United States Patent

[11] 3,608,634

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Houston, Tex.

[54] **HYDRAULIC SET LINER HANGER**
7 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **166/208,** 166/124, 166/212
[51] **Int. Cl.** **E21b43/10,** F21b 33/129
[50] **Field of Search** 166/124, 125, 181, 182, 208, 212

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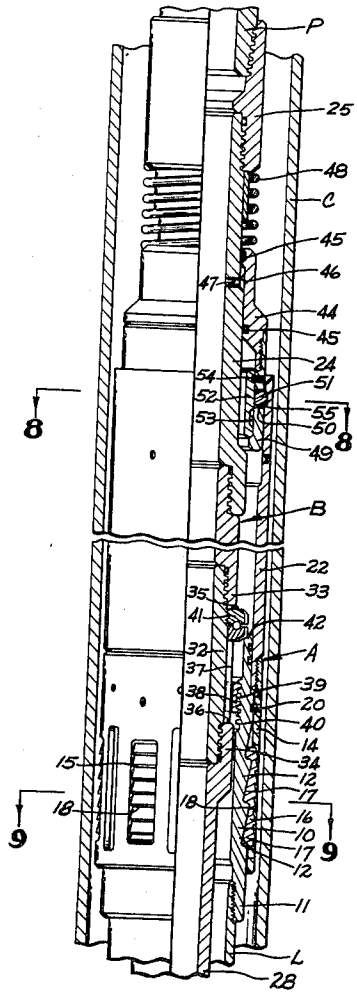
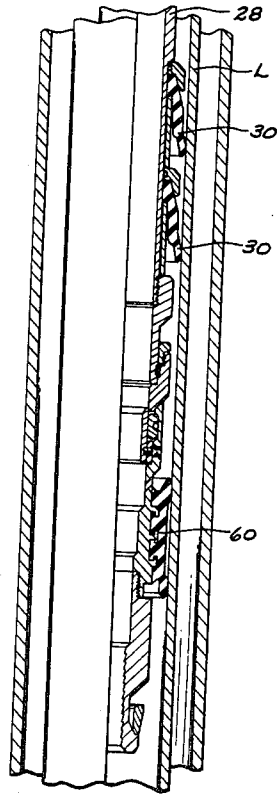
ABSTRACT: A liner hanger employing a hydraulically actuated setting tool structure which is removable substantially entirely after setting of the hanger leaving a minimal amount of hanger structure in the well. A dog-type latch provides an improved releasable connection between the setting tool and the hanger and a reset spring is provided in the event of premature setting of the hanger to enable release of the hanger for movement to the desired location.





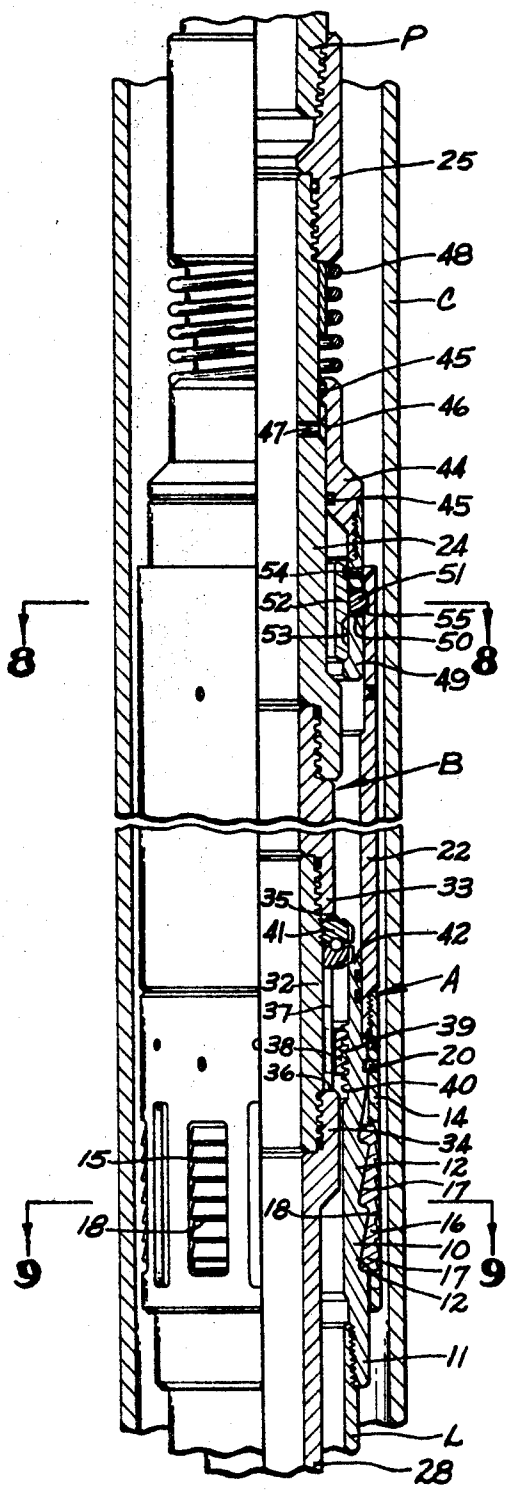


Fig. 1A

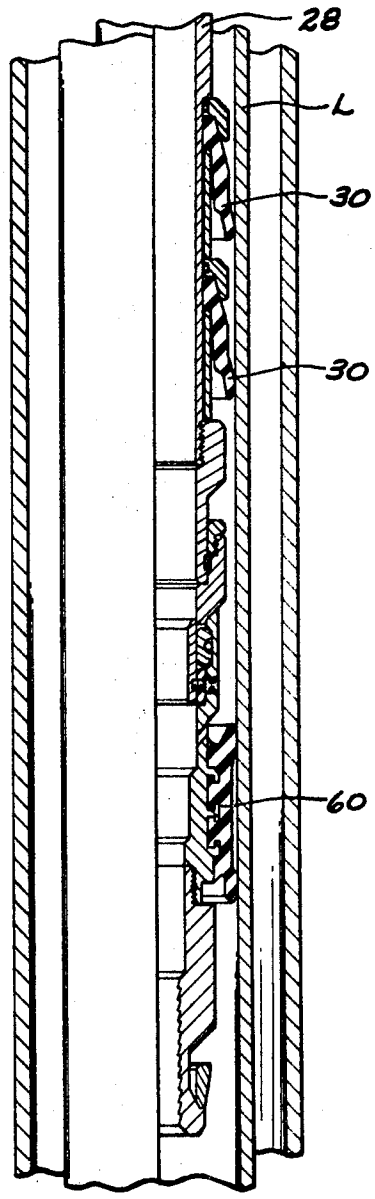


Fig. 1B

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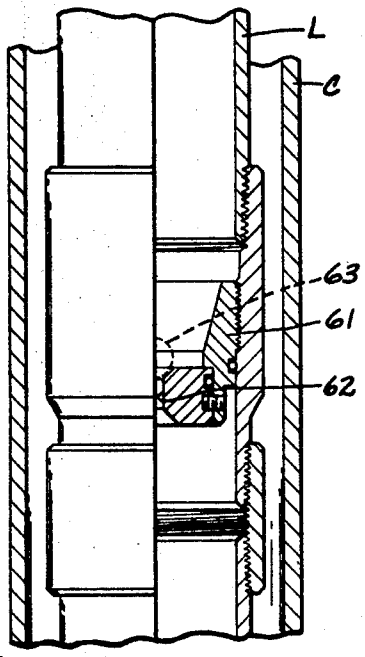

Fig. 1C

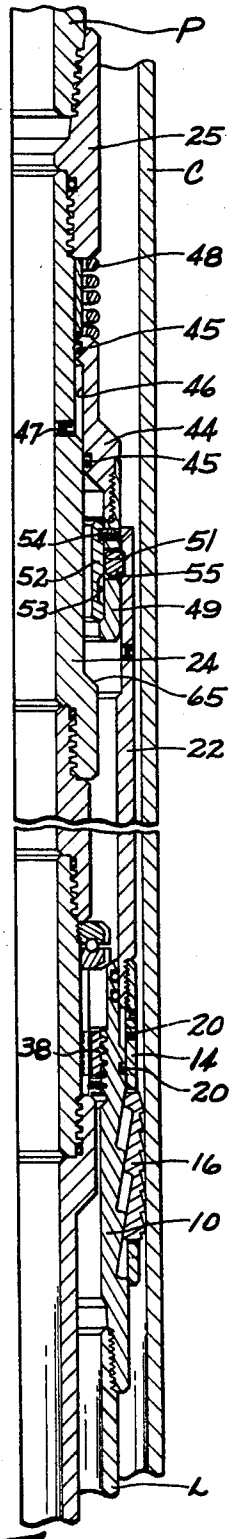

Fig. 2

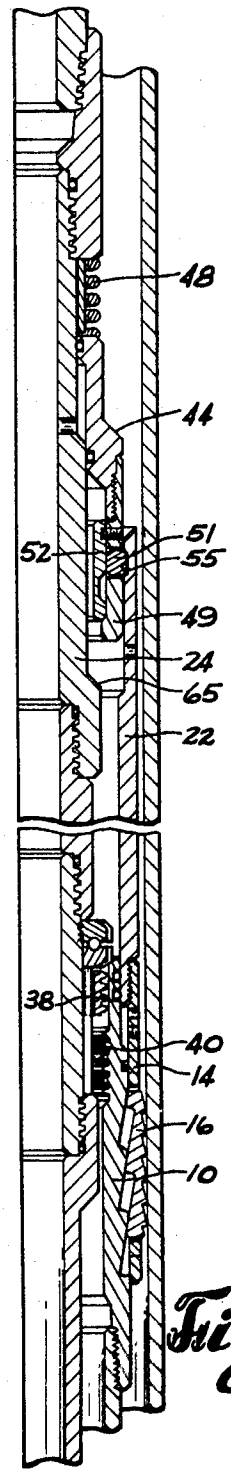

Fig. 3

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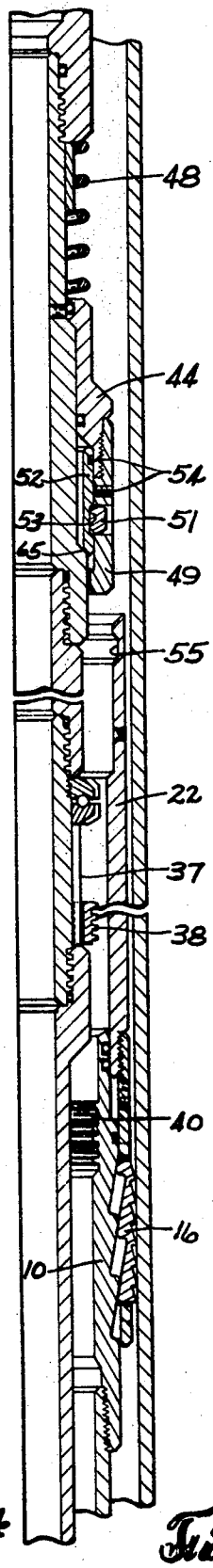

Fig. 4

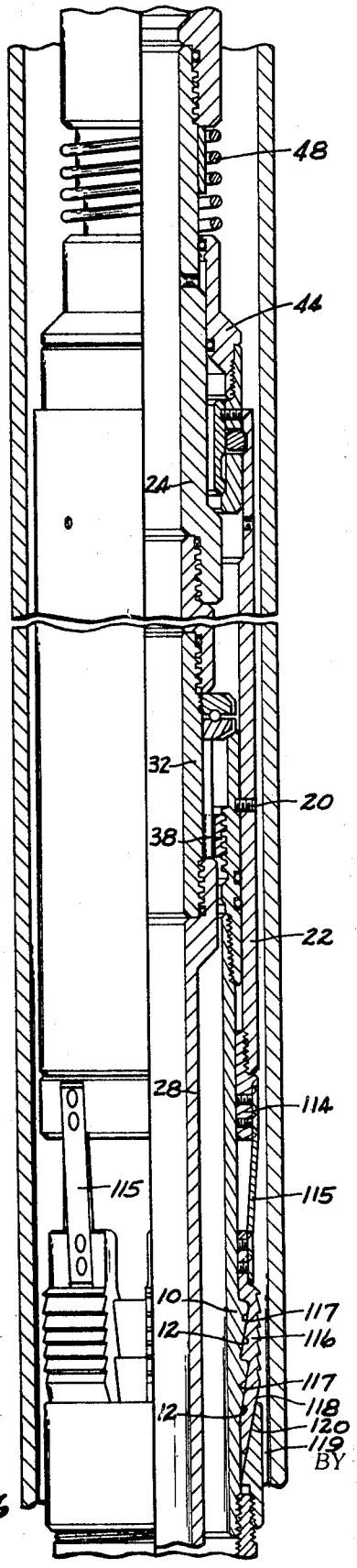

Fig. 6

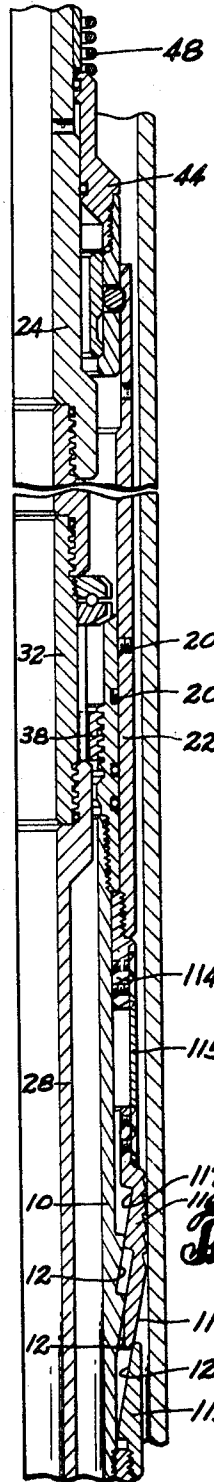

Fig. 7

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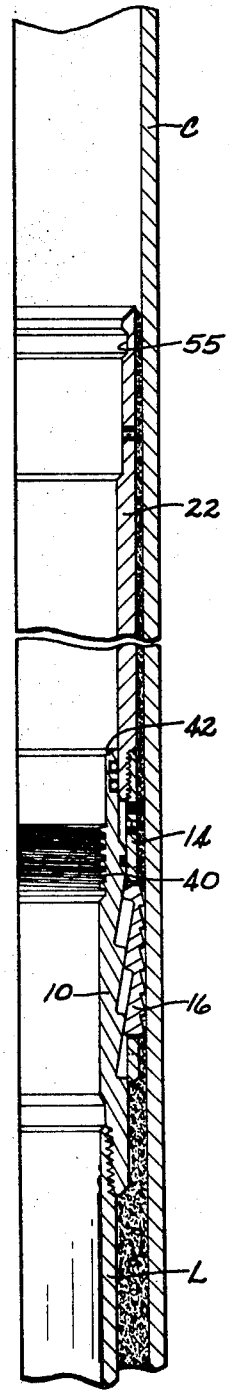

Fig. 5

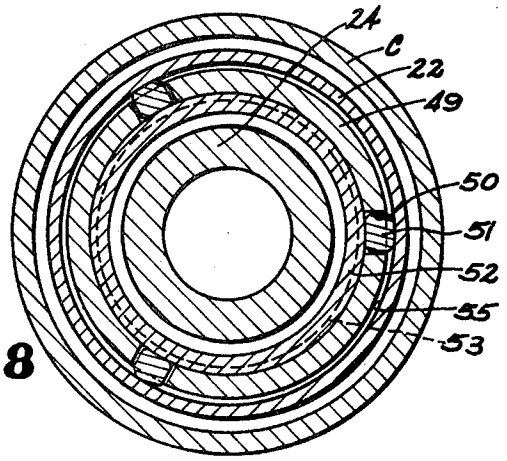

Fig. 8

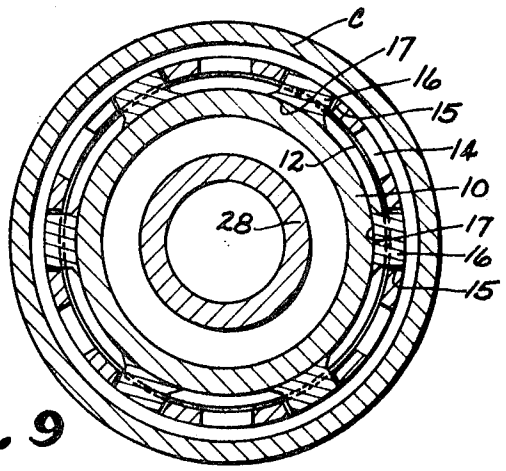

Fig. 9

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HYDRAULIC SET LINER HANGER

Liner hangers are employed to secure an inner pipe string or liner to an outer pipe string or casing in a well bore generally preparatory to cementing the liner in place in the well bore to seal off the surrounding earth formations.

Generally speaking, the liner hanger is secured to the upper end of the liner string and is run on a setting tool assembly which functions to secure the liner to the surrounding casing and to aid in the subsequent cementing operation. In more conventional liner hangers, substantial portions of the setting assembly form integral parts of liner hanger and must remain in the well, thereby substantially increasing the cost of the liner hanger to the well operator, as well as increasing the complexity of the operations involved in setting the hanger and conducting the subsequent cementing operations.

The present invention is directed to a greatly simplified liner hanger in which the setting tool is actuated by hydraulic pressure to anchor the liner to the surrounding casing, and is retrievable substantially in its entirety when setting is completed leaving only minimal hanger structure in the well.

In accordance with a preferred embodiment of this invention, the hanger body employs a multicone and slip construction which greatly reduces the overall length of the hanger itself. The setting tool includes a mandrel which carries a setting collar slidably mounted thereon and releasably attached to the hanger setting sleeve by a positive dog-type latch which assures against premature setting of the hanger during running. The setting collar embodies a cylinder communicating with the bore of the mandrel for admitting pressure fluid to actuate the hanger. A floating nut provides a releasable connection between the mandrel and the hanger which upon release, enables the setting tool to be withdrawn from the hanger. Spring means is provided in compression between the mandrel and the setting collar which functions to permit release of the hanger in the event the hanger is prematurely set during running to thereby allow the running of the hanger to be resumed without requiring the hanger to be withdrawn from the well for resetting.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate one embodiment of the invention and a modification thereof.

IN THE DRAWING

FIGS. 1A, 1B, and 1C, together, comprise a longitudinal quarter-sectional view of the liner hanger and setting tool assembly, together with some related parts employed in the liner cementing operation, but which do not themselves form a part of this invention, the tool parts being shown in the running position;

FIG. 2 is a longitudinal quarter-sectional view corresponding to FIG. 1A showing the hanger set in the surrounding well casing;

FIG. 3 is a view similar to FIG. 2 showing the setting tool released from the hanger body;

FIG. 4 is a view similar to FIG. 3 showing the setting tool completely released from the hanger preparatory to withdrawal of the setting tool from the well;

FIG. 5 is a view similar to FIG. 4 showing the hanger in place and cemented, the setting tool being completely removed;

FIG. 6 is a longitudinal quarter-sectional view of modified form of the liner hanger, the parts being shown in the running-in position;

FIG. 7 is a view generally similar to FIG. 6 showing the hanger in the set position with the setting tool in the same positions as seen in FIG. 2; and

FIGS. 8 and 9 are cross-sectional views taken on lines 8—8 and 9—9 respectively, of FIG. 1A.

Referring to the drawing, more particularly to FIGS. 1A to 1C, the hanger structure comprises the liner hanger, per se, designated generally by the letter A, and the setting tool structure designated generally by the letter B, which is secured to the hanger structure and by means of which the tool string is run inside a well casing C, to which the hanger A is to be attached.

Liner hanger A comprises a tubular body **10**, the lower end of which has a threaded socket **11** for connection of the hanger to tee upper end of a pipe string L which constitutes the liner to be anchored to the casing C. The exterior of hanger body **10** is provided with a stepped surface, the portions of which define successive upwardly and outwardly tapering frustoconical surfaces **12—12**, there being at least two of these steps on the exterior of the body **10** to form expander cones. Surrounding body **10** is a tubular cage **14** having a plurality of openings or windows **15** in which are mounted pipe-gripping slips **16**, having their inner surfaces stepped in a manner complementary to the stepped expander surfaces **12**, the complementary surfaces on the interior of the slips being indicated by the numerals **17—17**. Slips **16** are provided with buttress teeth **18** on their outer surfaces for biting into the wall of casing C, when the slips are moved outwardly and upwardly relative to hanger body **10**. Downward movement of the slips with cage **14** relative to body **10** will cause slips to retract out of gripping engagement with casing C. Cage **14** is held in its slip-retracting down position relative to hanger body **10** by means of shear pins **20** which secure the cage to body **10**. The upper end of cage **14** is secured to extension sleeve **22** which is termed the setting sleeve in this description.

Setting tool B comprises the tubular mandrel **24**, the upper end of which is externally threaded for connection by means of a coupling **25**, to a running pipe string P and the lower end of which is connected to a seal nipple **28** carrying downwardly opening cup seals **30** for sealing off the annular space between the seal nipple and the wall of liner L (FIG. 1B). Mandrel **24** includes a sub **32** threadedly received at its upper end in a threaded socket **33** forming a portion of the mandrel and at its lower end in a socket **34** carried by the upper end of the seal nipple, thus forming the connection between the latter and the mandrel. The ends of sockets **33** and **34** define spaced-apart external shoulders **35** and **36**, respectively.

The exterior of sub **32** between shoulders **35** and **36** is provided with one or more longitudinally extending radial splines **37** on which a floating nut **38** is slidably mounted. The exterior of nut **38** carries a section of left-hand threads **39** adapted to mate with a complimentary section of threads **40** formed in the inner wall of hanger body **10**. By means of the left-hand thread arrangement, rotation of the mandrel in the right-hand direction will cause nut **38** to move upwardly on splines **37** relative to hanger body **10** to effect release of this connection between the mandrel and the hanger body when the nut has cleared threads **40** (FIG. 3). Mounted about sub **32** between shoulder **35** and the upper end of splines **37** is an antifriction bearing **41** which is supported between shoulder **35** and a bearing shoulder **42** formed by the upper end of hanger body **10**. This bearing arrangement aids rotation of the mandrel relative to the liner hanger during operation of the tools.

A setting collar **44** is slidably mounted about the upper portion of mandrel **24** and carries spaced-apart internal packings **45—45** slidably sealing with the exterior of the mandrel to define between them a cylinder **46** which is in communication with the bore of the mandrel via one or more ports **47** which extend through the wall of the mandrel. Setting collar **44** is biased downwardly relative to the mandrel by means of a coil spring **48** disposed about the upper end portion of mandrel **24** in compression between the upper end of collar **44** and coupling **25**.

The lower end portion of collar **44** is enlarged in diameter and is connected to a tubular cage **49** concentrically spaced from the exterior of mandrel **24** and dimensioned to extend between the latter and the upper end of setting sleeve **22**. Cage **49** is provided with a plurality of angularly spaced radial windows **50** in which latching dogs **51** are mounted for radial movement. Dogs **51** are dimensioned to a radial thickness somewhat greater than that of the wall of cage **49** so as to

present shoulders exteriorly or interiorly of cage **49** depending on the direction in which the dogs are moved in windows **50**. A latching sleeve **52** is mounted in the bore of cage **49** and is provided near its lower end with an external recess **53** adapted to receive dogs **51** when moved upwardly inside cage **49** into registration with the dogs. Latching sleeve **52** is initially held in its upper position (FIG. 1A) by means of shear screws **54** connecting the sleeve to the cage. In this position sleeve **52** forces dogs **51** outwardly of the cage and the upper end of setting sleeve **22** is provided with an internal annular recess **55** to receive the thus outwardly projected dogs. In the position shown in FIG. 1A, the dogs **51** provide a positive connection between the running collar and the setting sleeve with provides greater assurance against untimely release of the setting tool from the liner hanger during running of the tools than is afforded by the more conventional shear pins commonly used for a corresponding purpose.

As the liner hanger is commonly employed in conjunction with tools for cementing the liner in the well bore after it is secured to the casing, FIG. 1B shows a conventional cementing plug **60** releasably secured to the lower end of seal nipple **28**, and FIG. 1C illustrates a conventional landing collar **61** mounted in the bore of casing C and provided with a central opening **62** adapted to be closed by means of a ball **63** (shown in broken lines) which is pumped down through the running string for closing off the casing bore to permit buildup of fluid pressure inside the liner hanger setting tool for purposes of setting the hanger as well as for other purposes in connection with the cementing operation.

It will be understood that seal nipple **28**, cementing plug **60** and landing collar **61**, do not, per se, form parts of the liner hanger structure of this invention, except insofar as they illustrate one means by which fluid pressure can be directed into cylinder **46** of the setting collar. Other means for this purpose will be readily evident to those skilled in the art to which the present invention pertains.

In operation, the liner hanger A connected to the top of liner L and with setting tool B connected thereto with the respective parts in the positions shown in FIGS. 1A to 1C, will be run into casing C on pipe string P. In this stage of operation running collar **44** will be secured to setting sleeve **22** and mandrel **24** connected to hanger body **10** by means of floating nut **38**.

When the tools have reached the desired point inside casing C, ball **63** will be dropped through the bore of pipe string P and pumped down with fluid, such as mud, to its seat on landing collar **61** closing port **62**, sealing off the casing, and allowing fluid pressure to build up inside the bore of mandrel **24**. The pressure will be transmitted through ports **47** into cylinder **46** and exert upward pressure on collar **44** and thence through setting sleeve **22** to slip cage **14** with sufficient force to break shear screws **20** (FIG. 2), moving the cage upward relative to body **10**. This relative upward movement of the cage will force slips **16** upwardly and outwardly over expander surfaces **17—17** until teeth **18** are caused to bite strongly into the wall of casing C, thereby setting the liner hanger and securing the liner to the casing. The upward movement of the setting collar on mandrel **24** will strongly compress spring **48**. If for any reason the slips on the liner hanger have set prematurely during the running of the tools, it is only necessary to pick up on the running string, whereupon the force of the compressed string **48** will act to push setting collar **44**, setting sleeve **22** and slip cage **14** downwardly relative to the mandrel to thereby push slips **36** downwardly and inwardly to their retracted positions, freeing the tools for further downward movement as may be required. The continued engagement of dogs **51** in recess **55** provides a positive connection between the running collar and the liner hanger which enables the necessary manipulation of the tools with assurance against premature release of the setting tool from the liner hanger.

When the hanger is firmly set, running string P will be rotated in the right-hand direction causing floating nut to move upwardly to the position releasing it from its connection to hanger body **10** (FIG. 3), thereby freeing the setting tool and its appended cementing tools for manipulation as may be required in conducting the operations for cementing the liner in the well. These operations will generally require some relatively short longitudinal movements of the setting tool while the cement is being placed and excess cement circulated out of the well.

Thereafter, to effect removal of the setting tool and its appended seal nipple, the other cementing tools being left in the well, upward pull will be applied through the running string to the mandrel to pull the latter upwardly. Running collar **44** will remain stationary through its connection to setting sleeve **22** which will be anchored to the casing wall by slips **16**. The resulting relative upward movement of mandrel **24** will bring a shoulder **65** on the exterior of the mandrel into abutting engagement with the lower end of latching sleeve **52** (FIG. 4) with sufficient force to break shear pins **54** and raise sleeve **52** upwardly sufficiently to place recess **53** in registration with dogs **51**. This will free the latter to retract from recess **55**, thereby releasing collar **44** from setting sleeve **22**. The entire setting tool assembly may now be withdrawn from the well leaving only the relatively short liner hanger in the well as best seen in FIG. 5, where it is shown cemented to the casing.

By providing the stepped conical surfaces on the hanger body, the overall length of the hanger will be substantially reduced as compared with more common designs and it will be evident that minimal hanger structure will be left in the well while the entire setting tool will be withdrawn and may be reused in its entirety with other hangers, thereby greatly reducing the cost to the user.

FIGS. **6** and **7** illustrate a modification of the liner hanger involving essentially a modified design of the slip cage and slips. In all other respects the parts are identical with those in the principal embodiment and bear the same numbers.

In this modification the slip cage comprises a ring **114** to which slips **116** are pendently connected by spring arms **115**. The slips have stepped internal surfaces **117** complementary to the stepped expander surfaces **12—12**. The lower ends of the slips have downwardly and inwardly tapering surfaces **118** adapted to be received in a keeper collar **119** having a tapered inner surface **120** matching the taper of slip surfaces **118**. Keeper collar **119** serves to hold the slips inwardly against expander surfaces **12—12** during the longitudinal movements of the slip cage during setting and releasing movements of the slips and to prevent premature engagement with the casing while the tools are being run into the casing. The operations of the setting tool in setting the hanger and in effecting release of the setting tool from the hanger are otherwise identical with the operations described above in connection with the first-described embodiment.

It will be apparent that numerous changes and modifications may be made in the details of the illustrative embodiments without departing from the disclosed invention.

What I claim and desire to secure by Letters Patent is:

1. A liner hanger, comprising,

a. a tubular body connectable to a liner;

b. upwardly and outwardly tapering expander surfaces on the body;

c. a cage member slidable longitudinally on the body;

d. pipe-gripping slips carried by the cage member cooperating with said expander surfaces for radial movement into and out of gripping engagement with a surrounding well pipe in response to longitudinal movement of said cage member relative to said body;

e. a tubular setting sleeve secured to the upper end of said cage member;

f. a setting tool including a tubular mandrel extending through the bores of said sleeve and of said body and connectable to an operating pipe string;

g. cooperating means connecting said mandrel to said body and releasable therefrom by right-hand rotation of the mandrel relative to the body;

h. a fluid pressure-actuated latching collar longitudinally slidable on the mandrel;

i. releasable latch means initially securing said collar to said setting sleeve and releasable therefrom in response to relative longitudinal movement of said mandrel;

j. means resiliently urging said collar downwardly on said mandrel; and

k. means in said mandrel for directing operating pressure fluid to said collar.

2. A liner hanger according to claim 1, wherein said expander surfaces are of stepped configuration; and wherein said slips have stepped inner surfaces of complementary configuration.

3. A liner hanger according to claim 1, wherein said cage member comprises a ring to which said slips are pendently supported by flexible arm means, and wherein a keeper collar is mounted on said body to slidably receive the free ends of said slips.

4. A liner hanger according to claim 1, wherein said cooperating means comprises:

a. a nut having external left-hand threads splined for longitudinal nonrotative movement on said mandrel; and

b. a section of complementary threads in the bore of said body.

5. A liner hanger according to claim 1, wherein said latching collar carries longitudinally spaced seals defining a cylinder surrounding said mandrel; and ports through the wall of said mandrel communicating with said cylinder.

6. A liner hanger according to claim 1, wherein said releasable latch means comprises:

a. a tubular cage secured to said collar and extending concentrically into the upper end of said setting sleeve;

b. latch dogs mounted in the wall of said cage for radial movement into and out of latching engagement with said setting sleeve; and

c. a latching sleeve mounted in the bore of the cage releasably secured therein to initially hold said dogs in said latching engagement and releasable by said relative longitudinal movement of said mandrel.

7. A liner hanger, comprising:

a. a tubular body connectable to a liner;

b. upwardly and outwardly tapering expander surfaces on said body, each of said expander surfaces having a stepped configuration comprising at least two successive steps;

c. a cage member slidable longitudinally on the body;

d. pipe gripping slips carried by the cage member having stepped tapered inner surfaces complementary to and cooperating with said expander surfaces for radial movement into and out of gripping engagement with a surrounding well pipe in response to longitudinal movement of said cage member relative to said body; and

e. setting means cooperating with said cage member for effecting said relative longitudinal movement thereof; said setting means including:

i. a tubular mandrel extending through said body and connectables to an operating pipe string,

ii. a setting collar slidably mounted on said mandrel; and

iii. latch means releasably connecting said collar to said cage member.