United States Patent

Slanker et al.

[15] **3,640,280**

[45] **Feb. 8, 1972**

[54] **POWER-DRIVEN RECIPROCATING BONE SURGERY INSTRUMENT**

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[21] Appl. No.: **880,094**

[52] **U.S. Cl.** **128/317**, 30/166, 32/46, 137/81.5

[51] **Int. Cl.** **A61b 17/14**, B23d 49/16

[58] **Field of Search** .... 30/166; 128/317; 145/31 R, 145/31 B, 31 C, 31 D; 32/46, 47

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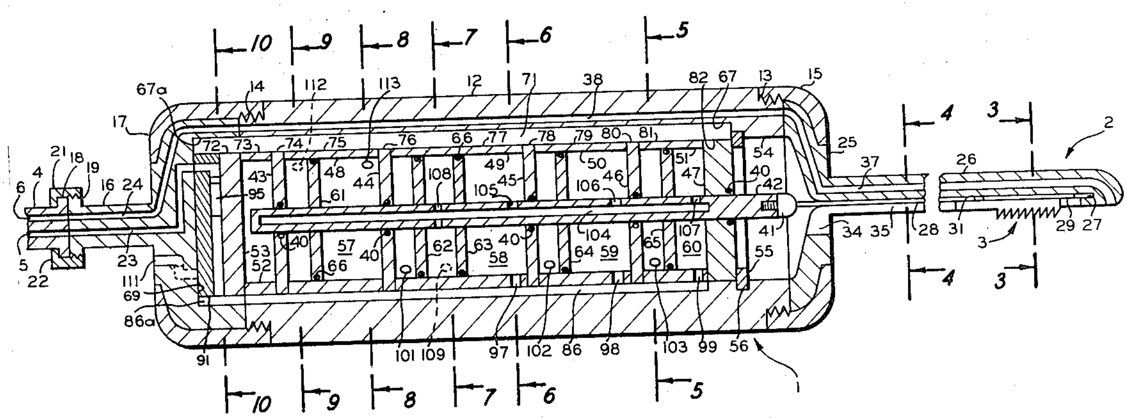
[57] **ABSTRACT**

A bone surgery tool is provided with a reciprocating drive means. The tool and a flexible drive band can be enclosed in a shroud to protect tissue against contact with the tool or the driving means. The shroud can also contain a channel for a flushing fluid. The power unit can utilize a double-acting fluid piston, with the reversal in the direction of movement of the piston being effected by a fluidic control device.

9 Claims, 18 Drawing Figures



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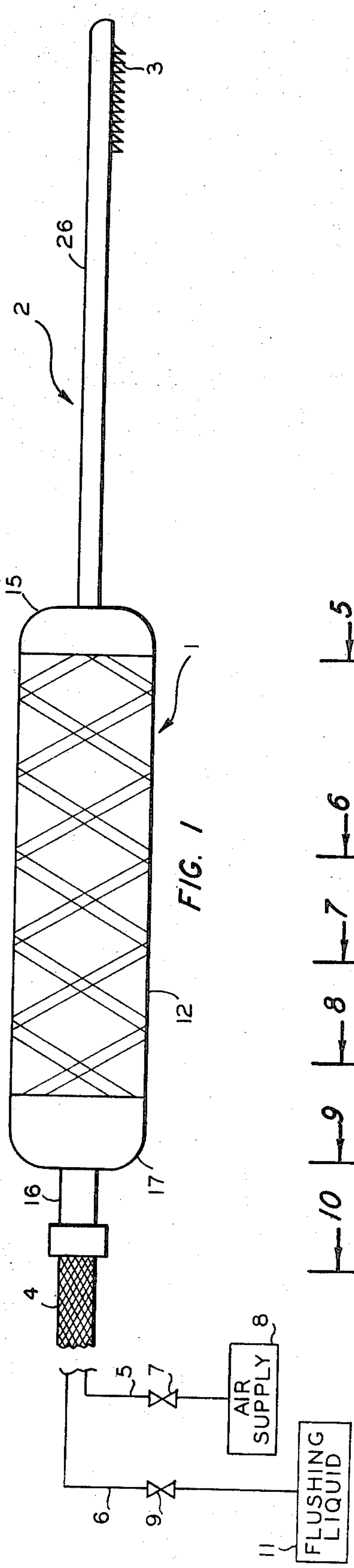

FIG. 1

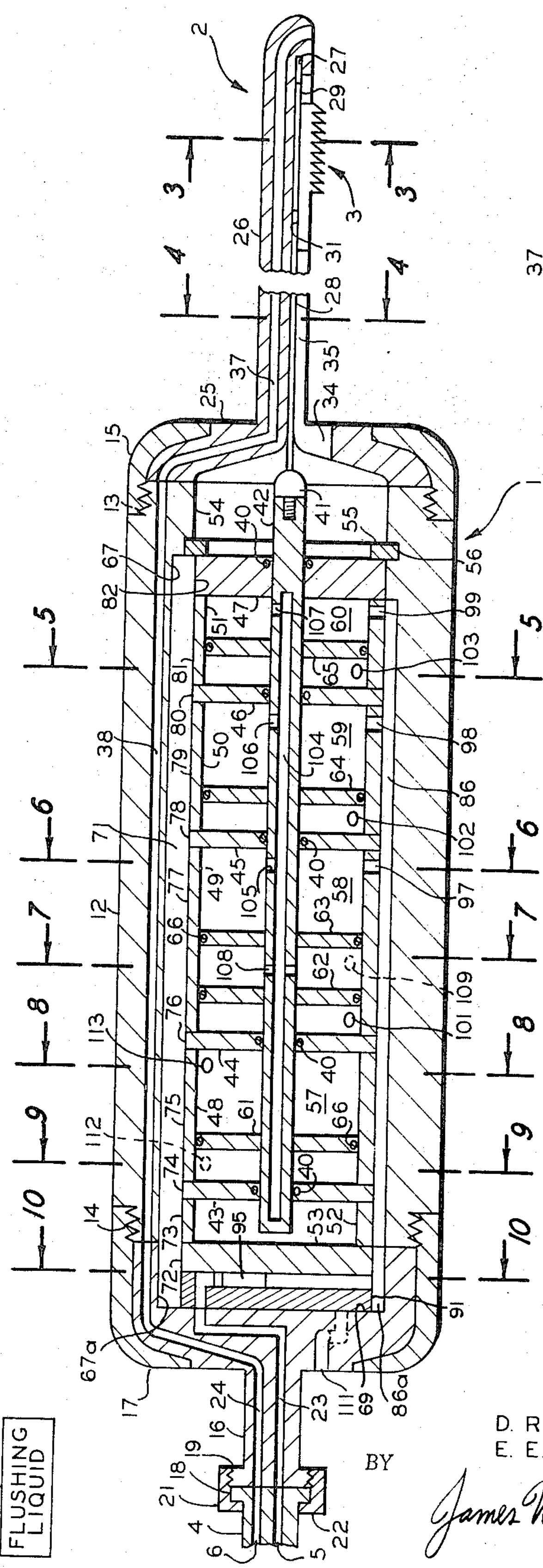

FIG. 2

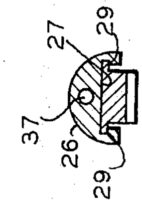

FIG. 3

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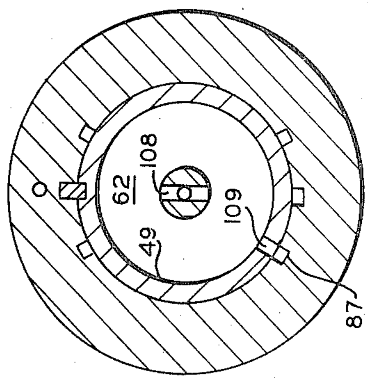

FIG. 7

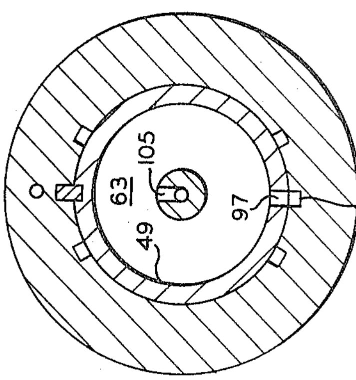

FIG. 6

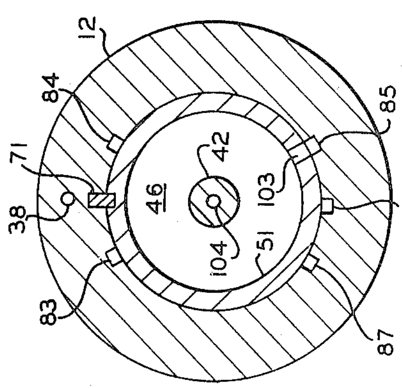

FIG. 5

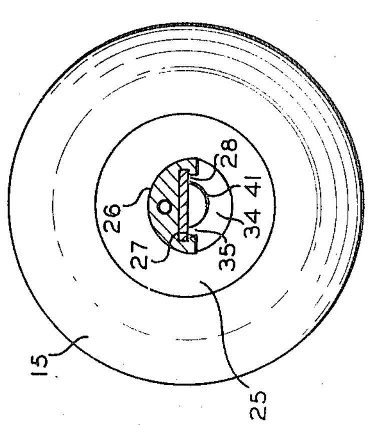

FIG. 4

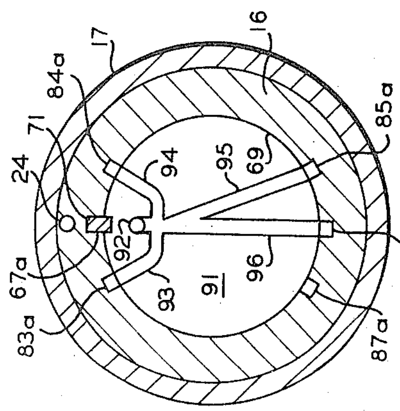

FIG. 10

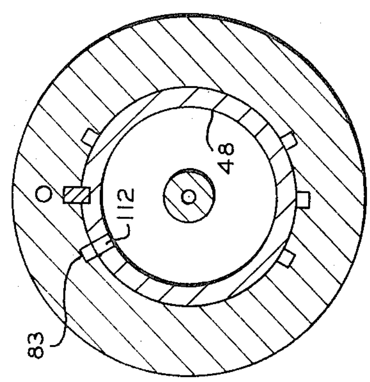

FIG. 9

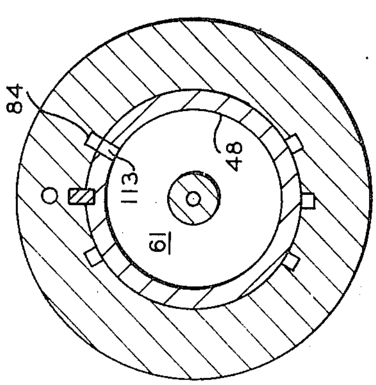

FIG. 8

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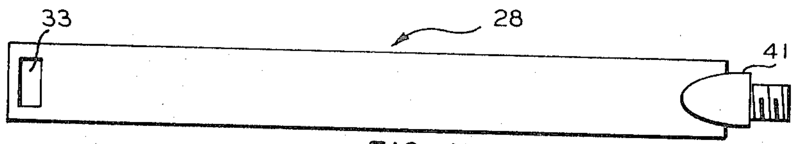

FIG. 11

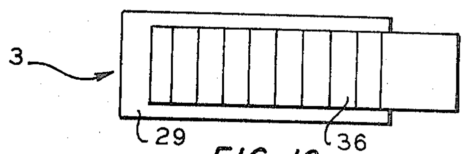

FIG. 12

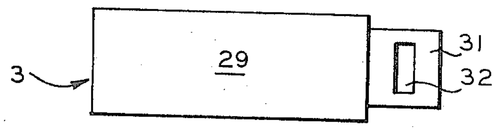

FIG. 13

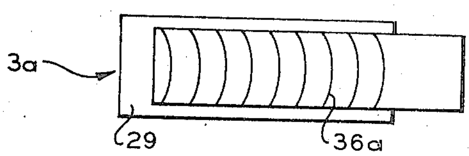

FIG. 14

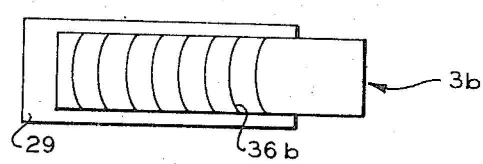

FIG. 15

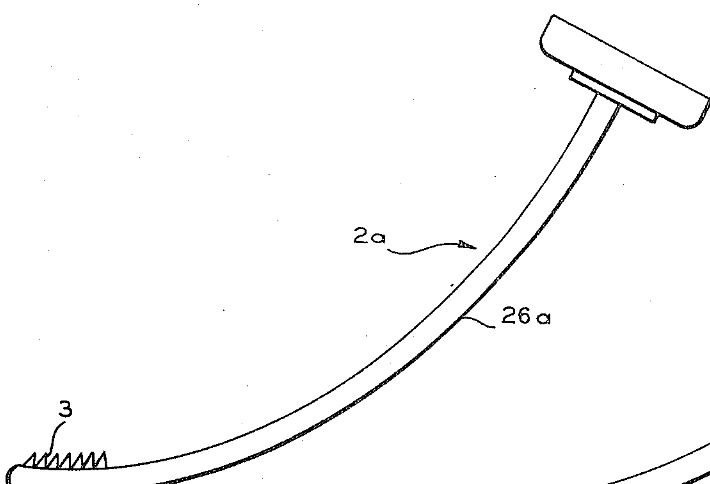

FIG. 16

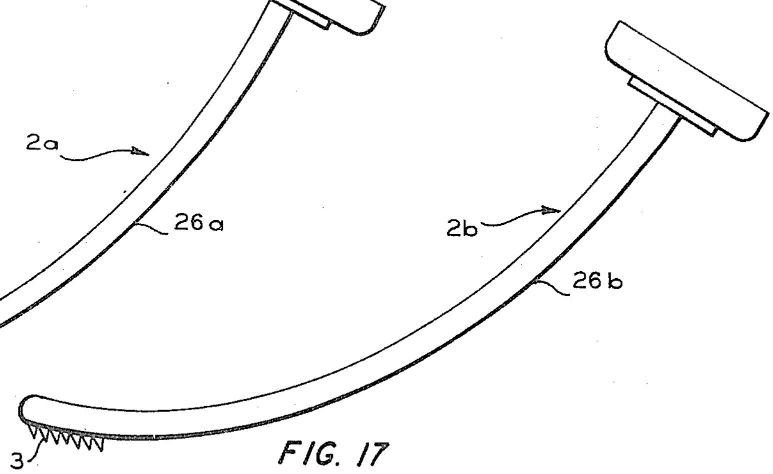

FIG. 17

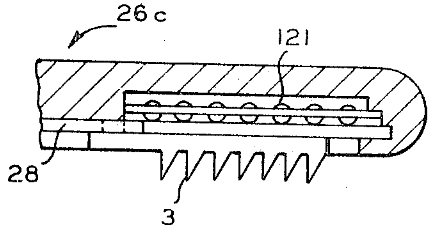

FIG. 18

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POWER-DRIVEN RECIPROCATING BONE SURGERY INSTRUMENT

The invention relates to a power-driven reciprocating bone surgery instrument. In one aspect the invention relates to a reciprocally driven bone-abrading tool. In another aspect the invention relates to a reciprocating bone surgery tool enclosed in a shroud. In yet another aspect the invention relates to a pneumatic-powered reciprocating drive for a surgical instrument.

Several types of powered bone-abrading instruments are commercially available. However, to our knowledge, each of these instruments utilizes either a rotating abrading tool surface or an arcuate abrading surface which is oscillated about the axis of the arc of the abrading surface. Both types present significant problems in the utilization thereof in various circumstances. With both types it is necessary that the soft tissue be well retracted from the area of the bone to be abraded to prevent contact of the abrading surface with the tissue and to permit visual observation of the abrading action. Thus, a large incision is required. The rotary-driven tool presents a problem with changes in speed. If the speed of the tool is decreased or increased, the tool tends to move laterally in an arc, the direction of lateral motion depending upon whether the speed is increased or decreased. Thus, considerable skill is required in maintaining the desired position of the abrading tool when a variation in speed is being made. Furthermore, if the rotating abrading tool is not maintained parallel to the surface being abraded or if areas of different hardness are encountered by opposite sides of the tool, the resulting unbalanced forces will result in undesirable lateral movement of the tool. The oscillating arcuate abrading tool generally cuts in both directions of movement, so that the surgeon must try to maintain the position of the instrument despite any unexpected variations in resistance encountered in either direction. This is not only a physical strain on the surgeon, but any unexpected slip in the positioning of the instrument can result in damage to the adjacent tissue.

Due to the danger to the patient and the surgeon of electrical shock, as well as the possibility of explosion if oxygen is being administered to the patient, it is highly desirable that the driving means for the bone surgery instrument be fluid actuated.

In accordance with the present invention, the disadvantages of the prior art instruments are avoided by the utilization of a reciprocally power-driven bone-abrading tool, which can be enclosed within a shroud. The utilization of a flexible driving band within the shroud permits the shroud to be either curved or straight. The shroud can also provide a means for directing a flushing fluid onto the bone area being abraded from the remote end of the work area, to thereby flush bone fragments from the work area. With the protective shroud, the abrading instrument can be inserted under the flesh, thus permitting a remote incision.

Accordingly, it is an object of the invention to provide a new and improved powered surgical instrument. It is an object of the invention to provide a powered bone-abrading instrument which minimizes the strain on the surgeon and which provides greater protection for the patient. Another object of the invention is to minimize, if not eliminate, the possibility of damage to surrounding tissue in a bone-abrading operation. A further object of the invention is to provide a bone-abrading tool having a flexible, reciprocating drive means. Yet another object of the invention is to provide means for directing a flushing fluid onto the area of the bone being subjected to abrasion. It is an object of the invention to permit a bone abrasion operation with a smaller incision or even with a remotely located incision.

Other objects, aspects and advantages of the invention will be apparent from a study of the specification, the drawings and the appended claims to the invention.

In the drawings:

FIG. 1 is an illustration, partly in elevation and partly in diagrammatic form, of a reciprocating bone surgery instrument in accordance with one embodiment of the invention;

FIG. 2 is an elevational view in cross section along the length of the instrument of FIG. 1;

FIG. 3 is an elevational view in cross section, taken along the line 3—3 in FIG. 2;

FIG. 4 is an elevational view in cross section, taken along the line 4—4 in FIG. 2;

FIG. 5 is an elevational view in cross section, taken along the line 5—5 in FIG. 2;

FIG. 6 is an elevational view in cross section, taken along the line 6—6 in FIG. 2;

FIG. 7 is an elevational view in cross section, taken along the line 7—7 in FIG. 2;

FIG. 8 is an elevational view in cross section, taken along the line 8—8 in FIG. 2;

FIG. 9 is an elevational view in cross section, taken along the line 9—9 in FIG. 2;

FIG. 10 is an elevational view in cross section, taken along the line 10—10 in FIG. 2;

FIG. 11 is a top view of the flexible driving band of FIG. 2;

FIG. 12 is a bottom view of the bone-abrading tool of FIG. 2;

FIG. 13 is a top view of the bone-abrading tool of FIG. 12;

FIG. 14 is a bottom view of a bone-abrading tool having the teeth thereof curved in a convex manner, which can be employed in the instrument of FIG. 2;

FIG. 15 is a bottom view of a bone-abrading tool having the teeth thereof curved in a concave manner, which can be utilized in the instrument of FIG. 2;

FIG. 16 is an elevational view of an inwardly curved tool shroud which can be utilized instead of the straight tool shroud of FIG. 1;

FIG. 17 is an elevational view of an outwardly curved tool shroud which can be utilized instead of the straight tool shroud of FIG. 1; and

FIG. 18 is a partial cross-sectional view of the front end of a tool shroud equipment with ball bearings.

Referring now to the drawings in detail, and to FIGS. 1 and 2 in particular, the bone surgery instrument comprises an elongated housing 1, which serves as a handle and which contains the reciprocating drive mechanism, a tool shroud 2, a bone-abrading tool 3, and a flexible hose 4 having at least two fluid conduits 5 and 6 therein. Conduit 5 is connected through valve 7, which may be manually actuated by a foot pedal or other suitable means to vary the reciprocating speed, to a pressurized air supply 8. Conduit 6 is connected through manually actuatable valve 9 to supply 11 of a flushing liquid under pressure. Housing 1 comprises a cylindrically shaped body member 12, the exterior surface of which can be knurled or shaped to provide a gripping surface for the tool. Body member 12 is provided with externally threaded, recessed portions 13 and 14 at the front and rear ends thereof, respectively. The tool shroud 3 is secured to the front end of body member 12 by means of internally threaded clamp ring 15. Similarly, the fluid inlet connector 16 is secured to the rear end of body member 12 by internally threaded clamp ring 17. The outlet end of hose 4 has an outwardly extending flange 18, which abuts against a similarly outwardly extending flange 19 on the inlet end of connector 16. Ring clamp 21 is internally threaded to engage external threads on flange 19, and has an inwardly directed flange 22 to hold flange 18 in fluidtight contact with flange 19. Flanges 18 and 19 can be suitably shaped to permit contact thereof only with fluid conduits 5 and 6 of hose 4 in alignment with fluid passageways 23 and 24, respectively, in connector 16, or one of the flanges 18 and 19 can be provided with positioning pins to engage openings in the other flange to accomplish the correct positioning.

Referring now to FIGS. 1, 2, 3 and 4, shroud 2 comprises a shank section 25 of circular cross section and a tool section 26. Shroud 2 is provided with a guideway 27 of substantially rectangular cross section in substantial conformity to and slightly larger than the cross section of the flexible driving band 28. The upper portion of abrading tool 3 has laterally extending flanges 29 on the front and on each side thereof substantially conforming to the rectangular cross section of passageway 27. The height of the rear portion 31 of tool 3 is reduced by at least the thickness of driving band 28. The rear portion 31 is provided with an upstanding pin 32 (FIG. 13) which fits within and closely conforms to an opening 33 in the front end of driving band 28 (FIG. 11). Shank portion 25 is provided with an opening 34 to permit the insertion of the tool 3 therethrough in the assembling of the instrument. Similarly, tool section 26 is provided with an elongated slot 35 in communication with guideway 27 to permit the insertion and subsequent reciprocation of the tool 3. Slot 35 is wider than the toothed portion 36 of tool 3, but narrower than band 28 and flanges 29. Thus the path of movement of driving band 28 and tool 3 is determined by guideway 27. Shroud 2 is provided with a fluid passageway 37 extending from the shank portion 25 along the upper portion of tool section 26 to a point in front of the front end of slot 35 and then downwardly to the lower surface of the tip of the shroud 2 to direct a steam of flushing front at the far end of the work area. Body member 12 has a fluid passageway 38 to provide communication between passageways 24 and 37.

Referring now to FIGS. 2 and 5 through 10, the inner or rear end 41 of band 28 is secured by suitable means, for example by threaded engagement, to the forward end of reciprocating shaft 42. Shaft 42 extends through sealing rings 40 positioned in aligned openings in disc 43, 44, 45, 46 and 47. Each adjacent pair of disc 43–47 is separated by a respective one of cylindrical sleeves 48, 49, 50 and 51. A sleeve 52 separates disc 43 and a solid closure disc 53, which is positioned in a recess 69 in connector 16. Discs 43, 44, 45, 46 and 47 and sleeves 48–52 are positioned within a cylindrical opening 54 extending axially through body member 12, and are rigidly held in place by split ring 55 engaging an annular slot 56 in the inner wall of body sleeve 12. Discs 43 and 44 and sleeve 48 form a chamber 57. Discs 44 and 45 and sleeve 49 form a chamber 58. Similarly discs 45 and 46 and sleeve 50 form chamber 59, while discs 46 and 47 and sleeve 51 form chamber 60. Shaft 42 has secured thereto radially extending piston diaphragm flanges 61, 62, 63, 64 and 65. Flange 61 is located in chamber 57 and sealably engages the inner wall of sleeve 48 to divide the chamber 57 into front and rear sections. Flanges 62 and 63 are located spaced-apart relationship in chamber 58 and sealably engage the inner wall of sleeve 49 to divide chamber 58 into front, middle and rear sections. Flange 64 is positioned in chamber 59 and sealably engages the inner surface of sleeve 50 to divide chamber 59 into front and rear sections. Similarly, flange 65 divides chamber 60 into a front section and a rear section. The sealing engagement of each of the piston flanges 61, 62, 63, 64 and 65 to the corresponding sleeve can be effected by any suitable means, for example O-rings 66.

A keyway 67 is cut in body 12 along the surface of cylindrical opening 54 parallel to the axis of opening 54. A matching keyway 67*a* is cut in the cylindrical wall of recess 69 in inlet connector 16. Key 71 is positioned in keyways 67 and 67*a*. Corresponding keyways 72–82 are cut in disc 53, sleeve 52, disc 43, sleeve 48, disc 44, sleeve 49, disc 45, sleeve 50, disc 46, sleeve 51 and disc 47, respectively, to receive and engage key 71 to maintain an accurate alignment of the discs and sleeves within connector 16 and body 12. The internal surface of body 12 is also cut to provide grooves 83, 84, 85, 86 and 87 which extend parallel to the axis of cylindrical opening 54. The cylindrical wall of recess 69 in connector 16 is similarly cut to provide correspondingly located grooves 83*a*, 84*a*, 85*a*,86*a* and 87*a*.

A fluid control disc 91 is positioned within recess 69 of inlet connector 16. The end of disc 91 in contact with disc 53 is grooved to form a fluidic amplifier which serves as a control switch. The power inlet passageway 92 extends through disc 91 into communication with fluid passageway 23 in inlet connector 16. The control or biasing fluid passageways 93 and 94 communicate with grooves 83*a* and 84*a*, respectively. The first power output passageway 95 communicates with groove 85*a*, while the second power output passageway 96 is connected to groove 86*a*.

Passageway 97 in sleeve 49 provides fluid communication for the second power output fluid stream from grooves 86*a* and 86 into the front section of chamber 58. Similarly passageways 98 and 99 connect groove 86 to the front section of chamber 59 and 60, respectively. Passageways 101, 102 and 103, in sleeves 49, 50 and 51, respectively, provide for the passage of the first power output fluid grooves 85*a* and 85 into the rear sections of chamber 58, 59 and 60, respectively. Shaft 42 is provided with an axially elongated passageway 104 having inlets 105, 106 and 107 and outlets 108. In the final portion of the rearward stroke of shaft 42, as illustrated in FIG. 2, and in the initial portion of the forward stroke of shaft 42, the inlets 105, 106 and 107 are in the front sections of chambers 58, 59 and 60, respectively. In the final portion of the forward stroke of shaft 42, the inlets 105 and 106 pass through discs 45 and 46 into the rear section of chambers 59 and 60, respectively, while inlet 107 becomes closed off by the greater thickness of disc 47. Outlets 108 permit continuous fluid flow from passageway 104 through the middle section of chamber 58, outlet opening 109, groove 87, groove 87*a*, and exhaust port 111 to the atmosphere. Passageway 112 and grooves 83 and 83*a* provide communication between the rear section of chamber 57 and control inlet passageway 93, while passageway 113 and grooves 84 and 84*a* connect the front section of chamber 57 to control inlet passageway 94.

At approximately the position shown in FIG. 2, the pressure feedback from the rear section of chamber 57 to control inlet 93 becomes sufficiently greater than the pressure feedback from the front section of chamber 57 to control inlet 94 to divert the flow of the fluid from inlet 92 to power output passageway 95 and grooves 85*a* and 85. This causes a buildup of pressure in the rear sections of chambers 58, 59 and 60 against pistons 62, 64 and 65, resulting in the forward movement of shaft 42. At the end of the forward movement of shaft 42, the pressure feedback from the front section of chamber 57 to control inlet 94 has become sufficiently greater than the pressure feedback from the rear section of chamber 57 to control inlet 93 to divert the flow of fluid from inlet 92 to power output passageway 96 and grooves 86*a* and 86. This causes a pressure buildup against the front surfaces of pistons 63, 64 and 65, resulting in the rearward movement of shaft 42. The frequency of the reciprocating motion of shaft 42 is determined by the pressure of the fluid in conduit 23, which is controlled by manual manipulation of valve 7. Due to the confinement of the flexible driving band 28 in guideway 27, the reciprocation of shaft 42 effects a corresponding reciprocating motion of abrading tool 3.

Reasonable variations and modifications of the bone surgery instrument are possible within the scope of the invention. As shown in FIGS. 14 and 15, the abrading tool can have convexly shaped teeth 36*a* or concavely shaped teeth 36*b* instead of the straight teeth 36 of FIG. 12. Other teeth configurations and combinations thereof can also be employed. Furthermore, as illustrated in FIGS. 16 and 17, the versatility of the flexible driving band 28 permits the utilization of an inwardly curved shroud tool section 26*a* or an outwardly curved shroud tool section 26*b*, the curvature of guideway 27 being in a plane perpendicular to the width of flexible band 28. The shroud 2 can be made of rigid material, such as stainless steel, or of material of sufficient flexibility to permit adjustment of the longitudinal curvature of the shroud during operation of the instrument. For example, a disposable, flexible shroud of hard rubber can be employed. In the larger sizes of the bone surgery instruments, it may be desirable to provide friction reducing means. One example of such means is the ball bearing plate 121 illustrated in FIG. 18. Plate 121 is positioned in tool section 26*c* immediately above the upper surface of tool 3. While the presently preferred embodiment of the invention has been illustrated in the drawings as having the tool 3 inserted into the tool section 26 of the shroud 2 through an opening 34 in the shank portion 25 of shroud 2, it is within the contemplation of the invention to utilize other shroud configurations which permit the insertion of the tool from the front end of the shroud, for example by the utilization of a detachable tip. Similarly, while it is preferable that a pneumatic driving means be employed to power the reciprocating tool, other means can be utilized. Thus, in the field of veterinary surgery, it would be permissible to employ electrically actuated reciprocating drive means to power the instrument. While air is the preferred power fluid from the standpoint of safety and economy, other fluids can be utilized when desired, for example, nitrogen or carbon dioxide.

The enclosure of the abrading tool 3 and the driving band 28 within the shroud 2 permits the tool to be inserted under soft tissue without damage to the tissue. This permits a technique wherein the incision is made at a point remote from the bone area to be abraded. The soft tissue can be separated from the bone from the point of incision to the area to be abraded, and the instrument can be inserted. The presence of the shroud also permits the utilization of a smaller incision as the gingival and soft tissue retraction would not be necessary to the extent required for a rotary or oscillating instrument. The occurrence of the abrading action only on the backstroke minimizes the occurrence of unbalanced forces in positioning the instrument, thereby reducing the strain on the surgeon. Thus, no forward pressure by the surgeon is required, eliminating the possibility of slipping and penetration of tissue or even vital structures. This gives the surgeon a greater tactile sense of control than is present with a rotary or oscillating instrument. The location of the flushing fluid outlet at the tip of the shroud permits the flow of the flushing fluid back along the path of insertion of the instrument, thereby facilitating the removal of the bone particles from the incision, as well as providing a cooling action for the work area, if desired. The remote location of the incision is particularly advantageous in facial surgery, such as operations on the nose. The invention is particularly useful with dental equipment, as the instrument can be attached directly to the conventional pneumatical power supply and controls. The invention is also useful for reducing bony tori, both maxillary and mandibular; reducing lingual bony shelf; for maxillary tuberosities, alveolectomies, alveolar osteoplasty, foot surgery, rhinoplasty, bone sculpting in plastic surgery, bone sawing, orthopedic surgery, autopsy surgery, skull surgery, veterinary surgery, and vein surgery.

We claim:

1. A reciprocally power-driven cutting instrument comprising a handle, an elongated shroud attached to the forward end of said handle, said shroud having an internal guideway extending along at least a portion of the length of said shroud and having a tool opening extending from at least a portion of said guideway to the exterior of said shroud, a cutting tool positioned in said tool opening, said cutting tool having retention means extending into said guideway to couple said tool to said shroud while permitting said tool to freely move along said guideway, and power means connected to said tool to effect reciprocation of said tool within said tool opening along the path of at least a portion of said guideway; said power means comprising a shaft mounted in said handle in alignment with the rear end of said shroud, means for reciprocally driving said shaft, and a flexible band positioned in said guideway, the rear end of said flexible band being connected to the front end of said shaft, the front end of said flexible band being connected to said cutting tool.

2. An instrument in accordance with claim 1 further comprising friction reducing means mounted in said shroud in contact with the inner surface of said tool.

3. An instrument in accordance with claim 1 wherein said guideway is curved in a plane perpendicular to the width of said flexible band.

4. An instrument in accordance with claim 1 wherein said shroud comprises a shank section and an elongated tool section, said guideway and said tool opening extending rearwardly through said shank section to permit the insertion of said tool and said flexible band into said shroud from the rear end of said shank section, and further comprising means for securing said shank section to said handle.

5. An instrument in accordance with claim 1 wherein said means for reciprocally driving said shaft comprises at least one power chamber and at least one control chamber formed in said handle; said shaft extending through said at least one power chamber and at least one control chamber; at least one piston flange mounted on said shaft in each said at least one power chamber and dividing each said at least one power chamber into a front section and a rear section; at least one piston flange mounted on said shaft in each said at least one control chamber and dividing each said at least one central chamber into a front section and a rear section; a fluidic amplifier having a power input, first and second control inputs and first and second power outputs; means for supplying a fluid under pressure to said power input; means providing fluid communication between the rear section of each said at least one control chamber and said first control input; means providing fluid communication between the front section of each said at least one control chamber and said second control input; means providing fluid communication between said first power output and the rear section of each said at least one power chamber; and means providing fluid communication between said second power output and the front section of each said at least one power chamber, so that the movement of the piston in each said at least one control chamber varies the relative magnitude of the pressure signals applied to said first and second control inputs to effect a switching of the flow of fluid entering said power input to said first power output at the end of the rearward motion of said shaft and to said second power output at the end of the forward motion of said shaft.

6. An instrument in accordance with claim 1 wherein said shroud is provided with a fluid passageway extending to a point in the forward tip of said shroud, and further comprising means for supplying a flushing fluid to said fluid passageway, and wherein said cutting tool is a bone surgery abrading tool.

7. An instrument in accordance with claim 6 wherein said guideway is curved in a plane perpendicular to the width of said flexible band.

8. An instrument in accordance with claim 1 wherein said shroud is formed of material of sufficient flexibility to permit adjustment of the longitudinal curvature of said shroud.

9. An instrument in accordance with claim 1 wherein said means for reciprocally driving said shaft comprises a double acting fluid piston and a fluidic control device connected to effect periodic reversals in the direction of movement of said piston.

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