United States Patent

Adkins

[15] **3,642,069**

[45] **Feb. 15, 1972**

[54] JAR STROKE ACCELERATOR FOR PUMPDOWN WELL TOOL

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

[22] Filed: **Sept. 28, 1970**

[21] Appl. No.: **76,188**

[52] **U.S. Cl.** **166/301**, 166/153, 166/178, 175/296

[51] **Int. Cl.** **E21b 23/00**

[58] **Field of Search** 175/296, 297; 166/301, 178, 166/153, 155, 156

[56] **References Cited**

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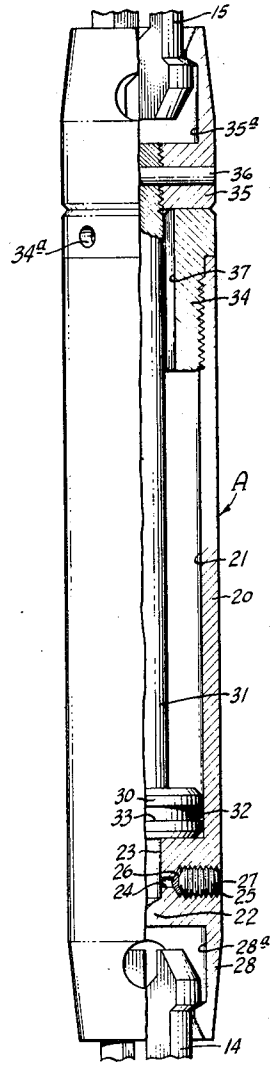
Primary Examiner—James A. Leppink

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[57] **ABSTRACT**

A jarring stroke accelerator for pumpdown well tool operation for reducing the effect of pumpdown operating fluid on the pumpdown locomotive pistons used with hydraulic jarring tools in pumpdown well operations wherein a liquid is used as the operating fluid. The expansible and contractable chamber provides a low-pressure chamber for movement of a pumpdown locomotive with respect to another tool in a well in which the locomotive is manipulated by liquid operating fluid. Variable capacity accelerators are provided, as are convertible accelerators which may be modified for use to apply strokes in opposite directions.

16 Claims, 15 Drawing Figures



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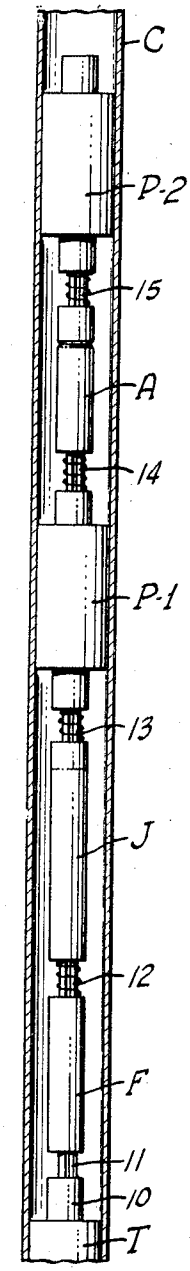


FIG. 1

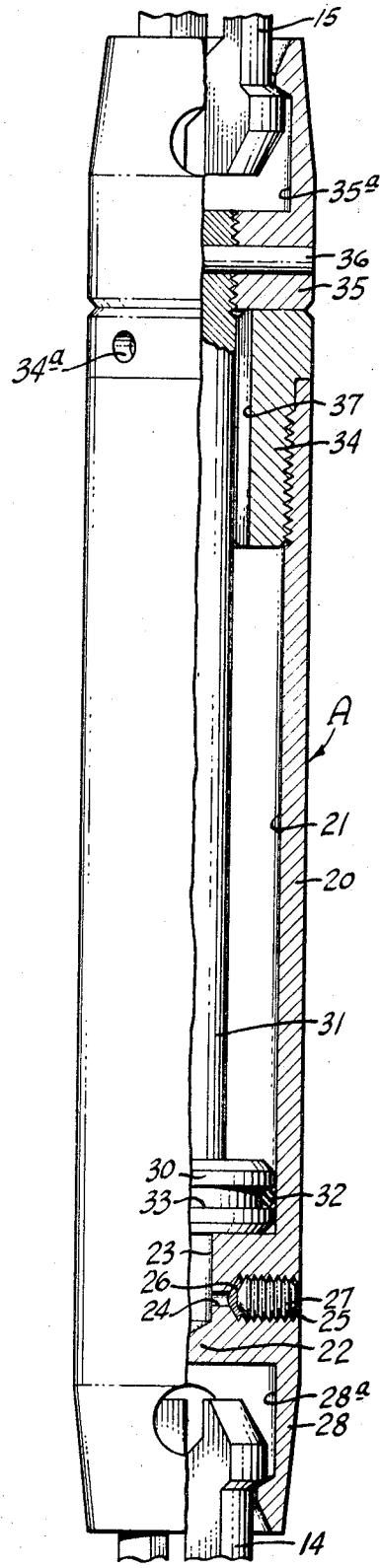


FIG. 2

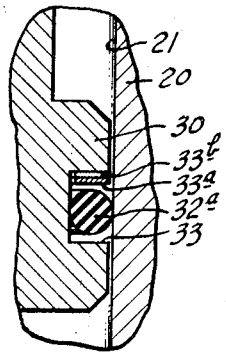


FIG. 3

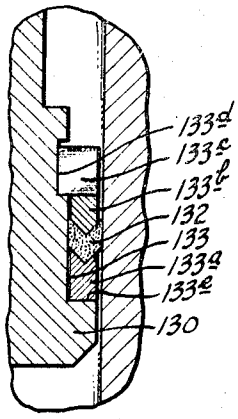


FIG. 4

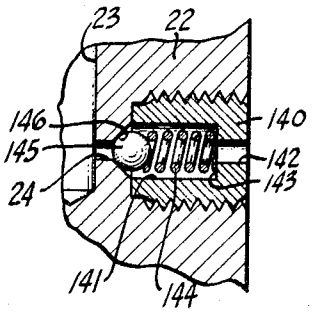


FIG. 5

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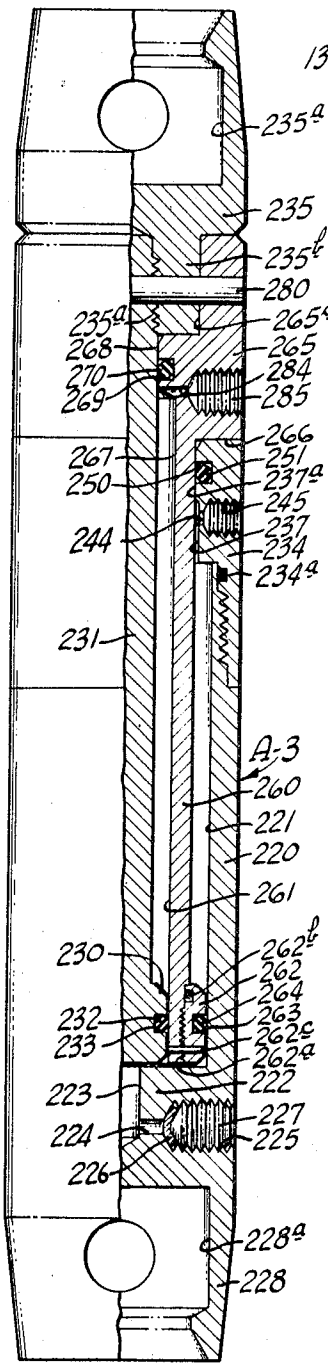


FIG. 8

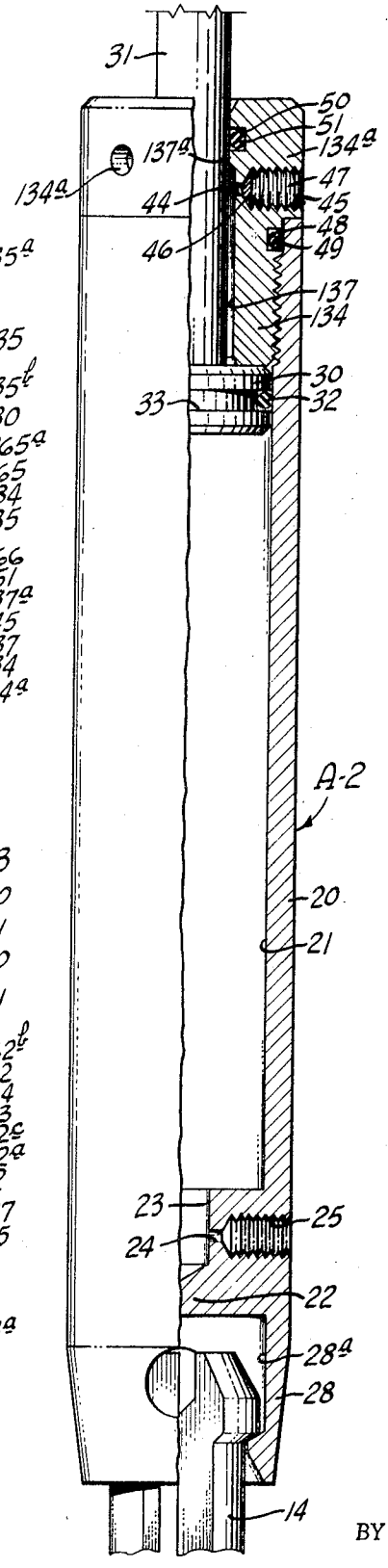


FIG. 6

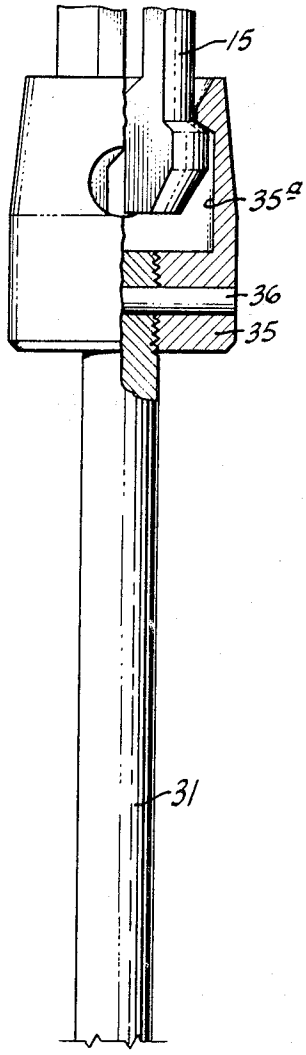


FIG. 7

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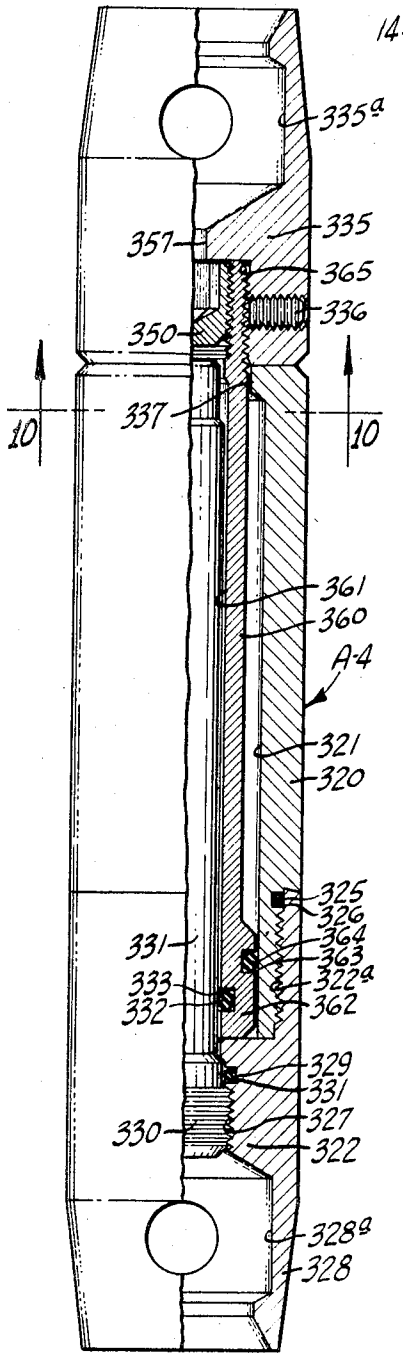


FIG. 9

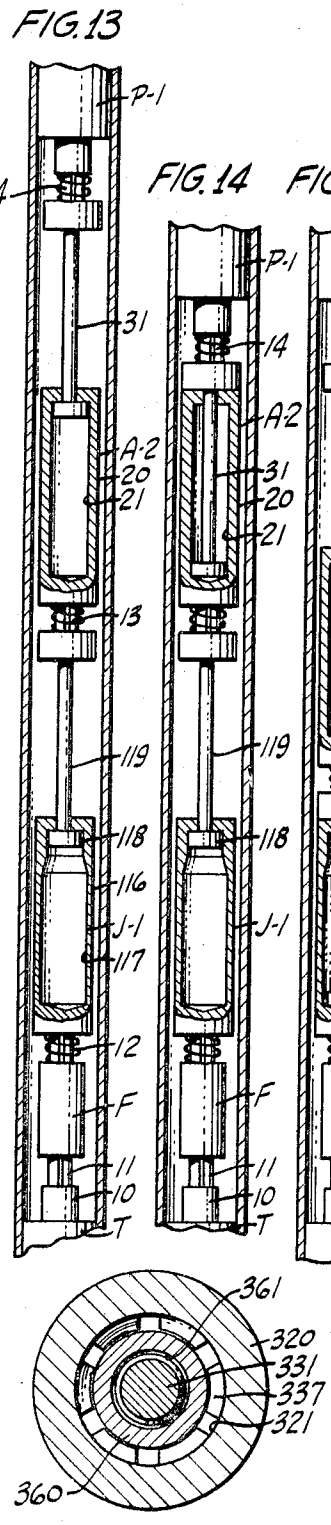


FIG. 13

FIG. 10

FIG. 14

FIG. 15

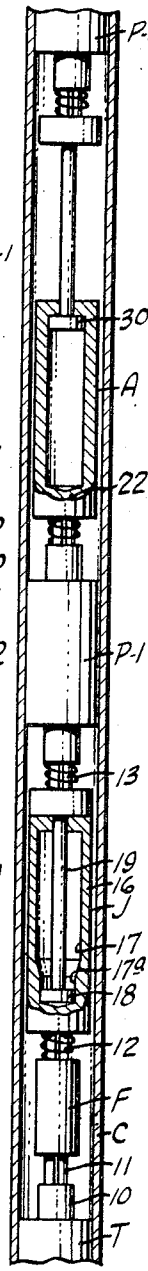


FIG. 11

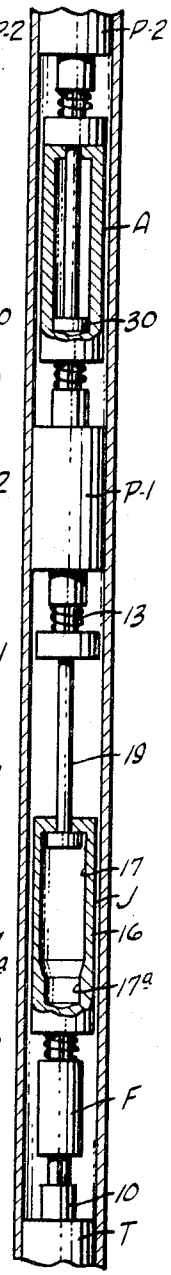


FIG. 12

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JAR STROKE ACCELERATOR FOR PUMPDOWN WELL TOOL

This invention relates to new and useful improvements in well tools, and more particularly to jarring stroke accelerators for use in pumpdown tool well operations.

One object of the invention is to provide an accelerator device for use with hydraulic jarring tools for permitting relative movement of a pumpdown locomotive or piston assembly with respect to another tool in a column of liquid in a flow conductor.

Another object of the invention is to provide an accelerator device for use with a hydraulic jarring tool for permitting an increased speed of movement of the jarring tool by reducing the volume of liquid between two separate locomotive piston assemblies to permit one of the assemblies to move toward the other without disturbing the column of liquid used in circulating the tools into and out of the well flow conductor.

It is still another object of the invention to provide a pumpdown accelerator and jarring mechanism combination which is operable by pumpdown tool strings in through-the-flow-line pumpdown well installation for imparting a substantial impact to tools in the well flow conductor for operating the same.

A particular object of the invention is to provide means for producing a chamber of reduced pressure in a pumpdown tool operating string for use in coaction with a hydraulic jarring mechanism for the purpose of permitting movement to actuate the jarring mechanism without causing movement of the entire column of liquid in the pumpdown system.

A further object of the invention is to provide a pumpdown accelerator mechanism which is operable to provide a chamber of reduced pressure in a column of liquid in a pumpdown well installation to permit sudden movement of the actuating tools of the pumpdown tool string without causing corresponding movement of the liquid column in the pumpdown system.

Another object of the invention is to provide a pumpdown accelerator operable for permitting movement of the tools in one direction and which may be adjusted to permit movement of the tools in the opposite direction in the flow conductor when desired.

Still another object of the invention is to provide a pumpdown accelerator device of the character described in which the volume of the chamber of reduced pressure may be varied to accommodate either a longer longitudinal movement or a higher speed longitudinal movement when desired.

A still further object of the invention is to provide a pumpdown accelerator which is simple in construction, economical to manufacture and operate and reliable and efficient in operation.

Still another object of the invention is to provide a pumpdown accelerator and jarring tool assembly which is operable to apply an impact stroke in the well flow conductor in either longitudinal direction thereof, as desired or selected.

Still another important object of the invention is to provide an improved method of actuating a pumpdown tool system to impart an impact of substantial force to a well tool in a pumpdown tool well installation with minimum movement of the circulating fluid of the system.

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

FIG. 1 is a schematic view of a well installation showing a portion of a well flow conductor having a pumpdown tool string therein with the accelerator and jarring mechanism of the invention arranged for applying an upward stroke to a well tool in place in the flow conductor;

FIG. 2 is an enlarged view, partly in elevation and partly in section, of the pumpdown accelerator used in FIG. 1;

FIG. 3 is an enlarged fragmentary vertical sectional view of one side of a piston for the mechanism of FIG. 2 showing a modified form of sealing element;

FIG. 4 is a view similar to FIG. 3 of a further modified form of sealing means on the piston;

FIG. 5 is an enlarged fragmentary sectional view showing a spring loaded one-way check valve in the cylinder of the accelerator body for cooperation with the piston of the accelerator to quickly produce a low pressure in the chamber of the accelerator;

FIG. 6 is a view similar to FIG. 2 of a modified form of the pumpdown accelerator showing the same in condition for use in combination with a jarring mechanism for applying a down stroke to well tools in the flow conductor;

FIG. 7 is a continuation of FIG. 6 showing the upper portion of the device;

FIG. 8 is a view, partly in elevation and partly in section, of a further modified form of the pumpdown accelerator showing a device convertible for use in either direction and for provided variable volumes;

FIG. 9 is a view similar to FIG. 8 of a still further modified form of the pumpdown accelerator;

FIG. 10 is a horizontal cross-sectional view taken on the line 10—10 of FIG. 9;

FIG. 11 is a schematic view of a well flow conductor having a pumpdown tool string therein showing the string in position preparatory to striking an upward impact to a well tool in the conductor;

FIG. 12 is a view similar to FIG. 11 showing the pumpdown tool string striking the upward impact;

FIG. 13 is a view similar to FIG. 10 of a pumpdown tool string having a jarring device and accelerator mechanism therein position for striking a downward impact to a well tool in the flow conductor;

FIG. 14 is a view of the pumpdown tool string of FIG. 12 immediately prior to activating the jarring device; and

FIG. 15 is a view similar to FIG. 12 showing the jarring device and accelerator activated to impact the downward impact to the well tool in the conductor.

In the drawings, FIG. 1, is shown a schematic illustration of a well flow conductor C having a well tool T therein having a fishing connection 10 at its upper end engaged by the dogs 11 of a fishing tool F connected by means of a connector member 12 to an oil jar other hydraulic jarring device J. The jarring device is connected by means of a connector 13 to a pumpdown tool locomotive piston assembly P–1, which is in turn connected by a connector 14 to a pumpdown accelerator A. The accelerator is connected at its other end by a connector 15 to a second pumpdown tool locomotive assembly P–2.

Well fluids in the well flow conductor C are circulated in the usual manner through a U-tube flow pattern, the fluids in the conductor being in this case moving from bottom toward the top of the conductor to move the pumpdown locomotive assemblies P–1 and P–2 upwardly in the conductor in an effort to dislodge or free the well tool T from its position in the conductor. If it is impossible to move the well tool in the usual manner by means of the circulated pumpdown tool operating fluid in the system, the jarring device J and accelerator A may be utilized to deliver an impact of desired force to the fishing tool F to jar or drive the tool free of its stuck or lodged position in the flow conductor.

The well tool T may consist of a string of pumpdown tools including a plurality of locomotive assemblies such as the locomotive assemblies B–1 and B–2, or may comprise a flow control device or similar tool which has become lodged in the flow conductor C so as not to be movably by the application of a pressure force resulting from the application of pressure to the column of circulating operating fluid in the system acting on the locomotive pistons B–1 and B–2. A constant pressure force such as would be developed by the action of the operating fluid on the pistons does not produce an impact or jarring force applied to the lodged well tool T when a continuous pressure is applied to the operating fluid. If, however, it is attempted to apply sudden force by means of changes in direction of flow or pressure of the operating fluid to the pistons to move the same to apply sudden force to the lodged well tool T, the entire column of operating fluid in the U-tube system must be moved as a unit, and such a long column of

liquid has a great inertia resisting sudden movement of the entire column to apply impact to the lodged well tool. Similarly, the jarring device J cannot be operated to produce a sufficiently great jarring impact by the movement of the column of liquids in the U-tube flow path, since the entire column of liquid must be moved as a unit to produce the movement of the jarring device and the inertia of the column resists any sudden movement of the jarring device which would produce the desired impact. Furthermore, the circulation of the fluids past the lodged well tool T in the flow conductor restricts the flow of the operating fluids past such well tools and further restricts the movement of the column of liquid in the U-tube system and increases the inertia or resistance to sudden movement of the column and so prevents the production of an impact to the jarring device. Also, the application of high pressure to the operating fluid could result in damage to the flow conductor itself or to the tools being operated in the system, as by rupturing or separating the flow conductor sections at the couplings or by destruction of the well tools or operating tools in the system.

It is for the purpose of producing a condition which will enable the jarring device to be operated safely, efficiently and with rapidity by the column of operating fluid in the system that the accelerator A of the invention is incorporated in the string of tools.

To actuate the jarring device J swiftly, the accelerator provides a means for permitting movement of the elements of the jarring device through their stroking movement with sufficient rapidity to produce a desired impact force. This is accomplished by providing a chamber or region of substantially reduced pressure which is quickly collapsible or compressible by the liquid in the column of operating fluid between the column downstream of the locomotive assembly and the column upstream of the jar, which permits movement of the jar through its stroking action without substantial interference to such movement by the operating fluids. In other words, a substantial void is provided in the column of operating fluid between the downstream column and the upstream column which is sufficient to permit the locomotive piston which actuates the jarring device to move with rapidity through the length of stroke of the jarring device without requiring movement of the downstream operating fluid column.

The column of fluid acting to move the jarring device through its stroking movement is permitted to act on the accelerator to effect such movement of the jarring device through its jarring stroke as a result of the pressure of the operating fluid acting thereon against the void or region of low pressure in the accelerator.

The accelerator A shown in FIG. 2 is designed for use in applying a longitudinal impact to the jarring device J in an upward direction or in the direction from the operating locomotive assembly piston P–1 toward the locomotive piston assembly P–2. The accelerator includes a cylindrical body **20** having a bore **21** which is closed at one end by a closure head **22** having a counterbore **23** provided therein which communicates by means of a lateral port **24** with a threaded opening **25** extending to the exterior of the head. The port **24** is closed by means of a seal plug member **26** which is held in place by a set screw **27** threaded into the threaded bore **25** to provide a fluid tight closure for the lateral port **24**. The head has a coupler socket **28** formed integral therewith having a bore **28***a* therein for receiving the connector member **14**, whereby the accelerator is coupled in the pumpdown tool string as has been previously described. The coupler socket and connector **14** are substantially identical with those illustrated and described in the patent to John B. Fredd, U.S. Pat. No. 3,428,346, issued Feb. 18, 1969, by means of which the accelerator is connected to the locomotive piston assembly P–1 which is likewise of the general type described in such patent.

A piston **30**, which is connected to or carried by the lower end of an elongated piston rod **31**, is slidable in the bore **21** of the cylinder **20**, and a seal member **32**, such as an O-ring, is disposed in an external annular groove **33** formed in the cylindrical external wall of the piston for sealing between the piston and the bore wall of the cylinder for purposes which will be hereinafter more fully described. The piston rod **31** extends upwardly through the bore **21** of the cylinder **20** and outwardly through a guide bushing **34** threaded into the upper end of the cylinder, and is connected at its upper projecting outer end to a coupler socket **35** threaded thereonto and secured in place thereon by means of a pin **36** extending through a transverse bore in the coupler socket and piston rod. The coupler socket has a bore or socket **35***a* which receives the connecting members **15** in the same manner as the coupler **28** receives the connector members **14** at the opposite end of the accelerator device. The guide bushing **34** is provided with a plurality of longitudinally extending slots **37** which are spaced circumferentially around the bore of the bushing to provide fluid passageways between the piston rod and the bushing for movement therethrough of the fluids which would otherwise be trapped in the bore **21** of the cylinder above the piston, so that the fluids may move easily and quickly into and out of the bore of the cylinder above the piston.

If desired, a spanner wrench opening or socket **34***a* may be provided in the flanged upper end of the bushing **34** for tightening the bushing in the cylinder.

It will be seen that movement of the piston **30** upwardly away from the head **22** of the cylinder **20** will produce a chamber or region of reduced pressure between the piston and the head of the cylinder. Thus, if the accelerator is located in a column of liquid fluid, the fluid of the column which is present in the bore **21** of the cylinder above the piston **30** will be displaced upwardly through the flow passages **37** and a substantial void or low-pressure region will be produced in the bore of the cylinder below the piston. The seal plug **26** held in place by the lock screw **27** effectively closes the lateral port **24** to prevent the liquids in the column from entering the bore **21** of the cylinder below the piston **30**, whereby the region of reduced pressure or substantial void is produced in the chamber by the bore of the cylinder below the piston. Thus, when desired, the piston **30** may be moved quickly by the pressure of the fluids in the column of operating fluid acting thereon, from the upper position of the piston, downwardly in the cylinder to the lower position therein shown in FIG. 2, and so produce a rapid telescoping movement of the piston rod and of the cylinder with respect to each other, to permit or cause a rapid movement of the jarring device J through its jarring stroke to produce an impact of a desired force on the well tool T by means of the jar.

The action of the accelerator and jar is illustrated schematically in FIGS. **11** and **12**, for the purposes of clarity and simplicity of explanation. As shown in FIG. **11**, the accelerator A has been moved to the extended position in which the piston **30** is spaced from the cylinder head **22** to produce the void space in the bore **21** of the accelerator cylinder **20**. With the tools in this position, further upward force applied to the upper locomotive piston assembly P–2 and the lower locomotive piston assembly P–1 will move the piston **18** of the jarring device J upwardly in the reduced lower portion **17***a* of the bore **17** in the cylinder **16** of the jarring device, and move the piston **18** upwardly out of such reduced lower portion into the enlarged upper portion **17** of the bore, where the piston may move rapidly through the oil or other fluid confined within the bore of the cylinder **16** of the jarring device. The piston rod **19** of the jarring device, being connected by means of the connector **13** to the lower locomotive piston assembly P–1 will move rapidly with the lower locomotive piston P–1 toward the upper locomotive piston P–2, such movement being possible because the accelerator piston **30** is movable toward the closure head **22** of the accelerator cylinder **20** by the pressure of the operating fluid acting on the cylinder in opposition to the relative void in the bore **21** of the accelerator cylinder between the piston and the head. The liquids in the space in the conductor C between the lower locomotive piston assembly P–1 and the upper locomotive piston assembly P–2 will

enter the bore of the accelerator cylinder **20** above the piston **30** during such movement, the flow passageways **37** permitting rapid transfer of the liquids from the exterior of the cylinder to the interior thereof as a result of the substantial differential between the pressure of the operating fluid or liquids and the substantial void within the bore of the accelerator cylinder below the piston **30**.

The volume of the region within the accelerator chamber which is under reduced pressure, or which is a substantial void, must be sufficient to permit movement of the jarring device through its full stroke.

Thus, the accelerator provides means for actuating a jarring device J, of the oil jar type or similar delayed release stroking device, to effect a sudden movement to produce an impact of a desired value as a result of the action of the pressure of the operating fluid as opposed to the reduced pressure chamber or region within the accelerator.

A modified form of sealing assembly for the piston of the accelerator is shown in FIG. **3**, wherein a one-way seal structure of the type illustrated and described in the patent to Jack W. Tamplen, U.S. Pat. No. 3,227,462, issued Jan. 4, 1966, is disposed in the external annular groove **33** formed in the piston. The piston **30** having the groove **33** therein has an O-ring sealing element **32***a* and a ventilated backup ring **33***a* disposed between the O-ring and one of the sides of the annular groove in which the sealing assembly is located. The ventilated backup ring has one or more lateral flow courses **33***b* formed in the surface of the ring which abuts the sidewall of the groove nearest which the ring is disposed. The bypass flow passages **33***b* permit flow of fluid pressure from below the piston **30** past the O-ring and through the bypass passages into the bore **21** of the cylinder **20** above the piston, so that the piston may return quickly from the extended position to the fully telescoped position. However, as is set forth in the Tamplen patent, the O-ring **32***a* will abut the shoulder or sidewall of the annular groove opposite the ventilated backup ring to seal between the piston and the bore wall **21** of the cylinder when the piston is moved upwardly toward the extended position, to provide a substantial vacuum or void or volume or region of reduced pressure within the cylinder bore.

A further modified form of sealing assembly is shown in FIG. **4**, wherein the piston **130** has an external annular groove **133** formed thereon in which a V-type packing ring **132** is supported between a pair of backup rings **133***a* and **133***b*. A split retaining ring **133***c* is disposed in an annular locking recess **133***d* which is of smaller diameter than the groove **133** in which the packing or sealing member is positioned and confines the sealing assembly between the retaining ring **133***c* and the shoulder **133***e* at the lower end of the groove **133**. This seal assembly will also permit the piston to move quickly from the fully extended position toward the fully telescoped position for permitting any fluids within the bore **21** of the cylinder **20** to move past the V-shaped packing ring as the piston moves downwardly in the cylinder, but will seal upon upward movement to provide the desired void in the chamber when the piston is moved upwardly to the extended position of the piston rod, it being well known that the V-type packing rings will only seal in one direction, as was also the case of the form of the seal shown in FIG. **3**.

To further assist in rapid return of the piston of the accelerator in the cylinder **20**, the spring-pressed check valve shown in FIG. **5** may be mounted in the threaded opening **25** after the closure plug or sealing plug **26** and the retaining set screw **27** have been removed therefrom. The check valve functions for facilitating return of the piston **30** of the device shown in FIG. **2** from extended to collapsed or telescoped position of the piston rod without the necessity of changing the sealing assembly from that shown in FIG. **2** to provide a one-way seal rather than two-way seal shown therein.

The check valve includes a threaded body bushing **140** having a bore **141** which is restricted at its outer portion **142** to provide a shoulder **143** which supports a helical coil spring **144** in the bore **141** of the bushing. A ball closure valve member **145** is biased into engagement with the beveled seat **146** formed at the outer end of the lateral port or aperture **24** in the closure head **22** of the cylinder **20**. Thus, any fluids trapped in the bore **21** of the cylinder **20**, or in the reduced bore **23** of the cylinder below the piston **30**, will be permitted to flow outwardly through the lateral port **24** past the ball check valve **145** and through the bore **141** and reduced bore **142** to the exterior of the cylinder to permit complete telescoping of the piston and piston rod in the bore of the cylinder of the accelerator. This check valve is designed for use with the O-ring of FIG. **2**, which will seal in both directions, but may also be used in combination with the other-type seals to provide an assured evacuation or expulsion of fluids from within the bore of the cylinder **20** of the accelerator.

For movement of the jarring device in an opposite direction longitudinally of the string of pumpdown tools, the accelerator A–2 of FIG. **6** is provided. This form of the accelerator is also operable in either direction longitudinally of the string of tools by proper positioning of the closure seal plug and retaining screw in the lateral apertures in the closed cylinder head **22**, and in the guide bushing **134** at the upper end of the cylinder **20** of the accelerator. The cylinder **20** is identical to that of the form of the accelerator shown in FIG. **2**. The bushing **134** differs in that the upper flange portion **134***a* of the bushing is elongated and provided with a lateral aperture **44** communicating with the longitudinal flow course **137** in the bore of the bushing and with an enlarged threaded opening **45**. A closure seal plug **46** is held in closing sealing engagement with the inner end of the threaded bore **45** by a retaining screw **47** for closing the lateral port **44**, in the same manner as the port **24** was closed in the accelerator of FIG. **2**, to prevent passage of fluid through the lateral port. In addition, an external annular groove **48** is formed in the outer surface of the bushing below the upper flange portion **134***a* and an O-ring **49** is mounted therein for sealing between the bushing and the bore wall of the cylinder **20**, and an internal annular groove **50** is formed in the reduced bore **137***a* of the upper portion of the bushing and an O-ring **51** is disposed in the groove and seals between the bushing and the piston rod **31**. A spanner wrench aperture **134***b* may be formed in the flange portion of the bushing for tightening the bushing into the threaded upper end of the bore **21** of the cylinder in the same manner as in the form of FIG. **2**.

In this form of the accelerator device, the piston is normally in the upper position with the piston rod **31** in extended position projecting from the cylinder **20**. The O-ring **32** in the annular groove **33** in the cylinder **30** seals between the piston and the cylinder wall and, as the piston is moved downwardly in the bore of the cylinder, a region of reduced pressure or a void is formed in the bore of the cylinder above the piston **30** and below the bushing **134**. The O-ring seal member **49** and the O-ring seal member **51** act with the closure seal plug **46** to close the upper portion of the chamber defined by the bushing against admission of fluids into the bore of the cylinder as the piston moves downwardly. Thus, when the piston is moved downwardly a void or region of low pressure is produced in the bore of the cylinder above the piston, and the piston may move rapidly upwardly in the cylinder when the pressure of the operating fluid is applied thereto cause actuation of the jarring device J in a downward direction in the well string.

As is shown in FIGS. **13**, **14** and **15**, the jarring device J–1 is designed for downward actuating movement of the piston and rod of the jarring device with respect to the cylinder in which the piston is disposed to produce a downward stroke or impact upon such downward longitudinal telescoping movement of piston and the rod with respect to the cylinder. This action produces a downward jarring impact upon the well tool T with which the tool string is connected by means of the fishing tool F and the dogs **11** and the fishing neck **10**. In operation of the tool string in which the convertible accelerator device A–2 of FIG. **6** is connected the string is assembled in the condition illustrated in FIG. **13**, wherein the fishing tool F is connected by the dogs **11** to the fishing neck **10** of the lodged well tool T.

The couplers 12 connect the fishing tool F to the jarring device J–1 at one end, while the couplers 13 connect the other end of the jarring device with the accelerator device A–2, which is in turn connected by the couplers 14 to a locomotive piston assembly P–1.

Since the chamber in the cylinder 20 of the accelerator device A–2 between the piston and the closure and guide bushing 134 is maintained under substantially atmospheric pressure, and is sealed off by the O-ring 32 of the piston, the O-rings 49 and 51 in the bushing, and the closure plug or seal plug 46 in the lateral aperture or opening 45, the accelerator piston will be held or maintained in the upper position in which the piston rod is extended. Also, the jarring device J–1 is held in the position in which the piston 118 is in the reduced portion 117*a* of the bore 117 of the cylinder 116 of the jarring device with the piston rod 119 is held in an extended position. The enlarged portion of the bore 117 of the jar cylinder 120 is closed at its lower end, and oil or other fluid is confined within the cylinder to retain the piston in the reduced portion of the bore until sufficient force is applied thereto to move it out of the bore into the enlarged portion 117 of the bore through which the piston may move with greater speed to deliver an impact or jarring stroke in the same manner as the jar J of the form first described.

With the tool string in the position shown in FIG. 13, the fluid pressure of the operating fluid in the U-tube flow conductor C of the well system moves the locomotive piston P–1 downwardly toward the well tool T which is lodged in place in the conductor C and which is to be dislodged. The piston 30 of the accelerator moves downwardly in the bore 21 of the cylinder 20 of the accelerator A–2, and the piston rod 31 telescopes into the bore of the cylinder to the fully telescoped position shown in FIG. 14. Further force applied by means of the locomotive piston P–1 then acts through the accelerator A–2 upon the piston rod 119 of the jarring device J–1 to force the same downwardly and move the piston 118 of the jarring device downwardly out of the reduced upper portion 117*a* of the bore 117 of the cylinder 116 of the jarring device and into the enlarged bore 117, where the piston may move rapidly toward the closed lower end of the bore for the jarring stroke against the closed end of the cylinder, and through the fishing tool F to the lodged well tool T.

The rapid movement of the jarring piston and piston rod after the piston has been moved out of the reduced portion 117*a* of the bore of the cylinder 116 of the jarring device J–1 is permitted by virtue of the region of reduced pressure in the bore 21 of the accelerator piston 20 between the piston 30 and the bushing 134 at the upper end of the cylinder, so that the cylinder 20 of the accelerator A–2 may move downwardly rapidly with respect to the piston and piston rod toward the position shown in FIG. 15 to permit the piston 118 and the piston rod 119 of the jarring device J–1 to move downwardly to the telescoped position to engage the lower closed end of the jar cylinder 116 to deliver the jarring stroke or impact. Any fluid trapped between the locomotive piston P–1 and the well tool T will not materially affect the movement of the jar and accelerator toward the well tool, since the void region or region of low pressure within the accelerator cylinder permits longitudinal movement of the cylinder of the accelerator with respect to the accelerator piston and rod to the extended position shown in FIG. 15. Operating fluid within the conductor C will enter through the lateral openings 25 and the port 24 into the bore 21 of the cylinder 20 of the accelerator device A–2 as the piston is moved upwardly in the cylinder to the extended position shown. The accelerator thus acts in the same manner as the form first described, but in a different direction, to permit a jarring impact of the jarring device in a downward direction rather than the upward direction shown in FIGS. 11 and 12.

All advantages of the accelerator first described are present in this form of the accelerator. In addition, however, this accelerator is convertible from a condition in which it is used for imparting the downward stroke just described, to a condition in which it is usable to impart an upward stroke in the same manner as the accelerator of FIG. 2. Such conversion is accomplished by removing the retaining screw 47 and seal plug 46 from the threaded opening 45 in the bushing 134, and placing the seal plug 46 in the opening 25 in the lower closed head of the cylinder and securing the plug in sealing position therein by means of the retaining screw 47 to close the lateral aperture 24 in the opening 25 against fluid movement therethrough. In this condition, the lateral aperture 44 and the threaded opening 45 are open to permit fluid to enter therethrough into the flow passages 137 and into the bore 21 of the cylinder 20 above the piston 30 and the void or region of reduced pressure would be formed in the bore of the cylinder between the piston and the head 22.

In this event, the accelerator A–2 would function in the same manner as the accelerator A shown in FIG. 2 and produce the same results.

If desired, of course, the apertures 24 and 44 may be enlarged to provide a larger flow passage into and out of the bore of the cylinder, or a plurality of such apertures and closure seal plugs and retaining screws may be provided to secure the desired volume of flow into and out of the cylinder.

A further modified form of accelerator A–3 is shown in FIG. 8. This accelerator is also convertible to provide for up or down strokes, and to provide a variable volume of displacement or movement for an increased jarring action when desired. The cylinder body 220 has a bore 221 which is closed at its lower end by a closure head 222 having a counterbore 223 formed axially therein, which communicates by means of a lateral port 224 with a threaded opening 225 extending to the exterior of the head. The port 224 is closed by means of a seal plug 226 which is held in place by a retaining screw 227 threaded into the bore 225 to provide a fluid tight closure for the lateral port 224. The head has a coupler socket 228 formed integral therewith with a bore or socket 228*a* therein for receiving the connecting members 14, whereby the accelerator is connecting in the pumpdown tool string in the same manner as the forms previously described.

A guide bushing 234 is threaded onto the upper end of the cylinder body 220, and an O-ring 234*a* disposed in an annular groove in the bushing seals between the bushing and body to prevent fluid leakage therebetween. The guide bushing is provided with enlarged portion 237 in the lower portion of its bore 237*a* which communicates with a lateral port 244 and a lateral threaded opening 245 which provides a flow passage from the bore 221 of the cylinder body to the exterior thereof when the flow port 244 and threaded opening 245 are open, so that fluids may easily enter into and flow out of the bore of the cylinder. The reduced upper portion of the bore 237*a* of the bushing provides a guide surface for a cylindrical tubular piston rod or plunger 260, and an internal annular groove 250 formed in such reduced bore receives an O-ring seal member 251, which seals against the exterior of said tubular piston rod or plunger. The tubular plunger is slidable in the guide surface 237*a* between extended and telescoped positions in the bore of the cylinder body 220.

A piston 262 is threaded on the lower portion of the tubular piston rod or shaft 260 and is held in place thereon by a pin 262*c* extending through aligned radially extending apertures in the piston and the shaft. An O-ring 262*b* positioned in an internal annular groove in the upper portion of the bore 262*a* of the piston seals between the piston and the rod, and an external annular groove 263 formed in the midportion of the piston receives an O-ring seal member 264 which seals between the piston 262 and the wall of the bore 221 of the cylinder during movement of the piston and shaft longitudinally of the cylinder body, as will be hereinafter explained. The upper end of the tubular shaft or rod is provided with an enlarged head 265 having a downwardly facing shoulder 266 which is adapted to engage the upper end of the bushing 234 when the shaft 260 and piston 262 are telescoped into the cylinder 220. The head 265 has a bore 267 therein communicating with the bore 261 of the tubular shaft 260, and a reduced bore at its

upper end providing a guide surface **268** in which an internal annular groove **269** is formed for receiving an O-ring seal member **270** for sealing between the head **265** and a piston rod **231** having a piston **230** at its lower end. This piston **230** has an external annular groove **233** in which an O-ring seal **232** is disposed for sealing between the piston **230** and the wall of the bore **261** of the tubular shaft **260**. The upper end of the piston rod **231** extends outwardly through the guide bore **268** and is threaded at its upper end into a counter bore **235***b* in the lower end of a coupler socket member **235** which has its lower external portion reduced at **235***b* to enter an enlarged bore **265***a* in the bushing **265**. The piston rod **231** is pinned to the coupler socket member by a transverse retaining pin **280** extending through aligned radial apertures in the bushing **265**, in the shank **235***b* of the coupler socket **235**, and in the upper end of the piston rod **231**.

The coupler socket **235** has a bore **235***a* which is adapted to receive the connector members or coupler **15** in the same manner as the same were received for connecting the device in the operating string in the form previously described.

In this form of the accelerator, the tubular shaft **260** having the piston **262** thereon is normally pinned by means of the connector pin **280** to the piston rod **231** having the piston **230** thereon, so that the two pistons move simultaneously as a unit in the bore **221** of the cylinder body **220**, and, when the lower port **224** is closed by the closure plug **226** and the two pistons are moved upwardly in the bore **221** of the cylinder body, a vacuum or region of reduced pressure is formed in the bore of the cylinder body between the pistons and the closure plug **226** in the head **222**, the same manner as the form of FIG. **2**. This permits the application of a downward jarring stroke upon telescoping movement of the pistons in the cylinder body.

If a longer jarring stroke is desired, the connecting pin **280** may be removed to permit the piston rod **231** and the piston **230** thereon to slide in the bore **261** of the tubular shaft **260** so that the rod **231** is extended beyond the head **265** at the upper end of the tubular shaft **260**. Such movement of the piston **230** and the rod **231** provides an increased volume of reduced pressure within the bore **261** of the tubular shaft **260** which is added to the volume within the bore **221** of the cylinder body **220** when the elements are in the extended position. This larger volume permits a longer stroke of the jarring device than is possible when the piston rod **231** is connected to the tubular shaft **260** by the pin **280**.

Also, when the piston rod is connected to the tubular shaft **260** by the pin **280**, the lateral port **244** may be closed by a closure plug and retaining screw with tubular shaft **260** in an extended position, similar to the device of FIG. **6**, whereupon downward telescoping movement of the piston **262** and piston **230** simultaneously in the bore **221** of the cylinder body **220** will produce an area of lower pressure within the cylinder body **221** above the piston **262** and below the O-ring seal **251** in the guide bushing **234**. Such movement of the connected pistons **262** and **230** in the bore **221** provides for an upward jarring stroke in the same manner as was accomplished by means of the device in FIG. **6**, when the lower port **224** is opened by removing the closure plug **226** and retaining screw **227** to permit flow of fluids into the bore **221** of the cylinder body below the two pistons.

Similarly, the piston rod **231** may be disconnected from the head **265** and the tubular shaft **260** by removing the pin **280**, and the lateral port **284** closed by a closure plug and retaining screw inserted in the threaded bore **285** to close the plug port **284**, in which event the piston rod **231** may be moved to an extended position and the tubular shaft **260** may be moved to an extended position before the ports **284** and **244** are closed by the closure plugs so that telescoping movement of the piston **230** in the bore **261** of the tubular shaft **260** and further telescoping movement of the piston **262** in the bore **221** of the tubular body cylinder body will produce regions of reduced pressure or void in the bore **261** of the tubular shaft above the piston **230** and in the bore **221** of the cylinder body above the piston **262**, which permits an elongated movement of the jarring device connected to the accelerator due to the increased volume of the region of reduced pressure so provided.

It will be seen, therefore, that this form of the accelerator provides for a variable volume of the region of reduced pressure or void in the accelerator, as desired; and, that the accelerator is convertible to permit upward or downward longitudinal jarring movement of the jarring device.

Another modified form of the accelerator is shown in FIGS. **9** and **10**, wherein the accelerator A–**4** also provides a variable volume or region of reduced pressure or void in the bores of the elements of the accelerator, but wherein the device is adapted for jarring movement in only one direction.

In this form of the device, the accelerator A–**4** has a cylinder body **320** with a bore **321** having a plurality of circumferentially spaced radially inwardly extending guide ribs **337** in the upper portion of the bore of the cylinder body for guiding the elongate tubular piston shaft **360** in its longitudinal telescoping movement in the cylinder. The cylinder body **320** is threaded at its lower end into the enlarged threaded counter bore **322***a* of a closure head **322**, and an O-ring seal **325** is disposed in an internal annular groove **326** formed in the cylinder for sealing between the cylinder and the bore wall of the enlarged counter bore **322***a* of the closure member. The lower end of the closure member is formed with a coupler socket member **228** having a socket or bore **328***a* for receiving connector members **14** in the same manner as the forms of the accelerator previously described for connecting the accelerator in the string of operating tools. An elongate rod **331** has an enlarged lower end **330** which is threaded into a threaded reduced axial bore **327** in the closure member **322**, and a seal ring **329** is disposed in an annular groove **330** in the reduced bore **327** above the threads for sealing between the rod and the closure head **322**. The rod **331** extends upwardly in the bore **361** of the tubular shaft **360** to a point adjacent the upper end of the cylinder body **330**. An internal annular groove **333** in the bore **361** of the piston **362** on the lower end of the tubular shaft **360** receives an O-ring seal member **332** which seals between the piston **362** and the exterior of the rod **331**. The piston **332** has an external annular groove **363** formed therein which receives an O-ring seal member **364** for sealing between the piston and the wall of the bore **321** of the cylinder body **320**. The upper end of the tubular shaft **360** is threaded into the enlarged counter bore **365***a* in an upper coupler socket member **335** and is secured thereto by means of a set screw **336**. The coupler member **335** has a socket or bore **335***a* for receiving connector members **15** for connecting the accelerator in the tool string in the same manner as the forms previously described.

A closure bushing or plug **350** is threaded into the internally threaded upper end of the bore **361** of the tubular shaft **360** to removably close the same. The upper coupler socket member **335** has an axial reduced bore **357** which communicates with the counterbore of the socket member and the bore of the tubular shaft **360** above the plug **350**.

In this form of the device, a variable volume is provided by removing the O-ring seal member **332** from the groove **333**, in which event the entire area of the region in the bore **361** of the tubular shaft **360** below the plug **350** and the area in the bore **321** of the cylinder body **320** below the seal ring **364** on the piston **362** will provide an area of reduced pressure or void.

By removing the seal ring **364** from the groove **363**, with the seal ring **332** in place, the area or region of reduced pressure is confined to that within the bore **361** of the tubular shaft **360** between the O-ring seal **332** and the plug **350**.

When both the O-ring **332** and the O-ring **360** are in place, and the plug **350** is removed, the entire area beneath the piston **362** in the bore **321** of the cylinder body **320** is converted to an area or region of reduced pressure or void.

It will thus be seen that the volume of the region of reduced pressure or void may be varied by selectively removing one of the O-ring seals and by removing the plug **350** as has been described to provide varied volumes of void or regions of

reduced pressure and so permit variations in the rapid actuation of the accelerator and the jarring device connected therewith in the tool spring. This device is adapted for accelerating a movement only in the direction of telescoping movement of the piston **362** in the bore **321** of the cylinder body **320**, and so a jarring stroke can only be effected in a down direction in the device as shown in FIG. **9**, although it is possible to connect the device in the string of tools in the reverse position to provide for stroking movement of the jarring device in the opposite direction. The smaller volume region of reduced pressure is usable where the device is used in an area of higher fluid pressure in the well U-tube flow system, while the larger volume of the region of reduced pressure is utilized where a lower fluid pressure area exists in the column of operating fluid. This provides for control over actuation of the jarring device in the well to prevent destruction of the tools or damage to the well conductor or well tools by an excessive jarring stroke.

Other features of the accelerators of the forms previously described are found in the device of this form.

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

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

1. A jarring stroke accelerator for pumpdown well tools including: a cylinder member; a piston movable longitudinally in said cylinder member; a piston rod connected with said piston and extending outwardly from said cylinder longitudinally beyond one end thereof; means at the other end of the said cylinder and at said projecting end of said piston rod for connecting the same to a string of pumpdown well tools including a jarring device; means sealing between the piston and the cylinder bore wall; said piston and rod when movable longitudinally of said cylinder producing a region of reduced pressure in said cylinder to permit said cylinder and piston to move quickly relative to each other in the direction of such region of reduced pressure to permit operation of a jarring device by the pumpdown well tools.

2. A jarring stroke accelerator for use in a string of pump down tools comprising at least one pumpdown locomotive and a jarring device for operation in a well by operating fluid movement of said pumpdown well tool string including: a cylinder; a piston movable in the cylinder; a piston rod connected with the piston and projecting from the cylinder; means for connecting the projecting end of the rod to the pumpdown well tool string adjacent one of said pumpdown locomotive and said jarring device; means for connecting the cylinder of the accelerator to the pumpdown well tool string adjacent the other of the pumpdown locomotive and the jarring device in said pumpdown tool string; means for moving the piston and cylinder longitudinally in one direction relative to each other to produce a region of reduced pressure in the cylinder between the piston and the cylinder and between the pumpdown locomotive and the jarring device connected to the accelerator; said piston and cylinder of the accelerator being movable longitudinally relative to each other in an opposite direction to eliminate the region of reduced pressure within the accelerator cylinder to produce a rapid movement of the jarring device connected with the accelerator without disturbing the column of operating fluids in the system.

3. A device of the character set forth in claim **2** wherein the accelerator piston and cylinder are movable longitudinally in one direction from telescoped to extended position to create a region of reduced pressure in the cylinder between the piston and the cylinder; and the piston and cylinder are movable longitudinally in the opposite direction with respect to each other to collapse the region of reduced pressure to produce a sudden movement of the pumpdown tools connected with the accelerator by operating fluid movement.

4. An accelerator of the character set forth in claim **2** wherein the piston and cylinder are movable longitudinally from extended to telescoped position to produce a region of reduced pressure in the cylinder between the piston and the cylinder; and said piston and cylinder are movable longitudinally from telescoped to extended position to collapse said region of reduced pressure to produce sudden movement of the pumpdown tools connected with the accelerator by movement of the operating fluid in the well.

5. For use in a pumpdown well installation having a U-tube flow path with a circulating operating fluid contained in said flow path, a string of pumpdown well tools in said flow path operable therein by movement by the fluid in the U-tube flow path including: a jarring device of a delayed action quick release type; and a jarring stroke accelerator for the jarring device comprising: a cylinder member having a bore; a piston movable longitudinally in the bore of said cylinder member; a piston rod connected with said piston and extending outwardly from said cylinder member longitudinally beyond one end thereof; means at the other end of the said cylinder member and at said projecting end of said piston rod for connecting the same to said string of pumpdown well tools adjacent said jarring device; means sealing between the piston and the cylinder bore wall; said piston and rod when movable longitudinally of said cylinder producing a region of reduced pressure in said cylinder bore to permit said cylinder and piston to move quickly relative to each other in the direction of such region of reduced pressure to permit operation of said jarring device by the movement of the circulating operating fluid acting on said pumpdown well tool string.

6. A pumpdown well tool string including: pumpdown locomotive means; a jarring stroke accelerator connected at one end with said pumpdown locomotive means; a jarring device connected with the other end of said jarring stroke accelerator; and a well tool connected with said jarring device for actuation thereby, said accelerator comprising: a cylinder member having a longitudinal bore; a piston movable longitudinally in the bore of said cylinder member; a piston rod connected with said piston and extending outwardly from said cylinder member longitudinally beyond one end thereof; means sealing between the piston and the cylinder member bore wall; said piston and rod when movable longitudinally of said cylinder member bore producing a region of reduced pressure in said cylinder member bore to permit said cylinder member and piston to move quickly relative to each other in the direction of such region of reduced pressure to permit operation of said jarring device by movement of the pumpdown locomotive means to actuate the well tool connected to the jarring device.

7. A method of accelerating the jarring stroke of a jarring device in a pumpdown well tool string operable by movement of circulating pumpdown fluid in a pumpdown well installation, which includes: creating a region of reduced pressure in the pumpdown fluid adjacent the pumpdown tools by moving one of the pumpdown tools by circulation of the pumpdown fluid in the pumpdown system to create said region of reduced pressure therein; actuating a jarring device in the string of pumpdown tools by the movement of the operating fluid to move said one pumpdown tool in a direction collapsing the region of reduced pressure to provide a sudden movement of the jarring device by the operating fluid.

8. A jarring stroke accelerator of the character set forth in claim **1** which includes: inlet opening means into said cylinder member adjacent each end thereof; means in one of said inlet opening means for closing said opening means against passage of fluid pressure whereby movement of the piston in the cylinder member produces said region of reduced pressure therein.

9. A jarring stroke accelerator of the character set forth in claim **1** wherein sealing means is provided between the end of the cylinder and the projecting piston rod for sealing therebetween; inlet opening means into said cylinder adjacent each end thereof; means in one of said inlet opening means for

closing the same against passage of fluid pressure whereby movement of the piston in the cylinder member produces said region of reduced pressure therein; said closure means being selectively secured in a selected one of said inlet opening means to provide said region of reduced pressure on a selected side of said piston in said cylinder member.

10. A jarring stroke accelerator of the character set forth in claim **1** wherein: said piston and rod comprise a plurality of members, one telescoped within the other; means is provided for securing said plurality of members together for movement as a unit, said securing means being releasable to permit independent movement of said members relative to each other to provide an increased stroke and an increased region of reduced pressure in the cylinder member.

11. A jarring stroke accelerator of the character set forth in claim **10** wherein: one of said plurality of members comprises a piston and a tubular stem movable in the cylinder member; sealing means is provided on said piston sealing between the piston and cylinder member; second sealing means is provided between said tubular stem and said cylinder member at one end of said cylinder member for sealing therebetween; a second piston and rod member is movable in the bore of said tubular stem with one end of said rod projecting from the bore of the stem, means sealing between said second piston and said tubular stem; and means for sealing between said rod and said tubular stem at the end of said stem opposite the piston thereon.

12. A jarring stroke accelerator of the character set forth in claim **1** wherein said rod comprises a tubular stem having a piston thereon; a stationary rod is disposed in the tubular stem and is secured to one end of the cylinder member and extends to the opposite end thereof and is disposed to telescope into and out of said tubular stem; sealing means is provided for sealing between said piston and said cylinder and second sealing means is provided for sealing between said piston and said stationary rod; and means is provided for removably closing the bore of said tubular stem at the end thereof opposite the piston thereon.

13. A method of the character set forth in claim **7** including: the additional step of further moving the pumpdown well tool string by movement of the operating fluid in said installation after said jarring device has been actuated.

14. A method of accelerating the jarring stroke of a jarring device connected in a string of pumpdown well tools having a pumpdown locomotive therein operable by movement of circulating pumpdown fluid in a U-tube pumpdown well installation which includes: positioning a jarring stroke accelerator in the pumpdown tool string adjacent the locomotive and the jarring device connected in said string; moving said string of tools into said well installation U-tube by circulating pumpdown fluid to move said locomotive; creating a region of reduced pressure in the accelerator by circulating pumpdown fluid in the system to actuate said accelerator to produce said region of reduced pressure; applying force to said jarring device by means of the pumpdown fluid to release the jarring device for actuation; actuating said jarring device by moving the locomotive by means of the operating fluid in a direction to collapse the region of reduced pressure in the accelerator to provide sudden jarring movement of the jarring device.

15. A jarring stroke accelerator of the character set forth in claim **1** wherein the sealing means provided sealing between the piston and the bore wall of the cylinder member comprises a one-way seal on said piston.

16. A jarring stroke accelerator of the character set forth in claim **8** wherein the means in the inlet opening means of said cylinder member for closing the said opening means comprises a one-way check valve by preventing flow of fluids through the inlet opening means into the cylinder member bore.

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