Dec. 12, 1961 K. A. WRIGHT ET AL 3,012,612

SLIP ACTUATING MECHANISM

Filed Oct. 24, 1957 3 Sheets-Sheet 1

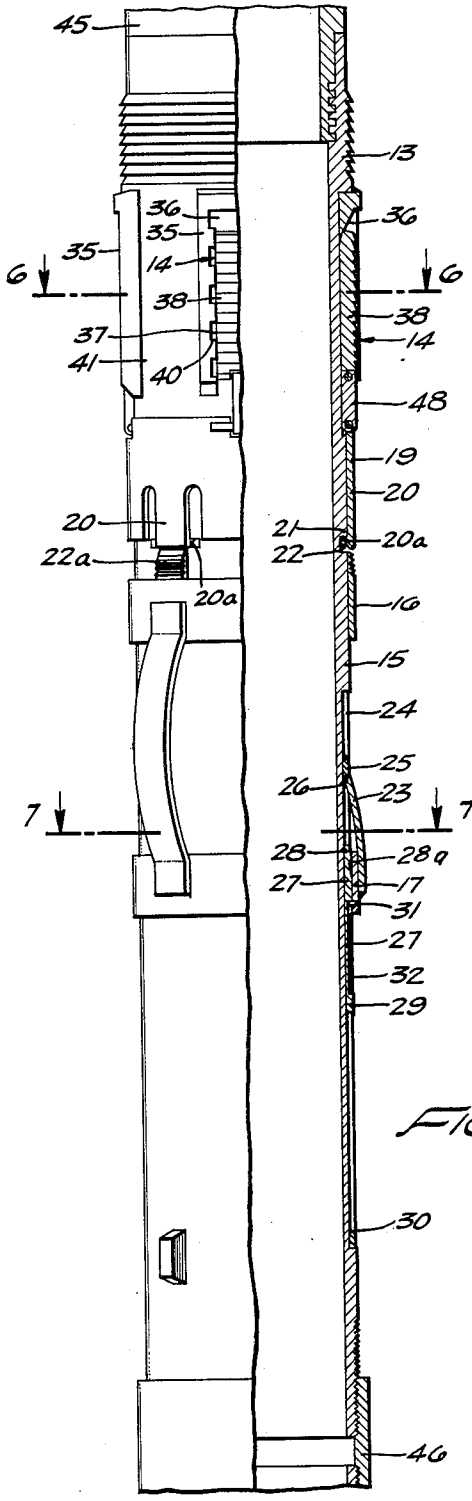
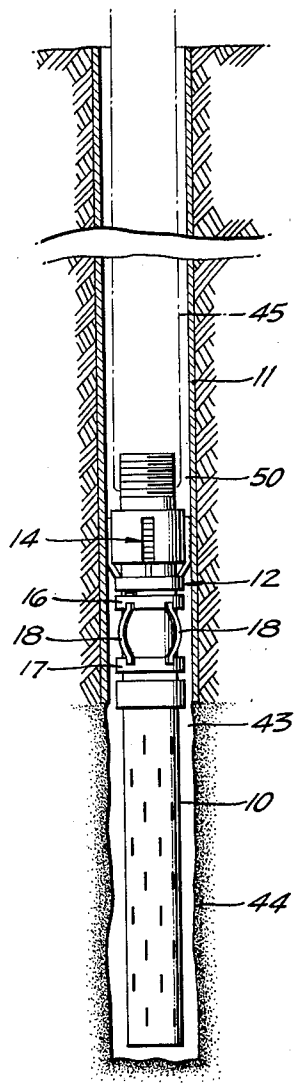


FIG. 2.

FIG. 1.



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SLIP ACTUATING MECHANISM

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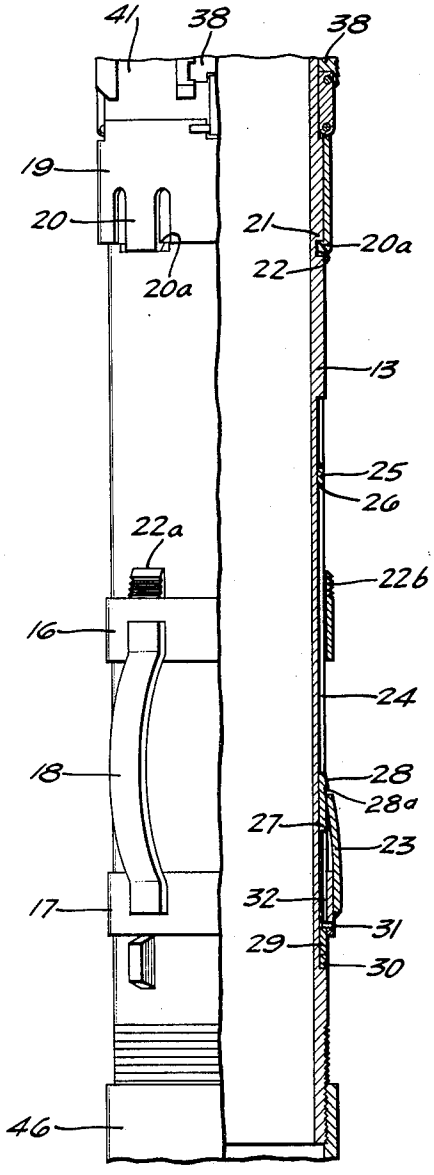
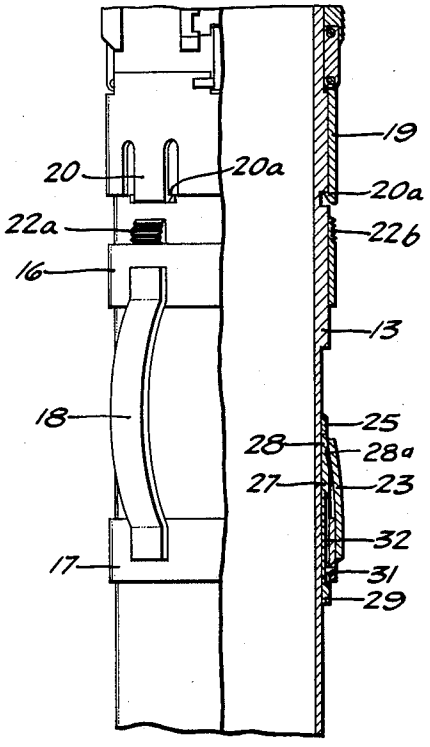


FIG. 3.

FIG. 4.



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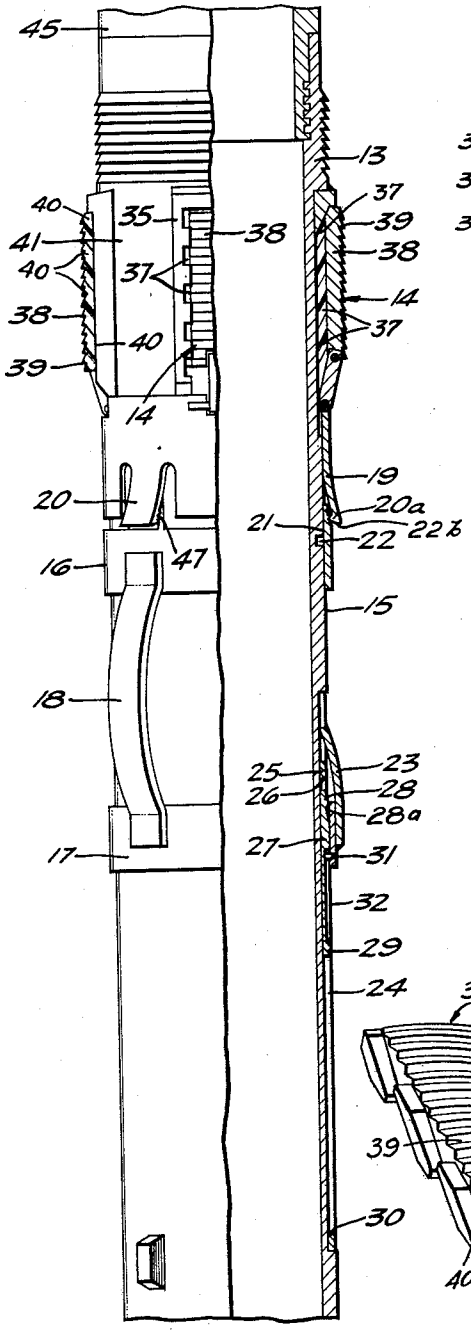


FIG. 5.

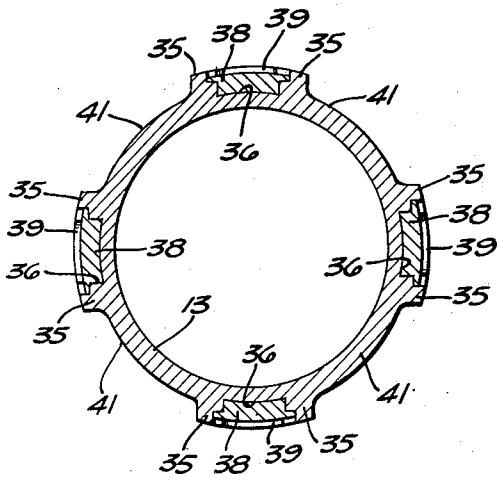


FIG. 6.

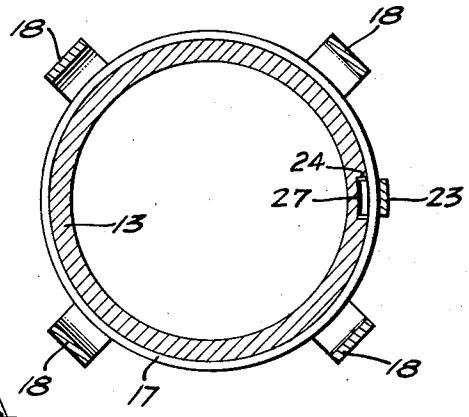


FIG. 7.

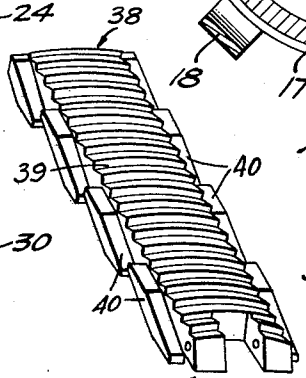


FIG. 8.

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3,012,612
SLIP ACTUATING MECHANISM

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Filed Oct. 24, 1957, Ser. No. 692,148
13 Claims. (Cl. 166—208)

This invention relates to liner hangers of the type employed in wells for suspending a perforated liner pipe within a well casing.

It is an object of this invention to provide an improved form of liner hanger which may be set in the desired position without requiring rotation of the setting tool. Another object is to provide an improved form of liner hanger which may be set and unset an unlimited number of times by predetermined amounts of reciprocation and is uneffected by rotation. Another object is to provide a liner hanger of this type which employs a series of wedge slips engageable with the inner surface of the casing which slips are latched in an inoperative position while the device is being lowered into the casing and wherein novel means are provided for releasing the latch means. Another object is to provide a device of this type in which the latch releasing means includes a pair of longitudinally spaced collars slidably mounted on the tool having casing contacting bow springs fixed to and extending between the collars.

Another object is to provide a liner hanger assembly particularly adapted for use in gravel packing operations. Another object is to provide a liner hanger assembly including a plurality of longitudinally extending wedge slips each mounted in a shallow recess formed between parallel ribs extending outward from the surface of the tool, and wherein clearance channels are provided between the pairs of ribs for the passage of well fluid. Another object is to provide a liner hanger including wedge slip assemblies of novel design providing clearance channels of maximum size to permit free passage of fluid outside the liner hanger mandrel and between the slip assemblies. Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIGURE 1 is a diagram showing a perforated liner pipe suspended within the lower end of a well casing.

FIGURE 2 is a longitudinal view showing a liner hanger constituting a preferred embodiment of this invention, the parts being shown in position for lowering into the well casing.

FIGURE 3 is a view similar to FIGURE 2 showing the position of the parts after the mandrel has been raised above the lowermost position reached in lowering the device into the well casing.

FIGURE 4 is a view similar to FIGURE 3 showing the position of the parts after the mandrel has been again lowered, but not far enough to bring the wedge slips into engagement with the casing.

FIGURE 5 is a view similar to FIGURE 4 showing the position of the parts when the wedge slips have been brought into engagement with the inner surface of the casing.

FIGURE 6 is a transverse sectional view taken substantially on the lines 6—6 as shown in FIGURE 2.

FIGURE 7 is a transverse sectional view taken substantially on the lines 7—7 as shown in FIGURE 2.

FIGURE 8 is an enlarged oblique view of one of the wedge slips removed from the liner hanger.

Referring to the drawings, the liner pipe 10 is suspended within the well from the lower portion of the casing 11 by means of the liner hanger generally designated 12. This liner hanger includes a tubular mandrel

13 provided with a plurality of wedge slip assemblies 14. The outer cylindrical surface 15 of the mandrel 13 slidably receives and supports an upper collar 16 and a lower collar 17 connected by longitudinally extending bow springs 18. These bow springs are fixed at their ends to the collars 16 and 17 and project laterally into resilient contact with the inner surface of the casing 11.

A slip actuating sleeve 19 is also slidably mounted on the outer surface 15 of the mandrel 13 and this sleeve 19 is provided with a plurality of spring latch elements 20 having upward facing shoulders 20*a* which engage downward facing shoulders 21 provided by pockets 22 on the mandrel 13. When the latch elements 20 engage the shoulders 21, the wedge slip assemblies 14 are maintained in retracted inoperative position.

The upper collar 16 is provided with upward projecting serrated elements 22*a* which contact the upwardly and inwardly tapered end portions 22*b* of the latch elements 20 to disengage the latch elements from the pockets 22 upon downward movement of the mandrel 13 relative to the upper collar 16. One or more resilient stop fingers 23 may be fixed to the lower collar 17 and the upper end of each stop finger 23 projects into a longitudinal groove 24 provided in the outer surface of the mandrel 13. A stop lug 25 having a downward facing abutment 26 is fixedly mounted in each groove 24 and is engaged by the upper end of the stop finger 23. The stop finger 23 thus serves to prevent downward movement of the mandrel 13 with respect to the lower collar 17.

A trip key 27 is mounted to slide in the groove 24 and extends within the lower collar 17. This trip key 27 is provided with a nose 28 adapted to contact the under side of the stop finger 23 and to move the projecting end thereof radially out of position for engagement with the lug 25. Movement of the trip key 27 to release the stop finger 23 is accomplished by engagement of the lower end 29 of the trip key 27 with the shoulder 30 at the lower ends of the groove 24, in the manner set forth below. A notch 28*a* may be provided in the outer surface of the trip key 27 just below the nose 28 to receive the upper end of the finger 23 when the latter is in the released position. The engagement of finger 23 in notch 28*a* helps to prevent the finger from riding over the nose 28 back into the groove 24 upon downward movement of the mandrel until the key 27 abuts lug 25 as shown in FIGURE 4. A pin 31 fixed on the lower collar 17 is free to travel in a longitudinal groove 32 provided in the outer surface of the trip key 27.

Each of the wedge slip assemblies 14 includes a pair of ribs 35 extending longitudinally of the mandrel and projecting radially from the cylindrical outer surface thereof. Each of these pairs of ribs 35 cooperate to define axially extending slip-receiving recesses 36 therebetween. The side edges of the ribs 35 adjacent the recesses 36 are provided with upwardly and outwardly inclined slots 37. A wedge slip 38 is mounted in each of the recesses 36 and is provided with the usual serrations 39 on its casing-engaging outer surface. Each side edge of each of the slips 38 is provided with longitudinally spaced inclined projections 40 for engagement with the similarly inclined slots 37 on the ribs. Accordingly, downward movement of the mandrel 13 with respect to the wedge slips 38 causes the slips to move radially outward along the inclined mating faces of the slots 37 and projections 40 to bring the surfaces 39 into engagement with the inner surface of the casing. A channel 41 for passage of well fluid is formed between each wedge slip assembly 14. The sides of the channel are defined by the parallel ribs 35 and the bottom of the channel is formed by the outer cylindrical surface 15 of the mandrel 13. The sectional view of FIGURE 6 shows that the channels 41 provide a relatively large passage area for

well fluid, which passage area is unobstructed by the wedge slip assembly. These channels 41 are thus particularly advantageous for use in gravel packing operations which require maximum passage area for fluid-carrying gravel particles into the annular space 43 between the perforated liner pipe 10 and the open hole 44 of the well formation.

In operation, the mandrel 13 is supported on a pipe string 45 and lowered into the casing. A coupling 46 at the lower end of the mandrel supports the liner pipe 10. The parts are in the position shown in FIGURE 2 during the operation of lowering the liner hanger 12 and liner 10 into position. The bow springs 18 resiliently engage the inner surface of the casing and the stop finger 23 engages the abutment 26 thereby preventing any downward movement of the mandrel 13 relative to the collars 16 and 17.

When the desired elevation is reached in the well bore, the mandrel 13 is raised for a predetermined distance to cause the lower end 29 of the trip key 27 to engage the abutment 30 at the lower end of the longitudinal groove 24. This moves the trip key 27 upward with the mandrel 13 and causes the nose 28 to swing the resilient stop finger 23 to an inoperative position on top of the trip key 27. The parts are then in the position shown in FIGURE 3. The collars 16 and 17 do not move upward with the mandrel 13 until the pin 31 abuts the lower end of the groove 32 in the trip key 27 because of the frictional contact of the bow springs 18 with the inner surface of the casing. Upon downward movement of the mandrel the upper end of finger 23 engages notch 23*a* to move the trip key 27 upward in the groove 24.

The mandrel 13 is then lowered for a distance somewhat less than the distance it was raised and this action serves to move the stop lug 25 downward into engagement with the nose 28 of the trip key 27. The extending end of the finger 23, becomes disengaged from notch 23*a* upon further lowering of the mandrel after engagement of the trip key 27 with the lug 25 but still rests on the exterior of the trip key and out of position to contact the stop lug 25. The parts are then in the position shown in FIGURE 4.

Continued downward movement of the mandrel 13 causes the stop lug 25 to move downward below the upper end of the stop finger 23 and causes the upper collar 16 to be brought into engagement with the slip setting sleeve 19. The projections 22*a* on the upper collar 16 engage the tapered end portions 22*b* of the latch elements 20 and continued downward movement of mandrel 13 moving each latch element 20 to an inoperative position by springing the elements 20 to move the upward facing shoulders 20*a* out of the pockets 22, and further downward movement of mandrel 13 causes the latch elements 20 to engage the outer serrated surface of projections 22*a* and the slip setting sleeve 19 moves upward relative to the mandrel 13 causing the wedge slips to be moved by the links 48 into engagement with the inner surface of the casing. The collars 16 and 17 do not move downward with the mandrel 13 because of the frictional drag caused by resilient engagement of the bow springs 18 with the inner surface of the casing 11.

After the slips 38 have been set, gravel may be introduced into the annular space 43 around the liner 10. The gravel is carried in a stream of fluid which passes through the annular space 50 between the upper end of the mandrel and the inner surface of the casing. The gravel-laden fluid then passes through the several channels 41 without serious restrictions and passes downward around the outside of the sleeve 19 and collars 16 and 17 into the upper ends of the annular space 43. The upward movement of the mandrel 13 causes the wedge slips 38 to move radially inwardly because of the slidable engagement of inclined slots 37 and inclined projections 40, and causing the serrated surfaces 39 to move away from engagement with the inner surface of casing 11. The frictional drag of bow springs 18 engaging the inner surface of casing 11 prevents upward movement of collars 16 and 17, and because of engagement of latch elements 20 with the outer serrated surface of projections 22*a* the sleeve 19 is prevented from moving upward. When the slips 38 are fully retracted, continued upward movement causes disengagement of latch elements 20 and projections 22*a*, causing latch elements 20 to spring inwardly into the pockets 22 and the engagement of shoulders 20*a* and shoulders 21. Further upward movement of mandrel 13 causes stop finger 23 to spring outwardly over and past the stop lug 25 into the groove 24 whereby the mandrel 13 can again be moved downward and the upper end of stop finger 23 engages the abutment 26 to prevent setting the wedge slips 38 (as shown in FIGURE 2). The gravel remains in the annular space while the fluid passes upward through the perforations of the liner pipe 10 and returns upward through the interior of the mandrel.

After the gravel packing operation is complete, the pipe string 45 may be disconnected from the upper end of the mandrel 13 and withdrawn from the hole. A packer device, preferably of the type shown in our co-pending application entitled "Packer Device for Wells" filed August 20, 1957, Serial No. 679,204, may then be installed to form a seal between the upper end of the mandrel 13 and the inner surface of the casing 11.

It will be understood from the above description that the slip actuating steps are accomplished without the requirement of rotation, and that, conversely, the entire device can be turned or rotated within the casing prior to the slip setting operation without adverse effect. Moreover it is possible to set and unset the slips as many times as desired. The unsetting operation is accomplished simply by lifting the pipe 45 and mandrel 13 to return the parts from the position shown in FIGURE 5 to the position shown in FIGURE 2.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. In a liner hanger for suspending a liner pipe from a well casing, a tubular mandrel having means for connection to a liner pipe, a plurality of wedge slips mounted upon the outer surface of the mandrel for engagement with the casing, latch means engageable with the mandrel below the slips and link means connecting the latch means to each of the slips for maintaining the slips in a retracted position, an upper collar and a lower collar each slidably mounted upon the outer surface of the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means carried by said upper collar positioned for engagement with said latch means to release said latch means from said mandrel on downward movement of the mandrel relative to the upper collar, thereby moving the mandrel downward relative to the latch means, link means and slips whereby the slips are urged into engagement with the casing, the mandrel having a longitudinal groove in its outer surface, a downward facing abutment positioned within said longitudinal groove on the mandrel, an element on the lower collar having a finger extending into the groove and engaging the abutment, a trip key slidably mounted in the groove and having a nose engageable with said element to move it out of engaging position whereby the mandrel and slips are permitted to move downward relative to the upper collar, and upward facing abutment means positioned in the lower end of the groove on the mandrel for actuating the trip key.

2. In a liner hanger for suspending a liner pipe from a well casing, a tubular mandrel having means for connection to a liner pipe, a plurality of wedge slips mounted upon the outer surface of the mandrel for engagement with the casing, latch means engageable with the mandrel

below the slips and link means connecting the latch means to each of the slips for maintaining the slips in a retracted position, an upper collar and a lower collar each slidably mounted upon the outer surface of the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means carried by said upper collar positioned for engagement with said latch means to release said latch means from said mandrel on downward movement of the mandrel relative to the upper collar, thereby moving the mandrel downward relative to the latch means, link means and slips whereby the slips are urged into engagement with the casing, the mandrel having a longitudinal groove in its outer surface, a stop lug fixed in the groove, an element on the lower collar having a finger extending into the groove below the stop lug, a trip key slidably mounted in the groove and having a nose engageable with said element to move the finger out of the lug-engaging position whereby the mandrel and slips are permitted to move downward relative to the upper collar, and upward facing abutment means positioned in the lower end of the groove on the mandrel for actuating the trip key.

3. In a liner assembly or the like, the combination of: a tubular mandrel having a generally cylindrical outer surface, a plurality of pairs of longitudinally extending ribs on the mandrel projecting radially outwardly from said surface, each pair of ribs defining a slip-receiving recess therebetween, each rib having a plurality of longitudinally spaced inclined slots, a plurality of wedge slips, one mounted in each of said recesses, each slip having a series of inclined projections extending from the side edges thereof and slidably engaging the rib slots, the mandrel having longitudinal clearance channels between said pairs of ribs, the bottom portion of the channel being substantially flush with said outer surface of the mandrel, and means for moving the slips along said inclined projections and slots.

4. In a liner assembly or the like, the combination of: a tubular mandrel having a generally cylindrical outer surface, a plurality of pairs of longitudinally extending ribs on the mandrel projecting radially outwardly from said surface, each pair of ribs defining a slip-receiving recess there-between, said ribs having a plurality of longitudinally spaced inclined slots along the sides of each recess, a plurality of wedge slips, one mounted in each of said recesses, each slip having a series of projections extending from the side edges thereof and having inclined faces engageable with said rib slots, the mandrel having longitudinal clearance channels between said pairs of ribs, the bottom portion of each channel being substantially flush with said outer surface of the mandrel, and means for moving the slips along said inclined faces.

5. In a liner assembly or the like, the combination of: a tubular mandrel having a generally cylindrical outer surface, a plurality of pairs of longitudinally extending ribs on the mandrel projecting radially outwardly from said surface, each pair of ribs defining a slip-receiving recess there-between, said ribs having a plurality of longitudinally spaced inclined slots along the sides of each recess, a plurality of wedge slips, one mounted in each of said recesses, each wedge slip having a series of projections extending from the side edges thereof and having inclined faces engageable with said rib slots, the mandrel having longitudinal clearance channels between said pairs of ribs, the bottom portion of each channel being substantially flush with said outer surface of the mandrel, a slip actuating collar slidably mounted on said mandrel surface and spaced longitudinally from said slips, and a plurality of links pivotally connected to said collar, each link being pivotally connected to one of said wedge slips.

6. In a liner hanger for suspending a liner pipe from a well casing, a tubular mandrel having means for connection to a liner pipe, a plurality of wedge slips mounted upon the outer surface of the mandrel for engagement with the casing, latch means on the mandrel below the slips and link means connecting the latch means to each of the slips for maintaining the slips in a retracted position, an upper collar and a lower collar each slidably mounted upon the outer surface of the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means carried by said upper collar positioned for engagement with said latch means to release said latch means from said mandrel upon downward movement of said mandrel relative to said upper collar, and thereby moving the mandrel downward relative to the latch means, link means and slips causing the slips to engage the casing, interengaging parts on said lower collar and said mandrel preventing downward movement of said mandrel relative to said lower collar, and trip means slidably mounted upon the mandrel operable upon upward movement of the mandrel relative to said lower collar to render said interengaging parts ineffective, whereby the mandrel may move downward relatvie to the upper collar to actuate said slips.

7. In a liner hanger for suspending a liner pipe from a well casing, a tubular mandrel having means for connection to a liner pipe, a plurality of wedge slips mounted upon the outer surface of the mandrel for engagement with the casing, latch means on the mandrel below the slips and link means connecting the latch means to each of the slips for maintaining the slips in a retracted position, an upper collar and a lower collar each slidably mounted upon the outer surface of the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means carried by said upper collar positioned for engagement with said latch means to release said latch means from said mandrel upon downward movement of said mandrel relative to said upper collar, and thereby moving the mandrel downward relative to the latch means, link means and slips causing the slips to engage the casing, stop means on said lower collar engageable with said mandrel preventing downward movement of said mandrel relative to said lower collar, and trip means upon the mandrel operable upon upward movement of the mandrel relative to said lower collar to render said stop means ineffective, whereby the mandrel may move downward relative to the upper collar to actuate said slips.

8. In a device of the class described for use within a well casing, the combination of: a tubular mandrel, a plurality of wedge slips mounted upon the mandrel for engagement with the casing, latch means on the mandrel and link means connecting the latch means to each of the slips for maintaining the slips in a retracted position, an upper collar and a lower collar each slidably mounted upon the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means carried by one of said collars positioned for engagement with said latch means to release said latch means from said mandrel upon downward movement of said mandrel relative to said collar, and thereby moving the mandrel downward relative to the latch means, link means and slips causing the slips to engage the casing, interengaging parts on the other collar and said mandrel preventing downward movement of said mandrel relative to said other collar, and trip means slidably mounted upon the mandrel operable upon upward movement of the mandrel relative to said other collar to render said interengaging parts ineffective, whereby the mandrel may move downward relative to both collars to actuate said slips.

9. In a liner hanger for suspending a liner pipe from a well casing, the combination of: a tubular mandrel, a plurality of casing-engaging slips movably mounted upon the mandrel, an upper collar and a lower collar each slidably mounted upon the mandrel, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means including latch means and link means connecting the latch means to each of the slips for maintaining said slips in retracted position on the mandrel, means on one of the collars op-

erable to release said latch means upon longitudinal movement of the mandrel in one direction relative to said collar, and thereby moving the mandrel downward relative to the latch means, link means and slips causing the slips to engage the casing, cooperating parts on the other collar and said mandrel preventing said relative movement, said cooperating parts being releasable upon longitudinal movement of said mandrel in the other direction relative to the latter said collar.

10. In a liner hanger for suspending a liner pipe from a well casing, the combination of: a tubular mandrel, a plurality of casing-engaging slips movably mounted upon the mandrel, an upper collar and a lower collar each slidably mounted upon the mandrel below the slips, a plurality of casing-contacting bow-springs connected to the collars and extending longitudinally between them, means including latch means and link means connecting the latch means to each of the slips for maintaining said slips in retracted position on the mandrel, means on said upper collar operable to release said latch means upon downward movement of the mandrel relative to said collar, and thereby moving the mandrel downward relative to the latch means, link means and slips causing the slips to engage the casing, cooperating parts on said lower collar and said mandrel preventing said relative movement, said cooperating parts being releasable upon upward movement of said mandrel relative to the said lower collar.

11. In a liner hanger for suspending a liner pipe from a well casing, the combination of: a tubular mandrel, a plurality of longitudinally extending pairs of ribs on the mandrel defining slip-receiving recesses, each rib having a radial recess-facing surface provided with spaced slots axially inclined relative to the mandrel, a plurality of wedge slips having side edges provided with inclined projections slidably engaging the rib slots, an upper and lower collar each slidably mounted upon the mandrel and having a plurality of casing-contacting bow-springs extending longitudinally between and connecting them, means having link means connected to each wedge slip and also having latch means engageable with the mandrel for maintaining said slips in retracted position on the mandrel, means on one of the collars operable to release said latch means to permit longitudinal movement of the mandrel in one direction relative to said collar, link means and wedge slips to move said wedge slips into engagement with the casing, cooperating parts on the other collar and said mandrel preventing said relative movement, said cooperating parts being releasable upon longitudinal movement of said mandrel in the other direction relative to the latter said collar.

12. In a liner hanger for suspending a liner pipe from a well casing, the combination of: a tubular mandrel, a plurality of longitudinally extending pairs of ribs on the mandrel defining slip-receiving recesses, each rib having a radial recess-facing surface provided with spaced slots axially inclined upwardly and outwardly from the mandrel, a plurality of wedge slips having side edges provided with inclined projections slidably engaging the rib slots, an upper and lower collar each slidably mounted upon the mandrel and having a plurality of casing-contacting bow-springs extending longitudinally between and connecting them, interengaging stop means on one of the collars and said mandrel preventing downward movement of said mandrel relative to said collar, trip means operable upon upward movement of said mandrel to render said interengaging stop means ineffective, means having link means connected to each wedge slip and also having latch means engageable with the mandrel for maintaining said slips in retracted position on the mandrel, means on one of the collars operable to release said latch means to permit longitudinal movement of the mandrel relative to said collar, link means and wedge slips, whereby the wedge slips move outward into casing engagement upon downward movement of said mandrel relative to said slips.

13. In a liner hanger for suspending a liner pipe from a well casing, the combination of: a tubular mandrel, a plurality of longitudinally extending pairs of ribs on the mandrel defining slip-receiving recesses, each rib having a radial recess-facing surface provided with spaced slots axially inclined upwardly and outwardly relative to the mandrel, a plurality of wedge slips having side edges provided with inclined projections slidably engaging the rib slots, an upper and lower collar each slidably mounted upon the mandrel and having a plurality of casing-contacting bow-springs extending longitudinally between and connecting them, interengaging stop means on one of the collars and said mandrel preventing downward movement of said mandrel relative to said collar, trip means operable upon upward movement of said mandrel to render said interengaging stop means ineffective, link means having means connected to each wedge slip and also having latch means engageable with the mandrel for maintaining said slips in retracted position on the mandrel, projecting elements on one of the collars operable to engage said latch means and to release same from the mandrel and to permit longitudinal movement of the mandrel relative to said collar, link means and wedge slips, whereby downward movement of the mandrel actuates the slips into casing engagement and subsequent upward movement of the mandrel in sequence retracts the slips, disengages the projecting elements and latch means thereby interengaging the latch means and the mandrel, and engages the said interengaging stop means.

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