

Dec. 8, 1959

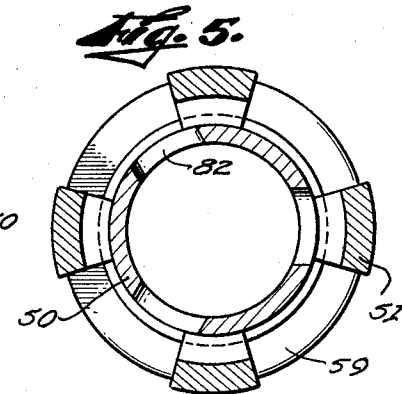
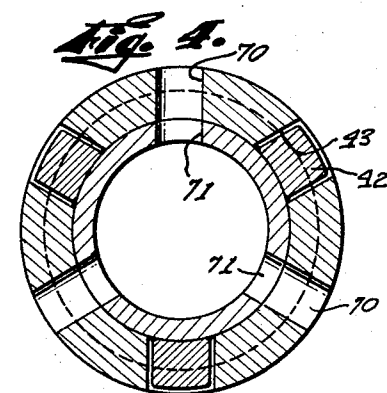
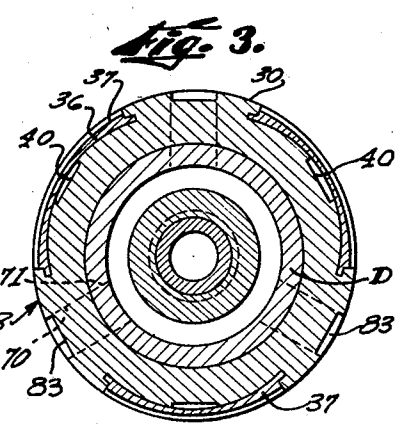
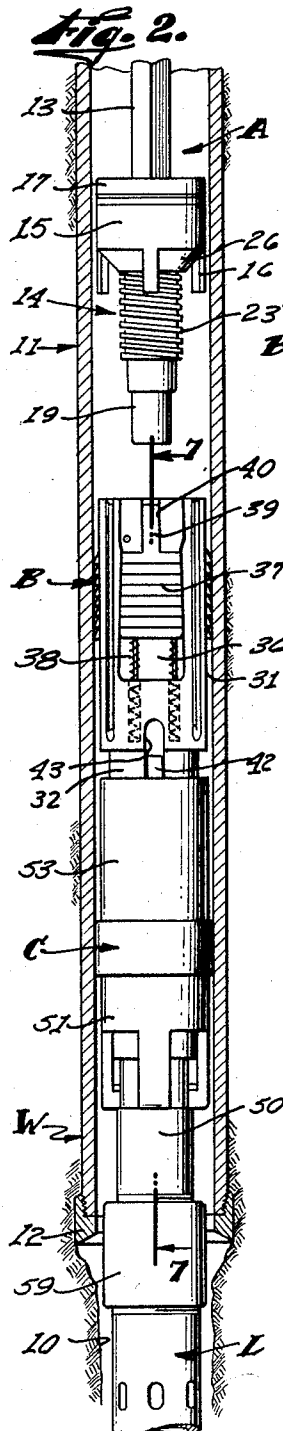
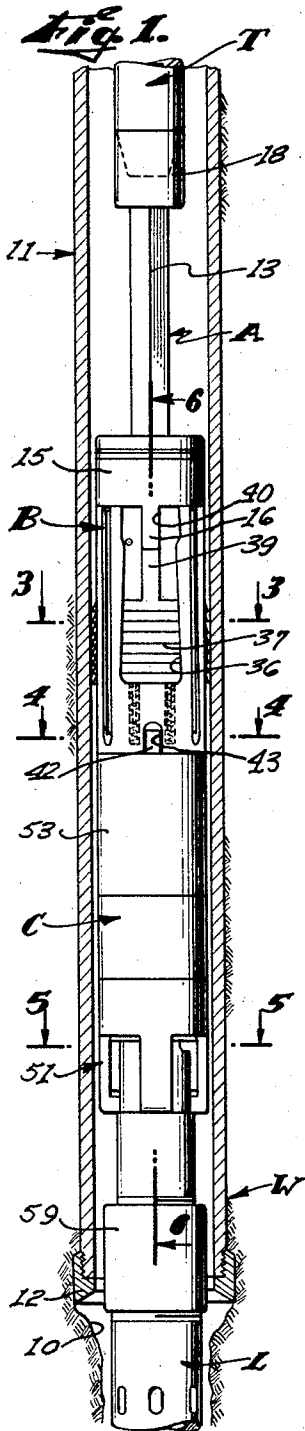
E. BURNS

2,916,092

BY-PASS LINER HANGING APPARATUS

Filed May 20, 1957

3 Sheets-Sheet 1



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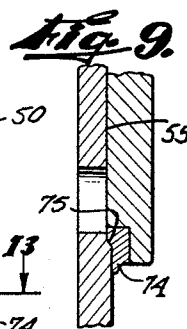
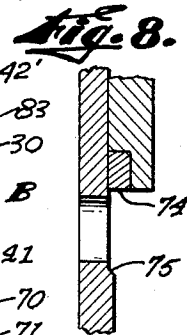
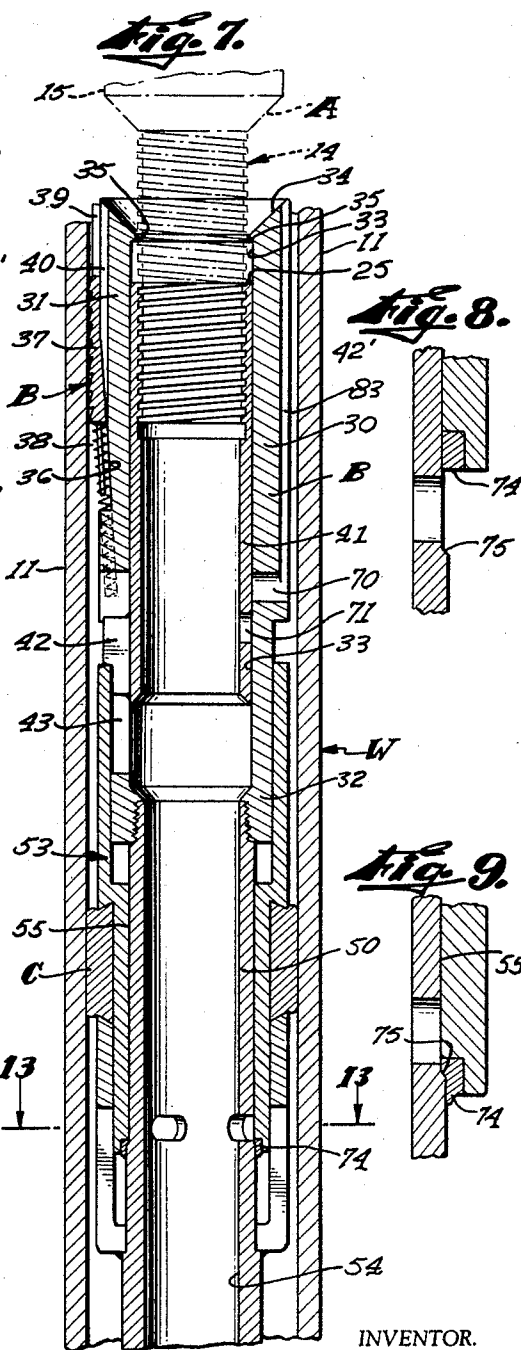
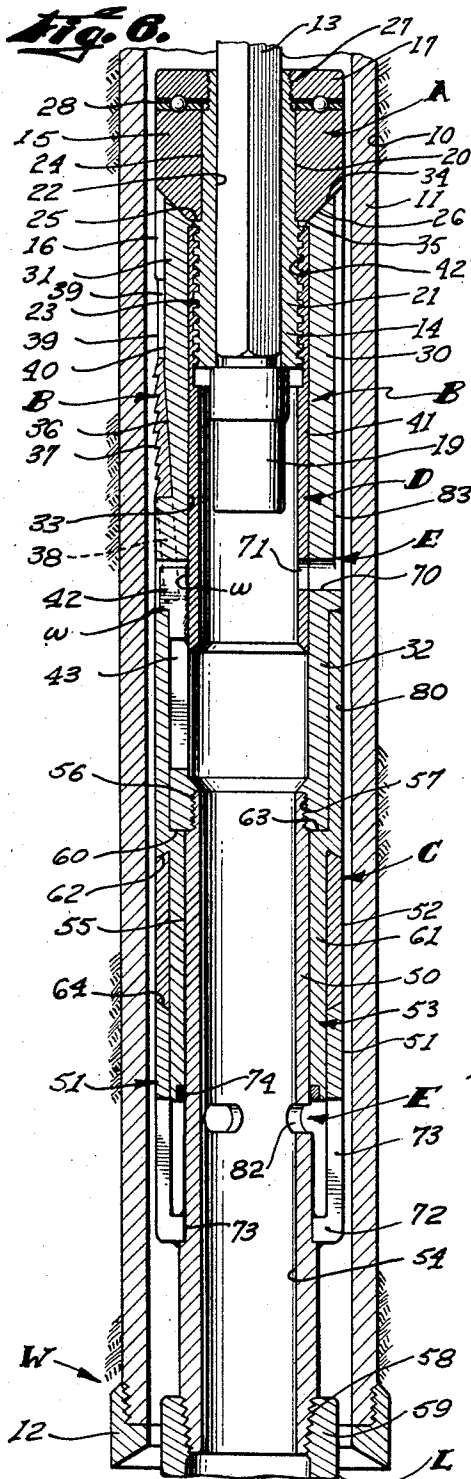
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Filed May 20, 1957

3 Sheets-Sheet 2



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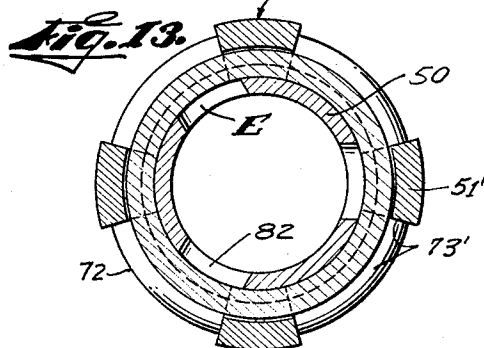
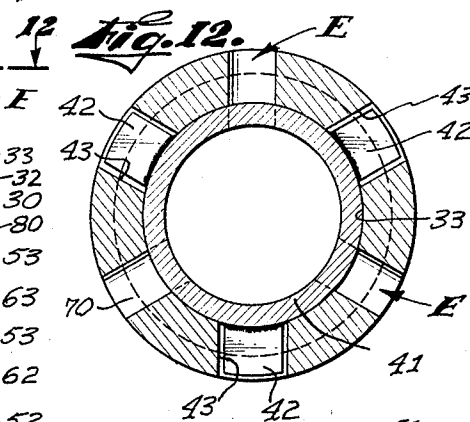
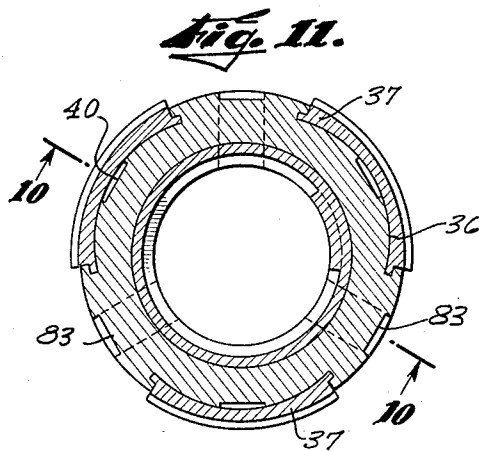
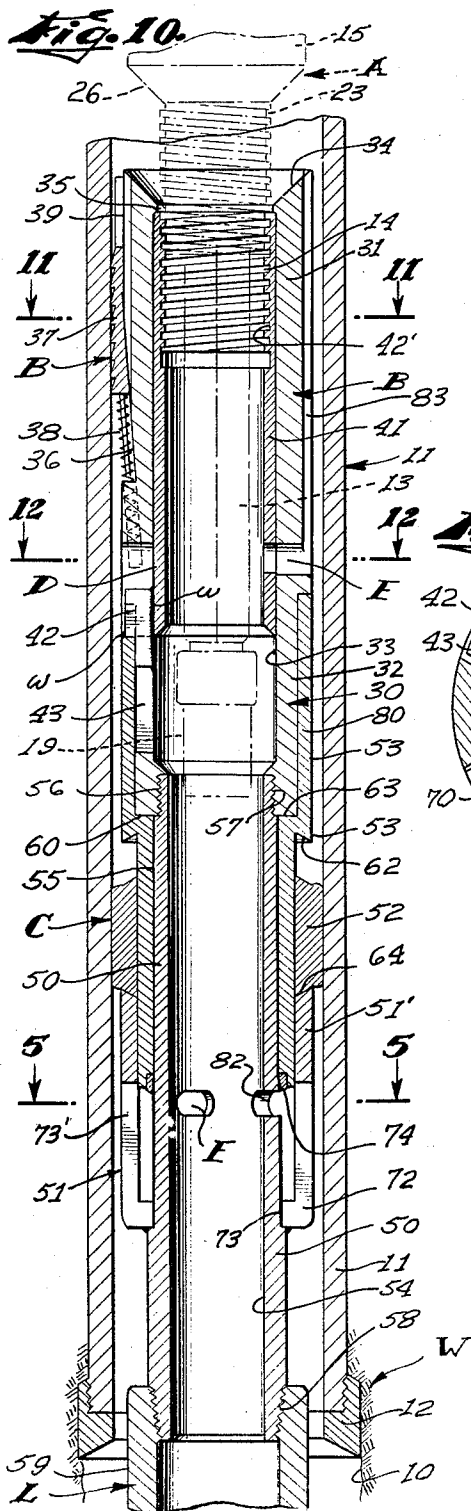
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## BY-PASS LINER HANGING APPARATUS

Filed May 20, 1957

3 Sheets-Sheet 3



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2,916,092

## BY-PASS LINER HANGING APPARATUS

Erwin Burns, Los Angeles, Calif.

Application May 20, 1957, Serial No. 660,107

10 Claims. (Cl. 166—124)

This invention relates to a liner hanging apparatus for use in oil wells and is more particularly concerned with a liner hanging apparatus having a deformable packing means related thereto and means for assuring for free flow of circulating fluid occurring in the well, past the packing as the apparatus is lowered into the well and operable to control the flow of circulating fluid past the packing means after it has been actuated into sealing engagement with the well casing.

In the course of running in and setting or suspending a liner in a well casing, by means of a liner hanging apparatus having a deformable packing means related thereto, it is desirable and often times necessary that suitable means be provided in and through the apparatus which will allow for free passage of circulating fluid in the well past the apparatus, due to the restriction in the well by the said apparatus. Still further, after the liner is suitably set or suspended and the packing means is actuated into sealing engagement with the well casing, it is frequently necessary and desirable that means be provided whereby the circulating of fluid past the packing means can be established for the purpose of flushing and/or cleaning the liner and the surrounding oil producing formation of the well, or for the purpose of packing the annulus between the liner and the oil producing formation of the well with gravel, or the like.

While liner hanging apparatus of the general character referred to are old and are widely used throughout the oil industry, each has specific weaknesses and/or limitations which materially limit its application and which oftentimes make it hazardous to use. The ordinary apparatus of the character referred to generally involves a substantial number of small hard to make and/or assembly parts, some of which are necessarily of light construction and materially weaken the overall construction.

It is a general object of the present invention to provide an improved, by-pass type liner hanging apparatus of the general character referred to involving a limited number of parts, which parts are both easy and economical of manufacture and to assemble.

Another object of my invention is to provide an apparatus of the character referred to wherein each of the parts which go to make up the apparatus are heavy and strong and are not subject to failure in ordinary use.

It is a feature of the present invention to provide a deformable packing means including a sturdy central longitudinally disposed barrel which is interposed between and couples the liner to the hanger.

Another feature of my invention is to provide means for supporting a body of deformable packing material in fixed position relative to the barrel and a longitudinally shiftable follower sleeve slidable about the barrel and adapted to engage and distend the body of packing material.

Still another object of the present invention is to provide a longitudinally shiftable actuating sleeve in the

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body of the hanger and operatively coupled with the follower sleeve.

Still another feature of my invention is to provide shiftable ports in the apparatus, above and below the said body of packing material, and adapted to control the flow of circulating fluid occurring in the well, about the exterior of the apparatus, through the apparatus and around the packing thereof.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred form and application of my invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a longitudinal elevational view showing the apparatus provided by the present invention engaged in a well structure, and showing the apparatus in an unactuated position.

Fig. 2 is a view similar to Fig. 1 and showing the apparatus that I provide in an actuated position in the well.

Fig. 3 is a transverse sectional view taken as indicated by line 3—3 on Fig. 1.

Fig. 4 is a transverse sectional view taken as indicated by line 4—4 on Fig. 1.

Fig. 5 is a transverse sectional view taken as indicated by line 5—5 on Fig. 1.

Fig. 6 is an enlarged detailed sectional view taken as indicated by line 6—6 on Fig. 1.

Fig. 7 is a view similar to Fig. 6 and showing the apparatus actuated to allow for the flow of circulating fluid around the set packing.

Fig. 8 is an enlarged detailed sectional view of a portion of the structure that I provide and illustrating a seal embodied in the construction in an unactuated position.

Fig. 9 is a view similar to Fig. 8 and showing the seal in an actuated position.

Fig. 10 is an enlarged detailed sectional view similar to Fig. 6 and showing the apparatus of the present invention in an actuated position.

Fig. 11 is a transverse sectional view taken as indicated by line 11—11 on Fig. 10.

Fig. 12 is a transverse sectional view taken as indicated by line 12—12 on Fig. 11.

Fig. 13 is a transverse sectional view taken as indicated by line 13—13 on Fig. 7.

The apparatus provided by the present invention is adapted to lower and suspend a liner in a well casing, to thereafter pack off the annulus between the apparatus and the casing and to selectively control the flow of circulating fluid in the well, past the packing.

In the particular case illustrated throughout the drawings, I have shown the apparatus of the present invention engaged in a well structure W, which structure is shown as including a well bore 10, a casing 11 engaged and fixed in the well bore. The casing 11 is shown terminating short of the bottom of the well bore 10 and is provided at its lower terminal end with a typical shoe 12.

The apparatus provided by the present invention involves, generally, an elongate run-in string of tubing T, a setting tool A fixed to the lower end of the run-in string, a hanger B releasably engaged on the setting tool and operable to engage and set in the well casing 11, a packing C related to the hanger and operable to be actuated into sealing engagement with the well casing, after the anchor is set, and a liner L fixed to the hanger and packer assembly to depend therefrom and extend into the well bore, below the lower terminal end of the casing 11.

In addition to the foregoing, the apparatus of the present invention is shown as including, a suitable actuating means D related to the setting tool, hanger and packer and adapted to be operated by the setting tool to actuate the packer into sealing engagement with the well casing,

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and fluid circulating and control means E in the hanger and packer and controlled by the said actuating means.

The setting tool A that I provide is shown as including, an elongate mandrel 13 adapted to be engaged with the lower terminal end of the run-in string T, an elongate coupler 14 carried by the mandrel and adapted to releasably engage the actuating means D, a sleeve 15 rotatably carried by the coupler and carrying a plurality of slip engaging fingers 16, and a bearing nut 17 on the coupler and retaining the sleeve.

The mandrel 13 is an elongate vertically disposed member polygonal in cross-section and is provided with an internally threaded enlargement 18 at its upper end to receive the male member of a drill pipe joint at the lower end of the run-in string T. The lower terminal end of the mandrel is threaded to receive a suitable stop nut 19.

The coupler 14 carried by the mandrel 13 is an elongate member having upper and lower portions 20 and 21 and a central longitudinally disposed polygonal opening 22 extending therethrough and in which the mandrel 13 is engaged for free longitudinal movement and for positive rotational drive. The exterior surface of the lower portion 21 of the coupler 14 is formed with left-hand square threads 23, adapted to engage with the actuating means in a manner that will hereinafter be described.

The upper portion 20 of the coupler is of reduced diameter with respect to the lower threaded portion 21 thereof and has a straight, cylindrical outer wall 24. The upper portion of the coupler is adapted to rotatably carry the sleeve 15. An upwardly facing stop shoulder 25 is established where the upper and lower portions 20 and 21 of the coupler meet or join.

The coupler 14 is free to shift longitudinally relative to the mandrel 30 and is retained from displacement on the mandrel by the enlargement 18 and the stop nut 19 at the upper and lower ends thereof.

The sleeve 15 is an elongate cylindrical member and is formed at its lower end with a frustoconical face 26. The sleeve 15 is engaged about the upper portion 20 of the coupler 14 to have a running fit therewith and so that its lower terminal end engages and rests on the upwardly facing stop shoulder 25 on the coupler.

The bearing nut 17 is a simple, internally threaded part screw threaded on an externally threaded sleeve-like extension 27 at the upper terminal end of the coupler 14, and projects radially outwardly from the coupler to overlie the top of the sleeve 15, to maintain the sleeve engaged on the coupler.

In practice, and as illustrated in the drawings, a suitable anti-friction bearing means 28 is engaged between the bearing nut 17 and the sleeve 15 to assure for free relative rotation therebetween.

The slip engaging fingers 16 carried by the sleeve of the setting tool A are simple, straight vertically disposed members secured to the sleeve 15 about its outer periphery, in circumferentially spaced relationship to each other. The fingers 16 depend from the sleeve to overlie and occur in spaced parallel relationship with the lower threaded portion 20 of the coupler 15, on which the sleeve is rotatably engaged. The fingers 16 are adapted to cooperate with longitudinally shiftable casing engaging slips of the hanger construction and to control the operation of the hanger construction in a manner that will hereinafter be described.

The hanger B that I provide and which is releasably carried by the setting tool A, is shown as including an elongate tubular body 30 having upper and lower portions 31 and 32 respectively and an elongate, central longitudinally disposed bore 33.

The top of the upper portion 31 of the body 30 is radially inwardly and downwardly inclined to establish a tapered seat 34 which is complementary to and which receives the frusto-conical bottom face 26 of the sleeve 15 of the setting tool A. A suitable radially inwardly

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projecting stop flange 35, of limited radial extent, is provided at the top of the bore 33 adjacent the inner periphery of the seat 34. This flange is adapted to engage and prevent displacement of a sleeve-like member of the actuating means D engaged in the bore, and in a manner that will be clearly set forth in the following description.

The upper portion 31 of the hanger body 30 is provided with a plurality of circumferentially spaced, upwardly and radially outwardly inclined or tapered guideways 36 about its outer peripheral wall, which guideways slidably receive wickered casing engaging slips 37. The slips 37 are adapted to be urged upwardly and outwardly in the tapered guideways 36 and into gripping engagement with the well casing 11 by suitable spring means 38 mounted in the body 30 adjacent the lower or bottom ends of the guideways 36 and acting upon the bottom or heels of the slips, as clearly illustrated in Figs. 1, 2 and 10 of the drawings.

The upper end of each slip 37 is provided with an upwardly projecting finger 39 which enters and extends along a longitudinally disposed slot 40 in the outer wall of the body 30, which notch extends from the guideway 36 in which the slip is engaged to the upper end of the body and into which one of the fingers 16 of the setting tool A extends. The fingers 39 and 16 of the hanger slips and the setting tool A are in longitudinal alignment with the result that when the sleeve 15 of the setting tool A is seated on the upper end of the hanger body 30, the fingers 16 thereof extend into the slots 40 in the body to engage the fingers 39 of the slips 37 engaged therein, and force the slips 37 downwardly in the guideways 36, against the action of the spring means 38, and hold the slips in their down or retracted position so that they will not grip the wall of the casing.

Slidably engaged in the bore 33 of the hanger body 30 is an elongate actuating sleeve 41, which sleeve is a part of the actuating means D. The sleeve 41 is internally threaded at its upper end as indicated at 42', to cooperatively receive the threads 23 on the lower portion 21 of the coupler 14. The actuating sleeve 41 is keyed against rotation in the body 30 by a plurality of circumferentially spaced radially outwardly projecting lugs or blocks 42 fixed to the lower portion of the sleeve. The lugs or blocks 42 on the lower end of the sleeve 41 project into and through elongate, vertically disposed and circumferentially spaced slots 43 milled or otherwise established in the lower portion 32 of the hanger body. The actuating sleeve is held against displacement from the bore in the body by the stop flange 35 provided at the upper end of the bore.

In practice, the lugs or blocks 42 are of sufficient radial extent so that they terminate substantially flush with the exterior of the upper portion of the body and are fixed to the actuating sleeve as by welding w.

With the relationship of parts set forth above, it will be apparent that the actuating sleeve 41 is positively held against rotation and against vertical longitudinal displacement from the body and that when the coupler 14 of the setting tool A is engaged in the sleeve 41, the sleeve supports and carries the body 31 of the hanger and all of the other parts of the apparatus which occur below the setting tool.

The actuating sleeve 41, as pointed out above, is an element of the actuating means D and is operatively related to the packing means C and the flow control means E in a manner that will hereinafter be described.

The packing means C of the apparatus provided by the present invention is adapted to pack and seal off the annulus between the liner L and the casing 11, after the hanger B has been set. The packing means C is shown as including, an elongate barrel 50 threadedly engaged in the lower terminal end of the hanger body 30 to depend therefrom, an annular cage 51 fixed to and surrounding the barrel in spaced relationship thereto, an annular body of deformable packing material 52, such as lead, carried

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by the cage and a sleeve-like follower 53 slidably carried by the barrel and the body.

The follower 53 is an element of the actuating means D and is operatively coupled with the actuating sleeve 41 in the hanger body 30 and is adapted to be shifted longitudinally of the barrel 50 and the body of packing material 52, to urge and distend the said body of packing material radially outward into sealing engagement with the inner wall of the casing 11 in which the apparatus is engaged.

The barrel 50 of the packing means is an elongate, vertically disposed tubular member having a central longitudinally disposed bore 54 and a cylindrical outer wall 55. The upper terminal end of the barrel is externally threaded as at 56 and is engaged in complementary threads 57 provided in the lower end of the bore 33 in the hanger body. The lower terminal end of the barrel 50 is externally threaded as at 58 and is threadably engaged in a suitable pipe joint 59 provided at the upper end of the liner L. With the above relationship of parts, it will be apparent that the barrel 50 is rigidly coupled to the hanger body 30 and the liner L, with the end result that the hanger body, packer barrel and liner establish a rigid assembly.

The barrel 50 is substantially smaller in outside diameter than the lower portion 31 of the hanger body 30, with the result that the lower terminal end of the hanger body establishes an annular downwardly facing shoulder 60.

The cage 51 of the packing means is shown as an upwardly opening cup-shaped member having a longitudinally disposed cylindrical side wall 51' spaced from the outer wall of the barrel and cooperating therewith to establish an annular recess adapted to slidably receive a portion of the follower sleeve 53 as will hereinafter be described.

The cage 51 is provided with a substantially horizontally disposed bottom wall 72 having an opening 73 therein to slidably receive the barrel 50. The bottom wall 72 of the cage is fixed to the barrel as by welding and so that the upper peripheral edge of the side wall thereof is spaced a substantial distance below the lower or bottom end of the hanger body 30. In accordance with the present invention, the lower portion of the side wall 51' and the bottom wall 72 of the cage are provided with a plurality of circumferentially spaced apertures or ports 73' adapted to pass circulating fluid in a manner that will hereinafter be described.

The upper peripheral edge of the cage 51 terminates in an upwardly disposed face 64 adapted to cooperate with and support the body of packing material 52 as will hereinafter be described.

The follower sleeve 53 that I provide is an elongate tubular member having radially offset upper and lower portions 80 and 61. The upper portion 80 of the follower sleeve is slidably engaged around the lower slotted portion 32 of the hanger body, while the lower portion 61 of the follower sleeve is of reduced diameter and is slidably engaged around the barrel 50 and is of sufficient longitudinal extent to slidably enter the annular recess established between the cage 51 and the barrel.

The lower end of the upper portion 80 of the follower sleeve establishes an annular downwardly disposed packing engaging face 62, which face is spaced above and opposes the upwardly disposed face 64 on the cage 51. The upper end of the lower portion 61 of the follower sleeve establishes an upwardly facing annular shoulder 63, which shoulder opposes and stops against the shoulder 60 established by the lower end of the hanger body 30, when the sleeve is in its up or unactuated position, as illustrated in Fig. 6 of the drawings.

The upper portion 80 of the sleeve 53 engages and is fixed to the lugs of the blocks 42 on the lower end of the actuating sleeve 41, as by welding *w*. With this relationship of parts, it will be apparent that the actuating

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sleeve 41 and the follower sleeve 53 are rigidly joined together by the blocks 42, which extend through the slots 43 in the hanger body 30 and cooperate to establish the operating means D. It will also be apparent that when the actuating sleeve 41 is urged downwardly in the bore 33 of the hanger body, as by means of the setting tool A, the follower sleeve 53 connected therewith is urged downwardly relative to the barrel 50 and the cage 51 of the packing means C.

The annular body of packing material 52 is a simple sleeve of lead, or other suitable deformable packing material, and is engaged around the lower portion 61 of the follower sleeve to occur between the opposing faces 64 and 62 of the cage and the follower sleeve. In practice, the body of packing material can be performed and slidably engaged about the sleeve or, if desired, can be poured or cast around the sleeve.

In the preferred carrying out of the invention, the packing engaging faces 64 and 62 and the opposing ends of the annular body of packing material 52 are pitched or inclined in the manner illustrated throughout the drawings, so that displacement of the packing will not occur when the packing is being actuated into sealing engagement with the well casing 11.

With the above relationship of parts, it will be apparent that when the follower sleeve 53 is urged downwardly on the barrel and relative to the cage 51 in the manner previously set forth, the body of packing material 52 surrounding the lower portion of the sleeve and occurring between the faces 64 and 62 on the cage and the upper portion of the follower sleeve, is compressed or caused to flow or distend radially outwardly into sealing engagement with the well casing occurring thereabout.

The fluid circulating and control means E provided by the present invention is adapted to allow for free flow of circulating fluid in the well W, past the packing means C when the apparatus is being lowered into the well, and is adapted to be operated to shut off and to re-establish the flow of circulating fluid past the packing means after the hanger is set and the packing means is actuated into sealing engagement with the well casing 11.

In the case illustrated, the means E involves a plurality of circumferentially spaced, laterally opening ports 70 in the upper portion 31 in the hanger body 30, a plurality of circumferentially spaced, laterally opening ports 71 in the actuating sleeve 41 of the means D and cooperating with the ports 70, and a plurality of circumferentially spaced, laterally opening ports 82 in the barrel 50 and under control of the lower portion 61 of the follower sleeve 53.

In addition to the foregoing the means E is shown as further including, longitudinally disposed flow channels 83 in the exterior of the hanger body to extend between the ports 70 and the upper terminal end of the body and a seal 74 at the lower end of the follower sleeve 53 and adapted to seal with a shoulder 75 on the barrel 50 when the said means is shifted downwardly to shut off the flow of circulating fluid through the apparatus.

The ports 70 in the body 30 in the hanger are positioned to occur below and circumferentially offset from the slip receiving recesses 36 in the body.

The ports 71 in the actuating sleeve are spaced a short distance above the lower end thereof and are adapted to register with the ports 70 in the hanger body when the sleeve is in its up or unactuated position, as clearly illustrated in Figs. 4 and 6 of the drawings.

The ports 82 in the packer barrel 50 are positioned to occur within the confines of the apertured cage engaged therearound and so that they occur immediately below the lower terminal end of the follower sleeve 53 when the sleeve is in its up or unactuated position, as clearly illustrated in Figs. 5 and 6 of the drawings.

With the above relationship of parts, it will be apparent

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that when the actuating means is in its unactuated or up position, the ports 70 and 71 establish open communication between the interior and exterior of the hanger body, which occurs above the packing 52, and the ports 82 establish open communication between the interior and the exterior of the packing barrel 50, below the packing 52. With this relationship of parts, it will be apparent that fluid in the annulus between the well casing 11 and the exterior of the apparatus is free to flow through the ports in the apparatus and around the packing means as circumstances require. It will also be apparent that when the operating means D is shifted downwardly relative to the hanger body 30 and the packing barrel 50, and so that the packing is urged into sealing engagement with the casing 11, the ports 70 and 71 in the hanger body and the actuating sleeve are shifted out of register with each other to shut off the flow of fluid therethrough and the lower end of the actuating sleeve is shifted over and shuts off the flow of circulating fluid in the ports 82 in the barrel 50, with the end result that the circulating fluid occurring in the annulus between the apparatus and the well casing is prevented from flowing through the apparatus and around the packing 52, as clearly illustrated in Figs. 10, 12 and 13 of the drawings.

It is significant to note that the ports 70 and 82 of the means E are so arranged that the flow of circulating fluid therethrough is shut off as soon as the means D is shifted to set the packing 52, and that a time delay between setting the packing and shutting off the flow of circulating fluid does not occur.

The channels 83 in the exterior of the hanger body 30 and extending between the ports 70 and the top of the body are adapted to allow for the free flow of circulating fluid longitudinally of the exterior of the body. These channels are necessary due to the fact that the apparatus is of substantial diametric extent with respect to the well casing 11 and materially restricts the flow annulus between the casing and the apparatus and through which the circulating fluid in the well must flow as the apparatus is lowered into the well casing.

The seal 74 at the lower end of the follower sleeve 53 is a simple annular lead ring engaged in a downwardly and radially inwardly opening recess at the lower terminal end of the sleeve and is adapted to engage and seal with the annular shoulder 75 about the exterior of the barrel, and which occurs immediately below the ports 82, when the sleeve is shifted downwardly to its actuated position, as clearly illustrated in Fig. 8 of the drawings.

In the particular case illustrated, the shoulder 75 is established on the barrel 50 by turning down the upper portion of the barrel and along which the follower sleeve is normally engaged.

In operation, the apparatus provided by the present invention is assembled in the manner shown in Figs. 1 and 6 of the drawings, wherein the coupler of the setting tool is engaged in the actuating sleeve in the hanger body and so that the frusto-conical bottom face 26 of the sleeve 15 of the setting tool is seated on the inclined seat 34 of the hanger body. When the sleeve 15 of the setting tool A is in its lowermost position, the fingers 16 carried thereby are registered with and project into the longitudinal slots in the hanger body to engage the upper ends of the fingers on the wickered slips and hold the slips in their down or unactuated position in the recesses 36 and against the action of the spring means 38. The sleeve 15 of the setting tool A is held in its lowermost position by the coupler 14 which is screwed into the actuated sleeve 41 in the hanger body. When the coupler is fully threaded into the actuating sleeve in the hanger body, and so that the sleeve of the setting tool is seated with the body, as set forth above, the actuating and follower sleeves are held or maintained in their uppermost or unactuated position by the setting tool, and in a position where the ports 70 and 71 of the fluid control means are in register and the fol-

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lower sleeve is above and out of engagement over the ports 82 of the fluid circulating control means.

When it is desired to set the liner L, the apparatus with the liner is lowered into the well casing 11 to the desired depth, after which the run-in string T and the mandrel of the setting tool are rotated a sufficient amount to unscrew and elevate the coupler and the sleeve of the setting tool A to a point where the fingers 16 of the setting tool are moved out of engagement with the hanger body and the fingers on the wickered slips and so as to allow the slips to be urged upwardly and outwardly into engagement with the wall of the casing 11 by the action of the spring means, as clearly illustrated in Fig. 10 of the drawings.

After the hanger is set in the manner set forth above, and the coupler of the setting tool is unscrewed or retracted from the actuating sleeve a sufficient distance to allow for free relative shifting between the sleeve of the setting tool and the hanger body, as indicated in phantom lines in Fig. 10 of the drawings, the weight of the run-in string T is placed onto the actuating sleeve through the setting tool A, thereby forcing the actuating means, that is, the actuating sleeve and the follower sleeve related thereto, downwardly relative to the hanger body and the packer barrel, which have already been set in the well casing by the action of wickered slips. Upon downward movement of the packer follower in the manner set forth above, the annular body of packing material is squeezed or distended radially outwardly to form a fluid tight seal with the casing in the manner set forth above. When the packing is actuated in the manner set forth above and the actuating and follower sleeves are shifted, the ports 70 and 71 in the hanger body and actuating sleeve are shifted out of register with each other and the lower end of the follower sleeve is shifted downwardly to overlie and close the port 82 in the barrel, thereby shutting off and preventing the flow of circulating fluid through the apparatus and around the actuated packer.

When the lower end of the follower sleeve is shifted to the down position, as shown in Fig. 10, the seal 74 at the lower end thereof engages and seals against the shoulder 75 and positively prevents the passage or leakage of fluid between the sleeve and the barrel and through the ports 82.

After the hanger B has been set and the packing 52 has been actuated into sealing engagement with the well casing 11 in the manner set forth above, the setting tool A is completely unscrewed from the actuating sleeve by further rotation of the run-in string and the mandrel of the setting tool, and the run-in string and setting tool are withdrawn from engagement with the remainder of the apparatus and thereafter from the well, as clearly indicated in Figs. 2 and 10 of the drawings.

If, after the liner has been set, the packing actuated into sealing engagement with the casing, and the ports of the fluid circulating means shifted out of register and closed, it is desired to open the ports and re-establish circulation around the packing means, the run-in string and actuating tool are again lowered into the well and threadedly engaged in the actuating sleeve of the means D whereupon upward movement of the actuating and follower sleeves can be obtained by pulling or lifting the run-in string and the setting tool connected thereto, as clearly illustrated in Fig. 10 of the drawings. When the run-in string and setting tool are re-engaged with the actuating sleeve in the manner set forth above, it will be apparent that by pulling or lifting up of the string and the tool, the actuating sleeve and follower sleeve can be returned to their up or unactuated position where the ports 70 and 71 are in register with each other and the follower sleeve is shifted out of engagement over the port 82 in the barrel of the packing means, thereby re-establishing open communication between the portion of

the annulus around the tool above and below the packer and through the apparatus. When the actuating sleeve is shifted upwardly in the manner set forth above and to re-establish circulation of fluid through the apparatus, the packer, being formed of lead, remains in its distended condition and in sealing engagement with the well casing 11.

When it is desired to again shut off the flow of circulating fluid through the body, the weight of the setting string T is again placed upon the sleeves of the actuating means, through the setting tool A and the sleeves are shifted downwardly so that the ports 70 and 71 are again placed out of register and the sleeve again overlies the ports 82.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

Having described my invention, I claim:

1. A by-pass type liner hanger of the character described including, a cylindrical body with a central longitudinal bore, a cylindrical barrel with a central longitudinal bore fixed to and depending from the body and adapted to engage and suspend a liner, slips carried by the body to engage the wall of a casing, an annular cage fixed to and surrounding the barrel in spaced relationship thereto, an annular packing of expansible packing material carried by the cage, an actuating sleeve engaged in the bore in the body to shift longitudinally therein, a follower sleeve slidably engaged around the barrel to extend through the packing and enter the cage and having a shoulder to engage the packing, connecting means between the actuating sleeve and the follower sleeve whereby downward movement of the actuating sleeve causes the follower sleeve to exert expansive pressure onto the packing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

2. A by-pass type liner hanger of the character described including, a cylindrical body with a central longitudinal bore, a cylindrical barrel with a central longitudinal bore fixed to and depending from the body and adapted to engage and suspend a liner, slips carried by the body to engage the wall of a casing, an upwardly opening cup-shaped cage, with circumferentially spaced apertures, fixed to and surrounding the barrel to establish an upwardly opening annular recess, an annular packing of expansible packing material carried by the rim of the cage, an actuating sleeve engaged in the bore in the body to shift longitudinally therein, a follower sleeve slidably engaged around the barrel to extend through the packing and entering the recess established by the cage and having a shoulder to engage the packing, connecting means between the actuating sleeve and the follower sleeve whereby downward movement of the actuating sleeve causes the follower sleeve to exert expansive pressure onto the packing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior of the barrel and the annular recess established by said apertured cage, said ports in the actuating sleeve and the body being shifted out of register with

each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

3. A by-pass type liner hanger of the character described including, a cylindrical body with a central longitudinal bore, a cylindrical barrel with a central longitudinal bore fixed to and depending from the body and adapted to engage and suspend a liner, slips carried by the body to engage the wall of a casing, an upwardly opening cup-shaped cage with circumferentially spaced apertures fixed to and surrounding the barrel to establish an upwardly opening annular recess, an elongate vertically disposed annular packing of expansible packing material carried by the rim of the cage to project upwardly therefrom in spaced relationship around the barrel, an actuating sleeve engaged in the bore in the body to shift longitudinally therein, a follower sleeve slidably engaged around the barrel to extend through the packing and entering the recess established by the cage, the follower sleeve having a downwardly facing shoulder spaced above the cage and engaging the packing, connecting means between the actuating sleeve and the follower sleeve whereby downward movement of the actuating sleeve causes the follower sleeve to exert expansive pressure onto the packing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior of the barrel and the annular recess established by said apertured cage, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

4. A by-pass type liner hanger of the character described including, a cylindrical body with a central longitudinal flow conducting bore, a cylindrical barrel with a central longitudinal flow conducting bore fixed to the body and adapted to engage a liner, slips carried by the body to engage the wall of a casing, an annular cage fixed to and surrounding the barrel, an annular packing of expansible packing material carried by the cage, an actuating sleeve engaged in the bore in the body, a follower sleeve engaged around the barrel to extend through the packing and enter the cage and having a shoulder engaging the packing, connecting means between the actuating sleeve and the follower sleeve whereby downward movement of the actuating sleeve causes the follower sleeve to exert distending pressure onto the packing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

5. A by-pass type liner hanger of the character described including, a cylindrical body with a central longitudinal fluid conducting bore, a cylindrical barrel with a central longitudinal fluid conducting bore fixed to and depending from the body and adapted to engage and suspend a liner, wickered slips slidably carried by the body to shift outwardly and engage the wall of a casing, an upwardly opening cup-shaped cage with circumferentially spaced apertures fixed to and surrounding the barrel to establish an upwardly facing annular seat and an upwardly opening annular recess, an annular packing of expansible packing material carried by the seat on the cage, an actuating sleeve engaged in the bore in the body

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to shift longitudinally therein, a follower sleeve slidably engaged around the barrel to extend through the packing and entering the recess established by the cage and having a downwardly facing shoulder spaced above the cage and engaging the packing, connecting means projecting through the body to extend between and connect the actuating sleeve and the follower sleeve whereby downward movement of the actuating sleeve causes the follower sleeve to exert pressure onto the packing and to distend the packing into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior of the barrel and the annular recess established by said apertured cage, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

6. A by-pass type liner hanger of the character described including, an elongate vertically disposed cylindrical body with a central longitudinal bore, an elongate vertically disposed cylindrical barrel with a central longitudinal bore fixed to and depending from the body and adapted to engage the upper end of and suspend an elongate liner, wickered slips slidably carried by the body to shift upwardly and outwardly into gripping engagement with the wall of a well casing, an upwardly opening cup-shaped cage establishing an upwardly facing annular seat and having circumferentially spaced apertures, said cage being fixed to and surrounding the barrel to establish an upwardly opening annular recess, an elongate vertically disposed annular packing of deformable packing material carried by the seat on the cage to project upwardly therefrom and in spaced relationship around the barrel, an actuating sleeve engaged in the bore in the body to shift longitudinally therein and adapted to be releasably engaged by a setting tool, a follower sleeve slidably engaged around the barrel to extend through the packing and enter the recess established by the cage, the follower sleeve having a downwardly facing shoulder spaced above the cage and engaging the packing, connecting means projecting through slots in the body to extend between and connect the actuating and follower sleeves whereby downward movement of the actuating sleeve causes the follower sleeve to exert expansive pressure onto the packing and to distend the packing into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior of the barrel and the annular recess established by said apertured cage, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly to set the packing.

7. A liner hanging apparatus of the character referred to including, a setting tool fixed to the lower end of a run-in string of tubing, a liner hanger and packer releasably carried by the setting tool and including, a body with a central bore and circumferentially spaced slots, a barrel with a central bore fixed to the body, a cup-shaped cage surrounding the barrel and having circumferentially spaced apertures, a liner fixed to the barrel, a plurality of circumferentially spaced slips carried by the body and adapted to engage a well casing in which the apparatus is engaged, an annular packing of deformable packing ma-

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terial surrounding the barrel and engaging the top of the cage, a follower sleeve slidably engaged in the packing and around the barrel and the cage, said follower sleeve having an annular shoulder opposing the top of the cage and engaging the packing, an actuating sleeve slidably engaged in the bore in the body, blocks on the actuating sleeve projecting through the slots in the body and fixed to the follower sleeve, said setting tool including a mandrel fixed to the lower end of the run-in string, a coupler carried by the mandrel and threaded into the actuating sleeve, a sleeve carried by the coupler and fingers depending from the sleeve and engaging the slips to hold them in an unactuated position, said setting tool being operable to release the slips and to thereafter shift the actuating sleeve downwardly in the body and thereby shift the follower sleeve into pressure engagement with the packing material and to distend the material into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the actuating sleeve and the exterior of the body above the packing and ports in the barrel establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly.

8. A liner hanging apparatus of the character referred to including, a setting tool fixed to the lower end of a run-in string of tubing, a liner hanger and packer releasably carried by the setting tool and including, an elongate body with a central longitudinal bore and having circumferentially spaced longitudinally disposed slots in its lower end portion, an elongate barrel with a central longitudinal bore fixed to and depending from one end of the body, an upwardly opening cage having an annular rim and downwardly and inwardly projecting supporting legs fixed to and surrounding the barrel, an elongate liner fixed to and depending from the lower end of the barrel, a plurality of radially outwardly shiftable slips carried by the body, spring means carried by the body and adapted to shift the slips upwardly and outwardly relative to the body and into gripping engagement in a well casing in which the apparatus is engaged, an annular packing of deformable packing material surrounding the barrel in spaced relationship thereto and engaging the top of the cage rim, an elongate follower sleeve having a lower portion slidably engaged around the barrel and through the packing and the rim of the cage and an upper portion slidably engaged around the lower slotted portion of the body and defining an annular downwardly facing shoulder to engage the top of the packing, an elongate actuating sleeve slidably engaged in the bore in the body, blocks on the actuating sleeve projecting through the slots in the body and fixed to the upper portion of the follower sleeve, said setting tool including an elongate mandrel fixed to and depending from the lower end of the run-in string, a coupler carried by the mandrel and threaded into the actuating sleeve, a sleeve carried by the coupler and fingers depending from the sleeve and engaging the slips to hold them down in an unactuated position, said setting tool being operable to release the slips and to thereafter shift the actuating sleeve downwardly in the body and thereby shift the follower sleeve into pressure engagement with the packing and to distend the packing into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the actuating sleeve and the exterior of the body above the packing and ports in the barrel below the rim of the cage and the lower end of the follower sleeve establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating

sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly.

9. A liner hanging apparatus of the character referred to including, a setting tool fixed to the lower end of a run-in string of tubing, a liner hanger and packer releasably carried by the setting tool and including, an elongate vertically disposed cylindrical body with a central longitudinal flow handling bore having circumferentially spaced longitudinally disposed slots in its lower end portion, an elongate vertically disposed cylindrical barrel with a central longitudinal flow handling bore fixed to and depending from the lower end of the body, an upwardly opening cup-shaped cage having an annular rim with an upwardly facing annular seat and a plurality of downwardly and inwardly projecting legs fixed to the barrel, said cage establishing an upwardly opening annular recess, an elongate vertically disposed liner fixed to and depending from the lower end of the barrel, a plurality of circumferentially spaced vertically and radially outwardly shiftable slips carried by the body and adapted to shift upwardly and outwardly relative to the body and engaging a casing in which the apparatus is engaged, an annular packing of deformable packing material surrounding the body in spaced relationship thereto and engaged on the seat on the rim of the cage, an elongate vertically disposed follower sleeve having a lower portion slidably engaged in the packing and around the barrel with its lower end entering the recess established by the cage, and an upper portion slidably engaged around the lower slotted portion of the body and defining an annular downwardly facing shoulder to engage the top of the packing, an elongate actuating sleeve slidably engaged in the bore in the body, said body having an inwardly projecting stop shoulder at the upper end of the bore and preventing vertical displacement of the actuating sleeve from the body, radially outwardly projecting blocks fixed to the lower portion of the actuating sleeve to project through the slots in the body and fixed to the upper portion of the follower sleeve, said setting tool including an elongate mandrel fixed to and depending from the lower end of the run-in string, a coupler carried by the mandrel and threaded into the actuating sleeve, a sleeve carried by the coupler and fingers depending from the sleeve and engaging the slips to hold them down in an unactuated position, said setting tool being operable to release the slips and to thereafter shift the actuating sleeve downwardly in the body and thereby shift the follower sleeve into pressure engagement with the packing material and to distend the material into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the actuating sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly.

10. A liner hanging apparatus of the character referred to including, a setting tool fixed to the lower end of a run-in string of tubing, a liner hanger and packer

releasably carried by the setting tool and including, an elongate vertically disposed cylindrical body with a central longitudinal flow handling bore having circumferentially spaced longitudinally disposed slots in its lower end portions, an elongate vertically disposed cylindrical barrel with a central longitudinal flow handling bore fixed to and depending from the lower end of the body, an upwardly opening cup-shaped cage having an annular rim with an upwardly facing annular seat and a plurality of downwardly and inwardly projecting legs fixed to the barrel, said cage establishing an upwardly opening annular recess, an elongate vertically disposed liner fixed to and depending from the lower end of the barrel, a plurality of circumferentially spaced vertically and radially outwardly shiftable slips carried by the body and adapted to shift upwardly and outwardly relative to the body and engaging a casing in which the apparatus is engaged, an annular packing of deformable packing material surrounding the body in spaced relationship thereto and engaged on the seat on the rim of the cage, an elongate vertically disposed follower sleeve having a lower portion slidably engaged in the packing and around the barrel with its lower end entering the recess established by the cage, and an upper portion slidably engaged around the lower slotted portion of the body and defining an annular downwardly facing shoulder to engage the top of the packing, an elongate actuating sleeve slidably engaged in the bore in the body, said body having an inwardly projecting stop shoulder at the upper end of the bore and preventing vertical displacement of the actuating sleeve from the body, radially outwardly projecting blocks fixed to the lower portion of the actuating sleeve to project through the slots in the body and fixed to the upper portion of the follower sleeve, said setting tool including an elongate mandrel fixed to and depending from the lower end of the run-in string, a coupler carried by the mandrel and threaded into the actuating sleeve, a sleeve carried by the coupler and fingers depending from the sleeve and engaging the slips to hold them down in an unactuated position, said setting tool being operable to release the slips and to thereafter shift the actuating sleeve downwardly in the body and thereby shift the follower sleeve into pressure engagement with the packing and to distend the material into sealing engagement with the casing, and fluid circulating means including registering ports in the body and the actuating sleeve establishing open communication between the interior of the actuating sleeve and the exterior of the body above the packing and ports in the barrel below the follower sleeve establishing open communication between the interior and the exterior of the barrel below the packing, said ports in the actuating sleeve and the body being shifted out of register with each other and the ports in the barrel being closed by the follower sleeve, when the actuating sleeve and follower sleeve are urged downwardly, said body having vertically disposed flow channels about its outer periphery and extending from the ports to the top of the body.

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