

April 28, 1959

J. V. FREDD
WELL TUBING PLUG

2,884,071

Filed April 5, 1954

4 Sheets-Sheet 1

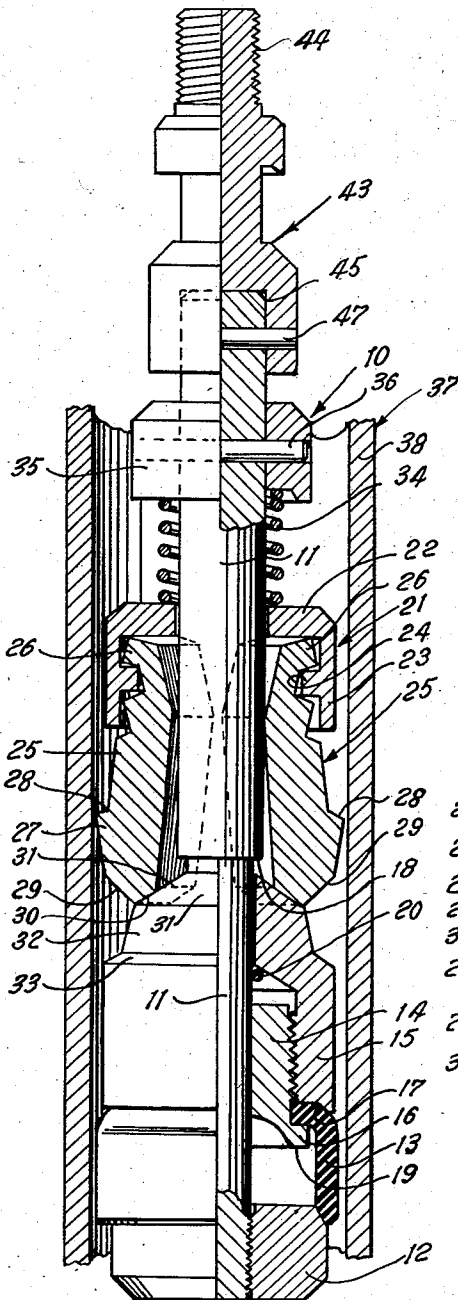


Fig. 1

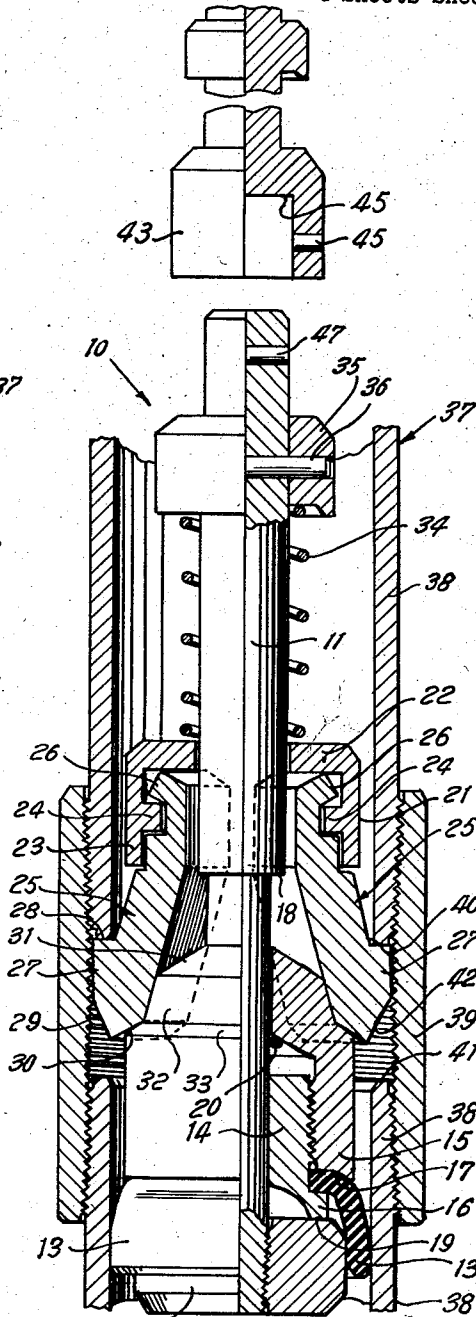


Fig. 2

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4 Sheets-Sheet 2

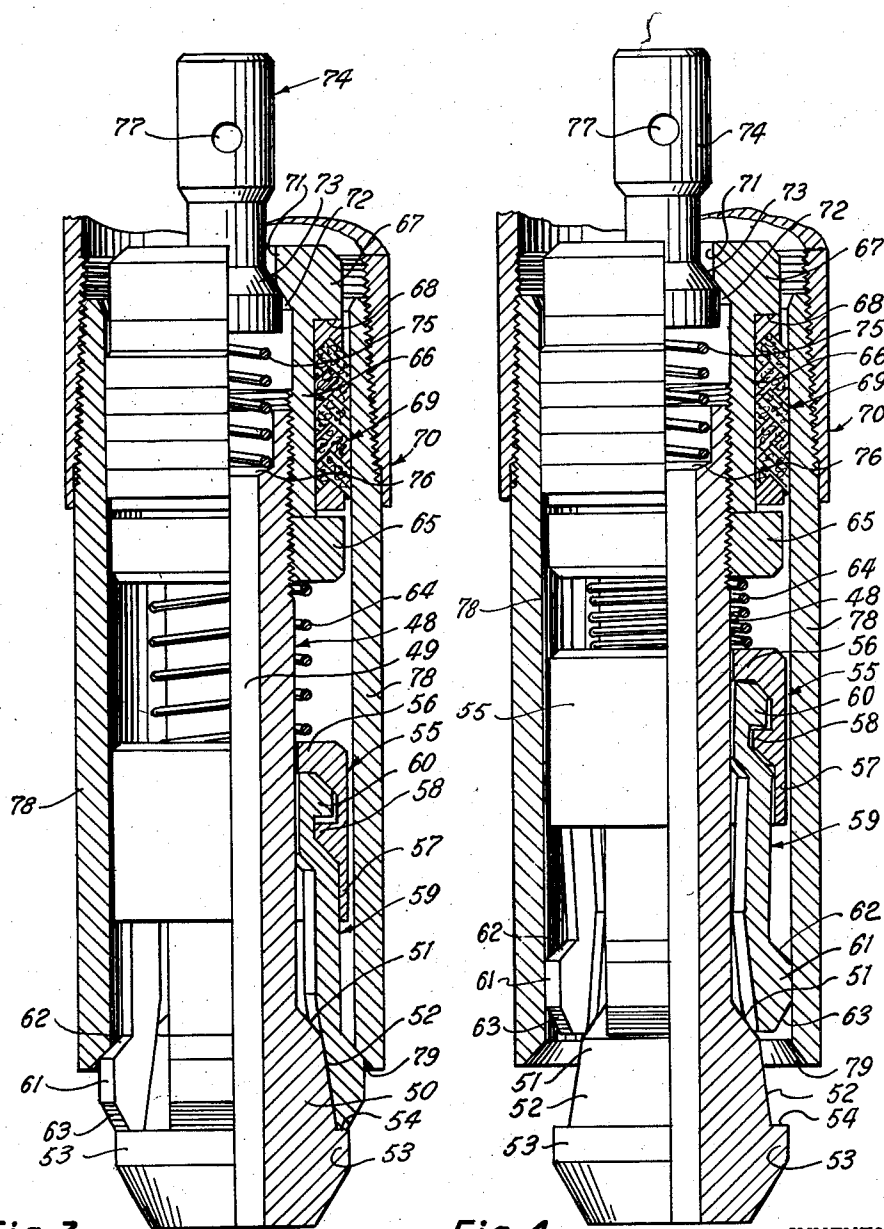


Fig. 3

Fig. 4

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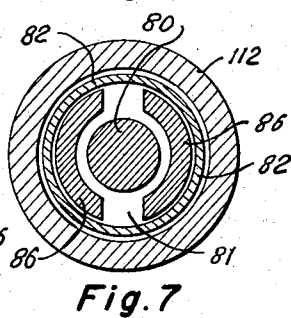
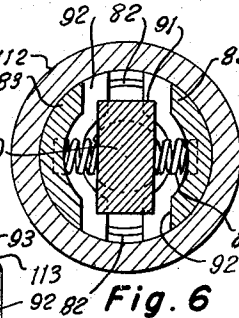
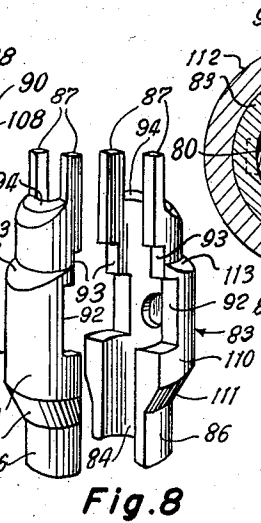
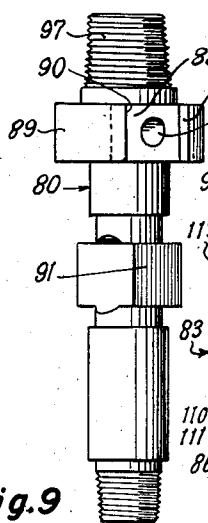
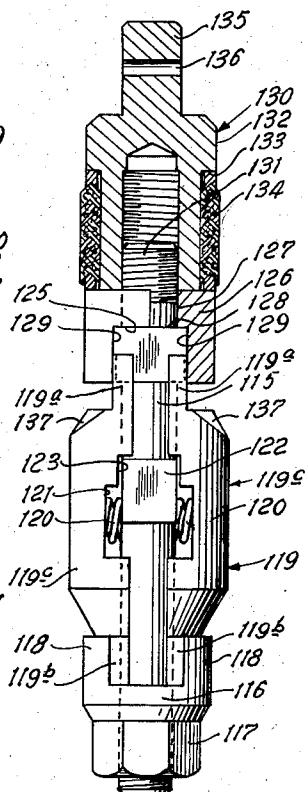
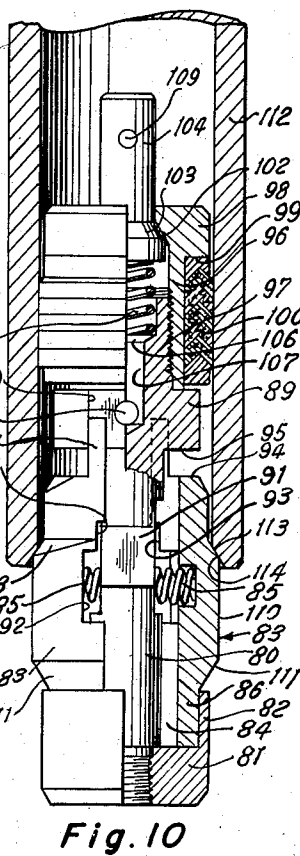
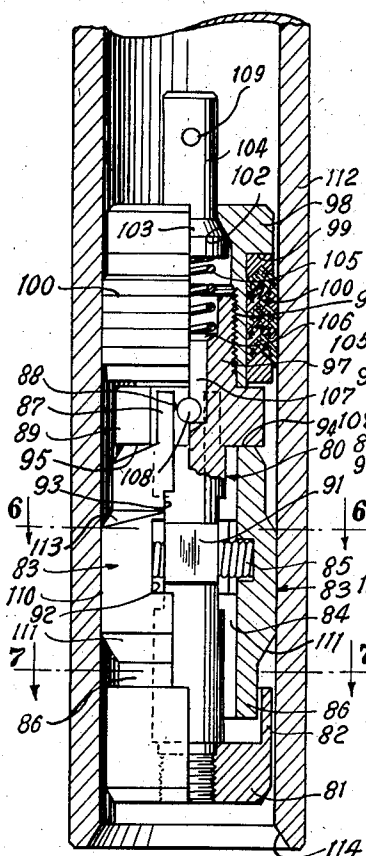
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

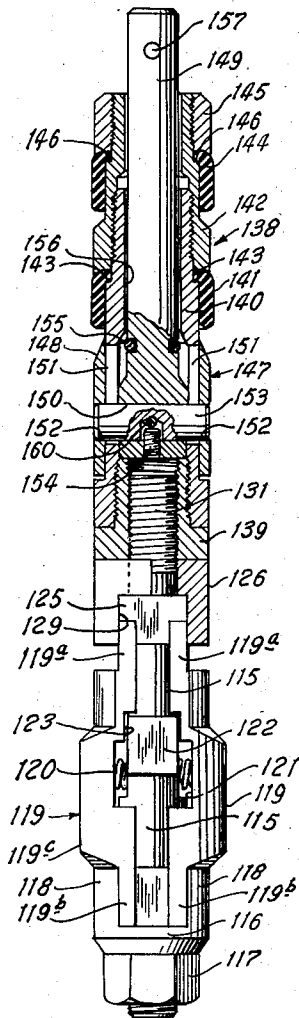


Fig. 12

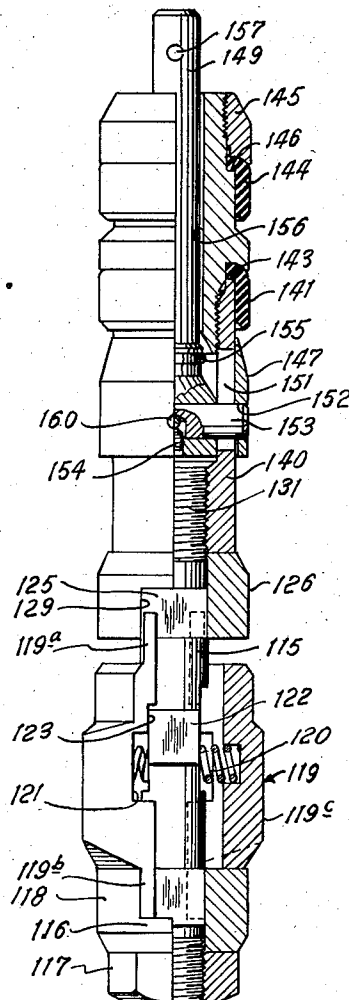


Fig. 13

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2,884,071

WELL TUBING PLUG

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Application April 5, 1954, Serial No. 420,945

16 Claims. (Cl. 166—137)

This invention relates to well tools and more particularly to a plug for closing the bore of well tubing.

An object of this invention is to provide a new and improved plug for wells.

Another object of the invention is to provide a new and improved plug having locking means for locking a plug in a well tubing against upward movement therein.

Still another object of the invention is to provide a plug, of the type described, which can be lowered into the well and locked in place by means of a flexible line.

A further object of the invention is to provide a plug, of the type described, having a sealing means expandable into sealing engagement with the well tubing by an upward force imparted to the flexible line after the plug has been lowered to the desired location in the well.

A further object of the invention is to provide a new and improved plug having expansible dogs engageable in a coupling recess of the well tubing to prevent upward movement of the plug therein.

A still further object of the invention is to provide a plug, of the type described, which can be pushed downwardly out of the tubing after it has served its purpose.

Another object of the invention is to provide a new and improved plug, of the type described, having locking means for preventing retractive movement of the dogs from expanded positions.

Still another object of the invention is to provide a new and improved plug, of the type described, having valve means which may be opened to relieve pressure differential existing across the plug when it is in situ prior to the removal of the plug from the well tubing.

A further object of the invention is to provide a new and improved plug, of the type described, having valve means which will permit downward passage of said plug through sections of the tubing string that have internal bores of the same size as the landing shoe for said plug; said valve means opening automatically when the wire line tools apply downward force to said plug.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of devices constructed in accordance with the invention and reference to the accompanying drawings thereof, wherein:

Figure 1 is a view, partly in elevation and partly in section, showing the plug as it is being lowered into the well tubing by means of a running tool and showing the various components of the plug in the positions they assume while the plug is being lowered through the well tubing;

Figure 2 is a similar view showing the plug locked in position in the well tubing;

Figure 3 is a view, partly in elevation and partly in section, of a modified form of the plug showing the plug locked in position in a landing nipple or shoe on the lower end of the well tubing;

Figure 4 is a similar view of the plug of Figure 3 showing the plug as it appears while being lowered through well tubing;

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Figure 5 is a view, partly in elevation and partly in section, of another form of the plug showing the various components of the plug in the positions they assume while the plug is being lowered through the well tubing;

Figures 6 and 7 are sectional views taken on the lines 6—6 and 7—7, respectively, of Figure 5;

Figure 8 is a perspective view of the dogs of the plug shown in Figure 5;

Figure 9 is a perspective view of the central mandrel of the plug shown in Figure 5;

Figure 10 is a view, partly in elevation and partly in section, showing the plug of Figure 5 locked in position in a landing nipple or shoe at the lower end of the tubing;

Figure 11 is a view, partly in elevation and partly in section of a slightly modified form of the plug shown in Figure 5;

Figures 12 and 13 are similar views of still other modified forms of the plug.

In the drawings, the plug 10 includes an elongate rod shaped main mandrel 11 having an expander head 12 threaded on its lower end. The expander head is adapted to enter into a cup-shaped packer or sealing means 13 which is carried by a sealing mandrel 14 threaded into the lower end of a lock or expander mandrel 15, both of which mandrels are slidably mounted on the main mandrel 11 above the expander head. The upper portion of the cup packer 13 is turned inwardly and is held firmly between an outwardly extending annular flange 16 on the sealing mandrel and the lower annular undercut end 17 of the locking mandrel.

The main mandrel is enlarged above the locking mandrel to provide a downwardly facing annular stop shoulder 18 which limits upward movement of the locking mandrel and the sealing mandrel on the main mandrel. Downward movement of the locking mandrel on the main mandrel is limited by the engagement of the lower end 19 of the sealing mandrel with the upper surface of the expander head, as is shown in Figure 2.

An O-ring 20 is disposed on the main mandrel between the main mandrel and the locking mandrel to prevent upward flow of well fluids through the bore of the locking mandrel.

A dog carrier 21 is slidably mounted on the main mandrel above the locking mandrel and has at its upper end an internal annular flange 22, spaced below which is an internal annular hanger flange 24. Below the hanger flange is a dependent annular skirt 23 which is spaced laterally from the main mandrel.

A plurality of locking dogs 25 are suspended from the hanger flange by means of hooks 26 provided on their upper ends. The dogs are also provided at their lower ends with outwardly extending bosses 27, said bosses having upwardly facing stop shoulders 28 at their upper ends and downwardly and inwardly extending beveled surfaces or shoulders 29 at their lower ends.

The dogs also have on their lower inner edges downwardly and outwardly extending camming shoulders 30 which engage the frusto-conical upper camming or expander surface 31 of the locking mandrel when the dogs are in the retracted positions shown in Figure 1. The lock mandrel has a more acute frusto-conical lock surface 32 disposed below the upper camming surface, and immediately below the lock surface is an annular stop shoulder 33 which engages the camming shoulders 30 of the dogs to limit downward movement of the dogs and the dog carrier relative to the locking mandrel, or upward movement of said locking mandrel relative to the dogs.

The dog carrier and the dogs are biased downwardly toward the locking mandrel by a spring 34 surrounding the main mandrel and having its lower end bearing against the internal flange 22 at the upper end of the dog

carrier and its upper end engaging the under side of a retaining ring 35 rigidly secured to the main mandrel 11 by a lock pin 36.

The plug 10 may be used to close the lower end of the bore of a string of well tubing 37, which is formed of sections 38 joined by collars or couplings 39 in the usual manner. The adjacent upper and lower ends 40 and 41 of adjacent sections 38 of the tubing string are spaced apart so that annular internal coupling recesses 42 are formed at each collar of the string of tubing. The plug may be lowered into the tubing by a running tool 43 having a threaded upper end 44 by means of which the running tool may be secured to a suitable flexible line running and pulling mechanism (not shown). The lower end of the running tool is provided with an axial bore 45 for slidably receiving the upper end of the main mandrel 11, whereby the running tool may be detachably connected to the main mandrel by a shear pin 47 extending transversely therethrough.

As the plug is lowered through the well tubing, the dogs 25 are in the retracted positions shown in Figure 1 with the bosses 27 thereof bearing against and sliding along the inner wall of the tubing. The dogs are biased downwardly by the spring 34 which exerts a downward force on the dog carrier and the dogs. The camming action between the camming shoulders 30 of the dogs and the frusto-conical expander surface 31 of the locking mandrel moves the dogs outwardly toward expanded positions when the dogs are moved downwardly on the locking mandrel.

When the bosses 27 of the dogs enter a coupling recess, the dogs are free to move downwardly on the locking mandrel, and their lower ends move outwardly so that the bosses 27 of the dogs enter into the recess. As the downward movement of the plug continues however, the beveled shoulders 29 on the lower ends of the dogs engage the upper end 41 of the lower tubing section and the camming action therebetween causes the dogs to move inwardly and upwardly with respect to the locking mandrel and the main mandrel, against the yielding resistance of the spring 34, to return the dogs to the retracted position shown in Figure 1. The bosses of the dogs thus bear against the walls of the tubing and will enter into and be moved out of the successive coupling recesses of the tubing string as the plug is lowered to the desired position in said well tubing.

The plug is particularly designed to be used to close the lower open end of a string of tubing in place in a well to seal off the bore of the string so that fluid pressure present in the well will be prevented from acting upon other well tools being manipulated in or other operations being carried out in the bore of the well tubing above said plug.

When the plug arrives at the desired location at the lower end of the tubing string, the plug is raised by pulling on the flexible line running and pulling mechanism until the bosses 27 of the dogs enter into the nearest coupling recess. The stop shoulders 28 at the upper ends of the bosses then engage the lower end 40 of the upper tubing section to prevent further upward movement of the dogs. A further upward pull on the flexible line will now move the main mandrel upwardly relative to the dogs causing the lock surface 32 of the locking mandrel to move between the dogs to lock them in the expanded positions. Upward movement of the locking mandrel relative to the dogs is limited, of course, by the engagement of the shoulders 30 of the dogs with the annular stop shoulder 33 of the locking mandrel.

When the main mandrel was moved upwardly, the expander head 12 on its lower end entered into the cup packer or seal 13 and expanded it into positive sealing engagement with the well tubing.

Further upward pulls or jars then imparted to the flexible line running and pulling mechanism will cause the pin 47 to shear, thus releasing the running tool from

the plug. The running tool is then removed from the tubing string, leaving the plug in place. Upward pressures exerted on the plug by well fluids will not dislodge the plug since the dogs are in expanded positions with their stop shoulders 28 abutting against the lower end 40 of a tubing section. The cup packer or seal 13 will prevent flow of fluid upwardly in the tubing past the plug. The plug is left in place as long as it is needed.

When it is desired to unplug the tubing, the plug may be pushed downwardly out of the open lower end of the tubing by any suitable well tool which first engages the upper end of the main mandrel to move it downwardly with respect to the dogs and the locking mandrel. During such movement of the main mandrel, the expander head 12 is moved out of engagement with the cup seal 13 and the annular stop shoulder 18 of the main mandrel then engages the upper end of the locking mandrel to move the locking surface 32 below the dogs, thus freeing the dogs for movement toward the retracted positions of Figure 1. Further downward force imparted to the upper end of the main mandrel will now cause the plug to move downwardly in the well tubing until it falls out of the open lower end of the tubing. Also, fluid pressure applied from above as by pumping liquid into the tubing at the well head may be used to move the main mandrel downwardly to free the plug and permit the fluid to flow the plug out of the open lower end of the tubing.

In some cases, the plug may be retrieved for further use if the well tubing is kept plugged until its removal from the well.

It will now be seen that a new and improved plug has been provided which is of simple, economical construction, so that it may be abandoned in the well without undue cost. Moreover, it will be seen that the plug may be lowered and locked in place in a well tubing by means of a flexible line to plug the well tubing against upward flow of fluids therein. Furthermore, it will be apparent that the plug may be unlocked and moved out of the tubing by a downward force applied thereto by any suitable well tool, or by fluid pressure applied from above.

In Figures 3 and 4 is shown a modified form of the plug having a tubular central mandrel 48 with a longitudinal bore 49 therethrough. The lower end portion of the central mandrel is enlarged to provide an expander head 50 having an upper frusto-conical camming or expander surface 51, below which is a more acute frusto-conical lock surface 52 having at its lower end an annular flange 53 which provides an annular upwardly facing stop shoulder 54.

A dog carrier 55 is slidably mounted on the central mandrel above the expander head and has an internal annular flange 56 at its upper end, spaced below which is an internal annular hanger flange 58. Below the hanger flange is a dependent annular skirt 57 which is spaced laterally from the main mandrel.

A plurality of locking dogs 59 are suspended from the hanger flange by means of hooks 60 provided on their upper ends. The dogs are also provided at their lower ends with outwardly extending bosses 61 having upwardly facing stop shoulders 62 at their upper ends and downwardly and inwardly inclined beveled surfaces 63 at their lower ends.

The dog carrier and the locking dogs are biased downwardly toward the position shown in Figure 3, in which further downward movement is limited by the engagement of the lower ends of the dogs with the stop shoulder 54, by a spring 64 which surrounds the central mandrel 48 and is confined between and bears at its lower end against the upper end of the dog carrier 55 while its upper end bears against a retaining ring 65 threaded on the upper end of the central mandrel.

A tubular packing sleeve 66 is also threaded on the upper end of the central mandrel and extends above it.

The sleeve is provided with an external annular flange 67 at its upper end having an annular downwardly facing shoulder 68, and a packing assembly 69 is disposed on the sleeve between the shoulder 68 and the retaining ring 65. The packing assembly is of slightly smaller diameter than the internal diameter of the well tubing into which the tool is lowered.

The tubular packing sleeve is also provided at its upper end with an internal annular flange 71 which provides an inwardly and upwardly inclined annular valve seat 72, which is engaged by the downwardly and outwardly inclined seat surface 73 of a valve 74. The valve is biased upwardly to closed position by a spring 75 whose upper end bears against the valve and whose lower end bears against an annular shoulder 76 provided in the bore of the central mandrel by the enlargement of the upper portion of said bore.

The valve 74 is provided with a transverse hole 77 so that it may be detachably connected by a shear pin to a running tool such as the running tool 43 shown in Figures 1 and 2, whereby the tool may be lowered into the tubing string.

In use, the plug is connected to a running tool on a flexible line by a shear pin which extends through the transverse hole 77 in the valve. As the plug is lowered through the well tubing, the dogs 59 are in the retracted position shown in Figure 4, with the bosses 61 bearing against the inner wall of the tubing. The dogs are biased downwardly by the spring 64, which exerts a downward force on the dog carrier and dogs. The camming action between the expander surface 51 of the expander head and the lower ends of the dogs moves the dogs outwardly toward the expanded position shown in Figure 3 when the dogs are moved downwardly on the central mandrel.

When the beveled surfaces 63 at the lower ends of the bosses of the dogs encounter an upwardly facing obstruction during downward movement of the plug through well tubing, the dogs are cammed inwardly and upwardly on the central mandrel. Also, the valve 74 may open against the force of the spring 75 to permit fluids to pass through the bore of the plug at any time the packing assembly 69 seals against the internal wall of any restricted bore in the tubing string as the plug is lowered.

When the plug passes through the open lower end of the shoe or nipple 78 on the lower end of the tubing, the dogs are free of restraint by the walls of the tubing and the spring 64 moves the dogs downwardly on the central mandrel, the engagement of the dogs with expander surface 51 of the expander head 50 causing the dogs to move outwardly and downwardly until they rest on the shoulder 54, so that when an upward pull is now imparted to the tool, the stop shoulders 62 of the dogs engage the shoulder 79 at the lower end of the shoe or nipple 78 and prevent further upward movement of the plug.

The packing assembly 69 now seals between the plug and the shoe or nipple 78 so that the well pressure acting on the plug maintains the plug in position in said shoe, the valve 74 being closed so that well fluids cannot flow upwardly through the bore 49 of the central mandrel.

Upward jars imparted to the running tool will shear the pin which secures the valve 74 to the running tool, and leave the plug in place in the shoe. The plug now closes or plugs the lower end of the tubing and is left in place as long as it is needed.

When it is desired to unplug the tubing, any suitable well tool is lowered into the well tubing to contact the valve 74 and move it downwardly in the sleeve 66 against the resistance of the spring 75 and against the pressure of the well fluids. This downward movement of the valve allows well fluids to flow upwardly through the central mandrel, relieving upward pressure on the plug and permitting it to be moved downwardly by downward blows or force applied to the valve 74 and the packing sleeve 66 until the plug falls out of the open lower end of the shoe or nipple. Or, fluid pressure may be ap-

plied from above to force the plug downwardly out of the shoe.

It will now be seen that the plug shown in Figures 3 and 4 may be used with a shoe or nipple 78 to plug the lower open end of the well tubing and it is held in plugging position by well fluid pressure. It will also be seen that the plug is provided with a valve 74 which may be opened to permit fluids to by-pass the packing assembly 69 as the plug is installed, and to equalize pressures above and below the plug when installed to permit easy removal of the plug by a downward force applied thereto by any suitable well tool.

A further modified form of the plug is illustrated in Figures 5 to 10, wherein the plug includes a central rod shaped mandrel 80 on whose lower end is threaded a dog retainer ring 81 having an upwardly extending annular flange 82 spaced laterally from the central mandrel.

A pair of dogs 83 are disposed on opposite sides of the central mandrel intermediate the ends of the central mandrel. The dogs are provided with arcuate inner surfaces 84 which are adapted to extend about the round sides of the central mandrel, to permit the dogs to fully retract and to provide a large area of locking interference. A pair of springs 85 interposed between the dogs and the mandrel bias the dogs outwardly toward expanded positions. The outward movement of the lower ends 86 of the dogs is limited by the annular flange 82 of the retainer ring since those lower ends are disposed in the annular space between the central mandrel and the annular flange.

The upper end of each of the dogs is provided with a pair of laterally spaced upwardly projecting ears 87 which are disposed on opposite sides of the central mandrel and are slidable in opposed recesses 88 in an external annular flange 89 of the central mandrel. The recesses 88 provide stop shoulders 90, and the ears 87 engage the stop shoulders, when the dogs are moved outwardly of the central mandrel, whereby outward movement of the upper ends of the dogs is limited by such stop shoulders.

The central mandrel is also provided with laterally extending lock bosses 91 disposed between the flange 89 and the dog retainer ring 81 and projecting outwardly between the dogs. Opposite sides of each dog 83 are provided with recesses 92 into which the lock bosses 91 are free to enter when the dogs 83 are in the upper retractable positions on the central mandrel, illustrated in Figure 5, so that the dogs are free to move inwardly toward the central mandrel. The upper portions of the dog recesses are reduced to provide lock shoulders 93 which engage the sides of the lock bosses 91 to prevent inward movement of the dogs toward retracted position when the dogs are in their lower expanded positions shown in Figure 10.

Downward movement of the dogs on the central mandrel is limited by the engagement of the lower ends of the dogs with the retainer ring 81 while upward movement of the dogs on the central mandrel is limited by the engagement of the upper ends 94 of the dogs with the lower surface 95 of the mandrel flange 89.

It will be seen that when the dogs are in their upper positions on the central mandrel they are free to move inwardly to retracted positions, and that when the dogs are in their lower expanded positions on the central mandrel they are locked by the bosses 91 in the expanded positions against inward movement toward the central mandrel.

A tubular packing sleeve 96 is threaded on the enlarged upper end 97 of the central mandrel, and is provided with an external annular flange 98 at its upper end having an annular downwardly facing shoulder 99. A packing assembly 100 is disposed on the sleeve between the annular shoulder 99 and the mandrel flange 89, being confined therebetween.

The tubular packing sleeve is also provided with an internal annular flange which provides an inwardly and upwardly inclined valve seat 102 at the upper end of the

sleeve, and the downwardly and outwardly inclined seat surface 103 of a valve 104 is adapted to seat thereupon. The valve 104 is biased upwardly toward closed position by a spring 105 whose upper end bears against the valve and whose lower end bears against an annular internal shoulder 106 provided in the bore 107 in the upper end of the central mandrel. A plurality of transverse ports 108 located in the central mandrel below the packing assembly communicate with the bore 107 to provide a flow passage for well fluids past the packing assembly when the valve is moved downwardly to open position.

The valve 104 is provided with a transverse hole 109 so that it may be detachably connected by a shear pin to a running tool similar to the running tool 43 shown in Figures 1 and 2.

In use, the plug is connected to the running tool by a shear pin which extends through the transverse hole in the valve. As the plug is lowered through the well tubing, the dogs 83 are in the retracted positions shown in Figure 5, with their bosses 110 bearing against the inner walls of the well tubing since they are biased outwardly by the dog springs 85. The frictional engagement of the dogs with the well tubing causes the dogs to move to and remain in the upper retractable positions on the central mandrel wherein the dog recesses 92 are aligned with the lock bosses 91, so that the dogs are free to move inwardly toward retracted positions. The downwardly and inwardly inclined beveled shoulders 111 at the lower ends of the bosses of the dogs engage any internal obstructions in the well tubing encountered during lowering of the plug and cam the dogs inwardly to permit downward movement of the plug past such obstructions.

When the plug passes downwardly through the lower open end of the shoe or landing nipple 112 on the lower end of the tubing, the bosses 110 of the dogs move out of frictional engagement with the well tubing and are consequently free to move downwardly on the central mandrel to the positions shown in Figure 10, wherein the stop shoulders 93 of the dogs are aligned with the upper portions of the lock bosses. An upward pull is then exerted on the running tool to move the plug upwardly until the upwardly facing stop shoulders 113 at the upper ends of the bosses on the dogs engage the annular shoulder 114 at the lower end of the landing nipple. The dogs now prevent further upward movement of the plug since they cannot move inwardly to retracted positions. A further upward pull imparted to the running tool now shears the pin securing the valve 104 to the running tool and frees the running tool for removal from the well.

The packing assembly 109 now seals between the central mandrel and landing nipple, and since the valve 104 is in its upper closed position, the pressure exerted by the well fluids tends to hold the plug in place.

When it is desired to unplug the well tubing, a suitable well tool is lowered into the well to contact the upper end of the valve 104 and move it downwardly. This opens the valve 104 and permits movement of well fluids from below the packing assembly through the lateral ports 108 into the central bore 107 and thence upwardly past the valve and the packing assembly to equalize the pressure acting on the plug. This equalization of pressure makes it easy to move the plug downwardly out of the landing nipple by further downward jars or blows imparted to the plug by the well tool or by fluid pressure applied from above.

In Figure 11 is illustrated a modified form of the plug which differs from the plug shown in Figures 5 to 10 chiefly in that it is not provided with a valve for equalizing the well fluid pressures exerted on the plug. The plug includes a central mandrel 115 having a dog retainer ring 116 secured to its lower end by a nut 117. The retainer ring is provided with a pair of arcuate upwardly extending flanges 118 which engage projecting ears 119b on the lower ends of the dogs 119 which are identical to the ears 119 at the upper ends of said dogs and which

together serve to limit the outward movement of the dogs 119 which are otherwise identical to the dogs 83 of Figures 5 and 10. The dogs are biased outwardly by springs 120 and are provided with recesses 121 which receive the lock bosses 122 of the central mandrel, when the dogs are in upper retractable positions on the central mandrel. The recesses are reduced to provide stop shoulders 123 which engage the lock bosses to lock the dogs in expanded positions when the dogs are in the lower expanded positions shown in Figure 11.

The pairs of spaced ears 119a at the upper ends of the dogs 119 extend upwardly into opposed recesses 125 of an upper dog retainer ring 126. The upper retainer ring 126 has an internal flange 127 which rests on an annular abutment 128 of the central mandrel, and the recesses 125 provide stop shoulders 129 which engage the ears 119a of the dogs to limit outward movement of the upper ends of the dogs.

A sub 130 is threaded on the upper reduced end 131 of the central mandrel, and the sub is provided at its upper end with an external annular flange 132 having a downwardly facing annular shoulder 133. A packing assembly 134 is disposed on the sub between the annular shoulder 133 and the upper end of the upper dog retainer ring 126. The sub has a reduced upper end 135 provided with a transverse hole 136 adapted to receive a shear pin whereby a running tool may be detachably secured to the sub and thus support the plug.

The plug illustrated in Figure 11 is lowered into the well tubing by a running tool, on a flexible line, which is secured to the sub by a shear pin. The dogs 119, like the dogs 83 of Figures 5 to 10, are held in their upper positions on the central mandrel during downward movement of the plug in well tubing by the frictional engagement of their bosses with the well tubing, and consequently are free to move inwardly upon meeting obstructions of the tubing during downward movement. When the plug moves out of the lower end of shoe or landing nipple, such as the nipple 112 of Figures 5 and 10, the dogs 119 move outwardly to expanded positions and, when the plug is lifted, the dogs engage the lower end of the shoe and are moved downwardly on the central mandrel to the lower positions shown in Figure 11. The stop shoulders 123 of the dogs now prevent inward movement of the dogs so that, when an upward force is applied to the running tool, upward movement of the plug is prevented by the engagement of the stop shoulders 137 of the dogs with the lower end of the landing nipple. A further upward force now exerted on the running tool will cause the shear pin connecting the sub to the running tool to shear and free the tool from the plug.

If desired, the bosses 119c on the dogs 119 may be of such vertical length that they will not engage in the recesses between adjacent joints of tubing at couplings and hence may be moved upwardly in the tubing. Also, this boss length may be suitably chosen to provide for locating the plug in a landing nipple having an internal annular recess of corresponding dimensions whereby the plug may be accurately positioned in the lower end of the tubing adjacent the open end.

When it is desired to remove the plug, downward jars or blows are imparted to the sub by means of any suitable well tool to drive the plug downwardly out of the lower end of the well tubing, or it may be flowed out by fluid pressure from above.

It will be noted that the sub and packer assembly connected to the central mandrel 115 does not have any means to equalize the well fluid pressures acting on the plug when it is desired to remove the plug. If desired, the central mandrel may be provided, in the manner shown in Figure 12, with a seal assembly 138 which includes an adapter sleeve 139 threaded on the reduced upper end 131 of the central mandrel, and a seal mandrel 140 in turn threaded on the adapter sleeve. A lower

cup-shaped seal 141 is secured on the upper portion of the seal mandrel by a seal retainer fitting 142 which is threaded on the upper end of the seal mandrel, the inner flange of the seal 141 being held between the lower end of the seal retainer fitting and an annular external shoulder 143 of the seal mandrel. A second upper cup-shaped seal 144 may in turn be secured on the seal retainer fitting 142 by a retainer ring 145 threaded on the upper end of the seal retainer fitting, the inner flange of the seal 144 being held between the lower end of the retainer ring 145 and an annular external shoulder 146 of the seal retainer fitting 142.

An expander sleeve 147 is slidably mounted on the seal mandrel and has a beveled upper portion 148 which is adapted to move upward between the lower cup seal 141 and the seal mandrel to expand said lower cup seal. A central plunger 149 is slidably disposed within the seal mandrel and has an enlarged lower end provided with a transverse bore 150 aligned with opposed vertically elongate slots 151 of the seal mandrel and opposed lateral apertures 152 of the expander sleeve. A connector pin 153 extends through the transverse bore 150, the elongate slots 151 and the apertures 152 to connect the expander sleeve to the plunger 149. A set screw 154 may be provided to prevent displacement of the pin. It will now be apparent that when the plunger is pulled up in the seal mandrel, the expander sleeve will be moved upwardly on the seal mandrel and will expand the lower end of the lower cup seal 141 radially outwardly.

An O-ring or seal 155 is disposed in an external annular groove spaced slightly above the lower enlarged portion of the plunger to seal between the plunger and the seal mandrel when the plunger is moved upwardly in the seal mandrel, the seal 155 engaging the wall of the reduced upper portion 156 of the central bore of the seal mandrel.

A shear pin 160 is disposed in a transverse hole extending through the expander sleeve 147, the seal mandrel 140, the central plunger 149 and the connector pin 153 to releasably hold the central plunger in its lowermost position and the expander sleeve out of engagement with the cup seal 141 while the plug is being lowered into the well. The shear pin may be selected of such length as to require it to be sheared in one, two, three or four planes between the central plunger, the seal mandrel and the expander sleeve, at the discretion of the operator, whereby a desired upward force must be applied to shear the pin 160 and move the central plunger and expander sleeve upwardly. The set screw 154 will hold a shear pin of any desired length in proper position.

In use, the plug is lowered by means of a running tool which is secured to the upper end of the plunger by a shear pin which extends through the transverse hole 157 in the plunger. The dogs 119 function in the manner already described above to allow the plug to descend through the well tubing. When the dogs move below the lower end of the well tubing, they expand outwardly and are then moved downwardly on the central mandrel 115 to the position shown in Figure 12 when an upward pull is imparted to the plunger by the running tool. With the dogs engaging the lower end of the tubing, a further upward pull on the running tool causes upward movement of the plunger 149 and the expander sleeve 147 slides between the seal mandrel and the lower cup seal 141 expanding the cup seal into sealing contact with the interior wall of the tubing, causing the cup to seal between the sealing mandrel and the tubing. Simultaneously, the O-ring 155 is moved into the reduced portion 156 of the bore of the sealing mandrel and seals between the plunger and the sealing mandrel. The plug now closes the lower end of the well tubing. A further upward jar or pull exerted on the running tool will now shear the pin securing the running tool to the plunger 149, freeing the running tool for removal from the wall.

The plug is then held in position by the well fluid pressures.

When it is desired to unplug the well tubing, a suitable well tool is lowered into the tubing to strike the upper end of the plunger. This causes the plunger to move downwardly in the sealing mandrel and the expander sleeve and the O-ring are moved back to the positions shown in Figure 12. As a result, well fluids may flow upwardly between the plunger and the seal mandrel to equalize the pressures acting on the plug, making it easy for further downward blows or for fluid pressure applied from above to move the plug downwardly out of the well tubing. The O-ring and plunger thus act as a valve for relieving pressures or pressure differentials across the plug.

In Figure 13 is shown a modified form of the plug which differs from the plug shown in Figure 11 only in that no adapter sleeve, such as the adapter sleeve 139 of Figure 12, is used, the sealing mandrel being directly threaded to the threaded upper end 131 of the central mandrel. Since this modified form of plug functions in exactly the same manner as the plug shown in Figure 12, further explanation or description is not deemed necessary.

It will be seen that several different forms of a well tubing plug have been illustrated and described, and that in each form the plug includes a central mandrel, a plurality of dogs slidably mounted on the central mandrel for movement between retracted and expanded positions, a spring means biasing the dogs toward expanded positions, and a sealing means mounted on the central mandrel in various different ways to seal between the plug and the well tubing. It will also be apparent that a locking means is provided in each of the plugs to lock the dogs against undesired movement from expanded toward retracted position by fluid pressures from below acting on the plugs.

It will also be seen that in the forms of the plug shown in Figures 1, 2, 12 and 13 a positive means is provided for expanding at least a portion of the sealing means into engagement with the interior wall of the well tubing. It will also be seen that in the forms of the plug shown in Figures 3, 4, 5, 12 and 13 a valve means is provided for relieving the pressure differentials across the plugs prior to their removal from the well tubing, which facilitates such removal, and which also provides for by-passing fluids past the sealing assemblies when necessary or desired.

The foregoing description of the invention is explanatory only, and changes in the details of the constructions illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

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

1. A well tool including: a central elongate mandrel; an expander head on the lower end of the central mandrel; a locking mandrel slidably mounted on the central mandrel above the expander head for limited longitudinal movement on the central mandrel; a sealing means secured to the locking mandrel, said expander head being adapted to enter into said sealing means to expand it into sealing position upon upward movement of the central mandrel relative to the locking mandrel; a dog carrier slidably mounted on said central mandrel above said locking mandrel; a plurality of dogs suspended from said carrier, said dogs and said locking mandrel having cooperating locking surfaces for moving said dogs into expanded positions upon downward movement of said dogs relative to said locking mandrel; and resilient means on said central mandrel biasing said dog carrier and dogs downwardly on said central mandrel relative to said locking mandrel.
2. A well tool including: a central elongate mandrel; an expander head on the lower end of the central mandrel; a locking mandrel slidably mounted on the central mandrel above the expander head for limited longitudinal movement on the central mandrel; a sealing means secured

to the locking mandrel, said expander head being adapted to enter into said sealing means to expand it into sealing position upon upward movement of the central mandrel relative to the locking mandrel; a dog carrier slidably mounted on said central mandrel above said locking mandrel; a plurality of dogs suspended from said carrier, said dogs and said locking mandrel having cooperating locking surfaces for moving said dogs into expanded position upon downward movement of said dogs relative to said locking mandrel; and resilient means on said central mandrel biasing said dog carrier and dogs downwardly on said central mandrel relative to said locking mandrel, said locking mandrel having a locking surface engageable with said dogs for preventing movement of said dogs from expanded position to retracted position, said locking surface engaging said dogs when said main mandrel is moved upwardly relative to said dogs after said dogs have moved to expanded position.

3. A well tool including: a central elongate mandrel; an expander head on the lower end of the central mandrel; a locking mandrel slidably mounted on the central mandrel above the expander head for limited longitudinal movement on the central mandrel; a sealing means secured to the locking mandrel, said expander head being adapted to enter into said sealing means to expand it into sealing position upon upward movement of the central mandrel relative to the locking mandrel; a plurality of locking dogs disposed above said locking mandrel; means supporting said locking dogs for longitudinal movement on said central mandrel, said locking dogs having downwardly and outwardly extending camming surfaces, said locking mandrel having an upper downwardly and outwardly extending annular expander surface engageable with said camming surfaces of said dogs to move said dogs outwardly to expanded position upon downward movement of said dogs relative to said mandrel, said mandrel having an annular locking surface below said expander surface engageable with dogs to lock said dogs in expanded position upon upward movement of said central mandrel after said dogs have been moved to expanded position, and resilient means disposed on said central mandrel for biasing said locking dogs downwardly relative to said locking mandrel.

4. A well tool including: a central elongated mandrel; an expander head on the lower end of the central mandrel; a locking mandrel slidably mounted on the central mandrel above the expander head for limited longitudinal movement on the central mandrel; a sealing means secured to the locking mandrel, said expander head being adapted to enter into said sealing means to expand it into sealing position upon upward movement of the central mandrel relative to the locking mandrel; a plurality of locking dogs disposed above said locking mandrel, means supporting said locking dogs for longitudinal movement on said central mandrel; said locking dogs having downwardly and outwardly extending camming surfaces, said locking mandrel having an upper downwardly and outwardly extending annular expander surface engageable with said camming surfaces of said dogs to move said dogs outwardly to expanded position upon downward movement of said dogs relative to said mandrel, said mandrel having an annular locking surface below said expander surface engageable with dogs to lock said dogs in expanded positions upon upward movement of said central mandrel after said dogs have been moved to expanded position, and resilient means disposed on said central mandrel for biasing said locking dogs downwardly relative to said locking mandrel, said dogs having upwardly facing shoulders engageable with downwardly facing shoulders of a well tubing to prevent upward movement of the plug in the well tubing and having downwardly and inwardly inclined shoulders for camming said dogs toward retracted positions upon meeting upwardly facing obstructions of the well tubing during downward movement of the plug through the well tubing.

5. A well tool including: a central elongate mandrel; an expander head on the lower end of the central mandrel; a locking mandrel slidably mounted on the central mandrel above the expander head for limited longitudinal movement on the central mandrel; a sealing means secured to the locking mandrel, said expander head being adapted to enter into said sealing means to expand it into sealing position upon upward movement of the central mandrel relative to the locking mandrel; a dog carrier slidably mounted on said central mandrel above said locking mandrel; a plurality of dogs suspended from said carrier, said dogs and said locking mandrel having cooperating locking surfaces for moving said dogs into expanded position upon downward movement of said dogs relative to said locking mandrel; and resilient means on said central mandrel biasing said dog carrier and dogs downwardly on said central mandrel relative to said locking mandrel, said dogs having upwardly facing shoulders engageable with downwardly facing shoulders of a well tubing to prevent upward movement of the plug in the well tubing and having downwardly and inwardly inclined shoulders for camming said dogs toward retracted positions upon meeting upwardly facing obstructions of the well tubing during downward movement of the plug through the well tubing.

6. A well tool including: a central mandrel; a plurality of dogs mounted on the central mandrel; means on said central mandrel for supporting such dogs for lateral and longitudinal movement between upper and lower positions on said central mandrel, said dogs being retractable when in said upper position on said mandrel; resilient means on said central mandrel biasing said dogs toward expanded positions; sealing means on said tool for sealing between said tool and well tubing when said tool is disposed in well tubing; and connecting means connected to said central mandrel for detachably connecting said tool to a running tool for lowering said tool into well tubing, said dogs having beveled camming shoulders for moving said dogs inwardly upon encountering obstructions during downward movement of the tool through well tubing and having stop shoulders engageable with downwardly facing shoulders of the well tubing for preventing upward movement of the well tool in the well tubing, said central mandrel having means thereon providing an expander surface engageable with said dogs to move said dogs to expanded position and a locking surface below said expander surface disposed to be positioned between said dogs to hold said dogs in expanded position wherein said stop shoulders on said dogs are disposed to engage said tubing string shoulders to prevent upward movement of said well tool in said well tubing; said well tool being movable downwardly from locking position.

7. The well tool of claim 6 wherein: said central mandrel is provided with a passage permitting longitudinal flow of well fluids within said tool past said sealing means, and wherein said connecting means is provided with longitudinally movable valve means for closing said passage, said valve means closing said passage when in an upper position, and means biasing said valve means toward said upper position, said valve means being movable downwardly to open position by a downward force being applied to said connecting means.

8. The device of claim 6 wherein: said sealing means is expansible; and expanding means provided on said central mandrel and movable with said connecting means for expanding said sealing means upon upward movement of said connecting means relative to said dogs.

9. The well tool of claim 6 wherein the means on the central mandrel providing the expander surface and the locking surface comprises a tubular mandrel slidable on said central mandrel.

10. The well tool of claim 6 wherein the sealing means for sealing between said well tool and the well tubing is mounted on the central mandrel above the dogs.

11. A well tool including: a central mandrel having a

central longitudinal bore; a plurality of dogs slidably mounted on said central mandrel; means on said mandrel for supporting said dogs for movement between upper laterally retracted positions and lower expanded positions, expanding means on the lower end of said central mandrel for moving said dogs to expanded positions upon downward movement of said dogs on said mandrel; means biasing said dogs downwardly on said central mandrel; locking means on said lower end of said central mandrel preventing inward lateral movement of said dogs toward retracted position when said dogs are in the lower expanded positions; valve means slidable longitudinally in said central longitudinal bore for closing said bore when in an upper position; means biasing said valve means upwardly toward said toward said closed position, said valve means having an upper end extending upwardly out of said central longitudinal bore; and sealing means on said central mandrel above said dogs for sealing between said mandrel and a well tubing.

12. A well tool comprising: a central mandrel; a pair of dogs slidably mounted for limited longitudinal movement on said central mandrel; means supporting said dogs for limited longitudinal and lateral movement on said central mandrel between upper positions wherein said dogs are movable inwardly toward retracted positions and lower positions wherein said dogs are in expanded positions, said dog supporting means permitting limited lateral outward movement of said dogs; means biasing said dogs outwardly; lock means on said central mandrel engageable with said dogs when said dogs are in said lower expanded positions for preventing inward movement of said dogs toward retracted positions; and sealing means on said central mandrel for sealing between said central mandrel and a well tubing; said dogs having lower beveled shoulders for moving said dogs inwardly upon encountering obstructions during downward movement of the tool through well tubing and having upwardly facing stop shoulders engageable with downwardly facing shoulders of a well tubing for preventing upward movement of the well tool in the well tubing.

13. The well tool of claim 12 wherein: said central mandrel is provided with a passage for allowing flow of fluid through said central mandrel past said sealing means; and valve means in said passage closing said passage when in an upper closed position, and means biasing said valve means toward said closed position, said valve means having an upper end extending upwardly out of said passage.

14. The well tool of claim 12 wherein: said sealing

means is expansible, and expander means on said central mandrel engageable with said sealing means for expanding said sealing means to sealing position upon upward movement of said valve means in said passage, said expander means being connected to said valve means.

15. A well tool including: a locking mandrel; a pair of locking dogs carried by said locking mandrel and movable longitudinally a limited distance thereon; means on said mandrel supporting said dogs for such limited longitudinal movement and for limited lateral movement with respect to said mandrel; sealing means carried by said mandrel; resilient means on said mandrel biasing said locking dogs toward expanded position; cooperating locking surfaces on said mandrel and said dogs for locking said dogs in expanded position upon downward movement of said dogs relative to said mandrel, said dogs being retractable from expanded position upon upward movement of said dogs relative to said mandrel; said dogs having an upwardly facing outwardly projecting stop shoulder thereon and a downwardly and inwardly inclined beveled surface below said stop shoulder, said tool being movable downwardly through the tubing from locked position upon movement of the mandrel downwardly relative to the dogs.

16. A well tool including: an elongate central mandrel; sealing means secured to said central mandrel; a locking surface on said central mandrel; a plurality of locking dogs disposed on said central mandrel; means supporting said locking dogs for longitudinal and lateral movement on said central mandrel, said central mandrel locking surface being engageable with said dogs for holding said dogs in expanded positions upon downward movement of said dogs relative to said locking surface; and resilient means on said central mandrel biasing said locking dogs outwardly relative to said central mandrel; means providing a flow passage in said tool extending past the sealing means secured to said mandrel, whereby fluids may flow through said flow passage past said sealing means; and a valve member disposed in said flow passage for closing off flow through said flow passage in an upward direction and permitting a downward flow therethrough.

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