Nov. 17, 1959 B. G. HARMON 2,913,052

LINER SET TOOL

Filed July 5, 1956 2 Sheets-Sheet 1

Fig. 1.

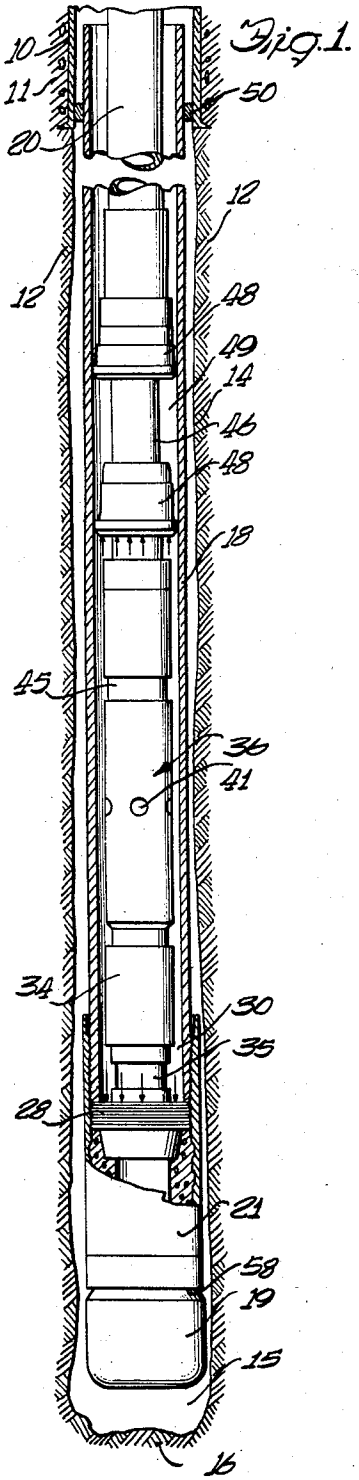


Fig. 2.

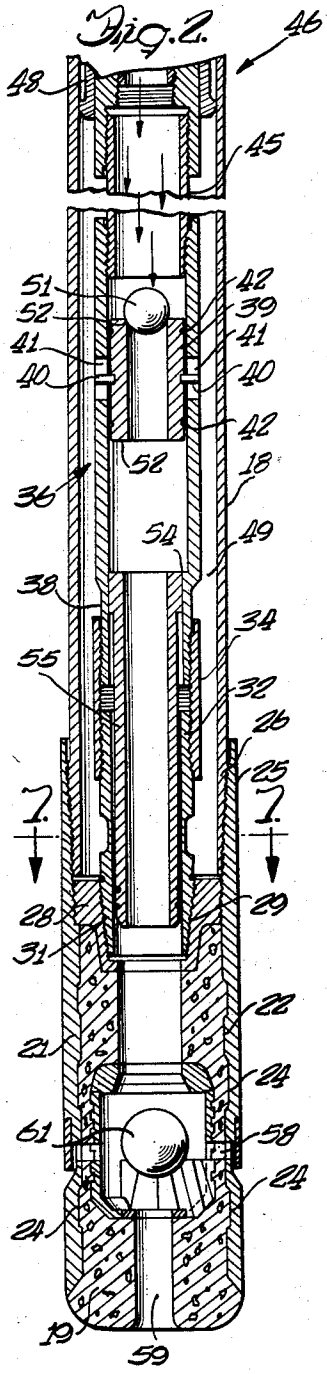
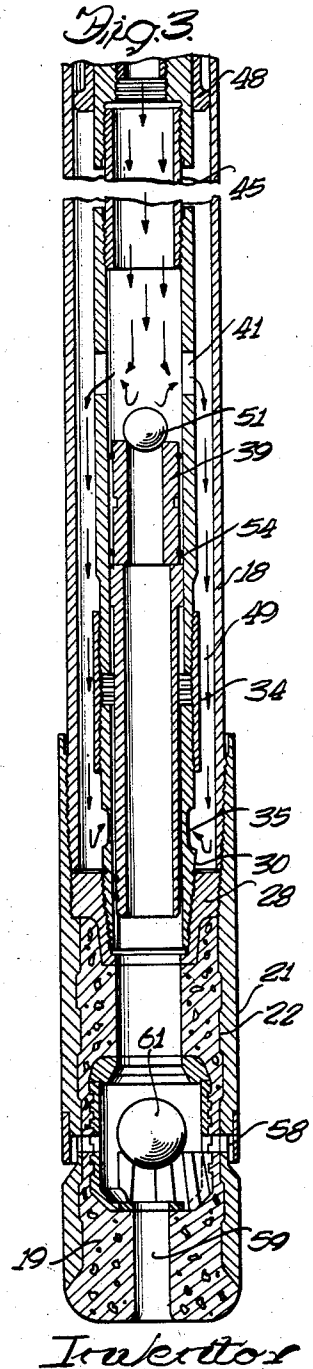


Fig. 3.



Inventor
Bill G. Harmon
Jack B. [illegible]
Attorney

Nov. 17, 1959 B. G. HARMON 2,913,052

LINER SET TOOL

Filed July 5, 1956 2 Sheets-Sheet 2

Fig. 4.

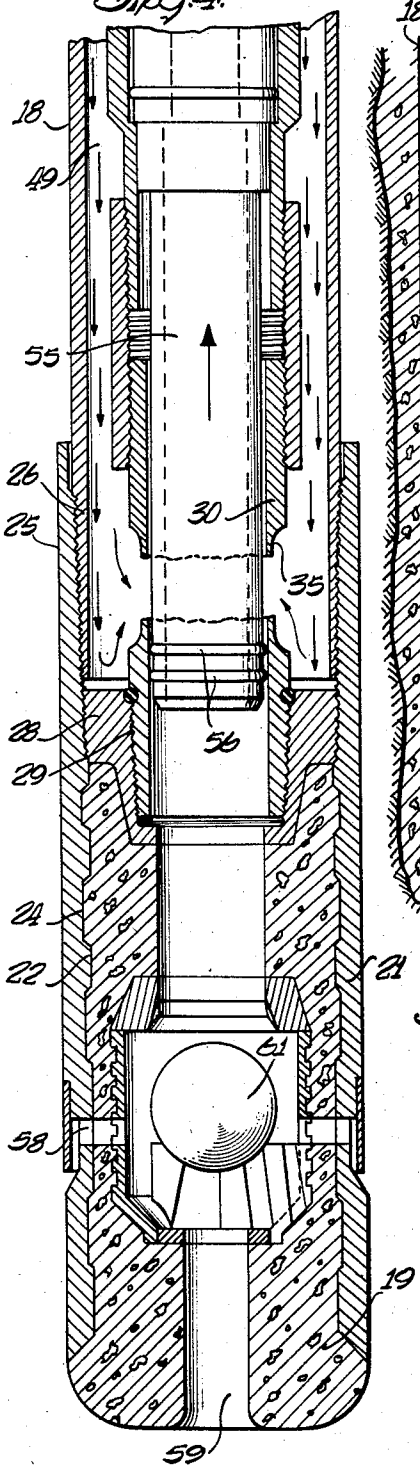


Fig. 5.

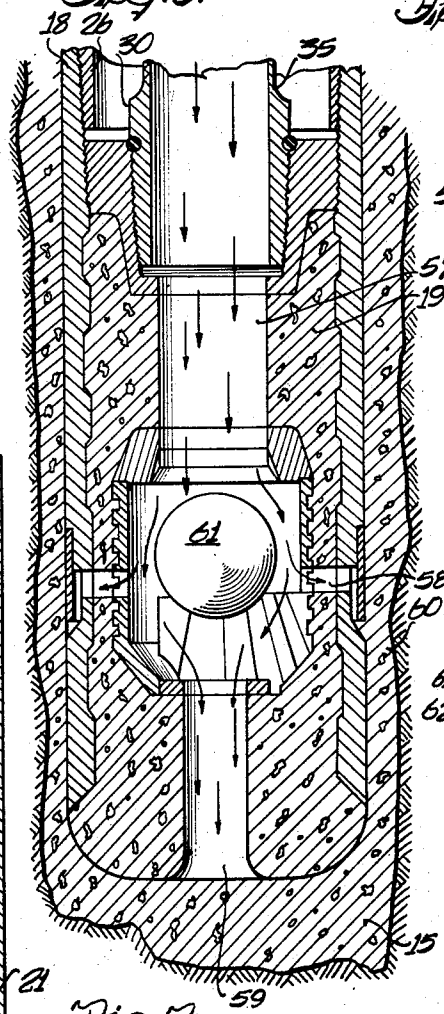


Fig. 6.

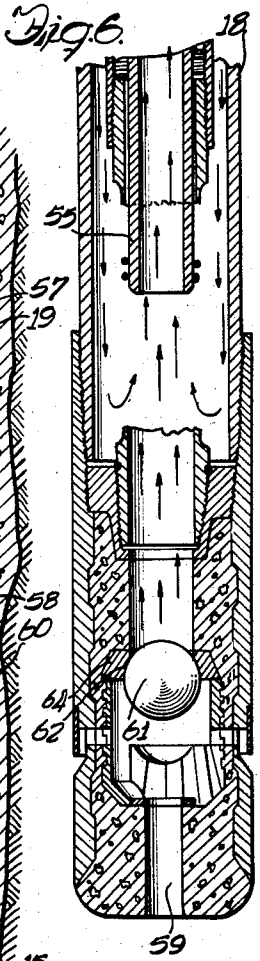
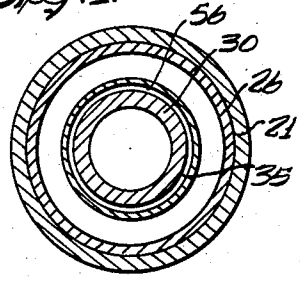


Fig. 7.



Inventor
Bill G. Harmon
Jack E. Dawson
Attorney

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LINER SET TOOL

Bill G. Harmon, Carmi, Ill., assignor to Engineered Grouting Service, Evansville, Ind., a partnership

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4 Claims. (Cl. 166—144)

The present invention relates to the general field of oil well equipment. More specifically the invention contemplates a tool for setting a liner in a well. The invention is particularly useful in setting a liner in an extension of a hole in which the casing has already been set.

Quite often after an oil field has been drilled in and produced, additional geological information is obtained which makes it desirable to drill deeper, through existing wells, to a secondary oil bearing strata. To complete the well, a secondary casing, known as a liner, must be cemented into the secondary drilling. To deliver the cement into the area between the walls of the secondary drilling and the liner, production or other tubing is usually connected to a shoe at the bottom of the liner.

After the cementing job has been completed, it then becomes necessary to withdraw the production tubing from the well and drill out the shoe before producing. Several techniques have been developed for separating the production tubing from the shoe. Some involve hooks which are jiggled loose. Others use trick couplers which are backed off to loosen. Almost invariably these various techniques and mechanisms have operational difficulties when even the most skilled and experienced operators are employed.

The general object of the present invention is to provide an oil well liner tool which is simple to operate and insures a complete release.

A more detailed object of the invention is to furnish a well liner set tool which is controlled and released by hydraulic pressure and consequently subject to accurate control from the well head.

Still another object of the invention is to provide a well liner set tool which is inexpensive to construct from standard shapes and sizes of materials.

Further objects and advantages of the present invention will become apparent as the following description of an illustrative embodiment proceeds taken in conjunction with the descriptive drawings in which:

Figure 1 illustrates in partial broken section the assembled setting tool employed with the liner in the bottom of an extension of an existing oil well.

Fig. 2 is a longitudinal sectional view in enlarged scale of the lower portion of the liner set tool shown in Fig. 1 illustrating the first phase of its operation.

Fig. 3 shows the same tool as illustrated in Fig. 2 but after the ports have been opened for operation.

Fig. 4 is an enlarged partial section of the lower portion of the liner set tool illustrating the tension sleeve severance at the initial stage of release.

Fig. 5 is an enlarged partial section of the lower portion of the liner set tool showing the cementing phase taking place.

Fig. 6 is a partial sectional view in reduced scale of the elements shown in Fig. 4 illustrating the final flushing operation after the liner has been cemented in place.

Fig. 7 is a transverse sectional view taken through the tension sleeve portion of the liner set tool along section line 7—7 of Fig. 2.

The heart of the present invention is the use of hydraulic pressure to accomplish all phases of the liner set tool operation, and particularly to accomplish its release. In essence, the invention proceeds from the discovery that a tension member, calculated to part at preselected hydraulic pressures, may be employed to accomplish the release of the tool in setting the liner.

Although the following description relates to a secondary drilling operation, and setting a liner after such a drilling, the mechanism may be employed in setting a liner whenever desired. Accordingly the invention contemplates setting a liner and is not intended to be limited to the specific operation shown in the drawings and described in detail.

Referring now to Fig. 1, it will be seen that the casing **10** of the original well has been set in cement **11** flush up against the earthen side wall **12** of the drilling. The secondary bore **14** extends down to the pay zone area **15** terminating at the bottom portion **16** of the well. When it is appreciated that the secondary casing or liner **18** may be set at any depth below the surface, it will be appreciated that the problem of orienting and controlling the liner **18** for cementing into the hole **14** is a difficult one.

After the secondary hole **14** has been drilled, a concrete shoe **19** is lowered to the bottom of the well communicating to the well head by means of a string of production tubing **20**. The invention resides in the structure employed to couple and uncouple the shoe **19** with the string of production tubing **20**.

Referring now to Figs. 2 and 3, it will be seen that the concrete shoe **19** is encased in a sleeve **21** having a plurality of lands **22** and grooves **24** which firmly anchor the concrete to the sleeve **21**. The upper portion **25** of the sleeve **21** is threaded and threadedly engages the lower portion **26** of the liner **18**. In this manner the depth to which the liner **18** penetrates the hole **14** will be largely a function of the depth to which the shoe **19** is permitted to descend.

To couple the shoe **19** with the production tubing **20**, a threaded ring **28** is secured in the upper portion **25** of the shoe sleeve **21**. The internal portion **29** of the threaded ring **28** is threaded to receive the tension sleeve **30**. The tension sleeve **30** is threaded at its lower end **31** for a threaded engagement with the ring **28** thereby coupling the tension sleeve **30** with the shoe **19**. At its upper end **32** the tension sleeve is similarly threaded to fit a standard sleeve type threaded coupling **34**.

It will be appreciated that if the tension sleeve **30** is severed at its narrow neck portion **35**, the entire upper assembly including the production tubing **20** may be withdrawn from the inner portion of the liner **18** leaving the shoe **19** and its related elements in place.

A by-pass valve assembly **36** is provided with the lower threaded portion **38** to threadedly engage the coupling sleeve **34**. The valve assembly **36** contains a hollow sliding sleeve **39** which is secured in place by means of shear pins **40** in such a manner that the by-pass sub-ports **41** are covered. The sleeve valve **39** has a pair of O-rings **42** at its upper and lower portion to seal off circulation around its periphery. The O-rings **42** hold the sliding sleeve in place until the ball **51** is dropped and the pressure raised within the string to open the by-pass sub-ports **41** as will be described hereinafter.

The upper portion of the valve assembly **36** is threaded internally to receive an externally threaded coupler **45** which in turn is connected to a single-acting packer assembly **46**. The single acting packer cup **48** serves to prevent the flow of fluid upwardly through the annulus **49** defined by the inner wall of the liner **18** and the outer portion of the valve assembly **36**.

The remaining details of construction will be more fully

appreciated as the sequential operation of the tool is set forth. As pointed out above, the liner tool illustrated is employed in a secondary hole **14** drilled through a completed well having a casing **10** cemented in place. The entire liner assembly is then lowered down the well supported by the production tubing **20** and lowered to a predetermined location to a secondary drilling **14**. In the event that the operation renders it undesirable to lower the shoe **19** directly on to the bottom of the well **16**, a liner hanging tool **50** is employed to fix the liner **18** to the existing casing **10** at a predetermined location. The advantageous use of the present tool will become quite apparent when it is appreciated that the liner hanging tool **50** is released by twisting the liner **18**. Such liner hangers are known in the art (see my copending application Serial No. 614,100), and any hanger tool which locks the casing **10** and liner **18** to each other will suffice. The entire operation of cementing the liner in place, by employing the unique tool of the invention, is accomplished without any subsequent twist of the liner **18** after the liner set tool **50** has been engaged.

After the liner **18** has been oriented to its appropriate depth in the secondary drilling **14**, the by-pass valve actuating ball **51** is dropped down the tubing **20** until it sits on the upper shoulder **52** of the sliding valve **39**. At this point the pressure of the fluid within the tubing is raised to place a sufficient load on the sliding valve to shear the sliding valve support pins **40**. This action drops the lower shoulder **52** of the sliding valve **39** on to the internal shoulder **54** of the valve assembly **36** as best illustrated in Fig. 3. This opens the by-pass ports **41** to permit the fluid passing down through the tubing to pass outwardly into the annulus **49** defined by the liner set tool periphery and the internal wall **18**. The shear pins **40**, or their remains, then are forced into the bottom of the hole by the force of gravity augmented by the fluid flow.

After the operator has assured himself that the tubing is sound by pressure testing at a predetermined testing pressure, the pressure is then raised to approximate the predetermined parting pressure. This pressure exerts a tensile force on the narrow neck **35** of the tension sleeve **30** because the fluid passing through the by-pass ports **41** bears downwardly on the threaded ring **28** and upwardly on the packer element **48**. The neck **35** of the tension sleeve **30** is so proportioned that it will separate as shown in Fig. 4. In order to insure that a complete severance at the neck **35** is achieved, a stinger **55** extends from the bottom of the valve assembly **36** and traverses the narrow neck portion **35** of the tension sleeve **30**. The stinger **55** also serves to add rigidity to the assembly. A pair of O-rings **56** at the bottom of the stinger **55** prevent any fluid from passing downwardly into the shoe **19** until after complete severance has been accomplished.

Although the cementing operation could be performed prior to severing the tension sleeve **30**, most operators prefer to release the liner prior to pumping the cement down the hole to cement the liner in place. Accordingly the operator will raise the string of tubing **20** in order to remove the stringer **55** from the lower portion of the tension sleeve **30** and then pump a slurry of cement down the tubing **20**. The cement then flows down through the hollow central portion **57** of the shoe **19** and passes outwardly through the lateral by-pass ports **58** and downwardly through the lower annulus **59** of the shoe **19**. When the total predetermined charge of cement is in place around the liner, the flow of fluid may be reversed by pumping the fluid past the single acting packer **48** and down through the annulus **49** on the outside of the string of equipment. The fluid then flows, as shown in Fig. 6, up through the central portion of the stinger **55** and the tubing **20**. It will be noted that the check valve **61** in the shoe **19** serves to prevent any excessive pressure on the outside of the shoe **19** from backing cement fluid up through the liner **18** as the flushing operation takes place. The ball valve **61** sits in the seat portion **62** of the check valve ring **64** in the bottom of the shoe assembly **19**.

After the hole has been flushed to clean out the excess cement, the string of production pipe along the associated valve assembly **36** is removed from the well and the cement foundation **60** is allowed to set. Thereafter the shoe **19** is drilled out with an ordinary drilling tool and the production operation completed. It will be appreciated that in order to facilitate this final drilling out of the shoe **19**, the shoe should be formed of a material which can be readily drilled such as concrete, plastic, aluminum and the like, and the various fittings within the shoe of soft materials such as brass and the like.

As pointed out above by using the set tool described, no rotation of the liner **18** takes place after it is lowered into the well. In addition, severance of the tension sleeve **30** permits a clean and positive removal of the string of tubing and associated valve mechanism. The liner hanger **50** may be employed in the event that it is not desired to lower the shoe to the bottom of the hole. On the other hand, the shoe may be lowered to the bottom of the hole supporting the liner and associated equipment until it is removed. Further, in view of the hydraulic pressures at various levels, various critical operations can be positively determined by the employment of pressure gauges at the well head.

Although particular embodiments of the invention have been shown and described in full here, there is no intention to thereby limit the invention to the details of such embodiments. On the contrary, the intention is to cover all modifications, alternative embodiments, usages and equivalents of the liner set tool as fall within the spirit and scope of the invention, specification, and appended claims.

I claim as my invention:

1. For use on a string of well tubing and associated liner, a liner set tool comprising, in combination, a support, means on the support for attachment to the liner at the lower end of the liner, a tension sleeve, means on the lower end of the string of tubing for slidable sealed engagement with the tension sleeve, means on the support for attaching the tension sleeve within the liner thereby defining a tubing-liner annulus closed at its lower end, said tubing having a port therein, valve means on the tubing adjacent the port for selectively diverting the fluid pressure within the tubing to the tubing-liner annulus, and a packer element within the tubing-liner annulus and above the valve means oriented so that when the pressure is diverted into the tubing-liner annulus the packer element prevents upward flow of the fluid thereby tensioning the tension sleeve to its parting load.

2. A liner set tool for setting a liner having a hollow central bore through which a string of tubing may be extended comprising, in combination, a liner support coupled to the liner at the lower end thereof, a tubular tension sleeve secured to the lower end of the string of tubing and to the liner support and defining an annulus between its outer surface and the inner surface of the liner, a tubular extension of the string of tubing, said extension having sealing means for a sliding sealed relationship with the tubular tension sleeve, a packer element sealing the annulus defined by the outer portion of the string of tubing and inner bore of the liner against an upward fluid flow, said tubing having port means therein below said packer element, and valve means slidable on the string of tubing adjacent said port means for opening the same thereby selectively diverting fluid pressure from within the tubing to the annulus defined by the liner and tubing in that portion below the packer element and above the support, the valve means being located below the packer element, the tension sleeve being structurally reduced so that increase in the pressure of the fluid diverted by the valve means will cause the tension sleeve to part at the reduced portion thereby permitting the tubing to be withdrawn from the well.

3. A liner set tool of the character defined in claim 2 above, in which the valve means is characterized by an inner sliding sleeve within said tubing having an annular shoulder at its upper end, the port means being constituted as by-pass ports, shear pins positioning the sleeve to cover the ports, the shoulder in the sleeve being proportioned to engage a ball dropped down the tubing thereby permitting hydraulic pressure to shear the pins and open the by-pass ports.

4. A liner set tool for setting a liner having a hollow central bore through which a string of tubing is extended comprising, in combination, a liner shoe having a central conduit, means on the shoe for lockingly engaging the liner, a tension sleeve secured to the shoe, means coupling the tension sleeve with the string of tubing, a packer element sealing the annulus defined by the outer portion of the string of tubing and inner bore of the liner, said tubing having a port therein below said packer element, valve means on the string of tubing adjacent said port

for selectively diverting fluid pressure from within the tubing to the annulus defined by the liner and tubing, a hollow stinger extending downwardly from the valve means into the tension sleeve, the tension sleeve being structurally reduced so that increase in the pressure of the fluid diverted by the valve means will cause the tension sleeve to part at the reduced portion thereby permitting the tubing to be withdrawn from the well leaving only the shoe and liner.

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