Sept. 9, 1947. L. SPENCER 2,427,330

LINER HANGER

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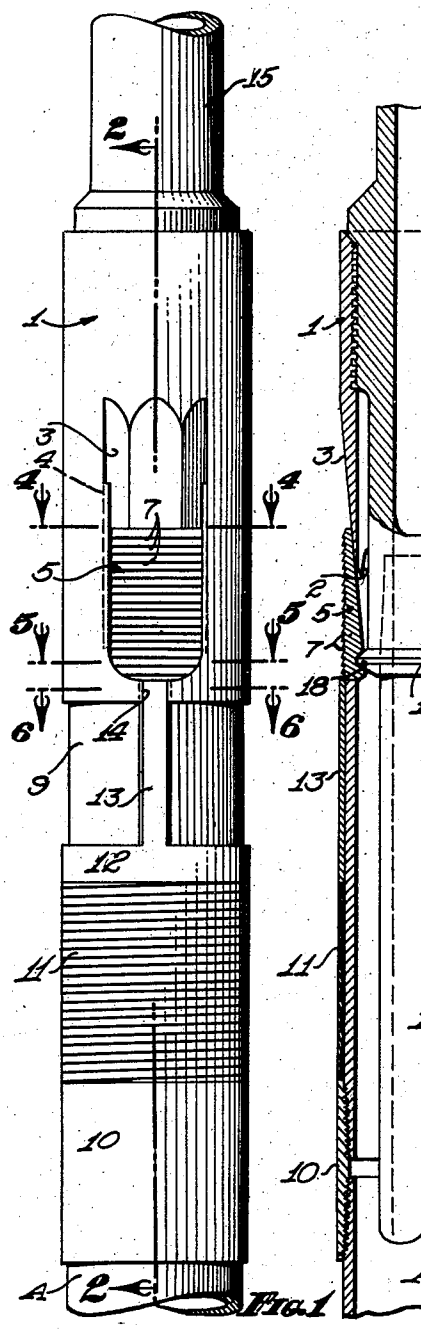


FIG. 1

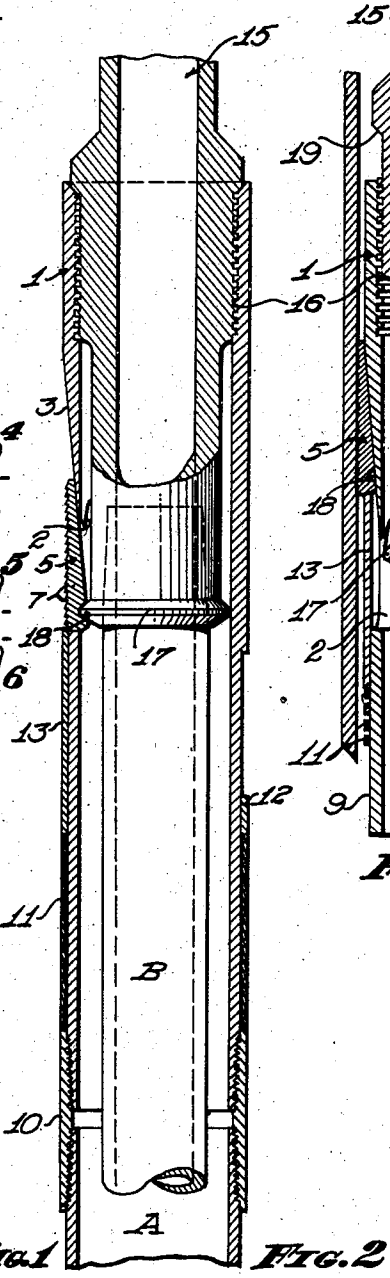


FIG. 2

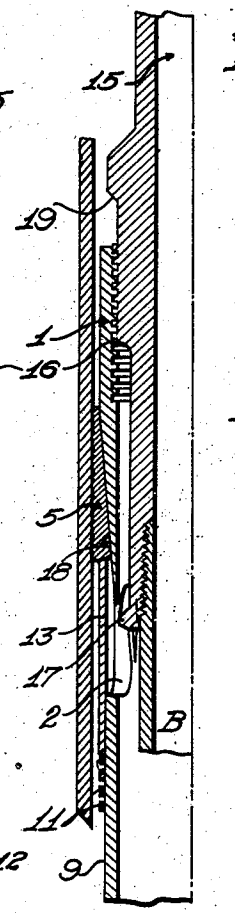


FIG. 3

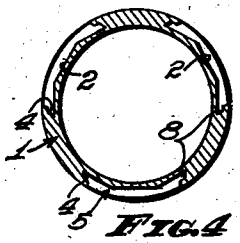


FIG. 4

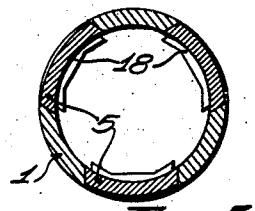


FIG. 5

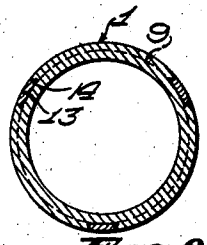


FIG. 6

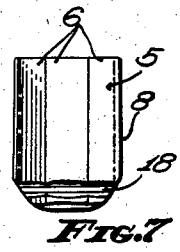


FIG. 7

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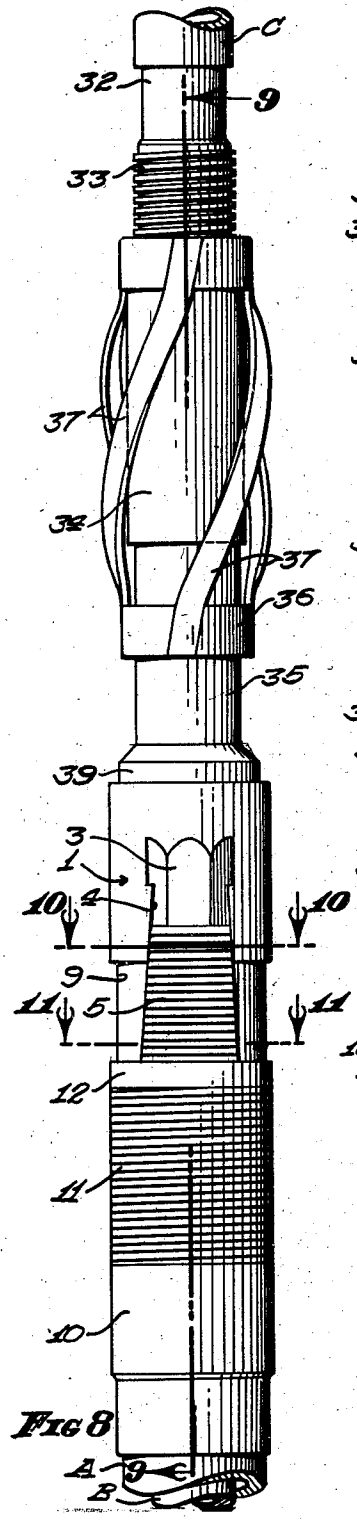


FIG 8

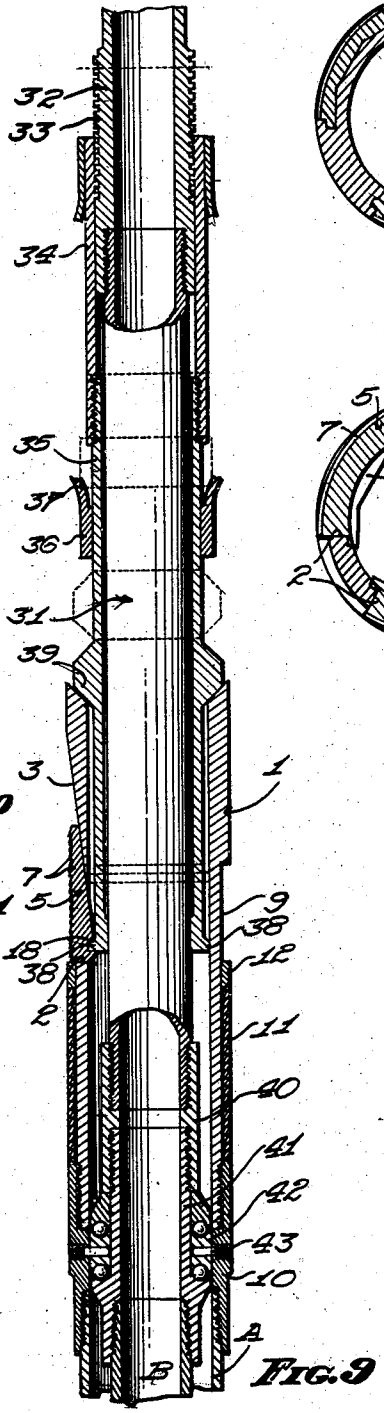


FIG. 9

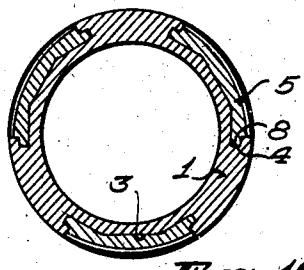


FIG. 10

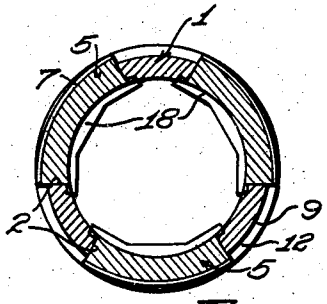


FIG. 11

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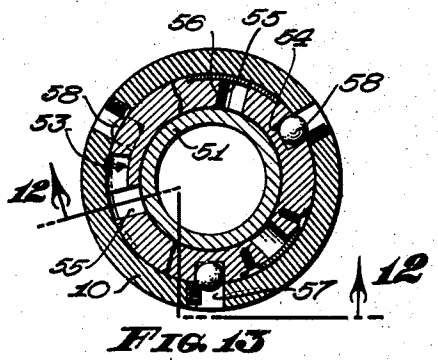


FIG. 13

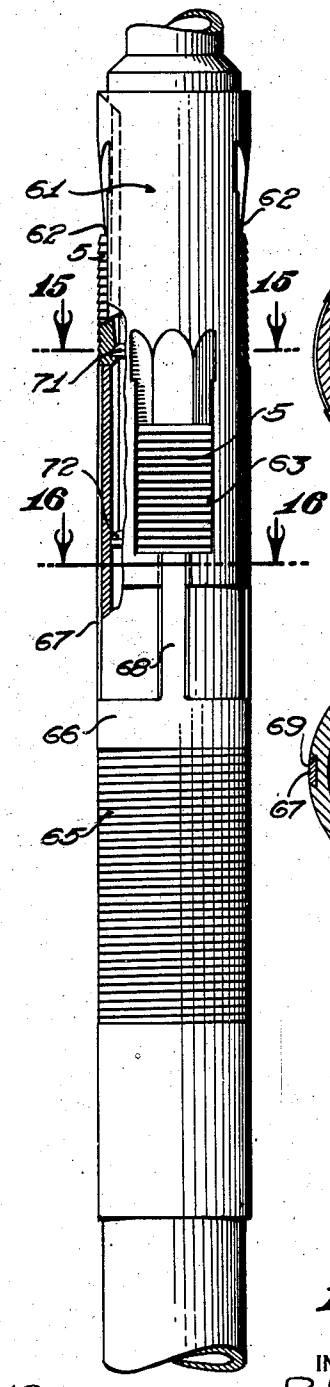


FIG. 14

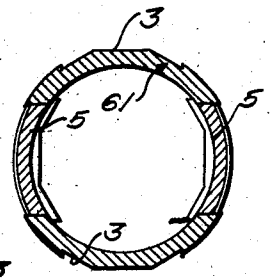


FIG. 15

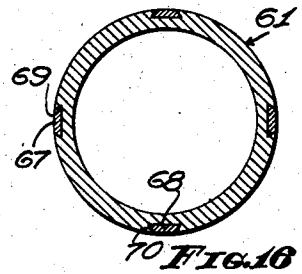


FIG. 16

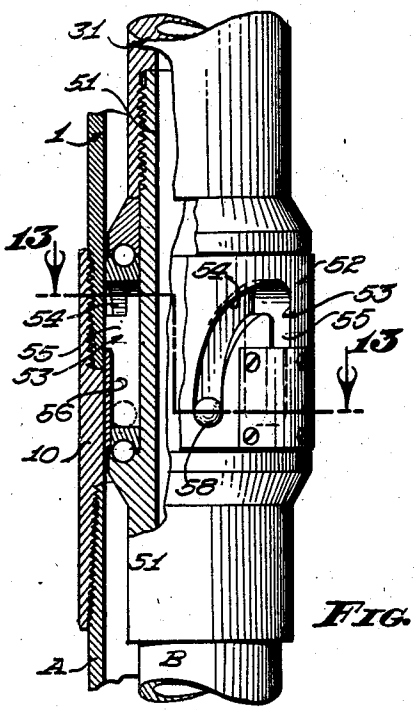


FIG. 12

INVENTOR

BY Lloyd Spencer

ATTORNEY

Patented Sept. 9, 1947 2,427,330

UNITED STATES PATENT OFFICE

2,427,330

LINER HANGER

Lloyd Spencer, Los Angeles, Calif., assignor to Lane-Wells Company, Los Angeles, Calif., a corporation of Delaware

Application October 1, 1941, Serial No. 413,197

12 Claims. (Cl. 166—12)

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My invention relates to liner hangers; that is, to devices designed to engage a well casing for the purpose of suspending therefrom a liner, usually perforated, which extends below the casing into the producing zone of the oil well. Among the objects of my invention are:

First, to provide a liner hanger, the wall thickness of which need be no greater than the liner which it supports, so that for a given size of casing a liner of maximum diameter may be inserted, with a full gauge opening through the liner hanger into the liner;

Second, to provide a liner hanger which incorporates a novel slip construction wherein the slips may be equal to if not actually greater than the wall thickness of the liner hanger itself, thus providing a liner hanger which, although constructed with a minimum wall thickness, is provided with large sturdy slips of maximum area for engagement with the casing;

Third, to provide a liner hanger and setting tool which are so arranged that should the liner hanger accidentally become disconnected from the setting tool the slips of the liner hanger are automatically released, so that the liner hanger functions as a tubing catcher to engage the walls of the casing and arrest downward movement of the liner and prevent its falling to the bottom of the well;

Fourth, to provide a liner hanger which, for a given clearance between the liner hanger and the surrounding casing, offers a minimum amount of resistance to circulation of fluid therebetween, there being no slip cages or other obstruction protruding from the normal diameter of the liner hanger;

Fifth, to provide a liner hanger which, after the slips are set, forms auxiliary internal by-pass ports around the slips so that the effective circulation area is not diminished by the setting of the slips, thus facilitating washing and cleaning of the formation around the liner below;

Sixth, to provide a liner hanger and setting tool therefor wherein the slips initially project through the liner into the interior thereof and are initially restrained by the setting tool, so that removal of the setting tool from within the liner hanger automatically releases the slips;

Seventh, to provide a liner hanger and setting tool wherein the liner hanger comprises a minimum number of parts and wherein many of the parts normally present in a conventional liner hanger constitute elements of the setting tool and may therefore be removed for repeated use; and

Eighth, to provide a liner hanger and setting

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tool wherein the setting tool is free of internal obstruction or sliding connection, so that a uniform diameter passage may be had through the tubing, setting tool and the wash pipe, and wash fluid or cement, or various well tools, may pass through the setting tool.

With the above and other objects in view, as may appear hereinafter, reference is directed to the accompanying drawings, in which:

Figures 1 through 7 show one form of my liner hanger, in which:

Figure 1 is an elevational view of one form of my liner hanger in its initial position, the setting tool from which the line hanger is suspended and the liner attached to the liner hanger being shown fragmentarily;

Figure 2 is a longitudinal sectional view through the liner, taken through 2—2 of Figure 1 and showing the setting tool partially in elevation therein, the parts being shown in the positions assumed when the liner is being lowered into the well bore;

Figure 3 is a fragmentary longitudinal sectional view similar to Figure 2, showing the position of the parts when the liner is engaged by means of its slips with a surrounding casing, the setting tool being shown partially disconnected from the liner;

Figures 4, 5 and 6 are transverse sectional views through 4—4, 5—5 and 6—6, respectively, of Figure 1 with the setting tool omitted; and

Figure 7 is an elevational view of one of the slips as viewed from its inner side.

Figures 8, 9, 10 and 11 show a modified form of my liner hanger and setting tool, in which:

Figure 8 is an elevational view of my liner hanger and setting tool showing the parts in the positions assumed when running into the well, and showing fragmentarily the tubing string, liner and wash pipe;

Figure 9 is a longitudinal sectional view through 9—9 of Figure 8 with a portion of the setting tool shown in elevation and indicating by dotted lines the positions of the parts when the slips of the liner hanger are released; and

Figures 10 and 11 are enlarged transverse sectional views taken through 10—10 and 11—11, respectively, of Figure 8.

Figures 12 and 13 show a modified means of connection between the setting tool and liner hanger body, in which:

Figure 12 is a fragmentary partial elevational, partial sectional view of the setting tool with the liner hanger body shown fragmentarily, the sec-

tion being taken substantially through 12—12 of Figure 13; and

Figure 13 is a transverse sectional view thereof through 13—13 of Figure 12.

Figures 14, 15 and 16 illustrate a further modified form of my liner hanger, in which:

Figure 14 is an elevational view thereof with a portion broken away and in section, the parts being shown in their initial positions as the liner is lowered into the well; and

Figures 15 and 16 are transverse sectional views through 15—15 and 16—16, respectively, of Figure 14.

Reference is first directed to Figures 1 through 7: The liner hanger here illustrated comprises a cylindrical body 1, preferably having the same inside diameter as the liner which it is adapted to suspend, and the same outside diameter as the collars which connect the sections of the liner.

The body is provided near its upper end with slots 2 which are formed by cutting downwardly through the body, so that the upper portions of the slots or openings form inclined slip expanding faces 3. Each inclined slip expanding face preferably comprises a central flat surface and flanking flat surfaces at obtuse angles therewith, so that a transverse section through the slip expanding face forms a section of a polygon, as shown in Figure 4. The side surface of each slip expanding face 3 is provided with undercut side grooves 4.

Each slot receives a slip 5 of wedge shape longitudinal section whose inner side forms wedge faces 6 conforming to the slip expanding faces 3. The outer side of each slip is grooved or serrated to form wickers 7 for engagement with a surrounding well casing, as shown in Figure 3. The vertical, radially inner margins of the slips 5 are provided with ribs 8 which coact with the side grooves 4. The slips are thus restrained to a sliding movement along the slip expanding faces 3.

Below the slots 2 the body 1 is provided with a reduced portion 9; that is, its wall thickness is reduced. The lower end of the body 1 is screw-threaded for connection to a coupling 10 which in turn is joined to a liner A. The reduced portion 9 receives a coil spring 11, at the upper end of which is positioned a slidable collar 12 having fingers 13 which extend upwardly to the upper end of the reduced portion 9 and through guide slots 14 cut into the body 1 below each of the slips 5. The fingers 13 bear against the slips 5 so that the spring 11 exerts an upward pressure on the slips 5 for moving them upwardly and outwardly from the lower or retracted position shown in Figures 1 and 2 to the outer or extended casing engaging position shown in Figure 3.

The slips are initially restrained against such upward movement by means of a setting tool mandrel 15 which extends into the body member and is provided with a threaded connection 16. The threaded connection 16 is preferably a square, left-handed thread so that the connection may be easily made or broken. The lower portion of the setting tool mandrel is provided with a slip-retaining flange 17 which, when the mandrel is screwed into the body 1, is opposite the lower or thicker ends of the slips 5. Here the slips are provided with slip-retainer channels 18 into which the flange 17 fits. A wash pipe B may be attached to the lower end of the mandrel 15 and extend into the liner A.

Operation of the liner hanger is as follows:

The liner hanger and setting tool are initially connected together as shown in Figures 1 and 2, and lowered into the well bore on a tubing string or the like (not shown). The liner is lowered to the bottom of the well bore so as to hold the liner hanger against rotation and thereupon the setting tool is rotated in a direction to partially unscrew the connection 16. This releases the slips 5 which are urged upwardly into engagement with the surrounding casing by the spring 11, as shown in Figure 3. The liner hanger may then be raised a few feet until the liner is clear of the bottom of the well. Thereupon weight is applied to the tubing string, wedging the slips between the liner and casing. After this is accomplished the setting tool is again rotated to completely disconnect the mandrel 15 from the body 1. The setting tool may then be withdrawn.

It should be noted, however, that with this arrangement a slip joint, such as that disclosed in Patent No. 1,944,481, issued January 23, 1934, is preferably employed between the mandrel 15 and the tubing string so that weight may be taken off the threaded connection 16; otherwise this connection might bind.

Reference is now directed to Figures 8 through 11: The liner hanger itself is essentially the same as that described in Figures 1 through 7 and therefore similar parts are given similar reference characters. The essential difference is that the reduced portion 9 continues upwardly to a point above the slot 2 and the fingers 13 are omitted so that the collar 12 bears directly against the slips. With this construction the wall thickness of the liner is preferably somewhat greater than that in Figure 1 in order to provide adequate strength between the slots 2.

The setting tool, however, departs from the construction shown in Figures 1, 2 and 3. The setting tool comprises a tubular mandrel 31 which is joined to an adapter 32. This in turn is joined to a coupling provided at the lower end of the tubing string C. The adapter 32 is a short tubular member having external threads 33 (preferably square threads) which coact with internal threads of an upper sleeve member 34. The upper sleeve member 34 is joined to a lower sleeve member 35, a collar 36 is slidably mounted on the lower sleeve member and this collar is connected by cage springs 37 to the upper end of the upper sleeve member 34. The cage springs frictionally engage the side walls of a surrounding casing and are preferably set helically so that as the setting tool is lowered into the well the sleeve members tend to rotate in a direction to screw downwardly on the adapter 32.

The lower end of the lower sleeve member 35 is provided with a flange 38 which corresponds to the slip-retaining flange 17 of the first described setting tool. The flange 38 therefore engages the slip-retainer channels 18 to initially restrain the slips in their lower position, as shown in Figures 8 and 9. Below the collar 36, but above the body 1, the lower sleeve member 35 is provided with a shoulder 39 which bears against the upper end of the body 1 when the flange 38 is in the proper position for restraining engagement with the slips 5.

The lower end of the mandrel 31 is connected by a coupling 40 to a journal member 41 which in turn is connected to a suitable wash pipe B extending downwardly within the liner. The journal member 41 journals a ring 42, preferably on ball bearings. The ring 42 is connected to the coupling 10 of the liner hanger by means

of shear pins 43 which extend inwardly through the coupling.

Operation of the setting tool and liner hanger shown in Figures 8 through 11 is as follows: The setting tool and liner hanger are initially in the solid line position shown in Figures 8 and 9; that is, the cage structure, comprising the sleeve members and cage springs, occupies a lower position on the threads 33, the spring 11 is compressed and the slips are in their lower position.

When the desired location is reached the tubing is rotated. By reason of the frictional engagement between the cage springs and the surrounding walls of the casing the cage does not rotate, thus the cage may be caused to travel upwardly on the threads 33 until the flange 43 releases the slips 5. The setting tool is still attached to the liner by reason of the shear pins 38. After the slips are released the setting tool is moved downward to shear the pins 43, it being noted that after the slips are released the shoulder 39 is in the dotted line position shown in Figure 9, so that the ring 42 may be moved downward sufficiently to shear the pins before reengagement of the shoulder 39.

In going into the well, that is with the parts in the positions shown by solid lines in Figure 9, any upward thrust on the liner due to engagement of the lower end of the liner, with an obstruction in the well, is not taken by the shear pins 43 but taken by the shoulder 39, the shear pins merely carrying the weight of the liner. By reason of the helical arrangement of the cage springs 37 the shoulder is continually urged downwardly into engagement with the body to eliminate any slack. However, should the shear pins give way accidentally the slips are automatically released as the setting tool and liner hanger separate and the liner hanger acts as a tubing catcher to engage the casing and prevent the liner from falling to the bottom of the well. It is then only necessary to lower a suitable tool into the liner hanger and retrieve it along with the liner.

Reference is now directed to Figures 12 and 13 in which a modified form of connection between the setting tool and liner hanger is illustrated. In this construction a key ball and slot arrangement is substituted for the shear pins. The remaining parts of the liner hanger and mandrel are similar to that shown in the preceding figures. In the construction shown in Figures 12 and 13 the lower end of the mandrel 31 is joined to a journal member 51 which in turn is connected to the wash pipe B. The journal member journals a sleeve 52 having a series of inverted U shaped slots 53. One leg 54 of each slot is curved helically and is shallower than the other leg 55, which is vertical. The lower end of each vertical leg is provided with a cover to form a pocket 56. Key holes 57 (shown in Figure 13) are provided in the liner hanger collar 12. These are located so that they are opposite the lower end of the curved slot when the shoulder 39 bears against the upper end of the body 1 and the cage is in its lower position, the flange 38 restraining the slips 5. Each of the key holes 57 receive key balls 58 which are held against outward movement by set screws 59.

By reason of the fact that the shoulder 39 bears against the upper end of the body 1 so that the liner hanger and, therefore, the key balls cannot raise in their curved slots and relative downward movement of the liner is prevented by reason of engagement of the key balls with the lower end of the slots, the liner hanger is

locked with respect to the setting tool. When the liner has been lowered to the desired position the setting tool is rotated to cause upward movement of the cage comprising the springs 37 and sleeve members 34 and 35, which releases the slips. The setting tool is now free to move downward a limited distance with respect to the liner, and in doing so the balls, by engagement with the curved legs of the slots 53, are guided into the vertical leg which, being deeper, permits the key balls to move radially inward and clear of the liner hanger. The balls drop into the pockets provided at the lower ends of the vertical legs 55 and the setting tool is free to be removed.

Reference is now directed to Figures 14, 15 and 16: The construction here shown is particularly adapted in those cases where the wall thickness of the liner hanger must be reduced to a minimum. It may, however, be used with any of the types of setting tools illustrated. This construction consists of a body 61 having an upper pair of slots 62 and a lower pair of slots 63 located at right angles to the first mentioned pair of slots. The slots are provided with slip expanding faces 3 as in the first described structures and receive slips 5 which may be similar to the first described construction. Below the slots 63 the body 61 is reduced in diameter as indicated by 64 and receives a spring 65 which bears against the collar 66. The collar 66 engages, or has attached thereto, upwardly directed pairs of fingers 67 and 68. The fingers 67 fit in grooves 69 and extend upwardly for engagement with the upper set of slips coacting with slots 62. The other fingers 68 fit in grooves 70 and extend into engagement with the lower set of slips coacting with slots 63. As stated previously, this construction may be used in any type of setting tool described hereinbefore, with the exception that a pair of flanges 71 and 72 are provided in place of the flanges 17 or 38. With the arrangement shown in Figures 14, 15 and 16 an increased section of body remains between slots 62 or 63. In addition, four instead of three slips may be provided and consequently the slip area may be increased.

When the slips are in engagement with the casing they, of course, form an obstruction to the flow of fluid between the casing and the liner hanger. However, in moving to their casing-engaging positions they uncover the slots 2, so that fluid may by-pass inwardly between the setting tool and liner hanger, the setting tool in such case being raised sufficiently after setting the liner to position the flange 17, 38, 71 or 72, as the case may be, clear of the liner hanger. It will also be noted that the liner itself is free of any cages or other means engaging the surrounding casing and which might obstruct the flow of fluid. The spring and slips lay close to and within the nominal diameter of the liner, so that they offer little or no obstruction. The setting tool, on the other hand, even though provided with a cage, may be smaller in diameter than the liner and, therefore, insure at least equal if not greater circulation area in spite of the cage springs. Also, it should be noted, at least in the construction shown in Figures 8 through 13, that the passage through the setting tool may be equal to that in the tubing above and the wash pipe below, and in addition be free of any slip joints that would interfere with circulation or impede cementing operations. Still further, it should be noted, in regard to the construction

shown in Figures 8 through 13, that it is not necessary for the liner to set on the bottom of the well for it is immaterial whether the liner or liner hanger rotate during rotation of the tubing string for the purpose of releasing the liner hanger, for only the cage, comprising the cage springs and the upper and lower sleeve, need remain fixed and this requires very little force.

Various changes and alternate arrangements may be made within the scope of the appended claims, in which it is my intention to claim all novelty inherent in the invention.

I claim:

1. The combination with a tubing string and liner hanger having slips and slip-expanding means wherein the slips are provided with slip-restraining elements which project into the interior of the liner hanger when the slips are in their retracted position, of a setting tool comprising: a tubular mandrel rigidly connected with the tubing string and extending into said liner hanger; means forming a separable connection between said mandrel and liner hanger, said separable connection being located below said slips; a cage structure screw-threaded to the exterior of said mandrel above said liner hanger and frictionally engageable with a surrounding well casing, said cage structure including means extending into said liner hanger for restraining said slips in retracted position by engagement with said slip-restrainng elements and adapted to release said elements upon rotation of said tubing string relative to said cage structure; and resilient means operative to move said slips into expanded position upon release of said slip restraining elements.

2. A construction, as set forth in claim 1, wherein said separable connection means comprises shear pins adapted to be sheared by relative longitudinal movement of said mandrel and liner hanger.

3. A construction, as set forth in claim 1, wherein said separable connection means includes: a collar rotatably mounted on said mandrel; and shear pins connecting said collar with said liner hanger, said pins adapted to be sheared by relative longitudinal movement of said mandrel and liner hanger.

4. A construction, as set forth in claim 1, wherein said separable connection means includes: a collar rotatably mounted on said mandrel; key elements extending between said collar and linear hanger; said collar having keyways accommodating said key elements, portions of said keyways being adapted to receive said key elements in their entirety so as to permit release of said key elements from said liner hanger; and means associated with said cage structure for preventing movement of said key elements into the releasing portions of said keyways while said slips are restrained.

5. The combination with a tubing string and hanger device having slips and slip expanding means wherein the slips are provided with slip restraining elements which project into the interior of the hanger device when the slips are in their retracted position, of a setting tool comprising: a tubular mandrel rigidly connected with the tubing string and extending into said hanger device; means forming a separable connection between said mandrel and hanger device; a cage structure screw-threaded to the exterior of said mandrel above said hanger device and frictionally engageable with a surrounding well casing, said cage structure including means extending into said hanger device for restraining said slips in retracted position by engagement with said slip-restraining elements, and adapted to release said elements upon rotation of said tubing string in one direction relative to said cage structure; and resilient means operative to move said slips into expanded position upon release of said slip restraining elements.

6. The combination with a liner hanger having slips and slip expanding means wherein the slips are provided with slip restraining elements which project into the interior of the liner hanger when the slips are in their retracted position, of a setting tool comprising: a tubular mandrel adapted to be rigidly connected with a tubing string and extending into said liner hanger; means forming a separable connection between said mandrel and liner hanger; a cage structure screw-threaded to the exterior of said mandrel and frictionally engageable with a surrounding well casing, said cage structure including means extending into said liner hanger for restraining said slips in retracted position by engagement with said slip-restraining elements, and adapted to release said elements upon rotation of said mandrel in one direction relative to said cage structure; and resilient means operative to move said slips into extended positions upon release of said slip restraining elements.

7. A hanger device for use in a tubing string comprising: a substantially cylindrical slip expander member having an internal bore; slip guide slots formed in said member having inclined slip guide surfaces extending unbrokenly from the exterior to the interior bore of said member; slips in said slots slidably supported on said guide surfaces and adapted to slide thereon from an innermost retracted position wherein the inner ends of said slips protrude into the interior bore of said member to an expanded position wherein the gripping surfaces of said slips protrude beyond the exterior surface of said member; a mandrel extending into the said bore of said member; a sleeve rotatable on said mandrel and arranged to occupy a first position relative to said mandrel in which the sleeve engages the inner, protruding ends of said slips in said bore to restrain said slips in retracted position and, upon rotation of said sleeve relative to said mandrel, to move to a second position relative to said mandrel to release said slips; means to impart rotation to said sleeve relative to said mandrel; and means to urge said slips into expanded position.

8. A liner hanger comprising: a cylindrical body member including a cylindrical slip expander portion, said body member and slip expander portion having substantially equal external diameters; a concentric bore in said body member; slip guide slots formed in said slip expander portion having inclined slip guide surfaces extending unbrokenly from the exterior surface to the interior bore of said body member; wedge-shaped slips in said slip guide slots, said slips having a maximum thickness substantially equal to the wall thickness of said slip expander portion of said body, said slips being slidably supported by said inclined guide surfaces for sliding motion from a retracted position in which the inner ends of said slips protrude into the interior bore of said body to an expanded position in which the outer gripping surfaces of said slips protrude beyond the exterior surface of said body member; a mandrel extending into said body member; a sleeve axially movable on said man-

drel from a first position in which the sleeve engages the inwardly protruding ends of said slips in said bore and constrains said slips in retracted position to a second position to release said slips for expansion; means to axially move said sleeve with respect to said mandrel from said first position to said second position; and means to urge said slips into expanded position.

9. A liner hanger comprising: a cylindrical body member including a cylindrical slip expander portion, said body member and slip expander portion having substantially equal external diameters; a concentric bore in said body member: slip guide slots formed in said slip expander portion having inclined slip guide surfaces extending unbrokenly from the exterior surface to the interior bore of said body member; wedge-shaped slips in said slip guide slots, said slips having a maximum thickness substantially equal to the wall thickness of said slip expander portion of said body member, said slips being slidably supported by said inclined guide surfaces for slidable motion from a retracted position in which the inner ends of said slips protrude into said interior bore of said body member, to an expanded position in which the outer gripping surfaces of said slips protrude beyond the exterior surface of said body member; a mandrel extending into said body member and detachably attached thereto with freedom for rotation relative to said body member; a sleeve threaded on said mandrel, said sleeve being axially movable, upon rotation of said mandrel relative to said sleeve, from a first position in which the sleeve is in locking engagement with the inwardly protruding ends of said slips in said bore to constrain said slips in retracted position to a second position to release said slips for expansion; means to rotate said mandrel with respect to said sleeve; and means to urge said slips into expanded positions.

10. A liner hanger comprising apparatus according to claim 9 in which the said mandrel is detachably attached to said body member by means, which, while maintaining said attachment, permits relative rotation but prevents longitudinal motion of said mandrel relative to said body member.

11. A liner hanger comprising apparatus according to claim 9 in which the said mandrel is detachably attached to said body member by frangible means, which, while maintaining said attachment, permits relative rotation but prevents longitudinal motion of said mandrel relative to said body member.

12. The combination with a liner hanger having slips and slip expanding means wherein the slips are provided with slip restraining elements which project into the interior of the liner hanger when the slips are in their retracted position, of a setting tool comprising: a tubular mandrel adapted to be rigidly connected with a tubing string and extending into said liner hanger; means forming a connection between said mandrel and liner hanger separable by downward motion of said mandrel relative to said hanger; a sleeve screw-threaded to the exterior of said mandrel, said sleeve including means engageable with said hanger when in one position to prevent downward motion of said mandrel relative to said hanger and means extending into said liner hanger for restraining said slips in retracted position by engagement with said slip-restraining elements, said sleeve being axially movable upon rotation of said mandrel relative to said sleeve to release said slip-restraining elements to permit expansion of said slips and to permit downward movement of said mandrel relative to said hanger to separate said connection; means for rotating said mandrel relative to said sleeve; and resilient means operative to move said slips into extended positions upon release of said slip restraining elements.

LLOYD SPENCER.

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