United States Patent [19]

Garwood

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[45] **Nov. 5, 1974**

[54] **WELL TOOLS**

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[73] Assignee: **Otis Engineering Corporation,** Dallas, Tex.

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[21] Appl. No.: **386,054**

[52] **U.S. Cl.** **166/154,** 166/186, 166/194, 166/224, 166/237

[51] **Int. Cl.** **E21b 43/12**

[58] **Field of Search** 166/224, 226, 237–239, 166/243, 133, 185, 186, 191–194, 188, 154, 166/155

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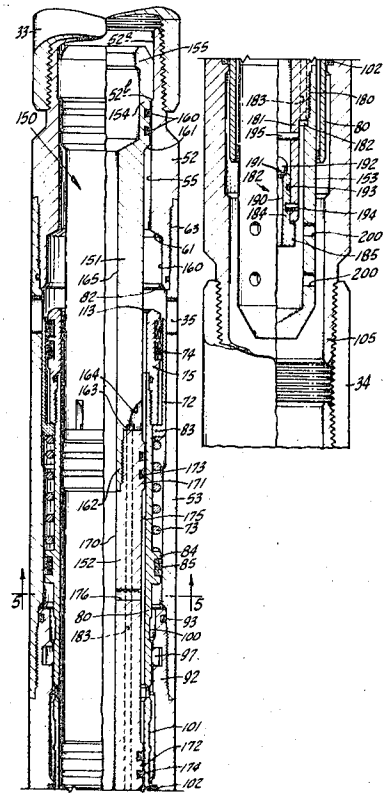
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Primary Examiner—David H. Brown
Attorney, Agent, or Firm—H. Mathews Garland

[57] **ABSTRACT**

A sliding sleeve valve for inclusion in a tubing string of a well to provide communication between the tubing string and the annular space around the string for circulation of fluids between the annulus and the interior of the tubing string. The valve is particularly characterized by a capability of being opened mechanically and closed either by fluid pressure or mechanically. The valve is provided in a nonselective form used for single applications in a tubing string and a selective form for multiple use at different depths in a single tubing string, any selected one of the valves being operable independently of the other valves. Both forms of the valve include a tubular housing connectible in a tubing string forming a continuous part of the string, a side port in the housing for communication between the bore of the housing and the annulus around the tubing string, an internal tubular valve member movable longitudinally within the housing between an upper closed position and a lower open position. The valve member has a head provided with ring seals which are retractable into a sleeve disposed around the valve member for protecting the ring seals against flow cutting during the opening and closing of the valve. The valve member includes longitudinally spaced seals of different diameters sealing with the housing and defining an effective annular area over which fluid pressure is applicable for pumping the sleeve valve open and closed. Suitable operating tools are disclosed for opening and closing the valve. The selective form of the valve includes internal operating recesses in the housing and in the valve member for engagement of suitable opening and closing tools to permit any one of a plurality of such valves in the tubing string to be opened and closed independently of the other valves.

22 Claims, 18 Drawing Figures



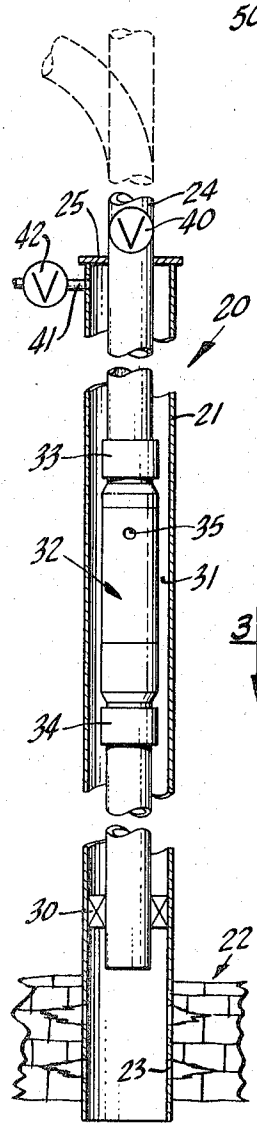


FIG. 1

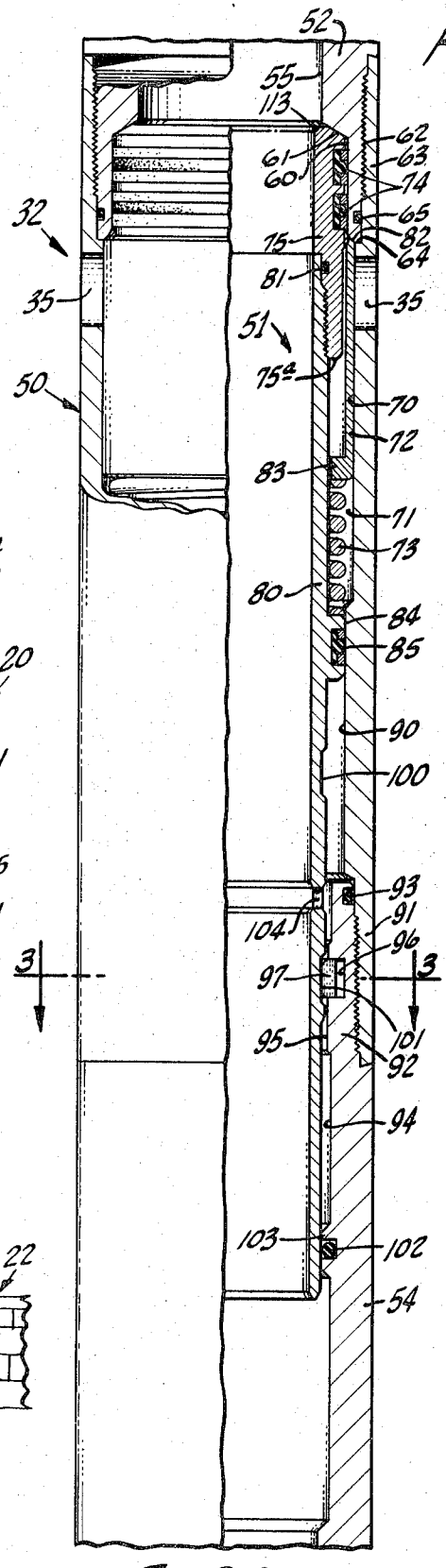


FIG. 2-A

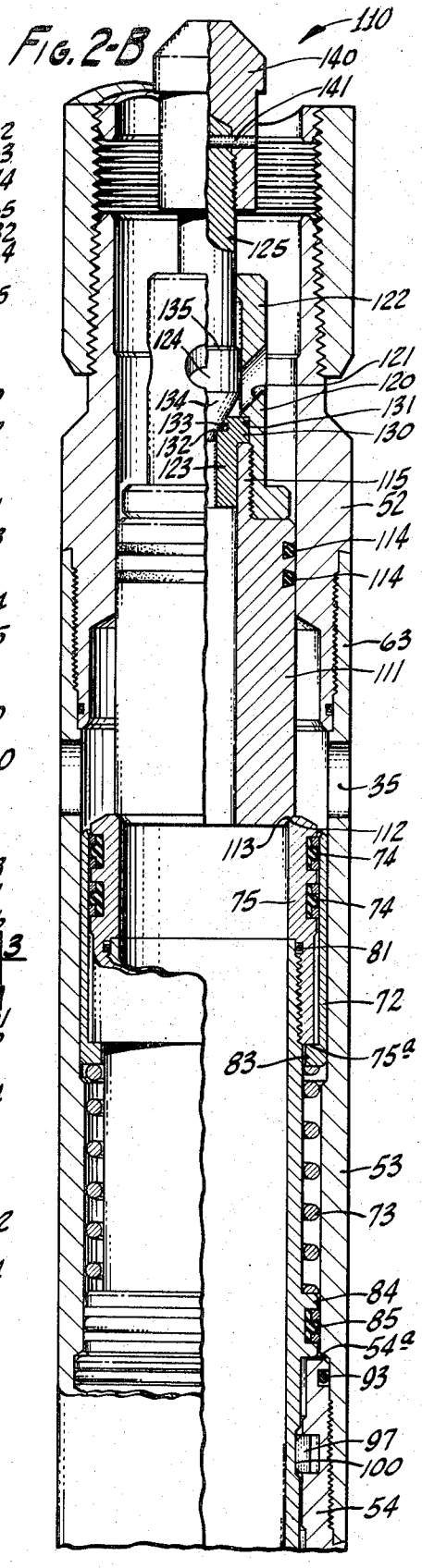


FIG. 2-B

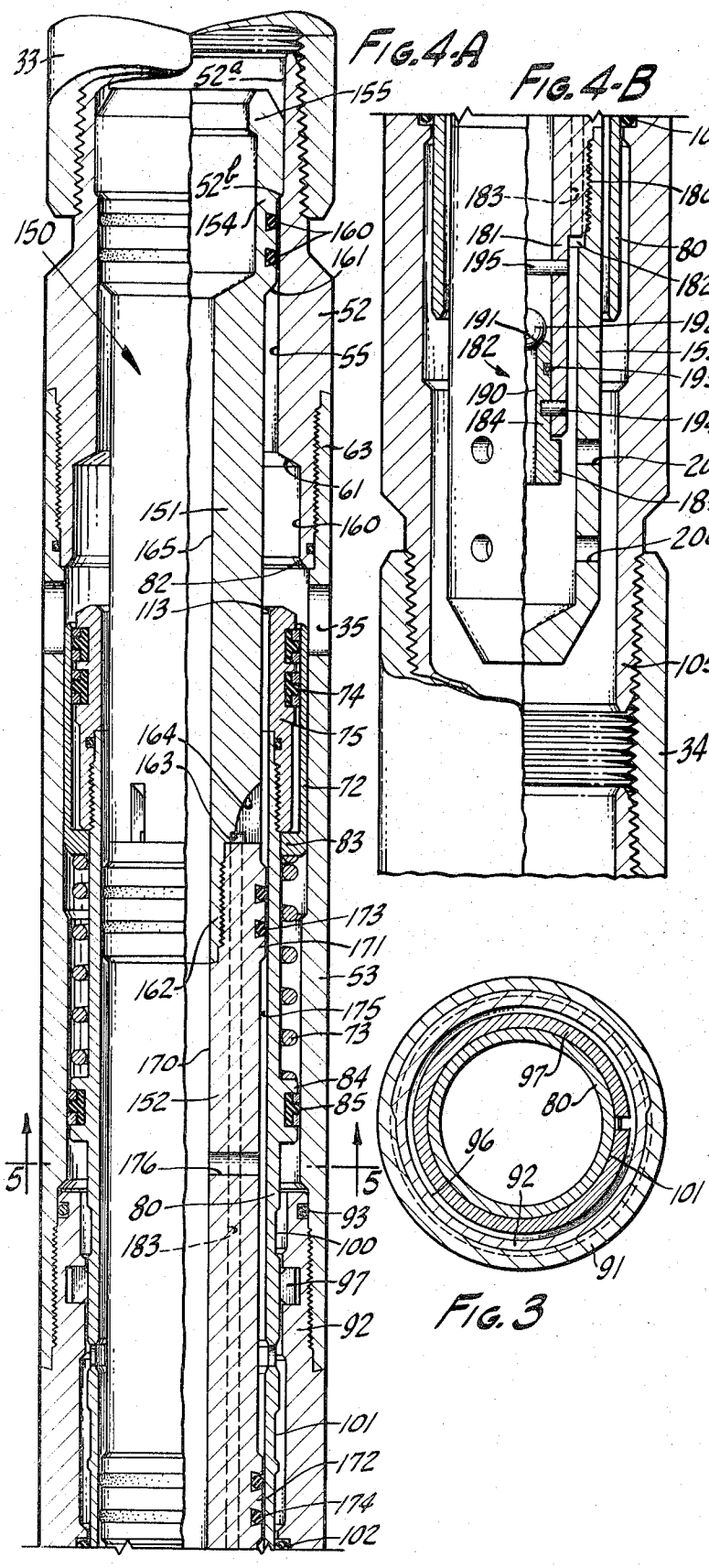


FIG. 4-A

FIG. 4-B

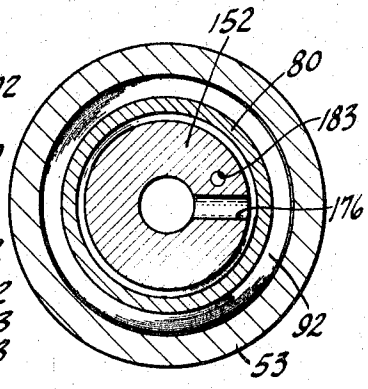
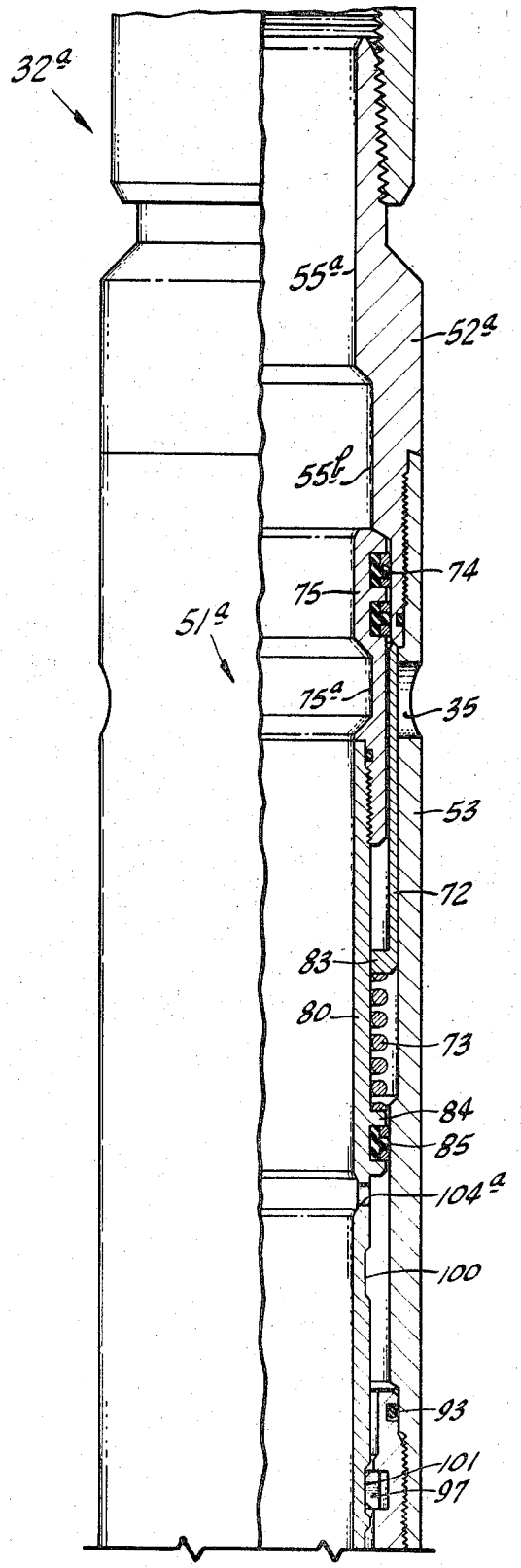


FIG. 5

FIG. 3

FIG. 6-A



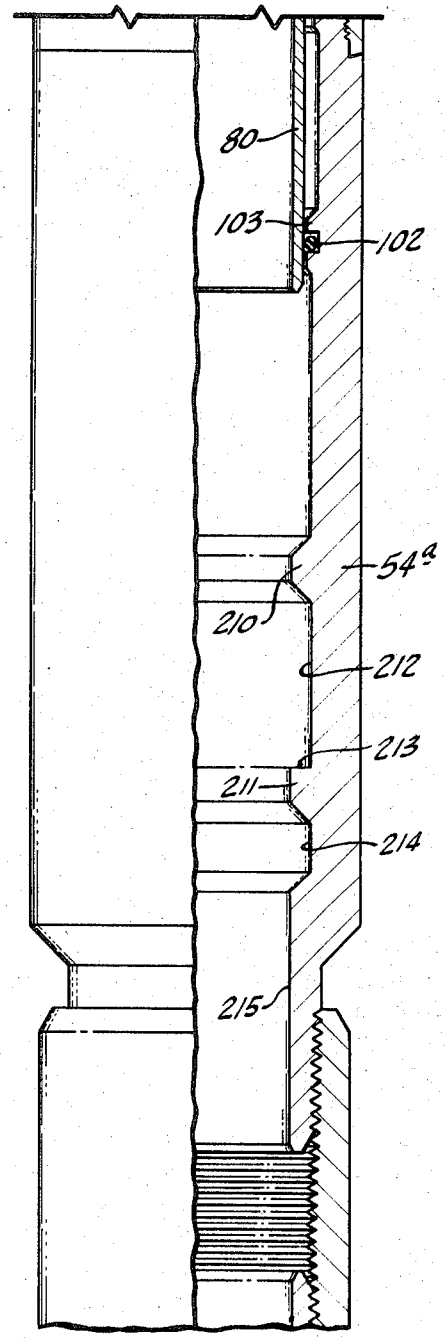


FIG. 6-B

FIG. 12

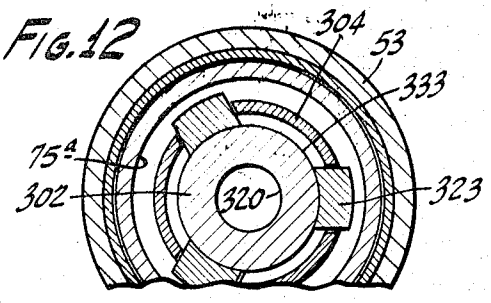


FIG. 9

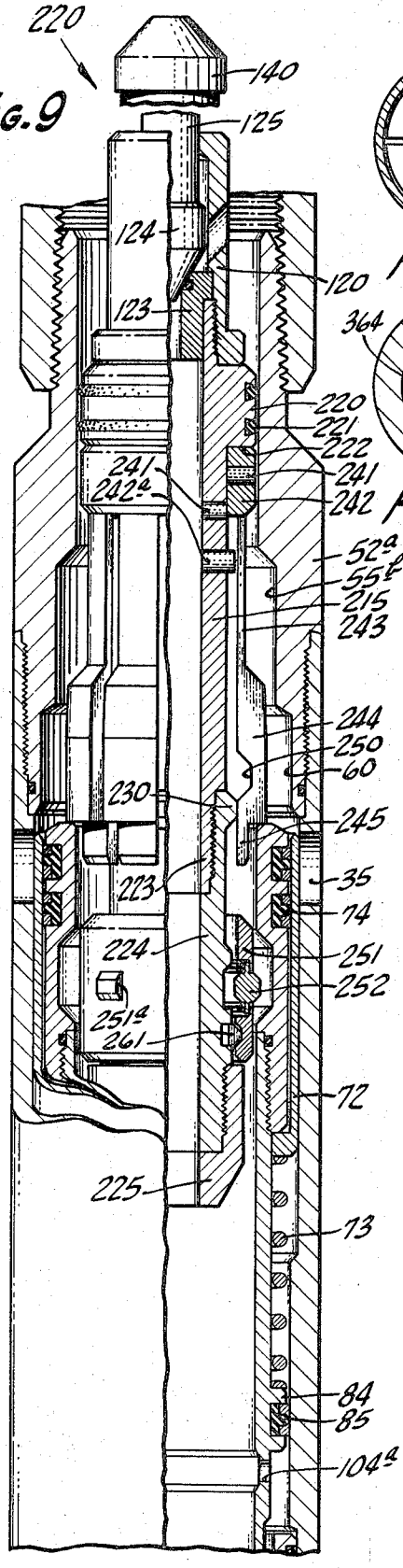


FIG. 11

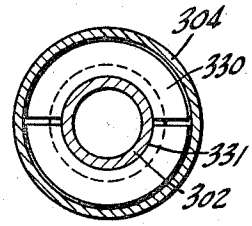


FIG. 13

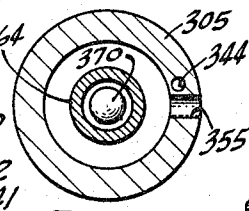


FIG. 7

FIG. 8

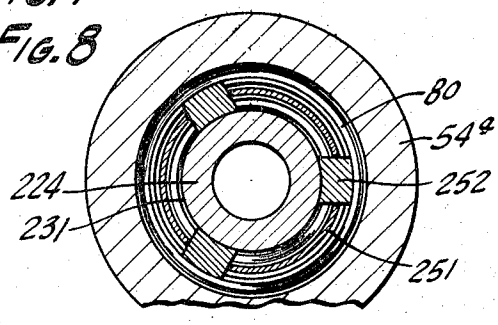


FIG. 10-A

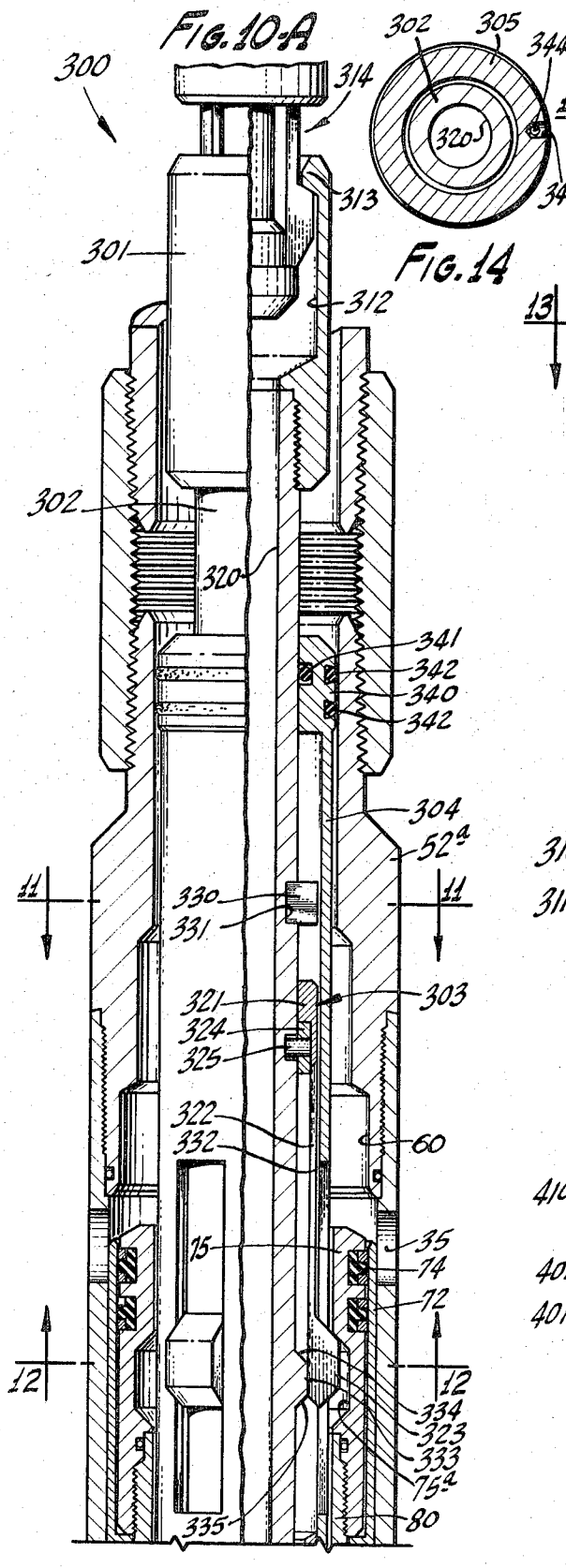


FIG. 14

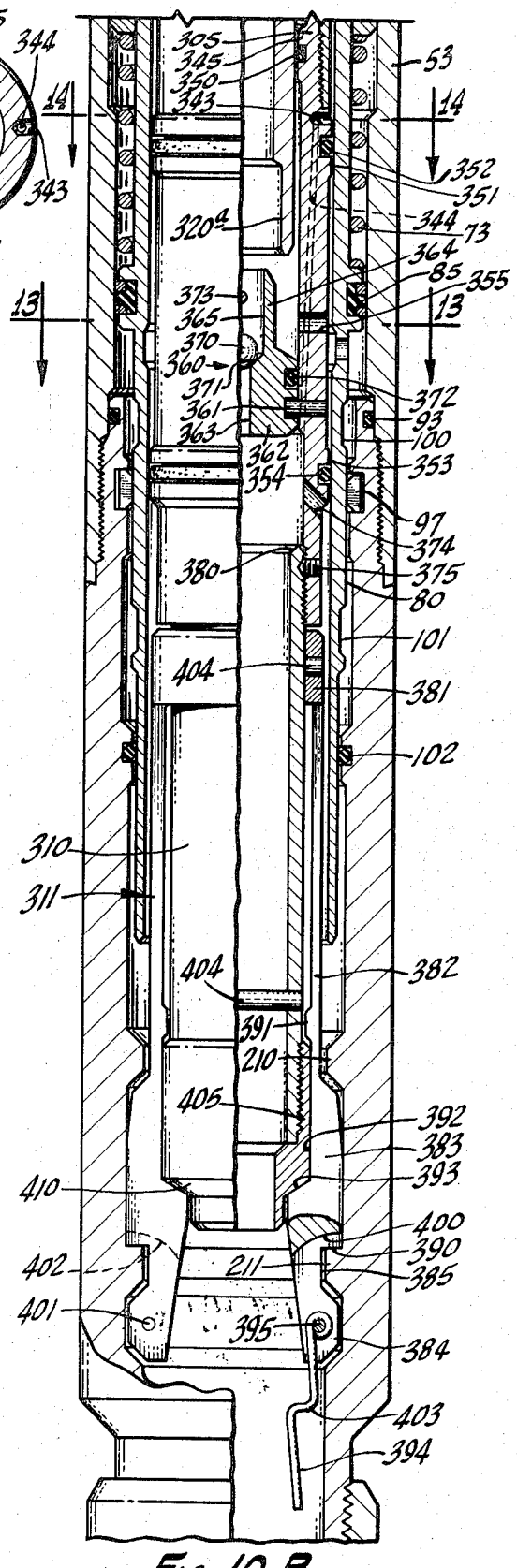


FIG. 10-B

WELL TOOLS

This invention relates to well tools and more particularly relates to sliding sleeve valves for use in the tubing strings of wells.

Sliding sleeve valves for well operation are well known, particularly in the oil industry arts. These valves generally are operated remotely from the surface by mechanical linkage including a tubing string extending to the surface or wireline equipment having an actuating member such as a flexible wireline extending to operating equipment at the surface end of the well. One well known fluid operated sleeve valve requires a fluid pressure from the surface to hold the valve open and does not include an open bore in the valve through which well operations and flow may occur. The presently available valves of the sleeve type use seals which tend to be flow cut as they do not retract fully from the flow path when the valve is open. Also, insofar as presently known, the readily available sleeve valves are not adapted to be opened or closed by use of a combination of mechanical and hydraulic forces. The present valve in contrast may be opened or closed by fluid pressure which may be supplemented by mechanical impact forces from wireline or pumpdown tools.

It is an object of the invention to provide a new and improved well tool of the sleeve valve type.

It is another object of the invention to provide a sleeve valve for use in well tubing which may be opened and closed by application of hydraulic pressure, by a mechanical force, or by a combination of such forces.

It is another object of the invention to provide a sleeve valve of the character described wherein the valve seals move into a protective sleeve below the flow path through the valve to eliminate flow cutting of the seals.

It is another object of the invention to provide a sleeve-type well valve which may be of either a non-selective or a selective form.

It is another object of the invention to provide a sleeve valve of the character described which may be mechanically opened or closed or opened or closed by application of a fluid pressure from the surface.

In accordance with the invention, there is provided a sleeve valve for use in tubing string of a well to provide fluid communication between the interior of the string and the annular space within around the string. The valve includes a housing adapted to be connected in and become a part of the tubing string and provided with one or more side ports for communication between the annulus around the housing and the bore of the housing. A tubular valve member is slidably supported in the housing and provided with a head portion having seals which engage a seal surface above the housing side port for closing the valve when the valve member is in an upper position and for opening the valve when the valve member is in a lower position. A protective cover is movably disposed between the housing and the valve member for preventing flow cutting of the seals in the valve member head when the valve member is moved between open and closed positions. Longitudinally spaced seals are provided between the valve member and the housing defining an annular area of the valve member over which fluid pressure is applied for pumping the valve member between opened and closed positions. With one form of

operating tool, the valve member is mechanically opened by fluid pressure applied from the surface. Other operating tools shown are used for pumping the sleeve valve member closed. When the valve is opened or closed, balanced pressure conditions are applied across the seals so that there is no tendency for pressure conditions within the well bore to bias the valve either open or closed. One form of the valve is non-selective in the sense that the valve operating tools cannot pass through it either upwardly or downwardly without actuating the valve. Another form of the valve includes operating recesses in the valve member and housing which coact with opening and closing tools for selectively operating one of several of the valves in a single tubing string independently of the other valves so that any one of the valves may be opened or closed without affecting the operation of the remaining valves in the string.

The foregoing objects and advantages and the details of preferred embodiments of sleeve type valves constructed in accordance with the invention will be better understood from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a longitudinal schematic view in elevation and section of a well installation using a sliding sleeve valve in accordance with the invention;

FIG. 2–A is a longitudinal fragmentary view in section and elevation of a non-selective form of sleeve valve constructed in accordance with the invention showing the valve closed;

FIG. 2–B is a longitudinal fragmentary view in section and elevation of the sleeve valve of FIG. 2–A opened by an operating tool shown engaged with the valve;

FIG. 3 is a view in section along the line 3—3 of FIG. 2–A;

FIGS. 4–A and 4–B, taken together, constitute a longitudinal view in section and elevation of the sleeve valve of FIG. 2–A being pumped back closed by a tool shown engaged with the valve;

FIG. 5 is a view in section along the line 5—5 of FIG. 4–A;

FIGS. 6–A and 6–B, taken together, constitute a longitudinal view in section and elevation of a selective form of sliding sleeve valve embodying the features of the invention;

FIG. 7 is a fragmentary view in section and elevation showing an opening tool coupled into the sliding sleeve valve of FIGS. 6–A and 6–B illustrating the tool at the lower end of the sleeve valve in an intermediate step in the coupling of the tool with the valve;

FIG. 8 is a fragmentary view in section along the line 8—8 of FIG. 7;

FIG. 9 is a fragmentary view in section and elevation of the opening tool of FIG. 7 showing the tool and the upper end of the sleeve valve during the latter stages of the opening of the valve with the tool;

FIGS. 10–A and 10–B, taken together, constitute a longitudinal view in section and elevation showing the sleeve valve of FIGS. 6–A and 6–B and a tool used for mechanically and/or hydraulically closing the sleeve valve;

FIG. 11 is a partial view in section taken along the lines 11—11 of FIG. 10–A;

FIG. 12 is a fragmentary view in section taken along the lines 12—12 of FIG. 10–A;

FIG. 13 is a partial view in section taken along the lines 13—13 of FIG. 10–B; and

FIG. 14 is a partial view in section taken along the lines 14—14 of FIG. 10–B.

Referring to FIG. 1, a well 20 has a casing 21 which penetrates a producing formation 22 communicating with the well bore through a plurality of perforations 23 in the casing. A tubing string 24 is supported in the casing from a wellhead 25 for producing fluids from the well. The tubing string is set through a packer 30 which seals the annular space 31 around the tubing string within the casing at a depth above the casing perforations 23 so that the well fluids are confined to flow upwardly in the well through the tubing string. A sliding sleeve valve 32 constructed in accordance with the invention is connected in and made a part of the tubing string by upper and lower coupling members 33 and 34, respectively. The sleeve valve has a side port 35 which communicates with the annulus 31. A valve 40 is connected in the tubing string above the wellhead to control the flow of well fluids through the tubing string from the well. A line 41 including a valve 42 is connected with the annulus 31 at the wellhead for control of fluid flow through the well into the annulus. The line 42 may be connected with such external systems as a drilling mud tank. The valve 40, as well as the valve 42, may constitute a part of a sub-sea wellhead or part of a conventional Christmas tree. The tubing 24 above the valve 40 is illustrated in both vertical and curved configurations by broken lines to represent that the tubing may stand directly upwardly and connect to a flowline, not shown, or may bend and run along an ocean floor to a remotely located shore station which serves the well through pumpdown tools. The well may be serviced including the manipulation of the sliding sleeve valve 42 either from directly above by such systems as wireline tools or pumpdown tools, or it may be served through the curved tubing by pumpdown methods and tool systems. The sliding sleeve valve 32 is opened and closed as desired to provide circulation between the tubing string and the annulus 31 as preferred or required by the particular needs of the well system. One or several sliding sleeve valves may be included in the tubing string. Where one non-selective type valve is employed, it will be of the nature of the valve illustrated in FIGS. 2–A through 5. If several valves of the selective type are desired, wherein any one of the valves may be opened or closed independently of the other valves, the type valve represented in FIGS. 6–A through 13 is preferred.

Referring to FIG. 2–A, the sliding sleeve valve 32 comprises a tubular housing 50 and a tubular valve member 51 supported for longitudinal movement within the housing to control flow through the side ports 35. The valve member is movable between and latchable at the closed position of FIG. 2–A and open position of FIG. 2–B. The housing is connectible by the couplings 33 and 34 into the tubing string 24, thereby forming a continuous part of the tubing string in the well bore. The housing includes an upper sub 52, an upper housing section 53 and a lower housing section 54. The upper sub 52 has an upper bore portion 55 which is substantially the diameter of the tubing 24 and an enlarged lower bore portion 60 which receives the upper end portion of the valve member 51. A downwardly and outwardly sloping stop shoulder 61 between the bore portions of the upper sub limits the upward movement of the valve member in the housing. The lower end of the upper sub is reduced externally and threaded at 62 for engagement with an internally threaded upper end portion 63 of the upper housing section. The upper sub threads into the upper end of the upper housing section to a stop shoulder 64 provided in the upper housing section at the lower end of the threaded portion. An O-ring seal 65 in an external annular recess in the lower end portion of the upper sub 52 seals between the upper sub and the upper housing section. A plurality of the side ports 35 are provided in the upper housing section 53 to provide communication to the interior of the sliding sleeve valve. Below the sub shoulder 64, the upper housing section has a bore wall portion 70 which defines an annulus 71 around the valve member 51 in the upper housing to accommodate a seal protector sleeve 72 and a biasing spring 73 mounted on the valve member 51. The sleeve 72 protects a pair of seals 74 on the valve member against flow cutting during the opening and closing of the valve member and while the valve member is open. The seals 74 are carried externally by a tubular head 75 threaded on the upper end of an upper tubular section 80 of the valve member. A ring seal 81 carried by the head 75 seals between the head and the tubular valve section 80. The external head seals 74 on the valve member seal with the housing bore portion 60 in the upper sub 52 when the valve member is at the upper closed position of FIG. 2–A. The lower end edge of the upper sub 52 has an internal downwardly and outwardly sloping seat surface 82 which is engageable by the upper end edge of the protector sleeve 72 when the valve is closed as in FIG. 2–A. The seal protector sleeve has an internal bottom flange 83 which rests on the upper end of the spring 73 for supporting the sleeve and biasing it uwpardly on the valve member so that when the valve member retracts toward the open position, the sleeve remains at an upper end position as the valve member head retracts into the sleeve to protect the seals 74. The lower end of the spring 73 rests on external flange 84 formed around the valve member 51. The flange 84 has an external seal 85 engageable with a reduced bore portion 90 defining a seal surface within the upper tubular housing section 53 below the bore surface 70.

The lower end of the upper housing section 53 is internally threaded along a portion 91 which is engaged on an upper externally threaded portion 92 of the lower housing section 54. An external ring seal 93 carried by the housing portion 92 seals between the upper and lower housing sections. The lower housing section 54 has a bore portion 94 which is reduced in diameter relative to the bore portion 90 of the upper housing section. A still further reduced bore portion 95 defines a flange in the housing portion 92 provided with an internal recess 96. A snap ring 97 disposed in the internal recess 96 is releasably engageable in an upper external locking recess 100 and a lower external locking recess 101 of the valve member 51 for selectively locking the valve member at the upper position of FIG. 2–A and the lower position of FIG. 2–B. The locking recesses 100 and 101 are longitudinally spaced along the valve member to lock the valve member at the upper closed position and the lower open position. The upper and lower ends of the locking recesses 100 and 101 in the valve member as well as the upper lower internal edges of the snap ring 94 are chamfered as illustrated to provide smooth positive engagement and disengagement

of the snap ring in the two locking recesses in the release and locking the valve member at the upper and the lower positions and during movement between such positions.

The lower end portion of the valve member below the recess 101 slides in sealed relationship through an internal O-ring 102 supported in an internal annular recess within an internal flange 103 of the lower housing section 54. A side port 104 is provided in the valve member between the upper and lower locking recesses 100 and 101 to permit fluid communication into the annular space along the housing around the valve member between the seal 85 and the seal 102 to permit pumping the valve member to the closed position. The line of sealing engagement of the seal 85 with the housing seal surface 90 is larger than the line of sealing engagement of the valve member with the seal 102 providing an effective annular area over the valve member to which fluid pressure may be applied for both opening and closing the valve member responsive to fluid pressure.

The lower housing section 54 is reduced and externally threaded along a lower end portion 105, FIG. 4–B, connected into the lower coupling 34 for securing the lower end of the valve housing into the well tubing string 24 below the valve as seen in FIG. 1.

The valve 32 is opened either mechanically or hydraulically by means of an opening tool 110 illustrated in FIG. 2–B. The opening tool has a tubular operator member 111 provided with a chamfered lower external edge 112 engageable with a corresponding upper internal edge surface 113 on the head 75 of the valve member to supply a downward mechanical force to the valve member for opening the member. A pair of external ring seals 114 are carried by the operator member 111 to seal with the bore surface 55 of the upper housing sub 52 so that the opening tool may be pumped downwardly as discussed hereinafter. An upper end portion 115 of the operator member is externally threaded into the lower end of a tubular cage 120 which is provided with side ports 121 and internal upper end flange 122. An annular valve seat member 123 is clamped within and between the operator member 111 and the cage 120 to cooperate with a valve head 124 on a stem 125 for closing off flow through the bore of the operator member. The valve seat member 123 has an external upper end flange 130 engaged in an internal recess 131 of the cage at the upper end of the portion 115 of the operator member for clamping the valve seat member between the cage and operator member as shown. The valve seat member 123 has a downwardly and inwardly sloping upper valve seat surface 132 provided with an internal seal 133 which is engageable by a downwardly and inwardly sloping conical valve surface 134 on the valve head 125. The enlargement of the valve head 125 provides an upper end shoulder 135 which is engageable with the internal flange 122 of the cage 120 for coupling the stem 125 in the cage. The distance between the valve seat 123 and the flange 122 permits longitudinal movement of the stem and valve head 125 between the lower closed position of FIG. 2–A and an upper position at which flow may occur through the side ports 121 in the cage and the valve seat. The upper end of the stem 125 is threaded into a fishing head 140 and secured by a pin 141 engaged through the stem and head.

With the sleeve valve 32 in closed position as in FIG. 2–A, the upper end edge of the head 75 of the valve member 51 engages the stop shoulder 61 within the valve housing section 52. The seals 74 seal between the housing bore surface 60 and the upper end of the valve member precluding flow into the bore of the valve since the seal 85 forms a closure below the ports 35 between the valve member and the valve housing. The protective sleeve 72 is biased to the upper position by the spring 73 with the upper end of the sleeve engaging the housing edge surface 82 precluding direct fluid contact with the seals 74. The snap ring 94 is engaged in the lower locking recess 101 of the valve member releasably holding the valve member at the upper closed position. The valve is fully pressure balanced so that there is no tendency for the pressure within the well annulus 31 as communicated through the side ports 35 to open the valve, and, similarly, the pressure within the tubing string 24 will not open the valve. The annulus pressure supplied to the side ports 35 is communicated into the valve annulus 71 between the seals 85 and 74, both of which seal with the valve housing along lines of equal diameter so that the upwardly and downwardly facing areas of the valve member exposed to the external pressure are equal. Similarly, the pressure within the bore of the valve, which is the pressure within the tubing string 24, acts above the seals 74 and below the seal 85 due to the pressure of the side port 104 in the valve member. The tubing pressure is applied below the seal 102 and above the seal 102 through the side ports 104 so that the upwardly and downwardly facing pressures affected areas of the valve member are all equal as exposed to the tubing pressure.

When opening of the valve 32 is desired, the opening tool 110 is inserted into the tubing string at the surface end of the well and transported to the sliding sleeve valve 32 by suitable standard wireline or pumpdown tools and methods, both of which are conventional and well known. As the opening tool moves down through the tubing string, fluid within the tubing string readily bypasses the opening tool flowing upwardly through the bore of the operator member 111, the bore of the valve seat 123 biasing the valve head 124 and stem 125 to an unseated upper position so that the bypassing fluids flow upwardly in the bore of the cage 120 and outwardly back into the tubing string through the side ports 121 of the cage. The opening tool moves into the valve housing coming to rest in the valve on the valve member 51 in the relationship represented in FIG. 2–B. The lower end edge 112 of the opening tool operator member 111 engages the upper edge 113 of the valve member head 75. The seals 114 on the operator member seal with the bore surface 55 in the upper sub of the valve housing. With the opening tool so positioned in relation to the valve member and the valve housing, fluid pressure is applied from the surface in the tubing string 24 urging the valve head 124 into the closed seated relationship shown in FIG. 2–B on the valve seat 123 closing off flow downwardly through the running tool. As the fluid pressure above the running tool in the tubing string is increased, the running tool is forced downwardly in the valve housing. When the force is at a sufficient level, the snap ring 94 is cammed outwardly from the upper locking recess 101 in the valve member 51 releasing the valve member for downward movement in the housing. The valve member is forced downwardly by the fluid pressure applied to the running tool

so that the valve member head **75** moves downwardly within the bore portion **60** of the upper sub of the valve housing. The upward bias of the string **73** holds the seal protector sleeve **72** against the sub edge surface **82** as shown in FIG. **2**–A while the valve member is moving downwardly. The head **75** retracts into the protective sleeve. The protective sleeve remains in the upper closed position until the lower end edge **75***a* of the valve head engages the top surface of the flange **83** in the sleeve **72.** Fluid flow from the ports **35** cannot reach the seals **74** as the head **75** and the seals move downwardly into the sleeve **72.** Further downward movement of the valve member carries the spring biased sleeve **72** downwardly with the valve member as shown in FIG. **2**–B. At the time that the valve head picks up and forces the protective sleeve downwardly, the sleeve has fully covered the ring seals **74** on the valve member head so that at no time during the opening of the valve are the seals **74** exposed to flow cutting by fluid from the annulus **31** entering the valve through the side ports **35.**

The valve member **51** is forced downwardly by the opening tool **110** until the lower edge of the valve member flange **84** engages the upper end **54***a* of the lower housing section **54** at which time the snap ring **94** contracts into the upper locking recess **100** on the valve member releasably locking the valve member in the lower open position of FIG. **2**–B. The opening tool is then withdrawn from the tubing string to permit fluid communication into the string through the open side ports **35.** As the opening tool is lifted from the valve housing, the raising of the fishing head **140** permits the operator member **111,** the cage **130,** and the seat member **123** to drop downwardly on the stem **125** until the shoulder **135** on the valve head **124** engages the lower edge of the internal flange **122** of the cage. At this hanging position of the cage, operator member, and valve seat member, fluid in the tubing string can readily flow downwardly through the side ports **121** and the bores of the valve seat member **123** and operator member **111** to permit fluid bypass of the opening tool as it is withdrawn from the tubing string.

While at the upper closed position of the valve shown in FIG. **2**–A, there is some force from the spring **73** against the sleeve **72** urging the valve member downwardly, the strength of the snap ring **94** is sufficient to prevent the spring from opening the valve member. At the lower opening position of the valve member shown in FIG. **2**–B, there is not, however, any force from the spring **73** to move the valve member as the full force of the spring is exerted against the sleeve **72** which is urged against the lower end **75***a* of the head **75** of the valve member. Also, at no time during the opening of the valve are the seals **74** ever exposed to fluid flow from the well bore, and at the fully open position shown in FIG. **2**–B, the seals **74** are fully retracted into the protective sleeve **72** so that there is no exposure to fluid flow passing inwardly through the side ports **35.**

As shown in FIG. **4**–A, the upper sub **52** is slightly enlarged in internal diameter at **52***a* providing an upwardly facing stop shoulder **52***b* within the upper sub for the seating and support of a closing tool **150** used for pumping the valve member **51** of the sliding sleeve valve **32** back upwardly to the closed position of FIG. **2**–A. The closing tool has an upper tubular head section **151,** a central body section **152** and a lower body section **153.** The head section has an enlarged upper portion **154** provided with an internal flange **155** to permit engagement of the closing tool by suitable handling tools, either pumpdown or wireline. A pair of external seals **160** are carried by the body portion **154** for sealing with the bore surface **55** of the upper sub **52.** The upper body section is reduced in diameter at **161** to provide an annular space around the closing tool within the housing of the valve for movement of the valve member **51** back upwardly to the closing position. The lower end of the upper tool housing section **151** is reduced and externally threaded at **162** for connection in the upper end of the central tool housing section **152.** The lower end portion of the housing section **151** also has a plurality of circumferentially spaced downwardly opening recesses **163** which communicate with outwardly opening arcuate slots **164** providing a fluid bypass function described hereinafter. The upper housing section **151** has a central bore **165** which is of the same diameter as and in communication with a central bore **170** of the central housing section **152.** The central housing section has an external diameter of the same dimensions as the diameter of the upper housing section **151** and is provided with a pair of longitudinally spaced external flanges **171** and **172** which are provided, respectively, with upper seals **173** and lower seals **174** defining an annular space **175** within the valve member around the central housing section **152** of the closing tool when the tool is in operating position within the sliding sleeve valve. A side port **176** provided in the central housing section **152** between the flanges **171** and **172** the bore **170** with the annulus **175** around the tool between the seals **173** and **174** within the valve member section **180** of the sliding sleeve valve when the closing tool is in operative position within the valve. Referring to FIG. **4**–B, the central tool section **152** has a reduced externally threaded portion **180** engaged in the internally threaded upper end portion of the botton section **153.** The intermediate tool section **152** has a still further reduced lower end portion **181** supporting a ball check valve assembly **182** which functions to bypass fluid in the tubing string as the tool is lowered in the string and to close the tool to fluid flow when pressure is required for operating the tool to close the sliding sleeve valve. At the junction of the tool section portion **180** with the lower end portion **181,** a downwardly opening slot or recess **182** is provided in communication with a longitudinal bore **183** in the tool section **152.** The bore **183** extends upwardly the entire length of the tool section opening at the upper end into the downwardly opening recess **163** of the upper tool section **151** to provide fluid bypass during the final stages of closing the sleeve valve with the tool.

The check valve assembly **182** includes a valve seat member **184** having a lower end flange **185** and a longitudinal bore **190** which opens through a ball valve seat **191** for supporting a ball check valve **192.** An external ring seal **193** in an external annular recess of the ball seat member seals between the member and the lower end portion **181** of the section **152** of the closing tool. The check valve assembly is held in place by a shear pin **194** extending through the tool section portion **181** into an external recess provided in the valve seat member. A stop pin **195** is secured across the tool section portion **181** above the ball limits upward movement of the ball. Lateral ports **200** in the bottom tool section **153**

allow bypass fluid to flow through the tool during movement of the tool in the tubing string.

For closing the sliding sleeve valve **32**, the closing tool **150** is inserted into the well at the surface and transported to and installed in the sliding sleeve valve to the position illustrated in FIGS. 4–A and 4–B by suitable pumpdown or wireline procedures and equipment. In installing the closing tool, the downward movement of the tool is limited by the engagement of the tool head portion **154** with the internal stop shoulder **52b** in the upper sub **52** of the sliding sleeve valve housing. During the downward movement of the closing tool in the tubing string, fluids in the string bypass the tool by flowing upwardly into the tool bore through the side ports **200** in the bottom section **153** of the tool, through the bore **190** of the valve seat member **184** lifting the ball check valve **192** above the seat **191** upwardly against the stop pin **195**, around the ball check valve upwardly into the bore **170** of the closing tool, and outwardly through the upper end of the closing tool back into the well tubing. When the closing tool is seated in the sliding sleeve valve, the upper and lower seals **173** and **174** on the central section of the tool span the side port **104** of the valve member **51** of the sliding sleeve valve. The fluid pressure within the tubing string above the closing tool is increased applying the higher pressure outwardly through the side port **176** into the annular space **175** around the closing tool within the valve member of the sliding sleeve valve between the seals **173** and **174.** At the same time that the pressure within the tubing string above the closing tool exceeds the pressure below the tool, the ball check valve **192** forced downwardly to the closed seated relationship on the valve seat **191** shown in FIG. 4–B. The pressure increase is communicated through the side port **104** of the sliding sleeve valve member **51** into the annular space around the valve member between the ring seals **85** and **102.** Since the annular area on the valve member **51** is defined by the difference in the lines of sealing engagement of the ring seals **85** and **102** with the sleeve valve housing faces downwardly, the increases in fluid pressure between the seals applies an upward force to the valve member **51.** When the upward force exceeds the force of the pressure being applied to the valve member from the well annulus **31** through the side ports **35** of the sliding sleeve valve and the holding force of the lock ring **97**, the lock ring is cammed outwardly from the upper locking recess **100** releasing the valve member **51** of the sliding sleeve valve for upward movement. FIGS. 4–A and 4–B show the valve member **51** fully released and partially moved upwardly toward the closed position within the valve housing. The pressure increase in the closing tool forces the valve member **51** upwardly in a first closing stage during which the seal protector sleeve **72** is carried upwardly in the sheathed relationship over the valve member seals **74** protecting the seals from being flow cut. When the upper end edge of the sleeve engages the lower end edge of the upper valve housing sub **52**, the protective sleeve seats against the valve housing sub and is held against further upward movement. This seated relationship while not being a pressure-tight seal is tight enough that there is no fluid flow past the sleeve to flow cut the seals **74** as the head of the valve member **51** moves upwardly into the bore **60** of the valve housing upper sub. The head moves upwardly with the seals **74** passing out of the protective sleeve **72** into the sub **52** along the surface of the bore **60** of the sub until the valve member **51** is stopped by engagement of the upper end of the head **75** with the stop shoulder **61** in the sub **52.** At this upper end closed position of the valve member, the various component parts of the sleeve valve **32** are all moved back to the positions shown in FIG. 2–A at which the snap ring **197** contracts into the lower locking recess **101** to releasably lock the valve closed. During the final stages of the closing of the sliding sleeve valve, when the upper seals **74** on the head of the sleeve valve member enter the bore **60** of the sub **52,** the fluid within the valve housing above the seals **74** is displaced downwardly within the valve member along the annulus around the closing tool section **151** within the valve member to the slots **164** which communicate with the downwardly opening annular recess **163.** The fluid displaced downwardly through the slots and the recesses **163** enters the longitudinal bore **183** in the central section **152** of the closing tool. The bypassed fluids flow downwardly in the passage **183** to the bottom recess **182,** into the lower tool section **153,** and outwardly through the side ports **200** so that the trapped fluids above the valve member seals **74** are permitted to escape allowing the valve member **51** to return to the upper end closed position.

With the valve closed and the lower end of the closing tool shut by the ball check valve **192,** the pressure will hold as there is no way for it to leak off. The pressure above the sleeve valve is built up sufficiently to shear the pin **194** releasing the check valve seat **184** with the ball **192** to drop downwardly to the lower end of the bottom tool section **153** relieving the pressure in the tubing string of the tool by permitting the fluids in the string to bypass downwardly through the tool and outwardly back into the tubing string in the side ports **200.** A suitable standard fishing tool is introduced into the tubing string to engage the fishing head **154,** remove the tool from the closed sliding sleeve valve and withdraw the tool from the well at the wellhead.

Another form of sleeve valve **32A** incorporating the principals of the invention is shown in FIGS. **6**–A and **6**–B in the closed position. All of the features of the sleeve valve **32A** are identical to the sleeve valve **32** with the exception of certain selected internal recesses and flanges and the dimensional characteristics of certain portions of the valve housing to adapt the valve to selective operation where several valves are installed in tandem in a single tubing string and the opening and closing of one or more of the valves in a certain sequence is desired. All of the features and components of the valve **32** which are common to the valve **32A** are designated by the same reference numerals used in the description of the valve **32.** Features which represent a modification as designated by the same reference number with "A" added. The upper sub **52A** of the valve **32A** has a smooth interal bore **55A** thereby eliminating the stop shoulder **52B** shown in the upper sub **52** of the valve **32.** The elimination of this stop shoulder is necessary inasmuch as operating tools for the valve **32A** frequently must pass downwardly entirely through the tool to perform the selective function of opening and closing one or more designated valves in a group. The sub **52A** also has an enlarged bore portion **55B** defining a recess for collet fingers on an opening tool as shown in FIGS. **7–9.** The side port **104A** of the valve **32A** corresponds with side port **104** of the valve **32,** but is located immediately below the flange **84** carrying the

seal **85.** The lower housing section **54A** of valve **32A** is substantially lengthened and provided with internal flanges **210** and **211** which are longitudinally spaced apart defining an internal locking recess **212** the bottom surface of which forms by a stop shoulder **213** which also is the top surface of the lower flange **211.** The flange **211** is spaced above the lower end bore portion **215** of the bottom housing section defining a lower recess **214.** The flange **210** has inwardly tapered upper end lower surfaces while the lower surfaces of the flange **211** is upwardly and inwardly tapered. The lower end of the internal recess **214** is defined by a downwardly and inwardly tapered surface. The head **75A** of the valve member **51A** has an internal locking recess **75a** for engagement of an upper collet on a closing tool shown in FIGS. **10**–A and **10**–B. The other features of the valve **32A** are identical to the valve **32.**

The valve **32A** is selectively opened by use of an opening tool **220** illusttated in FIGS. **7**–**9.** The head end portion of the opening tool **220** includes identical parts to those of the tool **110** shown in FIG. **2**–B and thus will be designated by the same reference numerals. The cage member **120** and the valve seat member **123** are connected on an upper body section **215** having an enlarged flanged head **220** which carries external ring seals **221** for sealing with the bores **55A** of the upper sub **42A.** The lower end of the head **220** defines a collet stop shoulder **222.** The lower end of the body section **215** is reduced and externally threaded at **223** into the upper end of a lower body section **224.** A bottom nose member **225** is threaded on the lower end of the section **224.** The body section **224** has an upper external flange **230** provided with upper and lower sloping shoulder surfaces, with a central external annular flange **231** having upper and lower sloping shoulder surfaces, and with a first lower flange **232** which has abrupt upper and lower shoulder surfaces and is spaced above a lower second external flange **223** defining a lower external annular recess **234** on the body member. The flange **232** is spaced below the flange **231** defining a recess **235.** A collet **240** is releasably secured by a shear pin **241** to the tool body section **215.** The shear pin **241** passes through a ring shaped collet head **242** from which a plurality of circumferentially spaced collet fingers **243** depend. Each of the collet fingers has an elongated external boss **244** and a lower latch flange **245.** Each of the collet fingers also has an internal recess **250.** A collet finger locking sleeve **251** is disposed around the lower section **224** of the tool body for movement between a collet locking position as shown in FIG. **7** and a collet release position shown in FIG. **9.** The locking sleeve has a plurality of circumferentially spaced windows **251***a* for operating lugs **252,** each of which has end ears or flanges **253** which extend from the opposite vertical ends of the lugs behind the windows to hold the lugs in the windows while permitting them to radially expand and contract. A pair of identical coil springs are positioned within the sleeve above and below the lugs inside of the lug ears biasing the outer portions of the lugs radially outwardly through the windows. The locking sleeve is provided internally with a lower end flange **255** and annular recess **260.** A snap ring **261** is disposed in the body recess **234** to coact with the locking sleeve **251** as discussed hereinafter. The upper end portion of the locking sleeve **251** is sized to telescope over the latch flanges **245** on the collet fingers as shown in FIG. **7** to clamp the collet fingers radially inwardly around the tool body. A stop pin **242A** is secured through the tool body section **215** below the collet head **242** to hold the collet against downward movement on the tool body. Basically, the function of the collet sleeve locking arrangement is to permit the opening tool to move downwardly as desired through any number of sliding sleeve valves without activating the sleeve shifting collet **240** and to release and activate the collet upon upward movement of the opening tool through a selected one of the sliding sleeve valves.

A typical installation using the valves **32A** will include several such valves connected at spaced locations along the length of the tubing string so that the valves are at different depths within a well. Such valves may be individually selectively opened and closed by use of the tools disclosed herein. When all of the valves are closed as shown in FIGS. **6** and the opening of one of the valves is desired, the opening tool **220** is run in the well on wireline or pumpdown tools as desired. The tool is run in with the collet fingers **243** positioned longitudinally and latched inwardly as shown in FIG. **7.** The tool body flange **230** is aligned with the collet finger recesses **250** permitting the collet finger to be contracted tightly around the tool body as shown. The fingers are held contracted by the locking sleeve **251** which is latched at an upper positon by the detent ring **261.** As shown in FIG. **7,** the normal diameter of the detent ring is sufficient for the ring to engage the lower end of the sleeve **251** to hold the sleeve at the upper position. When latched upwardly, the sleeve **251** and lugs **252** are longitudinally movable between the positions illustrated in FIG. **7** to an upper position, not shown, at which the lugs **252** are above the flange **231** and thus may be cammed inwardly sufficiently to allow the tool to pass downwardly through a sliding sleeve valve bore. At the upper end portion and the intermediate position of FIG. **7** of the locking sleeve and the lugs the locking sleeve **251** is telescoped over the collet finger flanges **245** holding the finger inwardly. At the normal expanded positions of the lugs, the outer bosses of the lugs project through the windows of the locking sleeve to an effective diameter greater than the bore through the valve member **51A** of the sliding sleeve valve. Thus, as the opening tool **220** moves downwardly in the tubing string and passes into the valve member of a sliding sleeve valve, the lugs **252** engage the upper end edge of the valve member causing the lugs and the locking sleeve **251** to be lifted from the position shown in FIG. **7** to an upper end position at which the locking sleeve is telescoped farther upwardly on the collet finger flanges **245** and the lugs **252** are above the flange **231** on the tool body. When above the flange **231** the lugs are cammed inwardly when they engage the upper end of the valve member **51** allowing the opening tool to pass downwardly through the sliding sleeve valve. When it is determined by either wireline or pumpdown techniques, depending on which approach is being used, that the tool **220** has passed below the selected sliding sleeve valve to be opened, the tool **220** is lifted back upwardly into the sliding sleeve valve to be operated. The opening tool passes into the sliding sleeve valve housing with the lugs **252** biased outwardly in the windows of the locking sleeve to a diameter greater than the diameter of the bore of the valve member of the sliding sleeve valve. The outer bosses of the lugs **252** engage the lower end edge of the valve member of

the sliding sleeve valve as shown in FIG. 7, dragging the lugs and locking sleeve 251 downwardly on the tool body with the lugs moving downwardly into alignment with the flange 231 on the tool body. At this position of alignment with the flange 231, the lugs cannot be cammed inwardly and thus are caught between the flange 231 and the lower end edge of the sliding sleeve valve member. As the tool continues upward movement, the lugs can only move downwardly and thus they are forced downwardly dragging the locking sleeve 251 downwardly while camming the split ring 261 inwardly in the recess 234 releasing the locking sleeve 251 and the lugs 252 to move farther downwardly to the positions shown in FIG. 9 at which the split ring 261 springs back outwardly engaging the internal recess 260 of the locking sleeve to releasably lock the sleeve and lugs at the lower end position. The movement of the lugs and locking sleeve from the intermediate to the lower position retracts the upper portion of the locking sleeve from the locking flanges 245 of the collet fingers releasing the collet fingers to spring outwardly.

As the tool 220 continues upward movement in the valve member of the sleeve valve, the collet fingers drag along the bore surface of the sleeve valve member until the toll is lifted above the valve member at which time the fingers spring back outwardly into the bore of the upper sub and the bore of the tubing string above the sliding sleeve valve housing if the tool is lifted above the sliding sleeve valve. The opening tool is then run back downwardly with the collet fingers 243 dragging along the wall of the tubing string and then moving into the bore 55A of the upper sub 52A of the sliding sleeve valve immediately below it. The seals 221 around the head 220 and the valve 124 in the tool cage 120 seal the upper end of the tool in the sleeve valve housing so that the opening tool may be pumped downwardly to open the sleeve valve. When the collet fingers reach the enlarged bore portion 55B, they spring outwardly with the downwardly facing abrupt shoulders 244a on the collet fingers engaging the upper end of the sleeve valve member 51 preventing further downward movement of the collet 240. Additional downward force on the opening tool shears the pin 241 so that the tool body 215 along with the connected parts move downwardly in the collet with the body flange 230 moving behind the collet fingers below the finger recesses 250 so that the collet fingers cannot be cammed inwardly but rather are held outwardly by the flange 230 as shown in FIG. 9. With the expanded collet fingers on the top of the sleeve valve member and the tool head portion 220 seated on the top edge of the collet finger head 242, downward force on the opening tool drives the sleeve valve member downwardly to open the sleeve valve. As previously described, the downward fluid pressure in the tubing string above the opening tool forces valve surface 134 on the stem 125 into a fluid-tight relationship against the valve seat 123 while the ring seals 221 are in sealed relationship along the upper sub bore surfaces 55A. Thus, a sufficient fluid pressure level above the opening tool forces the running tool downwardly moving the sleeve valve member 51A downwardly to open the sliding sleeve valve 32A. From this step of engagement of the collet fingers with the upper end of the sleeve valve member 51A to the completion of the opening of the sleeve valve, the step are identical to those described in connection with opening the valve 32 by means of the opening tool 110.

After the sleeve valve is fully opened to the position represented by 2–B, the opening tool 220 is withdrawn from the tubing string. It will be apparent that as the tool is lifted the bosses 244 of the collet fingers engage the sub surfaces at the upper end of the sub bore portion 55B dragging the collet downwardly on the tool body 215 until the collet ring 242 engages the stop pin 242a at which collet position the flange 230 is again aligned with the collet finger recesses 250 so that the collet fingers may be cammed fully inwardly around the tool body to release the tool from the sleeve valve. At this released position of the collet, the fingers drag along the tubing surface and cam inwardly when pipe joints are passed. The locking sleeve 251 and the lugs 252 reamin at the positions shown in FIG. 9 with the lugs being free to cam farther inwardly into the recess 235 so that the lugs allowing the tool to freely pass any restriction smaller than the expanded diameter of the lugs. During the lifting of the tool 220 in the tubing string, the portions of the tool hanging from the cage 120 pull the cage downwardly so that the head 125 is above the ports 121 in the cage. Fluids in the tubing string bypass the tool downwardly through the cage and the valve seat 123 flowing through the central bore of the valve body of the tool back into the tubing string.

The opening tool may be reset for reuse by installing a new shear pin 241 locking at the collet 240 at the position shown in FIG. 7 and moving the locking sleeve 251 with the lugs 252 back upwardly until the sleeve is over the end flanges 245 of the collet fingers and the split ring 261 is expanded to locking position below the lower end of the sleeve 251 as also shown in FIG. 7.

Any one or all of the sliding sleeve valves of the type 32A may be opened in a tubing string provided the proper sequence of operation is employed. It will be evident that once the latch sleeve 251 is shifted downwardly to the position of FIG. 9, the collet fingers 243 are released and cannot be contracted back inwardly without removing the tool from the well and resetting it. The tool, however, can be readily moved upwardly through any desired number of sliding sleeve valves. Thus, it is essential that if a series of sleeve valves are to be opened during a single operation of the opening tool, the bottom valve in the series must be opened first, and thereafter the opening tool is moved upwardly and back downwardly as desired at each of the succeeding sliding sleeve valves up the tubing string.

The sliding sleeve valve 32A is selectively closed by use of a closing tool 300 illustrated in FIGS. 10–A, 10–B, and 11–14. The closing tool has a fishing neck 301 threaded on the upper end of a mandrel 302 which supports an upper collet 303 and an outer housing sleeve formed by an upper sleeve section 304, a middle sleeve section 305, and a lower sleeve section 310. A lower locking collet 311 is supported from the lower sleeve section 310. The lower locking collet releasably locks the opening tool in the sliding sleeve valve housing while the upper collet releasably locks with the valve member of the sliding sleeve valve giving the opening tool the capability of also mechanically applying a closing force to the valve member in the event that the hydraulic pressure to pump the sleeve valve closed meets with excessive resistence such as when the

sleeve valve member is lodged or jammed open in some manner.

The closing tool fishing neck **301** has an internal recess **312** and an upper internal annular flange **313** which is engageable by a suitable running tool **314** supported from conventional wireline or pumpdown equipment. The recess **312** of the fishing head opens downwardly to a longitudinal bore **320** of the tool mandrel **302.** The upper collet **303** includes a head ring **321** and a plurality of circumferentially spaced dependent integral collet fingers **322** having locking heads **323.** The collet **303** is slidable on the mandrel **302** and supproted against the downward movement by a ring **324** secured to the mandrel by a shear pin **325.** Upward movement of the upper collet **303** is limited by a pair of split rings **330** in an external annular recess **331** of the mandrel **302** as seen in detail in FIG. **11.** The upper housing sleeve **304** has circumferentially spaced slots **332** positioned to permit the locking heads **323** on the collet **303** to project through the slots as shown in FIG. **10–A** for locking with the sleeve valve member **51A.** The slots **332** are of sufficient length to permit longitudinal movement of the upper collet heads within the limits required for operation of the opening tool. The tool mandrel **302** has an external flange **333** provided with tapered upper and lower shoulder surfaces **334** and **335,** respectively, for holding the collet finger heads **323** outwardly at locking positions as shown in FIG. **10–A.**

The upper sleeve section **304** is formed integral with an annular piston head **340** which has an internal seal **341** and external seals **342** for sealing around the mandrel **302** and within the bore of the sleeve valve housing upper sub **52A.** Referring to FIG. **10–B,** the lower end of the tool housing sleeve **304** is threaded on an upper end portion of the middle housing sleeve **305.** Immediately below the joint of the upper sleeve section with the middle sleeve section, the middle sleeve section has a side opening blind bore **343** which communicates with a longitudinal flwo passage **344** formed in the wall of the middle sleeve section and sloping downwardly and inwardly opening into the bore of the middle sleeve section for pressure relief purposes discussed in connection with the description of the operation of the opening tool. The middle sleeve section has an internal flange **345** which carries a ring seal **350** for sealing around the mandrel **302** within the sleeve section. The middle sleeve section also has an upper external flange **351** provided with a ring seal **352** and a lower external flange **353** which carries a ring seal **354** above and below a side prot **355** positioned to communicate fluid under pressure to the sliding sleeve valve for pumping the valve closed when the opening tool is in operating position within the valve.

A ball check valve assembly **360** is releasably held within the middle sleeve section **305** below the lower end of the mandrel **302** by a shear pin **361.** The check valve has a lower body portion **362** and a provided with a bore **363** and a reduced upper neck portion **364** having a larger bore **365** which accommodates a ball check valve **370.** The ball valve seats on a valve surface **371** defined at the juncture of the bore **365** with the bore **363** in the valve body. An external ring seal **372** is positioned in a recess around the check valve body to seal within the bore of the middle sleeve section. A stop pin **373** is secured across the neck portion **364** of the check valve body to confine the ball valve member limiting upward movement valve from the valve seat. The check valve assembly permits the opening tool to move downwardly in a fluid filled tubing string and holds against the downward flow when the tool is seated in a sliding sleeve valve to permit application of the required fluid pressure to the sleeve valve to pump it closed. The shear pin **361** permits the check valve assembly to be displaced downwardly for fluid bypass to allow removal of the opening tool from the well bore after it has performed the sleeve valve opening function. The lower end of the mandrel **302** has an enlarged bore portion **320***a* to permit the mandrel to telescope downwardly over the check valve body during operation of the closing tool.

Below the seal **354** the lower end portion of the middle sleeve section **305** is provided with a side port **374** which is located longitudinally in the housing sleeve to position the port above the check valve body portion **362** for fluid bypass when the check valve is released by the shear pin **361** and drops downwardly in the housing sleeve in taking the closing tool out of the well bore. The lower end portion of the middle housing sleeve **305** is threaded on the upper end portion of the lower sleeve section **310.** A set screw **375** threaded through the lower end portion of the middle sleeve section **305** into the upper end portion of the lower sleeve section holds the two sleeve sections together. The external diameter of the lower housing sleeve section **310** is substantially equal to the internal diameter of the intermediate housing sleeve section **305** providing a stop shoulder **380** on the upper end of the lower sleeve section which limits the downward movement of the check valve assembly **360** after the pin **361** has been sheared. The bottom locking collet **311** has a head ring **381** on which a pair of dependent collet fingers **382** are formed. Each of the collet fingers has a head provided with an external locking profile defined by an upper boss **383,** a lower boss **384,** and a recess **385.** The lower end of the boss **383** is an abrupt locking shoulder **390.** Internally the locking fingers **382** each is provided with a detent flange **391,** a locking recess **392** and a lower internal stop shoulder **393.** The collet fingers **382** are latched together in a contracted relationship by a lock wire **394** supported from a pin **393** extending laterally across a downwardly opening slot **400** in the bottom end of one of the collet fingers **382** while a latch pin **401** is secured across a similar slot **402** in the bottom end of the other of the collet fingers of the lower locking collet. The lock wire **394** has a hook-shaped latch portion **403** which engages the pin **401** when the spring is lifted to a generally horizontal locking angle for releasably holding the collet fingers of the lower locking collet contracted together for running the closing tool into a well bore. The lower locking collet is initially supported on the lower housing sleeve section **310** at a lower end position, not shown, by a shear pin **404** which is shown in a sheared condition in FIG. **10–B** which shows the lower locking collet expanded and the lower housing sleeve section **310** telescoped into the collet to lock the collet within the sliding sleeve valve housing. The lower housing sleeve section **310** is threaded into an expander and locking nut **405** which has a downwardly and inwardly sloping surface **410** to seat on the stop shoulders **393** within the lower locking collet heads limiting the downward movement of the housing sleeve within the lower locking collet. The external diameter of the nut **405** is slightly larger than the

effective internal diameter of the detent flanges 391 within the collet fingers of the lower locking collet so that the nut 405 is releasably held by the collet fingers at the lower position shown in FIG. 10–B locking the housing sleeve in the sleeve valve. The dimensional relationship of the locking nut 405, the detent flanges 391 of the lower locking collet fingers, the thicknesses of the lower locking collet fingers below the flanges 391, and the inside diameter of the flange 210 within the lower housing portion of the sleeve valve 32A are so related that a detent function is served by the collet finger flanges 391 and the lock nut 405. With the closing tool 300 locked as shown in FIG. 10–B, the lower collet fingers hold the lock nut 405 and housing sleeve section downwardly as illustrated until sufficient upward force is applied on the housing sleeve and the lock nut 405 to spread the collet fingers within the sleeve valve housing to allow the nut 405 to be released and pass upwardly within the collet finger flanges 391 which are spread apart by upward movement of the nut.

When the tool 300 is being prepared to close the sliding sleeve valve 32A, the lower locking collet 311 is telescoped downwardly on the housing sleeve section 310 to a position at which the shear pin 404 locks the collet ring 381 in alignment with that central portion of the shear pin shown in FIG. 10–B so that the ring 381 is pinned just slightly above the upper end of the nut 405. At this position of the lower locking collet, the major portion of the lengths of the collet fingers extends downwardly below the expander nut and the collet heads are latched together in contracted positions by hooking the latch portion 403 of the lock spring 394 over the pin 401 holding the two collet finger heads in a closely spaced contracted relationship with the free end of the lock spring 394 extending laterally from the pin 401 so that it drags along the wall of the tubing string as the closing tool is lowered in the string. The closing tool is coupled at the fishing neck 301 with a suitable handling tool 314 run into the wall by either pumpdown or wireline methods. With the exception of the lower locking collet 311 being secured by the shear pin 404 at a lower end position, and the collet fingers of the lower locking collet being locked together in contracted positions by the spring 394, the relationships and positions of the various other components of the closing tool 300 are generally as represented in FIGS. 10–A and 10–B. Gravity may cause the outer housing sleeve formed by the sleeve sections 304, 305 and 310 to drop downwardly relative to the mandrel 302 to a position at which the sleeve head 340 is supported on the split ring 330. This lower position is possible as the housing sleeve is slideable on the mandrel and the slots 332 in the sleeve section 304 permit relative movement between the upper collet 303 and the housing sleeve. The exact position of the housing sleeve, however, will vary as the tool is lowered due to drag of the housing sleeve head along the tubing wall. The upper limit of the housing sleeve position on the mandrel is limited by the engagement of the head 340 with the lower end of the fishing neck 301.

As the closing tool 300 is lowered in the well tubing string, the bosses of the upper collet finger heads 323 projecting through the housing sleeve slots 332 drag along the well tubing string biasing the upper collet in an upward direction lifting the ring 321 of the collet upwardly from the stop ring 324. The collet finger heads 323 are raised above the mandrel flange 333 so that the heads are cammed inwardly around the mandrel 302 above the flange 323. Depending upon the diameter of the tubing string, the collet finger heads may remain above the flange 333 until the closing tool reaches the larger locking recesses in the sliding sleeve valve housing. The larger internal diameters at the pipe joints along the tubing string may permit the collet fingers to momentarily expand at the joints though they will return to the contracted positions above the flange 333 as the tool moves into the more restricted bores along the length of the pipe sections forming string. Under any circumstances, as the closing tool is lowered in the tubing string, the upper collet is always free to move upwardly and contract permitting it to pass restricted bore sections along the string. The bottom collet 311 remains contracted with the free end of the locking spring 394 dragging along the tubing wall keeping the spring latched on the pin 401. Fluid within the tubing string passes upwardly around the lower end portions of the tool housing sleeve into the bore 363 of the check valve body 362. The ball valve 370 is lifted from the seat 371 allowing the fluid to flow upwardly through the bore 365 in the neck of the check valve body into the bore of the mandrel 302 and outwardly from the tool through the fishing neck 301. The pin 373 holds the ball check valve 370 against upward movement from the check valve body while allowing the ball to remain in the larger upper bore of the body so that the bypassing fluids can flow around the ball in an upward direction.

The downward progress of the closing tool in the tubing string is constantly monitored to keep tract of the location of the tool in the string so that it may be activated at the proper depth for closing the selected one of the sliding sleeve valves 32A. If the particular valve to be opened is below one or more other such valves which are to remain closed or already are closed, the closing tool readily passes through the valves. When the upper locking collet 303 reaches the various internal recesses along such valves, the collet finger heads 323 expand into the recesses such as that above the head of the sleeve valve member and the collet finger heads engage the shoulder surfaces at the lower ends of the recesses lifting the collet above the mandrel flange 333 so that the collet finger heads are cammed inwardly and will not lock in the sleeve valve recesses.

When the closing tool 300 has reached a depth in the tubing string closely above the particular sleeve valve 32A to be closed, the tool is lifted back upwardly a short distance which drags the bottom collet locking spring 394 downwardly along the tubing wall disengaging the latch portion 403 of the spring from the pin 401 so that the bottom collet fingers are released to expand and drag along the tubing wall surface. The closing tool is then lowered into the sleeve valve to be closed. The particular profile of the bottom collet finger heads and the relative dimensions of such profile as compared with the tool joint at the upper end of the sleeve valve housing and the recesses in the valve housing, such as at the upper end of the head of the valve member, allows the bottom collet to move downwardly in the sleeve valve housing passing all recesses until the collet finger heads reach the matching recesses 212 and 214 at the lower end of the housing where the collet finger heads expand into the recesses as shown in FIG. 10–B. Since externally the collet finger heads match the pro-

files of these recesses at the lower end of the valve housing, the abrupt shoulder **390** on the collet finger heads seats on the housing stop shoulder **213** arresting the downward movement of the closing tool. Because the bottom collet **311** hangs from the bottom section **310** of the tool housing sleeve, the downward force which activates the bottom collet and moves it into the locked position of FIG. **10–B**, also drives the mandrel **302** downwardly in the housing sleeve until the lower end of the fishing head **301** engages the upper end of the housing sleeve piston head **340.** In order for this telescoping action to occur, the lower end of the mandrel telescopes down over the neck portion **364** of the check valve body, the enlarged bore portion **320**a of the mandrel bore moving downwardly over the neck portion of the check valve body. The force drives the housing sleeve downwardly so that the pin **404** is sheared, the tool housing sleeve is driven downwardly within the bottom collet with the expander nut **405** moving past the detent flanges **391** within the bottom collet fingers until the nut shoulder surface **410** seats on the internal collet finger head stop shoulder surfaces **393.** The expander nut locks the bottom collet finger heads expanded in the valve housing as shown in FIG. **10–B.**

The longitudinal dimensions of the various tool parts are relatively proportioned to position the upper collet **303** in alignment with the recess **75***a* within the head **75A** of the valve member **51A** of the sliding sleeve valve so that the upper collet fingers expand into the recess releasably locking the collet with the sliding sleeve valve member. It will be recognized that with the mandrel **302** driven downwardly until the fishing head **301** engages the sleeve piston head **340,** the mandrel flange **333** is below the upper collet finger heads **323.** When the mandrel **302** is lifted for any reason, the mandrel flange **333** moves behind the collet finger heads **323** so that the collet fingers of the upper collet are locked as shown in FIG. **10–A** coupled with the valve member **51A** of the sliding sleeve valve providing a mechanical coupling with the valve member which allows upward jarring of the valve member, if necessary, in addition to fluid pumping action to close the sliding sleeve valve. Until the pin **325** supporting the stop ring **324** on which the upper collet **303** hands is sheared, the collet finger heads **323** remain locked outwardly with the sleeve valve member and cannot be contracted and released from the sleeve valve member responsive to an upward force on the closing tool.

With the closing tool **300** locked in the sleeve valve **32A** as shown in FIGS. **10–A** and **10–B**, fluid pressure is applied into the tubing string of the well from the well head. It will be noted in FIG. **10–B** that with the closing tool locked in the sleeve valve, the seals **352** and **354** in the sleeve section **305** of the tool housing sleeve are positioned above and below, respectively, the side port **104A** of the sleeve valve member **51A.** The pressure within the tubing string above the closing tool is applied downwardly through the tool in the bore **320** of the tool mandrel **302** forcing the ball valve **370** on the seat **371** shutting off downward flow through the check valve assembly **360.** The pressure increase is communicated outwardly through the side port **355** in the tool housing sleeve between the sleeve seals **352** and **353** so that such pressure is communicated to the side port **104A** of the sliding sleeve valve member. The pressure increase through the side ports **104A** is communicated into the annulus around the sleeve valve member between the lower seal **102** and the upper seal **85** which seals between the sleeve valve member **51A** and the housing of the sleeve valve. Since the line of sealing engagement of the upper seal **85** with the sleeve valve housing is greater than the line of sealing of the lower seal **102,** the effective downwardly facing annular area on the sleeve valve member over which the pressure increases is applied urges the sleeve valve member in an upward direction. When the pressure increase through the closing tool exceeds such pressure as may be applied to the sleeve valve member through the side ports **35** of the sleeve valve housing, the sleeve valve member is forced upwardly to the closed position at which the upper end edge of the valve member head **75A** engages the stop shoulder **61** of the sleeve valve housing above the side ports in the housing. As the sleeve valve member is pumped upwardly, the engagement of the upper collet finger heads **323** in the locking recess of the sleeve valve member head lifts the upper locking collet on the mandrel **302,** the collet being free to move upwardly relative to the tool housing sleeve section **304** because of the length of the slots **332** in the sleeve housing section. The downward pressure of the fluid in the tool string above the closing tool is, of course, applied to the head **340** of the tool housing sleeve around the mandrel **302** holding the housing sleeve firmly downwardly during the sleeve valve closing procedure which retains the bottom locking collet in the locked relationship shown in FIG. **10–B.**

In the event that the sleeve valve member is jammed in the open position sufficiently that the fluid pressure does not readily close the valve, an upward mechanical force may be applied to the fishing neck **301** urging the mandrel **302** in an upward direction. The upward force on the mandrel **302** lifts the upper collet **303** with the mandrel applying the upward mechanical force to the sleeve valve member through the collet heads **323.** So long as the holding force of the shear pin **325** is not exceeded, the upper collet **303** remains in the position on the mandrel **302** shown in FIG. **10–A** so that the collet finger heads remain locked with the sleeve valve member. Upward jarring mechanical force thus may be applied to the sleeve valve member in addition to the pumping action of the fluid pressure in the closing tool to aid in moving the jammed or stuck sleeve valve member upwardly to close the valve. As the sleeve valve member moves upwardly, the upper seal **74** in the valve member head enter the valve housing bore portion **60** so that fluid above the valve member head is trapped between the top head seal **74** and the seals in the head **340** of the closing tool housing sleeve. This trapped fluid is displaced downwardly within the sleeve valve member past the collet heads **323** between the sleeve valve member below the head **75A** around the lower end portion of the tool housing sleeve section **304** to the blind side port **343.** The displaced fluid flows downwardly through the passage **344** in the sleeve section **305** into the bore of the sleeve section below the check valve assembly **360** as seen in FIG. **10–B.** Thus, the trapped fluid above the sleeve valve member head is bypassed into the tool bore below the check valve as the sleeve valve member is closed.

When the sleeve valve member is fully closed, the closing tool **300** is released from the sliding sleeve valve and removed from the tubing string. The pressure is increased in the tubing string above the closing tool to a

sufficient level to shear the pin 361 releasing the check valve assembly 360 to drop downwardly to the stop shoulder 380 within the tool housing sleeve. At this lower position of the check valve assembly, the check valve body seal 372 is below the side ports 374 so that as the closing tool is lifted from the sliding sleeve valve fluid above the tool bypasses downwardly around the check valve body and outwardly through the side ports 374. An upward force is applied to the fishing neck 301 sufficient to shear the pin 325 holding the upper collet 303 at a locking position on the mandrel 302. When the pin 325 is sheared, the upward force on the tool lifts the mandrel 302 until the mandrel locking flange 333 engages the bottom edge of the ring 324. At this position of the mandrel within the upper locking collet, the collet finger heads 323 are below the mandrel locking flanges 333 so that additional upward force on the tool cams the locking heads 323 on the upper collet inwardly releasing the collet from the closed sliding sleeve valve member. During this upward movement of the closing tool, the split ring 330 on the mandrel 302 engages the head 340 of the tool housing sleeve applying upward force to the housing sleeve raising the sleeve in the bottom collet 311. The upward movement of the housing sleeve raises the expander nut 405 spreading the collet fingers 382 as the nut engages the detent flanges 391 so that the fingers are expanded sufficiently for the expander nut to pass between the detent flanges releasing the housing sleeve from the bottom collet. When the housing sleeve is lifted sufficiently for the upper end edge of the expander nut to engage the lower edge of the bottom collet ring 381, the upward lifting force is applied directly to the bottom collet. The bottom collet finger heads are cammed inwardly by the tapered bottom surface of the flange 211 within the sliding sleeve valve housing releasing the bottom collet finger heads from the housing so that the opening tool 300 is now fully disengaged from the sliding sleeve valve leaving the sleeve valve member in the upper closed position. The bottom collet fingers are free to expand and contract as they are dragged upwardly along the tubing string freely passing tool joints and other restrictions along the tubing string. The upper collet 303 drags downwardly on the mandrel 302 with the upper collet finger heads 323 being pulled below the mandrel locking flange 333 so that the collet fingers heads freely contract inwardly as various shoulders and other restricted portions along the tubing string are passed.

It will be seen that the selective form of the sliding sleeve valve 32A is closed by the tool 300 which is activated above the particular sleeve valve to be closed. The closing tool readily engages in the desired sliding sleeve valve at the proper longitudinal position in the valve due to the profile of the collet heads on the lower locking collet. The upper locking collet engages with the valve member of the sliding sleeve valve so that upward mechanical forces may be applied to the sleeve valve member simultaneously with fluid pressures applied to pump the valve member closed. The closing tool is released from the sliding sleeve valve by application of fluid pressure to free the check valve assembly and mechanical force to shear the pin holding the upper locking collet engaged with the sleeve valve member.

What is claimed is:

1. A well tool for controlling circulation with a tubing string in a well bore comprising: housing means adapted for connection in said tubing string and having port means for communicating the interior of said tubing string with the exterior thereof; tubular valve means longitudinally movable within said housing means between first and second positions for opening and closing said port means; and seal means for sealing between said housing means and said valve means defining first and second oppositely facing surfaces on said valve means, one of said surfaces being and defining a second area on said valve means responsive to pressure applied to said tool through said tubing string for closing said valve means.

2. A well tool in accordance with claim 1 wherein said seal means includes first and second spaced seals sealing between said housing means and said valve means at longitudinally spaced locations along said valve means defining said first and second pressure responsive surfaces on said valve means and said valve means includes a side port opening through said valve means between said first and second seal means for applying fluid pressure through said valve means to said second area of said valve means for moving said valve means to a closed position responsive to said fluid pressure.

3. A well tool in accordance with claim 2 wherein said valve means is provided with a shoulder surface for engagement of an opening tool for mechanically opening said valve means.

4. A well tool in accordance with claim 3 including a third seal carried by a head end of said valve means and a seal surface defined in said housing means engaged by said third seal when said valve means is closed.

5. A well tool in accordance with claim 4 including a protective sleeve on said valve means for telescoping over said third seal to protect said seal against flow cutting as said valve means moves between closed and open positions.

6. A well tool in accordance with claim 5 including spring means between said valve means and said protective sleeve for biasing said sleeve toward said thrid seal.

7. A well tool in accordance with claim 6 in combination with an opening tool comprising a body having a shoulder engageable with said shoulder surface on said valve means for urging said valve means from a closed to an open position, a seal means on said body for sealing between said body and a bore surface of said housing above said valve means, said body having a bore for bypassing fluid through said body during movement of said opening tool through said tubing string, and a valve in said bore of said body movable to an open position when said opening tool is lowered through said tubing string to said well tool and to a closed position responsive to fluid pressure applied in said tubing string above said opening tool for moving said valve means of said well tool from a closed to an open position.

8. A well tool in accordance with claim 6 in combination with a closing tool adapted to be lowered through said tubing string into said valve means of said well tool, said closing tool having a body mandrel provided with a longitudinal bore and a side port, seal means on said body mandrel above and below said side port in said body mandrel for sealing with surfaces of said valve means above and below said side port in said

valve means for directing fluid pressure from within said closing tool to an annular space within said well tool housing around said valve means of said well toll between said first and second seals to close said well tool responsive to said fluid pressure, and a check valve in said closing tool body mandrel below said side port in said mandrel to bypass fluid through said body mandrel during downward movement of said closing tool in said tubing string and to close said bore through said body mandrel responsive to pressure in said body mandrel above said check valve for applying said fluid pressure to said well tool for closing said valve means of said well tool.

9. A well tool in accordance with claim **6** wherein said housing means is provided with internal recesses above and below said valve means for selective engagement of operating bosses of opening and closing tools to selectively open and close said well tool when a plurality of said tools are installed in tandem in a well.

10. A well tool in accordance with claim **9** wherein said valve means includes an internal operating recess for engagement by a closing tool to permit application of mechanical force to said valve means simultaneously with fluid force for closing said valve means.

11. A well tool in accordance with claim **10** in combination with an opening tool comprising a body mandrel having a bore therethrough, a check valve at the upper end of said body mandrel for permitting upward flow through said body mandrel while lowering said tool into a well and for closing said tool against downward flow when applying an opening fluid pressure to said tool in said well, a collet on said body mandrel having radially movable collet fingers provided with external bosses adapted to fit an internal recess in said well tool housing at the upper end of said valve means and said collet fingers having downwardly facing operating shoulders for engagement with said shoulder surface on said valve means to move said valve means downwardly to an open position, said collet fingers having downwardly extending retaining flanges, a collet finger latch assembly longitudinally movable on said body mandrel of said opening tool for engaging and restraining said collet fingers contracted inwardly during downward movement of said opening tool and for engaging a downwardly facing shoulder responsive to upward movement of said opening tool to activate said collet latch assembly for releasing said collet fingers for outward movement to positions for engaging said valve means upon downward movement of said opening tool, and said body mandrel of said opening tool having an external locking flange for engaging inside faces of said collet fingers to hold said collet fingers outwardly while moving said valve means downwardly.

12. A well tool in accordance with claim **10** in combination with a closing tool comprising a body mandrel having a longitudinal bore therethrough, an upper operating collet on said body mandrel adapted to engage said internal recess in said valve means of said well tool at one relative position of said collet on said body mandrel and to release from said valve means at a second relative position on said body mandrel, a housing sleeve movable on said body mandrel and having slots for bosses on said upper operating collet, spaced seals along said housing sleeve for sealing with said valve means of said well tool, said housing sleeve having a side port for communicating through said sleeve between said spaced seals to conduct fluid pressure from within said closing tool through said housing sleeve into said side port of said valve means for closing valve means responsive to said fluid pressure, a lower collet on said housing sleeve, said lower collet having external collet finger profiles matching corresponding operating recesses within the well tool housing means of one of said well tools within a well bore for selectively engaging said recesses when closing said valve means of said well tool, latch means holding said lower collet contracted while said opening tool is lowered in a tubing string and releasing said collet responsive to upward movement of said opening tool in said tubing string, and a check valve in said housing sleeve below said body mandrel to permit fluids to bypass said closing tool while lowering said tool in said tubing string and adapted to close responsive to fluid pressure in said tool above said check valve for developing pressure in said closing tool sufficient to actuate said valve means of said well tool.

13. A well tool for use in a tubing string in a well bore to control communication between said tubing string and said bore around said tubing string comprising: a tubular housing adapted to be connected in said tubing string to form a longitudinal section of said string, said housing having a side port for communication with said well bore around said housing, said housing having a first enlarged bore portion extending above and below said side port defining a seal surface in said housing above said side port; said housing having a second further enlarged bore portion concentric with the shorter than said first enlarged bore portion extending from above said side port to below said side port to accommodate a protective sleeve; said tubular housing having a third bore portion smaller than said first bore portion below said first bore portion; an internal snap ring in a recess provided along said third bore portion of said tubular housing; a lower ring seal disposed in a recess along said third bore portion of said housing below said snap ring; a tubular valve slidably disposed within said tubular housing for longitudinal movement between a first upper closed position at which said valve engages said seal surface of said housing above said side port and a second lower open position at which said side port of said housing is uncovered by said valve, a lower end portion of said valve extending through said lower seal, said valve having a head portion provided with external seals for sealing with said seal surface of said first bore portion of said tubular housing above said side port, said valve having an external flange spaced from said head portion, said flange being provided with an external annular recess, an upper ring seal in said external annular recess of said flange on said valve member for sealing with the surface of said first bore portion of said tubular housing below said second bore portion of said housing, said upper ring seal sealing along a circle with said housing greater in diameter than the circle line of sealing of said lower ring seal with said valve defining a downwardly facing area on said valve; said valve having a side port below said external flange on said valve for applying a fluid pressure between said upper and lower ring seals to said downwardly facing area for closing said valve by fluid pressure; a protective sleeve slidably disposed on said valve; said sleeve having an internal lower end flange; said sleeve being adapted to engage a stop shoulder in said tubular housing above said side port to protect said seals on said valve head portion from flow cutting while said valve

is being moved between open and closed positions; a spring around said valve between said external flange on said valve and said flange of said protective sleeve for biasing said protective sleeve over said seals of said head portion of said valve as said head portion is telescoped into said protective sleeve; said sleeve being retracted with said head portion of said valve when said valve is moved downwardly to said second open position to open said side port of said housing; and said valve having longitudinally spaced external annular locking recesses to receive said split ring in said tubular housing for releasably locking said valve at each of said closed and said open positions.

14. A well tool in accordance with claim **13** in combination with an opening tool comprising a tubular body having a shoulder surface engageable with a head portion of said tubular valve of said well tool for moving said tubular valve downwardly to an open position; external ring seal means carried by said tubular body for sealing with the bore of said housing above said first enlarged bore portion of said housing, a valve seat member connected with the upper end of said tubular well tool housing; a cage member connected with said tubular housing around said valve seat member and extending upwardly therefrom, said cage member having side port means for fluid bypass into said tubular housing; a valve member on a stem movably disposed in said cage member for engagement with said valve seat member responsive to a downward force on said valve member to permit application of a fluid pressure to said opening tool and said well toll valve from above said housing, said valve of said opening tool being movable upwardly to permit fluid bypass from below said tool through said tubular housing and valve seat member outwardly through said side port means of said cage member, and a fishing head connected with said stem for handling said opening tool in a tubing string.

15. A well tool in accordance with claim **13** in combination with a closing tool comprising a tubular mandrel having an enlarged head portion provided with external seals for sealing with a bore surface of said well tool housing above said valve member; longitudinally spaced external seals on said mandrel for sealing with the bore of said tubular valve of said well tool above and below said side port in said valve, said tubular mandrel having a side port between said spaced external seals for communicating fluid pressure from the bore of said tubular mandrel into an annular spaced defined around said tubular mandrel within said well tool valve between said external spaced seals on said tubular mandrel; port means in said closing tool tubular mandrel below the lower of said external seals on said tubular mandrel; and a releasable check valve secured in said tubular mandrel above said port means in the lower end thereof for permitting fluid bypass upwardly through said closing tool during downward movement of said tool in a tubing string while preventing downward flow through said closing tool to permit application of fluid pressure above said tool through said side port in said tubular mandrel between said external ring seals on said mandrel to communicate a fluid pressure into said well tool when said closing tool is in operative position in said well tool for pumping the tubular valve of said well tool closed.

16. A well tool in accordance with claim **13** including an internal operating recess in the head portion of said valve member of said tool for engagement by an operating member of a closing tool for application of a mechanical force to assist in closing said tubular valve on said well tool in combination with a fluid pressure induced force for pumping said tubular valve closed, said tubular housing of said well tool having an operating recess defined by an enlarged bore portion in the upper end of said housing above said first enlarged bore portion and above said tubular valve when said valve is at an upper closed position for receiving collet members on a selctive opening tool for engaging the head portion of said tubular valve when opening said well tool with said opening tool, and said well tool housing having internal annular operating recesses along a lower end portion thereof below said valve member of said well tool for receiving collet fingers having external bosses of a defined configuration to permit selective operation of any one of said well tools when a plurality of said tools are included in a tubing string.

17. A well tool in accordance with claim **16** in combination with an opening tool comprising a tubular body mandrel, a valve seat at the upper end of said body mandrel, a cage member secured with said body mandrel around said valve seat, said cage member being provided with bypass port means above said valve seat, a valve member confined in said cage member for movement between open and closed positions relative to said valve seat to shut off flow downwardly through said valve seat responsive to a downward force on said valve member above said tool and to permit upward flow through said valve seat and outwardly through said side port means in said cage member responsive to downward movement of said opening tool in a well bore; a fishing head secured with said valve member for handling said opening tool in a well bore; an operating collet releasably secured on said tubular mandrel for engagement with the head portion of the tubular valve of said well tool for forcing said valve downwardly to an open position when said collet is in a normal expanded relationship, said collet having external bosses receivable in said operating recess of said well tool housing above said valve member; said tubular mandrel having an external annular flange engageable with inner faces of said operating collet for locking said collet in an expanded relationship in said tubular valve head portion when a downward force is applied to said fishing head of said opening tool, and a collet latch assembly on said tubular mandrel below said operating collet, said latch assembly being releasably engageable with said operating collet for holding said collet contracted during downward movement of said opening tool in a tubing string and said latch assembly being engageable with a downwardly facing shoulder surface for moving said assembly downwardly responsive to upward movement of said opening tool in a well bore to move said latch assembly to a collet release position at a desired depth within said well bore for permitting said operating collet to expand preparatory to engaging said collet with said tubular valve of said well tool in opening said valve.

18. A well tool in accordance with claim **16** in combination with a valve closing tool comprising a tubular body mandrel having a fishing head for handling said closing tool in a well bore; an upper operating collet movably supported on said tubular mandrel for engagement with said internal operating recess in said head portion of said tubular valve to apply an upward mechanical force to said tubular valve responsive to lifting

said body mandrel within said well tool bore; said body mandrel having an external flange adapted to be positioned behind within said operating collet to hold said collet in an expanded engaging relationship with said head portion of said tubular valve; a slidable housing sleeve on said mandrel, said housing sleeve extending below the lower end of said body mandrel and having a head portion slidable on said body mandrel above said upper operating collet, said head portion having external seals for sealing within said well tool housing above said tubular valve and having internal seals for sealing around said body mandrel, said housing sleeve having longitudinal slots to permit said upper operating collet on said body mandrel to extend through said housing sleeve to engage said head portion of said well tool tubular valve; longitudinally spaced external seals on said housing sleeve for engagement with the bore surface of said tubular valve above and below said side port of said valve; said housing sleeve having side ports between said spaced external seals for communicating fluid pressure from the bore of said body mandrel to said side port in said tubular valve of said well tool to permit fluid pressure to be applied to said tubular valve for pumping said valve upwardly to a closed position; a bypass check valve in said housing sleeve below said tubular body mandrel to close said closing tool against downward fluid flow to permit application of fluid pressure to said side port in said housing sleeve, said check valve being adapted to open responsive to upward fluid flow in said closing tool to allow said closing tool to be lowered in a tubing string in a well bore, said check valve being releasably engaged to permit said check valve to be displaced downwardly when said tool is to be removed from a well bore to allow downward bypass of fluids through said well tool; said housing sleeve having bypass port means below said check valve when said check valve is releasably locked in an upper operating position; and a lower operating collet on said housing sleeve engageable with said selective operating recesses within said well tool housing at the lower end of said housing for selectively locking said closing tool against downward movement in said well tool housing, said lower collet having latch means for releasably holding said collet contracted during downward movement of said closing tool in a tubing string and being adapted to release said collet for expansion responsive to upward movement of said closing tool in a tubing string.

19. An opening tool for opening a sliding sleeve valve used in a well bore comprising: a body having a shoulder engageable with a shoulder surface on valve means of said sliding sleeve valve for urging said valve means from a closed to an open position; seal means on said body for sealing between said body and a bore surface of the housing of said sleeve valve; said body having a bore for bypassing fluid through said body during movement of said opening tool through a tubing string; and a valve in said bore of said body movable to an open position when said opening tool is lowered through said tubing string to said sleeve valve and movable to a closed position responsive to fluid pressure applied in said tubing string above said opening tool for moving said valve means of said sliding sleeve valve from a closed to an open position.

20. A closing tool for moving a valve means of a sliding sleeve valve for use in a well bore from an open position to a closed position, said closing tool comprising: a body mandrel provided with a longitudinal bore and a side port; seal means on said body mandrel above and below said side port for sealing with internal bore surfaces of said valve means of said sliding sleeve valve above and below a side port in said valve means for directing fluid pressure from within said closing tool to annular space within the housing of said sliding sleeve valve around said valve means of said sliding sleeve valve between upper and lower seals in said sliding sleeve valve to pump said valve means of said sliding sleeve valve to a closed position responsive to fluid pressure directed to said closing tool; and a check valve in said body mandrel below said side port in said mandrel to bypass fluids through said body mandrel during downward movement of the closing tool in said well bore and to close said bore of said body mandrel responsive to pressure in said body mandrel above said check valve for applying said fluid pressure to said sliding sleeve valve for closing said valve means of said sliding sleeve valve.

21. An opening tool for moving a valve member of a sliding sleeve valve for use in a well bore from a closed position to an open position comprising: a body mandrel having a bore therethrough; a check valve at the upper end of said body mandrel for permitting upward flow through said body mandrel while lowering said opening tool into a well bore and for closing said tool against downward flow when applying an opening fluid pressure to said tool in said well bore; a collet on said body mandrel having radially movable collet fingers provided with external bosses adapted to fit an internal recess in a housing of said sliding sleeve valve at the upper end of the valve element of said sliding sleeve valve, said collet fingers having downwardly facing operating shoulders for engagement with a shoulder surface of said valve element to move said valve element downwardly to an open position, said collet fingers having downwardly extending retaining flanges; a collet finger latch assembly longitudinally movable on said body mandrel of said opening tool for engaging and restraining said collet fingers at radially contracted positions during downward movement of said opening tool and for engaging a downwardly facing shoulder within said well bore responsive to upward movement of said opening tool in said well bore to activate said collet latch assembly releasing said collet fingers for outward movement to positions for engaging said valve member of said sliding sleeve valve upon downward movement of said opening tool; and said body mandrel of said opening tool having an external locking flange for engaging inside faces of said collet fingers to hold said collet fingers outwardly while moving said valve member of said sliding sleeve valve downwardly.

22. A closing tool for closing a valve member of a sliding sleeve valve for use in a well bore comprising: a body mandrel having a longitudinal bore therethrough; an upper operating collet on said body mandrel adapted to engage an internal operating recess in a valve member of said sliding sleeve valve at one relative position of said collet on said body mandrel and to release from said valve member at a second relative position of said collet on said body mandrel; a housing sleeve movable on said body mandrel having slots for projection of operating bosses on said upper operating collet outwardly of the outer face of said housing; spaced seals along said housing sleeve for sealing with said valve member of said sliding sleeve valve; said

housing sleeve being provided with a side port for communicating through said sleeve between said spaced seals to conduct control fluid pressure from within said closing tool through said housing sleeve into a side port of said valve member of the sliding sleeve valve for closing said valve member responsive to said control fluid pressure; a lower operating collet on said housing sleeve, said lower collet having external collet finger profiles matching corresponding operating recesses within the housing of said sliding sleeve valve for selectively engaging said operating recesses for closing the valve member of said sliding sleeve valve; latch means holding said lower operating collet contracted while said opening tool is lowered in a tubing string and for releasing said lower operating collet responsive to upward movement of said opening tool in said tool string; and a check valve in said housing sleeve below said body mandrel to permit control fluids to bypass the closing tool while lowering said tool in said tubing string and adapted to close responsive to control fluid pressure in said tool above said check valve for developing sufficient pressure in said closing tool to actuate said valve member of said sliding sleeve valve.

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