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(54) Swivel assembly for a pneumatic underground piercing tool.

(57) A swivel assembly for supporting a valve sleeve in a cavity of a striker in a pneumatic underground piercing tool. A valve supporting means supports the valve sleeve on a valve body by cooperating spherical seat and bearing members to allow angular movement between the valve sleeve and valve body. A retaining mechanism is provided for resiliently securing the valve supporting means to the valve body.

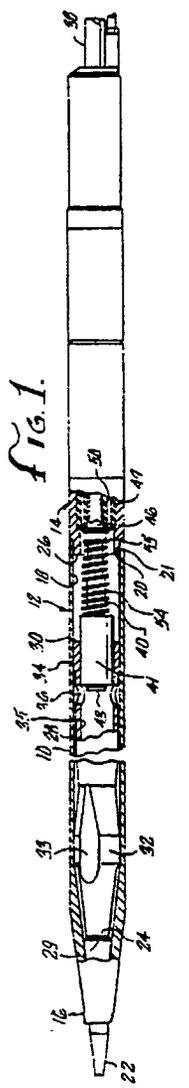

Fig. 1.

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This invention relates to a pneumatically operated underground piercing device and in particular to an improved mechanism for supporting a valve body within the piercing device.

Pneumatically operated devices have been developed for creating a hole in the ground by the internal mechanism of the bullet-shaped device causing forwardly directed impacts to advance the device by compressing the soil to form the hole. The device is merely connected by a hose to a source of compressed air and aimed in the desired direction whereupon it is self-propelled through the earth to the desired destination. These devices are particularly useful in forming a generally horizontal hole under a street or other surface obstruction to install pipes, cables or the like without the necessity of digging a trench across the obstructed surface or the problems in boring a hole. A small trench is dug on either side of the surface obstruction and this pneumatically operated device is aimed from one trench to the other beneath the surface obstruction. Several different mechanisms and methods (not addressed herein) have also been developed to guide or direct the pneumatically operated device in a particular direction as well as reverse its direction of travel in order to retract the device on occasions when, for example, the device runs into an obstruction or diverts off course.

One of the problems experienced with the internal working of the pneumatically operated device is known as "binding." Binding occurs when the striker catches or sticks to the sleeve as it rapidly reciprocates fore and aft relative to the sleeve. The sleeve is attached to a valve body resigned to allow for lateral and angular flexibility so that it can self-adjust to articulate easily with and follow the movement of the striker. However, this movement combined with the limited clearance between the inside diameter of the striker and the outside diameter of the sleeve and the speed of the striker's movement relative to the sleeve still may result in the sleeve binding to the striker. This phenomenon may also be encouraged when, for example, the tool runs into an obstruction causing the tool to deform slightly. This deformation of the tool may be enough to offset the movement of the striker thereby causing it to bind with the sleeve as it rides in the bore of the striker. Ultimately, binding may cause the valve body to crack or break.

Another problem experienced with the pneumatically operated device is the breaking of a sleeve retaining mechanism during the operation of the striker. In earlier pneumatically operated devices the repeated impacts of the striker components caused the sleeve and associated components including the sleeve retaining mechanism to vibrate substantially placing undue stress on the sleeve retaining mechanism resulting in breakage thereof. At least one attempt to overcome these problems included the use of a rubber mounting means between the sleeve and valve body to allow some resilient relative movement but that attempt has not been completely successful.

It is an object of this invention to provide an underground piercing tool with an improved mechanism for reducing the effects of binding while supporting a valve body inside the piercing device.

Another more detailed object of this invention is to provide a swivel assembly for supporting a valve body inside the striker which allows lateral flexibility of the valve body inside the sleeve without adversely effecting reciprocation of the striker relative to the sleeve. A still further detailed object of this invention is to provide a more durable retaining mechanism for securing the sleeve to the valve body.

Other and more detailed objects and advantages of the present invention will be apparent to those skilled in the art from the following description and the accompanying drawings whereas:

FIG. 1 is a partial sectional side view of the underground piercing tool illustrating the valve sleeve element in the forward position of operation with the striker impacting on the front of the tool for imparting forward motion.

FIG. 2 is an enlarged fragmentary sectional side view of FIG. 1 illustrating the components of the swivel assembly of this invention.

Turning in detail to the drawings and specifically to FIG. 1, the underground piercing tool of this invention includes a hollow cylindrical body 10 comprised of a front portion 12 threadably connected to a rear portion 14. The front portion 12 of the hollow body 10 includes a tapered front end 16 and an open rear end 18 with internal threads 20 thereon. A pointed anvil 22 having a striking surface 24 at its rear end is secured to the tapered front end 16 of the hollow body 10. The rear portion 14 of the hollow body 10 has an open annular end 26 with external threads 21 thereon to allow assembly and disasssembly of the front portion 12 and rear portion 14 of the hollow body 10.

A striker 28 is slidably mounted in the hollow body 10 to reciprocate fore and aft with a front end surface 29 for impacting on the striking surface 24 of the anvil 22 to drive the tool in the forward direction. The striker 28 has an annular rear end 30 adapted to impact against the front annular end 26 of the rear portion 14 for driving the tool rearwardly when the tool is adjusted to cause rearward movement, as described below. The front of the striker 28 is provided with an outer surface having cylindrical portions 32 for smooth engagement with the interior cylindrical surface of the body 10 and machined flat portions 33 for allowing air to pass through that area of the striker 28. The rear end of the striker 30 is provided with a cylindrical portion 34 slidably engaging the interior of the hollow cylindrical body 10 to comprise a piston and cylinder arrangement. The remaining exterior portions of the striker 28 are spaced from the interior of the cylindrical body 10 to provide annular passage-

ways for the air during operation of the device.

The striker 28 is provided with a cylindrical cavity 35 at its rear end with radial ports 36 communicating the cavity 35 with the exterior of the striker 28. A valve body 40 is connected to a cylindrical valve sleeve 41 at its front end slidably engaging the cylindrical cavity 35 in the striker 28. Valve body 40 has a central bore 42 (FIG. 2) extending its entire length and connected to an air hose 38 for supplying compressed air through the valve body 40 to the cavity 35 of the striker 28. As the striker 28 reciprocates within the hollow body 10 causing the striker cavity 35 to reciprocate over the valve sleeve 41, the ports 36 of the striker are either closed by the valve sleeve 41 or open by being positioned to the front or rear of the valve sleeve 41. The longitudinal position of the valve sleeve 41 determines whether the underground piercing tool will be operating in a forward or reversed mode by timing the opening and closing of the ports 36 to cause the striker 28 to impact at the front surface 24 on the anvil or front annular end 26 of the rear portion 14.

While in the forward operating mode, when the striker 28 is in the position shown in FIG. 1, the compressed air is supplied through the ports 36 to the entire front of the striker 28 forward of the piston surface 34 urging the striker rearwardly in its return stroke. However, as the ports 36 are closed, the cavity 35 and valve sleeve 41 form a piston and cylinder which is continually supplied with compressed air and therefore tends to arrest the rearward movement of the striker 28 in opposition to the compressed air previously admitted to the front of the striker 28. As the ports 36 pass the rear of the valve sleeve 41 to thereby exhaust the compressed air previously trapped in front of the striker 28, the compressed air within the cavity 35 drives the striker 28 forwardly to impact surface 24 to complete the cycle.

Similarly, the tool may operate in a reverse mode to drive the tool rearwardly. A variety of methods are available to alter the direction of the tool such as the methods described in U.S. Patent No. 4,662,457 and other patents identified therein. Generally, by selectively moving the valve sleeve 41 to a rearward position, the compressed air is supplied through the ports 36 to the front of the striker 18 for a longer duration in the forward portion of the movement of the striker to develop sufficient rearward force to prevent the striker from engaging the anvil 22 and causing the striker to reverse its motion. In addition, in the rearward motion of the striker, the ports 36 do not reach the rear end of the valve sleeve 41 to exhaust the compressed air until immediately before the rear end 30 of the striker 28 impacts on the front end 26 of the rear portion 14 of the hollow body 10 thereby driving the tool rearwardly for the reverse mode of operation.

The valve body 40 extends from the rear end where it is connected to the air hose 38 (not shown) forwardly to a front end 43 where it is secured to the valve sleeve 41. A rear portion of the valve body 40 is slidably received in the cylindrical interior of a valve guide generally designated 46. The value guide 46 is supported in the rear portion 14 of the hollow body 10 by an elastomeric sleeve or bushing 47 which serves as a shock absorber and support for the valve guide 46. The elastomeric bushing 47 is tightly fitted over the cylindrical outer surface of the guide 46 and then press fitted into the rear portion 14 of the hollow cylindrical body 10. The bushing 47 has a plurality of longitudinally extending holes 50 or other convenient shape through which the compressed air exhausts to atmosphere during the rearward stroke of the striker 28.

A coil type compression spring 54 surrounds the mid portion of the valve body 40 and extends between the rear shoulder of the valve sleeve 41 and the front end 55 of the valve guide 46 to continually urge the valve body 40 forwardly relative to the valve guide 46.

After the valve body 40 has been assembled to the valve guide 46 by compressing the spring 54 therebetween the air hose 38 may be interconnected to the rear end of the valve body 40 while the front portion 12 and rear portion 14 of the hollow body 10 may be threadably connected to complete the assembly.

Turning in detail to FIG. 2, the front end 43 of valve body 40 is provided with a reduced outside diameter smaller than the rest of the valve body 40 and is connected to the inside of the sleeve 41 by a swivel assembly generally designated as 48. The swivel assembly 48 includes a valve supporting means comprised of first and second cylindrical seats or carriages 51 and 52 having respective apertures 53 therethrough for slidable engagement along the outside surface of the front end 43 of the valve body 40, and hemispherical concave inner walls 59 for engaging and supporting first and second bearings or balls 56 and 57. The bearings 56, 57 are provided with hemispherical convex outside surfaces 58 for slidable engagement with the concave inside walls 59 of the seats 56, 57 and respective apertures 60 surrounding the valve body 40. The apertures 60 on the bearings 56, 57 are larger than the seat apertures 53 and front end 43 of valve body 40 such that when the bearings 56, 57 are supported by the seats 51, 52 as illustrated in FIG. 2 the bearing apertures 60 do not contact the valve body 40. The bearings 56, 57 are mounted to spherically rotate about the seats 51, 52 which act as a valve supporting means for simultaneously supporting the valve body 40 within the sleeve 41 and the bearings about the valve body 40. A shoulder is provided on the confronting outer edges of the bearings 56, 57 for engagement with an internal flange 62 protruding from the inside of the valve sleeve 41 such that the first bearing 56 is positioned and restrained between the flange 62 and the first seat 51, and the second bearing 57 is positioned and restrained between the flange 62 and the second seat 52.

A retaining mechanism 64 such as a retaining ring secures the seats 51, 52 and balls 56, 57 to the valve body 40. A biasing means 66 such as a wave washer is sandwiched between the retaining mechanism 64 and the first seat 51 and protects the retaining mechanism 64 from rigidly contacting and confining the seats 51, 52. The biasing means 66 biases the seat 51 towards the balls 56, 57 and tends to prevent excessive vibrations and rattling of the swivel assembly parts during rotating and sliding of the seats 51, 52 and balls 56, 57 about and along the valve body 40 and protects the retaining mechanism 64 from failing. By this arrangement, the swivel assembly 48 allows for 7° - 10° spherical movement of the bearing or ball components 56, 57 relative to the seat or carriage components 51, 52 which results in allowing 7°-10° of angular movement of valve sleeve 41 relative to valve body 40. Thus, the swivel assembly 48 allows the sleeve 41 to remain in perfect alignment and sliding contact with the cylindrical cavity 35 at all times, even upon bending of the body 10 that causes axial misalignment batween the striker and the valve body 40. This lateral flexibility of the valve body 40 permits the sleeve 41 to slide easily within the striker 28 without binding during fore and aft reciprocation of the striker 28 relative to the sleeve 41. The biasing means maintains a constant preload on the swivel assembly 48 to reduce the gaps or space variations that tend to form between the components as they move relative to each other.

Thus, a swivel assembly is disclosed which reduces the effects of binding while supporting a valve body inside the striker of a pneumatically operated piercing device. The swivel assembly allows angular movement of the valve sleeve relative to the valve body without adversely effecting reciprocation of the striker relative to the sleeve. Also, a more durable retaining mechanism for securing the sleeve to the valve body is disclosed. While specific embodiment and application of this invention have been shown and described, it will be apparent to those skilled in the art that many modifications are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims.

Claims

1. In a pneumatic underground piercing tool having a valve sleeve slidably fitting within a reciprocating striker, a swivel assembly comprising:

   a valve supporting means for supporting the valve sleeve on a valve body wherein said valve supporting means includes spherical bearing means for allowing relative angular movement between the valve sleeve and valve body.

2. The swivel assembly of claim 1 wherein said valve supporting means includes first and second seats having respective apertures therethrough for engagement with said valve body.

3. The swivel assembly of claim 1 wherein said valve support means includes first and second balls having respective apertures therethrough for surrounding said valve body.

4. The swivel assembly of claim 1 further including a biasing means for resiliently supporting said valve supporting means on the valve body.

5. The swivel assembly of claim 1 wherein said valve body extends through said valve supporting means.

6. The swivel assembly of claim 1 further comprising a retaining mechanism for securing said valve supporting means to the valve body.

7. The swivel assembly of claim 1 wherein said valve supporting means is comprised of a first and second seat having concave shaped inner walls and said bearing is comprised of a first and second ball having convex shaped outer walls said first and second seat respectively supporting said first and second ball.

8. In a pneumatic underground piercing tool having a valve sleeve slidably fitting within a reciprocating striker, a swivel assembly comprising:

   a seat supported on a valve body mounted in the tool;

   a bearing rotatably supported within said seat and supporting the valve sleeve;

   a retaining mechanism for securing said seat and bearing to said valve body; and

   a biasing means for biasing said seat toward said bearing.

9. The swivel assembly of claim 8 wherein said biasing means is sandwiched between said retaining mechanism and said seat.

10. The swivel assembly of claim 8 wherein said biasing means is a wave washer.

11. In a pneumatic underground piercing tool having a valve sleeve slidably fitting within a reciprocating striker and a valve body supported in the tool, an improvement comprising a swivel assembly comprising:

    first and second valve supporting seat means counted on the valve body and within the valve sleeve;

    first and second bearing means

sandwiched between said first and second valve supporting seat means; and

a biasing means for biasing said valve supporting seat means toward said bearings.

12. The swivel assembly of claim 11 wherein the valve body engages respective apertures within said first and second valve supporting seat means.

13. The swivel assembly of claim 11 wherein said first and second bearings are shaped to rotate within said first and second valve supporting seat means.

14. The swivel assembly of claim 11 further comprising a retaining mechanism for securing said swivel assembly to said valve body.

15. The swivel assembly of claim 11 wherein said biasing means protects said retaining mechanism from contacting said valve supporting seat means.

16. The swivel assembly of claim 11 wherein said first and second bearings form a spherical shape and fit within a spherical cavity formed by said first and second valve supporting seat means.

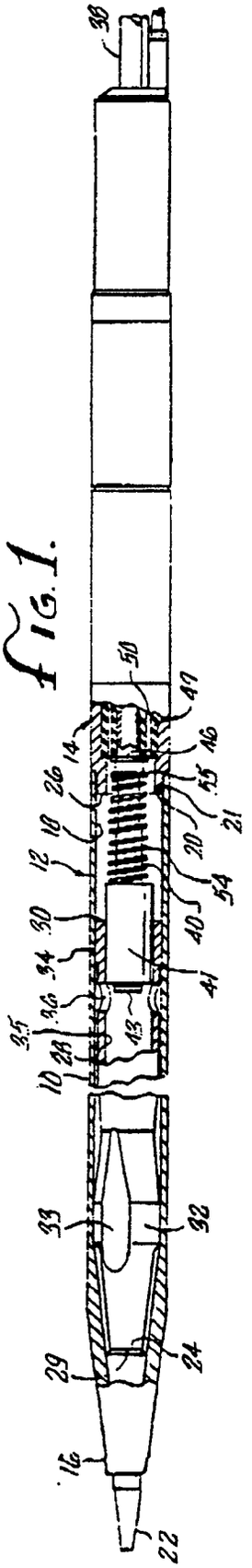

Fig.1.

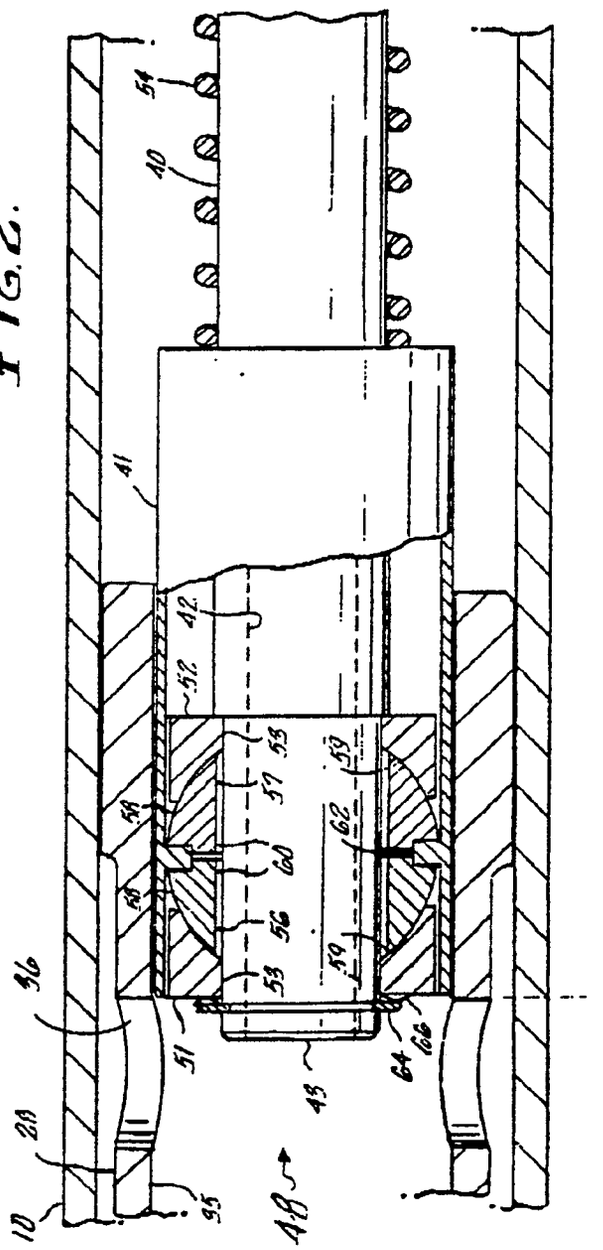

Fig.2.