United States Patent

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[54] WELL TOOLS
13 Claims, 8 Drawing Figs.

[52] U.S. Cl. 166/155, 92/180
[51] Int. Cl. E21b 33/16
[50] Field of Search 166/155; 155, 202; 92/180; 103/225

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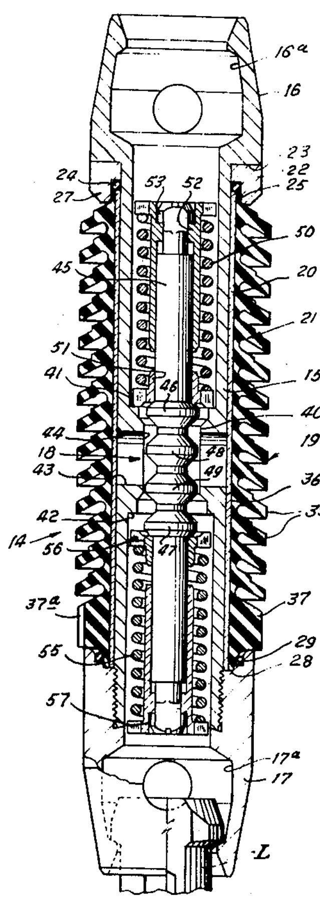
ABSTRACT: A motor unit, pump-down piston or impeller device for use in fluid pressure operated well systems. The impeller includes a body having a flow course therethrough provided with a flow restricting structure for limiting the application of fluid pressure differentials across the device, and is provided with external resilient sealing members in the form of flexible lips which turn from one position to another to bypass the pressure past the sealing element to further limit the pressure differential across the impeller device.



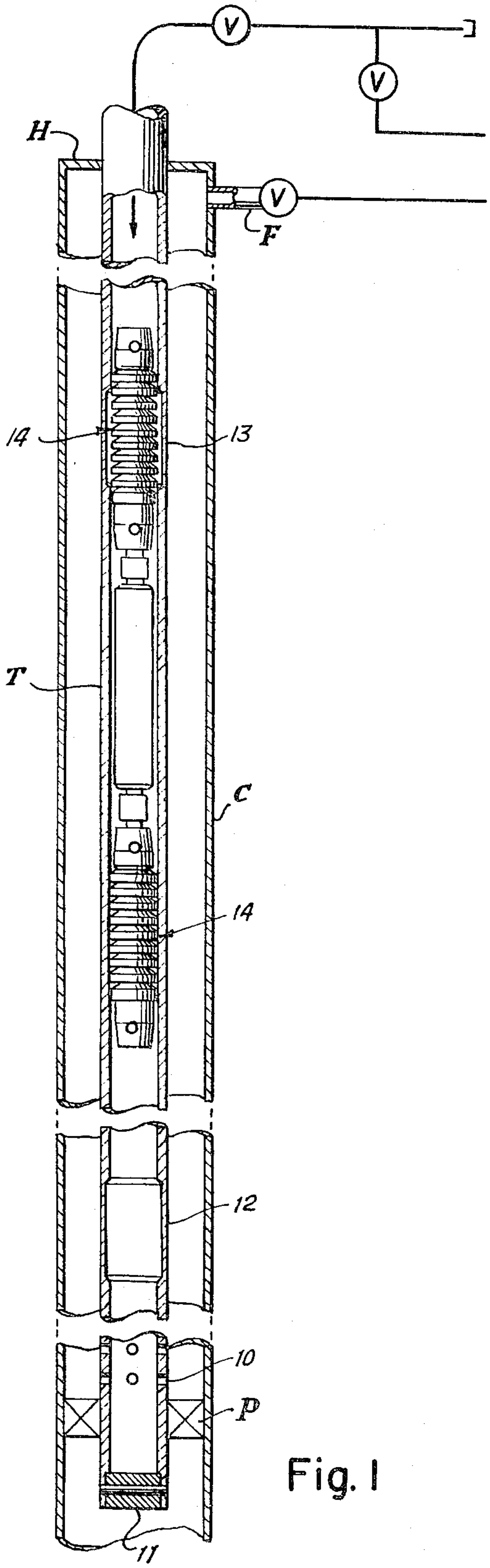


Fig. 1

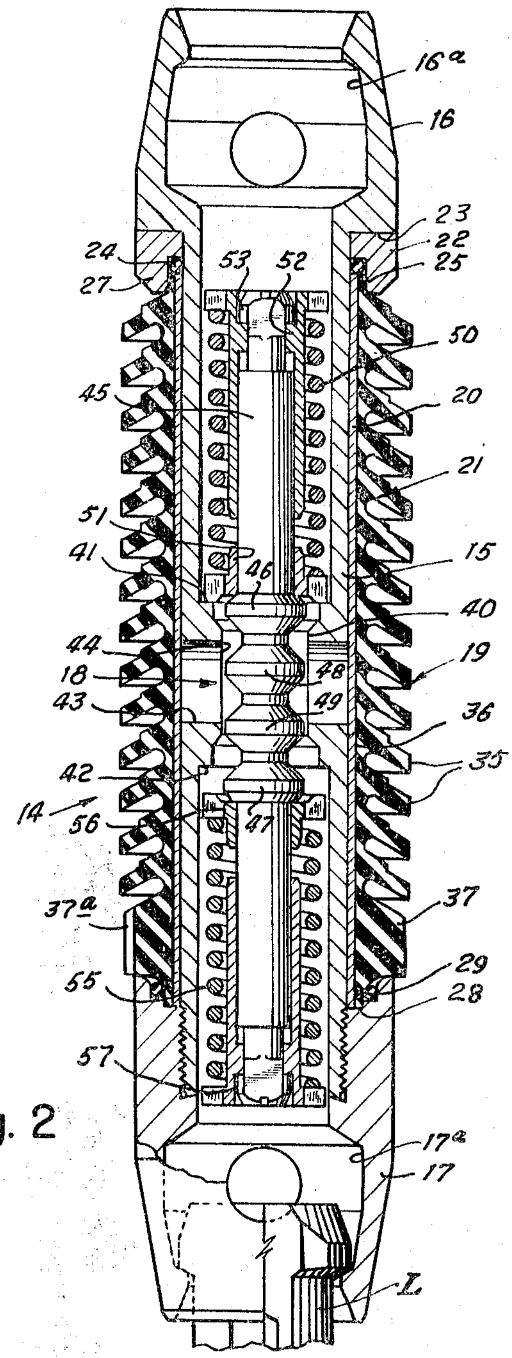


Fig. 2

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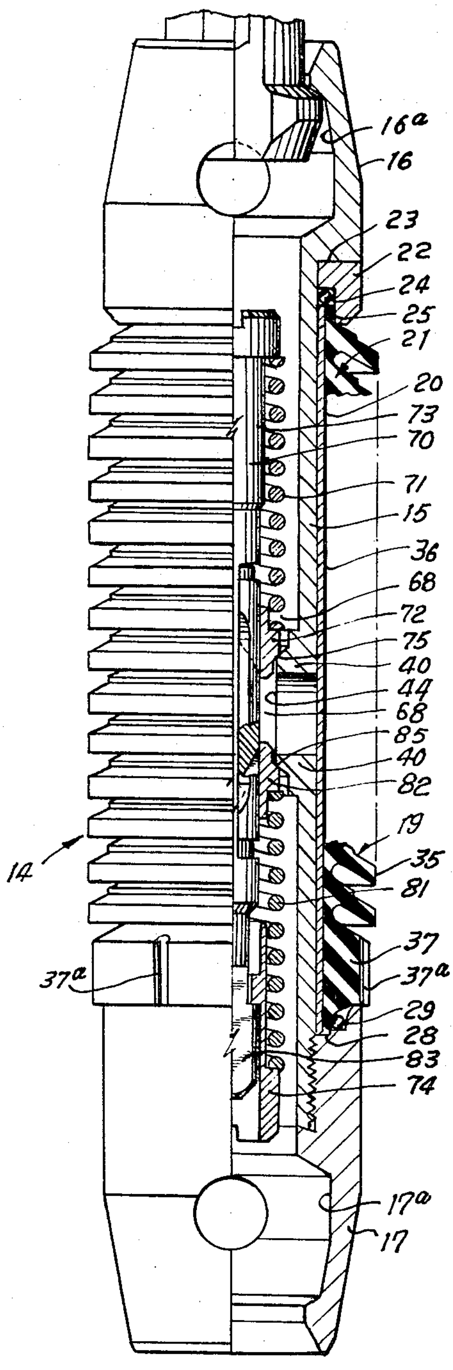

Fig.3

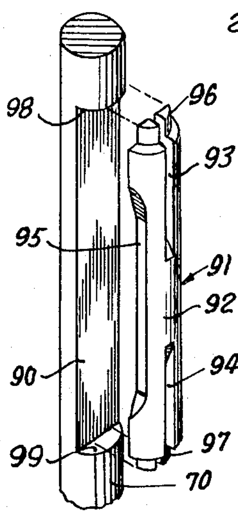

Fig.4

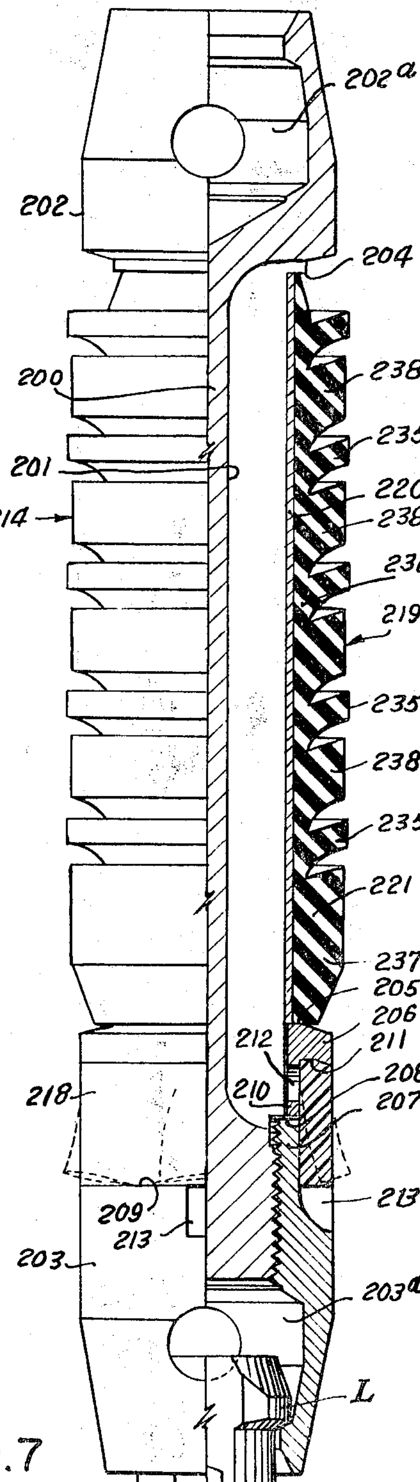

Fig.7

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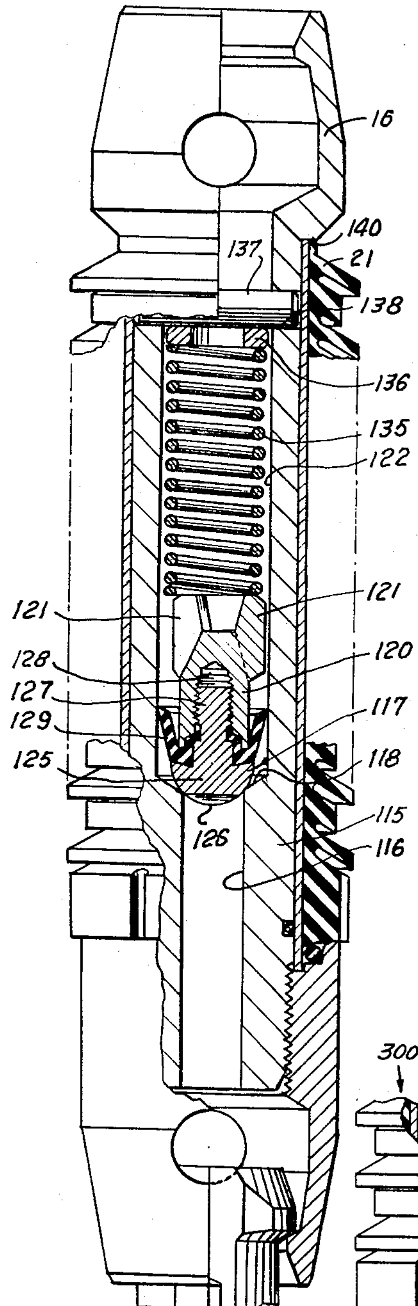

Fig. 5

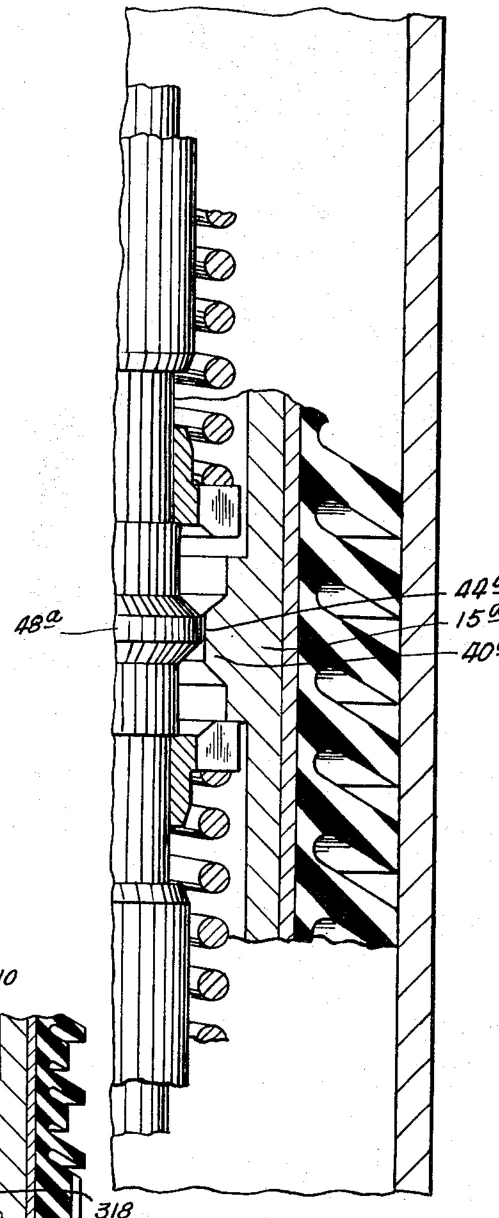

Fig. 6

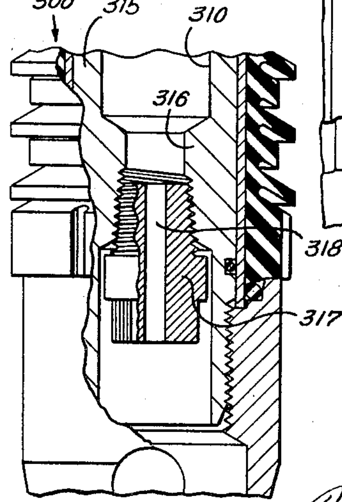

Fig. 8

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WELL TOOLS

This invention relates to new and useful improvements in well tools and more particularly to improvements upon pump-down pistons, or impeller units, for use in pump-down well operating systems such as are disclosed in the application of John V. Fredd and Norman F. Brown, Ser. No. 632,408.

It is one object of the invention to provide an improved pump-down piston or impeller unit for use in moving well tools in a fluid operated or pump-down well installation system. An important object of the invention is to provide an improved pump-down piston or impeller unit having protective means for preventing overload of the sealing elements and which provides for reduced wear of the sealing elements in motion through the well system.

A particular object of the invention is to provide an improved pump-down piston having a sealing element in the form of an annular collar of deformable material and having a plurality of annular sealing elements which are more flexible than the collar, said sealing elements being so arranged with respect to each other that upon the occurrence of an overloading condition, the sealing elements release pressure past the same, particularly when the impeller member is prevented from movement in the well flow conductor due to failure of well tools to release, sticking of tools or similar unusual conditions.

Another object is to provide, in a pump-down piston or impeller unit of the character described, suitable fluid pressure regulating or flow controlling passages for controlling the maximum fluid pressure applied to the device in the event of failure of the sealing element to function properly; and which will permit circulation of fluids through said impeller unit in the event the unit or the string of tools with which it is connected becomes stuck or lodged in the flow conductor.

A still further object of the invention is to provide a pump-down piston of the character described having seal means in the form of a plastic, resilient, elastomeric material which resists the action of wall fluids, and which in use is adapted to engage and seal the flow conductor in which it is moved with the minimum of friction to reduce wear of the sealing element and provide an element of long life.

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

FIG. 1 is a schematic illustration of a well installation providing for fluid pressure actuation of well tools in a flow conductor and showing schematically a tool string having pump-down pistons of the invention incorporated therein;

FIG. 2 is an enlarged sectional view of one of the pump-down units of FIG. 1;

FIG. 3 is a view partly in elevation and partly in section of a modified form of pump-down unit;

FIG. 4 is a fragmentary isometric view of a portion of the valve structure of FIG. 3;

FIG. 5 is a view, partly in elevation and partly in section, of a further modified form of the pump-down unit piston;

FIG. 6 is an enlarged fragmentary vertical view, partly in elevation and partly in section, of a modified form of valve for use in a pump-down piston of the previously described pump-down pistons;

FIG. 7 is a view, partly in elevation and partly in section, of a still further modification of the pump-down piston; and

FIG. 8 is a fragmentary view of the flow restricting portion of another modified form of the pump-down piston.

In the drawings, FIG. 1 illustrates schematically a well installation in which a well casing C is disposed in the well bore and a flow conductor or tubing string T is suspended in the well from a casing head H and is sealed at its lower end with the casing by a packer P. A lateral flow line F at the well head H communicates with the annular space between the casing and the tubing string, and suitable valves V are connected with the upper end of the tubing string and with the lateral flow line to control the circulation of fluid into the annular space and

into the bore of the tubing string. Lateral ports at the lower end of the tubing string provide communication between the bore of the tubing string and the annular space just above the packer and a plug or removable closure **11** is secured in the lower end of the tubing string to prevent flow at the lower end unless removed. A plurality of spaced landing nipples **12** and **13** are connected in the tubing string for receiving suitable well tools. The landing nipples are those commonly in use in the industry and may be such as illustrated in the Composite Catalog of Oil Field Equipment, 1966—1967, at page 3820. Of course, other types of landing nipples or well devices may be connected in the tubing string.

The system and the operation thereof generally conforms to that shown in the aforesaid application of John V. Fredd and Norman F. Brown, Ser. No. 632,408. One form of the pump-down piston or impeller unit **14** is shown in FIG. **2**. In this device, the mandrel **15**, the upper and lower connecter members **16** and **17**, respectively, and the valve structure **18** are identical to those of the device shown in the Fredd et al. application. The sealing element **19**, however, is different from that in the previous Fredd application, and comprises a cylindrical metallic sleeve **20** having a resilient elastomeric seal sleeve or member **21** formed on the exterior thereof. The metal sleeve **20** is slidable on the mandrel **15** of the pump-down piston **14** and surrounds the same in close engagement with the exterior thereof. An annular cuplike retaining ring **22** is mounted on the mandrel **15** abutting a downwardly facing shoulder **23** at the upper end of the mandrel and an O-ring **24** is confined within an internal annular recess **25** formed in the ring and seals against the upper ends of the metal sleeve **20** and the rubber or elastomeric sealing sleeve **21** of the sealing element **19**, which are disposed in said annular recess or groove. The downwardly projecting annular flange **27** of the cup or collar confines and retains the upper ends of the sleeve and sealing sleeve against displacement from position on the mandrel. The lower end of the sealing element **19** is engaged in an internal annular recess **28** formed in the upper end of the lower connecter member **17** and an 0-ring or sealing element **29** is disposed in an enlargement of said recess and engages against the exterior of the elastomeric seal member **21**. The upwardly projecting annular flange **30** of the lower connecter member confines and supports the lower end of the sealing element **19** on the mandrel.

The upper portion of the bore of the mandrel is enlarged within the upper connecter member to provide an upper internal coupler or locking chamber **16*a***, and the bore of the lower connecter member **17** is also enlarged to provide a lower internal coupler or locking chamber **17*a***, both of which chambers are arranged to receive locking members L of apparatus or well tools connected with piston or impeller unit **14**.

Since the sealing element **19** does not expand in the same manner as the element of the Fredd et al. device hereinbefore referred to, there is no need for the lateral ports and the multiple valve heads on the stem. However, the mandrel and the valve structure of this device shown in FIG. **2** remain unchanged in structure from that of the Fredd et al. device, since the conversion is effected by use of the sealing element of this invention.

The sealing element **19** includes the metallic sleeve **20** and the elastomeric seal sleeve **21** having a plurality of annular laterally projecting sealing elements or lips **35** formed integral with the body portion **36** and spaced from each other longitudinally of the unit. The sealing element illustrated is similar to that shown in the patent to Webber 2,719,768 and/or the patent to Webber 3,372,649, and includes not only the annular projecting lip members **35** but also a collar **37** such as is shown in the latter patent. It is preferable that the lip members **35** of the sealing element be approximately the diameter of the bore of the tubing string T in which the device is used, but the diameter of the lips or seal ring members may be slightly less than the bore of the tubing to effect a ready bypassing of fluid in one direction past the lips and thus to reduce wear. The protector collar **37** is normally substantially thicker than the lips

35 and slightly smaller in diameter than the bore of the well tubing when in a normal undistorted position. Vertical grooves 38 may be formed diametrically opposite each other in the exterior surface of the collar to provide a bypass area in addition to the annular bypass therearound, if desired.

Each sealing lip element 35 extends downwardly and outwardly when in its normal undeformed position, and is adapted to flex upwardly and outwardly upon application of an upward fluid pressure differential to seal against the bore wall of the tubing and to prevent passage of fluid until a predetermined pressure differential is applied thereacross. Each lip of the device of FIG. 2 flexes further upwardly to a releasing load position to relieve the excess pressure from below and permits the same to act on the next upper sealing lip. In this manner, a predetermined pressure differential may be carried across the sealing element which is determined by the number of sealing lip members and the thickness and deformable characteristics of the lips depending upon the kind of material of which they are made. The details of the manner in which the lips flex is more fully set forth in the Webber patents, particularly in the later patent, 3,372,649.

It will be seen, therefore, that a predetermined fluid pressure differential will be exerted across the valve assembly 18 within the bore of the mandrel 15 to cause fluid pressure to flow exteriorly of the pump-down piston or impeller unit and act across the external sealing lip members 35. Each lip member of the sealing element is deflected into sealing engagement with the bore wall of the tubing, and produces a predetermined pressure drop thereacross permitting all pressure in excess of the predetermined drop to pass to the elements thereabove. As each element is deflected, an additional pressure differential is applied across the total length of the sealing element, until the total maximum pressure differential provided for and determined by the number of sealing lip members formed on the element has been attained. Such differential will act on the sealing element 19 to move the mandrel longitudinally and to cause the same to move the well tools in the tubing string in the same manner as was explained in the Fredd et al. application. In the event of overload, the valve member 18 within the body, which is normally biased to a closed position, will release excess fluid pressure through the bore of the body, and, at the same time, the sealing elements also will permit any excess pressure to pass exteriorly of the mandrel.

Thus, the device is operable at a predetermined fluid pressure differential, and the amount of differential is controlled by the construction of the lip elements and the number of such elements provided on the external annular sealing element. It will also be seen that each of the sealing lips of the sealing element is in only slight engagement with the tubing string in which the device is used, and therefore wear therefore wear of the element is reduced, so that the device provides as element having an extremely long life.

The regulator valve assembly 18 further provides for accurate control of the device and, therefore, accurate operation of well tools connected to the pump-down piston as shown in FIGS. 1 and 2.

The mandrel 15 is formed with an internal annular reduced valve seat portion 40 in its bore intermediate the ends thereof having an upwardly facing stop shoulder 41 and a downwardly facing stop shoulder 42 at its opposite ends. As shown, lateral ports 43 are formed in the seat between the convergent beveled upper and lower end shoulders of the reduced portion 44 of the bore of the seat member.

The valve assembly 18 includes a valve stem 45 which is slidable longitudinally in the bore of the mandrel and has longitudinally spaced external annular end flanges 46 and 47 and a pair of intermediate flanges 48 and 49 spaced equally along the length of the stem. The flanges ordinarily coact with the lateral port 43 in the valve seat for controlling fluid communication from the bore of the mandrel through the lateral ports to the seal element utilized in the Fredd et al. application. However, in this device only a single flange is actually needed, though the flanges coact with the seat in the same manner as in the Fredd et al. application, to control and regulate flow through the bore of the mandrel. A helical coil spring 50 surrounds and is confined on the upper portion of the valve stem 45 between an upper stop spider 51 which engages the upper shoulder 41 of the valve seat and an upper lock sleeve 52 held on the upper end of the stem 45 by a lock head 53 on said stem in the same manner as in the Fredd et al. application. The spring 50 tends to bias the valve stem upwardly with respect to the seat.

A lower helical coil spring 55 surrounds and is confined on the lower portion of the valve stem 45 between a lower stop spider 56 and a lower lock sleeve 57 which is releasably held on the lower portion of the stem in the same manner as the upper lock sleeve. The spring 55 biases the stem downwardly to move the flanges 46 through 49 with respect to the reduced bore of the valve seat in the mandrel 15 to regulate flow through the bore of the mandrel, so that the flanges 46 through 49 coact with the reduced bore 44 of the valve seat 40 to limit fluid flow through the mandrel in either direction, but will also move to positions permitting restricted flow upon occurrence of a predetermined differential across the valve stem. No fluid flow takes place through the lateral ports 43, but merely longitudinally through the bore of the mandrel. Therefore, the valve assembly 18 serves as a regulator controlling the pressure of the fluid acting on the external seal element 19 and will relieve excess pressure across said seal element should the same occur.

Similarly, the valve assembly 18 coacts with the collar 37 to protect the seal elements against the forces generated by an overload of pressure differential applied across the sealing elements. The grooves 37*a* in the exterior of the collar will act as choke means to permit a predetermined rate of fluid flow past the collar to the lips of the seal element, to prevent overloading the element. The collar also serves as a guide during movement of the element through the tubing. In the event excessive flow takes place past the exterior of the piston, the collar 37 will move into a sealing position engaging the bore wall of the tubing and direct flow through the bore of the mandrel past the valve assembly 18, to prevent overload, particularly under temporary conditions of excess flow.

In any case, the valve assembly 18 and the grooves in the collar 37 positively prevent plugging the well bore at the mandrel.

As shown in FIG. 2, the sealing lips 35 are provided with a slightly greater annular thickness adjacent the metallic sleeve 20 so that the outer portions of the lips will flex more easily than the inner portions thereof, and this structure serves as means to control the pressure differential created across each lip. If desired, of course, the lips may be of relatively uniform thickness, as in the Webber patent 2,719,768.

In FIG. 3 and 4 a modified form of valve assembly 68 is illustrated which is similar to the valve structure shown in FIGS. 27 through 30 of the Fredd et al. application, Ser. No. 632,408.

The mandrel 15 and external seal assembly 19 are identical to the structure of FIG. 2 and are given the same identifying numerals. The reduced valve seat portion 44 coacts with a modified valve flow restricting valve member or assembly 68 to regulate flow through the bore of the mandrel. The valve stem 70 is movable longitudinally in the bore of the mandrel and is resiliently supported in a central position therein by an upper helical coil spring 71 and a lower helical coil spring 81 which surround the upper and lower portions, respectively, of the valve stem 70 and are each confined thereon between an upper annular valve member 72 and a lower annular valve member 82, and an upper lock sleeve 73 and a lower lock sleeve 74, respectively, similar to the lock sleeves 52 and 57 of the form first described. The lock sleeves are held against displacement from the ends of the valve stem 70 by upper and lower lock heads, the upper lock head being identical but the reverse of the lower lock head 83 shown in FIG. 3. It will thus be seen that the annular valve members 72 and 82 have external annular beveled seat surfaces 75 and 85, respectively, which engage and are supported on the beveled upper and lower end shoulders of the reduced portion of the bore of the seat member, so that the valve stem is supported by the springs in a central position with respect to the reduced seat portion 40 and is slidable longitudinally with respect to such annular valve members 72 and 82. Fluid pressure differential acting in either direction through the bore of the mandrel will tend to unseat the valve members 72 and 82 to permit a greater flow through the bore of the mandrel when the elements are unseated as will be hereinafter explained.

The valve stem is provided in its central portion with an elongate lateral recess or pocket 90 (FIG. 4) which receives a removable insert 91 having an outer cylindrical surface portion 92 corresponding to the external cylindrical surface of the valve rod 70 when the insert is disposed in operating position in the pocket 90. Upper and lower longitudinal slots 93 and 94, respectively, are formed in the opposite ends of the insert, and lateral longitudinal cut away portions 95 are formed on opposite sides of the insert. Obviously, a single relieved or cut away portion 95 may be formed on the insert, if desired. The opposite ends of the insert are reduced at 96 and 97, respectively, and these reduced portions cooperate with the upper and lower shoulders 98 and 99 at the opposite ends of the pocket 90 to provide a substantial flow into the slots 93 and 94 to provide maximum flow past the insert when the a valve stem is in its extreme end positions. This valve assembly acts in identically the same manner as the valve structure of FIG. 30 of the Fredd et al. application hereinbefore referred to. When the stem has moved in one direction flow is permitted in one direction until the slots 93 and 94 are moved out of the bore of the valve member 72 and 82, respectively. The flow is permitted through the bore of the mandrel in regulated amounts.

This form of the valve coacts with the seal element in the same manner and provides the same result as the valve assembly 18 of FIG. 2 to provide for a regulation of flow through the mandrel, and permit relief of an overload or excess pressure differential across the seal element when such occurs.

In FIG. 6 the mandrel 15*a* is provided with an internal annular reduced bore 44*a* providing a valve seat member 40*a* in the mandrel adapted to coact with an external annular flange valve member or a valve closure member 48*a* for restricting flow through the bore of the mandrel. This structure is a simplified version of the form of the valve shown in FIG. 2 and requires only a single annular flanged valve closure member 48*a* to coact with the reduced bore 44*a* of the valve seat member 40*a* in the mandrel to regulate flow therethrough. The stop spiders and springs are substantially the same as and operate in the same manner as those of the form of FIG. 2 to control and regulate flow through the mandrel of the piston.

A still further variation of the valve structure within the pump-down piston is shown in FIG. 5, wherein the mandrel 115 is provided with a reduced bore 116 in its lower portion, against which a valve closure assembly 117 is adapted to seat to close off flow downwardly through the bore of the mandrel, and to permit a regulated flow upwardly through the mandrel by displacement of the valve closure assembly 117 off the beveled seat 118 at the upper end of the reduced bore 116 in the mandrel by fluid pressure differential from below. The valve closure assembly 117 includes a body 120 having a plurality of radially extending offset vanes 121 at its upper end adapted to guide the body in its longitudinal movement in the enlarged portions 122 of the bore of the mandrel. A closure head 125 has a rounded nose 126 which engages the seat 118 and a stem 127 which is threaded into a threaded bore 128 in the body and confines an elastic sealing cup or seal member 129 on the closure member between the head nose portion 126 and the lower end of the body 120. The lip of the cup is adapted to seal against the bore wall 122 of the mandrel to close off downward flow, but will flex inwardly to permit upward flow. A transverse slot is formed in the nose 126 to facilitate assembly of the closure member and the body. An elongate helical coiled spring 135 is confined within the enlarged bore 122 of the mandrel between the upper ends of the vanes 121 of the body of the valve assembly, and a stop and spacer ring 136 slidable in the enlarged bore 122 and held in place therein by a cross pin 137 disposed in a transverse bore 138 formed in the opposite walls of the upper portion of the mandrel. The stop or spacer ring 136 may be of various thicknesses to vary the force exerted by the spring 135 on the valve closure member 117, to control the differential at which the valve closure member will move off the seat 118 and so control regulation of flow through the mandrel. The external seal assembly of the pump-down piston is substantially the same as that of the form of FIG. 2 and is given the same identifying numbers. There is no upper retaining and sealing collar provided on this form of the device, however, the upper end of the elastic seal member 21 engaging a downwardly facing shoulder 140 formed on the upper connecter member 16 of the mandrel. Also, the lower connecter member is threaded onto the lower end of the mandrel and presses against the lower end of the seal assembly 19 and forces the seal assembly upwardly to tightly engage the upper end of the seal assembly with the shoulder 140 to provide a seal therebetween. Other parts of the device are the same as the form in FIG. 2 and will not be further described.

In FIG. 7, a further modified form of the pump-down piston is illustrated having a slightly modified version of the resilient external seal assembly, a modified mandrel and a modified valve assembly for controlling flow through the mandrel.

In this form of the device the mandrel 200 is formed with a plurality of circumferentially spaced longitudinally extending grooves 201 forming flow passages exteriorly of the central portion of the mandrel. The grooves extend between the upper and lower connecter members 202 and 203, respectively. The sealing element 219 is confined on the mandrel between a downwardly facing external annular shoulder 204 at the upper end of the mandrel and the upper end a shoulder 205 at the upper end of a valve carrier or spacer ring 206 slidably mounted on the lower end of the mandrel and held in place thereon by the upper reduced end 207 of the lower connecter member 203. The upper ends of the longitudinal groove or flow courses 201 extend above the shoulder 204 and thus above the upper end of the seal element 219. The lower ends of the flow courses 201 extend below the lower end of the sealing assembly 219 and to or slightly below the upper end of the lower coupler or connecter member 203. It will thus be seen that fluid may pass downwardly through the grooves or flow courses 201 within the bore the sealing assembly 219 past such sealing assembly.

The lower connecter member 203 is threaded onto the lower end of the mandrel and abuts a downwardly facing shoulder 208 formed at the upper end of the reduced threaded lower end portion of the mandrel, and above the lower end of the longitudinal grooves or flow passages 201. The reduced upper end of the lower connecter member also engages the reduced lower end of the valve carrier or spacer ring 206 and confines the same tightly against the lower end of the metal sleeve 220 of the seal element 219 and against the reduced lower end of the elastic or flexible outer seal member sleeve 221 of the seal element, so that the ends of the seal element are tightly confined between the shoulder 204 at the upper end of the mandrel and the upper end of the spacer ring 206 and fluid flow can take place through the flow passage within the sealing element to pass the sealing element. More than one of the longitudinal flow passages 201 may be provided at circumferentially spaced positions around the exterior of the mandrel and, as shown in FIG. 7, four such devices are contemplated in the structure illustrated.

An upwardly facing stop shoulder 209 is formed at the upper end of the enlarged central portion of the lower coupler member 203, and an annular elastomeric sleeve valve member 218 is disposed around the reduced upper portion 207 of the coupler member and the reduced lower portion 210 of the spacer ring. The upper end of the elastomeric valve sleeve is shaped to conform to the undercut shoulder 211 at the upper end of the reduced portion 210 of the ring. The valve sleeve 218 may be formed of any suitable elastomeric material, such as Hycar, Nylon, Teflon, or an urethane material, which would provide a yieldable valve sleeve displaceably outwardly, as shown in dotted lines, to permit fluid flow from the flow passage 201 outwardly through lateral ports 212 formed in the reduced lower portion of the spacer ring 206 through the bore of the elastomeric sleeve valve and downwardly outside the reduced upper portion 207 of the lower coupler and outwardly below the valve sleeve 218 through the curved flow slots 213 formed at circumferentially spaced intervals around the enlarged central portion of the lower coupler member below the shoulder 209. It will thus be seen that fluid may flow from the flow course or groove 201 outwardly through the lateral ports 212 in the spacer ring downwardly through the bore of the valve sleeve 218 and outwardly through the slots 213 to the exterior of the coupler member. The resistance of the elastomeric valve sleeve to deformation by the fluid pressure from within determines the differential at which the fluid will be permitted to pass through the flow course of the mandrel within the sealing element 219. The stiffness and composition of the material of the valve sleeve will control the opening of the passage to flow and will regulate such flow in much the same manner as the valve assemblies of the forms already described.

The sealing element 219 includes the metallic sleeve 220 and the elastic seal sleeve 221. The seal sleeve is formed with a plurality of longitudinally spaced outwardly and upwardly inclined sealing lips 235 formed integral with the body portion 236 of said seal sleeve and adapted to engage the flow conductor to seal therewith. Between each pair of the outwardly and upwardly projecting lips 235, the seal sleeve is formed with longitudinally thickened flanges 238. The diameter of the flanges 238 is slightly less than the bore of the flow conductor in which the device is to be used and is less than the diameter of the lips 235. An elongate collar 237 is formed at the lower end of the seal sleeve and is substantially thicker longitudinally than the flanges 238. The collar 237 is tapered at its lower end and functions in substantially the same manner as the collar 37 of the forms already described. If desired, longitudinal grooves may be formed in the exterior surface of the collar similar to the grooves 37*a* already described and for the same purpose.

The flanges 238 form supports for the lips 235 under conditions of heavy load to increase the differential across the seal member exteriorly of the mandrel. When the lips are flexed downwardly and outwardly by fluid pressure acting downwardly thereon in the device shown in FIG. 7, the lips will engage the wall of the flow conductor in which the device is disposed and seal thereagainst. Fluid pressure will tend to move the lips downwardly to permit fluid pressure to bypass the same in the manner already described in connection with the seal element of FIG. 2. However, under conditions of heavy load, the lips will engage the flanges 238 and be supported thereby, or will deform the flanges into sealing engagement with the bore wall of the flow conductor to prevent excess flow past the exterior of the seal element. Of course, an excessive pressure may deform the flanges 238 sufficiently to permit fluid to bypass the same. In the event the pressure rises above a desired value, the fluid in the flow passages 201 of the mandrel will deform the valve sleeve 218 outwardly to open the passages 201 within the mandrel through the sealing sleeve 219 to flow and permit relief of such excess pressure through such flow passages or slots.

It will, therefore, be seen that the pump-down piston has a sealing element which is designed to engage the bore wall of the flow conductor to limit fluid flow past the sealing element to a predetermined maximum differential, and that the mandrel is provided with sleeve valve means 218 which further permits fluid flow past the seal element through the flow courses in the mandrel within the seal element to prevent overloading of the seal element and to prevent plugging the flow conductor in which the device is used.

The upper connecter member 202 is provided with an upper internal coupler or locking chamber 202*a*, and the lower connecter member 203 is provided with an internal coupler or locking chamber 203*a*, corresponding to the coupler or locking chambers in the connecter members of the form first described and providing means for receiving locking members L of well tools or other apparatus connected with the piston or pump-down locomotive unit 214.

A further modification of the impeller or pump-down piston 300 is shown in FIG. 8, wherein the means for restricting flow of fluid through the bore 310 of the mandrel 315 comprises an internal annular restriction 316 in said bore having a removable orificed flow restricting choke or bean 317 threaded into the bore of said restriction. The orifice 318 in said bean will permit restricted flow of fluids at desired predetermined rates through the bore 310 of the mandrel at all times, and in either direction. Excess pressure differentials across the piston or impeller will be relieved by flexing of the lips of the external seal element in the manner already described with respect to the other modifications of the invention. The orifice in the orificed bean may be varied in size to assure application of any desired operating fluid pressure differential across the impeller or piston. The orificed bean also assures that the flow conductor or tubing string in which the device is being used is not plugged or circulation shut off, if the impeller or string of well tools should become stuck at some point in said conductor, since the orifice in the bean will always permit flow through the bean and the flow conductor in which the device is being operated.

It will thus be seen that an improved pump-down piston or locomotive structure has been illustrated and described which is adaptable for use in pump-down well operations to move well tools through a flow conductor and to actuate well tools in said flow conductor. It will be seen that the seal assembly provides a piston device of the character described which may move through a flow conductor for long distances of travel with minimum wear, since the sealing elements are engaged with the bore wall of the flow conductor with a minimum of pressure and actually moved away from the bore wall under conditions of high pressure. It will also be seen that the regulator devices prevent overloading the seal elements and destruction of the sealing lips thereon; and that the valve assemblies or flow regulating valves, as well as the sealing elements, provide for a device which will prevent plugging the flow conductor in the event the well tool should become stuck or it be impossible to move the same in the well.

It will also be seen that improved valve means have been provided in a pump-down piston or locomotive for controlling the application of fluid pressure to such device.

The foregoing description of the invention is explanatory only, and changes in the detail 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. Apparatus adapted to be pumped through a flow conductor comprising: an elongate mandrel; external seal means carried by said mandrel, comprising a plurality of annular flexible sealing elements disposed on said mandrel in longitudinally spaced relationship, each of said elements being flexible by fluid pressure exteriorly of the mandrel into sealing position to maintain a predetermined pressure differential thereacross, said seal means being engageable with said flow conductor and actuated by fluid pressure within said flow conductor for moving said mandrel longitudinally of said flow conductor; pressure regulating fluid flow control means carried by said mandrel comprising means providing a flow course in said mandrel within said external seal means and communicating with the exterior of said mandrel beyond the opposite ends of said external seal means, and fluid pressure regulating means controlling fluid flow through said flow course operable by the fluid pressure differential acting on said seal elements to release fluid pressure differential acting on said elements in

excess of a predetermined differential for controlling the pressure differential applied to said external seal means; and means on said mandrel for connection with well tools for movement by said apparatus.

2. Apparatus of the character set forth in claim 1 wherein said flexible sealing elements are further flexible downwardly to a nonsealing position to release pressure differential thereacross in excess of said predetermined differential.

3. Apparatus of the character set forth in claim 1, wherein said pressure regulating means comprises flow controlling valve means in said flow course normally maintained in a position closing down flow through said flow course and yieldable to fluid pressure to open said flow course to regulated flow therethrough by fluid pressure differential across said seal means.

4. Apparatus of the character set forth in claim 3 wherein said valve means comprises seat means in said flow course; valve closure means movable with respect to said seat means and biased toward closed position.

5. Apparatus of the character set forth in claim 4, wherein said closure means comprises an elongate rod having flow controlling means thereon coacting with said seat means for controlling flow through said flow course; said rod and flow controlling means being longitudinally movable with respect to said seat means for opening in each longitudinal direction to regulate flow through said flow course; and means biasing said rod and flow controlling means to a medial longitudinal position and yieldable in each longitudinal direction to regulate flow through said flow course in either direction.

6. Apparatus of the character set forth in claim 1, wherein said pressure regulating means comprises an annular resilient valve sleeve member on said mandrel normally closing said flow course to flow in one direction and resiliently yieldable upon application of a fluid pressure differential thereacross in the other direction to permit regulated flow through said flow course.

7. Apparatus of the character set forth in claim 1, wherein said external seal means comprises a plurality of annular resilient flange members, one disposed between each pair of spaced sealing elements; each said flange member being disposed to support the flexible sealing element next adjacent it to provide for an increased total differential across the external seal means.

8. An impeller device for fluid operation of tools in a flow conductor including: mandrel means having a flow passage extending longitudinally thereof; external annular laterally projecting seal means supported on said mandrel means, said seal means sealing with said mandrel means and being flexed by fluid pressure exteriorly of said mandrel means to sealing position with respect to said flow conductor and arranged to produce a predetermined fluid pressure differential force exteriorly of said mandrel means acting on said mandrel means to move said mandrel means longitudinally of said flow conductor; and pressure regulating flow controlling means supported by said mandrel mean and exposed to fluid pressures in said flow passage and said flow conductor for controlling flow through said flow passage to limit the fluid pressure differential across said mandrel means, said flow controlling means being normally maintained in a position closing down flow through said flow passages and operable by the fluid pressure acting on said external seal means and in said flow passage to open said flow passage to regulated flow therethrough by said fluid pressure.

9. An impeller device of the character set forth in claim 8, wherein said external seal means comprises: a plurality of longitudinally spaced annular flexible sealing elements; each of said sealing elements being flexed by fluid pressure exteriorly of said mandrel into sealing position with respect to said flow conductor to maintain a predetermined fluid pressure differential across each said sealing element, said plurality of sealing elements producing a cumulative total predetermined fluid pressure differential across said external seal means dependent upon the number and physical characteristics of said spaced sealing elements.

10. An impeller device of the character set forth in claim 9 wherein said flexible sealing elements are further flexible downwardly to a non-sealing position to release pressure differential thereacross in excess of said predetermined differential.

11. An impeller device of the character set forth in claim 9 wherein said external seal means comprises a plurality of annular resilient flange members, one disposed between each pair of spaced sealing elements; each said flange member being disposed to support the flexible sealing element next adjacent it to provide for an increased total differential across the external seal means.

12. An impeller device of the character set forth in claim 8 wherein said pressure regulating flow controlling means comprises valve means in said flow passage of said mandrel means normally biased toward a position closing down flow through said flow passage and yieldable to fluid pressure in either longitudinal direction of said flow passage to open said flow passage to regulated flow therethrough by fluid pressure differential across said external seal means.

13. An impeller device of the character set forth in claim 8 wherein said pressure regulating flow controlling means comprises: an annular resilient valve sleeve member on said mandrel means normally closing said flow passage to flow in one direction and yieldable upon application of a fluid pressure differential thereacross in the other direction to permit regulated flow through said flow passage.