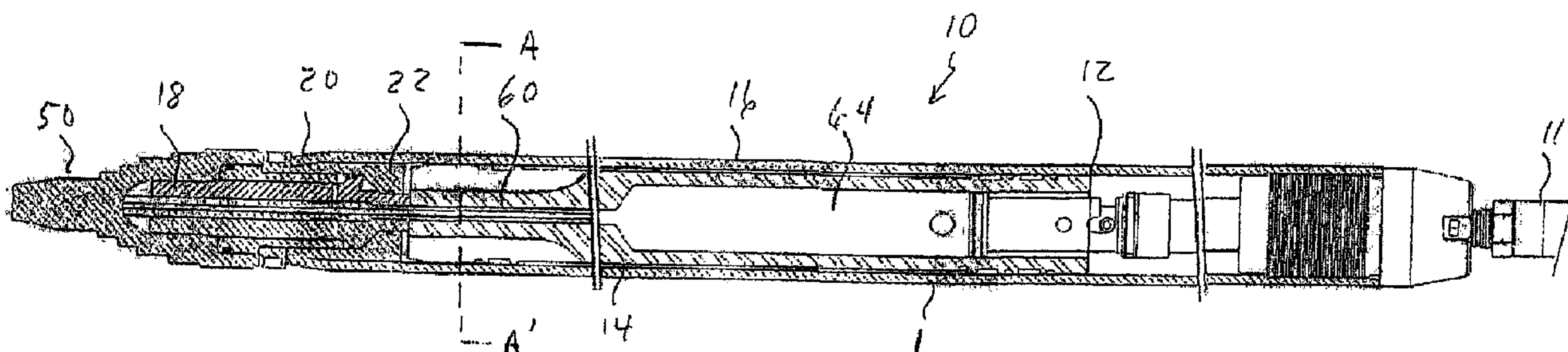




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(54) Titre : OUTIL PNEUMATIQUE POUR PERCER LE SOL
(54) Title: PNEUMATIC GROUND PIERCING TOOL



(57) Abrégé/Abstract:

A ground piercing tool includes a housing and an air distributing mechanism that reciprocates a striker to impact a chisel shaft in response to a supply of compressed fluid including a fluid inlet tube mounted in the bore of the striker having a radial port, a rear end of the inlet tube being in communication with the distributing mechanism, wherein the housing and chisel shaft cooperate to define a front chamber that decreases in volume as the chisel moves forward relative to the housing, and wherein the chisel shaft has a radial passage therein that conducts compressed fluid from the radial port of the inlet tube to the front chamber, which is configured to form an air spring.

1

ABSTRACT

2 A ground piecing tool includes a housing and an air distributing
3 mechanism that reciprocates a striker to impact a chisel shaft in response to a
4 supply of compressed fluid including a fluid inlet tube mounted in the bore of the
5 striker having a radial port, a rear end of the inlet tube being in communication
6 with the distributing mechanism, wherein the housing and chisel shaft cooperate
7 to define a front chamber that decreases in volume as the chisel moves forward
8 relative to the housing, and wherein the chisel shaft has a radial passage therein
9 that conducts compressed fluid from the radial port of the inlet tube to the front
10 chamber, which is configured to form an air spring.

1 **“PNEUMATIC GROUND PIERCING TOOL”**

2

3

TECHNICAL FIELD

4 The invention relates to pneumatic ground piercing tools, and in particular,
5 to a moveable chisel head assembly for pneumatic impact tool.

6

7

BACKGROUND OF THE INVENTION

8 Pneumatic impact ground piercing tools have been commercially useful
9 products for decades. Self-propelled pneumatic ground piercing tools are used
10 to install pipelines, power lines and information transmission cables such as fiber
11 optics installed beneath the ground with a minimal amount of surface disruption.
12 These tools include, as general components, a torpedo-shaped body having a
13 tapered nose and an open rear end, an air supply hose that enters the rear of
14 the tool and connects it to an air compressor, a piston or striker disposed for
15 reciprocal movement within the tool, and an air distributing mechanism for
16 causing the striker to move rapidly back and forth.

17 In the case of hard or rocky ground, it is often desirable to utilize
18 pneumatic ground tools that incorporate movable bits or chisels at the tapered
19 nose section of the tool to concentrate the striking force. For example, U.S.
20 Patent No. 6,273,201 to Randa et al., issued August 14, 2001, discloses a
21 reciprocating (front) head mole with a moveable chisel head that is axially
22 independent of the remainder of the mole. Randa et al. facilitates transfer of
23 striker energy directly to the leading end of the mole thereby improving
24 productivity in hard ground.

1 In many cases, impact moles are started from pits dug in the earth. The
2 mole is launched when the air valve supplying the mole with compressed air is
3 opened, actuating the striker to begin impacting. The front end of the mole is
4 forced against the sidewall of the launch pit until the mole penetrates the earth
5 far enough so that sufficient friction force is produced between the mole body
6 and the soil to hold the mole in position against the pneumatic reaction forces
7 generated as the striker reciprocates.

8 Launching larger diameter pneumatic impact tools, for example in the
9 range of 4" diameter, tend to be considerably more difficult to start than smaller
10 tools with diameters in the range of 2". As the striker impacts the chisel and
11 then the anvil, it generates a reaction force that first tends to move the movable
12 head or chisel of the tool forward, then pull the tool body along behind. The
13 striker then moves rearwardly in preparation for the next stroke. The difficulty
14 arises as the striker reverses its direction and move forward for the next impact
15 under the action of compressed air in the rear pressure chamber. The reaction
16 force from this operation tends to move the tool body rearwardly. During normal
17 operation when the mole is fully engaged in a borehole, friction between the
18 surface of the tool body and the surrounding soil absorbs this reaction force,
19 allowing the tool to make net forward progress through the ground. However,
20 when the mole is first launched and only the head is engaged by the soil, the
21 reaction forces generated by reciprocation of the striker can cause the movable
22 head to lose engagement with the soil and requires the operator to manually
23 apply an opposing force until the mole has penetrated the earth far enough so
24 that friction between the mole and the soil holds the mole body in place. In soft

1 soil, the friction between the mole body and the soil may not be sufficient to hold
2 the mole in place, making start-up unusually difficult.

3 Most prior movable chisel-type ground piercing tools have used a metal
4 spring or springs to bias the chisel in a rearward direction to return the chisel to
5 its starting position after being impacted by the striker and partially absorb
6 reaction forces during the forward stroke of the striker that would otherwise tend
7 to make the tool body to move backward, especially during startup. For
8 example, U.S. Patent No. 5, 095,998 to Hesse et al., issued March 17, 1992,
9 discloses such an arrangement. However, the use of springs in this application
10 raises issues of durability and design. Pneumatic impact moles normally operate
11 at a relatively high impact frequency, typically in the range of 250 to 600 impacts
12 per minute. Assuming an average travel rate of 1 foot/minute and 300 foot of
13 boring per day, an impact mole may be subjected to 50 million impacts per year.
14 Under these conditions, a spring is subject to fatigue fractures.

15

16

1 **BRIEF DESCRIPTION OF THE DRAWINGS**

2 For a more complete understanding of the features and advantages of the
3 present invention, reference is now made to the detailed description of the
4 invention along with the accompanying figures in which corresponding numerals
5 in the different figures refer to corresponding parts, and in which:

6 Figure 1 is a longitudinal sectional view of a pneumatic ground piercing
7 tool according to the invention showing the position of the striker at the moment
8 it contacts the chisel shaft;

9 Figure 2 is a longitudinal sectional view of the pneumatic ground piercing
10 tool of Figure 1 showing the orientation of the chisel and striker after the striker
11 has impacted the chisel shaft;

12 Figure 3 is a longitudinal sectional view of the pneumatic ground piercing
13 tool of Figure 1 illustrating the position of the striker upon completion of the
14 impact stroke;

15 Figure 3A is an enlarged portion of Figure 3 illustrating seals between the
16 striker of the ground piercing tool and a fluid supply tube passing through a bore
17 in the striker;

18 Figures 4-6 are partial, enlarged sectional views corresponding to Figures
19 1-3, respectively, wherein the forward section of the tool is illustrated in greater
20 detail; Figure 7 is a sectional view of a pneumatic ground piercing tool according
21 to the invention with a shortened air inlet tube;

22 Figure 8 is a cross sectional view of the striker of Figures 1-3 taken along
23 line A-A' of Figure 1;

24 Figure 9 is a lengthwise sectional view of a further embodiment of the
25 invention with vent passages; and

1 Figure 10 is a lengthwise sectional view of another embodiment of the
2 invention using a valve in place of a air supply tube.

3

4 DETAILED DESCRIPTION OF THE INVENTION

5 While the making and using of various embodiments of the present
6 invention are discussed in detail below, it should be appreciated that the present
7 invention provides many applicable inventive concepts which can be embodied
8 in a wide variety of specific contexts. The specific embodiments discussed
9 herein are merely illustrative of specific ways to make and use the invention and
10 are not to delimit the scope of the invention.

11 According to the invention, a moveable bit pneumatic ground tool is
12 provided with a variable volume forward chamber that is pressurized with a fluid
13 such as compressed air to form an air spring. The air spring offsets a substantial
14 fraction of the reaction force generated when the striker of the tool is accelerated
15 during the forward stroke of the striker. Reducing the reaction force in this
16 manner substantially reduces the amount of force that must be applied by the
17 operator as the tool is launched and reduces the tendency of the bit to break
18 lose from the surrounding soil and/or to move backwards in the borehole.

19 Referring now to FIGS. 1 - 4, a pneumatic ground piercing tool 10 having
20 a movable chisel assembly according to the invention includes an air distributing
21 mechanism 12 for reciprocating a striker 14 disposed within elongated tubular
22 tool housing 16. Air distributing mechanism 12 includes a reversing mechanism
23 actuated by rotating the air supply hose in a manner known in the art. A
24 preferred air distributing mechanism for use in the present invention are
25 exemplified in U.S. Pat. No. 5,603,383, February 18, 1997, Compressed air is

1 supplied through a hose 11 to air distributing mechanism 12, which causes
2 striker 14 to reciprocate within housing 16.

3 Housing 16 is cylindrical and is swaged or machined to a reduced
4 diameter nose 20 at its forward end. However, the anvil may instead be
5 threadedly secured in a threaded front opening of the housing, eliminating
6 reduced diameter nose 20 and use of a swaging process to produce it. Striker
7 14 slides within housing 16 to deliver forward impacts to a movable chisel shaft
8 18 and to an anvil 22 press-fitted into the forward end of housing 16. Anvil 22 is
9 preferably a steel tube that fits closely within the front end opening of housing
10 16; however, "anvil" as used herein also refers to the corresponding portion of a
11 one piece tool body, or a separate piece that is threadedly secured into the
12 housing as described above. A frustoconical front end portion 26 of anvil 22
13 thereof has an outer surface that engages a like-shaped inner surface of nose 20
14 of housing 16 to retain anvil 22 in housing 16.

15 Referring now to Figure 4, anvil 22 includes a central bore 28 with a large
16 diameter forwardly opening section 30, intermediate tapered transition 31 and a
17 small diameter rearwardly opening section 32. A tubular bushing 34 includes a
18 threaded end portion 38 that is screwed into threads on the inside surface of
19 large diameter forward section 30 of bore 28 to secure bushing 34 in place. A
20 round jamb nut 40 is threaded onto end portion 38 of bushing 34 forward of anvil
21 22. Jamb nut 40 has four blind holes 41 on its side set 90 degrees apart that
22 permit use of a spanner to tighten nut 40 against the front face of anvil 22.
23 Clamp loading produced by tightening nut 40 prevents the threaded engagement
24 between bushing 34 and bore 28 of anvil 22 from loosening during tool use. The

1 head assembly can be removed by first loosening jamb nut 40 and then
2 unscrewing bushing 34 from bore 28.

3 Chisel shaft 18 is slidably mounted in tubular bushing 34 with a small
4 diameter rear end 36 of the chisel shaft extending through the small diameter
5 rearwardly opening section 32 of bore 28. Chisel shaft 18 is slidable in bushing
6 34 between the position shown in Figure 4 where the rear end 36 of the shaft
7 protrudes through anvil 22 and the position shown in Figure 5 where rear end 36
8 is inside the anvil. Chisel shaft 18 includes a forward threaded end 42, a central
9 body portion 44 that passes through bushing 34 and an enlarged diameter
10 sealing shoulder 46. Enlarged diameter sealing shoulder 46 is rearwardly
11 tapered to small diameter rear end 36 of shaft 18 so as to match the inside
12 profile of bore 28. A seal bearing 48 extends around the outer circumference of
13 shoulder 46 to provide a gas tight seal between shoulder 46 and the inside wall
14 of bore 28. Similar seal bearings 49 are disposed between rear end 36 of bit
15 shaft 18 and the small diameter section 32 of bore 28, and between central body
16 portion 44 and bushing 34.

17 As illustrated, a stepped chisel head 50 is mounted on the forward
18 threaded end 42 of chisel shaft 18. Chisel head 50 includes an annular wall 53
19 that forms an axially extending central opening 52. A smaller diameter hole 54
20 extending forwardly from central opening 52 includes interior threads for
21 securing chisel head 50 onto threaded end 42 of chisel shaft 18. Opening 52 is
22 sized to receive the forward end 56 of bushing 34 and a seal 58 extending
23 around the circumference of forward end 56 of bushing 34 provides a gas tight
24 seal between bushing 34 and the inside wall of central opening 52.

1 As best illustrated in Figure 3, a fluid supply tube 60 extends from a
2 central bore 62 formed in chisel shaft 18 into a coaxially extending bore 66 that
3 passes through striker 14 to a variable volume rear striker chamber 64. Bore 66
4 is configured to allow striker 18 to slide over tube 60 as striker 18 reciprocates.
5 A seal 70 prevents leakage between tube 60 and bore 66. Supply tube 60 is
6 preferably formed from a resilient plastic material and is secured in chisel shaft
7 18 by means of a suitable adhesive and/or by molding the tube to the contour of
8 bore 62.

9 Referring to Figures 4-6, supply tube 60 is formed with radially extending
10 ports 72 that communicate with an annular space 74 between the supply tube
11 and the inside wall of bore 62. One or more second ports 76 extend from
12 annular space 74 through chisel shaft 18, opening into an annular variable
13 volume forward chamber 78 formed between anvil 22, chisel shaft 18 and
14 bushing 34. Tube 60 along with radial port 72, annular space 74 and second
15 port 76 form a fluid conduit or passage from rear striker chamber 64 to forward
16 chamber 78, allowing the chamber to be pressurized with compressed air from
17 the rear striker chamber.

18 Referring to Figures 1-3, when tool 10 is launched, air distributing
19 mechanism 12 supplies compressed air to rear striker chamber 64, accelerating
20 the striker forward (left to right). The force accelerating striker 14 to the left
21 simultaneously accelerates tool housing 16 to the right. During launch, the
22 operator must compensate for this force by holding the tool against the wall of
23 the launch pit. Figures 1 and 4 show tool 10 at the instant when striker 14
24 contacts rear end 36 of chisel shaft 18.

1 Figure 2 illustrates the position of chisel head 50 and chisel shaft 18 after
2 striker 14 has impacted chisel shaft 18. Shaft 18 and chisel head 50 have been
3 driven forward by striker 14 until the rear end 36 of shaft 18 is completely within
4 bore 28 of anvil 22. The forward movement of chisel shaft 18 relative to anvil 22
5 and tool housing 16 opens gap 80 between chisel head 50 and jamb nut 40.
6 Striker 14 then impacts anvil 22, driving tool housing 16 to the left and closing
7 gap 80. Simultaneously, air distributing mechanism 12 reverses the flow of
8 compressed air from rear striker chamber 64 to forward striker chamber 82,
9 accelerating striker 14 from right to left.

10 As striker 14 is accelerated from right to left, a corresponding reaction
11 force accelerates tool housing 16 from left to right, tending to drive housing 16
12 out of the borehole. As striker 14 moves from left to right, air distributing
13 mechanism 12 vents forward striker chamber 82 (Figure 3) to atmosphere,
14 stopping the rearward motion of the striker at the position shown in Figure 3 at
15 which time the cycle is repeated.

16 Referring again to Figure 1, if during the forward stroke of striker 14, the
17 operator is unable to compensate for the reaction force accelerating the tool
18 housing 16 to the right as striker 14 is accelerated to the left, housing 16 will
19 move to the right, opening gap 80 (as illustrated in Figure 5) between chisel
20 head 50 and jamb nut 40. If gap 80 opens to the maximum possible width,
21 bushing 34 impacts shoulder 46 of chisel shaft 18 in the manner of a slide
22 hammer, causing undesirable effects. Chisel head 50 and possibly housing 16
23 may break free of the frictional forces holding the chisel head and housing in the
24 bore before striker 14 impacts chisel shaft 18. If the frictional forces holding
25 chisel 50 in the borehole are overcome, chisel head 50 may be pulled rearwards

1 from the borehole (right to left), undoing the work accomplished during the
2 previous cycle of striker 14.

3 Tool 10 of the invention reduces the likelihood of these undesirable
4 effects by compensating in part for magnitude of the reaction force with an air
5 spring. The gas spring in forward chamber 78 is created when the chamber is
6 pressurized through tube 60. In order for gap 80 to open as striker 14 is
7 accelerated forward, bushing 34 must move toward shoulder 46 of chisel shaft
8 18, overcoming the pressure in forward chamber 78 as the volume of the
9 chamber is reduced. The force required to overcome the pressure in forward
10 chamber 78 substantially offsets the reaction force accelerating tool housing 16,
11 reducing the amount of force that must be applied by the operator.

12 For example, in the case of one tool having a body diameter of 2.2 inches
13 and a piston (striker) diameter of 1.614 inches, the reaction force generated
14 when the striker 14 is accelerated is calculated to be 155 lbs, assuming a
15 compressed air pressure of 100 psig. The calculated force to overcome the
16 pressure in forward chamber 78 is 83 lbs., resulting in a net force of 72 lbs
17 required to hold tool housing 16 in place as striker 14 is accelerated from left to
18 right during the forward stroke of the striker. Thus, the operator of tool need
19 only compensate for 72 lbs of force rather than 155 lbs. The effect is magnified
20 in the case of larger diameter ground piercing tools. Further, the reduction in the
21 amount of force required to compensate for the reaction force is accomplished
22 without the use of a metallic spring, alleviating the breakage and design
23 problems associated therewith.

24 Turning to Figure 7, in an alternate embodiment, a ground piercing tool
25 100, is in all respects substantially identical to tool 10 of Figure 1, with the

1 exception of supply tube 102. As illustrated, supply tube 102 extends only
2 partially into chisel shaft 18, eliminating the need for radially extending ports 72.

3 Figure 9 is a further alternative embodiment of the invention wherein a
4 ground piercing tool 110 is substantially identical to tool 10 of Figure 1, except
5 that a special vent passage has been added. As the seals of the tool begin to
6 leak, the effectiveness of the air spring is diminished due to pressure in the
7 space behind shoulder 46 that counteracts the pressure in chamber 78. Vent
8 passages 111-113 are provided behind enlarged diameter shoulder 46 of bit
9 shaft 18 to ensure that the pressure on the back side of this piston remains very
10 low. Passage 111 extends radially through anvil 22 from the surface of tapered
11 transition 31 to open onto one or more outwardly opening, frontwardly extending
12 grooves 112 on the outside of anvil 22. The ends of these grooves 112
13 communicate with an annular gap 113 between jamb nut 40 and housing 16.
14 Gap 113 is open to the atmosphere.

15 Maintaining low pressure on the back side of the shoulder 46 ensures that
16 the pressure supplied to the front side of shoulder 46 applies the maximum
17 amount of force in the rearward direction (to reset the bit shaft). This aspect of
18 the invention can also be used in connection with known designs that use a coil
19 spring (U.S. Patent No. 5,095,998 cited above) rather than the air spring
20 described herein.

21 Figure 10 illustrates a further embodiment of the invention wherein tube
22 60 and related structures are omitted entirely. Instead, a central valve 121 is
23 biased against a seat 122 by a relatively large, durable spring 123. Valve 121 is
24 mounted in central bore 124 of bit shaft 126, sealing chamber 78. During the
25 portion of the cycle in which the front pressure chamber ahead of striker 14 is

1 pressurized, such pressure pushes back valve 121 a short distance, slightly
2 compressing spring 123 and opening the passages leading to chamber 78.
3 Chamber 78 then remains pressurized during the exhaust stage of the cycle
4 because valve 121 closes under the action of spring 123 when the pressure
5 ahead of striker 14 drops. This embodiment avoids the need to provide an air
6 supply tube and thus may have better durability than the previous embodiments.

7 While certain embodiments of the invention have been illustrated for the
8 purposes of this disclosure, numerous changes in the method and apparatus of
9 the invention presented herein may be made by those skilled in the art, such
10 changes being embodied within the scope and spirit of the present invention as
11 defined in the appended claims.

12

1 CLAIMS:

2

3 1. A ground piercing tool, comprising

4 an elongated tubular tool housing, including a front anvil having a
5 lengthwise bore therein;6 a striker disposed for reciprocation within an internal chamber of the
7 housing to impart impacts to an impact surface of the anvil for driving the tool
8 forwardly through the ground;9 a chisel including a front head and a rearwardly extending chisel shaft
10 slidably disposed in the bore of the anvil, which chisel is movable between a
11 rearwardmost position at which a rear end portion of the chisel shaft protrudes
12 from the bore of the anvil to receive an initial impact from the striker, and a
13 forwardmost position at which the striker impacts on a rear impact surface of the
14 anvil; and15 a distributing mechanism that reciprocates the striker in response to a
16 supply of compressed fluid, wherein the housing and chisel shaft cooperate to
17 define a front chamber that decreases in volume as the chisel moves forward
18 relative to the housing, and the distributing mechanism includes passages that
19 conduct compressed fluid to the front chamber, which front chamber is
20 configured to form a gas spring using such compressed fluid.

21

22 2. The tool of claim 1, wherein the striker further comprises a central bore
23 that communicates with the distributing mechanism for supplying the front
24 chamber with compressed fluid.

25

1 3. The tool of claim 1, wherein the chisel shaft has a longitudinally
2 extending central bore for supplying the front chamber with compressed fluid, the
3 longitudinally extending bore being coaxial with the central bore of the striker.

4

5 4. The tool of claim 3, wherein the chisel shaft further comprises a
6 passage extending radially from the longitudinally extending central bore to the
7 front chamber for supplying the front chamber with compressed fluid.

8

9 5. The tool of claim 4, further comprising a fluid supply tube extending
10 through the central bore of the striker and into the longitudinally extending
11 central bore of the chisel shaft to supply the front chamber with compressed
12 fluid.

13

14 6. The tool of claim 5, wherein the fluid tube is secured in the
15 longitudinally extending central bore of the chisel shaft.

16

17 7. The tool of claim 1, wherein the front chamber is formed between the
18 anvil and the chisel shaft.

19

20 8. The tool of claim 1, wherein the housing has a nose including a
21 reduced diameter cylindrical front end portion and a forwardly tapering portion
22 rearwardly thereof.

23

1 9. The tool of claim 8, wherein the anvil comprises an insert having a
2 frustoconical front end portion extending into the nose, the front end portion
3 being configured to match the inside profile of the nose.

4

5 10. The tool of claim 1 further comprising a forwardly extending bushing
6 secured to the anvil, the chisel shaft being slidably mounted in the bushing.

7

8 11. The tool of claim 1, wherein the chisel shaft has a radially extending
9 shoulder, such that the housing and a front surface of the shoulder of the chisel
10 shaft cooperate to define the front chamber that decreases in volume as the
11 chisel moves forward relative to the housing, and passages are formed in the
12 housing for venting a space between a rear surface of the shoulder of the chisel
13 shaft and the anvil.

14

15 12. A ground piercing tool, comprising:

16 an elongated tubular tool housing, including a front anvil having a
17 lengthwise bore therein;

18 a striker disposed for reciprocation within an internal chamber of the
19 housing to impart impacts to an impact surface of the anvil for driving the tool
20 forwardly through the ground, the striker having a lengthwise, frontwardly
21 opening central bore therein coaxial with the bore of the anvil;

22 a chisel including a front head and a rearwardly extending chisel shaft
23 slidably disposed in the bore of the anvil, which chisel is movable between a
24 rearwardmost position at which a rear end portion of the chisel shaft protrudes
25 from the bore of the anvil to receive an initial impact from the striker, and a

1 forwardmost position at which the striker impacts on a rear impact surface of the
2 anvil; and

3 a distributing mechanism that reciprocates the striker in response to a
4 supply of compressed fluid, including a fluid inlet tube mounted in the bores of
5 the anvil and striker having a radial port, a rear end of the inlet tube being in
6 communication with the distributing mechanism, wherein the housing and chisel
7 shaft cooperate to define a front chamber that decreases in volume as the chisel
8 moves forward relative to the housing, and the chisel shaft has a radial passage
9 therein that conducts compressed fluid from the radial port of the inlet tube to the
10 front chamber, which front chamber is configured to form a gas spring using
11 such compressed fluid.

12

13 13. The tool of claim 12, wherein the housing has a nose including a
14 reduced diameter cylindrical front end portion and a forwardly tapering portion
15 rearwardly thereof and wherein the anvil comprises an insert having a
16 frustoconical front end portion configured to match the inside profile of the nose.

17

18 14. The tool of claim 12, wherein the chisel shaft is supported in a
19 bushing, the bushing being threadedly engaged in the central bore of the anvil.

20

21

1 15. A ground piercing tool, comprising
2 an elongated tubular tool housing, including a front anvil having a
3 lengthwise bore therein;
4 a striker disposed for reciprocation within an internal chamber of the
5 housing to impart impacts to an impact surface of the anvil for driving the tool
6 forwardly through the ground;
7 a chisel including a front head, a chisel shaft extending rearwardly from
8 the head, which chisel shaft is slidably disposed in the bore of the anvil and is
9 movable between a rearwardmost position at which a rear end portion of the
10 chisel shaft protrudes from the bore of the anvil to receive an initial impact from
11 the striker, and a forwardmost position at which the striker impacts on a rear
12 impact surface of the anvil, and a tubular bushing in which a midportion of the
13 chisel shaft is slidably mounted, the bushing having a rearwardly extending
14 threaded external portion that is threadedly engaged with internal threads in the
15 bore of the anvil in order to secure the chisel to the anvil;
16 a jamb nut mounted on the threaded external portion of the bushing in
17 front of the anvil, which jamb nut can be tightened against the anvil to apply a
18 clamp load to the threaded connection between the bushing and the anvil; and
19 a distributing mechanism that reciprocates the striker in response to a
20 supply of compressed fluid, wherein the housing and chisel shaft cooperate to
21 define a front chamber that decreases in volume as the chisel moves forward
22 relative to the housing, and the distributing mechanism includes passages that
23 conduct compressed fluid to the front chamber, which front chamber is
24 configured to form an gas spring using such compressed fluid.

25

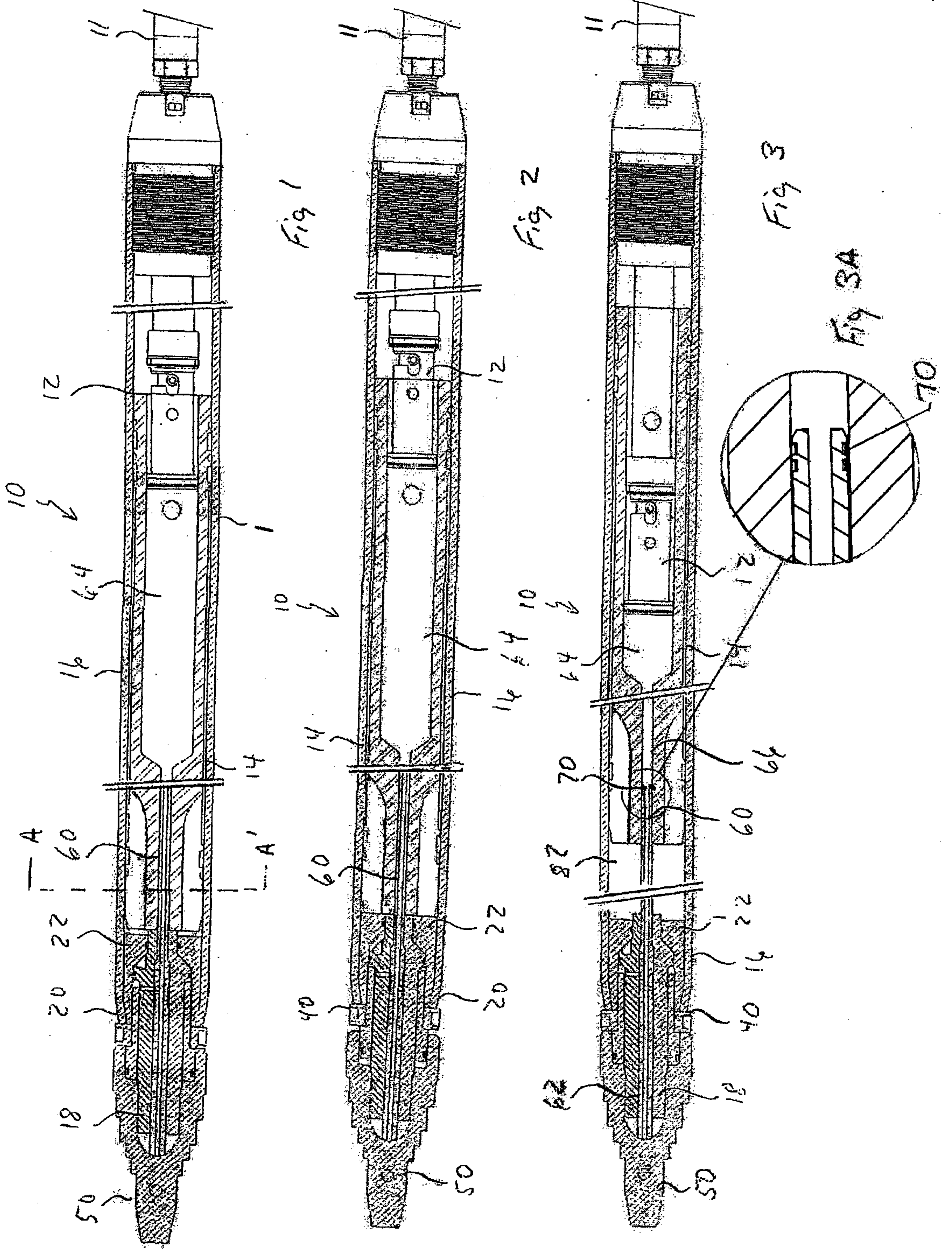
1 16. A ground piercing tool, comprising:
2 an elongated tubular tool housing, including a front anvil having a
3 lengthwise bore therein;
4 a striker disposed for reciprocation within an internal chamber of the
5 housing to impart impacts to an impact surface of the anvil for driving the tool
6 forwardly through the ground;
7 a distributing mechanism that reciprocates the striker in response to a
8 supply of compressed fluid;
9 a chisel including a front head and a rearwardly extending chisel shaft
10 slidably disposed in the bore of the anvil, which chisel is movable between a
11 rearwardmost position at which a rear end portion of the chisel shaft protrudes
12 from the bore of the anvil to receive an initial impact from the striker, and a
13 forwardmost position at which the striker impacts on a rear impact surface of the
14 anvil, wherein the chisel shaft has a radially extending shoulder, and the housing
15 and a front surface of the shoulder of the chisel shaft cooperate to define a front
16 chamber that decreases in volume as the chisel moves forward relative to the
17 housing;
18 a spring disposed in the front chamber that resists the decrease in volume
19 of the front chamber as the chisel moves forward relative to the housing; and
20 a passage in the housing for venting a space between a rear surface of
21 the shoulder of the chisel shaft and the anvil.

22

23 17. The tool of claim 15, wherein the spring is a coil spring.

24

25 18. The tool of claim 15, wherein the spring is a gas spring.



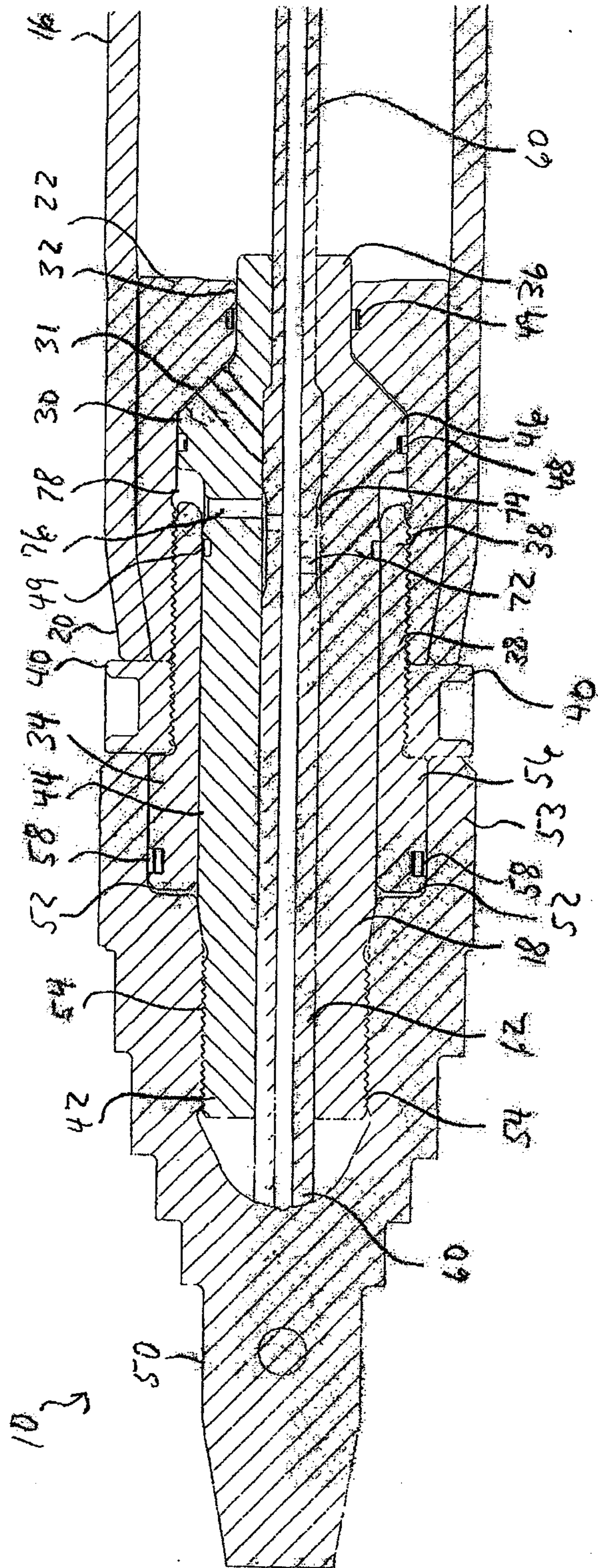


Fig 6

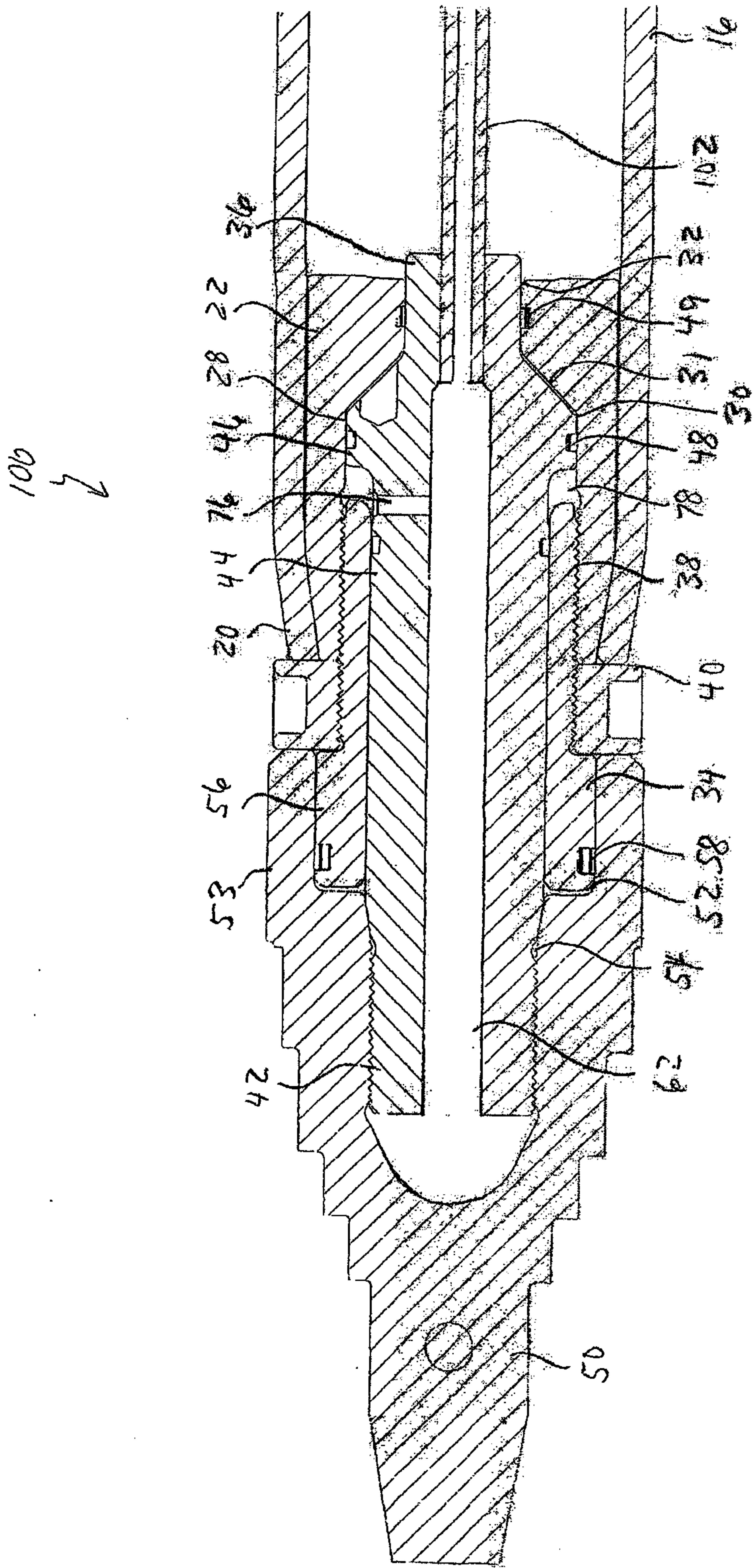


Fig. 7

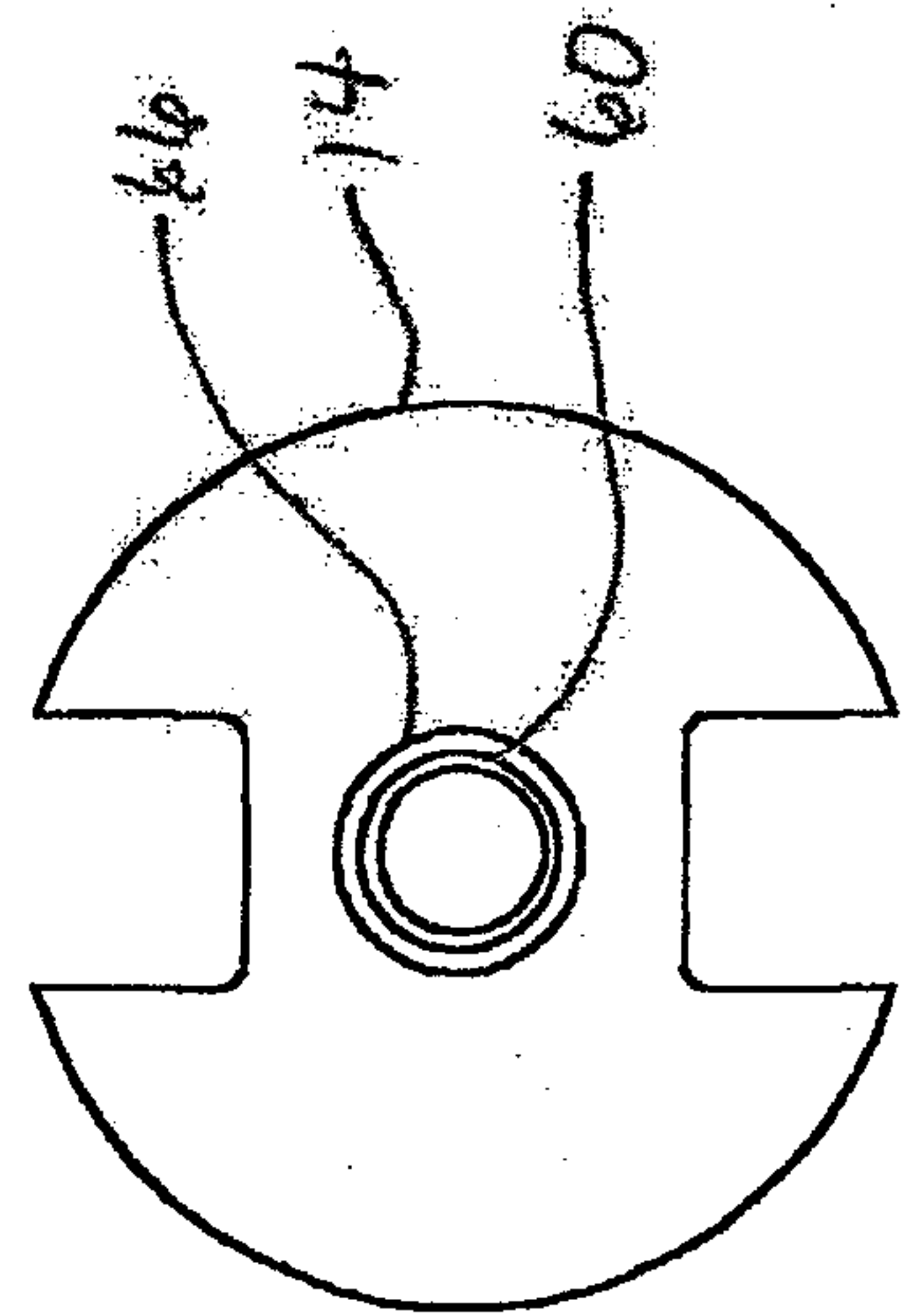


Fig. 8

