United States Patent

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[72] Inventor Harry E. Schwegman
Richardson, Tex.

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[73] Assignee Otis Engineering Corporation
Dallas, Tex.
a corporation of Delaware

[54] **SLIDING SLEEVE VALVE AND OPERATOR THEREFOR**
19 Claims, 13 Drawing Figs.

[52] U.S. Cl. 251/291, 166/226
[51] Int. Cl. F16k 31/46
[50] Field of Search 251/291; 166/224, 226

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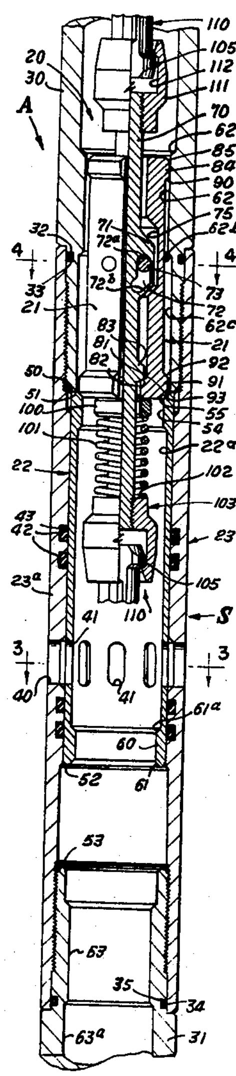
Primary Examiner—Robert G. Nilson
Attorney—E. Hastings Ackley

ABSTRACT: A well tool operable in a well flow conductor by means of fluid operated pumpdown apparatus, wire line operated tools, rods or a tubing string, for moving a shiftable sleeve member between operating positions in said conductor, said tool having sleeve engaging shifting keys swingably mounted on the body engageable with the sleeve for shifting the same longitudinally, and arranged for swingable manipulation past the sleeve after it has been shifted. The keys are also radially contractible for movement past restrictions which cannot be cleared by swingable movement of the keys.



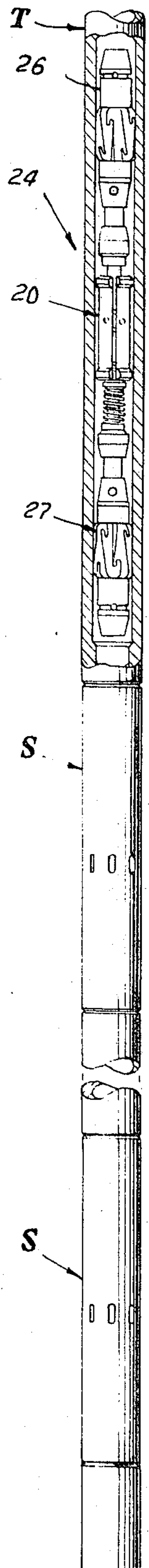


Fig.1

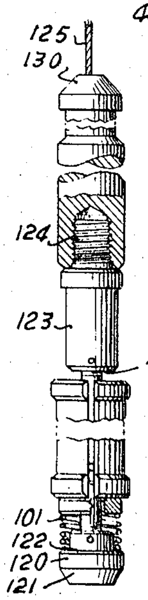


Fig. 2A

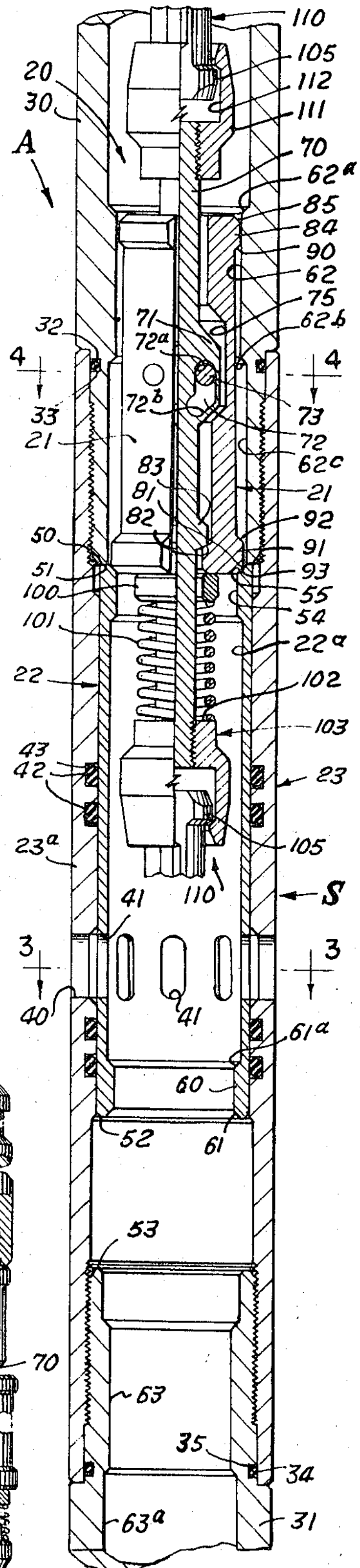


Fig.2

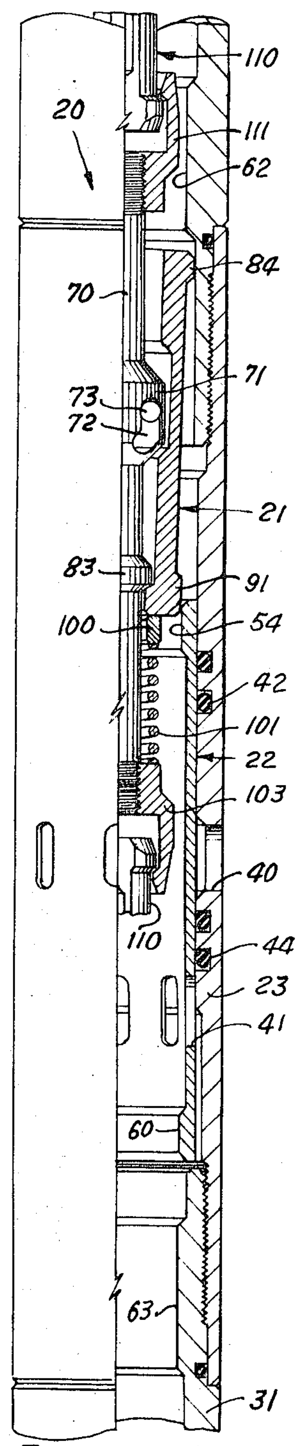


Fig.5

INVENTOR
Harry E. Schwegman
BY
Hastings Ackley
and
Walter J. Jagmin
ATTORNEYS

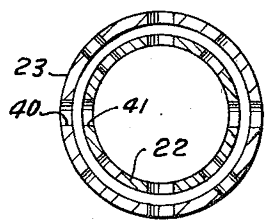


Fig. 3

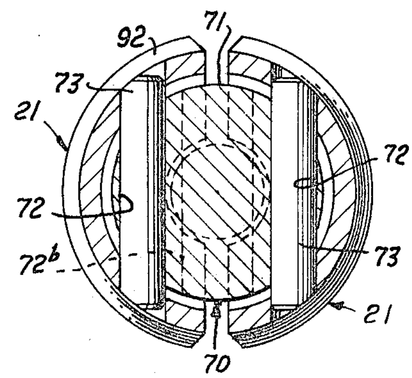


Fig. 4

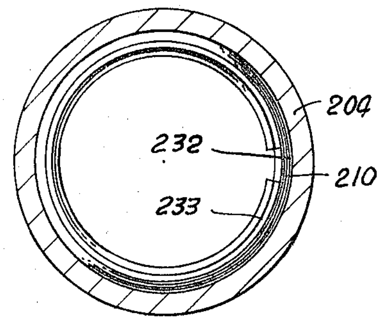


Fig. 8

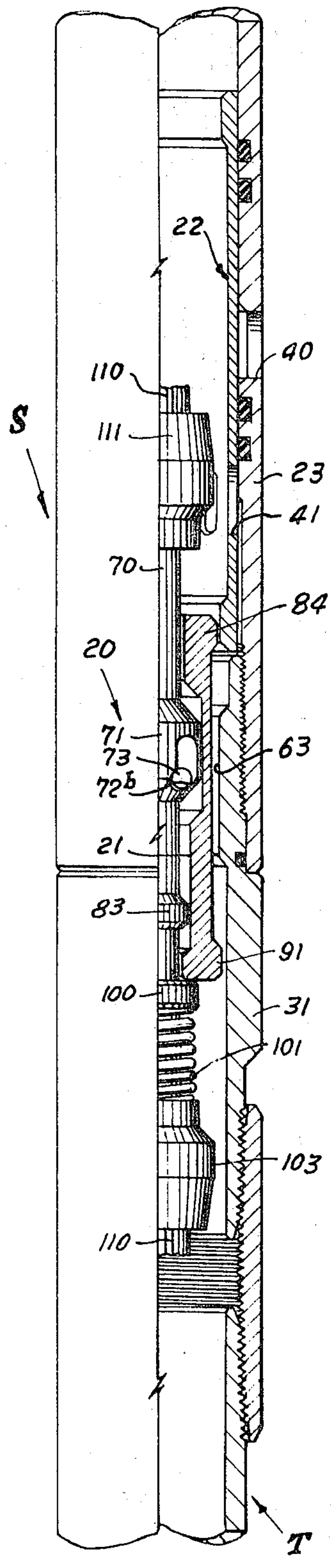


Fig. 6

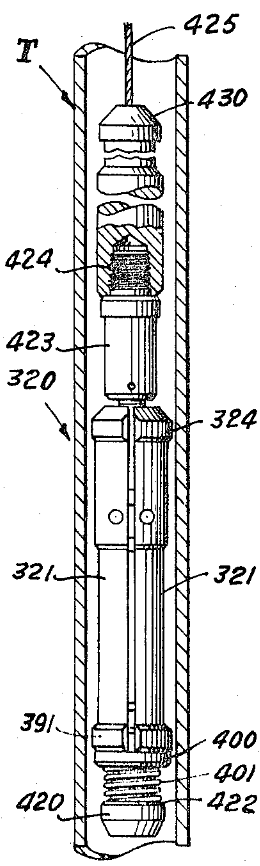


Fig. 10

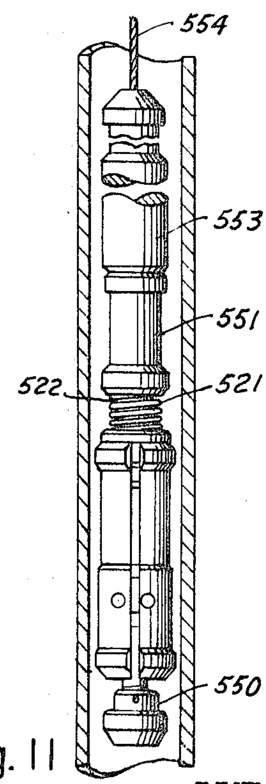


Fig. 11

INVENTOR

Harry E. Schwegman

BY

Hastings Ackley and Walter J. Jagmin

ATTORNEYS

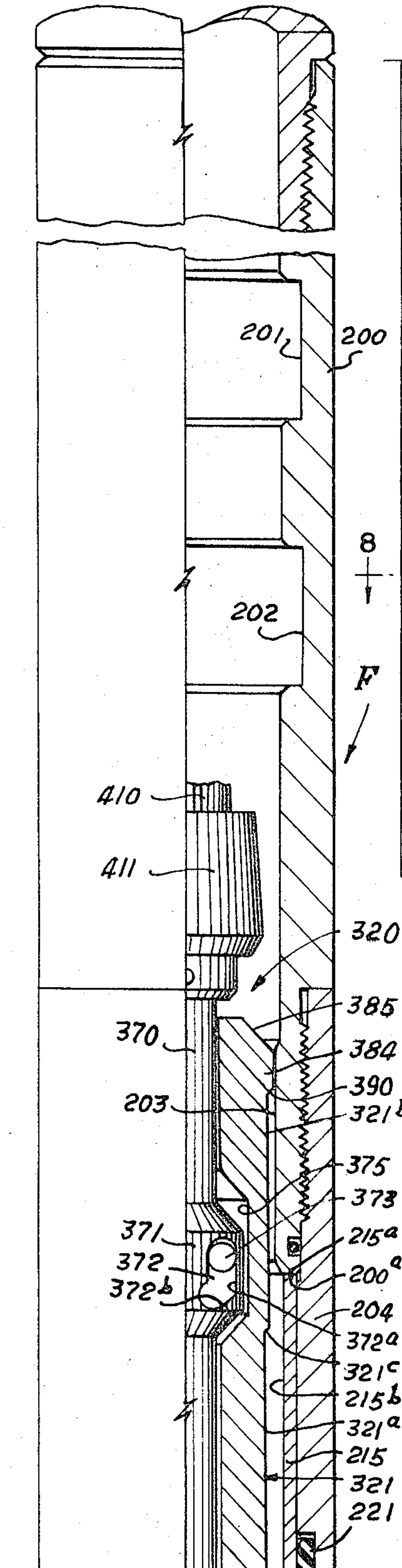


Fig.7

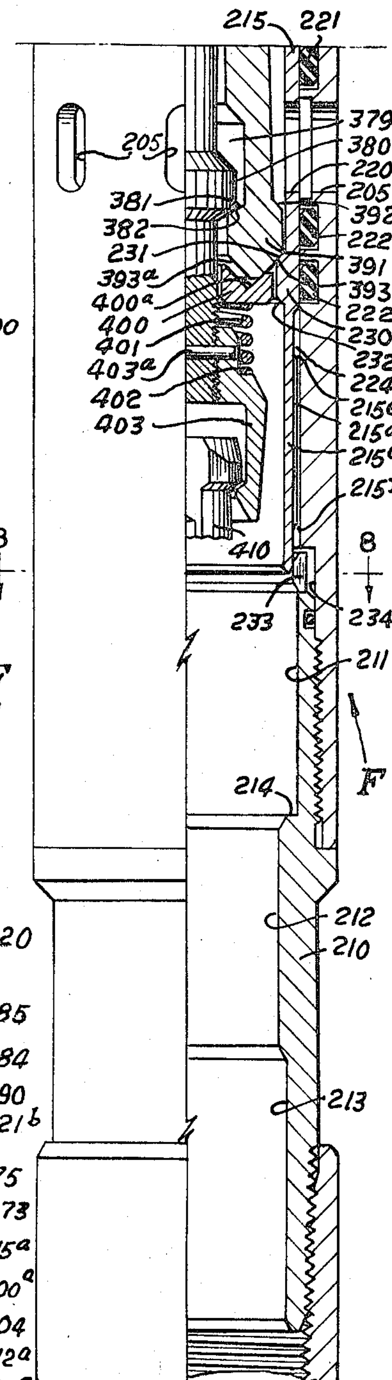


Fig. 7A

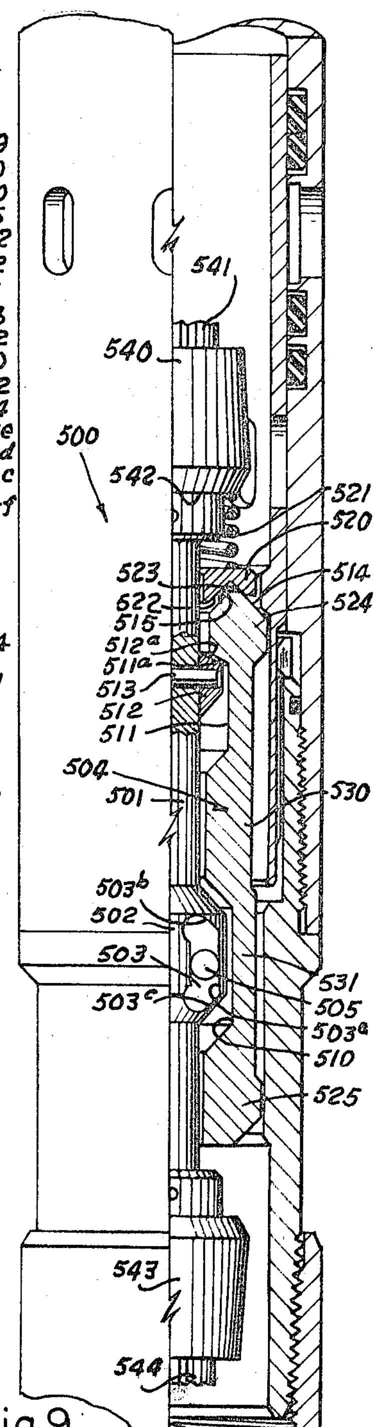


Fig.9

INVENTOR
Harry E. Schwegman

BY Hastings Ackley and Walter J. Jagmin

ATTORNEYS

SLIDING SLEEVE VALVE AND OPERATOR THEREFOR

This invention relates to well tools and particularly to well tools for shifting a member within a flow conduit between operating positions.

It is an important object of the invention to provide a well tool for shifting a sliding sleeve within a flow conduit between longitudinally spaced operating positions within the conduit, and more particularly for moving sliding sleeve valves between open and closed positions.

It is a further object of the invention to provide a well tool of the character described including pivotally supported sleeve shifting keys for operatively engaging a sliding sleeve at one position, moving the sleeve to another position, and then disengaging from the sleeve and moving past the sleeve.

It is another object of the invention to provide a well tool of the character described wherein the pivotally supported sleeve shifting keys are engageable at one end with an actuating cam surface within the flow conductor in spaced relationship to the sliding sleeve for pivoting the opposite ends of the keys to engagement with the sliding sleeve for moving the sleeve, the sleeve shifting keys having cam surfaces engageable with the cam surfaces within the flow conductor for pivoting the keys between sleeve engaging and sleeve release positions.

It is a still further object of the invention to provide a sleeve shifting tool of the character described wherein the pivotally supported sleeve engaging keys are pivoted or swing to sleeve engaging positions and subsequently to release positions as the tool is moved in one direction through the sliding sleeve, and are cammed to retracted nonengaging or inoperative positions when the tool is moved in the other direction through the sliding sleeve.

It is still another object of the invention to provide a sleeve shifting tool of the character described which is operable by wire line, by pumpdown procedures, by rods, or on a pipe string, and which is operable for shifting a series of longitudinally spaced sleeve valves in a single flow conductor.

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

FIG. 1 is a schematic longitudinal elevational view, partly in section, showing a sleeve shifting tool embodying the invention connected in a pumpdown type or fluid pressure operated tool train in a tubing string having a plurality of longitudinally spaced sliding sleeve valves therein;

FIG. 2 is a longitudinal sectional view, partly in elevation, of a sleeve shifting tool embodying the invention disposed within a sliding sleeve valve with the sleeve shifting keys of the tool engaging the upper end of the sleeve valve for moving it from the upper open position downwardly to a closed position;

FIG. 2A is an elevational view partly broken away showing the tool of FIG. 2 adapted to wire line operation;

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

FIG. 4 is an enlarged cross-sectional view along the line 4–4 of FIG. 2 showing the pins pivotally supporting the sleeve engaging keys;

FIG. 5 is a longitudinal elevational view, partly in section, similar to FIG. 2, showing the sleeve shifted downwardly to a closed position and the sleeve shifting keys cammed inwardly for releasing the shifting tool from operative engagement with the sleeve for downward movement of the tool through the sleeve;

FIG. 6 is a view similar to FIG. 5 showing the sleeve shifting keys cammed inwardly to retracted inoperative position and the tool moving upwardly in the tubing string through a sliding sleeve;

FIGS. 7 and 7A taken together constitute a longitudinal view, partly in section and partly in elevation, of another form of sliding sleeve valve and sleeve shifting tool embodying the invention, and showing the sleeve shifting keys of the tool engaged with the sliding sleeve for shifting it downwardly;

FIG. 8 is a view in section taken along the line 8–8 of FIG. 7A;

FIG. 9 is a longitudinal view, partly in section and partly in elevation, of still another form of sleeve shifting tool embodying the invention for moving the sleeve valve of FIGS. 7 and 7A, and showing the same engaged for moving the sleeve from a lower to an upper position;

FIG. 10 is a reduced view, partly in section and partly in elevation, of the sleeve shifting tool of FIG. 7 adapted to use with a wire line tool string; and

FIG. 11 is a reduced view similar to FIG. 10 showing the sleeve shifting tool of FIG. 9 adapted to use with a wire line tool string.

In the drawings, the numeral 20 designates a sleeve shifting tool embodying the invention having a pair of swingable or pivotally supported operator members or keys 21 for releasably engaging the slidable sleeve or valve member 22 of a tubular valve member or flow control device S for moving the sleeve in the housing 23 of the device between an upper position and a lower position therein. The sleeve shifting tool is operable by means of a fluid pressure displaceable tool train 24, as illustrated in FIG. 1; by means of a wire line tool string, as represented in FIG. 2A; or on a rod or tubing string movably supported in the well (not shown).

The sleeve valve member 22 is slidable within the housing 23 between an upper sub or tubular section 30 threaded into the upper end of the central section or nipple 23*a* and a lower sub or tubular member 31 threaded into the lower end of the central nipple. The upper sub, the central nipple section, and the lower sub form the housing of the flow control device S in which the sleeve or valve member is slidable. A ring seal 32 disposed in an external annular recess 33 of the upper sub 30 seals between the upper sub and the upper end portion of the nipple. Similarly, a ring seal 34 disposed in an external annular recess 35 of the lower sub seals between the lower end portion of the nipple and the lower sub. The nipple 23 has a plurality of circumferentially spaced lateral ports 40 providing fluid flow communication between the interior and exterior of the nipple. The sleeve or valve member 22 also has a plurality of circumferentially spaced lateral ports 41 which are arranged to be moved into registry with the ports 40 for allowing flow communication between the interior and exterior of the flow control device S and which are movable to a misaligned lower position for preventing such flow communication. A pair of longitudinally spaced upper ring seals 42 are disposed in internal annular recesses 43 within the bore of the nipple for sealing between the nipple and the sleeve valve above the nipple ports 40. Similarly, a pair of longitudinally spaced lower ring seals 44 are disposed in internal annular recesses 45 within the bore of the nipple below the ports 40 for sealing between the nipple and sleeve valve so that when the sleeve valve is moved downwardly to its closed position, shown in FIG. 5, the imperforate upper portion of the sleeve is disposed between the upper and lower ring seals 42 and 44, respectively, to prevent flow communication between the exterior and interior of the housing through the ports 40.

Upward movement of the sleeve valve is limited by engagement of its upper end surface 50 with the lower end surface 51 of the upper sub 30. Downward movement of the sleeve valve is limited by engagement of its lower end surface 52 with the upper end surface 53 of the lower sub 31. The sleeve or valve member is formed with an upper internal annular shoulder or boss 54 having an upper downwardly and inwardly extending or sloping surface 55. Similarly, the lower end portion of the sleeve or valve member is provided with an internal annular shoulder or boss 60 having a lower upwardly and inwardly convergent end surface 61. The sleeve valve bosses 54 and 60 are engaged by the keys 21 in shifting the sleeve and manipulating the keys 21, as described in detail hereinafter.

The bore of the upper sub 30 is reduced along a portion spaced from its lower end and above the upper end of the sleeve 23 and providing an internal annular boss or cam surface 62 which functions to pivot or swing the shifting keys 21 to a sleeve engaging position. The lower sub 31 is similarly provided with a reduced bore portion providing an internal annular cam surface or boss **63** spaced below the lower end of the sliding sleeve.

The upper end of the upper sub **30** and the lower end of the lower sub **31** are threaded (not shown) in the usual manner for connecting the flow control device S into a tubing string T to form a part thereof and to act as a valve means providing for flow communication between the bore of the tubing and the well bore exteriorly thereof. As illustrated schematically in FIG. **1**, a plurality of the devices may be connected in the tubing string at longitudinally spaced intervals to provide lateral flow communication with the well bore at various desired depths therein.

The sleeve shifting tool **20** includes an elongate body **70** having an annular external enlargement **71** provided with a pair of laterally spaced transversely extending slots **72** each of which has an upper longitudinal portion **72*a*** and a lower downwardly and inwardly inclined portion **72*b***. Each of the slots **72** receives a loosely fitted transversely extending pin **73** supporting one of the sleeve shifting keys **21** in longitudinally slidable and pivotal or swingable relationship on the body. Opposite end portions of each of the pins **73** are received in a pair of aligned holes **74** in the key **21** supported by the pin.

Each of the sleeve shifting keys **21** is a substantially semicylindrical member encompassing slightly less than 180 degrees of the portion of body **70** along which it is supported by the pin **73**. Each key has an internal arcuate recess **75** which is substantially complementary in shape to the external shape of the central enlargement **71** on the body and is longer than the enlargement to permit the key to move longitudinally on the body the distance of travel of the supporting pin **73** in the slot **72**. There is sufficient space between the external surface of the body **70** and each of the keys to permit a limited pivotal or swinging motion of each of the keys on the body, as discussed hereinafter. Each key **21** has a lower internal boss **80** providing a downwardly and inwardly sloping cam surface **81** on the lower end of the key which is engageable with a downwardly facing downwardly and inwardly sloping cam surface **82** of an external annular enlargement or cam member **83** on the tool body **70** spaced below and substantially smaller in diameter than the central enlargement **71**. Each of the keys also has at its upper end an upper external arcuate boss **84** provided with an upper cam surface **85** and a lower cam surface **90**, and has at its lower end a lower external arcuate boss **91** provided with an upper cam surface **92** and a lower cam surface **93**.

A biasing ring **100** is disposed on the body **70** below the lower ends of the keys **21** and a spring **101** confined between the ring and the upper end surface **102** of a lower coupler or connector socket **103** threaded on a lower end portion of the tool body **70** biases the ring and the keys upwardly along the body. The connector socket has a downwardly opening recess **104** for receiving upper end boss portions of fingers **105** of a coupler **110** used for connecting the shifting tool in the pumpdown type operating tool string **24** shown in FIG. **1**. An upper coupler or connector socket **111** is threaded on the upper end portion of the tool body **70** and has an upwardly opening recess **112** for receiving the coupling fingers **105** of a coupler **110** of the operating tool string.

The pumpdown type tool train **24** includes upper and lower fluid pressure actuatable seal or piston units **26** and **27**, respectively, secured to the shifting tool by the couplers **110**. Pistons or seal units and couplers suitable for use in the tool train are illustrated and described in detail in patent application Ser. No. 556,594, filed Jun. 10, 1966, now U.S. Pat. No. 3,419,074, issued Dec. 31, 1968. Such seal units and couplers are also illustrated and described at pages 3780–3781 of the Composite Catalog of Oil Field Equipment and Services, 1966–67 Edition, published by World Oil, Houston, Texas. Under some circumstances a single seal unit may be used to pump the shifting tool **20** through the tubing string. For example, the upper seal unit **26** may be used alone if it can supply sufficient force to the tool to move it through the tubing string and close the sliding sleeve valves.

The sleeve shifting tool **20** may also be operated by means of a conventional wire line tool string of the type illustrated at page 3890 of the Composite Catalog of Oil Field Equipment and Services, supra. Referring to FIG. **2A**, the sleeve shifting tool is adapted to wire line use by substitution of a lower spring retainer and guide member **120** threaded on the lower end of the body **70** in place of the socket member **103**. The member **120** has a downwardly convergent or tapered guide surface **121** to facilitate movement of the tool through a tubing string and has an upwardly facing shoulder **122** engaged by the lower end of the spring **101** holding the spring on the tool body. An upper fishing neck or connector **123** is threaded onto the upper end of the body **70** in place of the upper connector socket **111** shown in FIG. **2**. The connector **123** has a threaded pin **124** which is connected into the lower end of the tool string, such as into the knuckle joint or into the lowermost jar if the knuckle joint is not used. The tool string is from a wire line **125** connected with a wire line socket **130** at the upper end of the string.

The sleeve shifting tool **20** functions in the same manner in a pumpdown tool string as shown in FIG. **1**, in a wire line tool string, FIG. **2A**, or on a rod or pipe string.

As the sleeve shifting tool is moved downwardly in the normal bore portion of the tubing string T the spring biased ring **100** holds the sleeve shifting keys **21** at an upper end position on the body **70** at which the pivot pins **73** of each of the keys is at the upper end of the slot **72** in which it is disposed, and the upwardly facing shoulder **81** on the internal boss **80** of each of the keys engages the downwardly facing shoulder **82** on the enlargement **83** of the body. The engagement of the key surface **81** with the body shoulder surface **82** tends to cam the lower end portions of the key outwardly, pivoting the upper end portion of the keys inwardly toward the body as the tool is moved along the tubing string. When the tool arrives at the first flow control device S, the cam surfaces **93** on the lower bosses **91** of the keys **21** engage the upper cam surface **62*a*** on the boss or cam member **62** of the upper cam **30**, and such engagement cams the lower end portions of the keys inwardly as the keys pivot or swing on the pins **73**. The lower ends of the keys are moved inwardly sufficiently to pass downwardly along the cam member **62** of the upper sub until the bosses **91** on the keys pass below the lower cam surface **62*b*** at the lower end of the boss **62**, at which time the lower end portions of the keys are permitted to move outwardly into the larger bore portion **62*c*** of the upper sub above the sleeve **23**. The upward force of the ring **100** applied to the lower ends of the keys and the engagement of the cam surface **81** on the internal lower boss of the keys with the cam surface **82** on the body tends to cause the lower end portions of the keys to move outwardly. The tool continues downward movement with the upper external bosses **84** of the keys entering the restricted bore portion of the upper sub along the boss **62** holding the lower end portions of the keys outwardly so long as the upper key bosses **84** are moving downwardly along and held inwardly by the cam surface of the boss **62**. When the keys have moved downwardly sufficiently, the lower end surface **93** of the lower external bosses **91** of the keys engage the upper end surface **55** of the sliding sleeve or valve member **22** (FIG. **2**). While engagement of the cam surfaces **93** of the lower key bosses with the upper end surface **55** of the sleeve tends to cam the lower ends of the keys inwardly, they are prevented from moving inwardly by the engagement of the upper external key bosses **84** with the internal cam surface **62** of the upper sub. Since the lower ends of the keys cannot be moved inwardly, further downward motion of the shifting tool forces the sliding sleeve or valve member **22** downwardly until the upper external bosses **84** of the keys pass below the cam surface of the boss **62**, freeing the upper end portions of the keys to move outwardly and the lower ends to move inwardly.

At the time that the upper external key bosses clear the lower end of the restricted bore portion **62** of the sub, the sliding sleeve **22** has been moved downwardly sufficiently that the ports **41** in the sleeve are below the ring seals **44** of the nipple

23, thereby closing the flow control device so that there is no fluid communication between the exterior of the housing and the interior of the sliding sleeve. The downward force necessary to shift the sliding sleeve downwardly to its lower closed position is applied directly from the tool mandrel enlarged external cam member 83 through the lower end portions of the keys to the upper end surface 55 on the sleeve. Thus, the pivot pins 73 only pivotally support the keys and do not transmit forces between this mandrel and keys.

With the upper end portions of the keys free to move outwardly in the enlarged bore portion 62c of the upper sub, the camming action of the surface 55 at the upper end of the sliding sleeve forces the lower end portions of the keys inwardly with the inner bosses 80 of the keys being swung toward each other around the body 70 below the body enlargement or cam member 83. The slopes of the engaging surfaces 93 and 55 of the key and sleeve exceed the slopes of the inner key surface 81 and the cam surface 82 on the cam member of the tool body so that, when the keys are free to pivot as the upper end portions of the keys move into the enlarged bore portion 62c, the lower end portions of the keys are cammed inwardly, FIG. 5, until the lower outer bosses 91 on the keys pass within the upper boss 54 of the sliding sleeve, and the tool is released to move downwardly through the sleeve valve, leaving the sleeve valve at its lower closed position. When the keys release from the sleeve valve, the upper end portions of the keys are pivoted outwardly with the upper outer bosses 84 substantially engaging and sliding along the lower enlarged bore portion 62c of the upper sub. As the tool moves further downwardly, the lower outer key bosses 90 pass below the upper boss 54 of the sliding sleeve and enter the enlarged central bore portion 22a of the sleeve and the keys swing and the lower end portions of the keys move outwardly in such enlarged bore below the boss 54.

When the upper end portion of the keys reach the upper end of the sleeve valve the upper bosses 84 of the keys enter the upper end of the sliding sleeve through the boss 54 of the sleeve. The diameters of the inner boss 54 and the enlarged bore portion 22a of the sliding sleeve are sized and related such that the keys readily pivot to move fully into the sliding sleeve. As the upper bosses 84 of the keys pass through the upper boss 54 of the sleeve the lower portions of the keys are pivoted outwardly in the enlarged bore 22a of the sleeve. When the lower bosses 91 of the keys reach the lower cam surface 61a on the lower internal boss 60 of the sleeve, the lower end portions of the keys are cammed inwardly so that they clear the boss 60 and pass downwardly through the lower end of the sleeve. The lower end portions of the keys then enter the cam member or reduced bore portion 63 of the lower sub and move on downwardly into the lower enlarged bore portion 63a of the lower sub by the time the upper outer bosses 84 of the keys reach the lower internal boss 60 of the sliding sleeve, so that the lower end portions of the keys are pivoted or swing outwardly in such enlarged bore portion 63a of the lower sub to allow the upper end portions of the keys to pivot inwardly so that upper external bosses 84 thereon may pass through the internal boss 60 at the lower end of the sliding sleeve and the reduced bore portion or cam member 63 of the lower sub. With the keys clear of the lower end of the sliding sleeve, the sleeve is left at its lower closed position and the sleeve shifting tool continues downwardly in the tubing string to the next flow control device S, where the steps of entry into the slidable sleeve, shifting the sleeve downwardly to a closed position, and release from the sleeve, is repeated in the manner already described.

After the desired flow control devices in the tubing string have been closed by the downward movement of the sleeve shifting tool, the movement of the tool train is reversed by reversing the direction of fluid flow, if the pumpdown type of train is being used, or by lifting the line 125, in the case of the wire line tool string, and as the tool 20 moves upwardly in the tubing string the keys wobble, swing or pivot past the various bore restrictions in substantially the same manner as when the keys are moving downwardly through the flow control devices in the tubing string. However, the sleeve 22 is not shifted upwardly, but rather remains at its lower closed position, since there is no bore restriction below the flow control device to hold the upper end portions of the keys at an expanded position when the upper external bosses 84 of the keys engage the lower end surface 61 of the sleeve. In the normal bore portions of the tubing string below each sliding sleeve the lower portions of the keys are cammed outwardly engaging or in close proximity to the inner wall of the tubing string due to the upward force of the spring 101 acting through the ring 100 biasing the lower end portions of the keys against the cam member 83 on the tool mandrel, so that the camming action of the engaging surfaces 81 and 82 of the keys and the mandrel tends to expand the lower end portions of the keys while the upper end portions are somewhat pivoted inwardly. The end surface 61 on the sleeve cams the upper ends of the sleeves inwardly, if they are not already retracted sufficiently, for entry into the sleeve. As the tool moves upwardly, the upper end portions of the sleeve enter and expand in the bore portion 22a of the sleeve with the lower end portions of the keys being cammed inwardly when they engage the lower end cam surface 61 of the sleeve. The keys wobble or pivot as the tool continues upwardly, allow the tool to pass above the sleeve or valve member. By the time the upper bosses 84 of the keys enter the restricted bore portion 62 of the upper sub which holds the lower portion of the keys expanded, the lower bosses 91 have cleared the upper boss 54 of the sleeve and the lower end portions of the keys pass into and expand in the bore portion 62c of the upper sub above the sleeve. When the lower key bosses 91 reach the restricted bore portion 62, the upper key bosses 84 have moved into and expanded in the normal bore portion 30 of the upper sub, allowing the keys to pivot sufficiently inwardly along their lower end portions for the lower bosses 91 to clear the restricted bore portion 62 of the sub.

As the shifting tool is moved upwardly in the tubing string, the keys may be compressed or contracted inwardly along their full lengths if restrictions or obstruction conditions are encountered which preclude clearance by the keys by the normal wobbling or pivotal movement thereof. Such a condition is represented in FIG. 6, in which the keys are shown compressed fully inwardly, whereby they pass through a restriction which they cannot wobble past. Presuming for purposes of illustration that such a restriction is at the lower internal boss 60 of the sleeve, as the upper end portions of the keys enter the lower end of the sleeve the keys engage the restriction and are forced downwardly on the body 70 against the support ring 100 and spring 101, compressing the spring and moving the pivot pins 73 of the keys downwardly in the slots 72. When the pivot pins reach the downwardly and inwardly sloping portions 72b of the slots, the pivot pins move downwardly and inwardly, permitting the keys to move inwardly or be compressed or retracted toward each other on the body to provide added clearance around the keys for the tool to pass through the obstruction.

The sleeve shifting tool is thus lifted upwardly in the tubing string through each of the flow control devices S included in the string without affecting the position of the sliding sleeve in each of the devices, and when an obstruction is encountered which the tool cannot clear by the normal pivoting or wobbling of the sleeve shifting keys the keys are compressed or retracted fully inwardly on the tool body to provide additional space around the tool for clearance of the keys to allow the tool to move upwardly. The tool is retrieved at the surface from the tubing string in the usual manner.

While the sleeve has been described as shifted from open to closed positions, it is believed readily apparent that the arrangement of the lateral ports could be reversed so that the movement was from closed to open positions.

It will now be seen that a new and improved well tool for shifting a member within a flow conduit between longitudinally spaced positions therein has been described and illustrated, and that one particular form of the tool is adaptable to shifting a sliding sleeve or valve member of a flow control device in a tubing string from an upper position to a lower position.

It will also be seen that the tool includes pivotally or swingably supported sleeve shifting keys which are engageable along one end portion with the surface of a reduced bore portion of the housing of a flow control device for pivoting the other end portion of the keys outwardly for engaging the sliding sleeve member in the device, whereby the keys are positively acting and the tool may not pass downwardly through the device without shifting the sliding sleeve.

It will also be seen that the pivotally supported sleeve shifting keys pivot between sleeve engaging and sleeve releasing positions when moving in a direction to shift the sliding sleeve in a flow control device, and are compressible or retractable inwardly when moving in an opposite direction for clearing obstructions through which the tool cannot pass with the normal pivotal movement of the keys.

It will be further seen that a tool of the character described is operable by means of a pumpdown tool train, a wire line tool train, or by means of an operating string such as a string of rods, tubing or pipe.

A preferred form of sleeve shifting tool **320** embodying the invention for operating a modified form of flow control device F is illustrated in FIGS. 7 and 7A, where the tool is illustrated as disposed within the flow control device at a position for shifting the sleeve **215** of the device from an upper open position to a lower closed position. The flow control device F performs the same function of controlling communication between the interior and exterior of a tubing string as the device S of FIGS. **2** and **5** and already described. Further, the device F is compatible with the pumpdown well system illustrated and described in patent application Ser. No. 556,594, filed Jun. 10, 1966, now U.S. Pat. No. 3,419,074, issued Dec. 31, 1968, and accepts anchoring mechanisms and other apparatus shown in such application. One or more of the flow control devices F may be included in the tubing string T, spaced longitudinally at locations at which communication is desired into the tubing string.

The device F includes an upper sub **200** which is internally threaded at its upper end for connection with a section of tubing string above it. The sub is provided with internal spaced locking recesses **201** and **202** for receiving locking mechanisms of the apparatus described and illustrated in the aforesaid U.S. Pat. No. 3,419,074 and with a reduced bore portion **203** which receives a seal section of the apparatus and also functions in the present invention to hold the lower end portions of the sleeve shifting keys of the tool **320** pivoted outwardly while shifting the sleeve **215** of the flow control device F downwardly. The upper sub **200** is threaded at its lower end into the upper end of a nipple or housing section **204** which is provided with a plurality of circumferentially spaced lateral ports **205** for providing flow communication between the interior and exterior of the housing. The lower end of the housing **204** is threaded on the upper end of a lower sub **210** which has an upper bore portion **211**, a reduced middle bore or cam portion **212**, and a lower bore portion **213** of a diameter intermediate that of the bore portions **211** and **212**. An upwardly facing shoulder surface **214** is provided in the bore of the lower sub between the upper bore portion **211** and intermediate bore portion **212**.

A slidable sleeve or valve member **215** is slidably disposed in the housing section for movement between an upper open position, shown in FIGS. 7 and 7A, and a lower closed position FIG. **9**. Upward movement of the sleeve is limited by engagement of its upper end surface **215*a*** with the lower end surface **200*a*** of the upper sub. The sleeve has an upper bore portion **215*b*** which is larger in diameter than the cam bore portion **203** of the upper sub. A plurality of circumferentially spaced lateral ports **220** provided in the sleeve valve are alignable with the housing ports **205** when the sleeve valve is at its upper position to provide flow communication between the interior of the valve and the exterior of the housing. Upper ring seal **221** and lower ring seals **222** are disposed within internal annular recesses provided in the housing **204** above and below the lateral ports **205** for sealing between the sliding sleeve valve and the housing. Intermediate its ends, at the lower end of the upper bore portion **215*b*** the sleeve is provided with an internal annular flange or boss **230** providing an upwardly facing downwardly and inwardly sloping shoulder surface **231** and a downwardly facing upwardly and inwardly sloping surface **232** which are engageable by sleeve shifting keys on the tool **320** for moving the sleeve in the housing. The sliding sleeve has a lower end portion **215*c*** of reduced external diameter below the boss **230** which telescopes into the upper bore portion **211** of the lower sub **210** when the sleeve valve is moved downwardly to its lower or closed position. When the sleeve valve is moved downwardly to its closed position the ports **220** are below the seal rings **222** so that there is no fluid flow communication between the exterior of the housing and the interior of the sleeve **215** through the ports **205**.

The lower end portion of the sleeve valve **215** has a plurality of longitudinally extending circumferentially spaced lands **215*d*** which have upper shoulder surfaces **215*e*** effectively defining an external annular recess **224** around the sleeve valve at the upper ends of the lands. The lands are provided at their lower ends with downwardly and inwardly sloping surfaces **215*f***. An internal annular recess **234** is provided in the housing above the upper end of the lower sub **210**, and an inwardly sprung snap ring or detent **233** in the form of a "C" ring is disposed in the recess **234** to restrain the sleeve **215** against sliding movement at both its upper open position and its lower closed position so that it is not accidentally moved. The downwardly facing shoulder surfaces **215*f*** on the sleeve lands are engageable with the snapring for restraining the sliding sleeve against downward movement, but when sufficient downward force is applied to the sleeve the snapring is spread and expanded outwardly into the recess **234** releasing the sleeve to move downwardly until the snapring snaps or retracts inwardly into the recess **224** at the upper end of the lands for releasably restraining the sleeve at its lower position. An upward force on the sleeve engages the shoulders **215*e*** at the upper ends of the lands with the snapring to cam the snapring outwardly to release the sleeve for movement upwardly to its open position as shown in FIG. 7A.

The sleeve shifting tool **320**, FIGS. 7 and 7A is similar in function and structure to the sleeve shifting tool **20**, already described. The tool **320** has a mandrel or body **370** having an upper external annular enlargement **371** provided with a pair of laterally spaced transversely extending slots **372** each of which has an upper portion **372*a*** extending longitudinally substantially parallel with the longitudinal axis of the body and a lower downwardly and inwardly extending portion **372*b***. Each of the slots **372** receives a transversely extending pin **373** pivotally supporting one of the sleeve shifting keys **321** in longitudinally slidable and swingable or pivotal relationship on the body. The opposite end portions of the pivot pins **373** are secured with a key **321** supported thereby in the same manner as the keys **21** of the tool **20**. Each of the keys **321** is shaped generally similar to the keys **21** and fits in opposed pivotally supported relationship along opposite sides of the body **370** for both pivotal and laterally expandable and retractable movement on the body. Each key has an upper internal recess **375** conforming generally to the shape of the enlargement **371** on the body and sufficiently longer than the enlargement to provide for the necessary longitudinal movement of the key on the body which is required when each of the keys move downwardly and inwardly on the body. The keys are loosely fitted on the body to permit pivotal and longitudinal movement. Each key has a lower internal recess **379** for receiving a lower external annular enlargement or cam member **380** on the body. The lower end of the recess **379** in each key is defined by an upwardly facing downwardly and inwardly sloping cam surface **381** which is engageable with the downwardly facing downwardly and inwardly sloping external cam surface **382** on the lower enlargement or cam member **380** of the body, so that downward force is transmitted directly from the body to the lower end portion of each of the keys. Like the upper recess **375** of each of the keys, the lower recess **379** is substantially longer than the cam member **380** to provide for the desired pivotal and longitudinal movement of each of the keys along the body. Each of the keys has an upper external boss **384** providing an upwardly facing cam surface **385** and a downwardly facing cam surface **390**, and a lower external boss **391** provided with an upper cam surface **392** and a lower cam surface **393**. The cam surface **393** is engageable with the shoulder surface **231** of the sliding sleeve **215** for moving the sleeve downwardly. Additionally, the outer surface of each of the keys is relieved along a lower portion **321*a*** to facilitate wobbling or pivoting the keys past obstructions in the tubing string and in the flow control device. Each key is somewhat thicker along upper portion **321*b*** above an external shoulder **321*c*** to provide sufficient thickness for structural rigidity of the key along the internal recess **375**.

The lower end of each key is V-shaped in section as defined by an upwardly and inwardly sloping inner surface **393*a*** and the upwardly and outwardly sloping cam surface **393**.

A ring **400** is disposed on the body **370** below the keys and is supported on a spring **401** which biases the ring upwardly against the lower ends of the keys. The upper face of the ring **400** is in the form of a V-shaped groove **400*a*** which is substantially complementary to the shape of the lower ends of the keys, so that the upward force exerted by the ring on the lower ends of the keys tends to cam the lower ends of the keys inwardly toward the tool body. The slopes of the key end surfaces **393** and the corresponding outer surface portion of the groove **400*a*** in the ring **400** is greater than the slopes of the engaging cam surface **382** and the upwardly facing inner key cam surfaces **381** so that the net effect of the upward force of the ring on the lower ends of the keys is to cam the lower end portions of the keys inwardly.

The lower end of the spring **401** is supported by an upwardly facing shoulder surface **402** on a lower connector socket **403** threaded on the lower end of the tool body **370** and locked in place by a pin **403*a***. The socket **403** is identical to the socket **103** already described in connection with the sleeve shifting tool **20** and functions to receive a coupler **410** for connecting the lower end of the sleeve shifting tool in a pumpdown type tool string of the type illustrated in FIG. **1** and already discussed. An upper connector socket **411** is threaded on the upper end of the tool mandrel **370** for connecting a coupler **410** to the upper end of the tool in the pumpdown tool string.

FIG. **10** shows the sleeve shifting tool **320** fitted for use in a wire line tool string of the type already discussed in connection with the sleeve shifting tool **20**. A sub or fishing neck **423** is substituted on the upper end of the tool mandrel for the socket connector **411**. The sub **423** has a threaded pin **424** connected with the tool string which includes a wire line socket **430** at its upper end supported from a wire line **425**. A retainer **420** threaded on the lower end of the tool mandrel below the spring **401** is substituted for the lower connector socket. The retainer has an upwardly facing shoulder **422** engaged by the lower end of the spring **401**, so that the spring is confined between the retainer and the biasing ring **400** at the lower end of the keys **321**.

When the tool **320** is moving freely through a full diameter portion of the tubing string, as represented by FIG. **10**, the spring **401** holds the ring **400** fully in contact with or seated against the lower ends of the sleeve shifting keys so that the keys are restrained at a substantially neutral position generally parallel with the longitudinal axis of the tool body. At such position the internal cam surface **381** at the lower end of the lower recess **379** in each key is biased against the downwardly facing cam surface **382** on the lower enlargement **380** of the tool mandrel **370** and the lower end surfaces **393** and **393*a*** are seated in the key groove **400*a***. The pivot pin **373** of each key is located in its slot **372** substantially as shown in FIG. **7**, though the keys are parallel with the body as distinguished from pivoted outwardly along their lower ends as in FIG. **7**.

The sleeve shifting tool **320** is operable in a pumpdown system by means of a tool train of the type illustrated in FIG. **1**, by means of a wire line type of tool string as shown in FIG. **10**, or by means of a rod, tubing or pipe string, not shown, connected to the pin **424** of the sub **423**. The actual operation of the sleeve shifting tool is the same with each of the various apparatus for moving it through the tubing string. The tubing string in which the tool string is operated as illustrated in FIG. **1** will, of course, include the flow control devices F instead of the devices S since the devices F are especially designed for manipulation by the sleeve shifting tool **320**.

The tool is moved downwardly in the tool string with its sleeve shifting keys **321** held at their neutral position by the ring **400**, FIG. **10**, until the lower ends of the keys enter the restricted bore portion **203** at the lower end of the sub **200** of the first or uppermost flow control device F. Above this restricted bore portion the internal diameter of the sub, with the exception of those portions along the locking recesses **201** and **202**, is the same as the full diameter of the tubing string above the flow control device so that the sleeve shifting keys remain at their neutral position until their lower ends enter the restricted bore portion **203**. The restricted bore portion cams the lower ends of the keys slightly inwardly pivoting the keys on the pins **373** so that the lower end portions of the keys pass through the restricted bore portion into the upper bore portion **215*b*** of the sleeve valve **215**. As soon as the lower key bosses **391** pass below the restricted bore portion **203**, the upward force of the ring **400** against the keys returns the keys to their neutral positions until the upper external bosses **384** on the keys arrive at the restricted bore portion **203**. When the upper bosses **384** enter the restricted bore portion the upper end portions of the keys are cammed inwardly, pivoting the keys on the pins **373** and moving the lower end portions of the keys outwardly. The substantial length of the keys below the support pins compared with the length of the keys above the pins provides for a relatively small amount of inward movement of the upper end portions of the keys to effect a substantial outward movement of the lower end portions of the keys as the keys pivot. The keys and components of the flow control device F are so relatively proportioned that the upper key bosses **384** enter the restricted bore portion **203** when the lower cam surfaces **293** on the keys are slightly above the cam surface **231** of the sliding sleeve at the upper end of the internal annular flange **215**. The tool continues downward movement until the key surfaces **393** engage the sleeve shoulder surface **231**. Since the restricted bore portion **203** of the sub **200** holds the upper end portions of the keys inwardly, the lower end portions of the keys are held outwardly and cannot move inwardly, so that further downward movement of the tool also moves the sleeve **215** downwardly. The downward force applied at the upper end of the tool mandrel **370** from a piston unit **26** in a pumpdown tool train, a wire line tool string, or a supporting pipe string is transmitted directly from the lower cam surface **382** of enlarged portion **380** of the tool mandrel through the lower end portion of the keys to the sliding sleeve at its shoulder surface **231**, so that the pins **373** function for pivotal support of the keys but do not transmit force between the keys and the tool mandrel.

As the sliding sleeve valve **215** is forced downwardly in the housing **204** the downwradly facing shoulder surfaces **215*f*** on the lands **215*d*** engage the detent ring **233** expanding or spreading the ring outwardly releasing the sleeve for downward movement. The sleeve shifting tool continues to force the sliding sleeve valve downwardly so long as the upper bosses **384** of the keys are engaged with the restricted camming bore portion **203** of the upper sub. At substantially the same time as the upper key bosses pass downwardly from the camming bore, the detent ring **233** enters the upper recess **224** on the lower end portion of the sliding sleeve valve to hold the sleeve at its lower closed position. If the sleeve is forced downwardly slightly beyond the position of alignment of the detent ring with the recess **224** the lower end of the sleeve will engage the upwardly facing stop shoulder surface **214** in the bore of the lower sub **210** to prevent any further downward movement of the sleeve

As soon as the upper bosses **384** of the keys exit from the restricted camming bore portion **203**, the lower end portions of the keys are free to pivot inwardly. The upward force of the spring **401** acting on the ring **400**, coupled with the camming action of the shoulder surface **231** in the sliding sleeve against the lower outer end surfaces **343** of the keys, cams the lower ends of the keys inwardly as soon as the keys are free to swing or pivot, and the keys are disengaged from the surface **231** of the sliding sleeve, releasing the shifting tool to move downwardly in the tubing string.

The lower outer bosses **391** on the keys move through the internal boss or flange **230** of the sliding sleeve leaving the sleeve at its lower position as the shifting tool moves downwardly. When the upper bosses **384** of the keys arrive at the boss **230**, the lower bosses **391** are substantially below the restricted bore portion **212** of the lower sub so that the keys are free to pivot on the pins **373** and the upper end portions of the keys are cammed inwardly until the upper bosses **384** pass downwardly through the sleeve bore **230**. The keys continue to wobble, swing, or pivot sufficiently as the tool moves downwardly to fully clear the flow control device, after which the keys are returned by the spring biased ring **400** to their neutral position, in which they remain as the tool moves downwardly in the tubing string until the next flow control device is reached, at which time the cycle of engagement with the sliding sleeve, movement of the sleeve downwardly to its closed position, and release from the sleeve is repeated.

After the desired number of flow control devices F in the tubing string have been closed by the downward movement of the sleeve shifting tool **320**, the tool is returned to the surface through each of the sliding sleeve valves without shifting the valves from their lower closed positions. As the tool passes upwardly through the flow control devices the keys **321** wobble or pivot on the pins **373** sufficiently for the keys to pass through the various restrictions in the flow control devices. As in the case of the sleeve shifting tool **20**, if the keys **321** encounter an obstruction in the tubing string or in any of the flow control devices past which the keys cannot move by normal pivotal action on the pins **373**, the keys are forced downwardly and inwardly by the obstruction as the pins **373** move into the lower end portions **372***b* of the pivot pin slots. The inward position of the keys provides additional lateral clearance around the tool for movement past the obstruction, as already discussed.

It will now be seen that another new and improved form of sleeve shifting tool has been described and illustrated which includes sleeve shifting keys of substantial length swingably or pivotally supported near their upper ends whereby a minimum of lateral movement of the upper end portions of the keys effects maximum lateral movement of the lower end portions thereof. It will also be seen that the keys have V-shaped lower end cam surfaces engageable by a spring biased ring having a complementary recessed V-shaped upper face for biasing the keys to a neutral position on the mandrel while allowing the keys to pivot on pivot pins permitting lateral movement of the upper and lower end portions of the keys for engaging a sliding sleeve and providing for the keys to wobble or pivot sufficiently to pass through the sliding sleeve when not held at their sleeve engaging positions.

FIG. 9 illustrates a sleeve shifting tool **500** for moving the sliding sleeve **215** of the flow control device F upwardly from its lower closed to its upper open position, thereby returning the sleeve to the position of FIGS. 7 and 7A. The upshifting tool **500** has a mandrel or body **501** provided with a central annular enlargement **502** which has a pair of laterally spaced transverse slots **503** formed therein. Each slot has a central longitudinal portion **503***a* extending substantially parallel with the longitudinal axis of the mandrel, an upwardly and inwardly inclined upper portion **503***b*, and a downwardly and inwardly inclined lower portion **503***c*. A pair of oppositely positioned longitudinally extending sleeve shifting keys **504** are each loosely swingably or pivotally supported on the mandrel by a pivot pin **505** which passes through one of the slots **503** and is secured at its opposite ends in the key in the same manner as described in connection with the tool **20** and illustrated in FIG. 4.

Each of the keys **504** has a lower internal arcuate recess **510** which receives a portion of the mandrel enlargement **502** and is somewhat longer than the enlargement to permit longitudinal movement along the mandrel. Each of the keys also has an upper internal arcuate recess **511** which receives a cam ring **512** secured by a shear pin **513** on the mandrel for transmitting force from the mandrel to the keys. The ring **512** has a downwardly and outwardly sloping shoulder upper surface **512***a* which is engageable with the downwardly facing sloping shoulder surface **511***a* of each key at the upper end of the upper key recess **511**. The upper end of each of the keys has boss **524** formed with an outwardly facing upwardly and inwardly sloping upper cam surface **514** and an inner downwardly and inwardly sloping end surface **515** providing a substantially V-shape to the upper end of the key.

A ring **520** is movably disposed on the mandrel above the upper end of the keys and biased downwardly by a spring **521** confined between the ring and an upper socket connector **540** for biasing the keys to a neutral position in the same manner as the ring **400** in the downshifting tool **320**. The ring **520** has lower V-shaped face defined by an inner downwardly and inwardly sloping surface **522** and an outer downwardly and outwardly sloping surface **523**. The lower face of the ring is engageable with the V-shaped upper ends of the sleeve shifting keys for releasably holding the keys at a neutral position. Each of the keys also has at its lower end a lower external boss **525**. The outer surface of each of the keys is relieved along an upper portion **530** between the bosses to provide sufficient clearance for pivoting past the various restrictions encountered in the tubing string and flow control devices. Each of the keys is somewhat thickened along a lower portion **531** to provide sufficient material strength along the lower internal recess **510**.

The upper socket connector **540** is threaded on the upper end portion of the tool mandrel **501** for receiving a coupling **541** to connect the upper end of the upshifting tool into a pumpdown type tool string, as illustrated in FIG. 1. The socket connector **540** has a downwardly facing shoulder surface **542** engaged by the upper end of the spring **521** so that the spring for biasing the ring **520** downwardly is confined between the shoulder and the upper face of the ring **520**. Similarly, a lower socket connector **543** is threaded on the lower end portion of the tool mandrel for receiving a coupler **544** for connecting the lower end of the upshifting tool into the pumpdown type tool string.

The upshifting tool **500**, as in the case of the other sleeve shifting tools disclosed and described herein, is readily convertible for use in a conventional wire line tool string, as illustrated in FIG. 11. The lower socket connector **543** is replaced by a lower guide plug or member **550** while the upper socket connector **540** is similarly replaced by a fishing neck or sub **551** having a downwardly facing shoulder **552** engaged by the upper end of the spring **521**. The sub **551** is connected to the lower end of a conventional wire line tool string **553** supported from a wire line **554** in the usual manner.

Since the upshifting tool **500** is adapted for moving sleeves upwardly to their closed positions, it is necessary first to lower the tool to a position below the flow control device or devices to be closed by such upward movement of the tool.

As the tool is moved downwardly through the tubing string, the sleeve shifting keys **504** are held by the ring **520** in a neutral position in which they are substantially parallel with the tool mandrel, as represented in FIG. 11, so long as the tool is in normal diameter portions of the tubing string. When the tool reaches the uppermost flow control device F and the keys enter the restricted cam bore portion **203** of the device, the lower end portions of the keys are pivoted inwardly sufficiently to pass downwardly through such restricted bore into the larger bore of the housing **204** below the upper sub. When the upper bosses **524** of the keys enter the restricted cam bore portion **203** they are cammed inwardly, pivoting the lower end portions of the keys outwardly until the upper end portions of the keys pass below the restricted bore portion. Since the sleeve valve **215** is already at its lower position, the expanded lower end portions of the keys may move freely downwardly in the housing **204** and sleeve without engaging the shoulder **231** of the sleeve. The tool continues downwardly through the flow control device with the sleeve shifting keys wobbling, swinging, or pivoting sufficiently to clear the various restrictions within the flow control device, including the inner flange or boss **230** of the sleeve and the restricted bore portion **212** of the lower sub **210**. If the keys encounter an obstruction beyond which they cannot pass by the normal pivotal or wobbling effect, the keys are forced upwardly on the tool mandrel with the pivot pins **505** moving upwardly in the slots **503** to enter the inwardly sloping slot upper portions **503*b*** and the keys are retracted inwardly toward each other to provide additional clearance for the keys to pass beyond the obstruction.

After the upshifting tool is below the lowest of the flow control device or devices which are to be returned upwardly to closed positions, the tool train is reversed and moved upwardly in the tubing string. As the tool enters a flow control device from below, the upper end portions of the keys enter the restricted bore cam portion **212** of the lower sub **210** camming the upper ends of the keys slightly inwardly until they have moved above the restricted bore portion and enter the lower end of the bore of the sliding sleeve **215**. When the lower bosses **525** of the keys enter the restricted bore portion **212**, the lower ends of the keys are cammed inwardly to swing or pivot the keys on the pins **505**, swinging the upper end portions of the keys laterally outwardly so that the outer upper end surfaces **514** of the upper bosses engage the lower shoulder surface **232** of the sliding sleeve. The outward movement of the upper ends of the keys cams the ring **520** upwardly against the force of the spring **521**. FIG. **9** illustrates the upshift tool at about the position at which it initially engages the shoulder **232** of the sliding sleeve for moving the valve upwardly. The force applied to the mandrel of the tool for moving the tool upwardly is transmitted from the mandrel through the shear pin **513** to the ring **512**. The upper face **512*a*** of the ring engages the inner downwardly facing surface **511*a*** of each key, thereby applying upward force to the upper end portions of each of the keys which is then transmitted from the surface **514** of each of the keys to the internal shoulder surface **232** of the sliding sleeve. Thus, the upward force necessary to move the sleeve is not applied to the pivot pins **505**.

As the sleeve moves upwardly the detent ring **233** is cammed outwardly into the recess **234** by the upper end surfaces **215*e*** on the sleeve, releasing the sleeve for upward movement. The tool moves the sleeve upwardly until the bosses **525** at the lower ends of the keys emerge upwardly from the restricted bore cam portion **212**, at which time the sleeve is at its upper closed position and the detent ring **233** is contracted inwardly around the sleeve below the lower cam surfaces **215*f*** on the lower end portion of the lands **45*d*** on the sleeve.

Since the lower bosses **525** on the keys have moved above the restricted bore portion **212**, the lower ends of the keys are free to expand slightly, allowing the keys to pivot so the upper end portions of the keys swing inwardly due to the combined action of the spring biased ring **520** and the shoulder surface **532** acting on the key surfaces **514**. The keys are thus cammed inwardly back to their neutral positions.

The sleeve is thus released at its upper closed position, with the tool continuing upwardly and the sleeve shifting keys wobbling or pivoting to clear the remaining restricted bore portions of the flow control device.

If, when the keys engage the sliding sleeve, the sleeve is stuck and cannot be moved upwardly by the normal force employed with the operating tool string, the shear pin **513** holding the ring **512** on the tool mandrel is sheared, allowing the ring to move downwardly on the mandrel and thereby freeing the sleeve shifting keys for downward movement to the extent permitted by the engagement of the pivot pins **505** in the slots **503**. As the keys are forced downwardly, the pins **505** enter the downwardly and inwardly sloping lower end portions **503*c*** of the slots, so that the keys are retracted inwardly to provide additional clearance for the keys to move upwardly through the sliding sleeve, leaving it at the position at which it is stuck. The upshifting tool is then retrieved from the tubing string, and other standard tools including a jarring tool are incorporated into the tool string in accordance with normal procedures for releasing the sliding sleeve to return it to operative condition.

The procedure described for moving the sliding sleeve is repeated at each of the flow control devices encountered in moving the upshifting tool upwardly in the tubing string.

It will now be seen that a still further form of new and improved sleeve shifting tool for moving a sliding sleeve from a lower to an upper position has been described and illustrated. While the flow control device has been described as shifted from closed top to open position, it is obvious that the lateral flow ports may be arranged otherwise. It will be seen that the tool includes pivotally supported sleeve shifting keys urged upwardly by a shear pin supported driving ring which is releasable when a predetermined upward force is applied to the mandrel of the tool for allowing the sleeve shifting keys to be retracted inwardly by downward movement of the keys on the tool mandrel for clearing obstructions in the tubing string or flow control device. It will also be seen that the sleeve shifting keys are normally biased to a neutral position on the tool mandrel when either end portion of the keys is within a restricted bore portion of the tubing string or a flow control device therein.

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

I claim:

1. A well tool for moving a movable member between two longitudinally spaced positions in a housing having a restricted bore portion spaced from said movable member, comprising: an elongate body having means at opposite ends for connection with actuating mechanisms for moving said tool through said housing; and operator means pivotally supported on said body for releasably engaging said movable member for moving said member between first and second positions therein, one end portion of said operator means being mounted to be pivoted laterally outwardly into engaging relationship with said movable member when an opposite end portion of said operator means engages a cam surface provided by said restricted bore portion of said housing; said operator means being movable past said movable member after said movable member has been shifted from said first to said second position in said housing, said operator means being laterally retractably movable independently of said pivotal movement of said operator means for providing increased clearance around said operator means to permit said tool to pass obstructions in said housing past which said tool is precluded from moving by normal pivotal movement of said operator means.

2. A well tool as defined in claim **1** wherein said elongate body is provided with load bearing surface portion engageable with a surface portion of said operator means whereby force is transmitted from said elongate body to said operator means independently of the pivotal support between said operator means and said body for moving said movable member in said passage.

3. A well tool as defined in claim **2**, including: means operably connected between said elongate body member and said operator means for biasing said operator means toward said load bearing surface on said body.

4. A well tool for moving a sleeve of a flow control device connected in a well flow conductor, the flow control device having a cam surface away from which the sleeve valve is moved, said tool comprising: an elongate body having means

at opposite ends for connection with actuating apparatus for moving said well tool through said flow conductor; sleeve engaging means supported on said body for swingable movement relative thereto whereby engagement of one portion of said sleeve engaging means with said cam surface in said flow control device pivots another portion of said sleeve engaging means laterally outwardly for engaging said sleeve; said sleeve engaging means being retractable toward said elongate body independently of said swingable movement to provide increased clearance around said tool for passing obstructions in said flow conductor; and means operatively connected between said sleeve shifting means and said elongate body for biasing said sleeve shifting means to a predetermined position relative to said body.

5. A well tool as defined in claim **4** wherein said sleeve shifting means comprises: a plurality of sleeve shifting keys each swingably supported with respect to said elongate body by a pivot pin secured to said key and movably disposed in a longitudinally extending transverse slot provided in said elongate body, said slot having an inwardly sloping portion whereby said keys are compressible inwardly on said body responsive to longitudinal movement thereof relative to said body.

6. A well tool as defined in claim **5** wherein: each of said sleeve shifting keys is provided with a shoulder surface for engaging said sleeve and moving said sleeve between positions in said flow control device and for camming a portion of said key inwardly for disengagement from said sleeve when the portion of said key engaging said cam surface passes said cam surface, whereby said key is released to pivot on said elongate body to a position of disengagement from said sleeve for releasing said tool from said sleeve.

7. A well tool as defined in claim **6** wherein said elongate body is provided with a bearing surface engageable with a bearing surface provided on each of said keys for transmitting force from said body to each of said keys independently of the pivot pin supporting said key whereby force applied to said body is transmitted at said bearing surfaces to said keys for moving said sleeve when said sleeve is engaged by said keys.

8. A well tool as defined in claim **7** wherein said keys are biased on said elongate body in a direction biasing said bearing surface on said keys toward said bearing surface on said body.

9. A well tool as defined in claim **8** wherein: said elongate body has an external enlarged portion through which each of said transverse slots for receiving said pivot pins is formed, and each of said keys is provided with an internal recess longer in a longitudinal direction than the longitudinal length of said enlarged portion of said elongated body.

10. A well tool as defined in claim **9** wherein said elongate body is provided with a second external enlarged portion spaced from said first enlarged portion, said second external enlarged portion being provided with said bearing surface of said elongated body engageable with said bearing surfaces of said keys; and biasing means is confined between an end surface of said keys and said elongate body for biasing said keys toward said second enlarged portion.

11. The well tool as defined in claim **10** wherein said biasing means includes a ring biased against an end surface of said keys for biasing said keys toward said enlarged portion of said elongate body.

12. A well tool as defined in claim **11** wherein: said ring has a surface of predetermined configuration facing toward said keys, and the end surfaces of said keys adjacent to and engageable with said ring are shaped complementary to said surface of the ring.

13. A well tool as defined in claim **11** wherein: the angle between said bearing surfaces of both said elongate body and said keys and the longitudinal axis of said body is greater than the angle between said longitudinal axis and the slope of said sleeve engaging shoulder surfaces on said keys, whereby said engagement between said shoulder surfaces of said keys and said sleeve cams said keys inwardly, disengaging said keys from said sleeve after said keys pass the cam surface of said flow conductor.

14. A well tool as defined in claim **11** wherein: said second enlarged portion of said elongated body comprises an annular ring secured on said body by shearable means releasable for releasing said ring to provide for said keys to move longitudinally on said elongate body and be retracted inwardly responsive to engagement with a sliding sleeve requiring more than a predetermined force for movement in such flow conductor, and said transverse slots in said first enlarged portion of said elongated body slope inwardly along both opposite end portions whereby said keys are retractable inwardly on said body responsive to movement toward an end position in either direction on said body.

15. A well tool comprising a flow control device for a well flow conductor and an actuator therefor, including: an elongate tubular housing having means at each end for coupling the same to a flow conductor; an aperture in the wall of said housing communicating the exterior and interior thereof; a valve element in said housing slidable longitudinally therein between a position closing said aperture and a position in which the aperture is open to permit flow therethrough; means in said housing spaced from said valve element providing a cam surface; an actuator tool having operator means pivotally supported thereon and engageable with said valve element and said cam surface for moving said valve element in said housing between open and closed positions, said operator means being mounted to move out of engagement with said cam surface and to pivot out of engagement with said valve element when said valve element has been moved from one of said open and closed positions to the other, and to be movable laterally to a retracted position to permit said operator means to pass obstructions in said housing independently of pivotal movement of said operator means.

16. A flow control device for a flow conductor and an actuator therefor, including: an elongate tubular housing having means at each end for coupling the same to a flow conductor; an aperture through the wall of said housing; a sleeve valve element in said housing for controlling flow of fluids between the interior and exterior of said housing through said aperture; said valve element being slidable in said housing between a position in which said aperture is open to permit flow therethrough and a position in which the lateral aperture is closed to prevent flow therethrough; seal means between said housing and said lateral aperture when said valve element is in closed position; means providing actuating shoulder means on said valve element and relief means in the form of an enlarged bore in said valve element; a cam surface in said housing spaced from said valve element; an actuator tool for moving said valve element between said open and said closed positions in said housing comprising an elongate body having means thereon for connection with a tool string for moving said actuator through said housing and said valve element; operator means pivotally supported on said elongate body of said actuator means having means for releasably engaging said actuating shoulder means of said valve element for moving said valve element longitudinally of the housing between a first position and a second position, said operator means being movable laterally and retractable from engagement with said shoulder means for movement past said shoulder means after said valve element has been shifted in said housing, said cam surface in said housing engaging one end of said operator means for holding the opposite end thereof in actuating engagement with said shoulder means of said valve element for moving said valve element in said housing between said first and second positions, said cam surface being disposed in spaced relationship with respect to said valve element to free the end of said operator means in engagement with said cam surface from such engagement when said valve element has been moved to said second position, whereby said end of said operator means which engaged said cam surface may pivot outwardly to permit said opposite end to pivot out of engagement with said shoulder means of said valve element to permit said operator means to pass said valve element after the same has been shifted to said second position in said housing.

17. A device of the character set forth in claim wherein said operator means is laterally retractable independently of the pivotal movement thereof on said elongate body for providing increased clearance around said operator means to permit said actuator to pass obstructions in said housing through which said actuator is precluded from passing by normal pivotal movement of said operator means.

18. A flow control device for a flow conductor adapted for use with an actuating tool having thereon elongate pivotally mounted operator means having opposite ends swingable about said pivotal mounting, said flow control device comprising as a subcombination: an elongate tubular housing having means at each end thereof for coupling the same to a flow conductor; an aperture through the wall of said housing; a tubular valve element slidable longitudinally in said housing between a first open position admitting flow through said aperture in said housing wall and a second closed position closing off flow through said aperture; seal means between said tubular housing and said valve element sealing therebetween when the valve element is in said second closed position to prevent flow of fluids through said aperture in said housing; means providing actuating shoulder means on said valve element and an enlarged relief bore in said valve element; and means providing camming surface means in said housing spaced from said shoulder means of said valve element and adapted to be engaged by one swingable end of said operator means of said actuating tool when said valve element is in said first position to hold the opposite swingable end of said operator means of said actuating tool in engagement with said shoulder means of said valve element for movement of said valve element between said first position and said second position.

19. A flow control device of the character set forth in claim 18 wherein said relief bore in said valve element is disposed to receive said one end of said operator means to permit said opposite end of said operator means of said actuating tool to pivot out of engagement with and move past said shoulder means of said valve element when said one end of said operator means is out of engagement with said camming surface.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,552,718 Dated January 5, 1971

Inventor(s) Harry E. Schwegman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 10, line 60, for "downwradly" read --downwardly--

Column 17, line 1, after "claim" insert --16--

Signed and sealed this 11th day of May 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR
Commissioner of Patents