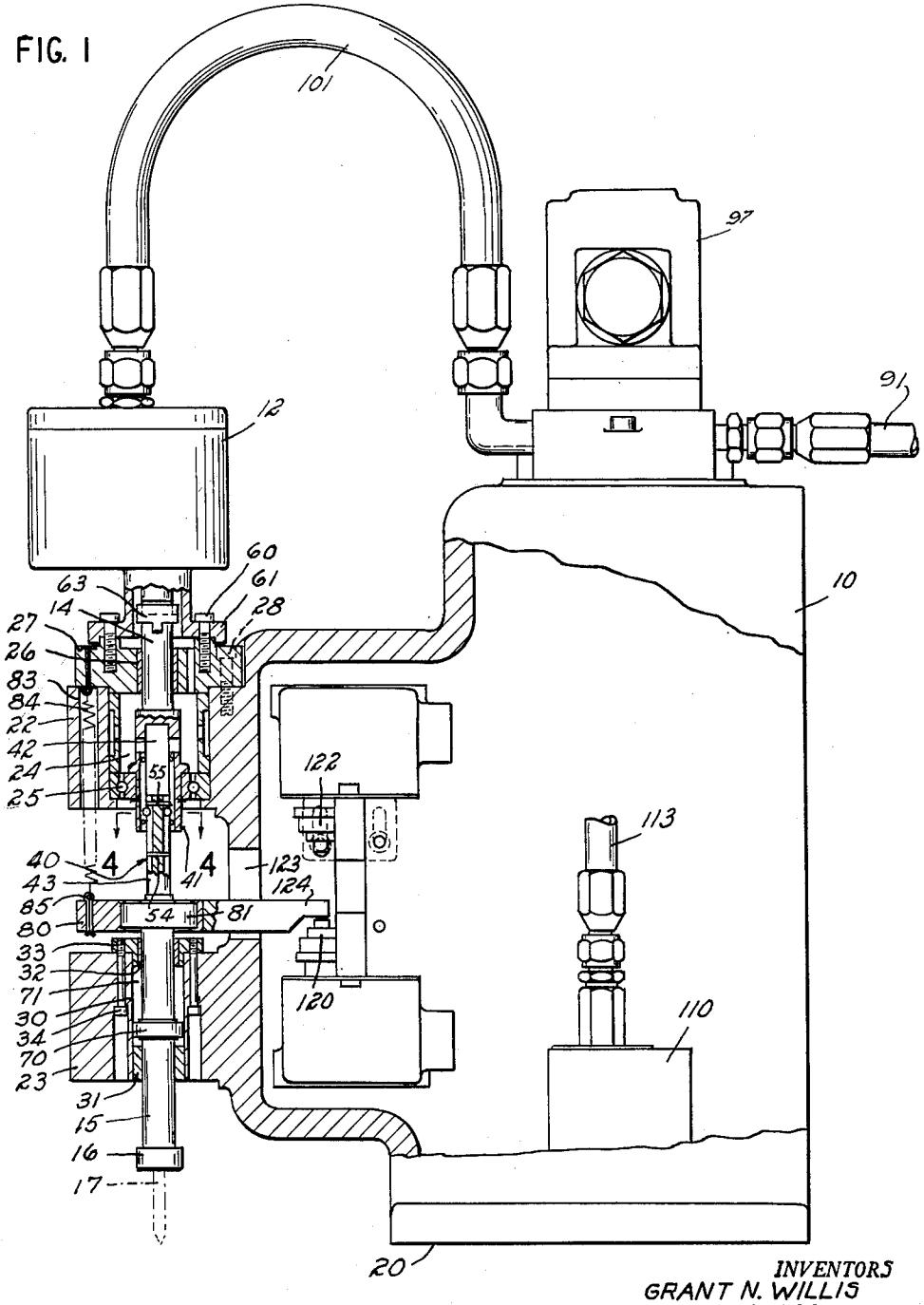
March 10, 1964 G. N. WILLIS ETAL 3,123,847

FLUID DRIVEN ROTARY TOP SPINDLE WITH FLUID DRIVE MEANS TO ADVANCE SPINDLE TO WORK

Filed Feb. 4, 1960 3 Sheets-Sheet 1

FIG. 1



INVENTORS
GRANT N. WILLIS
LIONEL H. SECCOMBE, JR.
BY IRVING Y. LAKE

Lindsey and Prutzman
ATTORNEYS

March 10, 1964 G. N. WILLIS ETAL 3,123,847

FLUID DRIVEN ROTARY TOP SPINDLE WITH FLUID DRIVE MEANS TO ADVANCE SPINDLE TO WORK

Filed Feb. 4, 1960 3 Sheets-Sheet 2

FIG. 2

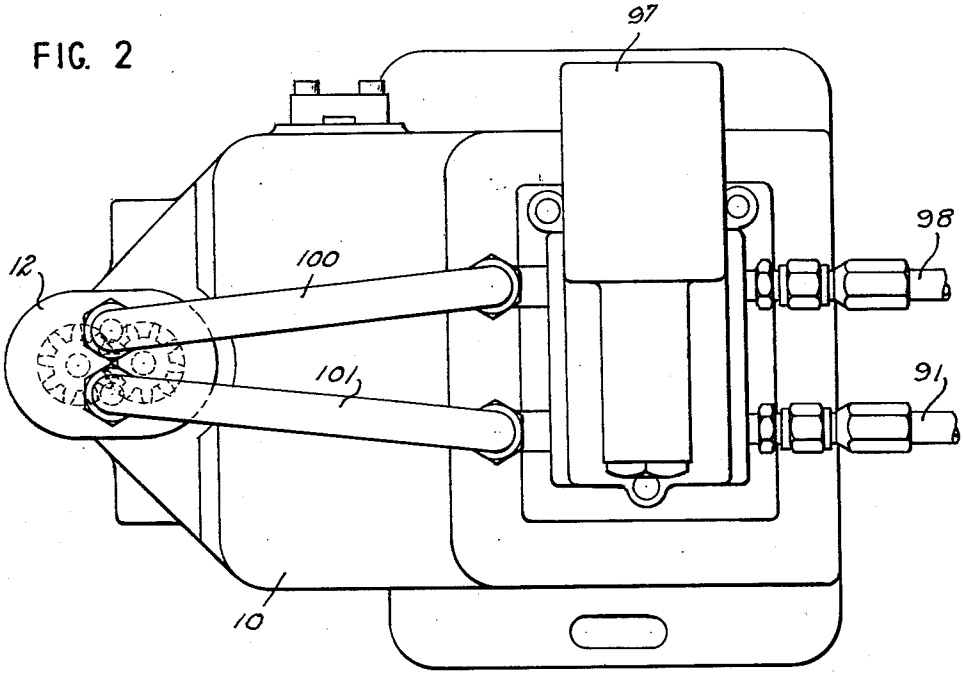


FIG. 3

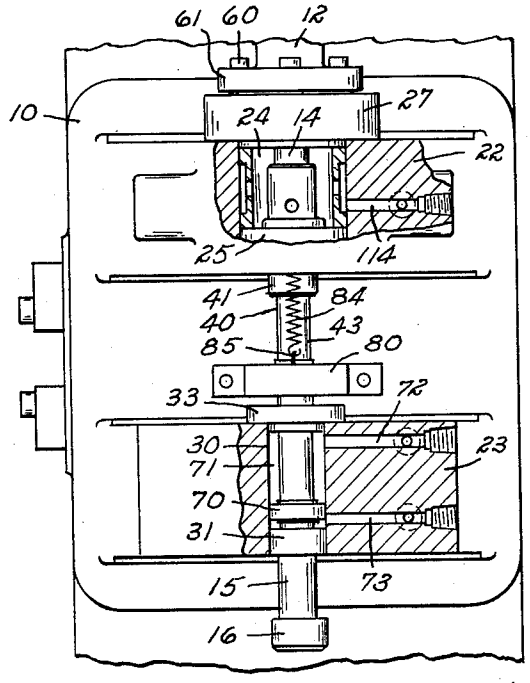
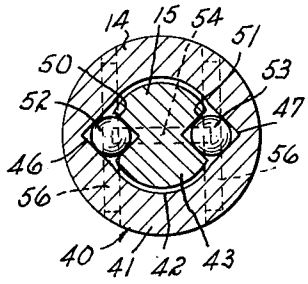


FIG. 4



INVENTORS
GRANT N. WILLIS
LIONEL H. SECCOMBE, JR.
BY IRVING Y. LAKE

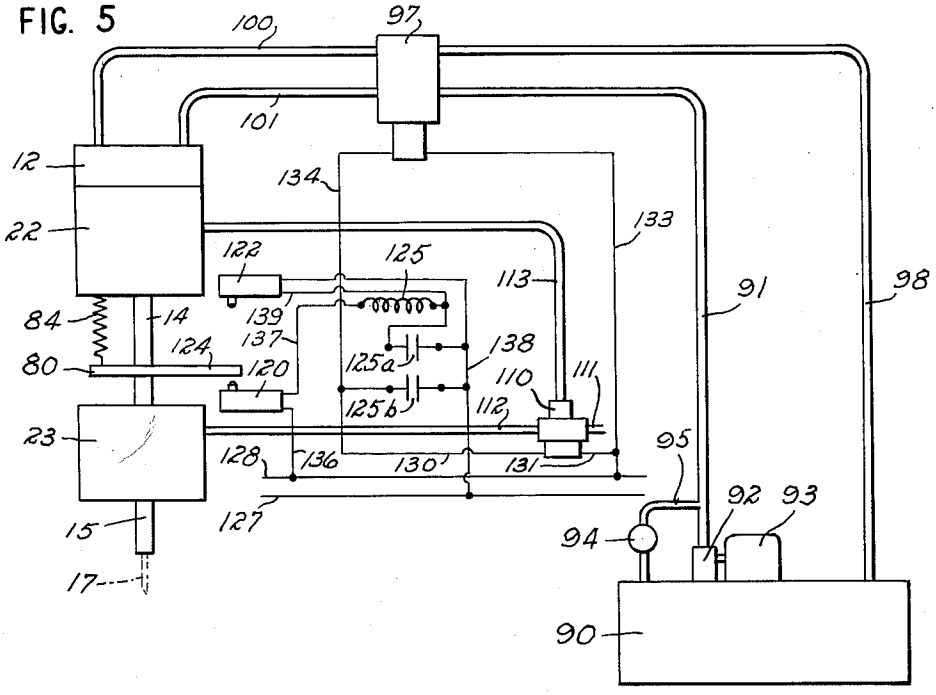
Lindsey and Prutzman
ATTORNEYS

March 10, 1964 G. N. WILLIS ETAL 3,123,847

FLUID DRIVEN ROTARY TOP SPINDLE WITH FLUID DRIVE MEANS TO ADVANCE SPINDLE TO WORK

Filed Feb. 4, 1960 3 Sheets-Sheet 3

FIG. 5



INVENTORS
GRANT N. WILLIS
LIONEL H. SECCOMBE, JR.
BY IRVING Y. LAKE

Lindsey and Prutzman
ATTORNEYS

United States Patent Office 3,123,847 Patented Mar. 10, 1964

3,123,847

FLUID DRIVEN ROTARY TAP SPINDLE WITH FLUID DRIVE MEANS TO ADVANCE SPINDLE TO WORK

Grant N. Willis and Lionel H. Seccombe, Jr., Bristol, and Irving Y. Lake, Terryville, Conn., assignors to United-Carr Fastener Corporation, Boston, Mass., a corporation of Delaware

Filed Feb. 4, 1960, Ser. No. 6,684
4 Claims. (Cl. 10—136)

This invention generally relates to machines for forming threads and more particularly to an improved thread cuting device such as a tapping machine or the like capable of high speed operation.

It is a general object of this invention to provide an improved high speed drive mechanism for a thread cutter which is easily and quickly cycled to complete a large number of accurate threading operations in an extremely short period of time.

It is a further object of this invention to provide an improved drive mechanism for thread cutters and the like which is fast and accurate but which effectively protects the cutting tool.

It is an additional object of this invention to provide an improved thread cutting machine which is economical to manufacture and operate, fast and durable in operation and which retains its ability to produce accurate threads for extended periods of use.

It is a still further object of this invention to provide an improved thread cutting machine which is easily adapted to automatic or semi-automatic operation.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a side elevation view of a preferred embodiment of this invention with a portion of the housing and operating mechanism shown in vertical cross section;

FIG. 2 is a top plan view of the apparatus of FIG. 1;

FIG. 3 is a partial front elevation view of the apparatus of FIG. 1 with a portion of the support pedestals cut away;

FIG. 4 is a cross section view taken along the lines 4—4 of FIG. 1; and

FIG. 5 is a schematic view of the controls and power circuits of a preferred embodiment of this invention.

Because the thread cutting machine of this invention has particular utility in a tapping operation, the illustrated embodiment is described as a tapping machine and, by referring to the drawings, it is seen that this machine generally comprises a frame 10, a hydraulic gear motor 12 mounted on frame 10 and connected to drive shaft 14, a driven shaft 15 whose uppe rend is coupled to shaft 14 and whose lower end carries chuck 16 to releasably retain a suitable tap 17 (shown in phantom). As hereinafter pointed out in greater detail, driven shaft 15 is mounted for rotation coaxial with drive shaft 14 and for axial movement relative thereto.

With the tapping machine arranged for vertical operation, frame 10 is mounted on a suitable support (not shown) engaging bottom surface 20 and is provided with an outwardly extending top pedestal 22 and an outwardly extending bottom pedestal 23, spaced from pedestal 22 and in vertical alignment therewith. Top pedestal 22 is provided with vertical bore or passageway 24 in which driven shaft 14 is mounted for rotation in ball bearing 25 and sleeve bearing 26. Sleeve bearing 26 is carried by

pedestal cap member 27 and is fastened to frame 10 by a plurality of threaded fasteners 28.

Lower support pedestal 23 is provided with a cylindrical bore or passageway 30, generally coaxial with passageway 24. Driven shaft 15 is supported for rotational and axial movement in passageway 30 by sleeve bearing 31 carried by pedestal 23 and sleeve bearing 32 carried by bearing guide member 33 which is secured to pedestal 23 by threaded fasteners 34.

In order to connect driven shaft 15 and drive shaft 14 for simultaneous rotation while permitting shaft 15 to move axially relative to shaft 14 there is provided a low inertia coupling generally designated 40. Although a conventional spline connection or the like may be suitable for many applications, extreme high speed operation requires a low inertia, low friction-type coupling of the improved type shown in FIGS. 1 and 4. Drive shaft 14 is provided with an enlarged end portion 41 having an axial bore 42 formed therein, the diameter of bore 42 being slightly greater than the diameter of upper end 43 of driven shaft 15 so that end 43 slides freely within bore 42. The side walls of bore 42 are provided with diametrically opposed grooves 46 and 47 formed therein and upper end 43 of driven shaft 15 is also provided with diametrically opposed grooves 50 and 51. Ball 52 is disposed in the aligned grooves 46 and 50 and ball 53 is disposed in the aligned grooves 47 and 51 thereby to establish a positive rotary drive connection between drive shaft 14 and driven shaft 15 throughout the range of relative axial shaft movement permitted by rolling of the balls along the respective grooves. Stop pins 54 and 55 in end 43 prevent the balls from leaving the grooves and stop pins 56 prevent end 43 from being inadvertently withdrawn from bore 42.

In order to withdraw the tap from the newly tapped hole, it is necessary that the direction of rotation of the tap be reversed and it is therefore essential that the drive motor for rotating shafts 14 and 15 be easily and quickly reversible if high speed machine operation is to be achieved. It has been found that our hydraulic gear motor can be operated at high speeds and yet is almost instantaneously reversible because of its low rotating mass and positive drive characteristics. Accordingly, a constant volume hydraulic gear motor 12 is mounted on top guide plate 27 by threaded engagement of fasteners 60 which clamp flange 61 of motor 12 in proper alignment with shaft 14 so that coupling 63 is easily engaged with shaft 14.

In order to accomplish safe, controlled downward movement of driven shaft 15 and tap 17 into proper engagement with the workpiece, there is provided on shaft 15 a piston in the form of a nylon collar 70 disposed within bore 30 on lower pedestal 23 and of a diameter slightly less than that of bore 30. Guide plate 33 cooperates with shaft 15 to close the upper end thereof so as to define a cylinder 71 closed at its upper end. As most clearly seen in FIG. 3, lower pedestal 23 is provided with a first bored passageway 72 and a lower bored passageway 73 which permit air to be supplied to and vented from cylinder 71 to exert a downward force on piston 70 to move tap 17 into operative engagement with the workpiece. Because the diameter of piston 70 is smaller than the diameter of cylinder 71 there is provided a "leaky piston" arrangement such that engagement of the tap with the workpiece or any other obstruction to downward movement causes the air to leak around piston 70 without exerting an excessive downward force that would cause excessive tap wear and oversize cutting of the thread.

In order to provide for the return of shaft 15 and tap 17 to the "up" position wherein a new workpiece can be indexed into proper working position, there is provided

the collar 80 which is rotatably mounted by ball bearing 81 on shaft 15 intermediate upper pedestal 22 and lower pedestal 23. Bored passageway 83 in upper housing 22 accommodates coil spring 84 which has its lower end attached to collar 80 by cotter pin 85 and its upper end attached to frame 27. Not only does spring 84 provide the necessary return force, but it also can be selected in accordance with the operating air pressure to balance the downward air pressure force on piston 70 at the point of contact of tap 17 with the workpiece thereby to eliminate any downward force on tap 17 as a result of air pressure while the tap is in operation. Thus, the tap can be advanced into the workpiece by its own lead.

Turning now to the hydraulic and air supply circuits together with the various control features, it is noted that by referring to FIG. 5 in conjunction with the other drawings that oil is supplied from sump 90 to output line 91 by gear pump 92 driven by electric motor 93. A relief valve 94 is provided in line 95 connected between line 91 and sump 90 to prevent damage to the system because of an obstruction in the hydraulic circuit. Line 91 is connected to four-way solenoid valve 97 mounted on the top of frame 10 and return line 98 is also connected to valve 97 for return of hydraulic fluid to the oil sump. Fluid supply lines 100 and 101 are connected between valve 97 and gear motor 12 and act as supply and return lines for gear motor 12 depending upon its direction of rotation as determined by the position of valve 97. That is, valve 97 acts as a reversing valve to connect supply line 91 to line 100 or to line 101 as desired.

Air is supplied to solenoid valve 110 from a suitable source (not shown) through line 111. Supply line 112 connects valve 110 to passageway 72 and exhaust line 113 connects valve 110 to passageway 114. If desired, an aspirator or other suitable means (not shown) can be provided in the air supply line to add oil to the air so as to enable the bearings in top pedestal 22 and bottom pedestal 23 to be easily and properly lubricated.

Automatic and semi-automatic operation of the tapping device of this invention is accomplished by the provision of lower limit switch 120 and upper limit switch 122 which are adjustably mounted on frame 10 in any desired manner. Frame 10 is provided with a slot 123 through which extends arm 124 of collar 80 to preclude rotation of collar 80 with shaft 15 and to engage the limit switches 120 and 122 to effect operation of the associated valves as hereinafter described.

Further understanding of my invention can best be obtained by referring to FIG. 5 and a description of the operation of the structure and circuitry of this invention under automatic conditions. Control solenoid 125 is provided to control the automatic operation of my tapping device. Suitable electrical supply lines 127 and 128 are connected to energize solenoid valve 110 through lines 130, 131 and solenoid valve 97 through lines 133, 134 through contact 125*b* of solenoid 125. Actuation of contact 125*b* is, of course, controlled by solenoid 125 whose energization is controlled by normally closed lower switch 120 acting through lines 136, 137, normally open limit switch 122 acting through lines 138, 139 and sealing contact 125*a*.

Assuming shaft 15 to be moving under the force of spring 84 with pneumatic solenoid valve 110, hydraulic solenoid valve 97, and control solenoid 125 de-energized, the tap is rotating in a backward or counterclockwise direction. When shaft 15 reaches the upper limit of travel so that arm 124 engages upper limit switch 122 to close the normally open contact, it is seen that power is supplied to control solenoid 125 through line 136, lower limit switch 120, line 137, upper limit switch 122 and line 138. Energization of solenoid 125 closes contacts 125*b* and sealing contact 125*a* to keep solenoid 125 energized when upper limit switch 122 opens. Upon closing of contacts 125*b*, both pneumatic solenoid valve 110 and hydraulic solenoid valve 97 are energized thereby reversing the direction of rotation of gear motor 12 and supplying air through line 112 to cylinder 71 to drive shaft 15, tap 17 and collar 80 downwardly. As previously pointed out, spring 84 is, in the preferred embodiment, selected to counterbalance the force exerted by piston 70 at the point of contact of tap 17 with the workpiece so that the advancing of tap 17 into the workpiece is controlled almost solely by the lead of the cutting teeth thereon. Upon completion of the tapping operation, arm 124 engages lower limit switch 120 to open the contacts and de-energize solenoid 125 thereby opening contact 125*b* and de-energizing pneumatic solenoid valve 110 and hydraulic solenoid valve 97. Gear motor 12 thereby is reversed in direction to cause the tap to back out of the hole and cylinder 71 is vented to the atmosphere through supply line 112 and exhaust line 113. When tap 17 clears the hole, shaft 15 is free to return its uppermost position under the force of spring 80, whereupon arm 124 engages upper limit switch 122 to repeat the operative cycle. If desired, the closure of upper limit switch 122 can be brought about by the proper positioning of a workpiece beneath tap 17.

If semi-automatic operation is desired, upper limit switch 122 is replaced by a pair of normally open contacts operated by a manual push button. It is necessary only to close these contacts to initiate each complete cycle of operation.

To provide a typical example of the type of operation obtainable with the tapping device of this invention, it is noted that with the device arranged for automatic operation it has been possible to accurately tap 120 holes per minute with a No. 10 tap including proper indexing of the workpiece. These figures are based upon a gear motor which provides 3600 r.p.m. for the driven shaft 15 with air at 40 pounds per square inch.

It is noted, in addition, that the constant volume hydraulic system utilized to rotate the tapping device of this invention not only provides positive and accurate tapping rotation but, in addition, permits almost instantaneous reversal of the direction of rotation of the tap. It is further noted that the design of the various elements and couplings of this invention minimize the rotational inertia of the system so as to further facilitate substantially instantaneous reversal of rotation and fast positive action of the moving parts. The leaky piston arrangement of the axial drive mechanism protects the tap from breakage because of improper contact with the workpiece and the use of the return spring not only simplifies return of the driven shaft for proper indexing but provides counterbalancing of the air drive forces to reduce wear and tear on the tap. The described structure permits holes to be tapped in an extremely accurate manner at speeds heretofore unobtainable with a structure that is both economical to manufacture as well as extremely durable in operation.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

We claim:

1. A high speed tapping device comprising a frame having a top support pedestal and a bottom support pedestal mounted thereon in spaced apart relationship, a drive shaft rotatably supported by said top pedestal, a cylindrical passageway formed in said bottom support pedestal coaxial with said drive shaft, a driven shaft of smaller diameter than the passageway in said bottom pedestal, means supporting said driven shaft in the passageway for rotation coaxial with said drive shaft and for axial movement relative thereto, said support means cooperating with said dirven shaft to close the upper end of the passageway, a coupling connecting said drive shaft in said driven shaft for simultaneous rotation while permitting relative axial movement, a collar rotatably mounted on said driven shaft and axially movable therewith, said collar having a portion thereof in engagement

with said frame intermediate said pedestals to preclude rotation thereof, a piston mounted on said driven shaft within the cylindrical passageway and of smaller diameter than the cylindrical passageway, a chuck mounted on the end of said driven shaft for releasably retaining a tap therein, means to supply air to said cylnider to move the tap into operative engagement with the workpiece, said last-nameed means nicluding a solenoid valve operable in one direction to vent the air in the cylinder to the atmosphere, restoring means opposing movement of said driven shaft by said piston, a hydraulic gear motor mounted on said top support pedestal and operative to rotate said drive shaft in either direction, means for supplying hydraulic fluid to rotate said motor, said last-named means including a solenoid operable in one direction to reverse the direction of rotation of said drive shaft, and a limit switch mounted on said frame and engageable by said collar to effect operation of said solenoid valve to reverse the direction of rotation of the hydraulic motor and to operate said solenoid air valve to vent the air contained in said cylinder to the atmosphere.

2. A high speed tapping device comprising rotatably mounted drive shaft, a driven shaft, means supporting said driven shaft for rotation coaxial with said drive shaft and for axial movement relative thereto, said drive shaft having a substantially tubular end disposed about and in spaced relationship to said driven shaft, a pair of diametrically opposed longitudinally extending grooves formed in each said shaft, a ball disposed between each pair of opposed radially aligned grooves and connecting said drive shaft and said driven shaft for simultaneous rotation while permitting relative axial movement, a piston mounted on and coaxial with said driven shaft, a cylinder operatively disposed about said piston and fixedly positioned relative to the support means for said driven shaft, a chuck on the end of said driven shaft for releasably retaining a tap therein, means for supplying air to said cylinder to move said piston relative thereto to bring the tap into operative engagement with the workpiece, said last-named means including a solenoid valve operable in one direction to vent the air contained within the cylinder to the atmosphere, restoring means opposing movement of said dirven shaft by said piston, said piston and cylinder being arranged to permit leakage of air around said piston, a hydraulic gear motor connected to said drive shaft for rotating said drive shaft in either direction, means for supplying hydraulic fluid to said hydraulic gear motor including a solenoid valve operable to reverse the direction of said hydraulic motor, a limit switch, and means carried by said driven shaft and engageable with said limit switch to effect operation of said solenoid valve to vent the air contained in the cylinder and to reverse the direction of rotation of the hydraulic motor.

3. A high speed tapping device comprising a rotatably mounted drive shaft, a driven shaft, means supporting said driven shaft for rotation and for axial movement, a coupling connecting said drive shaft and said driven shaft for simultaneous rotation, said coupling permitting axial movement of said driven shaft relative to said drive shaft while rotating, a piston mounted on and coaxial with said driven shaft, a cylinder operatively disposed about said piston and fixedly positioned relative to the support means for said driven shaft, a chuck on the end of said driven shaft for releasably retaining a tap therein, means for supplying air to said cylinder to move said piston relative thereto to bring the tap into operative engagement with the workpiece, said last-named means including a solenoid valve operable in one direction to vent the cylinder to atmosphere, restoring means opposing movement of said driven shaft by said piston, said piston and cylinder being arranged to permit leakage of air around said piston, a hydraulic gear motor operatively connected to said drive shaft to rotate said drive shaft in either direction, means for supplying hydraulic fluid to said motor including a solenoid valve operable to reverse the direction of rotation of said motor, a limit switch, and means carried by said driven shaft and engageable with said limit switch to effect operation of said solenoid valves.

4. A high speed tapping device comprising a rotatably mounted drive shaft, a driven shaft, means supporting said driven shaft for rotation and for axial movement, a coupling connecting said drive shaft and said driven shaft for simultaneous rotation, said coupling permitting axial movement of said driven shaft relative to said drive shaft while rotating, a piston mounted on and coaxial with said driven shaft, a cylinder operatively disposed about said piston and fixedly positioned relative to the support means for said driven shaft, a chuck on the end of said driven shaft for releasably retaining a tap therein, means for supplying air to said cylinder to move said piston relative thereto to bring the tap into operative engagement with the workpiece, said last-named means including a solenoid valve operable in one direction to vent the cylinder to atmosphere, restoring means opposing movement of said driven shaft by said piston, a hydraulic gear motor operatively connected to said drive shaft to rotate said drive shaft in either direction, means for supplying hydraulic fluid to said motor including a solenoid valve operable to reverse the direction of rotation of said motor, a limit switch, and means carried by said driven shaft and engageable with said limit switch to effect operation of said solenoid valves to thereby simultaneously reverse the direction of the motor and vent the cylinder to atmosphere.

References Cited in the file of this patent

UNITED STATES PATENTS

1,904,848	Beavers	Apr. 18, 1933
2,310,124	Shartle	Feb. 2, 1943
2,317,275	Kinzie	Apr. 20, 1943
2,346,297	Garbe	Apr. 11, 1944
2,472,968	Goldberg	June 14, 1949
2,542,866	Grossman	Feb. 20, 1951
2,857,789	Robinson	Oct. 28, 1958
2,901,928	Heyer	Sept. 1, 1959
2,981,961	Molitor	May 2, 1961