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(54) Title: FOLLICLE UNIT EXTRACTION DEVICE

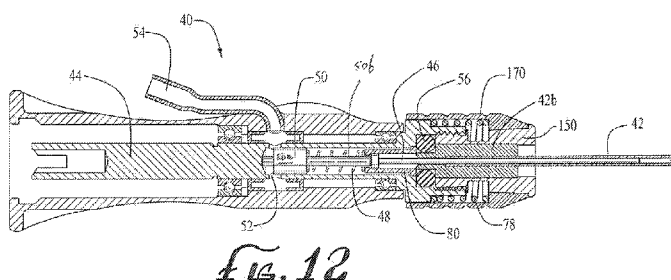


Fig. 12

(57) **Abstract:** A follicular unit extraction device comprises a handpiece for holding a follicle punch at its distal end which extends from the handpiece and terminates distally in a cutting edge. The punch is releasably coupled to a motor-driven drive shaft within the handpiece for rotation therewith. A portion of the driveshaft is tubular, and houses a piston that can move towards and away from the punch. An ejector pin is also supported within the tubular portion of the driveshaft distally of the ejector piston and is positioned to move towards the cutting edge of the punch when pushed by the piston. The handpiece and driveshaft have respective fluid inlet ports. The clearance between the piston and driveshaft interior, and the clearance between the ejector pin and punch interior, define a fluid path for conducting fluid entering the handpiece and drive shaft via inlet ports so that the fluid exits the punch at its cutting edge. The clearances limit the quantity of fluid exiting the punch to the small amount needed to protect the follicle to be extracted. Means are provided for selectively increasing the flow rate of the fluid entering the handpiece beyond the limit imposed by said clearances to thereby increase the fluid pressure within the driveshaft, moving the piston distally and, consequently, moving the pin towards the cutting edge of the punch to eject impacted graft or debris. Bias means returns the piston proximally when the flow rate is reduced below the level required to overcome the bias means.

## 1 Follicle Unit Extraction Device

### 2 Background of the Invention

3 Follicular Unit Extraction ("FUE") is a surgical hair transplantation technique that  
4 involves moving skin containing hair follicles from one part of the body (the donor site) to bald  
5 or balding parts (the recipient site). Hair naturally grows in follicles that contain groupings of 1  
6 to 4 hairs, and the transplant technique typically moves the 1–4 hair "follicular units" from the  
7 donor site to the recipient site.

8 The follicle units (sometimes referred to as "grafts") are typically removed from the  
9 donor site using punches of between 0.7mm and 1.25mm in diameter. The punches are typically  
10 tubular bodies having a skin-contacting cutting edge, and are typically mounted in a hand-held  
11 electric-powered tool that causes the punch to rotate or oscillate as the cutting device is brought  
12 into contact with the donor site, but are sometimes used manually.

13 Hair follicles are very easily broken during the removal, and broken follicles are unlikely  
14 to be successfully transplanted. One of the major causes of low yield in FUE is attributable to  
15 desiccation forces imparted on the graft following its dissection from its tissue investiture; more  
16 specifically, as it is pulled from the donor site, and as it is placed in a physiological holding  
17 solution such as normal saline, ringer's lactate, etc. for subsequent transplantation at the  
18 recipient site.

19 One known FUE device even uses a suction mechanism to suck out the graft  
20 immediately following desiccation and propel it pneumatically through a tube into a collection  
21 canister that contains a physiological medium. The sucked graft is subjected to traumatic forces  
22 as it is funneled at high force and velocity out of the donor site and through the narrow tube,  
23 banging against the tube wall as it is propelled to the canister. Additionally, sucking and pulling  
24 the graft as it is cut from the donor site creates a risk of transection from the combined vectors of  
25 pulling and rotating as the rotating cutting device creates a like rotation in the graft being  
26 extracted while it is tethered to the surrounding tissue at the donor site. Moreover, the suction  
27 effect strips the graft of some of its protective tissue investiture, further diminishing its  
28 protection from damaging desiccating factors as well as trauma.

### 29 Summary of Description

30 An FUE device constructed in accordance with the invention is directed to the  
31 elimination of, or at least a substantial reduction in, the desiccation forces to which extracted

follicle units are subjected during the extraction process to thereby increase the yield of successfully transplantable follicles harvested from the donor site. The FUE device comprises a handpiece configured to securely hold a follicle punch, and utilizes fluid irrigation and a pumping mechanism whereby fluid is delivered to the cutting edge of the punch during the cutting and extraction of the follicle unit. In its preferred embodiment, the fluid is delivered through the punch's lumen. As an additional feature, the fluid is selectively delivered in greater quantity through the punch lumen to clear impacted follicles and/or debris from the punch

The fluid can be carried to the cutting edge in any of a number of ways. For example, it can be delivered through the lumen of the punch and directed outwardly towards the cutting edge at the skin-contacting end of the punch or delivered to the punch via a conducting path external to the punch.

Any of a number of fluids can be used, including physiologic or other solutions, and may also be a fluid that may or may not have been proven to prolong or sustain graft or tissue viability.

In addition, the handpiece is preferably configured to cause punch rotation during at least the cutting phase of the extraction process.

#### The Drawing

Figure 1 is a sketch of a front elevation view in schematic illustrating the skin-contacting edge of a follicle punch to which fluid is being delivered in accordance with the invention;

Figures 2A and 2B are sketches of front elevation views in schematic illustrating an intact graft impacted within the lumen of a follicle punch, and being ejected into a receptacle in accordance with the invention;

Figure 3 is a sketch in schematic of an FUE system constructed in accordance with the invention;

Figure 4 is a side view of a an FUE handpiece constructed in accordance with the invention;

Figure 5 is a longitudinal sectional view of the handpiece and follicle punch in the orientation shown in Figure 4.

Figure 6 is a perspective view of a follicle punch assembly constructed in accordance with the invention;

Figure 7 is a front left perspective view of the drive socket 58 illustrated in Figure 5;

Figure 8 is an enlarged view of the chuck sleeve 70 illustrated in section in Figure 5;

Figure 9 is a longitudinal sectional view of the driveshaft 44 shown in Figure 5;

Figure 10 is a front right perspective view of the ejector piston 50 illustrated in Figure 5;

Figure 11 is a right front perspective view of the piston guide 80 illustrated in Figure 5.

Figure 12 is a longitudinal sectional view of an alternative embodiment of a handpiece constructed in accordance with the invention and in the orientation shown in Figure 4;

Figure 13 is an enlarged view of the preferred chuck sleeve used in connection with the embodiment of Figure 12;

Figure 14 is a side view of the collet 150 illustrated in Figure 12;

Figure 15 is a side view of the preferred ejection pin 46 illustrated in Figures 5, 12 and 16; and

Figure 16 is an explosion view of the currently preferred embodiment of a handpiece constructed in accordance with the invention.

For visual clarity, like reference numerals have been used throughout the Figures to denote corresponding components, although some corresponding components may have described or illustrated modifications.

#### Detailed Description of Preferred Embodiment

One embodiment of the FUE device maintains a continuous drip of variable rate that creates and sustains a fluid film around the partially or completely separated graft to protect the exposed tissue around the graft from ambient desiccation factors, including air. These desiccating factors contribute to low viability of the grafts during the period between its dissection from the surrounding tissue at the donor site and its placement in the physiological medium. Further, the fluid in the punch lumen, serves as a lubricant that reduces the friction between the graft and the internal wall of the punch thereby reducing the twisting of the upper

1 portion of the follicle which has been partially or wholly dislodged from its surrounding tissue  
2 attachments. This serves to further reduce the transection rate.

3 The delivered fluid also creates a moist skin surface around the targeted follicle,  
4 presenting a smoother surface against which the cutting end portion of the punch glides for a  
5 cleaner cut than a dry surface as well as a reduction in friction-generated shearing force by the  
6 rotating punch on the follicle.

7 In addition, the reduced friction experienced by the cutting edge of the punch results in a  
8 lesser dulling effect on the cutting edge and a consequential increase in the life of the punch.

9 The flow rate of the fluid can be controlled automatically via a digit or analog control  
10 circuit, by computer control and/or or by a manually rotated dial or slider or button mechanism  
11 located either in the handpiece of the rotary tool or in a control box near the patient, or by foot  
12 control. The flow rate can be controlled by wired or by wireless communication/control  
13 technology. The handpiece may or may not be autoclavable by heat or immersion, either in  
14 whole or in parts.

15 As illustrated by way of example in Figure 1, fluid droplets 12 exiting from the region of  
16 a punch 10 near the cutting edge have formed a fluid film 14 around a follicle unit 16 at a donor  
17 site.

18 A variation of the foregoing embodiment employs a fluid conduit external to the punch  
19 to direct the fluid to the cutting edge.

20 A second variation of the FUE device provides an additional pulsed application of the  
21 fluid through the lumen of the punch at a sufficiently high pressure to push out any graft or  
22 tissue debris, enabling the graft or tissue debris to be ejected into a receptacle. This services  
23 several purposes. First, it addresses the current need to interrupt the dissection and removal  
24 procedure at the donor site to clean out the punch's lumen when the lumen becomes impacted  
25 with debris. The application of pulsed fluid through the lumen reduces and minimizes the  
26 interruption. The term "pulsed" includes, within its scope, one or more pulses of predetermined  
27 or user-determined length which raise the pressure sufficiently to push out the graft or debris.

28 Second, an intact graft that gets completely separated from its surrounding tissue by the  
29 punch may be impacted within the lumen of the punch close to the cutting tip. When this occurs,  
30 work must conventionally be interrupted in order to manually extract and salvage the impacted  
31 graft and continue the work. Again, the application of pulsed fluid through the lumen to eject

1 the impacted graft reduces and minimizes the interruption of the procedure and provides a means  
2 for salvaging the graft with minimal chance of desiccation while saving a considerable amount  
3 of time.

4 Figure 2 illustrates an example of the foregoing. An impacted graft 20 (Fig. 2A) within a  
5 punch 22 is subjected to a pressurized fluid 24 variation, and is expelled (Fig. 2B) into a  
6 container 26 of physiological fluid.

7 A third variation, which is the currently preferred configuration, is exemplified in  
8 Figures 4 and 5, and utilizes a mechanical component to push out any graft or tissue debris. The  
9 illustrated and currently preferred mechanical component includes a pin 46, described  
10 hereinafter in more detail.

11 The fluid reservoir from which the delivered fluid is taken may be remote from the  
12 device and located separately in a drip stand, for example, as shown in Figure 3 at 30, or it may  
13 be integral with the control box 34 (if one is used) or some other part of the device.

14 The hardware by which the fluid is pumped towards the cutting edge may include an  
15 electro-mechanical pump, a gravity system or a manual or other mechanical pump without  
16 departing from the intended scope of the invention. The hardware can be controlled manually  
17 or be computer-controlled.

18 Figure 3 illustrates an example of the foregoing. Physiological fluid is delivered from a  
19 bag 30 to a follicle punch 32 via a rate controller 34. The punch 32 is held by a handpiece 36  
20 that is provided with a pump-controlling button 38 by which the fluid can be caused to pulse at a  
21 pressure sufficient to dislodge the impacted follicle and/or debris.

22 Figure 4 is a side view of a preferred FUE handpiece 40 constructed in accordance with  
23 the invention wherein the preferred mechanical component is utilized to clear the follicle punch  
24 of impacted follicles and/or debris, and Figure 5 is a sectional view of the handpiece in the  
25 orientation shown in Figure 4. The preferred handpiece 40 comprises a generally cylindrical  
26 body, with an ergonomically contoured exterior, extending along a generally central axis 41.  
27 The handpiece holds a follicle punch 42 that is coupled to a motor-driven driveshaft 44 within  
28 the handpiece for rotation about axis 41. An ejector pin 46 is positioned within the handpiece  
29 for axial movement within the follicle punch to eject an impacted graft from the punch's interior.  
30 To eject the impacted graft, the ejector pin is urged forward axially into the punch. In the  
31 illustrated embodiment, the ejector pin 46 is urged forward axially into the punch, against the  
32 force of a return spring 48, by an ejector piston 50 in response to a build-up of fluid pressure

1 behind the piston. The fluid is introduced behind the piston through ports 52 within the  
2 handpiece. As described in greater detail below, the fluid is preferably an irrigation liquid, such  
3 as a suitable sterile saline solution that is also applied to the donor site by the handpiece.  
4 Accordingly, the preferred liquid is introduced into the handpiece via an inlet conduit 54 that is,  
5 in turn, fluidically coupled to the content of a container of irrigation fluid (not illustrated).

6 It will be understood that the ejector pin can alternatively be moved mechanically,  
7 electrically or magnetically instead of hydraulically. For example, the pin can be mechanically  
8 linked to a slider mechanism or other contact surface that is manually actuated by the user. The  
9 pin can thereby be manually moved forward or both forward, or can be mechanically urged  
10 forward against a return spring or other biasing means so that the rod moves away from the  
11 cutting end upon the user's release of the slider mechanism or other contact surface.  
12 Alternatively, the pin can be linked to the slider mechanism (or other contact surface)  
13 magnetically rather than mechanically.

14 The piston 50 and the pin 46 may be integrally formed as a single piece, but this is not  
15 preferred. The pin 46 is very thin (e.g., 0.025 inches (0.635 mm) in diameter) and delicate.  
16 When the punch is removed from the handpiece to be changed, an integrated pin would extend  
17 from the handpiece without substantial support and could easily be bent. If bent, the pin will not  
18 move freely within the punch, if at all. Even if not bent, the extending pin would require the  
19 new punch to be carefully mounted to the handpiece to avoid damaging the rod, making its  
20 attachment to the handpiece more difficult. By maintaining the pin separate from the piston, the  
21 pin can be removed from the handpiece with the punch, and place within the new punch just  
22 prior to its mounting to the handpiece, permitting the punches to protect the integrity of the rod.  
23 As used herein, the term "piston" will accordingly include the portion of the integrated  
24 component functioning as the piston, and the terms "rod" and "ejection rod" will include the  
25 portion of the integrated component functioning as the pin unless the context of the usage clearly  
26 denotes otherwise.

27 Figure 6 is a perspective view of the preferred follicle punch assembly illustrated in  
28 Figure 5. It comprises a generally tubular follicle punch 42 having a cutting edge 42a and a  
29 coupling block 42b. The coupling block can be formed integral with the punch, but it is  
30 preferred that that it be pressed-fit or welded onto the punch. The coupling block is provided  
31 with an exterior shape that, as will be seen, is securely engaged by the handpiece for rotation .  
32 In the illustrated embodiment, and as best shown in Figure 6, the coupling block is an elongated  
33 tubular body of generally square cross-section, and is beveled at diagonally opposite corners 42c

1 (of which one such corner is hidden in the view of Figure 6) to provide the desired engagement.  
2 Many other possible shapes will be apparent to those of ordinary skill in the art.

3 The rear portion, or nub, 42d of the follicle punch assembly is generally cylindrical, and  
4 is preferably manufactured as part of the block. As illustrated in Figure 5, the rear portion 42d  
5 fits within a sealing ring 56 in the handpiece, while the coupling block 42b is engaged within a  
6 driver socket 58. The preferred driver socket 58 in this embodiment is illustrated more clearly in  
7 Figure 7, and is a generally tubular component having a threaded rear end portion 58a, a front  
8 portion 58b of relatively larger outside diameter, an axially-extending through-hole 58c and a  
9 pair of radially-extending holes 58d formed in its mid-portion therebetween. The axially-  
10 extending through-hole 58c is shaped to firmly engage the coupling block 42b when the punch  
11 assembly is mounted within the driver socket 58; accordingly, the preferred cross-section of the  
12 illustrated through-hole is square and sized to securely engage the coupling block.

13 As illustrated in Figure 5, the threaded end 58a of the driver socket 58 mates with the  
14 internally-threaded end region 44b of the drive shaft 44, shown more clearly in Figure 9. As  
15 also illustrated in Figure 5, two steel balls 60 nest within the radially-extending holes 58d of the  
16 drive socket (Figure 7) and are pressed into releasable engagement with the beveled surfaces 42c  
17 of the coupling block 42b (Fig. 6) as described below to function as a detente. Preferably, the  
18 balls extend over the corners on opposite flat sides to keep the block 42b in.

19 The balls 60 are pressed into the holes 58d by a radially-protruding inner shoulder 72 of  
20 a chuck sleeve 70 (Figs. 4-5, 8). The chuck sleeve can be slid axially rearward against a spring  
21 78 to disengage the balls from the shoulder 72 and thereby permit removal of the follicle punch  
22 assembly 42 from the handpiece as the balls slide or roll along the beveled corners 42c (Fig. 6)  
23 of the punch assembly. Preferably, the balls slide along the flats. The spring 78 is captured  
24 between the inner shoulder 72, at region 76, and a radially outwardly-projecting shoulder 44a of  
25 the driveshaft 44 (best seen in Figure 9). The spring 78 is compressed as the chuck sleeve 70 is  
26 slid axially rearward, and returns the sleeve to the punch-securing position illustrated in Figure 5  
27 when released by the user.

28 An alternative punch-engaging structure is illustrated in Figures 12 and 13, which are  
29 respectively similar to Figures 5 and 8, and in Figure 14 which illustrates the component  
30 corresponding to that in Figure 7. In this alternative, a collet arrangement is used to secure the  
31 punch within the handpiece. Accordingly, one or both of the inter-engaging surfaces of the  
32 driver socket 150 and sleeve 170 are provided with a taper, with the driver socket being formed  
33 as a collet. Accordingly, the OD of the illustrated driver socket's interengaging region 150b and

1 the ID of the illustrated sleeve are dimensioned so the collet expands slightly as the sleeve 170 is  
2 slide rearwardly (i.e., away from the cutting end of the illustrated punch 42), releasing its grip on  
3 the punch. Conversely, a punch can be inserted into the driver socket 150 while the sleeve is in  
4 its rearward position, and the collet of the driver socket will be compressed radially inwardly by  
5 the ID of the sleeve as the spring 78 urges the sleeve forward upon the user's release of the  
6 sleeve. Those of ordinary skill in the art will recognize that other interengaging surface  
7 configurations can be used and are within the scope of the invention.

8 As described earlier with respect to Figure 5, the ejector pin 46 is positioned within the  
9 handpiece for axial movement within the follicle punch to eject an impacted follicle unit from  
10 the punch's interior. To eject the impacted follicle unit, the ejector pin is urged axially forward  
11 into the punch, against the force of a return spring 48, by an ejector piston 50, best illustrated in  
12 Figure 10. As illustrated in Figure 10, the preferred piston comprises a generally cylindrical  
13 piston head 50a and a forwardly-extending rod portion 50b of comparatively smaller diameter.  
14 As illustrated in Figure 5, the rod portion sized to move axially forward within a piston guide 80  
15 to push an impacted follicle unit out of the cutting end of the punch with the pin 42. An  
16 approximately 0.060 inch protrusion on the backside of the piston keeps the back side of the  
17 piston at least half way exposed to inlet conduit 54 through the inlet hole 52 to speed the  
18 operation of the piston; the volume behind the piston can thereby fill more rapidly than if it had  
19 to fill through the clearance around the piston.

20 The ejector piston 50, in its preferred form, is a total of 0.615 inches (15.621 mm) in  
21 length, including the 0.060 inch (15.24 mm) long rearward-extending nub, a head that is 0.180  
22 inches (4.572 mm) long and a rod that is 0.375 inches (9.525 mm) long. Preferably, the nub  
23 diameter is 0.048 inches (1.2192 mm), the head diameter is 0.139 inches (3.5306 mm), and the  
24 rod diameter is 0.048 inches (1.2192 mm). A small clearance between the outer diameter of the  
25 rod and the internal diameter of the piston guide 80 (e.g., 0.002-0.003 inches (0.0508-0.0762  
26 mm)) provides a clearance through which irrigation liquid can be delivered to the cutting edge of  
27 the punch during operation, as described below. As shown in Figure 5, the piston rod 50b  
28 extends into one end of a generally tubular piston guide 80 (illustrated more clearly in Figure  
29 11), where it engages the rearward end of the ejector pin 46 as it is urged forwardly. The  
30 forward end portion of the piston guide preferably has an enlarged outer diameter in sealing  
31 contact with a seal 56.

32 A return spring 48 (Figure 5) is captured between the rearward-facing end 80a of the  
33 piston guide 80 (Figure 11) and the head 50a of the ejector piston 50 (Figure 10) so that it is

1 compressed as the piston moves the ejector pin 46 forwardly to eject an impacted follicular unit,  
2 and thereby returns the piston to its initial position once the hydraulic pressure behind the piston  
3 is sufficiently reduced via operator control or automatically after a period of time has elapsed  
4 since the beginning of the pulse if preferred by the equipment designer.

5 Figure 15 is a side elevation view of the preferred ejector pin 46. The proximal end of  
6 the pin 46 had a head 46a of larger cross-section than the pin. The head has one or more flats  
7 that enable fluid to pass more easily around the head and flow through the piston guide 80 and  
8 into the punch. The head 46a further serves to provide a contact surface for the piston rod 50b  
9 (Figure 10) and to limit the depth within the punch to which the ejector pin 46 can extend.

10 Because the preferred ejector pin 46 is not integral with the ejector piston 50, the reader  
11 will note that the return of the piston 50 to its initial position does not in itself return the pin 46.  
12 However, the distal end of the pin 46 has a head 46a of larger outer diameter than the internal  
13 diameter of the punch 42, limiting the depth to which the pin can extend into the punch. The  
14 length of the pin is dimensioned so that it cannot extend through the last millimeter or two  
15 nearest the cutting edge of the punch. Accordingly, the pin will not interfere with the gathering  
16 of hair follicle, even when the head 46a is in contact with the proximal end of the punch.  
17 Impacted grafts and debris, on the other hand, will push the freely moving pin 46 proximally,  
18 thereby moving the head 46a away from the proximal end of the punch and permitting the piston  
19 to urge the pin distally to eject the impacted graft and/or debris.

20 Figure 16 is an explosion view of the preferred embodiment further illustrating the  
21 preferred relative positioning and configurations of the various elements of the invention. In the  
22 embodiment illustrated in Figure 16, a further modification is shown in that the coupling block  
23 42b associated with the punch 42 has a substantially cylindrical exterior that is secured by the  
24 collet 150. The coupling block continues to have a greater outer dimension than the remainder  
25 of the punch body. The generally cylindrical exterior of the coupling block may result in less  
26 "wobble" as the punch rotates owing to slight differences that can occur when manufacturing  
27 coupling block having exterior of other shapes.

28 Figure 16 also illustrates the placement of other preferred components used in  
29 assembling the preferred handpiece: snap ring 202, ball bearings 204, 210, seal backup spacer  
30 206, and Teflon seals 208a,b.

31 In preferred operation, an electric motor causes the driveshaft 44 to rotate about axis 41  
32 (Figure 4) so that the driver socket coupling block and punch rotate about that axis as well.

1 Irrigation fluid is introduced via inlet 54 by means of a pump that may conveniently be driven  
2 by the shaft-rotating motor or a separate motor. The irrigation liquid enters the handpiece via  
3 the irrigation ports 52, and leaks past the piston head 50a into the piston guide 80, nub 42d (Fig.  
4 6), and punch 42 to irrigate the donor site. The leakage rate preferably provides about 1 tiny  
5 drop of irrigation fluid per second.

6 If a follicle unit becomes impacted within the punch, the pump speed is increased by  
7 operator-actuated means such as an operator-actuated foot pedal or handpiece button to create a  
8 flow rate in excess of the leakage rate, and a consequential build-up of hydraulic pressure on the  
9 rearward surface of the piston 50, urging it forward against return spring 48 to thereby clear the  
10 punch with the forwardly moving ejector pin 46.

11 Thus, the preferred configuration provides a pump that runs very slowly during the  
12 follicle extraction process to provide irrigation wherein the irrigating liquid leaks around the  
13 piston and out through the center of the punch, with the return spring 48 keeping the piston back,  
14 while for plug removal from the punch, the pump is run at or near full speed, overcoming the  
15 leakage and forcing the piston forward.

16 Other methods for increasing the pressure against the piston, either hydraulically,  
17 mechanically or electrically, can be utilized as well, and will be obvious to those of ordinary  
18 skill although the preferred embodiment uses the fluid used that is also used to irrigate the donor  
19 site during the follicle extraction procedure.

20 All components of the preferred handpiece are formed from stainless steel, except for the  
21 sealing rings which are formed from by a silicone rubber o-ring and Teflon shaft seals, so that  
22 the handpiece is preferably autoclavable. Accordingly, the irrigation fluid is safely delivered to  
23 the donor site and risk is minimized with respect to infection to the patient from bacteria that  
24 could be transferred to the punch and/or donor site from a non-sterile handpiece.

25 Although a liquid fluid is the preferred medium for ejecting the impacted grafts and/ or  
26 debris from the punch lumen, air, gas, vapor or other medium may be used, and is within the  
27 scope of the invention.

28 The connection of the device to the punch might take any form, including but not limited  
29 to fluid and/or air sealed formats to facilitate the efficient delivery of liquid, vapor, air, or other  
30 gas from the device to and through the lumen of the punch and/or the punch's cutting edge.

1           It will also be understood that that the handpiece may be held and manually manipulated  
2 by a human operator or by a machine operating under human or microprocessor control, and that  
3 the term “handpiece” as used herein does not connote or denote the need for it to necessarily be  
4 grasped by a human hand.

5           Although a preferred punch, and variations thereof, were used in illustrating the  
6 functions of the embodiment, the use of any cutting device that has a lumen and a cutting end  
7 could be used without departing from the spirit of the invention.

8           Although a preferred embodiment of the present invention and its advantages have been  
9 described in detail above, it should be understood that various details, changes, substitutions and  
10 alterations will be apparent to those of ordinary skill in the art having the benefit of the  
11 foregoing specification. It is intended that all such variations be within the scope and spirit of  
12 the invention, and that the invention be solely defined by appended claims that shall be given the  
13 broadest allowable interpretation consistent with the Doctrine of Equivalents.

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15           We claim:  
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1           1. A handpiece for follicular unit extraction comprising:  
2           a handpiece body extending along a generally central axis for holding a follicle punch  
3           having a cutting edge;  
4           a motor-driven driveshaft mounted within the handpiece body for rotation about the axis  
5           for rotating the follicular punch when said punch is held by the handpiece; and  
6           a fluid path carried by the handpiece for conducting a liquid from a source external to  
7           the handpiece into the lumen of the follicle punch held by the handpiece for delivery of the fluid  
8           to the cutting edge of the follicle punch.

9

10           2. The handpiece of Claim 1 including

11           an ejector pin positioned within the handpiece for axial movement from a retracted  
12           position to a deployed position within the follicle punch when the punch is held by the  
13           handpiece so as to eject an impacted graft or debris from the punch's interior; and

14           operator-controlled means for moving the pin axially between the retracted and deployed  
15           positions.

16

17           3. The handpiece of Claim 2 wherein

18           the ejector pin is positioned within the fluid path for axial movement towards the cutting  
19           edge in response fluid pressure within the fluid path to clear the interior of a punch held by the  
20           handpiece, and

21           the handpiece includes a return spring positioned to oppose said axial movement by the  
22           ejector pin, and exhibiting a force that substantially prevents such movement until said fluid  
23           pressure exceeds a threshold value.

24

25           4. The handpiece of Claim including:

26           an ejector piston positioned in the fluid path and having a distal end portion for moving  
27           the ejector pin from said retracted position to said deployed position, and further having a

1 proximal face positioned upstream in said fluid path from said distal end portion and configured  
2 to be responsive to the force of flowing fluid in said fluid path, and

3 a biasing component for preventing movement of the ejector piston when the force of the  
4 flowing fluid is less than an activating level.

5  
6 5. The handpiece of Claim 4 further including a follicle punch having a generally  
7 tubular body defined between an inner wall and an outer wall, said follicle punch being  
8 removably secured within the handpiece body in substantial axial alignment with said ejector pin  
9 to permit the ejector pin to move axially within the punch between said retracted position and  
10 said deployed position.

11  
12 6. The handpiece of Claim 5 wherein the handpiece body includes an inlet port, and the  
13 fluid path within the handpiece is defined by a path that extends from the inlet port, around the  
14 ejector piston and through the path defined by the inner wall of the punch and ejector pin, with  
15 the fluid exiting from the punch at its cutting end.

16  
17 7. The handpiece of Claim 6 wherein the fluid path is dimensioned to limit the  
18 volumetric rate of fluid exiting from the cutting end of the punch.

19  
20 8. The handpiece of Claim 2 including  
21 a generally tubular follicle punch removably secured within the handpiece body in  
22 substantial axial alignment with said ejector pin and positioned to permit the ejector pin to move  
23 axially within the punch between said retracted position and said deployed position.

24  
25 9. The handpiece of Claim 8 wherein the follicle punch includes a cutting edge at its  
26 distal end region and a coupling block region proximal to the distal end region, the coupling  
27 block region having one or more larger outside dimension than the corresponding one or more  
28 outside dimensions of the punch at its distal end.

1

2           10. The handpiece of Claim 9 wherein the coupling block includes a nub at its proximal  
3 end.

4

5           11. The handpiece of Claim 10 further including a sealing ring sealingly circumventing  
6 the nub.

7

8           12. A generally tubular follicle punch having proximal and distal ends, a cutting edge at  
9 its distal end, and a coupling block region proximal to its distal end, the coupling block region  
10 having a larger outside dimension in at least one direction than the outside dimension of the  
11 punch at its distal end and in that same direction.

12

13           13. The follicle punch of Claim 12 wherein the coupling block region and the punch  
14 are each generally cylindrical and the coupling block region has an outside diameter greater than  
15 the outside diameter of the punch.

16

17           14. The follicle punch of Claim 13 wherein the coupling block includes a nub at its  
18 proximal end.

19

20           15. The follicle punch of Claim 12 wherein the follicle punch comprises a first generally  
21 tubular body having an interior passageway for accommodating an extracted hair follicle, and  
22 a second body of larger exterior dimension than the first body in at least one dimension  
23 and having a through-hole in which a region of the first body proximally displaced from the  
24 cutting edge is securely held.

25

26

27

1           16. A follicular unit extraction tool comprising:

2           a generally tubular handpiece body extending between proximal and distal ends for  
3 holding in its distal end region a follicle punch having a cutting edge, said handpiece body  
4 having a first inlet port for coupling the interior of the handpiece to a source of fluid;

5           a generally tubular follicle punch removably secured within the distal end region of the  
6 handpiece and extending distally therefrom along an axis, said punch terminating in a cutting  
7 edge at its distal end;

8           a motor-driven driveshaft mounted within the handpiece body for rotation about the axis  
9 for rotating the follicular punch, the driveshaft having a generally tubular distal portion and a  
10 second inlet port extending between the exterior and interior of said tubular portion for  
11 conducting fluid entering the handpiece into the interior of the driveshaft;

12           an ejector piston positioned within the tubular portion of the drive shaft distally of the  
13 second inlet port, and axially movable between a relatively proximal retracted position and a  
14 relatively distal deployed position;

15           an ejector pin supported within the tubular portion of the driveshaft distally of the ejector  
16 piston and positioned to move axially within the punch distally towards and proximally away  
17 from a distal deployed position;

18           the clearance between the ejector piston and driveshaft interior, and the clearance  
19 between the ejector pin and punch interior, defining a fluid path for conducting fluid entering the  
20 handpiece and drive shaft via the first and second inlet ports so that the fluid exits the punch at  
21 its cutting edge,

22           the clearance between the ejector piston and driveshaft interior, and the clearance  
23 between the ejector pin and punch interior, limiting the quantity of fluid exiting the punch;

24           bias means for retaining the piston at its proximal position unless the pressure of the fluid  
25 entering the driveshaft exceeds a threshold value,

26           the piston thereby responding to fluid pressure in excess of the threshold value by  
27 moving distally to contact the pin and urge the pin axially to its deployed position within the  
28 punch to clear the punch interior of impacted matter,

29           the piston thereby returning to its proximal position when the fluid pressure within the  
30 driveshaft falls below the threshold value, and

1 means for selectively increasing the fluid pressure within the driveshaft by increasing the  
2 entry rate of fluid entering the first inlet port beyond the limit imposed by said clearances.

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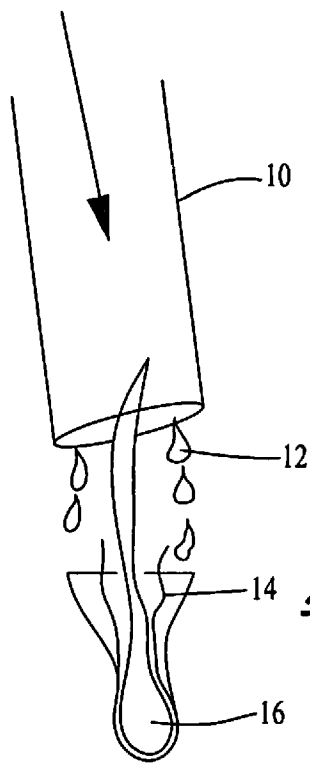


*Fig. 1*

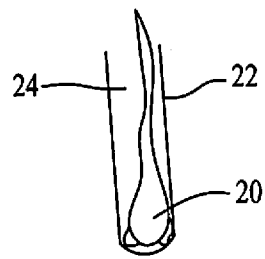


*Fig. 2A*

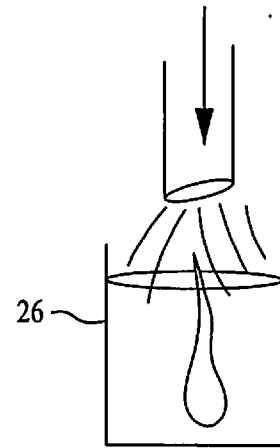


*Fig. 2B*

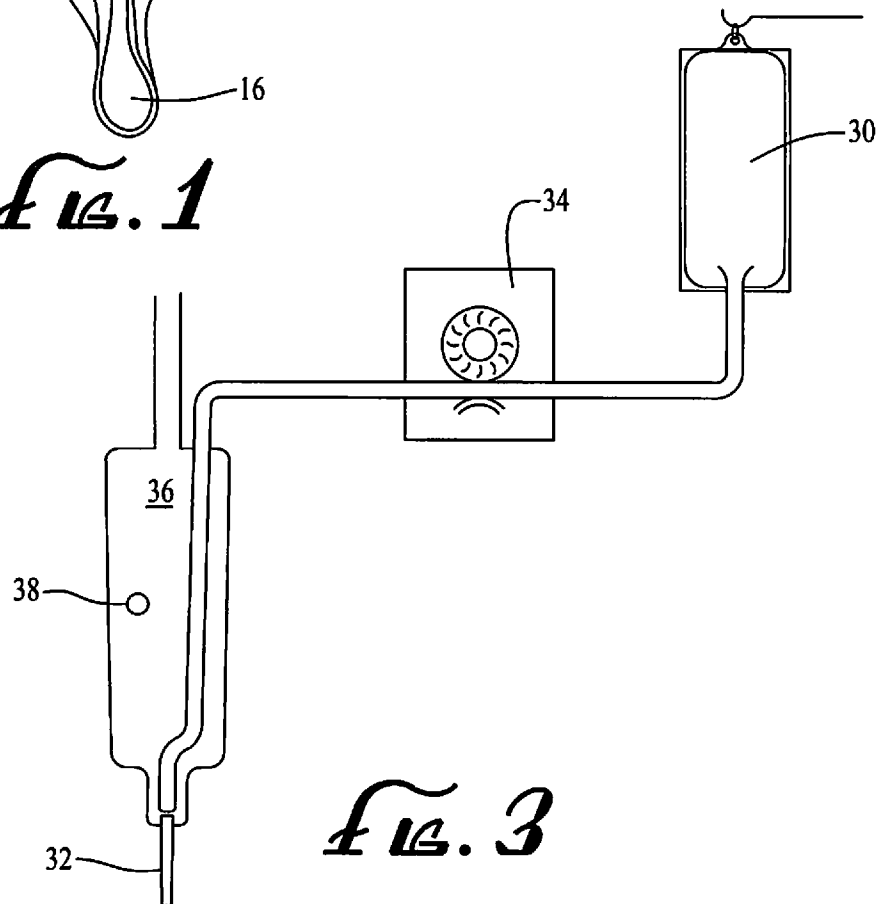


*Fig. 3*

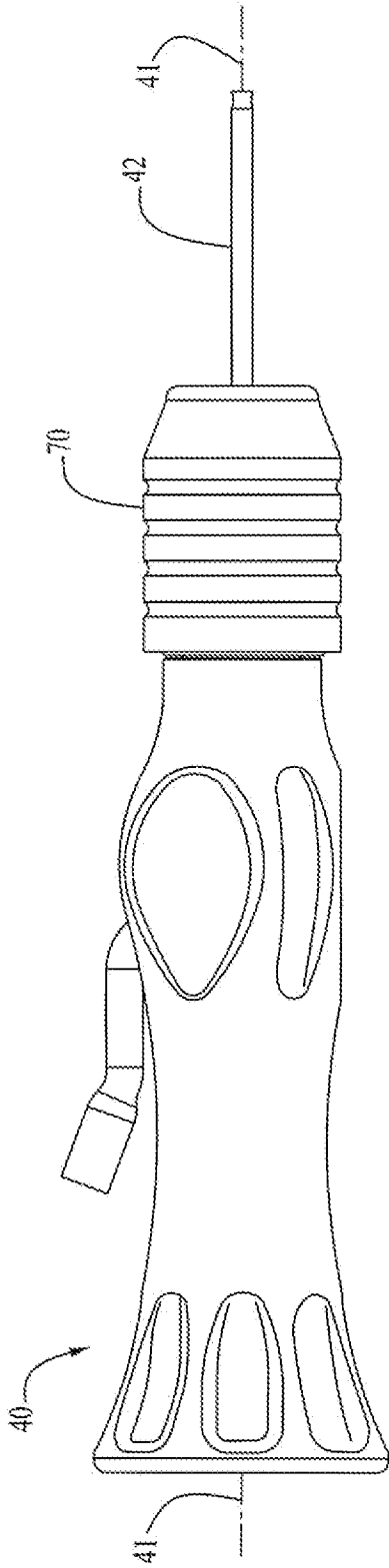


FIG. 1

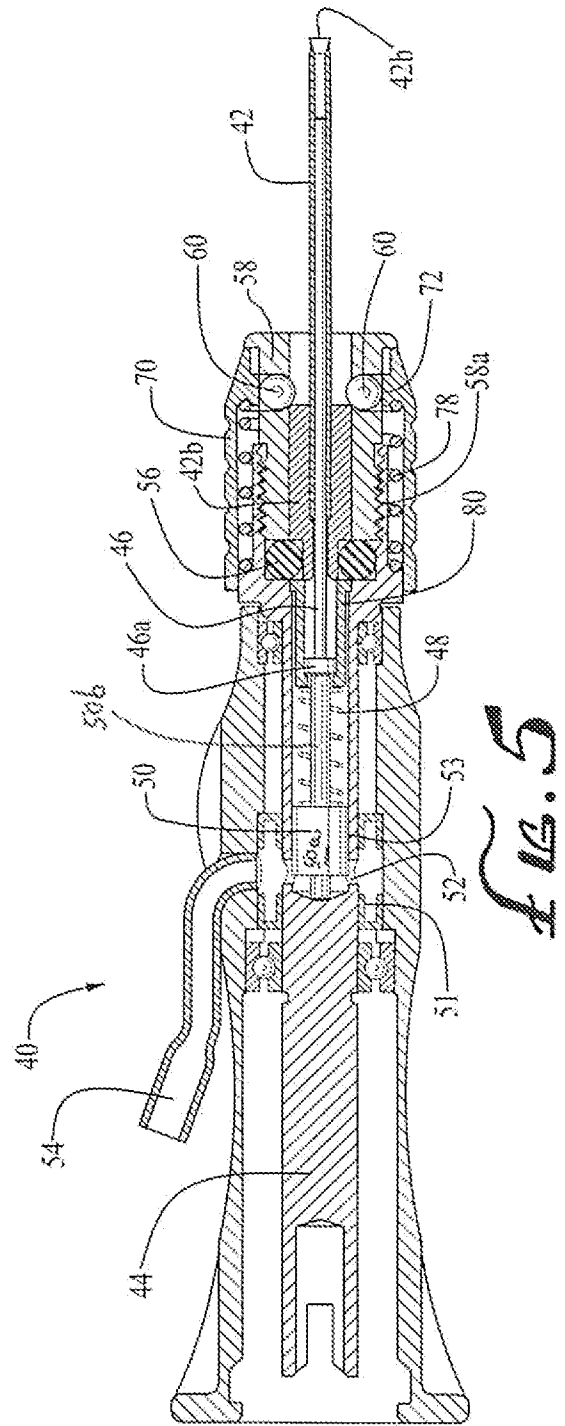


FIG. 5

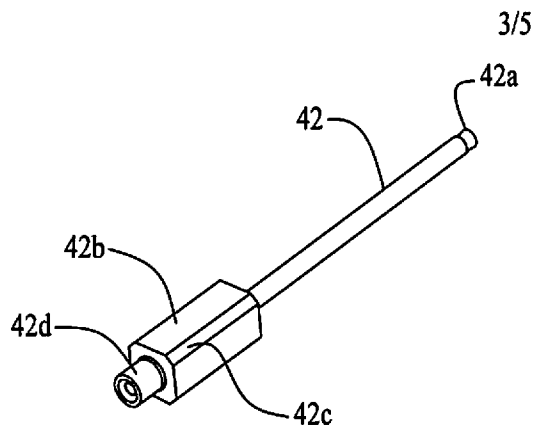


*Fig. 6*

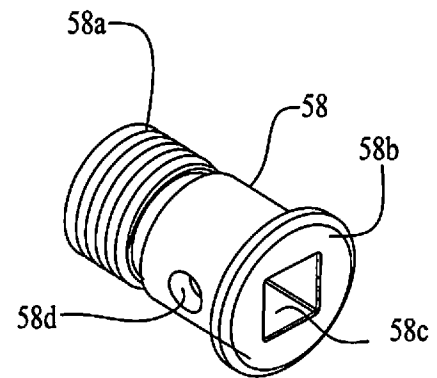


*Fig. 7*

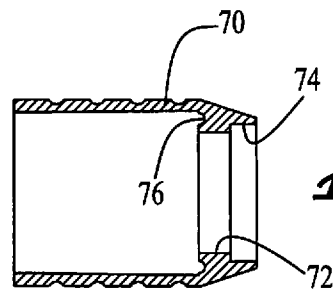


*Fig. 8*

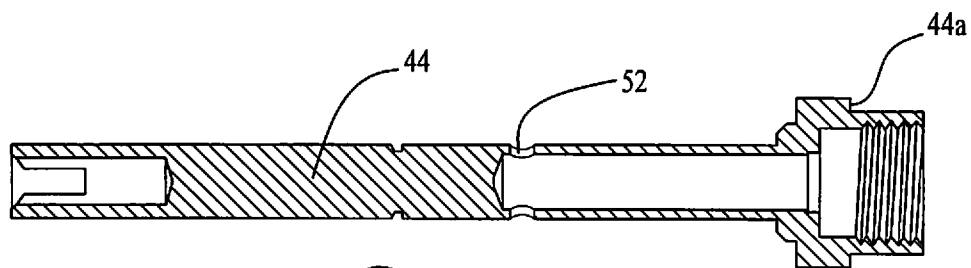


*Fig. 9*

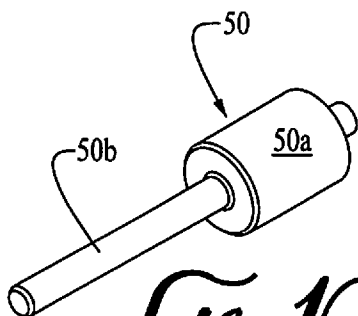


*Fig. 10*

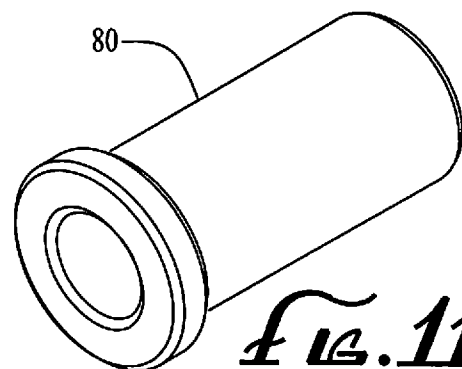


*Fig. 11*

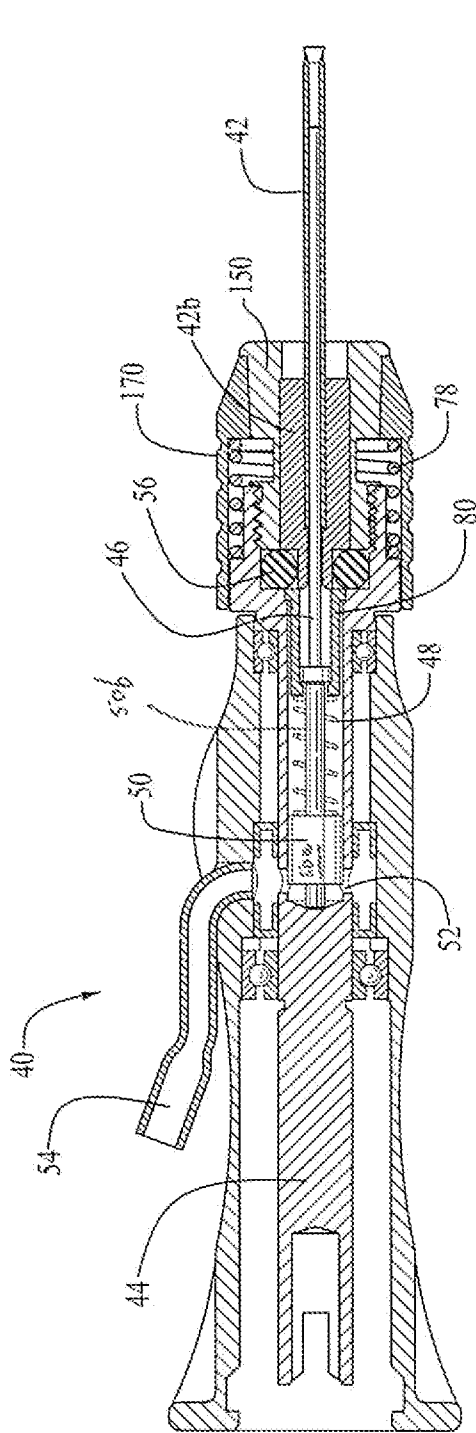


FIG. 12

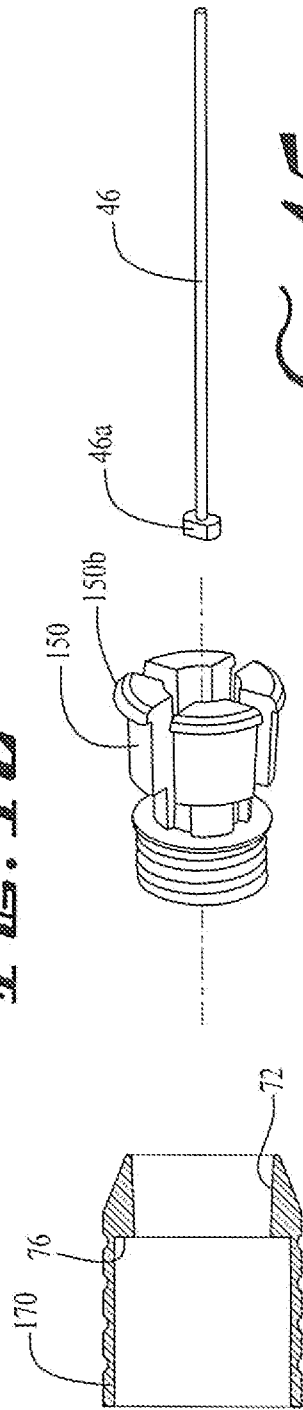


FIG. 13

FIG. 14

FIG. 15

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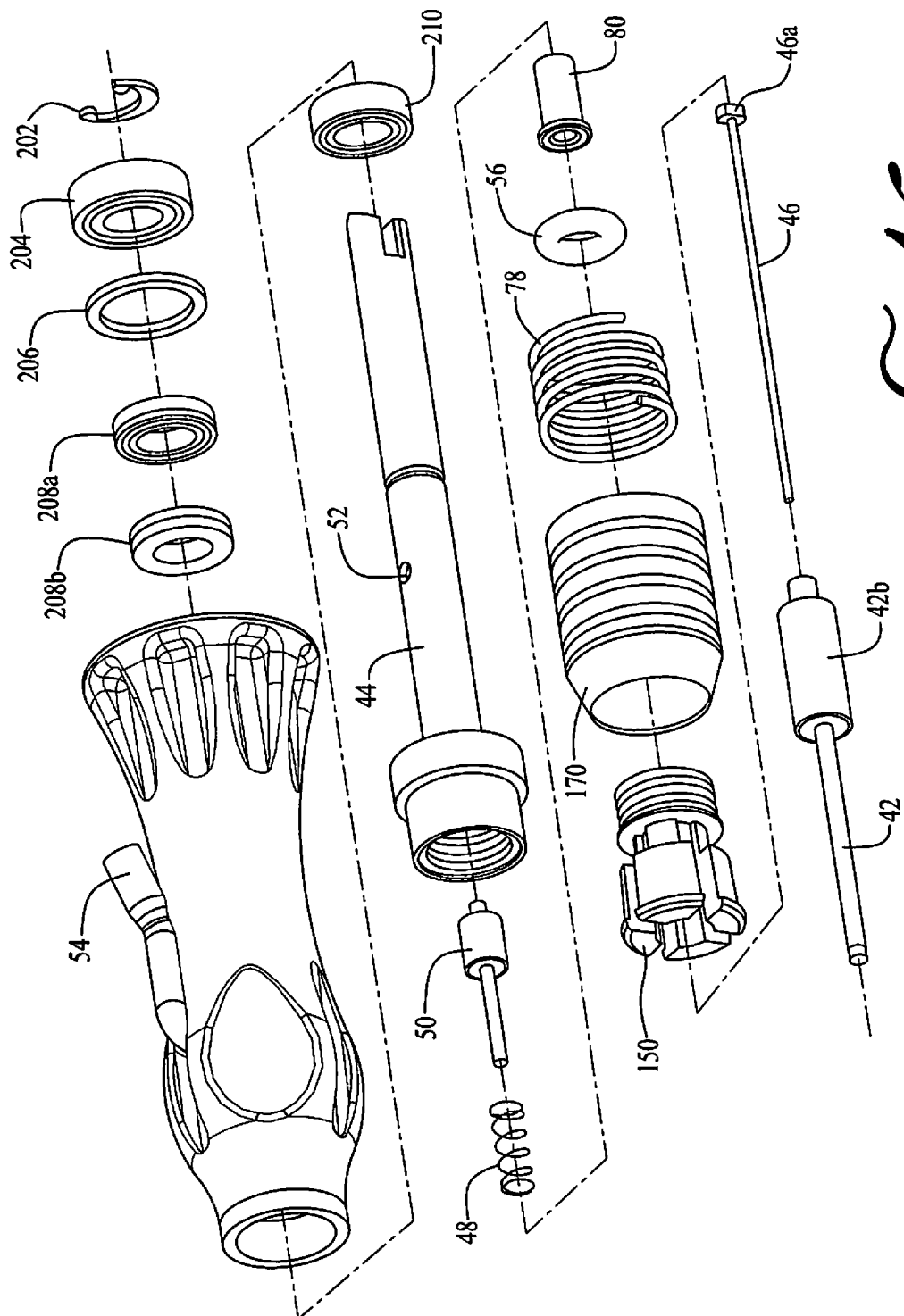


*Fig. 10*