

May 21, 1963

G. M. RAULINS

3,090,438

MULTIPLE FLOW CONDUCTOR SUSPENSION APPARATUS

Filed Oct. 29, 1958

3 Sheets-Sheet 1

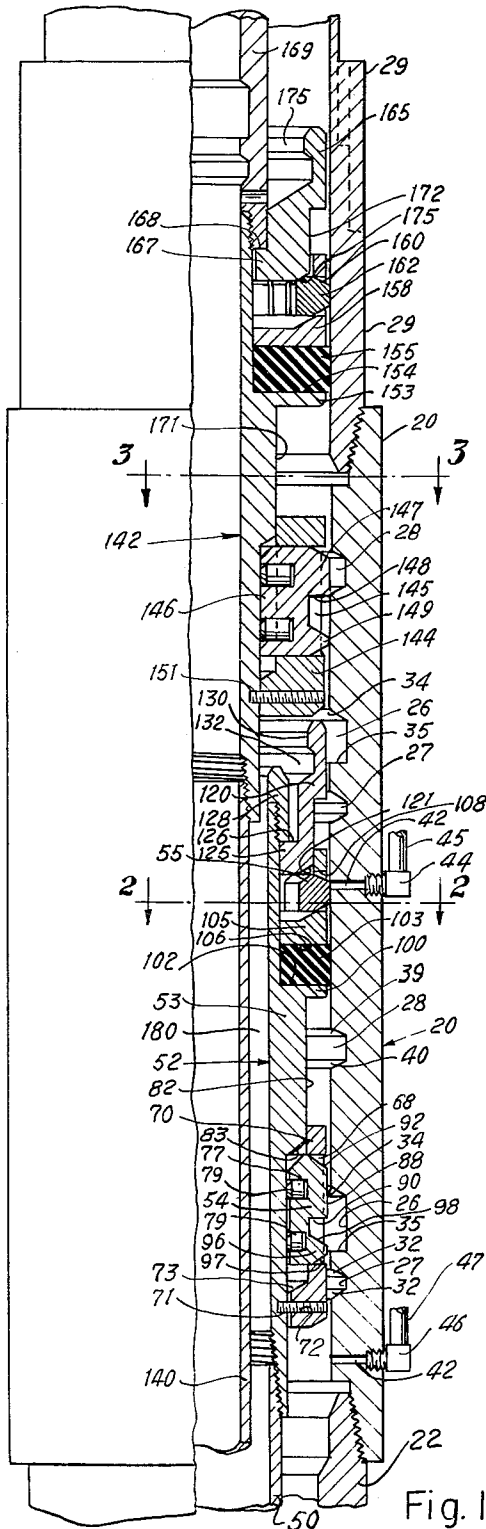


Fig. 1

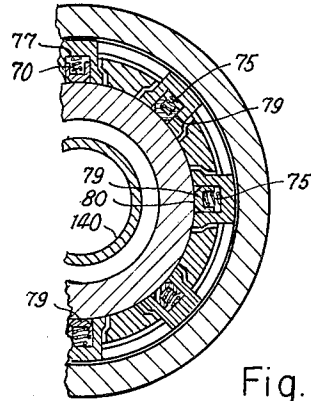


Fig. 6

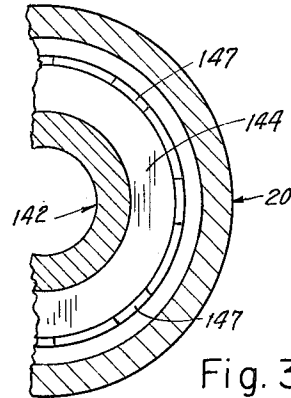


Fig. 3

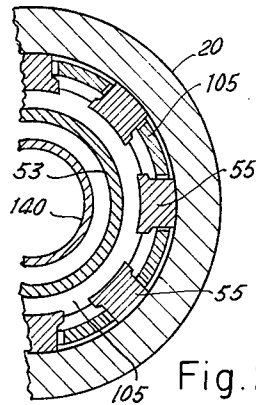


Fig. 2

INVENTOR
George Max Raulins

BY

Testastings Cullery

ATTORNEY

May 21, 1963

G. M. RAULINS

3,090,438

MULTIPLE FLOW CONDUCTOR SUSPENSION APPARATUS

Filed Oct. 29, 1958

3 Sheets-Sheet 2

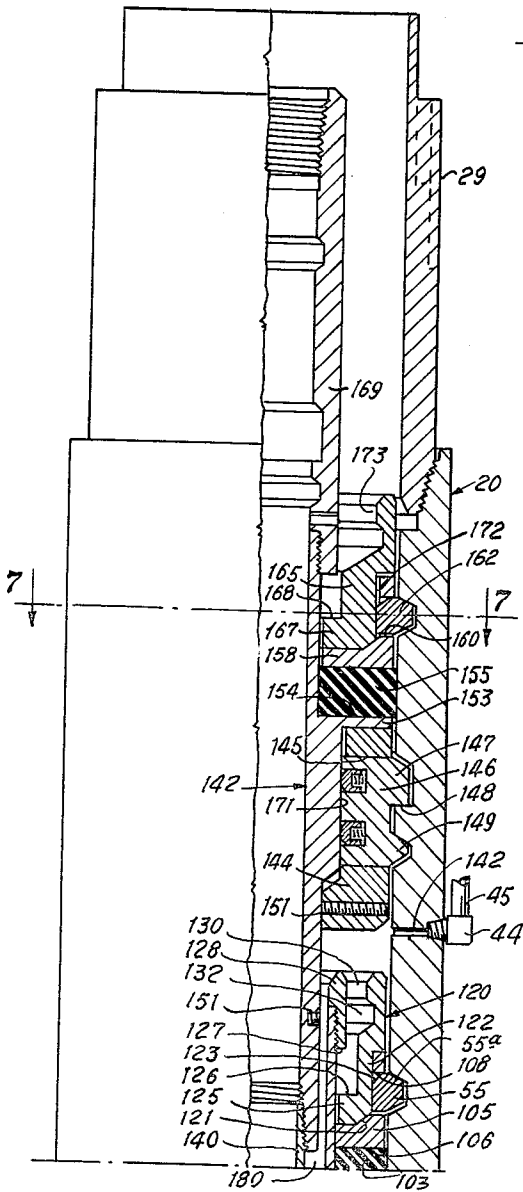


Fig. 4

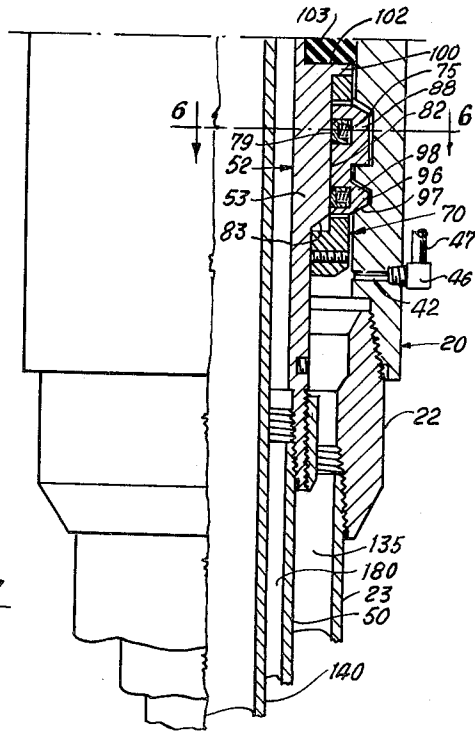


Fig. 5

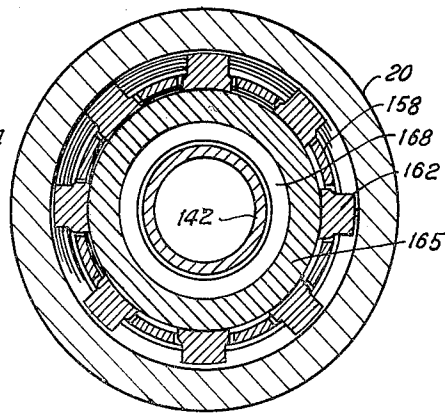


Fig. 7

INVENTOR

George Max Raulins

BY *Restarungs Kelley*

ATTORNEY

May 21, 1963

G. M. RAULINS

3,090,438

MULTIPLE FLOW CONDUCTOR SUSPENSION APPARATUS

Filed Oct. 29, 1958

3 Sheets-Sheet 3

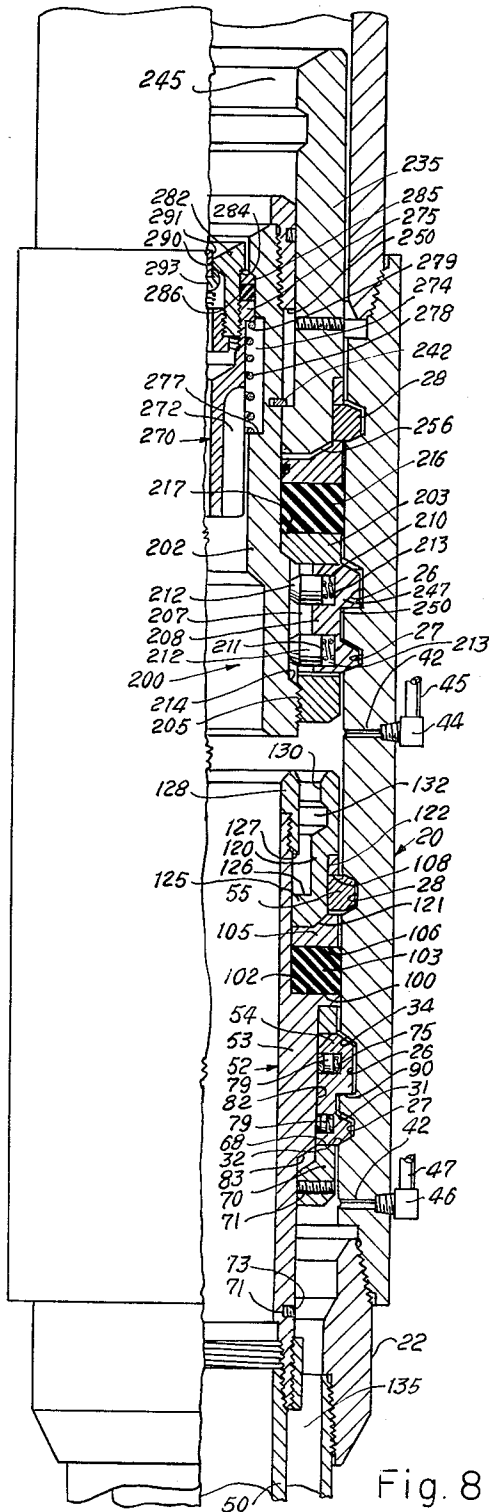


Fig. 8

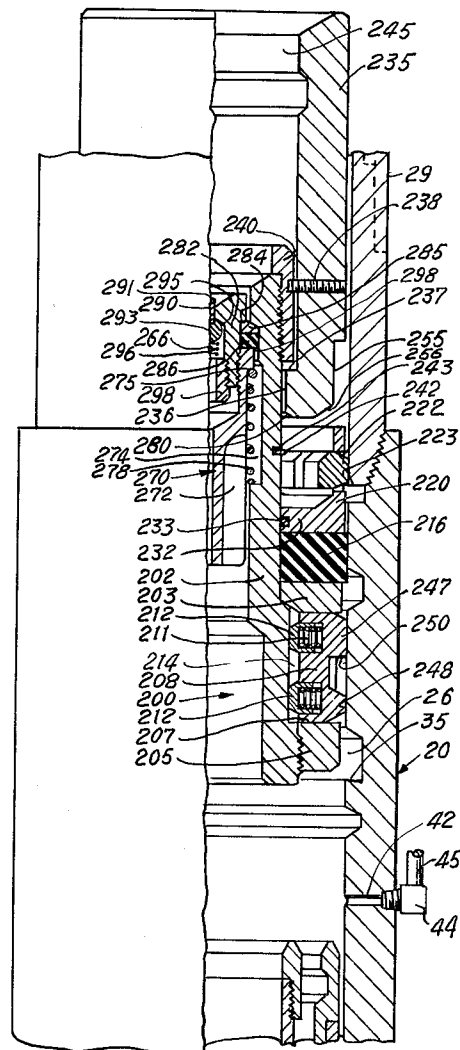


Fig. 9

INVENTOR
George Max Raulins

BY *Robert H. Kelley*
ATTORNEY

1

2

3,090,438

MULTIPLE FLOW CONDUCTOR SUSPENSION APPARATUS

George Max Raulins, Dallas, Tex., assignor, by mesne assignments, to Otis Engineering Corporation, Dallas, Tex., a corporation of Delaware

Filed Oct. 29, 1958, Ser. No. 770,385

16 Claims. (Cl. 166-75)

This invention relates to well tools and more particularly to a well tool system having a plurality of well tools connected in telescoped relation and to well tools for connecting a plurality of well tools, such as well casings or plugs, in a tubular member, such as a wellhead.

An object of this invention is to provide a new and improved well tool for hanging a plurality of well casings in a tubular member, such as a wellhead.

Still another object of the invention is to provide means for releasably and sequentially connecting a plurality of tools, such as well casings, in a tubular member.

Still another object is to provide means for releasably connecting a plurality of casings in the bore of a tubular member such as a wellhead from a location remote from the wellhead.

A further object is to provide means for releasably connecting a plurality of well tools, such as well casings or plugs, in preselected locations in a wellhead.

A still further object of the invention is to provide means for selectively connecting a plurality of casings at predetermined locations in a wellhead.

Another object is to provide well tools for releasably connecting a plurality of tools in a tubular member having sealing means for sealing between such tools when the well tools are connected in the tubular member.

Still another object of the invention is to provide a wellhead having a plurality of longitudinally spaced means whereby a plurality of tools may be selectively located in and locked to the wellhead at preselected locations therein.

A further object of the invention is to provide a wellhead having a plurality of longitudinally spaced locating and locking means engageable by selector and locking means on well tools whereby the well tools may be selectively positioned at predetermined positions in the wellhead and releasably locked therein.

A still further object of the invention is to provide a wellhead wherein the selective locating and locking means comprise a plurality of sets of key and lock grooves longitudinally spaced in the wellhead, the well tools having selector keys and lock dogs receivable in the sets of selector and locking grooves for removably positioning the well tools in preselected locations in the wellhead.

Another object of the invention is to provide a wellhead having a plurality of longitudinally spaced means for selectively positioning intermediate and inner well casings in the well.

Still another object is to provide a new and improved hanger mandrel having selector and lock means for releasably connecting a well tool in a predetermined location in a tubular member such as a wellhead or another mandrel.

Still another object of the invention is to provide a releasable plug means which may be releasably connected in the wellhead.

A further object of the invention is to provide a new and improved well tool system having a plurality of well tools connected in telescoped relation to one another.

A still further object of the invention is to provide a new and improved well tool system having a plurality of well tools connected in telescoped relation to one

another which are releasably connected to one another for sequential assembly or disassembly.

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

FIGURE 1 is a longitudinal partly sectional view of a well tool system embodying the invention and showing a plurality of hanger mandrels in positions prior to being releasably connected in the wellhead and supporting casings;

FIGURE 2 is a sectional view taken on line 2-2 of FIGURE 1;

FIGURE 3 is a sectional view taken on line 3-3 of FIGURE 1;

FIGURE 4 is an enlarged vertical partly sectional view similar to FIGURE 1 showing the upper portion of the well tool system showing the hanger mandrels releasably connected to the wellhead and to each other;

FIGURE 5 is a view similar to FIGURE 4 and is a continuation thereof showing the lower portion of the well tool system;

FIGURE 6 is a sectional view taken on line 6-6 of FIGURE 4;

FIGURE 7 is a sectional view taken on line 7-7 of FIGURE 4;

FIGURE 8 is the vertical partly sectional view showing the wellhead illustrated in FIGURE 1 in which a single well casing and a well plug are releasably connected; and

FIGURE 9 is a vertical partly sectional view showing the elements of the well plug and of the selector and lock means carried by the well plug of FIGURE 8 in their relative positions prior to their operative engagement with the selector and lock means of the wellhead.

Referring now particularly to FIGURES 1 through 7 of the drawings, the well tool system there illustrated includes a wellhead 20 provided at its lower end with the bushing 22 by means of which an outer casing 23 is connected to the wellhead. The upper end of the wellhead is provided with the mandrel 29 by means of which blowout preventers or a guide pipe (not shown) may be connected to the wellhead.

The wellhead is provided with a plurality of sets of internal selector grooves or recesses 26 and 27. A lock recess 28 is located above each set of the selector grooves 26 and 27. Although only two sets of the selector grooves 26 and 27 and their associated lock recesses 28 have been shown in the wellhead 20, it will be understood that any number of such sets of selector and lock recesses may be longitudinally spaced in the wellhead. Each of the selector recesses 26 is of narrower width or height than the selector recess 26 located immediately below it for purpose to be described below.

The lower selector recesses 27 are provided with inwardly divergent upper and lower surfaces 31 and 32 while the selector key recesses 26 are provided with upper upwardly and inwardly extending shoulders 34 and abrupt upwardly facing lower shoulders 35. The lock recess of each set of selector and lock recesses is provided with upper and lower inwardly divergently extending shoulders 39 and 40, respectively.

The wellhead is provided with a lateral port 42 below each set of selector and lock recesses. The upper lateral port 42 may be provided with a suitable fitting 44 by means of which a conduit 45, which may extend to a remote location, may be connected to the wellhead. A similar fitting 46 may be threadedly connected to the lower lateral port 42 of the wellhead by means of which a conduit 47 may be connected to the lower lateral port 42.

The conduits 45 and 47 may extend from the wellhead which may be disposed at the bottom of a body of water, to a remote location such as to a position above the surface of the water either immediately above the wellhead or laterally spaced therefrom.

An intermediate well casing 50 may be connected to the wellhead by means of a hanger assembly 52 which includes a hanger mandrel 53 provided with selector keys 54 which are adapted to be received in the lowermost selector recesses 26 and 27 of the wellhead to position the hanger mandrel in the desired position in the wellhead and with lock lugs 55 which are receivable in the lowermost annular lock recess 28 to lock the mandrel, and therefore the intermediate casing 50, against longitudinal displacement in the wellhead.

The selector keys 54 are disposed in slots 68 of a key cage 70 which is slidable on the mandrel 53. The key cage is initially held in a lower position (FIGURE 1) by a shear screw 71 which extends through a suitable bore 72 of the key cage into a threaded bore or recess 73 of the hanger mandrel 53.

Each of the keys is biased outwardly on the mandrel 53 by resilient members or springs 75 whose outer ends extend into internal recesses 77 of the keys and whose inner ends are telescoped in recesses 78 of caps 79. The caps 79 also telescope into the internal recesses 77 of the keys and have their inner ends 80 bearing against the mandrel 53.

The hanger mandrel 53 has an enlarged locking portion 82 which provides a downwardly and upwardly facing cam shoulder 83 which is adapted to engage the upper ends of the keys 54 to cam them outwardly toward the expanded position indicated in FIGURE 5 when the hanger mandrel 53 is moved downwardly relative to the selector keys after the shear screw 71 has been sheared. The enlarged locking portion 82 of course locks the key against inward movement to retracted position when it is in lower position illustrated in FIGURE 5.

The selector keys have upper bosses 88 having downwardly facing shoulders 90 which are adapted to engage the upwardly facing shoulder 35 of the associated selector slot 26 to arrest downward movement of the keys 54 relative to the wellhead 20 when the keys 54 are moved into alignment with the preselected recesses 26 and 27. The upper bosses 88 are also provided with downwardly and outwardly sloping upper cam shoulders 92 which are adapted to engage the downwardly and outwardly sloping shoulders 34 defining the upper selector recesses 26 whereby a camming action takes place upon upward movement of the keys 54 relative to the wellhead 20 which moves the selector keys inwardly on the hanger mandrel 53. The lower bosses 96 of the selector keys have outwardly convergent lower and upper surfaces 97 and 98 which correspond in slope to the lower and upper shoulders 31 and 32, respectively, of the lower selector recesses 27.

The selector keys 54 on the intermediate casing hanger 53 have upper bosses 88 of such length that the keys 54 will pass the upper set of selector recesses 26 and 27 without permitting their upwardly facing abrupt shoulders 90 to engage the abruptly upwardly facing shoulder 35 of the selector recess 26 of the upper set of recesses but are of such length that the selector keys will move into their expanded positions under the influence of the resilient spring 75 when aligned with the lower set of selector recesses whereupon their downwardly facing abrupt shoulders 90 engage the upwardly facing abrupt shoulders 35 of the lower set of selector recesses.

Once the keys 54 are moved into the expanded positions shown in FIGURE 5, further downward movement of the hanger mandrel 53 causes the cam shoulders 83 to complete such outward movement of the selector keys 54 and simultaneously causes the locking portion 82 of the mandrel to engage the inner surfaces of the selector keys

to lock them in the expanded position as shown in FIGURE 5.

The intermediate casing hanger 53 is provided above the locking portion 82 with an external flange 100 which provides a rest shoulder 102 on which is disposed a resilient packer or seal member 103. A dog retainer sleeve 105 is slidably disposed on the upper end of the hanger mandrel 53 above the seal member 103 and has a lower surface 106 which abuts the upper surface of the seal member 103. The dog retainer sleeve is provided with a plurality of apertures 108 in which are received the dogs 55.

A lock sleeve 120 is slidably disposed on the upper end of the hanger mandrel 53 and is provided with a downwardly and inwardly extending cam shoulder 121 which is adapted to engage the upper cam shoulders 123 of the dogs 55 to cam them toward fully expanded positions when the sleeve is moved downwardly on the hanger mandrel and has a lock surface 122 which is adapted to engage the inner surfaces of the dogs 55 to lock the dogs 55 in their expanded positions when the lock sleeve 120 is moved downwardly on the hanger mandrel to the locking position shown in FIGURE 4. The cam shoulder 121 also limits inward movement of the dogs.

The lock sleeve is provided with an internal flange 125 at its lower end which provides an upwardly facing shoulder 126 engageable by the downwardly facing shoulder 127 of a retainer nut 128 threadedly secured to the upper end of the hanger mandrel 53. The shoulders 126 and 127 limit upward movement of the lock sleeve and of the dog retainer sleeve 105 on the hanger mandrel. The lock sleeve 120 is also provided with an internal annular flange 130 and an internal annular recess 132 adjacent its upper end which are engageable by any suitable running tool by means of which the lock sleeve, and therefore the casing hanger mandrel 53 and the casing 50, may be positioned in or removed from the wellhead 20.

It will now be seen that when it is desired to connect or hang the intermediate casing 50 from the wellhead 20, a suitable running tool engages the upper internal flange 130 of the lock sleeve 120 and the entire assembly is then lowered into the wellhead through the usual blowout preventers and the blowout connector mandrel 29. The key cage 70 is now in its lowermost position on the hanger mandrel 53 as shown in FIGURE 1, and the selector keys 54 and the locking dogs 55 are in their retracted positions. The upper bosses 88 of the selector keys 54 are of such length that the keys are prevented from moving towards the extended positions wherein they might engage the upwardly facing abrupt shoulders 35 of the upper set of selector recesses 26 as they move downwardly therepast through the wellhead 20. When the selector keys 54, however, are aligned with the lower set of selector recesses 26 and 27, the keys 54 move outwardly therein causing the downwardly facing abrupt shoulders 90 of the upper bosses 88 to engage the upwardly facing abrupt shoulder 35 of the lower selector recess 26 whereupon further downward movement of the selector keys in the wellhead 20 is arrested. The keys 54 now move outwardly into the expanded position shown in FIGURE 5.

Further downward movement of the hanger mandrel 53 now causes the locking surface 82 of the mandrel to move behind and engage the internal surfaces of the selector keys to move them into fully expanded positions, the shear pin 71 shearing due to the weight of the intermediate casing to permit such downward movement of the casing hanger mandrel 53 relative to the selector keys.

When the hanger mandrel moves to the lowermost position shown in FIGURES 4 and 5, the lock dogs 55 are moved into alignment with the lower lock recess 28. The running tool then is caused to impart downward force to the lock sleeve 120 to cause it to move downwardly on the upper part of the hanger mandrel 53, the engagement of the beveled cam shoulders 121 and 123 during such downward movement causing the lock dogs to move

5

into their fully expanded locking positions illustrated in FIGURE 4. The locking surface 122 of the lock sleeve 120 is then positioned inwardly of the inner ends of the lock dogs 55 and prevents their movement from their expanded operative locking positions illustrated in FIGURE 5 toward their retracted inoperative positions illustrated in FIGURE 1.

The casing hanger and therefore the intermediate casing 50 is now connected and releasably secured to the wellhead 20. Downward pressure upon the casing hanger mandrel 53 and the intermediate casing 50 cannot cause any downward movement of the intermediate casing in the wellhead due to the action of the shoulders 90 of the selector keys and of the lower abruptly facing shoulder 35 of the wellhead. Any fluid pressure which might exert upward forces on the hanger mandrel 53 and the intermediate casing 50 are prevented from causing upward movement of the mandrel and the intermediate casing by the engagement of the upper surfaces 55a of the dogs with the upper shoulders 39 of the lock recess 28. It will be apparent that upward forces exerted on the intermediate casing 50 and the casing hanger mandrel 53 may cause some slight upward movement of the casing hanger relative to the wellhead and that such movement will cause the resilient packer or seal member 103 to be compressed to cause it to seal more tightly between the hanger mandrel and the wellhead. The intermediate casing 50 and the outer casing 23 now define an annular cylindrical space 135 which is sealed at its upper end by the resilient seal 103. The lateral port 42 communicates with this annular cylindrical space so that well fluids flowing in such annular space may be conducted to the surface through the conduit 47 or, if desired, pressure fluids or well treating fluids may be caused to flow into the annular space 135 from the surface through the conduit 47.

If it is desired to remove the intermediate casing from the wellhead, a suitable running tool is lowered thereinto to engage the internal flange 130 of the lock sleeve and to move it upwardly from the position shown in FIGURE 4 to the position shown in FIGURE 1. Further upward movement of the lock sleeve then causes the hanger mandrel 53 to be moved upwardly relative to the wellhead 20. Such upward movement is possible since the upper beveled shoulders 55a of the dogs now engage the upper inwardly and upwardly beveled shoulders 39 of the lock recess 28 in which they are disposed and the resultant camming action causes the dogs to move inwardly toward the retracted position shown in FIGURE 1. Simultaneously, the engagement of the downwardly facing shoulders 34 and 31 of the selector recesses 26 and 27 with the downwardly and outwardly facing shoulders 92 and 98, respectively, of the upper and lower bosses of the selector keys causes the keys to be biased inwardly to move toward their retracted positions after the mandrel has moved upwardly from the locking position shown in FIGURE 5 to the position shown in FIGURE 1 wherein the locking surface 82 thereof no longer engages the internal surfaces of the selector keys. The dogs 55 and keys 54 are similarly cammed inwardly upon meeting any other downwardly facing obstructions in the wellhead 20, in the blowout preventers connecting mandrel 24, or in the blowout preventers themselves. It will thus be seen that the intermediate casing 50 may be removably located and locked in preselected positions in the wellhead 20.

An inner casing 140 may similarly be releasably hung or connected in the wellhead 20 by means of a similar hanger mandrel 142 identical in configuration with the hanger mandrel 53 except that it is smaller in dimensions. The inner casing hanger mandrel 142 is provided with a similar key cage 144 having circumferentially spaced slots 145 in which are movably disposed the selector keys 146. The selector keys 146 are biased outwardly by springs similar to the springs 75 of the selector keys 54 of the intermediate casing hanger mandrel and have upper bosses 147 which are of smaller height than the upper bosses 88 of the selector keys 54 so that the selector keys 146

6

will be moved outwardly into the upper set of selector recesses 26 and 27 of the wellhead to cause their downwardly facing abrupt shoulders 148 to engage the upwardly facing abrupt shoulders 35 of the upper selector recess 26 and thus prevent further downward movement of the selector keys in the wellhead. The lower bosses 149 of the selector keys 146, of course, are then received in the lower recesses 27 of the upper set of selector recesses. The inner hanger mandrel key cage 144 is secured in the lowermost position on the inner hanger mandrel 142 by a shear screw 151. The inner casing hanger mandrel 142 is also provided with an external flange 153 which provides an upwardly facing shoulder 154 on which a sealing or packing member 155 is disposed.

A lock dog retainer sleeve 158 is slidably disposed on the inner casing hanger mandrel 142 above the resilient seal member 155 and is provided with a plurality of circumferentially spaced slots 160 in which are received the lock dogs 162 which are identical in configuration with the lock dogs 55 of the lower hanger mandrel 53. A lock sleeve 165 is slidably disposed on the hanger mandrel 142 and is provided with an internal flange 167 which provides an upwardly facing shoulder 168 engageable by the lower end of a connector sub 169 threadedly secured to the inner casing hanger mandrel 142. This engagement limits upward movement of the lock sleeve 165 on the hanger mandrel 142. The mandrel 142 and the lock sleeve 165 are provided with locking surfaces 171 and 172 which are adapted to abut the internal surfaces of the selector keys 146 and the lock dogs 162, respectively, to hold them in the expanded positions illustrated in FIGURE 4 in the same manner as the lock surfaces 82 and 122 of the intermediate casing hanger 53 and the lock sleeve 120 lock the selector keys 54 and the lock dogs 55 in their expanded positions.

The inner casing 140 can thus be hung in a preselected position in the wellhead in substantially the same manner as the intermediate casing 50 is hung or connected in the wellhead. Briefly, the inner casing 140 and the inner casing mandrel 142 and their components are lowered into the wellhead and into the intermediate casing 142, which is already in place, by a suitable running tool which engages the internal flange 173 at the upper end of the lock sleeve 165, the dogs 162 and the selector keys 146 being in the positions illustrated in FIGURE 1. When the inner casing hanger mandrel 142 is lowered to the position wherein the selector keys 146 are in alignment with the upper set of selector recesses 26 and 27, the springs which bias the selector keys 146 outwardly cause the selector keys 146 to move outwardly into the upper set of recesses 26 and 27 and the downwardly facing abrupt shoulders 148 of the upper bosses 147 of the selector keys engage the abrupt upwardly facing shoulder 35 of the upper selector recess 26 to prevent further downward movement of the selector keys in the wellhead 20. Further downward movement of the mandrel 142 then causes the locking surface 171 to move behind the internal surfaces of the selector keys 146 to lock them in the expanded positions illustrated in FIGURE 4. Such further downward movement of the inner casing hanger mandrel 142 also causes the lock dogs 162 to move into alignment with the upper lock recess 128. Further downward movement is then imparted to the lock sleeve 165 by downward force applied thereto by means of the running tool to cause the cam shoulder 175 to engage the cam shoulders of the dogs to move them outwardly into the lock recess and the locking surface 172 to move behind the internal surfaces of the lock dogs 162 to lock them in the expanded positions shown in FIGURE 4.

The inner casing 140 and the inner casing hanger mandrel 142 are then held against longitudinal movement relative to the intermediate mandrel and the resilient seal or packer member 155 seals between the inner casing hanger mandrel 142 in the wellhead above the upper lateral port 42. The upper lateral port 42 communicates

with the annular or cylindrical flow passage 139 between the inner and intermediate casings 50 and 140 whereby fluids may be caused to flow into or out of the cylindrical flow passage 139 to or from the surface through the upper lateral port 42 and the conduit 45. The resilient seal 155 is compressed and caused to engage more tightly both the inner mandrel 142 and the wellhead 20 whenever the fluid pressures exerted on the inner casing and the inner casing hanger mandrel 142 are increased in either direction as was explained above in connection with the action of the seal 103 of the intermediate casing hanger 53.

It will now be seen that a tubular member or wellhead 20 has been illustrated and described which is provided with selective locating and locking means, the sets of selector and locking recesses 26, 27 and 28, engageable by cooperating selector means of the mandrels 53 and 142 which releasably lock well tools, such as the intermediate and inner casings 50 and 140, in selected positions in the wellhead.

It will further be seen that the selective locating means on the well tools are the selector keys 54 and 146 which are adapted to engage and be received in selected sets of the selector recesses 26 and 27 whereby the intermediate casing may be suspended only in the lowermost position in the wellhead 20 since the bosses 88 of the selector keys 54 are of too large dimension to be received in the upper selector recess 28 of the wellhead.

It will also be seen that the well tools, such as the intermediate casing 50 and the inner casing 140, are provided with mandrels 53 and 142 which have locking means for holding the selector keys in the expanded positions and that they are also provided with lock sleeves 120 and 165 which lock the lock dogs 55 and 162, respectively, in the expanded locking positions illustrated in FIGURE 4 wherein the lock dogs prevent upward movement of the well tool relative to the wellhead. It will further be seen that the well tools are removably positioned in the wellhead since the upper surfaces of the selector keys and the lock dogs are beveled downwardly and outwardly whereby upward force exerted on the lock sleeves 120 and 165 causes the locking surfaces of the lock sleeves and of the mandrels to move out of engagement with the selector keys and the lock dogs to permit the selector keys and the lock dogs to be cammed inwardly against the forces exerted by their associated springs to permit upward movement of the hanger mandrels, and therefore of the well tools 50 and 140, relative to the wellhead.

Referring now to FIGURES 8 and 9 of the drawing, the wellhead 20 is shown provided with the intermediate casing 50 releasably connected to the wellhead by means of the selector keys 54 and lock lugs 55 in the manner described above. The upper sets of selector recesses 26 and 27 and the upper lock recess 28, however, are shown employed to releasably hold a plug assembly 200 in the wellhead above the intermediate casing 50. The plug assembly includes a plug mandrel 202 and is provided with a key cage 203 whose lower end is threadedly connected, as at 205, to the plug mandrel 202. The key cage 203 is provided with a plurality of slots 207 in which are movably positioned keys 208 which are identical in all respects with the keys 146 illustrated in FIGURES 1 and 4, and which are provided with springs 210 whose inner ends are received in caps 212 and whose outer ends are received in suitable recesses 213 of the selector keys. The plug mandrel is provided with slots 214 in which the inner ends of the caps 212 are received.

A resilient packer or seal 216 is disposed on the plug mandrel 202 and rests on the upper annular surface 217 of the key cage. A lock dog mandrel 220 is positioned above the seal 216 and is provided with a plurality of circumferentially spaced slots 222 in which are received the lock dogs 223. The lock dog sleeve is provided with an internal flange 232 whose inner surface is provided with an internal annular recess in which is received a

sealing means, such as an O ring 233, which seals between the dog sleeve 220 and the plug mandrel 202.

A lock sleeve 235 is mounted on the plug mandrel above the lock lug sleeve 220 and is provided with an internal annular flange 236 at its lower end which provides an annular upwardly facing shoulder 237 whose purpose will be described below. The lock sleeve is releasably held in the upper position shown in FIGURE 9 by a shear screw 238 which is threaded into a suitable bore in a retainer nut 240 threaded on the upper end of the plug mandrel 202. A resilient split ring 242 is yieldably positioned in an annular recess 243 of the plug mandrel and is adapted to engage the upwardly facing shoulder 237 of the lock sleeve 235 when the lock sleeve 235 is moved to the lower position illustrated in FIGURE 8.

It will now be seen that the plug mandrel 202 may be releasably positioned in a wellhead 20 above the upper lateral port 42 and also above the upper end of the intermediate casing 50 by the use of a suitable running tool 20 which engages the internal flange 245 of the lock sleeve 235 when all elements of the selector key and lock dog assembly are in the positions illustrated in FIGURE 9. When the plug mandrel 202 reaches the wellhead 20, it moves downwardly until the selector keys 208 are aligned with the upper selector recesses 26 and 27 whereupon the bosses 247 and 248 of the selector keys enter into the selector recesses 26 and 27, respectively, and the downwardly facing abrupt shoulder 250 engages the upwardly facing abrupt shoulder 35 of the upper selector recess 26 and thus prevent further downward movement of the selector keys in the wellhead. The lock dogs are simultaneously moved into alignment with the upper lock recess 28.

Downward force is then imparted to the lock sleeve 235 to shear the shear screw 238 and free the lock sleeve for downward movement to the position illustrated in FIGURE 8. The internal flange 232 of the lock sleeve is provided with an inwardly and upwardly beveled shoulder surface 280 which engages the split ring 242 as the lock sleeve 235 moves downwardly on the plug mandrel 202 and cams the split ring inwardly to permit downward movement of the internal flange 236 past the split ring. When the internal flange has moved below the split ring 242, the resilient split ring again moves to its outward position wherein the upwardly facing shoulder 237 of the internal flange 236 of the lock sleeve 235 engages the split ring 242 which thus prevents upward displacement of the lock sleeve 235 on the plug mandrel 202.

The lower end of the lock sleeve 235 is provided with an upwardly and outwardly beveled shoulder 256 which cams the lock dogs outwardly into the lock recess 28 upon downward movement of the lock sleeve. During such movement locking surface 255 of the lock sleeve is moved behind the internal surfaces of the lock dogs 223 which are thus held in their expanded locking positions by the lock sleeve 235 when the latter is in the lowermost position illustrated in FIGURE 8.

The plug mandrel 202 is now releasably held in position in the upper portion of the wellhead 20, the lock dogs 223 preventing upward movement of the plug mandrel in the wellhead and both the lock lugs 223 and the selector key 208 preventing downward movement of the plug mandrel in the wellhead.

If it is desired to remove the plug mandrel 202 from the wellhead, a suitable running tool is lowered to engage the internal flange 245 of the lock sleeve and to exert an upward pull thereon sufficiently strong to break or shear the snap ring 242 to permit the lock sleeve 235 to move upwardly to a position wherein its upwardly facing shoulder 237 engages the downwardly facing annular end 260 of the retainer nut 240. A further upward pull on the lock sleeve 235 now causes the plug mandrel 202 to be moved upwardly in the wellhead 20, the outwardly and downwardly beveled upper surfaces of the lock dogs 223 and the bosses 247 and 248 of the selector keys 208

coacting with the downwardly and outwardly disposed shoulders of the lock and selector recesses 23, 26 and 27, respectively, to cam the lock dogs and the selector keys inwardly towards their retracted positions to free the plug mandrel for removal from the wellhead.

It will be apparent that when the plug mandrel 202 is in its operative locked position illustrated in FIGURE 8 that the seal 216 seals between the plug mandrel and the wellhead. The internal bore of the well plug 202 is provided with a plug 270 whose lower outer surface is provided with a plurality of vertical slots 272 whose upper ends communicate with an internal annular recess 274 intermediate the ends of the plug mandrel 202. The plug 270 is provided at its upper end with an external annular flange 275 which is disposed above the upwardly facing annular shoulder 277 of the internal recess 274 of the plug mandrel 202. A spring 278 bears against the lower shoulder 279 of the external flange of the plug 270 and against the upwardly facing shoulder 277 of the plug mandrel to bias the plug 270 upwardly relative to the plug mandrel.

A retainer ring 282 is threaded into the upper end of the plug 270 and is provided with a downwardly facing external flange 284 at its upper end. A back up ring 285 and a seal 286 are disposed on the retainer ring and between the upper end of the plug 270 and the shoulder 284 of the retainer ring whereby the seal 286 seals between the retainer ring and the plug mandrel 202 when the plug 270 is in the upper position illustrated in FIGURES 8 and 9. The retainer ring is provided with a central aperture 290 in which is received the guide pin 291 of a ball valve 293. The retainer ring has a valve seat 295 against which the ball valve 293 is resiliently urged by a spring 296 held in the retainer ring 282 by a retainer sleeve 298 threaded in the lower end thereof.

The plug 270 is provided to permit downward flow of fluids into the wellhead and to prevent upward flow of fluids from the wellhead upwardly through the plug mandrel 202. The ball valve 293 is provided to permit equalization of pressures on both sides of the plug 270 prior to its opening by an increase of the fluid pressure above the plug 270 which is accomplished by increasing the fluid pressure above the well plug, the spring 296 and ball valve 293 being so dimensioned that the ball valve will be moved downwardly against the pressure of the spring 296 when a predetermined pressure differential exists thereacross. After this predetermined pressure differential is exceeded, the ball valve opens to permit equalization of pressures or a decrease in the pressure differential across the plug 270 which is then moved downwardly against the resistance of the spring 278 by the downwardly acting fluid pressure to permit a freer or greater flow of well fluids past the outer sides of the plug 270 once the seal 286 moves below the sealed surface 298 of the plug mandrel and into alignment with the internal recess 274 thereof. The longitudinal slots 272 of course afford communication between the interior of the plug mandrel 202 and the internal recess 274 thereof when the plug 270 is moved to its lower open position.

It will now be seen that the selector and lock recesses 26, 27 and 28 of the wellhead may be utilized to removably position tools other than well casing in the wellhead.

It will further be seen that such well tools as the plug assembly 200 may be positioned in any desired location in the wellhead by properly positioning appropriate selector and lock recesses at such locations in the wellhead. It will further be seen that such well tools may be positioned in the wellhead whether or not intermediate or inner well casing is connected or hung from such wellheads. It will further be seen that while only two sets of selector and lock recesses have been shown that any number of sets of such selector and lock recesses may be provided whereby any given number of well tools may be releasably connected in and to the wellhead.

It will further be seen that by providing any tool with

properly dimensioned selector keys, such tools may be locked in any selected position by use of the appropriate set of selector recesses.

The foregoing description of the invention is explanatory only, and changes in the details of the construction 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 is claimed and desired to be secured by Letters Patent is:

1. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses in which each of said sets of recesses is of a different cross-sectional configuration from each of the others of said sets of recesses; a plurality of well tools having dependent portions disposed in telescoped spaced relation relative to one another and said outermost tubular member, each of said well tools having selector and lock means projecting outwardly therefrom and of a configuration conforming to a selected one of said sets of recesses in said outermost tubular member, the selector means of each of said well tools being freely movable outwardly of the well tool and being biased outwardly, said well tools being releasably secured to said outermost tubular member by said selector and lock means, said selector and lock means of each of said well tools being receivable in a selected set of said selector and lock recesses of said outermost tubular member whereby each well tool may be positioned and locked in a selected position in said internal tubular member upon downward movement through the outermost tubular member.

2. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets including a selector recess and a lock recess of a cross-sectional configuration different from the configuration of the other sets of recesses; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting configuration corresponding to the cross-sectional configuration of a selected one of said sets of recesses in said tubular member and movable to extended position wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said well tools having dependent portions disposed in telescoped spaced relation relative to one another and said tubular member.

3. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets including a selector recess and a lock recess having a cross-sectional configuration differing in cross-sectional configuration from the cross-sectional configuration of each of the other sets of selector and lock recesses; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting configuration corresponding to the cross-sectional configuration of a selected one of said sets of selector and lock recesses of said tubular member, said selector means being movable to extended position wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said

mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said mandrel having locking means engageable with said selector means and said lock means when said selector means and said lock means are in extended positions for releasably holding said selector means and said lock means in extended positions, said well tools having portions disposed in spaced telescoped relation relative to one another and to said tubular member.

4. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a different cross-sectional configuration from each other set of selector and lock recesses of said tubular member; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting configuration conforming to the configuration of a selected one of said sets of selector and lock recesses of said outer tubular member, said selector means being movable to extended position wherein said selector means engage in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one set of said selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said mandrel having locking means for releasably holding said selector means and said lock means in extended positions, said lock means for said selector means comprising a lock surface on said mandrel and said locking means for said lock means comprising a lock sleeve movable on said mandrel to engage said lock means, said well tools having portions disposed in spaced telescoped relation relative to one another and to said tubular member.

5. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a configuration differing in cross-sectional configuration from the cross-sectional configuration of the selector recess and lock recess of each of the other sets of recesses of said tubular member; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting configuration conforming to the configuration of a selected one of said sets of selector and lock recesses of said outer tubular member, said selector means being movable to extended positions wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of said selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said well tools comprising casings suspended from said mandrels in telescoped spaced relation to one another.

6. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a configuration differing in cross-sectional configuration from the cross-sectional configuration of the selector recess and lock recess of each of the other sets of recesses of said tubular member; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and movable to extended position wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said well tools comprising casings suspended from said mandrels in telescoped spaced relation to one another, said tubular member being provided with a plurality of lateral ports disposed between adjacent sets of selector and lock recesses and communicating with the cylindrical flow passages provided in the tubular member by the spaced well casings.

7. A well tool system comprising: an outer tubular member having a well casing connected therewith and having in its bore a plurality of sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a cross-sectional configuration differing from the cross-sectional configuration of each other set of selector recesses and lock recesses of said outer tubular member; a plurality of well tool carrying means each having laterally movable lock means with a projecting configuration conforming to the cross-sectional configuration of a selected one of said sets of selector and lock recesses of said outer tubular member and releasably engageable in said sets of selector and lock recesses for positioning and locking said well tool carrying means in selected ones of said sets of selector and lock recesses, one of the well tools carried by one of said well tool carrying means including a well casing spaced from said well casing connected to said tubular member, said tubular member being provided with lateral port means communicating with the interior of the tubular member above said tool carrying means which supports said well casing and with a lateral port means communicating with the cylindrical space provided between said spaced well casings, at least another of said tool carrying means having a well plug for closing the bore of said tubular member above said one of said well tool carrying means.

8. A well tool system comprising: an outer tubular member having a well casing connected thereto and having in its bore a plurality of sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a cross-sectional configuration differing from the cross-sectional configuration of each other set of selector recesses and lock recesses of said outer tubular member; a plurality of well tool carrying means each having laterally movable lock means with a projecting configuration conforming to the cross-sectional configuration of a selected one of said sets of selector and lock recesses of said outer tubular member and releasably engageable in said sets of selector and lock recesses for positioning and locking said well tool carrying means at selected positions in said outer tubular member, one of the well tools carried by one of said well tools carrying means including a well casing spaced from said well casing connected to said tubular member, said tubular member being provided with lateral port means communicating with the interior of the tubular member above said tool

carrying means which supports said well casing and with a lateral port means communicating with the cyclindrical space provided between said spaced well casings, at least another of said tool carrying means having a well plug for closing the bore of said tubular member above said one of said well tool carrying means, said well plug being provided with valve means for permitting downward flow of fluids into said tubular member but preventing upward flow of the fluids therefrom.

9. A well tool for use with an outer tubular member having a plurality of sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a cross-sectional configuration differing from the cross-sectional configuration of each of the other of said sets of selector and lock recesses in said outer tubular member, said well tool including: a mandrel having a selector means having a projecting face thereon conforming to the cross-sectional configuration of a selected one of said sets of selector and lock recesses of said outer tubular member, said selector means being movably mounted on said mandrel for movement between expanded and retracted positions, said selector means being engageable in the selector recess of only one of said sets of selector and lock recesses of said tubular member whereby the mandrel may be positioned in a predetermined position in said tubular member, said mandrel having a lock surface movable into engagement with said selector means after it has moved into expanded position to prevent inward movement of said selector means toward retracted position; carrier means longitudinally movably mounted on said mandrel for limited longitudinal movement thereon; lock means carried by said mandrel and movable between expanded and retracted positions, said lock means being movable into the lock recess of said one of said sets when said selector means is engaged in said selector recess of said one of said sets; seal means for sealing between the mandrel and the outer tubular member carried by said mandrel below said carrier means and engageable by said carrier means whereby upward movement of said mandrel after said lock means is engaged in a lock recess causes compression and expansion of said sealing means into tighter engagement with said outer tubular member; and a locking means longitudinally movable on said mandrel for engaging said lock means to hold said lock means in expanded position upon downward movement of said locking means on said mandrel.

10. A well tool for use with an outer tubular member having a plurality of sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a cross-sectional configuration differing in cross-sectional configuration from that of each of the other of said sets of selector and lock recesses, said well tool including: a mandrel having a selector means movably mounted thereon for movement between expanded and retracted positions, said selector means having a projecting face conforming to the selector and lock recesses of a selected one of the selector and lock recesses of said outer tubular member and being engageable in the selector recess of only one of said sets of selector and lock recesses of said tubular member whereby the mandrel may be positioned in a predetermined position in said tubular member, said mandrel having a lock surface movable into engagement with said selector means after it has moved into expanded position to prevent inward movement of said selector means toward retracted position; carrier means mounted on said mandrel for limited longitudinal movement thereon; lock means carried by said carrier means and movable between expanded and retracted positions, said lock means being engageable in the lock recess of said one of said sets to lock said mandrel against longitudinal movement in said outer tubular member; seal means for sealing between the mandrel and the outer tubular member carried by said mandrel below said carrier means and engageable by said carrier means whereby up-

ward movement of said mandrel after said lock means is engaged in a lock recess causes compression and expansion of said sealing means into tighter engagement with said outer tubular member; and a locking means longitudinally movable on said mandrel for engaging said lock means to hold said lock means in expanded position upon downward movement of said locking means on said mandrel, said well tool having means resiliently yielding biasing said selector means toward expanded positions.

11. A well tool for use with an outer tubular member having a plurality of sets of selector and lock recesses, each of said sets comprising a selector recess and a lock recess having a cross-sectional configuration differing from the cross-sectional configuration of each of the other of said sets of selector and lock recesses, said well tool including: a mandrel having a selector means movably mounted thereon for movement between expanded and retracted positions, said selector means having a projecting face with a configuration conforming to the configuration of a selected one of the sets of selector and lock recesses of said tubular member and including: a mandrel having a selector means movably mounted thereon for movement between expanded and retracted positions, said selector means being engageable in the selector recess of only one of said sets of selector and lock recesses of said tubular member whereby the mandrel may be positioned in a predetermined position in said tubular member, said mandrel having a lock surface movable into engagement with said selector means after it has moved into expanded position to prevent inward movement of said selector means toward retracted position; carrier means mounted for limited longitudinal movement on said mandrel; lock means carried by said carrier means and movable between expanded and retracted positions, said lock means being engageable in the lock recess of said one of said sets when said selector means is engaged in said selector recess; seal means on said mandrel below and engageable by said carrier means for sealing between said mandrel and said outer tubular member whereby said seal means is compressed upon upward movement of said mandrel after said lock means is engaged in said lock recess; and a locking means longitudinally movable on said mandrel for engaging said lock means to hold said lock means in expanded position upon downward movement of said locking means on said mandrel, said well tool having means resiliently yieldingly biasing said selector means and said lock means toward expanded positions, said selector means, said lock means and said selector and lock recesses having coaxing beveled shoulders for camming the said selector means and said lock means inwardly toward retracted positions upon upward movement of said mandrel in said tubular member.

12. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a lock recess and a selector recess having a cross-sectional configuration differing from that of the selector recess of each of the other sets of selector and lock recess; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting configuration conforming to the cross-sectional configuration of one of said sets of selector and lock recesses of said outer tubular member movable to extended position wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate said mandrel in a predetermined position in said outer tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by said mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said man-

drel in said tubular member, said well tools comprising casings suspended from said mandrel in telescoped spaced relation to one another, said tubular member being provided with a plurality of lateral ports disposed between adjacent sets of selector and lock recesses and communicating with the cylindrical flow passages provided in the tubular member by the spaced well casings, each of said well tools being provided with seal means for sealing between said well tools and said tubular member to prevent flow of fluid therebetween and between said lateral ports.

13. A well tool system including: an outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a lock recess and a selector recess having a cross-sectional configuration differing from the corresponding configuration of the other sets of lock and selector recesses; a plurality of well tools, said well tools each including a mandrel, selector means carried by said mandrel and having a projecting portion with a configuration of a selected one of said sets of lock and selector recesses of said outer tubular member movable to extended position wherein said selector means engages in the selector recess of a selected one of said sets of selector and lock recesses to locate the said mandrel in a predetermined position in said outer tubular member to limit further downward movement of said mandrel in said tubular member; and lock means carried by the mandrel movable between an extended position wherein said lock means is received by the lock recess of said selected one of said sets of selector and lock recesses to prevent upward movement of said mandrel in said tubular member and a retracted position wherein said lock means is disposed inwardly of said lock recess to permit upward movement of said mandrel in said tubular member, said well tools comprising casings suspended from said mandrels in telescoped spaced relation to one another, said tubular member being provided with a plurality of lateral ports disposed between adjacent sets of selector and lock recesses and communicating with the cylindrical flow passages provided in the tubular member by the spaced well casing, each of said well tools being provided with seal means for sealing between said well tools and said tubular member to prevent flow of fluid therebetween and between said lateral ports, and compression means mounted on said well tools for engaging and compressing said seal means into tighter sealing engagement with said tubular mandrel upon upward movement of the well tool in said tubular member while the well tool is locked in said tubular member.

14. A well tool system including: a wellhead having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a lock recess and a selector recess having a configuration differing in configuration from the other sets of selector and lock recesses; and a plurality of well tools telescoped in said wellhead in pretermined positions therein, said well tools each having selector and lock means laterally movable thereon and having a projecting surface conforming in cross-sectional configuration to the shape of the lock recess and selector recess of a selected set of selector and lock recesses of

said wellhead, said projecting surfaces of said selector and lock means being operatively engageable in said selector and lock recesses of a selected set of said plurality of sets, said selector means being freely movable outwardly of the well tool and being biased outwardly of the well tool, said well tools comprising well casings disposed in telescoped spaced relation relative to one another and said wellhead, said wellhead having lateral ports communicating with the flow passages provided by said well casings; and seal means on said well tools for sealing between said well tools and said wellhead to prevent fluid flow between said passages.

15. An outermost tubular member having a plurality of longitudinally spaced sets of selector and lock recesses, each of said sets comprising a lock recess and a selector recess having a cross-sectional configuration differing from the cross-sectional configuration of the corresponding selector recesses of each other set of recesses in said outer tubular member; a plurality of well tools, each of said well tools having selector and lock means laterally movable thereon and having a projecting face corresponding to the selector recess and lock recess of a selected one of said sets of selector and lock recesses of said outer tubular member, said selector means of each of said well tools being freely movable outwardly and being biased outwardly of said well tool, said well tools being releasably secured to said outermost tubular member by said selector and lock means, said selector and lock means of each of said well tools being receivable in a selected one of said sets of said selector and lock recesses of said outer tubular member, whereby each of said well tools may be positioned at a preselected position in said outermost tubular member upon downward movement thereof through said outermost tubular member, at least one of said well tools having a dependent portion disposed in telescoped spaced relation relative to said outermost tubular member, another of said well tools being provided with a plug longitudinally movable in said well tool between a lower open position wherein it permits flow of fluid downwardly through said well tool and upper position where it prevents upward flow of fluids through said well tool.

16. The well tool system of claim 15 wherein said plug of said another of said well tools is provided with a pressure relief valve means mounted for relieving the pressure differential across said plug to permit its downward movement upon downward displacement of said pressure relief valve means by fluid pressure acting downwardly thereon.

References Cited in the file of this patent

UNITED STATES PATENTS

1,927,190	Stephens	Sept. 19, 1933
2,035,834	Penick et al.	Mar. 31, 1936
2,186,139	Hild	Jan. 9, 1940
2,798,559	Fredd	July 9, 1957
2,813,588	O'Reilly	Nov. 19, 1957
2,862,560	Bostock et al.	Dec. 2, 1958
2,862,564	Bostock	Dec. 2, 1958