Aug. 28, 1962 G. G. GRIMMER ET AL 3,051,243

WELL TOOLS

Filed Dec. 12, 1958 4 Sheets-Sheet 1

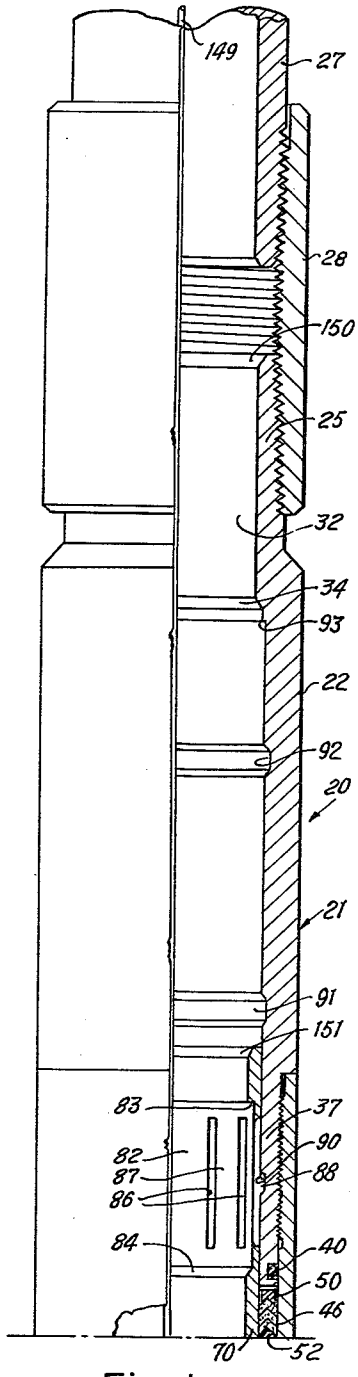

Fig. 1

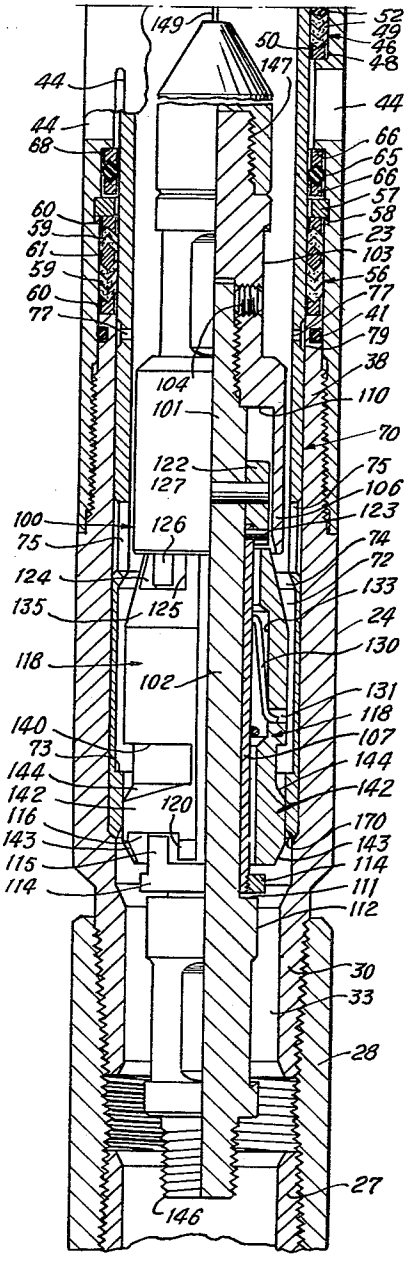

Fig. 2

INVENTORS
George G. Grimmer
James H. Bostock

BY Kostas Cushman & Cushman
ATTORNEY

Aug. 28, 1962 G. G. GRIMMER ET AL 3,051,243

WELL TOOLS

Filed Dec. 12, 1958 4 Sheets-Sheet 2

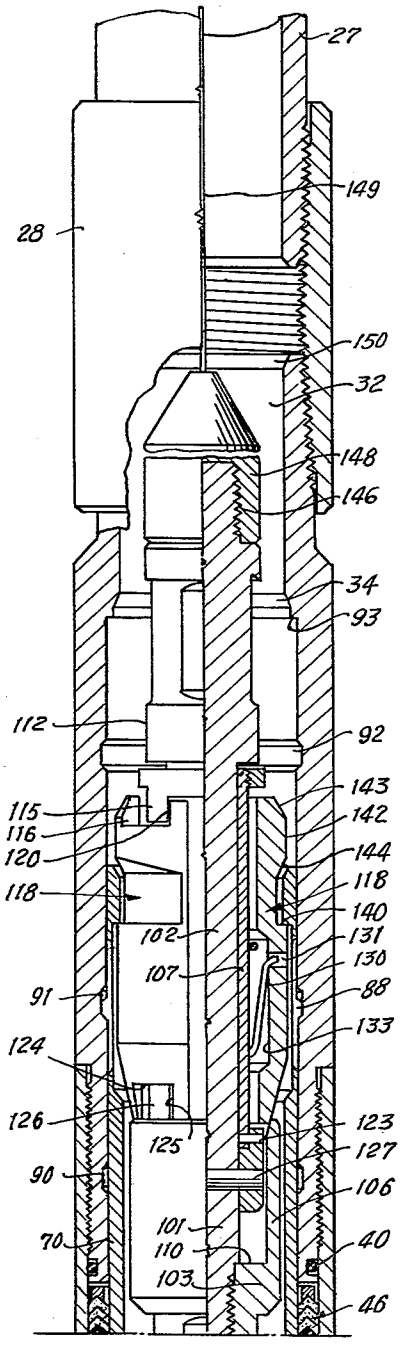

Fig. 3

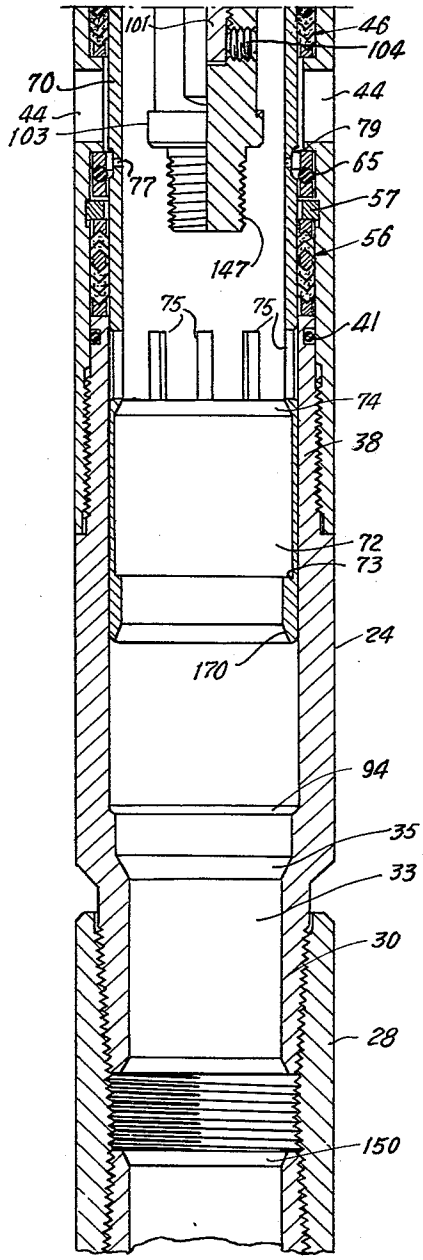

Fig. 4

INVENTORS
George G. Grimmer
James H. Bostock

BY Hastings Ashley
ATTORNEY

Aug. 28, 1962 G. G. GRIMMER ET AL 3,051,243

WELL TOOLS

Filed Dec. 12, 1958 4 Sheets-Sheet 3

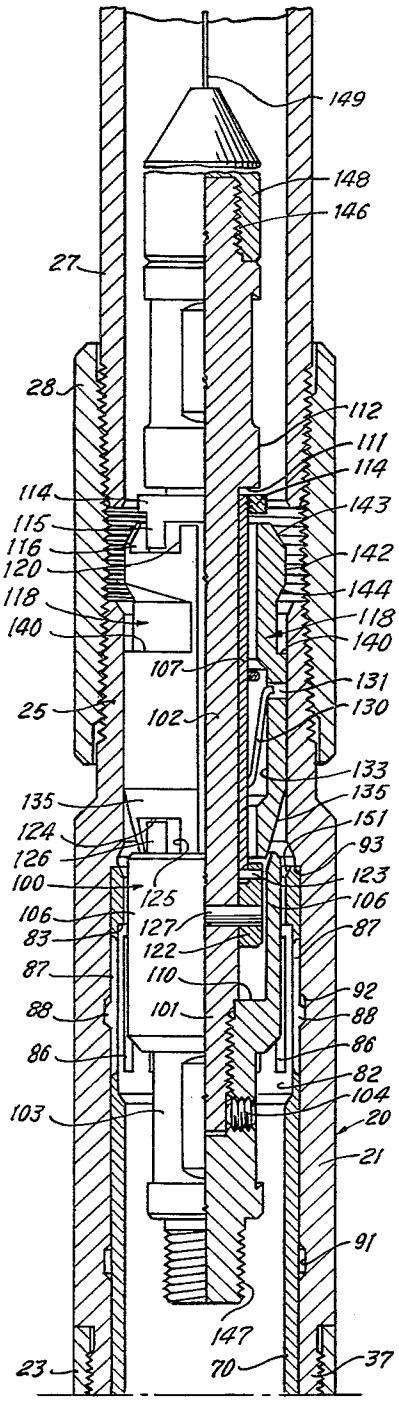

Fig. 5

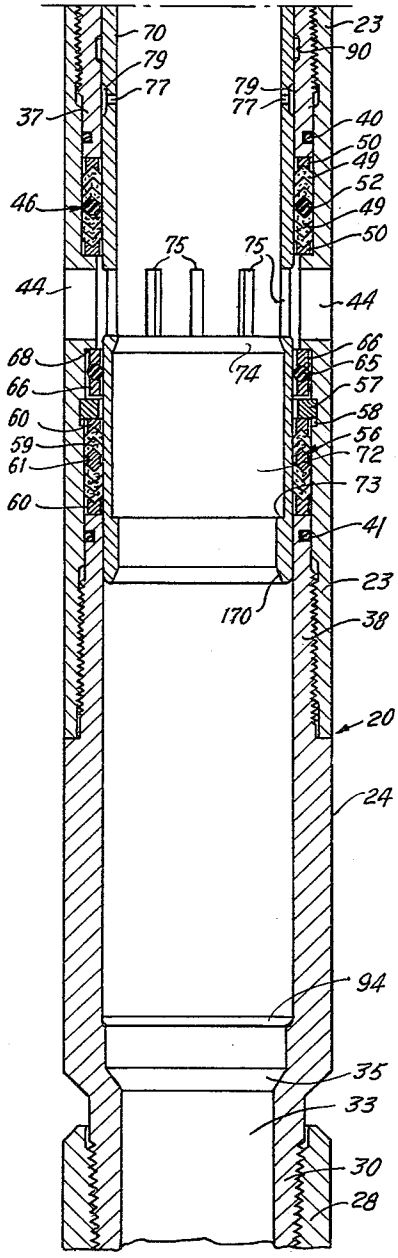

Fig. 6

INVENTORS
George G. Grimmer
James H. Bostock

BY

ATTORNEY

Aug. 28, 1962 G. G. GRIMMER ET AL 3,051,243

WELL TOOLS

Filed Dec. 12, 1958 4 Sheets-Sheet 4

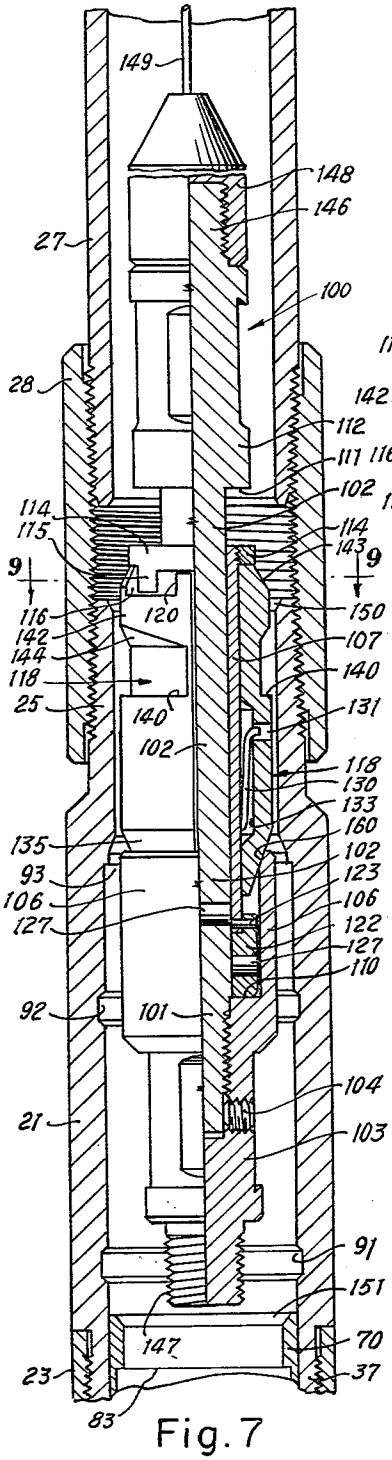

Fig. 7

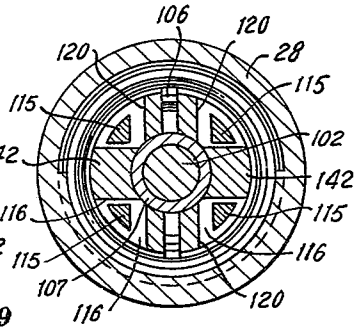

Fig. 9

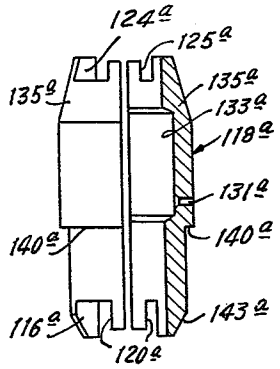

Fig. 10

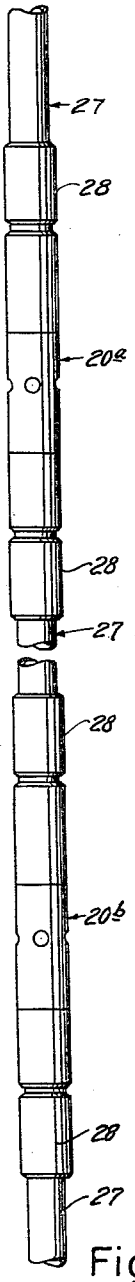

Fig. 8

INVENTORS

George G. Grimmer

James H. Bostock

BY Westerfield & Ashley

ATTORNEY

United States Patent Office 3,051,243 Patented Aug. 28, 1962

3,051,243

WELL TOOLS

George G. Grimmer, 10617 Coogan Drive, and James H. Bostock, 5615 La Foy Blvd., both of Dallas, Tex.

Filed Dec. 12, 1958, Ser. No. 780,112
21 Claims. (Cl. 166—224)

This invention relates to well tools and more particularly to flow control devices connectable in a well flow conductor and to well tools for operating the flow control devices while they are connected in the well flow conductor.

An object of this invention is to provide a new and improved flow control device for connection in a well flow conductor.

Another object is to provide a flow control device connectable in a well flow conductor for controlling the flow of fluids into the flow conductor at a predetermined position in the flow conductor.

Still another object of the invention is to provide a flow control device which is operable to open and close port means to permit flow of fluids into the interior of the well flow conductor and which has means for slowly equalizing the pressure between the exterior and the interior of the flow conductor prior to the full opening of the port means.

A further object of the invention is to provide a flow control device which includes a nipple, connectable in and constituting a section of the well flow conductor, having port means providing communication between the interior of the flow conductor and the exterior thereof which is provided with a longitudinally slidable valve sleeve for selectively closing and opening the port means.

A still further object of the invention is to provide a flow control device wherein the valve sleeve and the nipple are provided with co-operable positioning means for locating the valve sleeve in preselected operable positions relative to the port means of the nipple.

A still further object of the invention is to provide a flow control device having a nipple provided with lateral ports and a valve sleeve longitudinally slidably positioned in the nipple for movement between an open position wherein the ports of the nipple are fully opened to permit flow of fluids into the conductor, an equalizing position wherein the flow of well fluids through the ports is restricted whereby the pressure differential between the exterior and the interior of the flow conductor may be equalized slowly, and a closed position wherein the lateral ports of the nipple are closed to prevent any flow of fluids therethrough into the well flow conductor.

Another object of the invention is to provide a flow control device for well flow conductors, such as a tubing string, which includes a nipple connectable in and constituting a section of a tubing string provided with lateral ports, and having a valve sleeve slidably mounted in the nipple for limited longitudinal movement therein, the valve sleeve having a plurality of restricted orifices which communicate with the lateral ports of the nipple to permit slow or restricted flow of fluids therethrough when the valve sleeve is in an equalizing position in the nipple and having a plurality of large apertures which permit unrestricted flow of fluids through the lateral ports of the nipple into the well flow conductor when the valve sleeve is in an open position in the nipple, the valve sleeve also being movable to a closed position wherein it prevents any flow of fluids through the lateral ports of the nipple.

Still another object of the invention is to provide a flow control device for a well flow conductor which includes a nipple, connectable in and constituting a section of the flow conductor, which has longitudinal passage or bore therethrough diminished at opposite ends of the nipple to provide camming surfaces engageable with a running tool, usable for moving the valve sleeve between its various operative positions, to cause the latch or key means of such running tool to be biased into retracted positions out of engagement with the valve sleeve whereby the running tool may be easily moved in either direction through the nipple and the valve sleeve as desired in order that the running tool may be used to close or open preselected ones of a plurality of flow control devices connected at longitudinally spaced positions in the well flow conductor.

Still another object of the invention is to provide a running tool for shifting a valve sleeve longitudinally in its nipple between its various operative positions which includes a latch or key means mounted for lateral movement on the running tool between expanded and retracted positions; the keys, when in expanded positions, being engageable with shoulders of the valve sleeve whereby engagement of the keys with such shoulders causes the valve sleeve to move with the running tool as the latter is moved in the nipple.

A further object is to provide a running tool for shifting a longitudinally movable valve element in a flow conductor which is provided with a longitudinal member, connectable to a flexible line whereby the running tool may be lowered through a well flow conductor, on which are mounted a plurality of keys for lateral movement between retracted and expanded positions, the keys having shoulders extending perpendicularly to the longitudinal axis of the running tool so that when the running tool is lowered by one end through the valve element the keys are adapted to engage an upwardly facing shoulder of the valve element to cause the valve element to be moved downwardly in its nipple and when the running tool is suspended by its other end the keys are adapted to engage a downwardly facing shoulder of the valve element to cause the valve element to be moved upwardly.

A still further object of the invention is to provide a running tool wherein the keys are provided with cam surfaces which are engageable with cam surfaces of the landing nipple to cause the keys to be moved inwardly to their retracted positions when the valve element has been moved to either of the extreme positions in the nipple.

Still another object of the invention is to provide a running tool wherein the cam surfaces of the keys, when the running tool is suspended from one end, cause the keys to move toward retracted positions upon meeting upwardly facing obstructions during the passage of the running tool through the well flow conductor and through the valve element, and which cause the keys, when the running tool is suspended from its other opposite end, to be cammed toward the retracted position when the running tool is moved upwardly in the well flow conductor upon meeting downwardly facing obstructions in the well flow conductor.

A particular object of the invention is to provide in a flow control device of the character described means for equalizing fluid pressures inside and outside of the device during the opening operation, whereby fluid pressure will not act on the shifting or running tool used in moving the sliding sleeve valve element from closed to open position to move the sleeve suddenly to open position and disconnect the shifting tool therefrom and blow such shifting tool up the well conductor or tubing and ball up or tangle the flexible line by which the shifting tool is operated.

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

FIGURE 1 is a vertical view partly in elevation and partly in section showing the upper portion of a flow con-

trol device embodying the invention with the valve element or sleeve in its lowermost closed position in the nipple;

FIGURE 2 is a view similar to FIGURE 1, being a continuation thereof, and showing partly in elevation and partly in section the lower portion of the flow control device and a running tool embodying the invention as it appears after it has moved the valve element to its lower closed position and is moving downwardly through to the flow control device;

FIGURE 3 is a vertical view, partly in elevation and partly in section, of the flow control device illustrated in FIGURES 1 and 2 showing the valve element in its intermediate pressure equalizing position and showing the running tool in engagement with the valve sleeve for moving it upwardly in the nipple;

FIGURE 4 is a view similar to FIGURE 3, being a continuation thereof, and showing the lower portions of the flow control device and the running tool;

FIGURE 5 is a vertical view, partly in elevation and partly in section, of the upper portion of the flow control device showing the valve element in its uppermost open position and showing the running tool as it appears moving upwardly through the flow conductor after having moved the valve sleeve to its uppermost open position;

FIGURE 6 is a view similar to FIGURE 5, being a continuation thereof, showing the lower portion of the flow control device.

FIGURE 7 is a vertical view, partly in elevation and partly in section, showing the keys of the running tool moved to retracted positions by a camming sleeve of the running tool to permit movement of the running tool through a flow control device when the valve thereof is for some reason immovably held or stuck in its nipple in a position other than its fully open or fully closed position;

FIGURE 8 is a vertical elevational view of a well flow conductor provided with a plurality of longitudinally spaced flow control devices embodying the invention;

FIGURE 9 is a horizontal cross-sectional view taken on the line 9—9 of FIGURE 7; and

FIGURE 10 is a perspective view of a modified form of the running tool keys illustrated in FIGURE 2.

Referring now to the drawing, the flow control device **20** embodying the invention includes a nipple **21** having an upper sub section **22**, an intermediate sleeve or sealing section **23** and a lower sub section **24**. The upper sub section **22** has a reduced externally threaded upper end portion **25** so that it may be connected to the lower end of a well flow conductor or tubing string section **27** by means of a tubular coupling or collar **28**. The lower sub section **24** is similarly provided with a lower reduced end portion **30** which is externally threaded whereby it may be connected to the upper end of a well flow conductor or tubing string section **27** by means of a similar tubular coupling or collar **28**. The upper and lower sub sections **22** and **24** have reduced internal bores adjacent their end portions **25** and **30** to provide key retaining surfaces **32** and **33** and key camming shoulders **34** and **35**, respectively, whose functions will be set forth below.

The upper and lower sub sections have reduced lower and upper end portions **37** and **38**, respectively, which are threaded into opposite ends of the sealing sleeve section **23**. The reduced end portions **37** and **38** of the upper and lower sub sections are provided with external annular recesses in which are disposed O-rings or seals **40** and **41** which seal between the sub sections and the sealing sleeve sections. The sealing sleeve section **23** is provided with a plurality of circumferentially spaced lateral apertures or ports **44**.

An upper seal assembly **46** is carried by the sealing sleeve section **23** above the ports **44** and is held between the upper annular shoulder **48** of an internal flange of the sealing sleeve section **23** and the lower end of the upper sub section **22**. The sealing assembly **46** may be of the chevron type having a plurality of resilient elements **49** positioned between female adapters **50**, which engage the upwardly facing shoulder **48** and the lower end of the upper sub section **22**, and may also include a male adapter **52** disposed in the usual manner between central oppositely facing adjacent resilient elements of the assembly.

The sleeve or sealing section **23** is provided with a similar seal assembly **56** which is held in place therein by a split retainer ring **57** disposed in a suitable internal annular recess **58** of the lower sub section **23**, and by the upper end of the lower sub section **24**. The sealing assembly **56** may include a plurality of resilient elements **59** disposed between female adapters **60** which bear against the retainer ring **57** and the upper end of the lower sub section **24**. A male adapter **61** may be disposed between adjacent central oppositely facing resilient elements **59** of the assembly in the usual manner.

An O-ring seal **65** is carried by the lower sealing sleeve section **23** and is disposed between a pair of female adapters **66** so that only small portions of the O-ring or sealing element **65** extend outwardly of the female adapters. The female adapters **66** abut the lower annular shoulder **68** of the sealing sleeve section **23** and the upper surface of the retainer ring **57** which thus hold the O-ring **65** and the female adapters **66** assembly in proper operative position between the lower seal assembly **56** and the ports **44**.

The sealing assemblies **46** and **56** and the O-ring **65** are adapted to seal between the sealing sleeve section **23** and an internal valve element or valve sleeve **70** which is longitudinally movable in the nipple **21**. The valve sleeve **70** is provided adjacent its lower end with a lower internal annular key recess **72** which provides an upwardly facing abrupt stop shoulder **73** and an upwardly and inwardly extending cam shoulder **74**. The valve sleeve is also provided with a plurality of circumferentially spaced longitudinal slots or flow ports **75** disposed above the key recess **72** which are adapted to be aligned with the lateral ports **44** of the nipple **21** when the valve sleeve is in its uppermost position, FIGURES 5 and 6, and with a plurality of equalizing ports **77** of restricted orifice which are adapted to communicate with the lateral ports **44** of the nipple **21** when the valve sleeve is in an intermediate position in the nipple as shown in FIGURES 3 and 4. The valve sleeve is provided with external reliefs or recesses **79**, preferably of circular dish-shaped configuration, which slope inwardly to the equalizing ports **77** in order to permit pressure of the fluids from the exterior of the well flow conductor to be exerted on the O-rings **65** prior to the achievement of full communication between the equalizing ports **77** and the lateral ports **44** of the nipple **21** so that the O-ring is moved slowly out of engagement with the external surface of the valve sleeve **70** prior to the establishment of a free flow of fluids through the equalizing ports **77**.

This slow compression or inward movement of the O-ring between the female adapters **66** serves to protect the O-ring against injury or damage which might occur were the pressure differential thereacross to be suddenly increased due to the alignment of the equalizing ports **77** with the lateral ports **44**. Moreover, it will be noted that only small portions of the O-ring **65** are ever in engagement with the valve sleeve **70** since the largest part of the O-ring is disposed between, and is protected by, the female adapters **66**.

The upper portion of the valve sleeve **70** above the equalizing port **77** is provided with an upper annular key recess **82** which provides an abrupt downwardly facing shoulder **83** and an inwardly and downwardly extending cam shoulder **84**. The valve sleeve at the upper key recess **82** is provided with a plurality of longitudinal slots **86** which provide resilient flexible collet sections **87** each having an external boss **88** provided with outwardly

convergent upper and lower shoulders. The bosses 88 are receivable in the internal longitudinally spaced annular locating recesses 90, 91 and 92 of the upper sub section 22.

When the valve sleeve 70 is so positioned in the nipple that the bosses 88 are disposed in the lowermost locating recess 90, the ports 44 are closed by the valve sleeve and no flow of fluids between the interior of the well flow conductor and the exterior thereof can take place. When the bosses 88 are disposed in the intermediate locating recess 91, the equalizing ports 77 are in alignment or communication with the lateral ports 44 so that a restricted flow of fluids may take place between the exterior and the interior of the flow conductor so that the pressure differential therebetween may be equalized slowly. Finally, when the bosses 88 are located in the uppermost locating recess 92, the longitudinal slots 75 are aligned with the lateral ports 44 of the nipple so that substantially unrestricted flow through the ports 44 may take place between the interior and the exterior of the flow conductor 27.

The outwardly convergent upper and lower shoulders of the bosses cooperate with the upper and lower shoulders of similar configuration of the locating recesses to cam the bosses, and therefore the resilient collet strips 87 inwardly, to permit movement of the valve sleeve between such lowermost, intermediate and uppermost positions in the nipple 21. Upward movement of the sleeve in the nipple 21 is limited by the engagement of the upper end of the valve sleeve 70 with the downwardly facing annular shoulder 93 of the upper sub which is located below the cam shoulder 34 thereof and above the uppermost locating recess 92. Downward movement of the valve sleeve is limited by the engagement of the lower end of the valve sleeve with the upwardly facing annular shoulder 94 which is located above the cam shoulder 35 of the lower sub section 24.

It will therefore be seen that when the valve sleeve 70 is moved downwardly from the open position toward the closed position, the flow ports or slots 75 will be positioned below the lower seal assembly 56 when flow inwardly through the lateral ports 44 is cut off by engagement of the exterior surface of the sleeve 70 with the O-ring above the equalizing ports 77 and dish-shaped reliefs 79. Obviously, this prevents moving of the slotted ports 75 through the lower packing assembly 56 under a pressure differential and prevents damage to the sealing rings 59 of such lower seal assembly when the ports are moved therethrough.

Furthermore, it will be seen that when the sleeve is moved from the closed to the open position, as has already been explained, the provision of the equalizing ports 77 and the external recesses 79 provides for transfer of fluid pressure from exteriorly of the device inwardly through the lateral ports 44 and slowly through the reliefs 79 to the space below the O-ring 65, to equalize pressures above and below the O-ring 65, slowly and prevent damage to the O-ring. Also, the slow equalization of pressures through the equalizing ports 77 prevents application of a pressure differential to the lower packing assembly 56 while the longitudinal slots or flow ports 75 of the valve sleeve 70 are moved through such sealing assembly to the upper open position. The packing is thus protected against damage or injury as the ports are moved therethrough in either direction.

It will also be seen that the flow control device for controlling the flow of fluids between the exterior and the interior of the nipple 21 includes a valve element or sleeve which is provided with equalizing ports of restricted orifice and with flow ports or slots 75 of substantially the same effective orifice as the lateral ports 44 and that upward opening movement of the valve sleeve in the nipple 21 causes first the equalizing orifices 77 to be placed in communication with the lateral ports 44 so that a restricted and therefore slow flow of fluids may take place between the interior and the exterior of the nipple 21 whereby the pressure differential therebetween may be equalized slowly. It will further be seen that after the pressure differential has been equalized, further upward movement of the valve sleeve causes the flow ports or slots 75 to be aligned with the lateral ports 44, whereby substantially unrestricted flow of fluids may take place between the interior and the exterior of the landing nipple and therefore between the interior and the exterior of the flow conductor or tubing string 27.

It will further be seen that the valve sleeve 70 and the nipple 21 are provided with cooperable locating means 88 and 90, 91 and 92 whereby the valve sleeve may be releasably latched or positively positioned in fully closed position, in pressure equalizing position and in fully opened position by longitudinal movement of the valve sleeve in the nipple.

It will further be seen that the valve sleeve is disposed in the nipple for limited longitudinal movement therein, such longitudinal movement being limited by the stop shoulders 93 and 94 in the upper and lower sub sections 22 and 24, respectively, of the nipple. It will further be seen that the valve sleeve is provided with key recesses 72 and 82 having upwardly facing and downwardly facing abrupt shoulders 73 and 83, respectively, which are engageable by a suitable running tool to move the sleeve downwardly in the landing nipple toward closed position and to move the valve sleeve upwardly toward its open position.

It will further be seen that the landing nipple 21 is provided with seal means which seal between the valve sleeve and the nipple on opposite sides of the lateral ports 44 and the longitudinal slots 75, so that all flow of fluids between the exterior and the interior of the flow device is directed through such ports and slots when the sleeve is in its upper open position. Similarly, when the valve sleeve is in the lower closed position, the seal means positively seal between the valve sleeve and the nipple on opposite ends of the ports 44 to prevent any flow of fluids inwardly through the ports into the sleeve.

It will further be seen that the landing nipple is provided with upper and lower cam shoulders 34 and 35 and with key retaining surfaces 32 and 33 which are of substantially the same internal diameter as the flow conductor 27 which cooperate with suitable running tools to permit movement of the running tools through the flow control device 20 to selectively allow movement of the running tool through the flow conductor device 20 by moving the keys or latch means of such retrieving tool into retracted position and out of engagement with the abrupt shoulders 83 or 73, as the case may be, when it is desired to move such running tool through a pre-selected flow control device without actuating it from either its closed to its open position or from its open to its closed position.

The running tool 100 for moving the sleeve between its various positions includes an elongate body 101 having a main body section 102 on whose lower end is threaded a lower sub section 103 locked immovably thereto by means of a set screw 104 threaded in the lower sub section which engages a flat on the lower end of the main body section. The lower sub section 103 is provided with an annular tubular camming sleeve 106 which extends about and is spaced from the main body section 102.

A key retainer sleeve 107 is slidably mounted on the main body section 102 for longitudinal movement thereon limited in one direction by the annular shoulder 110 of the lower sub section and limited in the other direction by the shoulder 111 provided by the enlarged intermediate portion 112 of the main body section. The key retainer sleeve 107 is provided at its upper end with a retainer ring 114 which is rigidly secured to the key retainer sleeve by any suitable means, such as weld. The key retainer ring 114 is provided with a plurality of longitudinally extending lugs 115 which are adapted to extend into end recesses 116 of the keys 118 carried by the key retainer

sleeve 107. The lugs 115 are adapted to engage the stop shoulders 120 of the keys to limit outward movement of the keys relative to the key retainer sleeve 107.

The retainer sleeve is provided at its other end with a similar key retainer ring 122 secured to the sleeve by means of a pin 123 which extends through suitable aligned lateral apertures in the sleeve and in the ring. The key retainer ring 122 is provided with similar lugs 126 which extend into the slots 124 in the other end of the keys 118 and are adapted to abut the stop shoulders 125 of the keys to limit outward movement of the keys relative to the key retainer sleeve.

The key retainer sleeve 107 is held in the position illustrated in FIGURES 2 and 4, wherein its key retainer ring 114 is adjacent the shoulder 111 of the main body section 102, by means of a shear pin 127 which extends through suitably aligned bores in the main body section and in the key retainer ring 122. In this position the keys are free to move between the retracted positions illustrated in FIGURES 2 and 5 and the expanded positions illustrated in FIGURE 3. The keys are biased outwardly toward expanded positions by springs 130 whose outer ends are disposed in recesses 131 of the keys and which have sections which bear against the key retainer sleeve. The springs are disposed in suitable internal recesses 133 of the keys.

The keys are provided at one end with beveled cam shoulders 135 which are adapted to engage obstructions, such as the shoulders 73 and 83 of the valve sleeve, when the running tool is being moved through the valve sleeve to move the keys inwardly to retracted positions to permit their movement past such obstructions in one direction. The keys are provided with abrupt shoulders 140 which are adapted to engage the abrupt shoulders 73 and 83 of the valve sleeve when the keys are in their expanded positions in the key recesses 72 or 82 of the valve sleeve to cause the valve sleeve to move with the running tool. The keys are also provided with guide bosses 142 at the ends opposite the cam shoulder 135 which have outwardly convergent upper and lower cam shoulders 143 and 144 which are also adapted to cam the keys to the retracted positions. It will be apparent that if the running tool is being moved in a direction such that the cam shoulders 135 are at the ends of the keys which are in the direction of movement of the running tool the cam shoulders 135 and also the cam shoulders 144 will cam the keys inwardly toward retracted positions upon meeting obstructions. When the bosses 142 are at the ends of the keys which are forward in respect to the direction of movement of the keys the cam shoulders 143 of the bosses engage such obstructions and cam the keys inwardly against the force of the springs 130 to permit movement of the keys and of the running tool past such obstruction. The main body section and the sub section are provided with reduced externally threaded end portions 146 and 147 to which a suitable flexible line fitting or coupling 148 may be secured to connect the running tool to the flexible line 149 and to other line equipment, such as jars.

If it is now assumed that the valve sleeve 70 of a flow control device 20 is in its uppermost open position in a nipple 21 and it is desired to close the flow control device by moving the valve sleeve downwardly, the flexible line fitting or coupling 148 is threaded on the reduced end portion 147 of the running tool sub section 103 so that the running tool is lowered through the flow conductor 27 with the bosses 142 at the forward or lower end of the running tool in the direction of movement thereof. The cam shoulders 143 of the keys cam the keys inwardly when the keys meet such upwardly facing obstructions as the shoulder 150 of the upper sub section 22 of the nipple, the upwardly facing shoulder 151 of the valve sleeve and the shoulder 84 defining one end of the upper key recess 82 of the valve so that the running tool will move through the sleeve until the keys 118 are aligned with and therefore move outwardly into the lower key recess 72 of the valve sleeve whereupon the abrupt shoulders 140 of the keys engage the upwardly facing shoulders 73 of the valve sleeve. Downward jars are then imparted to the running tool to cause the valve sleeve to move downwardly in the nipple 21 from the position illustrated in FIGURES 5 and 6 to the position illustrated in FIGURES 1 and 2, the collet members 87 flexing inwardly to permit the bosses 88 to cam out of the upper locating recess 92 and then out of the intermediate locking recess 91 as the valve sleeve moves downwardly to its lowermost position wherein the bosses 88 enter into the locating recess 90.

As the locating bosses 88 enter into the lowermost locating recess 90 of the nipple, the cam shoulders 143 of the bosses 142 engage with the cam shoulder 35 of the nipple and cam the keys inwardly to their retracted positions to move the abrupt shoulders 140 of the keys out of engagement with the abrupt shoulder 73 of the valve sleeve so that the running tool is then again free to move downwardly, if desired, through the flow conductor 27 below the flow control device 22. During such downward movement of the valve sleeve, the flow passages or ports 75 of the valve sleeve were moved out of alignment with the lateral ports 44 of the nipple and then below the sealing assembly 56. Subsequently the equalizing orifices 77 were also moved downwardly out of communication with the lateral ports 44 and below the sealing assembly 56. In this manner the running tool may be used to move the valve sleeve from its upper open position to its lower closed position.

After the valve sleeve has been moved to its lower closed position the running tool may either be moved downwardly as was explained above or may be pulled upwardly out of the flow conductor since the cam shoulders 135 of the keys will engage the cam shoulders 74 of the sleeve and the cam shoulder 34 of the nipple to retract the keys and permit such upward movement of the running tool.

If it should be desired to move the valve sleeve from the closed position illustrated in FIGURES 1 and 2 to the open position illustrated in FIGURES 5 and 6 the flexible line fitting or coupling 148 is threadedly secured to the reduced threaded end 146 of the main body section 102 so that the abrupt shoulders 140 of the keys will face upwardly as when the running tool is lowered through the well flow conductor 27. As the running tool is lowered through the flow conductor 27, the cam shoulders 135 of the keys cam the keys inwardly toward their retracted positions upon meeting such upwardly facing obstructions as the shoulders 150 of the nipple, the shoulders 151 and 84 of the valve sleeve and the shoulders 94 and 35 of the nipple. The keys of course move outwardly into their expanded positions when they are positioned in alignment with the upper key recess 82 of the valve sleeve.

An upward pull on the running tool now causes the now upwardly facing abrupt shoulders 140 of the keys to engage the downwardly facing abrupt shoulders 83 of the key recess 82 of the valve sleeve so that a further upward force applied to the running tool will cause the valve sleeve to move upwardly, the bosses 88 of the collet strips 87 causing the collet strips to flex inwardly to permit such upward movement of the valve sleeve.

During such upward movement of the valve sleeve, the valve sleeve is first moved to the intermediate position wherein the bosses 88 engage in the intermediate locating recess 91 of the nipple so that the equalizing orifices 77 are placed in communication with the lateral ports 44 of the nipple and a slow equalization of the pressures on the exterior and interior of the nipple is achieved. As was explained above, the external recesses 79 permit a gradual equalization of the pressure differential to which the O-ring 65 is subjected so that the O-ring is caused to move slowly out of sealing engagement with the valve sleeve as the latter moves towards its intermediate position.

Should the well device 20 not be provided with equaliz-

ing ports 77, if the valve sleeve 70 is moved upwardly rapidly to its uppermost position in which the lateral flow ports or slots 75 are moved into full open comunication with the lateral ports 44 of the nipple, the in-rush or fluids through such ports into and upwardly through the tubing would cause the shifting or running tool to be moved upwardly at the rapid rate and cause the bosses 142 of the keys to suddenly engage the downwardly facing shoulder 34 of the nipple and cam the keys inwardly so that the shoulders 140 would be moved out of engagement with the downwardly facing shoulder 83 in the valve sleeve and the running tool permitted to move rapidly upwardly in the tubing by such in-rushing well fluids. This would result in the running tool moving upwardly faster than the flexible line 149 could be withdrawn from the well with the result that the line would become tangled or wadded in a ball, and wrapped around the upper end of the running tool. The running tool would thus be jammed or hung in the bore of the well pipe. This would result in a prolonged fishing and wire cutting operation to the detriment of the well operator.

However, the equalizing ports 77 permit the slow restricted entry of well fluids from exteriorly of the nipple inwardly through the lateral ports 44 and the restricted equalizing ports 77 into the bore of the valve sleeve and into the bore of the tubing thereabove so that pressures within and without the tubing become equalized before the shifting or running tool is moved upwardly to the uppermost position wherein it is released from engagement with the valve sleeve as will now be described.

When the pressure between the exterior and the interior of the nipple has been equalized, further upward movement is imparted to the valve sleeve by pulling upwardly on the flexible line 149 whereby the bosses 88 again are cammed inwardly and out of the intermediate locating recess 91 and permit movement of the valve sleeve to its uppermost position wherein the flow passages or slots 75 of the valve sleeve are aligned with the lateral ports 44 of the nipple and unrestricted flow of fluids may take place between the interior and the exterior of the well flow conductor. As the valve sleeve moves to the uppermost position and the bosses 88 move into the upper locating recess 92 of the nipple, the cam shoulders 143 of the keys 118 engage the cam shoulder 34 of the nipple and their camming engagement moves the keys into their retracted position simultaneously with the movement of the bosses 88 into the upper locating recess 92 so that once the valve sleeve is in its uppermost open position, the now upwardly facing stop shoulders 140 of the keys are moved out of engagement with the downwardly facing stop shoulder 83 of the upper key recess 82 so that the running tool is again freed for further upward movement out of the valve sleeve and through the well flow conductor.

In the event that the valve sleeve or element 70 becomes imovable or struck in the nipple prior to reaching either its fully closed or fully opened position, the keys 118 will not be cammed into retracted positions to move the abrupt shoulders 140 out of engagement with the shoulders 73 or 83 of the key recesses 72 and 82, respectively, as the case may be, in order to permit further downward or upward movement of the running tool. In the event that the valve sleeve becomes stuck prior to reaching its fully closed position while being moved downwardly by the running tool, the running tool of course may be removed upwardly from the valve sleeve and the nipple 21. However, should the valve sleeve become immovable in the nipple while it is being moved from its fully closed position to its fully opened position prior to the engagement of the cam shoulders 143 of the bosses 142 of the keys 118 with the shoulder 34 of the nipple, upward removal of the running tool from the valve sleeve is prevented due to the continued engagement of the stop shoulders 140 of the keys with the shoulder 83 of the valve sleeve. In this event, upward jars are imparted to the running tool to cause the shear pin 127 to shear whereupon the beveled annular shoulder of the camming sleeve 106 engages the cam shoulders 135 of the keys as the running tool body 101 moves upwardly relative to the key retainer sleeve and therefore upwardly relative to the keys. During such upward movement the camming action between the cam surfaces 135 of the keys and the cam shoulder 160 of the camming sleeve 106 causes the keys to move to the retracted positions illustrated in FIGURE 7 and move the abrupt shoulders 140 out of engagement with the shoulder 83 of the valve sleeve thereby freeing the running tool for upward removal through the landing nipple.

It will now be apaprent that a new and improved running tool for moving a valve element of a flow conductor provided with longitudinally spaced upwardly and downwardly facing shoulders has been illustrated and described which is provided with outwardly biased keys or latch means having abrupt shoulders which face upwardly when the running tool is moved through the well flow conductor with one end foremost to engage the downwardly facing shoulder of the valve sleeve whereby the valve element may be moved upwardly and which face downwardly when the running tool is moved with the other end down through the well flow conductor to engage the upwardly facing shoulder of the valve element to move it downwardly.

It will further be seen that the keys of the running tool are provided with cam shoulders which engage cam shoulders of the flow control device to move the keys out of engagement with the valve element as the valve element reaches either of its extreme open or closed positions whereby the running tool may be moved in the same direction through the valve element to perform another operation on another valve element of the flow conductor connected at a spaced distance from the first flow control device in the flow conductor.

It will further be seen that the running tool is provided with a releasable means for camming the keys toward retracted positions should the valve element for some reason become immovable or stuck prior to reaching its fully open or fully closed positions.

In FIGURE 8 is illustrated a well flow conductor 27 having a plurality of vertically spaced flow control devices of the same type as illustrated in FIGURES 1 and 2 which are connected in and constitute vertically spaced sections of the well flow conductor 27. The uppermost flow control device 20 has been provided with a subscript *a*, the intermediate flow control device 20 has been provided with a subscript *b* and the lowermost flow control device 20 (not shown) will be referred to herein as having been provided with a subscript *c* to identify their relative vertical positions in the well. The flow control devices of course are connected in the well flow conductor 27 by the couplings 28. At various times it may be desirable to have any one or any number of the flow control devices either all open or closed and the running tool 100 may be used to open any one or any group of the flow control devices. The running tool 100 may also be employed to close all flow control devices or all flow control devices above a specific level.

If it is desired to open all the flow control devices 20*a*, 20*b* and 20*c*, the running tool is lowered into the flow conductor with the coupling 148 connected to the reduced end 146 of the main body section 102 until the running tool is positioned below or in the valve sleeve of the lowermost flow control device 20*c*. The running tool is then lifted and the now upwardly facing abrupt shoulders 140 of the keys engage the shoulder 83 of the valve sleeve of the lowermost flow control device 20*c* so that upward movement of the running tool first moves the valve element to the intermediate position wherein the relieving ports are in communication with the lateral ports of the nipple. The valve sleeve is then allowed to remain in this position until the pressures are equalized and then the running tool is moved further upwardly until the valve sleeve of the lowermost flow control device 20*c* is in its fully opened position. At this moment of course

the keys 118 have been retracted due to the engagement of the cam shoulders 143 of the bosses with the cam shoulder 34 and the retaining surface 32 of the nipple 21 of the lowermost flow control device 20c so that the running tool may be moved upwardly into the next higher flow control device 20b until the keys are again aligned with the upper key recess 82 of the valve sleeve of the flow control device 20b whereupon the keys move into their expanded positions to again cause their shoulders 140 to engage with the downwardly facing shoulder 83 of the valve sleeve of the flow control device 20b which is then moved first to its intermediate pressure relieving position and then to its fully opened position. After the valve sleeve of the flow control device 20b has been moved to its fully opened position the keys of course are again retracted so that the running tool may be moved further upwardly to have its keys 118 engage in the upper key recess 82 of the valve sleeve of the flow control device 20a and move it in a similar manner to its fully opened position.

It will be apparent that if it were desired to open only the uppermost flow control device 20a the running tool would have been lowered only to such position wherein its keys 118 were positioned in the upper key recess 82 of the valve sleeve of the flow control device 20a so that upward movement of the running tool would then open the flow control device 20a while leaving the lower flow control devices 20b and 20c in closed positions.

When it is desired to close all of the flow control devices or to close all flow control devices above a specific level, the running tool is connected to the flexible line by screwing the coupling 148 on the threaded end 147 of the body sub section 103. As the running tool is first lowered into the uppermost flow control device 20a, the now downwardly facing shoulders 140 of the keys 118 will engage the shoulder 73 of the lower key recess of the valve sleeve when the keys are aligned with the lowermost key recess 72 so that further downward movement of the running tool will cause the sleeve to be moved downwardly therewith. When the sleeve is moved to its lowermost fully closed position the keys of course will have been retracted due to the engagement of the bosses 143 with the shoulder 35 of the nipple so that the running tool may then move downwardly to the next lower flow control device 20b to, in a similar manner, move its valve sleeve to its lowermost closed position. When the required number of devices have been closed the running tool may be moved upwardly through the flow conductor, the cam shoulders 135 camming the keys inwardly as the running tool moves past downwardly facing obstructions, such as the upwardly and inwardly extending annular shoulder 170 of the valve sleeve of each flow control device, so that the valve sleeves of such upper flow control device which are in their lowermost closed positions are not moved from such lowermost closed positions by the upward passage of the running tool therethrough.

When it is desired to open only one flow control device, for example the flow control device 20b, which is not the uppermost flow control device, or to open a number of flow control devices which are below other flow control devices, the running tool is provided with keys 118a, FIGURE 10, which are similar in all respects to the keys 118 except that they are not provided with the bosses 142. The running tool is then connected to the flexible line 149 by threading the coupling 148 on the reduced threaded end 146 of the main body section 102 of the running tool and the running tool is then lowered into the flow conductor passing through the uppermost flow control device 20a which is to be left closed and into the flow control device 20b which is to be opened. When the keys 118a of the running tool are positioned in alignment with the upper key recess 82 of the flow control device 20b, the now upwardly facing shoulders 140a of the keys engage the downwardly facing shoulder 83 of the valve sleeve so that upward movement of the running tool now cause the valve sleeve to move to its upper open position. Since the keys 118a are not provided with bosses 142 the keys will not be moved to their retracted positions when the valve is moved to its fully opened position. If this is the only flow control device which is to be opened, upward jars are imparted to the running tool to cause the shear pin 127 to shear so that the cam sleeve 106 will cam the keys into their retracted positions to permit upward movement of the running tool out of the nipple 21 of the flow control device 20b and upwardly, while still being held under retracted position by the cam sleeve, through the uppermost flow control device 20a. If it were also desired to open the lowermost flow control valve (not shown) the running tool would have been raised in the flow control device 20b only until the valve sleeve had been moved to its fully opened position and no further upward jarring would have been imparted to the running tool. Instead, it would have been lowered downwardly to the next lowermost flow control device (not shown) to again position the keys 118a in the upper key recess 82 to cause the now upwardly facing shoulder 140 to engage the shoulder 83 of the valve sleeve of the flow control device 20c to move it upwardly. Only then, after the valve sleeve of the flow control device 20c had been moved to its fully open position, would upward jars have been imparted to the running tool to cause the shear pin 127 to shear and thus permit upward movement of the cam sleeve 106 relative to the keys 118a to move them to their retracted positions so that the running tool could then be moved through the now open flow control devices 20c and 20b and through the still closed flow control device 20a to the surface.

It will now be apparent that a new and improved running tool has been illustrated and described which may be used to open and close preselected flow control devices connected in vertically spaced positions in a flow control device.

It will also be readily apparent that the provision of the equalizing ports 77 and the intermediate stop grooves or recesses 91 which are engaged by the bosses 88 of the collet section of the valve sleeve to position such equalizing ports in communication with the lateral ports 44, provide for slow equalization of pressures within and without the flow control device 20 to prevent premature and undesired disengagement of the shifting or running tool 100 when the valve sleeve is being moved from the closed to the open position, and that the valve sleeve may subsequently be moved without difficulty to the upper fully opened position by the shifting or running tool after the pressures have been equalized within and without the flow control device. This, it will be seen, eliminates the danger of the running tool being blown up the flow conductor with consequent balling up of the wire line by which the tool is operated, and so eliminates the need for expensive wire line cutting and fishing operations to disengage and remove the tool from the balled up wire line in the tubing.

It is also believed readily apparent that the running tool is not disengaged from the shiftable valve sleeve, with which it is engaged for moving the valve from one position to another, until the valve sleeve has been completely shifted to its extreme positions; that the equalizing ports provide for equalizing pressures within and without the flow control device while the running tool is still connected with the valve sleeve without danger of the incoming fluids blowing the running tool loose from such connection, after which the valve sleeve may be moved to its extreme open position and the running tool only then disconnected from the valve sleeve.

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

What is claimed and desired to be secured by Letters Patent is:

1. A flow control device for a flow conductor having a lateral port including: a valve element in said well flow conductor for controlling flow of fluids between the interior and the exterior of the well flow conductor through said lateral port, said valve element having an equalizing port and a flow port for permitting flow of fluids through said lateral port when one of said equalizing port and said flow port is in communication with said lateral port, said valve element being movable longitudinally in said flow conductor between a first closed position wherein said lateral port is closed by said valve element, a second intermediate position wherein said equalizing port is in communication with said lateral port to permit flow therethrough, and a third open position wherein said flow port is in communication with said lateral port to permit flow of fluids between the exterior and the interior of said flow conductor through said flow port and said lateral port, said valve element having means engageable with stop means of the well flow conductor to limit longitudinal movement of the valve element in the flow conductor; and means for releasably restraining said valve member against longitudinal movement with respect to the housing in said intermediate position with said equalizing port in communication with said lateral aperture of said housing.

2. The flow control device of claim 1 including: sealing means between said valve element and said flow conductor to prevent flow of fluids therebetween.

3. The flow control device of claim 1 including: said valve element and said flow conductor having cooperating means for locating and releasably holding said valve element in said first, second and third positions.

4. The flow control device of claim 3 including: sealing means between said valve element and said flow conductor for preventing flow of fluids therebetween.

5. A flow control device for a flow conductor having a lateral port including: a valve element in said well flow conductor for controlling flow of fluids between the interior and the exterior of the well flow conductor through said lateral port, said valve element having an equalizing port and a flow port for permitting flow of fluids through said lateral port when one of said equalizing port and said flow port is in communication with said lateral port, said valve element being movable longitudinally in said flow conductor between a first closed position wherein said lateral port is closed by said valve element, a second intermediate position wherein said equalizing port is in communication with said lateral port to permit flow therethrough, and a third open position wherein said flow port is in communication with said lateral port to permit flow of fluids between the interior and the exterior of the flow conductor through said flow port and said lateral port, said valve element having means engageable with stop means of the flow conductor for limiting longitudinal movement of the valve element in the flow conductor, and sealing means between said valve element and said flow conductor to prevent flow of fluids therebetween, said valve element and said flow conductor having cooperating means for locating and releasably holding said valve element in said first, second and third positions, said valve element having an external relief recess of larger dimension than the equalizing port and communicating with the equalizing port.

6. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; and a valve sleeve disposed in said nipple for limited longitudinal movement therein, said valve sleeve and said nipple having coengageable means for limiting longitudinal movement of the valve sleeve in said nipple, said valve sleeve having a lateral flow port and a lateral equalizing port spaced from one another, said equalizing port being of smaller effective orifice than said lateral flow port, said valve sleeve being movable between a first closed position wherein said valve sleeve prevents flow of fluids through said lateral port, a second position wherein only said equalizing port of said sleeve is in communication with said lateral port of said nipple, and a third position wherein only said flow port of said sleeve is in communication with said lateral port of said nipple, said valve sleeve and said nipple having cooperating means for locating and releasably holding said valve sleeve in said first, second and third positions in said nipple, and sealing means external to said valve sleeve and internal to said nipple to prevent flow of fluids between said valve sleeve and said nipple.

7. The flow control device of claim 6 wherein said valve sleeve is movable longitudinally in said nipple and has longitudinally spaced abrupt upwardly and downwardly facing stop shoulders whereby said valve sleeve may be moved between said first, second and third positions by a running tool having means for engaging one of said stop shoulders.

8. The flow control device of claim 7 wherein said nipple has longitudinally spaced cam shoulders engageable by the running tool for causing disengagement of the running tool from engagement with one of the stop shoulders of the valve sleeve when the valve sleeve has been moved to one of the first and third positions.

9. In combination with the flow control device of claim 7 a running tool for moving said valve sleeve in said nipple including: an elongate body; and a means on said elongate body yieldably biased outwardly toward expanded position, said expandable means having a stop shoulder engageable with said upwardly facing shoulder when said running tool is lowered through said valve sleeve with one end lowermost and engageable with said downwardly facing shoulder when said running tool is raised through said valve sleeve with said one end topmost.

10. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; and a valve sleeve disposed in said nipple for limited movement therein, said valve sleeve having a lateral flow port and a lateral equalizing port spaced from one another, said valve sleeve being movable between a first closed position wherein said valve sleeve prevents flow of fluids through said lateral port, a second position wherein only said equalizing port of said sleeve is in communication with said lateral port of said nipple; a third position wherein only said flow port of said sleeve is in communication with said lateral port of said nipple, said valve sleeve and said nipple having cooperating means for locating and releasably holding said valve sleeve in said first, second and third positions in said nipple, said valve sleeve being movable longitudinally in said nipple and having longitudinally spaced abrupt upwardly and downwardly facing stop shoulders, said nipple having longitudinally spaced cam shoulders engageable by the running tool for causing disengagement of the running tool from engagement with one of the stop shoulders when the valve sleeve has been moved to one of the first and third positions; and a running tool including; an elongate body, and a means on said elongate body yieldably biased outwardly toward expanded position, said expandable means having a stop shoulder engageable with said upwardly facing shoulder when said running tool is lowered through said valve sleeve with one end lowermost and engageable with said downwardly facing shoulder when said running tool is raised through said valve sleeve with said one end topmost whereby said valve sleeve may be moved by said running tool between said first, second and third positions; said running tool having means on said body engageable with said outwardly biased expandable means to positively retract said stop shoulder from engagement with the abrupt stop shoulder of the valve sleeve, by longitudinal movement of said body relative

to said expandable means while the stop shoulder of said expandable means is engaged with one of the abrupt stop shoulders of the valve sleeve and movement of said valve sleeve by said running tool is prevented.

11. A flow control device for a flow conductor including: a nipple connectable in the flow conductor to constitute a section thereof, said nipple having a lateral port providing communication between the exterior and interior thereof; and a valve sleeve dispoesd in said nipple for limited movement therein, said valve sleeve having a lateral flow port and a lateral equalizing port spaced from one another, said valve sleeve being movable between a first closed position wherein said valve sleeve prevents flow of fluids through said lateral port, a second position wherein only said equalizing port of said sleeve is in communication with said lateral port of said nipple and a third position wherein only said flow port of said sleeve is in communication with said lateral port of said nipple, said valve sleeve and said nipple having cooperating means for locating and releasably holding said valve sleeve in said first, second and third positions in said nipple; and a running tool; said valve sleeve being movable longitudinally in said nipple and having longitudinally spaced abrupt upwardly and downwardly facing stop shoulders whereby said valve sleeve may be moved between said first, second and third positions by said running tool having means for engaging one of the stop shoulders, said nipple having longitudinally spaced cam shoulders engageable by the running tool for causing disengagement of the running tool from engagement with one of the stop shoulders when the valve sleeve has been moved to one of the first and third positions, said running tool including, an elongate body, a means on said elongate body yieldably biased outwardly toward expanded position, said expandable means having a stop shoulder engageable with said upwardly facing shoulder when said running tool is lowered through said valve sleeve with one end lowermost and engageable with said downwardly facing shoulder when said running tool is raised through said valve sleeve with said one end topmost, said expandable means having means engageable with said cam shoulders for moving said expandable means to retracted position out of engagement with the stop shoulder of the sleeve engaged when said valve sleeve is moved to said first and third positions whereby continued movement of the running tool in the same direction is permitted; said running tool body having means thereon engageable with said expandable means for positively moving said expandable means to retracted position out of engagement with the abrupt stop shoulder of the valve sleeve by longitudinal movement of said body relative to said expandable means while said stop shoulder of said expandable means is engaged with one of said abrupt shoulders of said valve sleeve and movement of said valve sleeve in said housing by said running tool is prevented.

12. A running tool for use with a device of the type described including: an elongate body having means at its opposite ends for connecting the same to a raising and lowering mechanism whereby it may be moved in a well flow conductor with either end upwardly, expandable means carried by said body for limited outward lateral movement; said expandable means having an abrupt shoulder intermediate its ends extending laterally outwardly, said expandable means having cam means adjacent one end thereof for moving said expandable means inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor to prevent engagement of said abrupt shoulder of said expandable means with such obstructions as said running tool is moved through said flow conductor; means releasably holding said expandable means against longitudinal movement relative to said body; and retractor means on said body engageable with said expandable means for moving said expandable means toward said retracted position upon relative longitudinal movement between said body and said expandable means in one direction, whereby said abrupt shoulder may be retracted from engagement with an obstruction in said well flow conductor or from engagement with said well flow control device.

13. A running tool for use with a device of the type described including: an elongate body having means at its opposite ends for connecting the same to a raising and lowering mechanism whereby it may be moved in a well flow conductor with either end upwardly, expandable means carried by said body for limited outward lateral movement; said expandable means having an abrupt shoulder intermediate its ends extending laterally outwardly substantially normal to the longitudinal axis of the body and adapted to engage a corresponding abrupt shoulder of a movable well flow control device for operating the same, said expandable means having cam means adjacent one end thereof for moving said expandable means inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor, said expandable means having a second cam means adjacent the other end thereof for moving said expandable body inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor to prevent engagement of said abrupt shoulder of said expandable means with such obstructions as said running tool is moved through said flow conductor; means releasably holding said expandable means against longitudinal movement relative to said body; and retractor means on said body engageable with said expandable means for moving said expandable means toward said retracted position upon relative longitudinal movement between said body and said expandable means in one direction, whereby said abrupt shoulder may be retracted from engagement with an obstruction in said well flow conductor or from engagement with said well flow control device.

14. A running tool for use with a device of the type described including: an elongate body having means at its opposite ends for connecting the same to a raising and lowering mechanism whereby it may be moved in a well flow conductor with either end upwardly, expandable means carried by said body for limited outward lateral movement; said expandable means having an abrupt shoulder intermediate its ends extending laterally outwardly substantially normal to the longitudinal axis of the body and adapted to engage a correspondingly abrupt shoulder of a movable well flow control device for operating the same, said expandable means having cam means adjacent one end thereof for moving said expandable means inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor, said expandable means having a second cam means adjacent the other end thereof for moving said expandable body inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor to prevent engagement of said abrupt shoulder of said expandable means with such obstructions as said running tool is moved through said conductor, said cam means extending outwardly and convergently from the ends of said expandable means on opposite sides of said abrupt shoulder; means on said body releasably holding said expandable means against longitudinal movement relative to said body; and retractor means on said body engageable with said expandable means for moving said expandable means toward said retracted position upon relative longitudinal movement between said body and said expandable means in one direction, whereby said abrupt shoulder may be retracted from engagement with an obstruction in said well flow conductor or from engagement with said well flow control device.

15. A running tool for use with a device of the type described including: an elongate body having means at

its opposite ends for connecting the same to a raising and lowering mechanism whereby it may be moved in a well flow conductor with either end upwardly, expandable means carried by said body for limited outward lateral movement; said resilient means biasing said expandable means laterally outwardly relative to said body; expandable means comprising a plurality of laterally movable members each having an abrupt shoulder intermediate its ends extending laterally outwardly substantially normal to the longitudinal axis of the body and adapted to engage a correspondingly abrupt shoulder of a movable well flow control device for operating the same, said expandable means each having cam means adjacent one end thereof for moving said expandable means inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor to prevent engagement of said abrupt shoulder of said expandable means with such obstruction as said running tool is moved through said flow conductor, said expandable means each having a second cam means adjacent the other end thereof for moving said expandable means inwardly toward retracted position upon meeting obstructions in the path of its movement through a flow conductor, said cam means extending outwardly and convergently from the ends of said expandable means on opposite sides of said abrupt shoulder, said elongate body having attaching means at each end whereby it may be moved through the flow conductor with either end lowermost; means on said body releasably holding said expandable means against longitudinal movement relative to said body; and retractor means on said body engageable with said expandable means for moving said expandable means toward said retracted position upon relative longitudinal movement between said body and said expandable means in one direction, whereby said abrupt shoulder may be retracted from engagement with an obstruction in said well flow conductor or from operating engagement with said well flow control device.

16. A flow control device for a flow conductor including: a tubular nipple connectable in a flow conductor to constitute a section thereof, said nipple having a longitudinal bore and a lateral port intermediate its ends providing communication between the exterior of the nipple and the bore thereof; and a valve sleeve disposed in said nipple for longitudinal movement between a first position and a second position in the bore of said nipple, said valve sleeve having a lateral flow port formed therein disposed to communicate with the lateral port of said nipple when said valve sleeve is in said first position and disposed at a point spaced from said lateral port of said nipple when said valve sleeve is in said second position; seal means between said sleeve and said nipple spaced longitudinally therein on opposite sides of said lateral port in said nipple and disposed to seal between said nipple and said sleeve to direct flow of fluids through said port in said nipple to said port in said sleeve when said sleeve is in said first position in said nipple, said seal means being disposed to seal between said nipple and said sleeve to close off flow of fluids through said lateral port in said nipple to said flow port in said sleeve when said sleeve is in said second position in said nipple, said nipple having internal stop shoulders engageable with the ends of said sleeve for limiting movement of said sleeve in said nipple; said nipple having beveled internal camming shoulders provided in its bore spaced longitudinally towards the ends of said nipple beyond said stop shoulders, whereby the ends of said sleeve are stopped by said stop shoulders at points spaced from said camming shoulders of said nipple, the spaces in the bore of said nipple between the ends of said sleeve and said camming shoulders providing internal annular grooves at each end of said sleeve defined by the ends of said sleeve and the beveled camming shoulders; said sleeve having means providing longitudinally spaced abrupt upwardly and downwardly facing shoulders in its bore disposed inwardly from the ends thereof.

17. A flow control device of the character set forth in claim 16, including: detent means on said sleeve and said nipple engageable when said sleeve is in said first position to releasably restrain said sleeve in said first position and engageable when said sleeve is in said second position in said nipple to releasably restrain said sleeve in said second position.

18. A flow control device of the character set forth in claim 16 wherein: said valve sleeve is movable in said flow conductor between said second position wherein said lateral port is closed and said first position wherein said lateral port in the sleeve is in flow communication with the lateral port in the nipple, and also being movable to a third position intermediate said first and said second positions; said valve sleeve having an equalizing port disposed therein and communicating with said lateral port of said nipple when said sleeve is in said intermediate third position.

19. The flow control device of claim 16 wherein said sleeve is provided with beveled edges at the ends thereof, the bevel edge of each end of said sleeve and the adjacent camming shoulder in said nipple being inwardly divergent.

20. The flow control device of claim 16, wherein said sleeve has port means providing restricted flow of fluids through the lateral port of said nipples between the bore of said nipple and the exterior thereof as said sleeve is moved between said first and second positions.

21. A tool for moving a selected one of a plurality of longitudinally spaced elements each disposed for limited longitudinal movement between upper and lower positions in a well flow conductor, each of said elements having an abrupt downwardly facing shoulder and an abrupt upwardly facing shoulder therein, said tool including: an elongate body having means at its opposite ends for connecting the same to a raising and lowering mechanism whereby it may be moved in a well flow conductor with either end upwardly; expandable means carried by said body for limited lateral outward movement relative to said body, said expandable means comprising a plurality of elongate members each movable laterally with respect to the longitudinal axis of said body and each having intermediate its ends an abrupt outwardly extending shoulder formed thereon and disposed substantially normal to the longitudinal axis of said body; resilient means between said body and each of said expandable elongate members biasing said elongate members outwardly relative to said body; each of said elongate members having outwardly convergent cam means at its opposite ends for moving said elongate member inwardly toward retracted position upon meeting obstructions in the path of its movement through a well flow conductor to prevent engagement of said abrupt outwardly extending shoulder of said elongate member with obstructions in said well flow conductor; said abrupt outwardly facing shoulder of said expandable means being engageable with a corresponding oppositely facing shoulder of said selected one of said longitudinally spaced elements for moving the same longitudinally in said flow conductor; means releasably securing said elongate expandable members in one longitudinal position with respect to said body against longitudinal movement relative thereto, said expandable members being movable longitudinally relative to said body to a second position thereon spaced longitudinally from said first position; and retractor means carried by said body and engageable with the cam means at one end of said elongate members upon longitudinal movement of said body relative to said expandable means in a direction moving said expandable members from said one position to said second position for moving said expandable means to retracted position upon such longitudinal movement of said body relative to said expandable members while said abrupt shoulder

of said expandable members is in engagement with an obstruction in the well bore or is in engagement with one of the corresponding abrupt shoulders of any one of said longitudinally spaced elements in said well flow conductor, movement of which element in said conductor by said running tool is prevented while said shoulders are in engagement; said running tool being movable in a well flow conductor to a selected one of said elements to cause the abrupt outwardly facing shoulder of the elongate expandable members to engage a corresponding abrupt shoulder of a selected one of said elements whereby longitudinal movement of the running tool will first move the selected element from one to the other of its lower position and its upper position; the cam means on the opposite end of said expandable members engaging said element and the flow conductor in which said element is connected to bias said expandable means to retracted position and to free the tool for further longitudinal movement in said conductor upon completion of the movement of said element to said other of said positions; engagement of said abrupt shoulder of said elongate expandable members with said corresponding abrupt shoulder of said element when said element cannot be moved by said running tool from said one to said other of its lower and upper positions permitting application of force to said elongate body to move said body longitudinally with respect to said expandable members to move said retractor means into engagement with said expander members to move said expander members to retracted position, whereby said running tool may be retracted to pass the abrupt shoulders of said elements disposed above or below said selected element without engaging such shoulders thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,606,616	Otis	Aug. 12, 1952
2,630,999	Lee	Mar. 10, 1953
2,675,875	Potts	Apr. 20, 1954
2,715,443	McKinley	Aug. 16, 1955
2,723,677	Middleton et al.	Nov. 15, 1955
2,806,539	Green et al.	Sept. 17, 1957
2,842,162	Schwegman	July 8, 1958
2,845,130	Austin	July 29, 1958
2,924,278	Garrett et al.	Feb. 9, 1960
2,949,963	McGowen et al.	Aug. 23, 1960
2,960,165	Schramm	Nov. 15, 1960
2,962,097	Dollison	Nov. 29, 1960