Jan. 17, 1967 M. B. CONRAD 3,298,437

ACTUATOR DEVICE FOR WELL TOOL

Filed Aug. 19, 1964 2 Sheets-Sheet 1

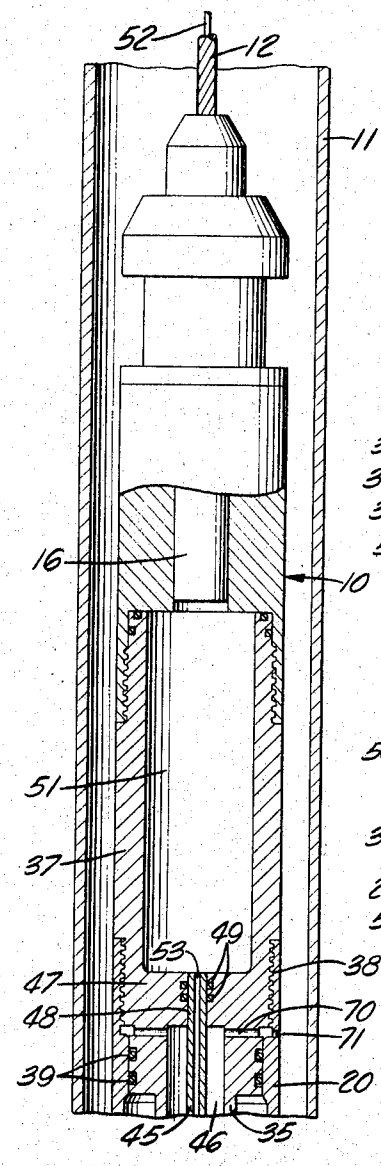


FIG. 1a.

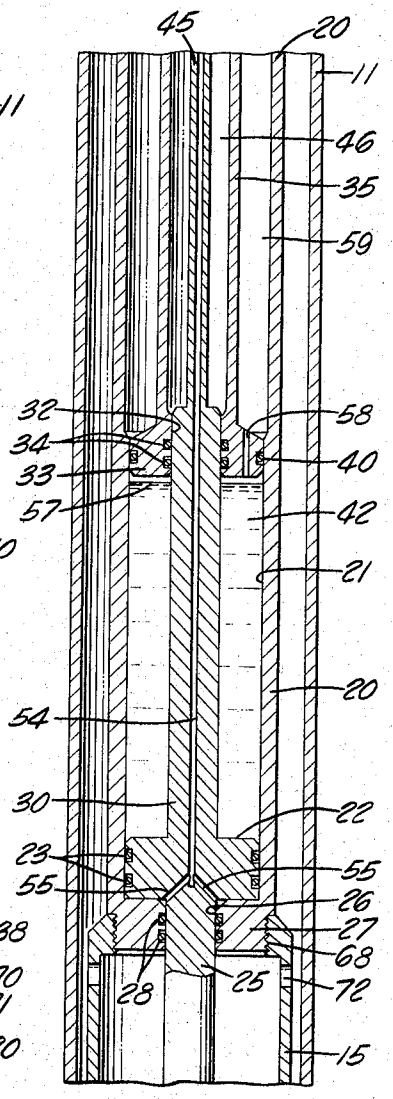


FIG. 1b.

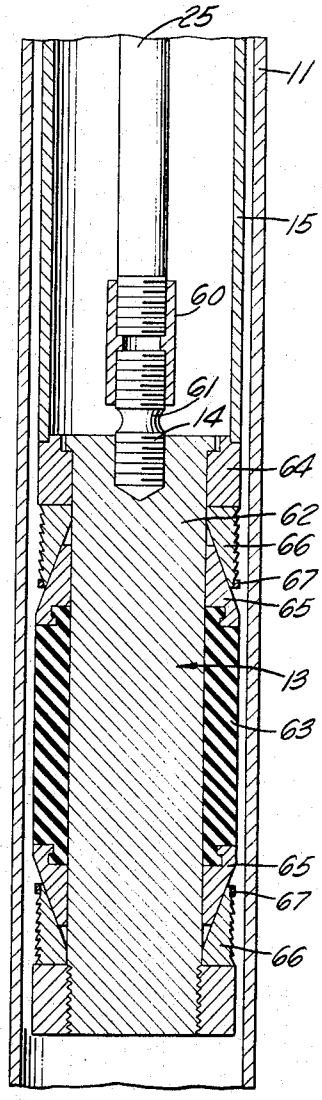


FIG. 1c.

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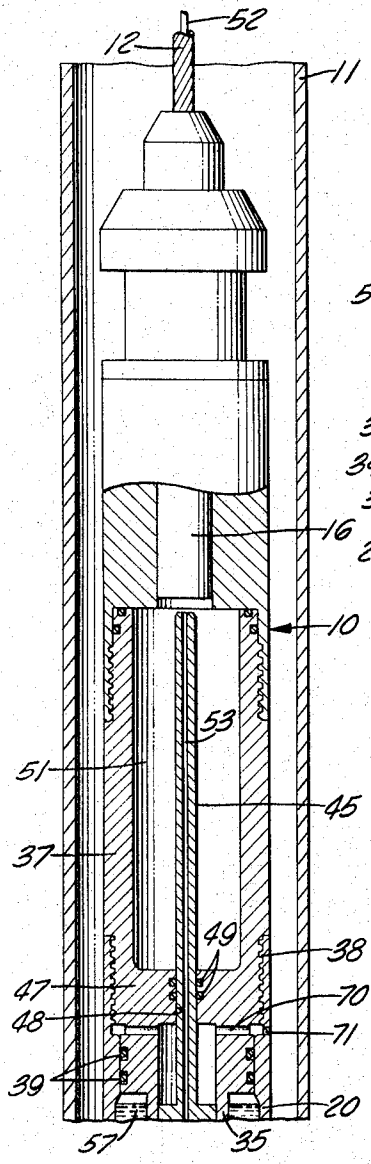


FIG. 2a.

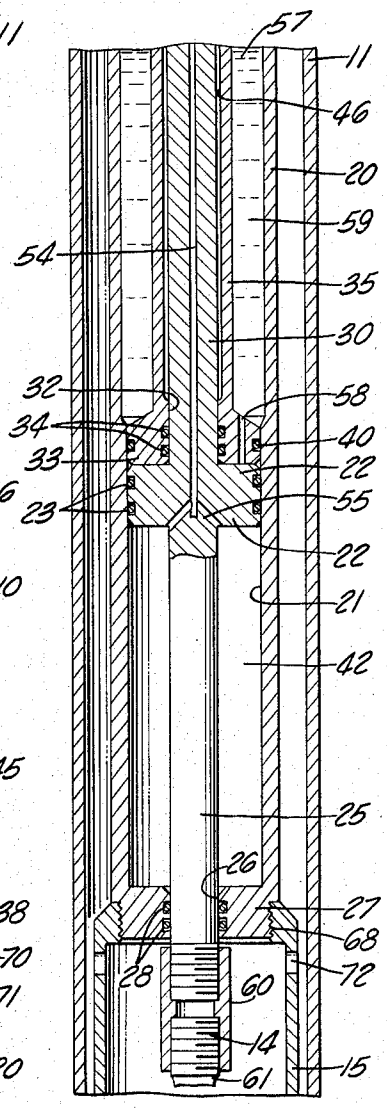


FIG. 2b.

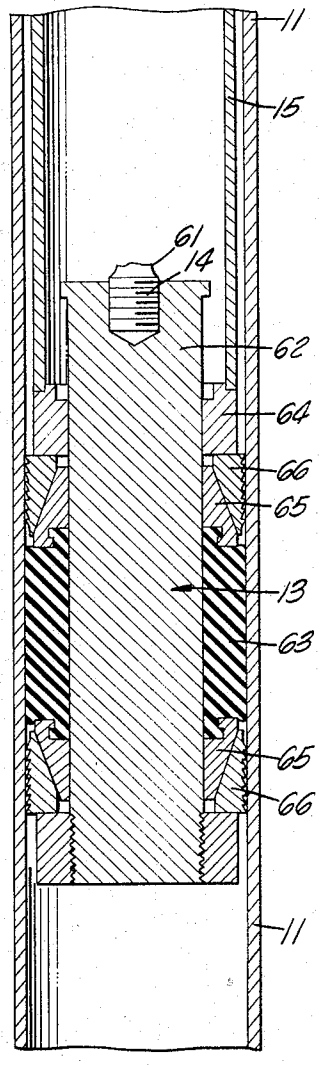


FIG. 2c.

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ACTUATOR DEVICE FOR WELL TOOL

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9 Claims. (Cl. 166—63)

This invention relates to an actuator for a well tool and is particularly directed to a setting tool for a bridge plug.

The objects of the present invention are to provide a setting tool for a bridge plug in a well, the setting tool being energized by high-pressure gas obtained, for example, by ignition of a powder charge within the setting tool. Another object is to provide a device of this type of short over-all length, and yet having adequate stroke to actuate well tools of various sizes and types. Another object is to provide a device of this type which is hydrostatically balanced so that it operates equally well in a dry hole or submerged in liquid to any depth in the well. Another object is to provide a device of this type in which recoil after firing is minimized or substantially eliminated. A related object is to provide a device of the type described which is economical to manufacture, having relatively few parts and reliable in operation.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIGURE 1 shows a preferred embodiment of this invention in longitudinal sectional elevation, FIGURE 1*b* comprising a continuation of the lower end of FIGURE 1*a*, and FIGURE 1*c* comprising a continuation of the lower end of FIGURE 1*b*. FIGURE 1 shows the parts of the actuator for setting tool and the parts of the bridge plug in initial position prior to firing.

FIGURE 2 is a view similar to FIGURE 1, showing the parts in position after firing and showing the bridge plug set within the casing. FIGURE 2*b* is a continuation of the lower end of FIGURE 2*a*, and FIGURE 2*c* is a continuation of the lower end of FIGURE 2*b*.

Referring to the drawings, the actuator device generally designated **10** comprises a setting tool adapted to be lowered into a well casing **11** on a wire line **12**. A bridge plug assembly **13** of conventional design is attached to the lower end of the actuator **10** by means of the frangible connector **14** and spacer **15**. In the general plan of operation, the setting tool **10** and bridge plug **13** are lowered as a unit into the well casing **11** on the wire line **12**, and when the desired depth is reached, the power charge **16** is ignited electrically to cause the actuator to expand the bridge plug **13** into contact with the casing **11** and to break the frangible connection **14**, as shown in FIGURE 2*c*. The actuator or setting tool assembly **10** may then be withdrawn from the well casing on the wire line **12**, leaving the bridge plug **13** in place in the casing.

The actuator or setting tool **10** includes a cylinder member **20** provided with an axial cylindrical bore **21**. A piston **22** having seal rings **23** is slidably mounted within the bore **21**. A downward-extending piston rod **25** is fixed to the piston and extends through the central axial opening **26** in the lower end wall **27** of the cylinder member **20**. Seal rings **28** mounted in the opening **26** engage the piston rod **25**.

A post **30** is fixed to the piston **22** and extends axially upward therefrom and projects slidably through an opening **32** in the annular plug **33**. Seal rings **34** in the opening **32** contact the post **30**. The annular plug **33** is formed on the lower end of the axial concentric sleeve **35**, which is provided on the lower end of the body **37**. Threads **38** connect the upper end of the cylinder member **20** to the body **37**. Seal rings **39** on the body engage the cylinder member **20** to prevent leakage. A seal ring **40** on the annular plug also engages the cylinder member

20 to prevent leakage. The annular plug **33** forms the upper end wall of a chamber **42** within the cylindrical bore **21** of the cylinder member **20**. The end wall **27** forms the lower end wall of the chamber **42**.

An axial-extending central tube **45** is fixed to the upper end of the post **30** and extends through the space **46** within the sleeve **35** and between the annular plug **33** and the wall **47** of the body **37**. A central opening **48** in the wall **47** slidably receives the tube **45**, and seal rings **49** in the opening **48** engage the outer surface of the tube **45**. The walls of the body **37** define a closed pocket **51** adapted to receive high-pressure gas from ignition of the powder charge **16**. The ignition system for the powder charge **16** is conventional and is operated by electrical energy transmitted through an electric lead wire **52** in the cable **12**.

When the powder charge **16** is ignited, gas under high pressure in the pocket **51** passes through the central opening **53** in the tube **45** and through the connecting central passage **54** in the post **30** and outward through lateral ports **55** in the piston **23**. The high-pressure gas is thus delivered into the chamber **42** below the piston **22**. The piston **22** moves upward, causing the body of oil **57** in the chamber **42** above the piston to pass through one or more restricted ports **58** in the annular plug **33** into the closed cavity **59**, defined between the sleeve **35** and the cylinder member **20**. This cavity **59** is initially filled with air. It may be at atmospheric pressure, or somewhat higher in order to return the piston **22** to its initial position. Upward movement of the piston **22** under the force of high-pressure gas is slowed by the dashpot action of the oil **57** passing through the restriction **58**.

The lower end of the piston rod **25** is connected by coupling **60** to the frangible pin **14** having a weakened section **61**. The bridge plug assembly **13** has a mandrel **62** connected to the lower end of the frangible pin **14**. The usual expansible elastomeric sleeve **63** is mounted on the mandrel **13** and is caused to expand outward into engagement with the casing **11** when the mandrel **62** moves upward with respect to the ring **64**. The usual cones **65** are provided at the opposite ends of the expansible sleeve **63**, and wedge slips **66** co-operate with the cones **65** to hold the sleeve **63** in expanded position, as shown in FIGURE 2*c*. The slips **66** may be initially retained in place by frangible bands **67** or by other conventional means. The ring **64** is engaged by the lower end of the spacer **15** which is connected by threads **68** to the lower end of the cylinder member **20**.

Accordingly, when the piston **22** moves upward in the chamber **42** the spacer **15** acts in compression while the piston rod **25** acts in tension. After the bridge plug **13** has been set, continued upward movement of the piston **22** overloads the frangible pin **14** in tension, causing it to rupture. Recoil of the actuator **10** at the moment of rupture of the frangible pin **14** is minimized because of the dashpot action of the oil being transferred from the upper portion of the chamber **42** through the restricted ports **58** into the closed cavity **59**. The chamber **42** below the piston **22** as well as the pocket **51** remained filled with gas under pressure, after the piston **22** has moved to the upper end of its stroke.

The upper end of the space **46** is vented through ports **70** and **71** to the space outside the actuator tool **10** and within the casing **11**. Accordingly, any hydrostatic head of liquid in the casing acts through the ports **71** and **70** and through the space **46** on the exposed upper end of the post **30**. Also, the piston rod **25** below the seal rings **28** is exposed to the same hydrostatic pressure through the ports **72** in the upper end of the spacer **15**. The relative diameters of the post **30**, tube **45**, and piston rod **25** are so chosen that the effective area of the piston rod **25** is equal to the effective area of the post **30**, minus the

effective area of the tube 45. The result is that the piston is hydrostatically balanced regardless of the depth of submergence of the actuator 10 in liquid within the well casing 11.

Having fully described my invention, it is to be understood that I am not to be limited to the details herein set forth, but that my invention is of the full scope of the appended claims.

I claim:

1. An acuator device for a well tool, comprising in combination: a cylinder member having a bore and having upper and lower end walls defining a chamber within said bore, each end wall having an axial opening, a piston slidably mounted within said bore, a piston rod fixed to the piston and projecting slidably through the opening in the lower end wall, a post fixed to the piston and projecting slidably through the opening in the upper end wall, an axial sleeve fixed to the upper end wall forming a closed cavity within the cylinder member, ports in the end wall connecting said cavity to said chamber, the sleeve having interior space into which said post may project, port means venting said interior space to the exterior of said actuator device, walls forming a pocket above the sleeve to receive a pressure-generating charge, and means forming a passage connecting said pocket to the chamber below the piston.

2. An actuator device for a well tool, comprising in combination: a cylinder member having a bore and having upper and lower end walls defining a chamber within said bore, each end wall having an axial opening, a piston slidably mounted within said bore, the chamber above the piston containing oil, a piston rod fixed to the piston and projecting slidably through the opening in the lower end wall, a post fixed to the piston and projecting slidably through the opening in the upper end wall, an axial sleeve fixed to the upper end wall forming a closed cavity within the cylinder member, said closed cavity containing atmospheric air, ports in the end wall connecting said cavity to said chamber, the sleeve having interior space into which said post may project, port means venting said interior space to the exterior of said actuator device, walls forming a pocket above the sleeve to receive a pressure-generating charge, axially slidable telescoping parts including a tube extending between said post and said pocket, and passage means in the post and piston connecting the chamber below the piston to said pocket through the interior of the tube.

3. An actuator device for a well tool, comprising in combination: a cylinder member having a bore and having upper and lower end walls defining a chamber within said bore, each end wall having an axial opening, a piston slidably mounted within said bore, a piston rod fixed to the piston and projecting slidably through the opening in the lower end wall, a post fixed to the piston and projecting slidably through the opening in the upper end wall, an axial sleeve fixed to the upper end wall forming a closed cavity within the cylinder member, ports in the end wall connecting said cavity to said chamber, the sleeve having interior space into which said post may project, port means venting said interior space to the exterior of said actuator device for balancing said piston against hydrostatic pressure of fluid in which the actuator device may be immersed, walls forming a pocket above the sleeve to receive a pressure-generating charge, axially slidable telescoping parts including a tube extending between said post and said pocket, and passage means in the post and piston connecting the chamber below the piston to said pocket through the interior of the tube.

4. An actuator device for a well tool, comprising in combination: a cylinder member having a bore and having upper and lower end walls defining a chamber within said bore, each end wall having an axial opening, a piston slidably mounted within said bore, a piston rod fixed to the piston and projecting slidably through the opening in the lower end wall, a post fixed to the piston and projecting slidably through the opening in the upper end wall, an axial sleeve fixed to the upper end wall forming a closed cavity within the cylinder member, ports in the end wall connecting said cavity to said chamber, the sleeve having interior space into which said post may project, port means venting said interior space to the exterior of said actuator device for balancing said piston against hydrostatic pressure of fluid in which the actuator device may be immersed, walls forming a pocket above the sleeve to receive a pressure-generating charge, one of the walls having an opening, a tube fixed coaxially to said post and slidably received in the latter said opening, and passage means in the post and piston connecting the chamber below the piston to said pocket through the interior of the tube.

5. An actuator device for a well tool, comprising in combination: a cylinder member having an axial bore, a piston slidable axially within said bore and having a piston rod fixed thereto and projecting downward therefrom, the cylinder member having an end wall provided with an opening slidably receiving said piston rod, the piston also having a concentric cylindrical post fixed thereto and projecting upward therefrom, a tubular body fixed to the cylinder member and having an axial sleeve extending into said cylinder member and having an annular plug sealed within the cylinder member above said piston, said annular plug having an opening slidably receiving said post, the space within the cylindrical bore between the end wall and the annular plug comprising a chamber, said sleeve and said cylinder member co-operating to form a closed cavity, ports in said annular plug connecting said closed cavity to the chamber above said piston, ports in the body member venting the space within the sleeve to the exterior of the actuator device, the body having walls forming a pocket above the sleeve to receive a pressure-generating charge, axially slidable telescoping parts including an element extending between said post and said pocket, and passage means connecting the chamber below the piston to said pocket.

6. An actuator device for a well tool, comprising in combination: a cylinder member having an axial bore, a piston slidable axially within said bore and having a piston rod fixed thereto and projecting downward therefrom, the cylinder member having an end wall provided with an opening slidably receiving said piston rod, the piston also having a concentric cylindrical post fixed thereto and projecting upward therefrom, a tubular body fixed to the cylinder member and having an axial sleeve extending into said cylinder member and having an annular plug sealed within the cylinder member above said piston, said annular plug having an opening slidably receiving said post, the space within the cylindrical bore between the end wall and the annular plug comprising a chamber, said sleeve and said cylinder member co-operating to form a closed cavity, ports in said annular plug connecting said closed cavity to the chamber above said piston, ports venting the space within the sleeve to the exterior of the actuator device for balancing said piston against hydrostatic pressure of fluid in which the actuator device may be immersed, the body having walls forming a pocket above the sleeve to receive a pressure-generating charge, axially slidable telescoping parts including a tube extending between said post and said pocket, and passage means in the post and piston connecting the chamber below the piston to the pocket through the interior of the tube.

7. For use with a well tool having two parts adapted for relative axial movement, an actuator device comprising, in combination: a cylinder member having an axial bore, means for connecting the cylinder member to one of the well tool parts, a piston slidable axially within said bore of said cylinder member and having a piston rod fixed thereto and projecting downward therefrom, means for connecting said piston rod to the other of the well tool parts, the cylinder member having an end wall provided with an opening slidably receiving said

piston rod, the piston also having a concentric cylindrical post fixed thereto and projecting upward therefrom, a tubular body fixed to the cylinder member and having an axial sleeve extending into said cylinder member and having an annular plug sealed within the cylinder member above said piston, said plug having an opening slidably receiving said post, the space within the cylindrical bore between the end wall and the annular plug comprising a chamber, said sleeve and said cylinder member cooperating to form a closed cavity, ports in said annular plug connecting said closed cavity to the chamber above said piston, ports in the body member venting the space within the sleeve to the exterior of the actuator device, the body having a pocket above the sleeve to receive a pressure-generating charge, axially slidable telescoping parts including a tube extending between said post and said pocket, and passage means in the post and piston connecting the chamber below the piston to the pocket through the interior of the tube.

8. The device of claim 7 in which the closed cavity contains atmospheric air and the chamber above the piston contains oil.

9. For use with a well tool having two parts adapted for relative axial movement, an actuator device comprising, in combination: a cylinder member having an axial bore, means for connecting the cylinder member to one of the well tool parts, a piston slidable axially within said bore of said cylinder member and having a piston rod fixed thereto and projecting downward therefrom, means for connecting said piston rod to the other of the well tool parts, the cylinder member having an end wall provided with an opening slidably receiving said piston

rod, the piston also having a concentric cylindrical post fixed thereto and projecting upward therefrom, a tubular body fixed to the cylinder member and having an axial sleeve extending into said cylinder member and having an annular plug sealed within the cylinder member above said piston, said annular plug having an opening slidably receiving said post, the space within the cylindrical bore between the end wall and the annular plug comprising a chamber, said sleeve and said cylinder member co-operating to form a closed cavity, ports in said annular plug connecting said closed cavity to the chamber above said piston, ports in the body member venting the space within the sleeve to the exterior of the actuator device, the body having walls forming a pocket above the sleeve to receive a pressure-generating charge, one of the walls having an opening, a tube fixed on said post and slidably received in the latter said opening, and passage means in the post and piston connecting the chamber below the piston to the pocket through the interior of the tube.

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