

July 3, 1951

J. D. HAYNES ET AL

2,559,536

LINING WELLS

Filed Dec. 20, 1945

2 Sheets-Sheet 1

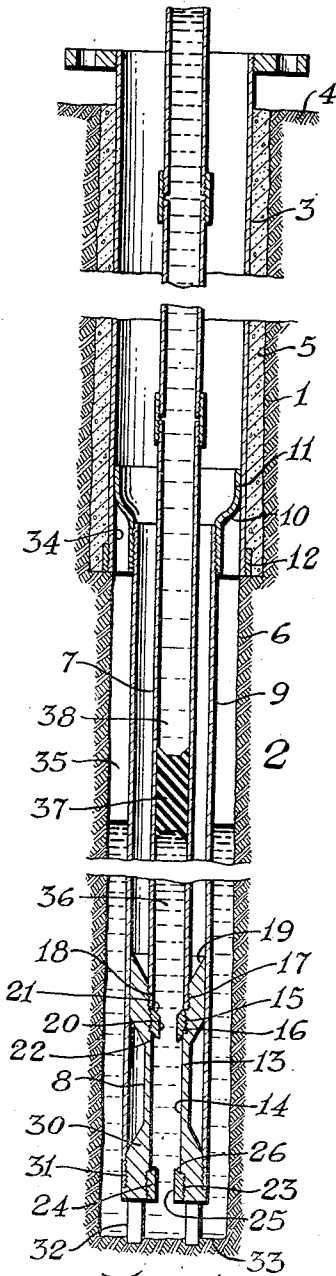


Fig. 1

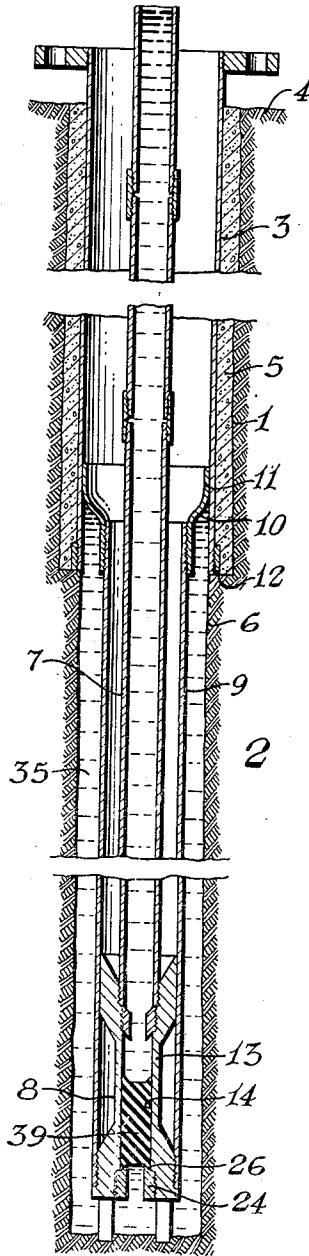


Fig. 2

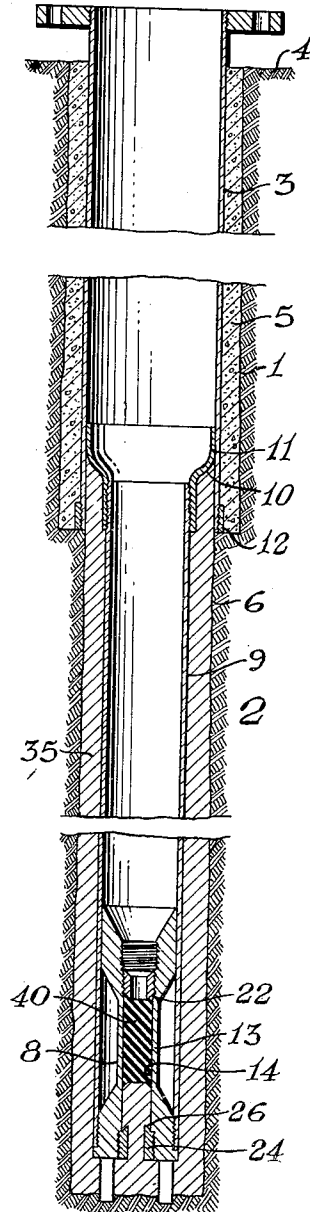


Fig. 3

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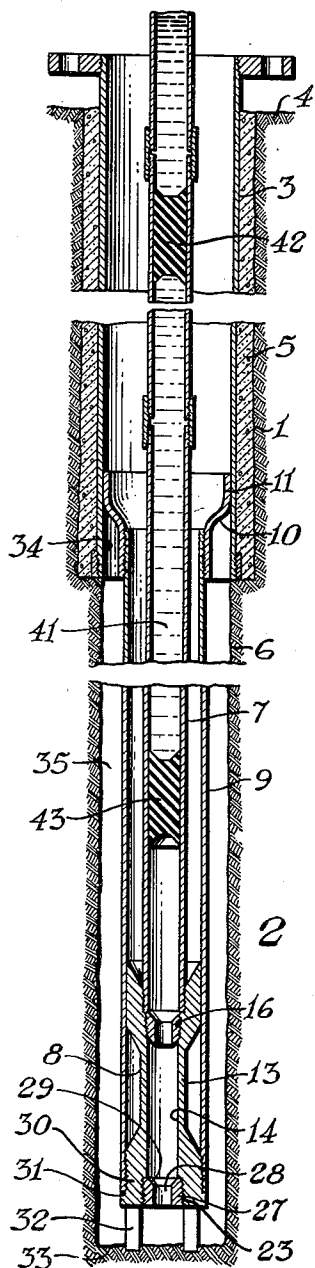


Fig. 4

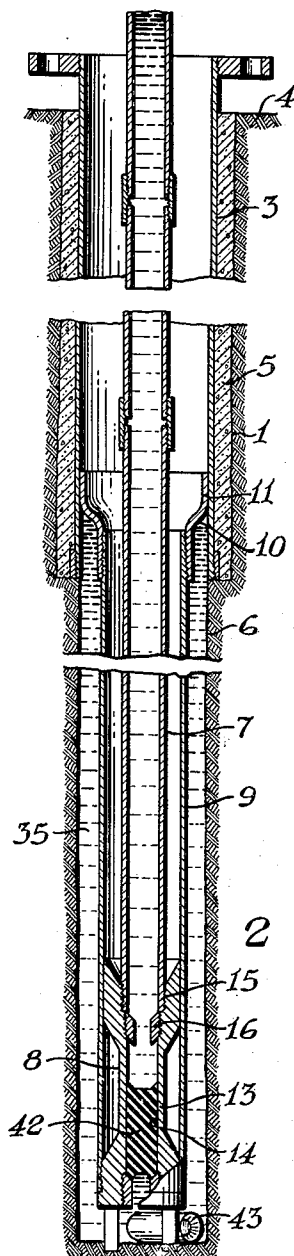


Fig. 5

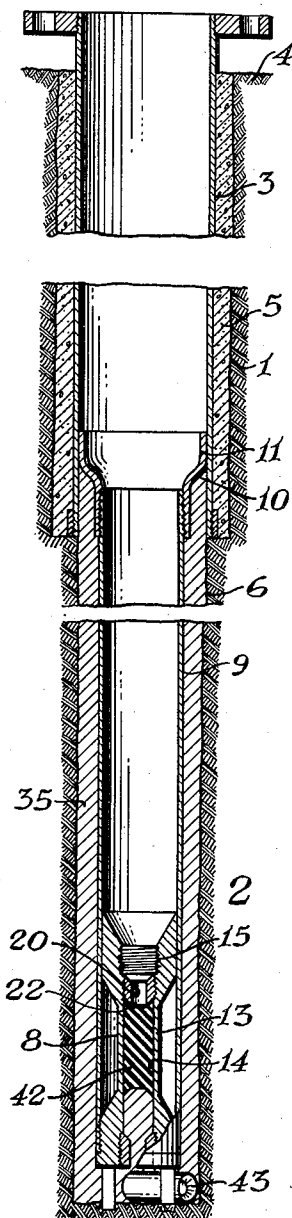


Fig. 6

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2,559,536

LINING WELLS

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4 Claims. (Cl. 166—1)

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The invention relates to lining wells drilled into the earth. It more particularly concerns an apparatus for setting a liner in a producing formation below a cased portion of a well hole.

In constructing deep wells, especially those drilled for oil or gas, one of the practices has been to drill a hole through the overlying earth to the producing stratum, case the hole, and then extend the drilled hole into the productive stratum to reach the oil or gas. To prevent the wall of the producing stratum from caving a liner is generally set in the well hole below the casing, the liner being cemented in place by delivering a charge of cement behind it. The cemented liner is then perforated to permit the passage of oil or gas to the well while holding back earth or rock particles. A number of disadvantages accrue to such practice, outstanding ones of which are the complexity of the devices used and the difficulty with conventional apparatus of ensuring the completeness of the transfer of the cementing material from the well into the space behind the liner.

Accordingly, it is an object of the invention to provide an improved liner setting apparatus for setting a liner in a well whereby cementing is readily and effectively accomplished. Other objects and advantages will appear from the following description of the invention taken in connection with the accompanying drawings, in which:

Fig. 1 is a vertical largely sectional schematic view of a well drilled into a productive stratum, the well being equipped with suitable apparatus, including our improved liner setting tool for practicing the invention and the liner setting operation being in its initial stages.

Fig. 2 is a similar view to Fig. 1 showing the liner setting operation in a later stage.

Fig. 3 is a similar view to Fig. 1 showing the liner setting operation in the final stage.

Fig. 4 is a similar view to Fig. 1 and shows a modification of the liner setting tool, the liner setting operation being in its initial stages.

Fig. 5 is a similar view to Fig. 4 showing the liner setting operation in a later stage.

Fig. 6 is a similar view to Fig. 4 showing the liner setting operation in the final stage.

In the several figures, like numerals refer to like parts.

Referring in detail to the several figures, 1 designates a hole drilled into the earth overlying the productive stratum 2. The hole is provided with a casing 3 extending above the ground 4, the space between the casing 3 and hole 1 being filled with a cement 5. Penetrating the productive

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stratum 2 is the drilled hole 6. Shown extending into the hole 6 is a tubing string 7 on the lower end of which is assembled the liner setting tool, designated generally by numeral 8, and the liner 9. The upper end of the liner is fitted with the liner adapter 10 having a big end 11 making a loose fit with the interior of the casing 3 adjacent to the casing shoe 12.

Referring to the liner setting tool 8, numeral 13 designates the body which is generally cylindrical in form, having a central bore or chamber 14 of the same diameter as that of the tubing string, the bore serving as a plug catching chamber. This central bore or plug catching chamber has a length somewhat greater than the length of the resilient compressible tubing plugs used with the apparatus and described later. The upper end of the bore 14 is enlarged, forming a recess 15 which is internally threaded to receive the upper bore constricting element or choke 16 comprising a short length of externally threaded thick wall tubing, and a recess 17 in which is cut a dizzy or back off thread (left hand) for engaging a complementary thread on the lower end 18 of the tubing string. A countersink 19 tapering inwardly is provided to facilitate the engagement of the tubing thread with the recess thread.

The bore of the choke element 16 has a cross-sectional area between about 25 and 75 per cent of that of the chamber 14. The upper end of the choke 16 is countersunk, thereby providing a funnel shape entrance 21 to the bore 20 from the tubing string. The lower end of the bore constricting element 16 is conical and projects into the bore 14, thereby providing a conical shoulder 22 adjacent to the upper end of the bore 14. The lower end of the bore 14 has an internally threaded recess 23.

In the modification of the setting tool of Figs. 1, 2, and 3, an externally threaded plug stop 24 is screwed into the recess 23. The upper end of the plug stop 24 is conical and projects upwardly in the bore 14, thereby forming a conical shoulder 26 adjacent to the lower end of the bore 14.

In the modification of the setting tool of Figs. 4, 5, and 6, a lower bore constricting element 27 or choke comprising a short length of externally threaded thick wall tubing is screwed into the recess 23 in place of the plug stop 24. The bore 28 of the lower choke has substantially the same cross section as that of the upper choke 16. The upper end of the lower choke is countersunk, thereby providing a funnel shape entrance 29 to the bore 28.

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The lower end of the setting tool body 13 is provided with an externally threaded boss 30, the thread of which engages the internal thread 31 on the lower end of the liner 9. Prongs 32 project below the lower end of the body and may be used to engage the bottom of the hole to restrain the liner setting tool from turning when unscrewing the tubing to permit its withdrawal.

In setting a liner according to the invention, a suitable length of liner 9 is screwed onto the externally threaded boss 30 of the setting tool 8 so that when the prongs 32 engage the bottom 33 of the well hole 6, the liner will extend into the lower end 34 of the casing. A liner adapter 10, of suitable dimensions so that the big end 11 fits the bore of the casing, is attached to the upper end of the liner. The assembly of the liner and setting tool is screwed onto the end 18 of the tubing string 7, the thread of the recess 17 engaging the threaded end of the tubing so that the liner telescopes over the lower end of the tubing string. The assembly is then lowered into the well by adding the necessary lengths of tubing until the prongs 32 engage the bottom 33 of the well. The foregoing procedure may be followed with either of the two modifications of the setting tool.

In cementing or sealing the liner in place using the modification of the setting tool of Figs. 1, 2, and 3, the cementing compound is delivered to the annular space 35 behind the liner as follows. A volume of sealing compound, calculated to fill the annular space 35 from bottom to top, including the space in the well hole around the bottom of the setting tool and between the outside of the liner adapter and casing, is introduced into the tubing string, and immediately behind it, there is inserted into the tubing string a resilient compressible plug making a sliding fit with the bore of the tubing. Suitable plugs for the purpose are made of rubber, preferably polychloroprene, having a cylindrical form and recessed ends so that the wall of the plug tapers to a thin edge at each end. A suitable length of plug is one to three times the diameter, although other lengths may be used. Behind the plug, there is introduced into the tubing a pressuring fluid, such as water, so as to move the sealing compound and plug down the tubing string. Referring to Fig. 1, the relative positions of the sealing compound 36, resilient plug 37, and pressuring fluid are shown as the sealing compound is about to pass through the bore 14 of the setting tool into the annular space 35. Continued introduction of pressuring fluid moves the sealing compound through the setting tool while the resilient plug follows, a strong rise followed by a decline in pressure on the pressuring fluid being observed as the plug is compressed and squeezed through the choke 16 into the bore or chamber 14 of the setting tool. In the chamber 14 the plug expands to fit the bore and its expulsion from the chamber is prevented as the plug is caught by the conical shoulder 26 of the plug stop 24. The pressure rise thus obtained on the pressuring fluid as the plug is forced into its position 39 in the chamber 14, as shown in Fig. 2, signals the completion of the transfer of sealing compound into the annular space 35. The pressure on the pressuring fluid may be released after the resilient plug is in the plug catching chamber or bore 14 and the tubing string backed off and withdrawn from the well. Referring to Fig. 3, the resilient plug is shown in the position 40 attained when the pressure is released

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and the tubing withdrawn. In this position, the conical projection 22 engages the tapered edge of the upper end of the plug preventing its expulsion from the bore 14 so that the plug acts as a back-pressure valve to retain the sealing compound in place until set. The foregoing modification of the invention may be used advantageously where there is no fluid in the tubing ahead of the sealing compound to contaminate or mix with it or where some mixing or contamination of the sealing compound with fluid already in the tubing is not objectionable.

In cases in which it is necessary or desirable to reduce or prevent contamination of the sealing compound by fluid already in the tubing, the modification of the invention, as shown in Figs. 4, 5, and 6, preferably is used. With this modification, the bottom of the plug catching chamber or bore 14 contains a bore constricting element 27 instead of the plug stop 24. The liner 9 is assembled with the liner setting tool 8 and lowered into the well on a tubing string 7, as already described with reference to the first modification. After positioning the liner and apparatus in the well hole, cementing or sealing the liner in place is accomplished by introducing into the tubing string in succession, a resilient compressible plug, a suitable volume of fluid sealing compound, another similar plug, and a pressuring fluid for forcing the charge of sealing compound and the two plugs subtending it down the tubing. Referring to Fig. 4, a stage in this operation is shown in which the charge of cementing sealing compound 41 is in the tubing string between upper and lower plugs 42 and 43, respectively. Introduction of pressuring fluid into the tubing is continued above the upper plug until it has driven the charge down the tubing and caused the lower plug 43 to be compressed and squeezed through first the upper constriction or choke 16, in the setting tool, and then the lower choke 27. The passage of the lower plug 43 through the upper and lower chokes 16 and 27, respectively, produces corresponding increases followed by decreases in pressure on the pressuring fluid, thereby giving a double pressure signal. These pressure signals indicate that the expulsion of the first plug has occurred from the bore 14 into the space below the setting tool and the transfer of sealing compound from the tubing string into the space outside the setting tool and around the liner has begun. Introduction of pressuring fluid is continued until the second plug 42 is driven through the choke 16 into the bore 14 (but not through choke 27), as shown in Fig. 5, the lower plug 43 resting upon the bottom of the well.

The passage of the second plug through the choke 16 into the bore 14 is signalled by an abrupt rise followed by a decline in pressure upon the pressuring fluid, whereupon further introduction of pressuring fluid is ceased immediately so as to avoid expelling the second plug 42 into the well. Since a pressure differential of 500 to 2,000 pounds per square inch is required to drive a resilient plug of the type described through a choke having relatively small bore and a tapered entrance as in 16 and 27, respectively, it is relatively simple to control the pressure on the pressuring fluid so as to prevent driving a plug through a choke, as when it is desired to retain a plug in the bore or plug catching chamber 14. When the second plug 42 is in the bore 14, the sealing or cementing compound is completely displaced from the tubing and occupies the annular

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space 35 around the liner up to the liner adapter. The pressure on the pressuring fluid is released after the second plug 42 has landed in the bore 14 and the tubing 7 is unscrewed from the left handed thread in the recess 15 and withdrawn from the well. The plug 42 now acts as a closure for the passage 20 against return flow of sealing compound, as the tapered edge of the upper end of the plug engages the conical shoulder 22, as shown in Fig. 6. While thus held in place, the sealing compound is allowed to harden, thereby sealing or cementing the liner and liner adapter in place.

After sealing the liner in the well hole, as described, lateral perforations may be made in conventional manner in the liner as by the use of a gun perforator lowered into the well so that production can flow into the well. On the other hand, if desired, the liner setting tool can be drilled out, thereby opening the well below the liner.

Although various fluid sealing or cementing materials may be used in accordance with the invention, such as Portland cement slurries, synthetic resin-forming liquids, gypsum, etc., we have found that the use of resin-forming liquids are especially advantageous in the method. Resin-forming liquids, which may be used, are disclosed in U. S. Patent No. 2,274,297.

Among the advantages of the invention are that the sealing or cementing compound is completely displaced from the tubing string into the space behind the liner; the operator is precisely advised as to when the displacement from the tubing string is completed; the apparatus is of simple construction; the setting tool itself is free from moving parts so that it is practically impossible to get out of order in use; and the use of a float valve in running in the tubing string is obviated.

We claim:

1. A liner setting tool for running a liner on the lower end of a tubing string in telescopic relationship thereto into an uncased portion of a well hole below casing therein and cementing the liner in place, said liner being of smaller diameter than the said casing but of larger diameter than the said tubing string, said liner setting tool comprising a tubular body member having an axial bore of substantially the same diameter as that of the said tubing string; thread means formed in the body member for securing the tool to the lower end of the said tubing string so that the bore of the said tubing string and that of the body member form a continuous passage with the bores of the said tubing string and body member in alignment when the tool is secured to the tubing string, said thread means being disengageable permitting disengagement of the tubing string from the tool after the liner is cemented in place; an upper annulus secured in the upper end of the bore of the body member, said upper annulus having a bore in axial alignment with the bore of the said body member and whose cross-sectional area is from 25 to 75 per cent less than that of the body member, said upper annulus having upper and lower edges whose surfaces slope upwardly and outwardly from its bore; a lower annulus secured in the lower end of the bore of the body member, said lower annulus having a bore of the same cross-sectional area as that of the upper annulus and in alignment with the axis of the body member, the length of the bore of the body member be-

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tween the upper and the lower annuli being sufficient to accommodate a cementing plug adapted to fit the tubing string; an annular boss surrounding the tubular body member at its lower end; and thread means on the external surface of the annular boss adapted to engage the internally threaded lower end of the liner, whereby the tubing string and liner are joined through the annular boss between them at their lower ends in telescopic relationship by the tool when the liner is secured to the tool on being run into and cemented in a well hole.

2. A liner setting tool for running a liner on the lower end of a tubing string in telescopic relationship thereto into an uncased portion of a well hole below casing therein and cementing the liner in place, said liner being of smaller diameter than the said casing but of larger diameter than the said tubing string, said liner setting tool comprising a tubular body member having an axial bore of substantially the same diameter as that of the said tubing string; thread means formed in the body member for securing the tool to the lower end of the said tubing string so that the bore of the said tubing string and that of the body member form a continuous passage with the bores of the said tubing string and body member in alignment when the tool is secured to the tubing string, said thread means being disengageable permitting disengagement of the tubing string from the tool after the liner is cemented in place; an upper annulus secured in the upper end of the bore of the body member, said upper annulus having a bore in axial alignment with the bore of the said body member and whose cross-sectional area is from 25 to 75 per cent less than that of the body member, said upper annulus having upper and lower edges whose surfaces slope upwardly and outwardly from its bore; a lower annulus secured in the lower end of the bore of the body member, said lower annulus having a bore of the same cross-sectional area as that of the upper annulus and in alignment with the axis of the body member, said lower annulus having an upper edge whose surface slopes downwardly and outwardly from its bore, the length of the bore of the body member between the upper and the lower annuli being sufficient to accommodate a cementing plug adapted to fit the tubing string; an annular boss surrounding the tubular body member at its lower end; and thread means on the external surface of the annular boss adapted to engage the internally threaded lower end of the liner, whereby the tubing string and liner are joined through the annular boss between them at their lower ends in telescopic relationship by the tool when the liner is secured to the tool on being run into and cemented in a well hole.

3. A liner setting tool for running a liner on the lower end of a tubing string in telescopic relationship thereto into an uncased portion of a well hole below casing therein and cementing the liner in place, said liner being of smaller diameter than the said casing but of larger diameter than the said tubing string, said liner setting tool comprising a tubular body member having an axial bore of substantially the same diameter as that of the said tubing string; thread means formed in the body member for securing the tool to the lower end of the said tubing string so that the bore of the said tubing string and that of the body member form a continuous passage with the bores of the said tubing string and body member in alignment when the tool is secured to the

tubing string, said thread means being disengageable permitting disengagement of the tubing string from the tool after the liner is cemented in place; an upper annulus secured in the upper end of the bore of the body member, said upper annulus having a bore whose cross-sectional area is from 25 to 75 per cent less than that of the body member, said upper annulus having upper and lower edges whose surfaces slope upwardly and outwardly from its bore; a lower annulus secured in the lower end of the axial bore of said body member, said lower annulus having a bore of the same cross-sectional area as that of the upper annulus, the surface of the upper edge of the lower annulus sloping upwardly and outwardly from its bore, the length of the bore of the body member between the upper and the lower annuli being sufficient to accommodate a cementing plug adapted to fit the tubing string; an annular boss surrounding the tubular body member at its lower end; and thread means on the external surface of the annular boss adapted to engage the externally threaded lower end of the liner, whereby the tubing string and liner are joined through the annular boss between them at their lower ends in telescopic relationship to the tool when the liner is secured to the tool on being run into and cemented in a well hole.

4. A liner setting tool for running a liner on the lower end of a tubing in telescopic relationship thereto into an uncased portion of a well hole below casing therein and cementing the liner in place, said liner being of smaller diameter than the said casing but of larger diameter than the said tubing string, said liner setting tool comprising a tubular body member having an axial bore of substantially the same diameter as that of the said tubing string; thread means formed in the body member for securing the tool to the lower end of the said tubing string so that the bore of the said tubing string and that of the body member form a continuous passage with the bores of the said tubing string and body member in alignment when the tool is secured to the tubing string, said thread means being disengageable

permitting disengagement of the tubing string from the tool after the liner is cemented in place; an upper annulus secured in the upper end of the bore of the body member, said upper annulus having a bore whose cross-sectional area is from 25 to 75 per cent less than that of the body member, said upper annulus having upper and lower edges whose surfaces slope upwardly from and outwardly its bore; a lower annulus secured in the lower end of the axial bore of said body member, said lower annulus having a bore of the same cross-sectional area as that of the upper annulus, the surface of the upper edge of the lower annulus sloping upwardly and outwardly from its bore, the length of the bore of the body member between the upper and the lower annuli being sufficient to accommodate a cementing plug adapted to fit the tubing string; an annular boss surrounding the tubular body member at its lower end; thread means on the external surface of the annular boss adapted to engage the internally threaded lower end of the liner, whereby the tubing and liner are joined through the annular boss between them at their lower ends in telescopic relationship by the tool when the liner is secured to the tool on being run into and cemented in a well hole; and prong means secured to and projecting from the lower end of the tubular body member in alignment therewith for engaging the bottom of the well.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,083,625	White	June 15, 1937
2,156,207	Terrill	Apr. 25, 1939
2,342,930	Fortune	Feb. 29, 1944
2,352,744	Stoddard	July 4, 1944
2,370,833	Baker	Mar. 6, 1945
2,411,260	Glover et al.	Nov. 19, 1946