictional engagement with said conduit and having an unusually large aperture penetrating longitudinally therethrough.

2. The method of claim 1 wherein said liner is disposed below both said swage means and said setting sleeve means and is connected with said setting sleeve means; said swage means engaging said force generating means for subjecting sad swage means to a force acting downwardly and said setting sleeve means being connected with said force generating means for subjecting said setting sleeve means to a reaction force acting upwardly; and wherein said force generating means is actuated to push said swage means downwardly completely out of the bottom of said liner, which is held by said setting sleeve means, while said reaction force is still acting upwardly on said liner.

3. The method of claim 2 wherein said setting sleeve means is connected with the top of said liner and is detachably connected with said force generating means; and wherein said setting sleeve means is detached during the operation of setting said liner and is left in said conduit with said liner expanded into tight frictional engagement with said conduit.

4. The method of claim 3 wherein a reduced outside diameter of said swage means is effected to facilitate removal of said swage means upwardly through the expanded liner.

5. The method of claim 1 wherein said liner is disposed above both said swage means and said setting sleeve means and is connected with said setting sleeve means, said swage means being connected with said force generating means for subjecting said swage means to a force acting upwardly and said setting sleeve means engaging said force generating means for subjecting said setting sleeve means to a reaction force acting downwardly; and wherein said force generating means is actuated to pull said swage means completely through and out of the top of said liner, which is held by said setting sleeve means, while said reaction force is still acting downwardly on said liner.

6. The method of claim 5 wherein said setting sleeve means is connected with the bottom of said liner and has a portion that abuts a portion of a downwardly extending thrust member that is subjected to said reaction force from said force generating means, and said setting sleeve means is left in said conduit with said liner expanded into tight frictional engagement with said conduit.

7. The method of claim 6 wherein said setting sleeve means has connection means for connecting with a supplemental element emplaced therewithin.

8. The method of claim 7 wherein a seal unit is emplaced within said liner and said setting sleeve means, and has seal means engaging a longitudinally extending surface defining an internal bore in said liner, said longitudinally extending surface being effected by said

swage means in expanding said liner outwardly into said tight frictional engagement with said conduit; said seal unit having a mating second connection means engaging said connection means.

9. The method of claim 1 wherein said liner is disposed above said swage means and below said setting sleeve means, said swage means being connected with said force generating means for subjecting said swage means to a force acting upwardly and said setting sleeve means engaging said force generating means for subjecting said setting sleeve means to a reaction force acting downwardly; and wherein said force generating means is actuated to pull said swage means completely through and out of the top of said liner, which bears against said setting sleeve means, and into a portion of said setting sleeve means while said reaction force is still acting downwardly on said liner.

10. The method of claim 9 wherein said swage means is pulled upwardly through said liner in a single stroke.

11. The method of claim 9 wherein said force generating means comprises a setting tool of a type wherein a piston assembly and a cylinder assembly are powered for relative movement by an ignitable charge.

12. The method of claim 11 wherein said setting sleeve means is connected with said setting tool, has flexible expander means and an expander support ring disposed concentrically within said expander means for support and wherein said swage means moves said expander support ring from within said expander means upon its passage therepast, said expander means expanding outwardly to allow passage of said swage means and springing inwardly to a position of normal repose thereafter, whereby a large upwardly acting force may be applied to said swage means without distorting said setting sleeve means, and said liner can be emplaced in said conduit with a single actuation of said force generating means and a single passage upwardly of said swage means.

13. The method of claim 9 wherein said liner positioned at said given depth in said conduit is connected with a second said liner via a connector means, which includes an elongate sleeve portion; said swage means is connected with a second swage means that has a slightly smaller diameter than said swage means and is arranged below said second liner; said swage means is pulled through said liner and said second swage means is pulled through said second liner to expand both liners outwardly into frictional and sealing engagement with said conduit; and both said swage means are removed in accordance with step (c) of claim 1.

14. The method of claim 13 wherein said swage means and said second swage means are drawn, respectively, through said liner and said second liner singly, whereby said force generating means does not have to generate a force great enough to pull both swaging means through both liners simultaneously.

15. A combination of liner and apparatus for setting the liner in conduit in a well penetrating subterranean formations comprising:

a. a liner including an annular body portion having substantially cylindrical interior and exterior surfaces that are at least partially coextensive, having an outside diameter less than the diameter of said conduit, having sufficient malleability for and adapted for being expanded to conformingly engage said conduit, having a wall thickness sufficient to effect a wall after expansion capable of withstanding the pressure within or outside said conduit, and having a modulus of elasticity in compression sufficient to retain tight frictional engagement with said conduit after expansion thereagainst;

b. swage means adjacent said liner for moving through and expanding said liner outwardly into tight frictional engagement with said conduit, the external dimensions of said swage means having been pre-selected in accordance with the internal dimensions of said conduit and the diameter and wall thickness of said liner to effect said tight frictional engagement with said conduit after expansion;

c. an adapter rod means for connecting said swage means with a force generating means; said adapter rod means being connected at one end portion with said swage means and having, at the other end portion, means for engagement with a force generating means for subjecting said swage means to a force acting to move said swage means completely through said liner and expand said liner into said tight frictional engagement with said conduit; and

d. setting sleeve means disposed radially of the central axis of said adapter rod means and adjacent said liner and having means for engagement with said force generating means for opposing movement of said liner by transmission of a reaction force that acts oppositely to said force from said force generating means; said setting sleeve means being constructed and disposed so as to allow movement of said swage means completely out of said annular body of said liner while said reaction force is still being applied to said liner.

16. The combination of claim 15 wherein said liner has a top portion integrally connected with said body portion and said top portion has an inner inverted frusto-conical section to form a stabbing section to facilitate entry of other elements into said liner once emplaced in said well.

17. The combination of claim 16 wherein said top portion has a plurality of notches in its top edge.

18. The combination of claim 15 wherein said swage means is disposed below said liner; said adapter rod means passes through said liner for pulling said swage means upwardly through and completely out of the top of said liner; said setting sleeve means is disposed below said liner with its upper end portion connected with said liner and has a portion that abuts a downwardly extending thrust member, said thrust member having means for engaging said force generating means and adapted for transmitting a downwardly acting reaction force for opposing movement of said liner when said swage means is pulled upwardly therethrough; and space is provided above the top of said annular body of said liner to allow said swage means to pass completely out of the top of said annular body while said reaction force is still being applied to said setting sleeve means.

19. The combination of claim 31 wherein said setting sleeve means has connection means for connection with a supplemental element emplaced therewithin; is sealingly connected with said liner, and removably

abuts said thrust member such that said thrust member may be removed with said swage means and said setting sleeve means left in said conduit with said liner expanded into tight frictional engagement with said conduit.

20. The combination of claim 15 wherein said swage means is disposed above said liner; said adapter rod means is adapted for transmitting said force downwardly for pushing said swage means downwardly through said liner; said setting sleeve means is disposed above said liner with its lower end portion connected with said liner and is connected with a tensile means for transmitting a tensile force upwardly, said tensile means having means for engaging said force generating means and adapted for transmitting said reaction force upwardly for opposing movement of said liner when said swage means is pushed downwardly therethrough; and space is provided below the bottom of said annular body of said liner to allow said swage means to pass completely out of the bottom of said annular body while said reaction force is till being applied to said setting sleeve means.

21. The combination of claim 20 wherein said swage means has a frusto-conical section and a sectioned ring means for effecting said external dimensions of said swage means; said sectioned ring means being disposed peripherally of said frusto-conical section and freely movable longitudinally thereof, said sectioned ring means having a plurality of sections coupled together so as to effect an outside diameter when positioned at the largest portion of said frusto-conical section that effects said external dimensions of said swage means and is continuous for effecting a smooth bore in said liner; said sections being displacable sectionally vertically so as to effect a reduced outside diameter that can be readily withdrawn upwardly through said liner after emplacement.

22. The combination of claim 20 wherein said setting sleeve means is connected with the top of said liner and is connected with said tensile means via detachable connector means for being detached from said tensile means and left in place with said liner in said conduit.

23. The combination of claim 22 wherein said detachable connector means comprises a plurality of paired, mating, tension-sustaining connectors that are separable by lateral movement, one portion being carried by said setting sleeve means and one portion being carried by a biased portion of said tensile means that is biased for lateral movement so as to disengage from said setting sleeve means when not restrained, and a restraining means is disposed adjacent said biased portion for maintaining connection with said setting sleeve means until said swage means has passed completely out of said annular body of said liner.

24. The combination of claim 23 wherein said restraining means comprises a restraining ring and a shearable means for maintaining said restraining ring adjacent said biased portion; and said adapter rod means has a shoulder portion for shearing said shearable means and moving said restraining ring downwardly to release said biased portion after said swage means has passed downwardly through said liner and expanded it into tight frictional engagement with said conduit.

25. The combination of claim 23 wherein said paired connectors comprise respective mating apertures and protrusions.

26. The combination of claim 25 wherein said apertures are disposed in said setting sleeve means and said protrusions are carried by said biased portion, and said biased portion comprises inwardly biased collet fingers.

27. The combination of claim 15 wherein said swage means is disposed below said liner; said adapter rod means passes through said liner for pulling said swage means upwardly through and completely out of the top of said liner; said setting sleeve means is disposed above said liner with its lower end portion engaging the top of said liner and has means at its upper end portion for engagement with the force generating means and adapted for transmitting a downwardly acting said reaction force for opposing upward movement of said liner when said swage means is pulled upwardly therethrough; and said setting sleeve means has means allowing movement of said swage means completely out of the top of said liner and within a portion of said setting sleeve means while said reaction force is still being applied to said setting sleeve means.

28. The combination of claim 27 wherein one of said adapter rod and said setting sleeve means are operatively connected with one of a piston assembly of a setting tool and a cylinder assembly of said setting tool for transmission respectively of said force acting upwardly and said downward acting reaction force; and said setting tool comprises a fluid actuated means means comprising a head assembly including igniter means, said cylinder assembly and said piston assembly within said cylinder assembly, with said piston assembly being slideable relative to said cylinder assembly; means including a combustion chamber adapted for receiving a combustible material power charge and disposed within said cylinder assembly for imparting relative motion to said cylinder assembly relative to said piston assembly to move said swage means upwardly through said liner, movement of which is opposed by said setting sleeve means.

29. The combination of claim 27 wherein said setting sleeve means expandably engages the top of said liner via flexible spring fingers for retaining said liner in place during setting, said spring fingers being adapted to flex outwardly to allow passage of said swage means therethrough and spring back into position after said swage means has passed therethrough.

30. The combination of claim 29 wherein an expander support ring is employed in said setting sleeve and is held in place adjacent said liner and within said flexible spring fingers with a shearable means for supporting said fingers during the interaction of the large force and reactive force pulling said swage means through said liner, said expander support ring having a shoulder for conformingly engaging a portion of said swage means after said swage means has passed through said liner and for moving said expander support ring upwardly as said swage means passes upwardly out of said liner.

31. The combination of claim 27 wherein the bottom of said body portion of said liner is sealingly connected with one end of a connector means and said connector means is sealingly connected at its other end with a terminal element.

32. The combination of claim 31 wherein said terminal element is at least a section of a production liner whereby said section of said production liner and any extensions thereof desired can be emplaced at a given location in said conduit by expansion of said body portion into frictional and sealing engagement with said conduit, and said production liner will resist being displaced upwardly by pressure or downwardly by its own weight.

33. The combination of claim 31 wherein said terminal element is a bull plug seal means and wherein said bull plug seal means can be emplaced at a given location in said conduit by expansion of said annular body portion into frictional and sealing engagement with said conduit and said bull plug seal means will resist being displaced upwardly or downwardly by force of a pressure acting thereon.

34. The combination of claim 31 wherein said terminal element is a second liner smaller than the diameter of said conduit, said second liner is sealingly connected at one end to said connector means via an expansible portion, and said connector means includes an elongate sleeve portion, to form a straddle patch for emplacing in said conduit for blocking a communicating passageway between the interior of said conduit and the exterior of said conduit; and wherein said swage means is connected with a second swage means below said second liner, said second swage means having a diameter slightly less than said swage means, said second swage means and said second liner cooperating to effect sealing engagement of said second liner with said conduit when said second swage means is drawn upwardly through said second liner; whereby said second swage means can also pass through said liner after said swage means has expanded said liner into contact with said conduit.

35. The combination of claim 34 wherein said second swage means is immediately below and contiguous with said second liner and said swage means is spaced a distance below said liner sufficient to enable said second swage means to traverse through said second liner before said swage means starts its traverse of said liner.

36. The combination of claim 31 wherein said terminal element comprises a seal sub having a longitudinally extending internal sealing surface defining a bore for receiving in sealing relationship a large bore packer including single bore packers such as seal nipples; whereby said seal sub can be emplaced at a given location in said conduit by expansion of said annular body portion into frictional and sealing engagement with said conduit and said seal sub will resist being displaced upwardly or downwardly by a weight and the force of a pressure acting thereon.

37. The combination of claim 36 wherein there is included a large bore packer that conformingly and sealingly fits within said bore of said seal sub and has a portion that seals contiguous said sealing surface.

38. The combination of claim 37 wherein said large bore packer comprises a body having a longitudinally extending aperture penetrating therethrough.

39. The combination of claim 38 wherein said large bore packer body has a plurality of apertures extending longitudinally therethrough.

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