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Smithson

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[54] **FLUID-ACTUATED CHUCK-OPERATING MECHANISM WITH A FLUID LOCK**

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[21] Appl. No.: **200,992**

Related U.S. Application Data

[62] Division of Ser. No. 30,636, April 22, 1970, abandoned.

[52] **U.S. Cl.** **91/32,** 91/420, 279/4

[51] **Int. Cl.** **F15b 12/042,** F23b 31/30

[58] **Field of Search**.....91/6, 16, 30, 32, 91/420; 274/4

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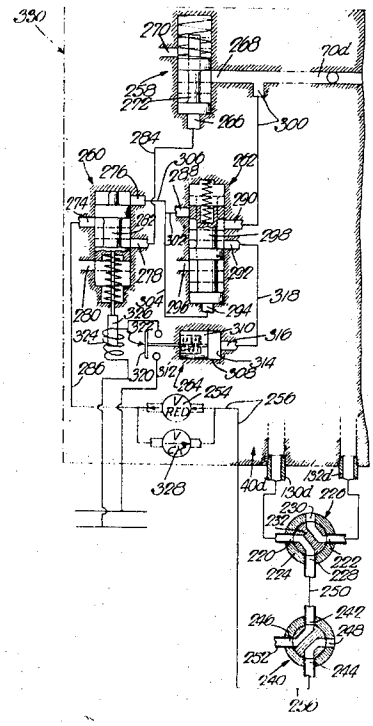
[57] **ABSTRACT**

Fluid-actuated chuck-operating mechanism having an operationally turning cylinder with a piston therein, a swivel coupling with companion parts of which one part turns with the cylinder and the other part is operationally non-turning, with operating fluid under a given high-level pressure being supplied to the non-turning coupling part for its transmission through the latter part and its turning companion part to either cylinder end, and a unit having operating parts embodied in the non-turning coupling part and operative to lock the operating fluid in at least the chuck-closing cylinder end in case the pressure of the supply fluid to the latter should during a chuck operation drop from any cause below the pressure of the operating fluid in this chuck-closing cylinder end, and featuring a device for decreasing the pressure of the fluid in the chuck-closing cylinder end from the given high-level pressure to a given low-level pressure, which includes a manual control and a fluid passage by-passing the operating parts of the fluid-lock unit and leading directly to a fluid passage in the non-turning coupling part which, through a passage in the turning coupling part, is in permanent communication with the chuck-closing cylinder end, with this device being, on manipulation of the control, operative to vent the chuck-closing cylinder end until the pressure of the fluid therein reaches a given minimum level below the given low-level pressure, then discontinue venting of this cylinder end and apply to the latter fluid under the given low-level pressure.

3 Claims, 7 Drawing Figures



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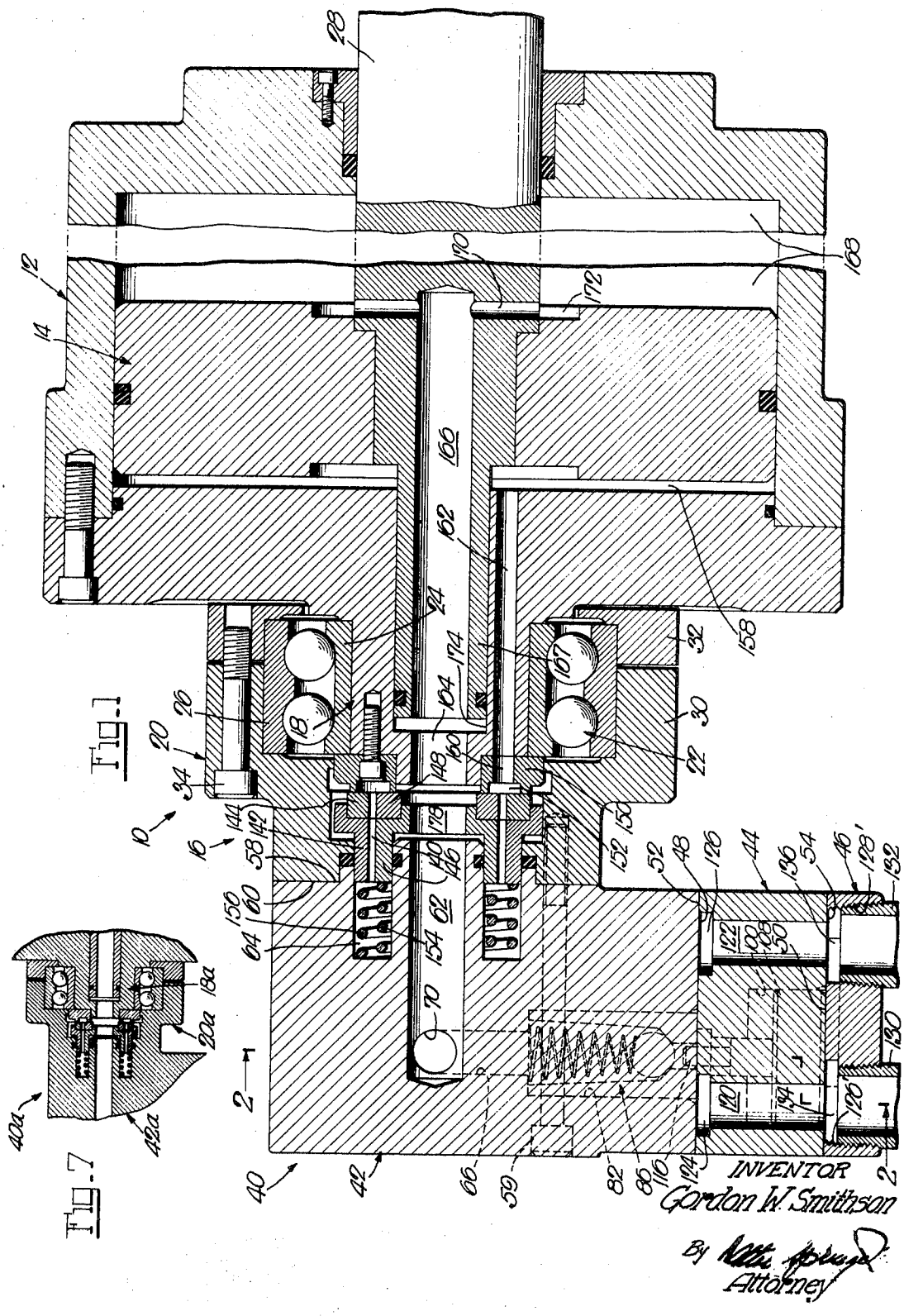

Fig. 1

Fig. 7

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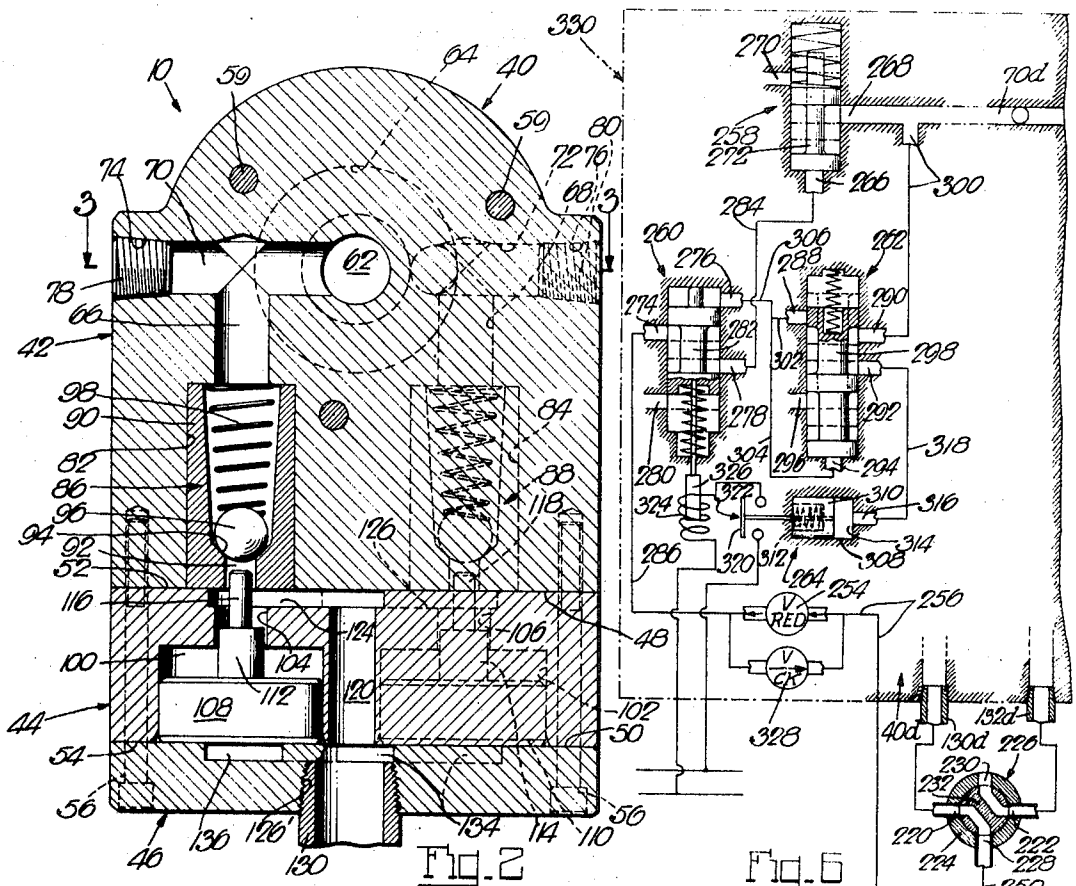

Fig. 2

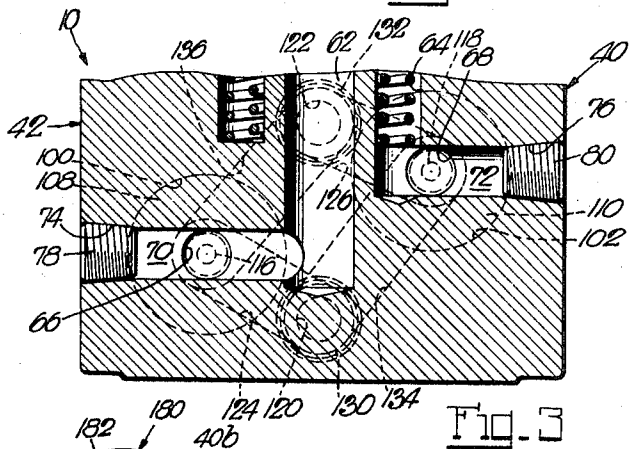

Fig. 3

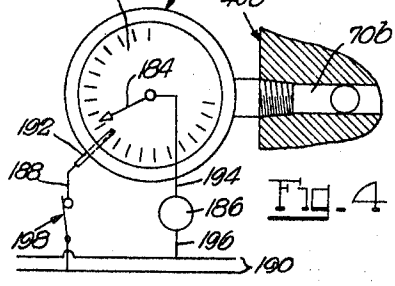

Fig. 4

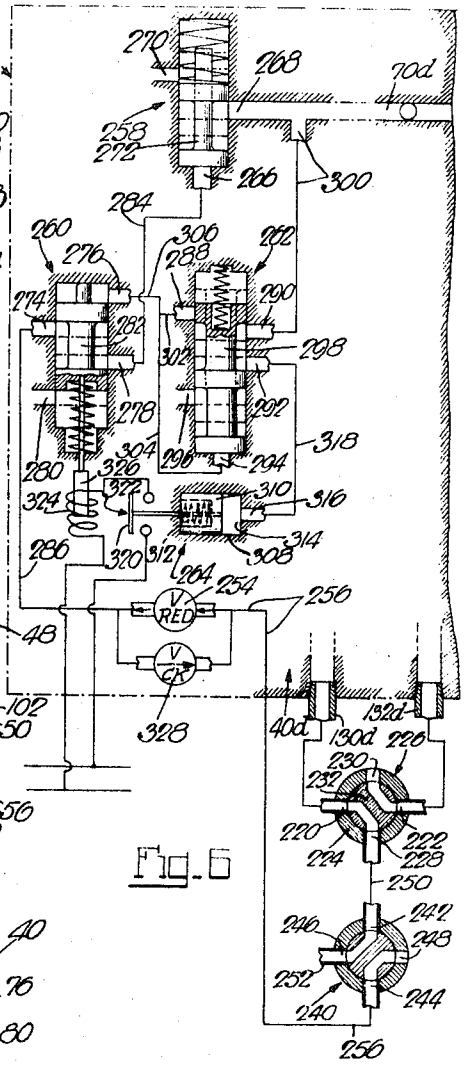

Fig. 6

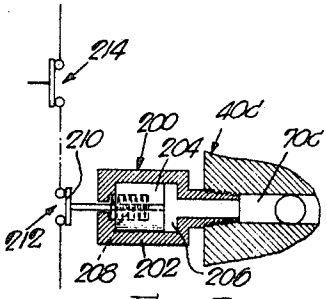

Fig. 5

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FLUID-ACTUATED CHUCK-OPERATING MECHANISM WITH A FLUID LOCK

This is a division of my copending application Ser. No. 30,636, filed Apr. 22, 1970, now abandoned.

This invention relates to fluid-operated chucks in general, and to fluid-operating mechanism of high-low operation for rotary chucks in particular.

Conventional fluid-operating mechanism for rotary chucks provide a cylinder, usually double-acting, and a piston therein, as well as a swivel coupling. The cylinder is customarily adapted for mounting on the chuck-carrying spindle of a lathe or the like so as to be turnable therewith, and the piston is adapted for operative connection with the jaw actuator of the chuck, while the swivel coupling has companion parts of which one part turns with the cylinder and the other part is connectible with two conduits and held against rotation, with these coupling parts being suitably ported for fluid flow between the conduits and the opposite sides, respectively, of the cylinder. There is also provided a control valve which for operation of the mechanism is connected with the two conduits and with a fluid pressure source, with the control valve being shiftable into two positions, in one position of which fluid from the source is admitted into the chuck-closing cylinder side and the opposite, chuck-opening, cylinder side is simultaneously vented, and in the other position fluid from the source is admitted into the chuck-opening cylinder side and the chuck-closing cylinder side is simultaneously vented.

There is also known fluid-operating mechanism of a type which will act to lock the operating fluid at least in the chuck-closing cylinder side whenever the pressure of the supplying fluid drops below a safe work-gripping pressure from any cause whatever, including a leak or break anywhere in the supply line to this cylinder side. This is achieved by interposing a check valve in that part of the fluid passage which leads to the chuck-closing side of the cylinder, with the check valve opening to admit fluid into, but closing to block fluid flow from, this cylinder side, and providing a plunger which is subjected to fluid in the part of the fluid passage that leads to the chuck-opening side of the cylinder, and which on admission of operating fluid into this passage part for work release, opens the check valve for venting the chuck-closing cylinder side. The check valve and plunger are provided in a self-contained "fluid-lock" unit which may either be directly embodied in, or formed separately and removably mounted on, the operationally non-turning part of the swivel coupling so as to be operationally stationary in either case, with this unit having conduit connections and being ported to link with the ports in the swivel coupling that lead to the opposite cylinder sides.

It is an object of the present invention to provide fluid-operating mechanism of the aforementioned type which lends itself to high-low operation, i.e., operation under manual control to supply the chuck-closing cylinder side with operating fluid under a given high-level pressure for an initial part of a machining operation on work held in an associated closed chuck, then under automatic or manual control vent the chuck-closing cylinder side until the pressure of the operating fluid therein drops to a given minimum level below a given low level, and then immediately supplying the chuck-closing cylinder side with operating fluid under pressure of the given low level for the conclusion of the machining operation on the work in the associated chuck.

Further objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a section through fluid-operating mechanism embodying the present invention;

FIG. 2 is a section through a fluid-lock unit of the mechanism taken substantially on the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary section through the same unit taken on the line 3—3 of FIG. 2;

FIGS. 4 and 5 are fragmentary diagrammatic views, partly in section, of the mechanism of FIG. 1, but embodying different safe-operation devices;

FIG. 6 is a diagrammatic view, partly in section, of fluid-operating mechanism of high-low operation which embodies the invention; and

FIG. 7 is a fragmentary section through modified fluid-operating mechanism.

Referring to the drawings, and more particularly to FIGS. 1 to 3 thereof, the reference numeral 10 designates fluid-operating mechanism having a cylinder 12 with a piston 14 therein, and a swivel coupling 16 having companion parts 18 and 20, and including in this instance an antifriction bearing 22 with inner and outer races 24 and 26. The cylinder 12 is adapted for mounting on a chuck-carrying power spindle of a lathe or the like and, hence, is operationally turning, and the piston 14 has a rod 28 adapted for usual connection with a draw bar to operate a jaw actuator of the chuck (neither shown). The piston 14 is made to turn with the cylinder 12 by suitable provisions (not shown). The coupling part 18, on which the inner race 24 of the antifriction bearing 22 is mounted, is carried by, and in this instance formed integrally with, the cylinder 12 and, hence, turns with the latter, while the other coupling part 20, in which the outer bearing race 26 is mounted, is operationally non-turning. The non-turning coupling part 20 is formed in two sections 30 and 32 which at 34 are bolted together and straddle the outer bearing race 26 so as to be held against axial removal from the turning coupling part 18. The coupling parts 18 and 20 have orifices to-be-described which lead to the interior of the cylinder.

The fluid-operating mechanism also provides a fluid-lock unit 40 which is separate from the non-turning coupling part 20, but is mounted thereon so as to be operationally non-turning. The unit 40 is formed, preferably and advantageously, in two casing sections 42 and 44 and a cover section 46, of which the sections 42 and 46 are end sections having mounting surfaces 48 and 50, respectively, while section 44 is an intermediate section having opposite mounting surfaces 52 and 54 which in the assembled relation of the sections are adjacent the mounting surfaces 48 and 50 of the respective end sections 42 and 46, with suitable gaskets (not shown) being preferably interposed between adjacent mounting surfaces. The unit sections 42 to 46 are assembled by being removably secured to each other, as by bolts 56 (FIG. 2), with their mounting surfaces adjacent each other and preferably having interposed gaskets.

The end section 42 has an adapter end or surface 58 for mounting on a matching adapter end or surface 60

of the non-turning coupling part **20**. The end section **42**, and therewith the entire unit **40**, is removably mounted on the non-turning coupling part **20**, as by bolts **59**, for example. Provided in the adapter surface **58** of the end section **42** are a bore **62** and a ring-shaped recess **64** which is concentric with the bore **62**. The end section **42** is further provided with two spaced, parallel fluid passages or bores **66** and **68** which in this instance extend with their axes normal to the axis of the bore **62** and lead into transverse passages or bores **70** and **72**, respectively, which lead to the bore **62** and ring-shaped recess **64**, respectively, and have their open ends **74** and **76** threaded for reception in this instance of plugs **78** and **80** (see also FIG. **3**). The fluid passages **66** and **68** are at the mounting surface **48** counterbored to provide seats **82** and **84** for exemplary two check-valve assemblies **86** and **88**, respectively. Since both check-valve assemblies are identical, only one will be described in detail. Thus, the valve assembly **86** provides a cylindrical body **90** which is fittedly received in the seat **82** and has a fluid passage **92** with an interposed valve seat **94**, with the valve proper being preferably a ball **96** which is normally urged against the seat **94** by a spring **98**. Accordingly, the valve **96** will permit fluid flow to the bore **62** through the passages **66** and **70**, but will normally lock these passages against fluid flow in the opposite direction. Similarly, the other valve assembly **88** will permit fluid flow to the ring-shaped recess **64** through the passages **68** and **72**, but will normally lock these passages against fluid flow in the opposite direction.

The intermediate unit section **44** has in its mounting surface **54** two spaced, machined annular recesses **100** and **102** which are in axial alignment with the respective check-valve assemblies **86** and **88**, and are in this instance continued as diametrically-reduced bores or passages **104** and **106** to the opposite mounting surface **52**. The annular recesses **100** and **102** constitute cylinder formations for plungers **108** and **110** which in this instance have shanks **112** and **114** and valve-opening pins **116** and **118**, respectively, of which the shanks **112** and **114** have in this instance a sliding fit in the bores **104** and **106**. The intermediate unit section **44** is also provided with two through-passages or bores **120** and **122** which are spaced from the annular recesses **100** and **102** and are open at both mounting surfaces **52** and **54**, and is further provided in its mounting surface **52** with grooves **124** and **126**, of which groove **124** provides communication between through-passage **120** and check-valve assembly **86**, while groove **126** provides communication between the other through-passage **122** and the other check-valve assembly **88** (see also FIG. **3**). Accordingly, on admission of fluid pressure into through-passage **120**, check valve **86** will be opened for fluid flow to the bore **62** via the passages **66** and **70**, while on admission of fluid pressure into the other through-passage **122**, the other check valve **88** will be opened for fluid flow to the annular recess **64** via the passages **68** and **72**.

The cover section **46** is provided in its mounting surface **50** with two through-holes **126'** and **128'** which are aligned and in communication with the through-passages **120** and **122**, respectively, in the intermediate unit section **44**, and in this instance are threaded and connected with conduits **130** and **132**. Further provided in the mounting surface **50** are two grooves **134** and **136**, of which groove **134** provides communication between conduit **130** and plunger **110**, while groove **136** provides communication between the other conduit **132** and the other plunger **108** (see also FIG. **3**).

The aforementioned orifices in the swivel coupling **16** that extend to the interior of the cylinder **12** lead from the adapter end **60** of the nonturning coupling part **20**, of which one of these orifices in the coupling part **20** is a ring-shaped passage **140** formed in this instance between outer rings **142** and **144** and the outer peripheries of inner rings **146** and **148**, of which the outer and inner rings **144** and **148** are of any suitable wear-resistant material of good sealing properties, and are nested in the respective outer and inner rings **142** and **146**. These sealing rings **144** and **148** bear against a slip ring **150** on the turning coupling part **18** for providing communication between the ring-shaped passage **140** in the non-turning coupling part **20** and an annular groove **152** in the operationally turning slip ring **150**. The outer and inner rings **142** and **146** are fitted in the ring-shaped recess **64** in the unit section **42** in which there are also springs **154** and **156** that urge the rings **144** and **148** against the slip ring **150** with appropriate sealing pressure. The annular groove **152** in the slip ring **150** is in communication with the cylinder end **158** via a duct **160** in this slip ring and continuing duct **162** in the turning coupling part **18**.

The other orifice part in the non-turning coupling part **20** is formed by a central duct **164** therein and a continuing duct **166** in a reduced shank **167** of the piston rod **28** which leads to the opposite cylinder end **168** via a transverse bore **170** in the rod **28** and a recess **172** in the piston **14**, with the shank **167** having a sliding fit in an annular recess **174** in the turning coupling part **18**.

For operation of the mechanism, the conduits **130** and **132** are connectible with a suitable fluid-pressure source, usually compressed air, by means of a two-way control valve (not shown). Thus, in on position of the control valve fluid pressure is admitted to the conduit **130** and the other conduit **132** is vented, and in the other valve position fluid pressure is admitted to the conduit **132** and the conduit **130** is vented. Assuming now that the cylinder end **168** is the chuck-closing end, and that the associated chuck is to be closed, the control valve is operated to admit fluid pressure from the source to the conduit **130** and vent the other conduit **132**. The fluid pressure admitted to the conduit **130** passes through bore **120** and groove **124** to open check valve **86** and continue its pass to the cylinder end **168** via the passages **66**, **70** and **62** in the unit **40** (FIG. **2**), thence through the successive passages **178**, **164**, **166** and **170** (FIG. **1**). The fluid pressure admitted to the conduit passes also through the groove **134** to the plunger **110** to open the other check valve **88** and thereby to vent the opposite cylinder end **158** through the straight passages **162** and **160**, the ring-shaped passages **152** and **140**, annular recess **64**, passages **72** and **68**, open check valve **88**, groove **126**, and passage **122** which is open to the vented conduit **132**. Accordingly, on admission of fluid pressure to the conduit **130**, fluid pressure passes to the cylinder end **168** and the other cylinder end **158** is simultaneously vented, with the result that the associated chuck is closed.

In order to open the associated chuck, the control valve is operated to admit fluid pressure from the source to the conduit **132** and vent the other conduit **130**. As a result, fluid pressure passes to the cylinder

end 158 via passage 122 and groove 126 to open check valve 88, thence through passages 68 and 70, recess 64, ring-shaped passages 140 and 152, and straight passages 160 and 162. Fluid pressure admitted to the conduit 132 also passes through groove 136 to the plunger 108 (FIGS. 2 and 3) for opening the check valve 86, and thereby vent the other cylinder end 168 via the passages 166, 164, 178, and 62 (FIG. 1), passages 70 and 66, the open check valve 86, groove 124 and passage 120 which is open to the vented conduit 130.

If after once closing the associated chuck on work with a safe grip, there should occur from any cause whatever a sudden pressure drop, or failure altogether, of the fluid source, or a leak anywhere in the fluid pressure line from the source to the check valve 86 which would cause the pressure of the fluid at this check valve to drop below the pressure of the operating fluid in the chuck-closing cylinder end 168, the check valve 86 will immediately be spring-closed and thus lock the operating fluid in this cylinder end and hold it at its safe work-gripping pressure, so that the work, when once safely gripped, may be turned at normal speed and machined while remaining safely gripped. It is, of course, advantageous to provide for ready indication to an operator of such pressure drop or failure of the fluid source, or leak in the fluid line from the source to the check valve 86, in order to avoid renewed closing of the chuck with less-than-safe pressure of the fluid, and this may be achieved by connecting with this fluid line, preferably close to the check valve 86, any suitable pressure-sensing instrumentality (not shown) to visibly indicate the sensed pressure or to activate any suitable alarm device when the sensed pressure is below safe work-gripping pressure.

If the opposite cylinder end 158 should be the chuck-closing end, then the other check valve 88 will similarly respond to a pressure drop or failure of the fluid, or a leak in the fluid line from the source to this check valve, by closing and thereby locking the operating fluid in the chuck-closing cylinder end 158 and holding it at its safe work-gripping pressure.

While the described fluid-lock unit 40 is adapted to the non-turning part of the swivel coupling, FIG. 7 shows a modified fluid-lock unit 40*a* which in all respects is like the unit 40, except that its end section 42*a* also embodies the non-turning coupling part 20*a* for assembly of the unit 40 with the rest of the mechanism by connection of its coupling part 20*a* with the turning coupling part 18*a* of the mechanism.

The described fluid-lock unit, by being operationally stationary, is further advantageous in that the same may perform a further function of safe chuck operation, namely to sense the actual pressure of the operating fluid in the chuck-closing cylinder end, and to visibly indicate the sensed pressure at all times and/or sound an alarm or stop the chuck drive when the sensed pressure is for any reason below safe work-gripping pressure. Thus, FIG. 4 shows fluid-operating mechanism having a fluid-lock unit 40*b* which may in all respects be like the described unit 40, for example, except that the plug has been removed from the bore 70*b* and there is connected therewith a pressure gauge 180 with a graduated dial 182 and a pointer 184. The bore 70*b* forms in this instance a part of the fluid passage to the chuck-closing cylinder end of the mechanism, so that the pressure gauge 180 visibly indicates at any time the actual pressure of the operating fluid in the chuck-closing cylinder end. This holds true even if there should develop a fluid leak in the swivel coupling with an ensuing pressure drop in the chuck-closing cylinder end, for substantially the same pressure drop would then also occur at the nearby pressure gauge 180, and it holds further true if a pressure drop in the operating fluid in the chuck-closing cylinder end is occasioned by fluid leakage across the piston to the other cylinder end on breakdown of the usual sealing ring in the piston, for example. Of course, the pressure gauge 180, by visibly indicating the pressure of the operating fluid in the chuck-closing cylinder end at any time, also affords detection of either or both of the fluid leaks just mentioned and thus makes for further enhanced safety in chuck operation.

This enhanced safety in chuck operation is carried further by associating with the pressure gauge 180 an electric alarm 186, such as a bell, for instance, having a circuit which comprises a lead 188 from one side of a power line 190, a contact 192 at the dial 182, a pointer 184, a lead 194 from the pointer 184 to the alarm 186, and a lead 196 from the alarm 186 to the other side of the power line. The contact 192 may be set at a pressure indication on the dial which denotes a given lower-than-permissible, but not yet dangerously low, "alarm" pressure, whereby on a pressure drop of the fluid sensed by the pressure gauge to this given alarm pressure, the alarm 196 will sound. To avoid sounding of the alarm 186 on releasing gripped work and while the chuck-closing cylinder end is vented, there is preferably interposed in the lead a switch 198 which by suitable provisions (not shown) is open except while work is gripped by the associated chuck.

Safe chuck operation is carried still further with the fluid-lock unit 40*c* of FIG. 5, in which the bore 70*c* is connected with a pressure-sensing instrumentality 200 in the exemplary form of a cylinder 202 with a piston 204 therein, with one cylinder end 206 being in communication with the bore 70*c* and thus subjected to fluid pressure therein. The piston 204 is by a calibrated spring 208 urged toward the cylinder end 206, and carries the movable contract 210 of a switch 212. As long as fluid pressure in the bore 70*d* and, hence, in the chuck-closing cylinder end, is at a given safe work-gripping pressure, this fluid pressure will cause the piston 204 to keep the switch 212 closed, as shown, with this switch 212 being in series connection with a main switch 214 for the power drive of the chuck. If for any reason the pressure of fluid in the bore 70*c* and, hence, in the chuck-closing cylinder end, should drop below the given safe work-gripping pressure during chuck operation, the spring 208 will urge the piston 204 from its shown switch-closing position, whereby immediately on opening of the switch 212 the power drive of the chuck will be stopped even though the main switch 214 remains closed.

The fluid-lock unit, by being operationally stationary, also lends itself to a featured high-low chuck operation. Such chuck operation is highly desirable for many applications requiring an initial heavy grip on work followed by a lighter work grip without stopping the chuck drive. Just one example of such an application is specified external rough-machining of internally gripped sleeve-type work to a smaller outer diameter requiring a heavy work grip, followed by specified external finish-machining of the internally-gripped work requiring a lighter work grip to avoid fracturing of the

progressively more fragile work. Such chuck operation requires, for initial rough machining of work, operating fluid of a given high pressure in the chuck-closing cylinder end of fluid-operating mechanism, and requires, for the following finish-machining of the work, fluid of a given lower operating pressure in this chuck-closing cylinder end. The change from the high pressure to the lower pressure of the operating fluid in the chuck-closing cylinder end is achieved by bleeding fluid from this cylinder end while leaving the other cylinder end vented. However, while the given lower pressure is fully adequate to hold the work safely gripped for finish-machining, mere reduction of the pressure of the fluid in the chuck-closing cylinder end to the given lower pressure by bleeding this cylinder end, is mostly insufficient to permit operating chuck parts to break loose from their tight binding engagement ensuing from the heavy work grip exertion. Accordingly, in order to permit these operating chuck parts to break loose from their tight binding engagement and thereby relax the heavy work grip in the first place, the pressure of the fluid in the chuck-closing cylinder end must be reduced from the given high pressure momentarily to a given minimum pressure below the given lower pressure, with the chuck responding to this minimum pressure in relaxing the heavy work grip. Accordingly, for high-low chuck operation, the fluid-operating mechanism must function to first admit to the chuck-closing cylinder end fluid under the given high pressure, then bleed fluid from this cylinder end until the pressure of the fluid therein drops to the given minimum pressure, and then immediately admit to this cylinder end fluid at the given lower operating pressure.

FIG. 6 shows diagrammatically fluid-operating mechanism, including a fluid-lock unit 40*d*, for high-low chuck operation as just explained. The fluid-lock unit 40*d* may in all respects be like the unit 40 of FIGS. 1 to 3 or the unit 40*a* of FIG. 7, and all there is shown of this unit is the bore 70*d* which in this instance is part of the fluid passage to the chuck-closing cylinder end, and the conduits 130*d* and 132*d* which are parts of the fluid passages to the chuck-closing and chuck-opening cylinder ends, respectively. These conduits 130*d* and 132*d* are shown connected to ports 220 and 222 in the body 224 of a two-way valve 226, with this body having another port 228 and a vent opening 230, and the turnable valve member 232 has two orifices for connecting certain of the ports with each other and with the vent opening 230. Associated in this instance with the valve 226 is another two-way valve 240 the body of which has three ports 242, 244 and 246 and a vent opening 248, and the turnable valve member thereof has two orifices for connecting certain of the ports with each other and with the vent opening 248. In this instance, the ports 228 and 242 of the valves 226 and 240 are connected with each other through a conduit 250, and the port 246 of valve 240 is through a conduit 252 connected with any suitable fluid-pressure source at the given high pressure.

High-low chuck operation also requires another fluid-pressure source at the given lower pressure. To this end, there is provided a pressure-reducing valve 254 with an inlet and an outlet, of which the inlet is through a conduit 256 connected with the port 244 in the valve 240. Accordingly, on shifting valve 240 into the position other than that shown, fluid from the high-pressure source is through conduits 252 and 256 admitted to the inlet of the pressure-reducing valve 254, so that the fluid pressure in the outlet of this valve is at the given lower pressure and, hence, constitutes the fluid-pressure source of the given lower pressure.

High-low chuck operation further requires certain valve and other instrumentalities. These are a "first" valve 258, a "second" valve 260, a "third" valve 262, and an instrumentality 264.

The first valve 258 has in its body two ports 266 and 268 and a vent opening 270, and the shiftable valve member 272 is normally spring-urged into the full-line position in which to intercept communication between port 268 and vent opening 270, and is on admission of fluid pressure into the other port 266 shifted to its other, dot-and-dash line position in which to provide communication between port 268 and vent opening 270. Port 170 is in open communication with bore 70*d* and, hence, with the chuck-closing cylinder end.

The second valve 260 has in its body three ports 274, 276 and 278 and a vent opening 280, and the shiftable valve member 282 is normally spring-urged into the full-line position in which to provide communication between the ports 274 and 278, and is shiftable into the other, dot-and-dash line position in which to provide communication between the ports 274, 276 and provide also communication between port 278 and vent opening 280. Port 278 is through a conduit or "first duct" 284 connected with the port 266 in the first valve 258, while port 274 is connected with the outlet of the pressure-reducing valve 254 by a conduit or "third duct" 286.

The third valve 262 has in its body four ports 288, 290, 292 and 294 and a vent opening 296, and the shiftable valve member 298 is normally spring-urged into the full-line position in which to provide communication between the ports 290 and 292, and is on admission of fluid pressure to the port 294 shifted to its other, dot-and-dash line position in which to provide communication between the ports 288 and 290 and also provide communication between port 292 and vent opening 296. Port 290 is through a conduit or "fourth duct" 300 connected with the bore 70*d* and, hence, with the chuck-closing cylinder end, while the ports 288 and 294 are connected with branches 302 and 304, respectively, of a conduit 306 which, in turn, is connected with the port 276 in the second valve 260.

The instrumentality 264 provides a cylinder 308 and a piston 310 therein which is normally urged by a spring 312 against the cylinder end 314. The cylinder 308 has in its end 314 a port 316 which through a conduit 318 is connected with the port 292 in the third valve 262. The piston 310 carries the movable contact 320 of a switch 322 which is open, as shown, when the piston 310 is shifted to the position shown by fluid pressure in the cylinder end 314. The switch 322 is in the circuit of a relay 324 which includes an armature 326 carried by the shiftable valve member 282 of the second valve 260. Assuming that the pressure-reducing valve 254 is of a type passing fluid in the direction of the arrows, but not in the opposite direction, there is provided a check valve 328 in bypass relation with the pressure-reducing valve 254 to permit venting of the third duct 286 via the check valve 328.

Following is a description of a high-low chuck-operating performance of the mechanism. In order to chuck work with the heavy grip and retain the heavy work grip during initial rough-machining of the work,

the two-way control valves 240 and 226 are set, as shown, to admit fluid pressure from the high-pressure source to the chuck-closing cylinder end of the mechanism, via conduit 252, valve 240, conduit 250, valve 226, and conduit 130d which through the fluid-lock unit 40*d*, including bore 70*d*, communicates with the chuck-closing cylinder end, while the opposite, chuck-opening cylinder end is then vented via the fluid-lock unit 40*d*, conduit 132*d* and vent opening 230 in control valve 226. While the work is thus being gripped and held gripped with the heavy grip, the first, second and third valves 258, 260 and 262 and the instrumentality 264 assume the respective full-line positions in which the first valve 258 prevents venting of the chuck-closing cylinder end, and the third valve 262 subjects the piston 310 of the instrumentality 264 to fluid under the pressure of the fluid in the chuck-closing cylinder end to hold switch 322 open.

With rough-machining of the work finished, the heavy work grip is relaxed and then held at the lighter work grip required for finish-machining the work. To this end, control valve 240 is shifted to its other position in which to provide communication between the high-pressure fluid source and pressure-reducing valve 254 via conduit 252, the ports 246 and 244 of valve 240, and conduit 256, thereby passing from the outlet of this pressure-reducing valve fluid at the given lower pressure. In thus shifting control valve 240 to its other position, and leaving the other control valve 226 in the position shown, the conduit 130*d* of the fluid-lock unit 40*d* is vented via valve 226, conduit 250 and port 242 and vent opening 248 of control valve 240. However, even though the conduit 130*d* of the fluid-lock unit 40*d* is then vented, the high-pressure operating fluid in the chuck-closing cylinder end remains locked therein by the check valve in the fluid-lock unit which is associated with this chuck-closing cylinder end.

Fluid passing from the outlet of the pressure-reducing valve 254 at the given lower pressure passes to the first valve 258 via the third duct 286, the second valve 260, and the first duct 284, thereby opening this first valve for bleeding operating fluid from the chuck-closing cylinder end via bore 70*d* and port 268 and vent opening 270 of the first valve. With the cylinder end 314 of the instrumentality 264 being then also connected with the bore 70*d* via conduit 318, the third valve 262 and the fourth duct 300, there takes place an equal pressure drop of the fluid in the cylinder end 314 and in the chuck-closing cylinder end on thus bleeding fluid from the latter. This fluid-pressure drop continuous until the spring 312 forces the piston 310 of the instrumentality 264 toward the cylinder end 314 to an extent where the associated switch 322 is closed, with the spring 312 being calibrated to close this switch 322 at the given minimum pressure of the fluid in the cylinder end 314, and this given minimum pressure, being less than the given lower pressure, is adequate to permit the operating chuck parts to break loose from their tight binding engagement and relax the heavy work grip sufficiently to avoid in any event fracture of the now more fragile work prior to and during finish-machining of the same. It is to be distinctly understood, however, that the pressure drop of the fluid involved is reached only momentarily, for bleeding of fluid from the chuck-closing cylinder end is stopped and fluid under the given lower pressure is admitted to the latter the moment switch 322 is closed.

Closure of the switch 322 in this manner closes the circuit of the solenoid 324 which causes a shift of the second valve 260 to its dot-and-dash line position, in which port 266 of the first valve 258 is vented through the vent opening 280 in the second valve 260 to permit spring-closure of this first valve, and fluid under the given lower pressure in the third duct 286 is through this second valve, conduit 306 and branch 304 thereof admitted to the port 294 in the third valve 262 to shift the latter to its dot-and-dash line position. With this third valve 262 in its dot-and-dash line position, fluid under the given lower pressure in the conduit 306 is, through its other branch 302, valve 262, fourth conduit 300 and bore 70*d* also admitted to the chuck-closing cylinder end for applying to the work the lighter grip which safely holds the work for finish-machining without any danger of fracturing the work. Further, simultaneously with the shift of the third valve 262 into its dot-and-dash line position, this valve interrupts communication between the fourth conduit 300 and the conduit 318 which leads to the cylinder end 314 of the instrumentality 264, and provides communication between this conduit 318 and the vent opening 296 in the third valve 262, thus venting the cylinder end 314 and spring-holding piston 310 in position to keep switch 322 closed. With the switch 322 being thus held closed, the second valve 260 remains in its dot-and-dash line position in which the chuck-closing cylinder end remains subjected to fluid under the given lower pressure, thereby keeping the safe lighter grip on the work for its finish machining.

Once the work is finish-machined and the chuck drive stopped, the work is released from the chuck. This is achieved preferably by first returning control valve 240 to its position as shown, and immediately thereafter shifting the other control valve 226 to the position other than that shown, thereby providing communication between the high-pressure fluid source and conduit 132*d* of the fluid-lock unit via conduit 252, ports 246 and 242 of valve 240, conduit 250, and ports 228 and 222 of valve 226, and simultaneously venting the other conduit 130*d* of the fluid-lock unit 40*d* via port 220 and vent opening 230 in valve 226. Further, in thus shifting the control valve 240, the same on the one hand intercepts communication between the high-pressure fluid supply and conduit 256 so that fluid under the given lower pressure no longer passes to the chuck-closing cylinder end, and on the other hand provides communication between conduit 256 and vent opening 248 in the valve to vent port 294 of the third valve 262 via conduit branch 304, conduit 306, the second valve 260, the third duct 286, check valve 328, conduit 256 and control valve 240, and thereby permit spring-return of the third valve 262 to its full-line position.

In providing communication between the high-pressure fluid source and conduit 132*d* of the fluid-lock unit 40*d* and simultaneously venting the other conduit 130*d* of this fluid-lock unit in the manner just described, operating fluid under high pressure is admitted to the chuck-opening cylinder end and the opposite, chuck-closing cylinder end is simultaneously vented as will be readily understood from the preceding description of the operation of the fluid-lock unit, resulting in release of the work from the chuck. In view of the above-mentioned preferred sequential shift of the control valves 240 and 226, spring-return in the manner

just described of the third valve **262** to its full-line position will occur just before the chuck-closing cylinder end is vented, so that the cylinder end **314** of the instrumentality will again be subjected to fluid under the given lower pressure to cause opening of the circuit of the solenoid **324** at the switch **322** and, hence, spring-return of the second valve **260** to its full-line position, but this fluid will then temporarily remain in this cylinder end until the latter is vented simultaneously with the chuck-closing cylinder end via the fluid-lock unit **40***d*, at which time the solenoid circuit will be reclosed and the second valve **260** shifted to its dot-and-dash line position. However, reclosure of the solenoid circuit and ensuing shift of the second valve **260** in no wise interferes with proper high-low chuck operation, for even though this second valve **260** remains in its dotted-line position during the interim between work-release from the chuck and gripping new work in the chuck, the first and third valves **258** and **262** and the instrumentality **264** are during this interim in positions to start a new high-low chuck operation, meaning that while the instrumentality **264** will during this interim keep the solenoid circuit closed, this instrumentality will on the start of the next high-low chuck operation respond immediately to renewed admission of high-pressure to the chuck-closing cylinder end in opening the solenoid circuit and permit spring-return of the second valve **260** to its full-line position. Hence, to start a new high-low chuck operation, it is merely necessary to return control valve **224** to the position shown, and leave the other control valve **240** in the position shown, whereupon high-low chuck operation identical with the one described will take place.

The first, second and third valves **258, 260, 262,** the instrumentality **264,** the pressure-reducing valve **254,** and their conduit connections, termed collectively a "high-low chuck-operating device" for simplicity of expression, may be provided outside the fluid-lock unit **40***b*, or may be embodied with the fluid-lock unit **40***b* in one self-contained unit **330.**

What is claimed is:

1. Fluid-operating mechanism for a chuck, comprising an operationally turning cylinder with opposite first and second ends and a piston therein; a swivel coupling having companion parts, of which one coupling part is operationally stationary, and the other coupling part is turnable with said cylinder and has first and second orifices leading to said first and second cylinder ends, respectively, said one coupling part having first and second apertures in communication with said first and second orifices, respectively, first and second conduit connections, first and second fluid passages leading from said first and second conduit connections to said first and second apertures, respectively, a check valve interposed in said first passage and normally closed against fluid flow in said first passage from said first cylinder end, a movable plunger operatively aligned with said check valve and having an end adapted on subjection to fluid pressure to move said plunger for opening said check valve, a port branching from said second passage and leading to said plunger end; first valve means shiftable into first, second and third positions, with said valve means in said first position providing communication between a first fluid source of a given high-level pressure and said first conduit connection and simultaneously venting said second conduit connection, and in said second position providing communication between said first fluid source and said second conduit connection and simultaneously venting said first conduit connection; and a device for decreasing the pressure of operating fluid in said first cylinder end from said high-level pressure to a certain low-level pressure, including said first valve means, and further providing a vent, second valve means normally closed to intercept communication between said vent and first aperture, and having an end adapted on subjection to fluid pressure to open said second valve means for providing communication between said vent and first aperture, third, fourth and fifth passages, of which said fifth passage leads to said end of said second valve means, and said fourth passage leads to said first aperture, third valve means normally urged into a first position in which to provide communication between said third and fifth passages, and shiftable into a second position in which to provide communication between said third and fourth passages and vent said fifth passage, with said first valve means in said third position providing communication between a second fluid source of said certain low-level pressure and said third passage, intercepting communication between said first fluid source and said first conduit connection, and venting said second conduit connection, and control means operative in said third position of said first valve means to shift said third valve means into said second position on a pressure drop of fluid in said first aperture to a given minimum level below said low-level pressure, and retain it in said second position while said first valve means is in said third position.

2. Fluid-operating mechanism as in claim **1** in which said control means provides an instrumentality including a cylinder chamber with another piston therein, and a spring urging said other piston to one end of said chamber, and operative on movement of said other piston to said one chamber end to shift said third valve means into said second position, and fourth valve means interposed in said fourth passage and dividing the latter into first and second branches of which said second branch extends between said fourth valve means and first aperture, with said fourth valve means being normally urged into a first position in which to intercept communication between said branches and provide communication between said second branch and said one chamber end, and being by fluid pressure in said first branch shifted into a second position in which to provide communication between said branches and vent said one chamber end, with said spring being calibrated to force said other piston to said one chamber end when the pressure of fluid in the latter is at and below said minimum level.

3. Fluid-operating mechanism as in claim **2,** which further provides a pressure-reducing valve with a fluid inlet and outlet, of which said outlet communicates with said third passage, and said first valve means in said third position providing communication between said first fluid source and said fluid inlet, intercepting communication between said first fluid source and said first conduit connection, and venting said second conduit connection, so that on connection of said inlet with said first fluid source fluid in said outlet constitutes said second fluid source of said low-level pressure.

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