March 26, 1963 J. B. McGAY ET AL 3,082,596

PNEUMATIC TIMED DRIVE

Filed Oct. 16, 1959 2 Sheets-Sheet 1

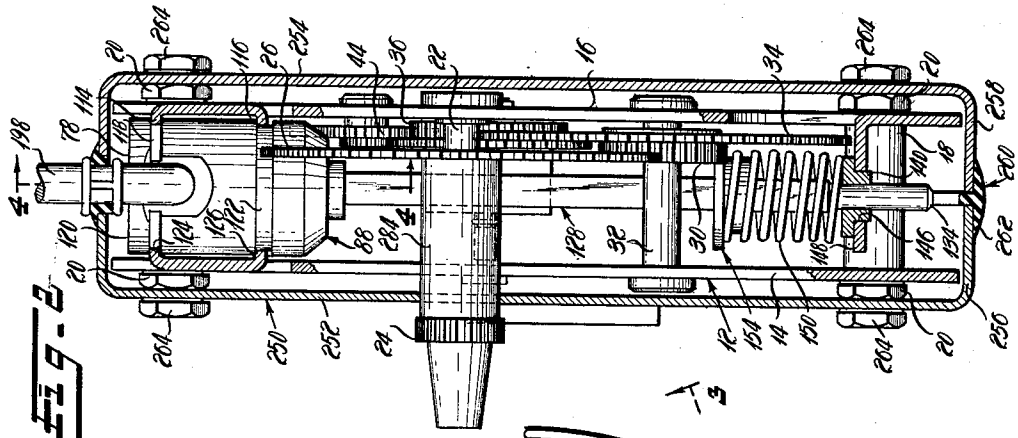


FIG. 2

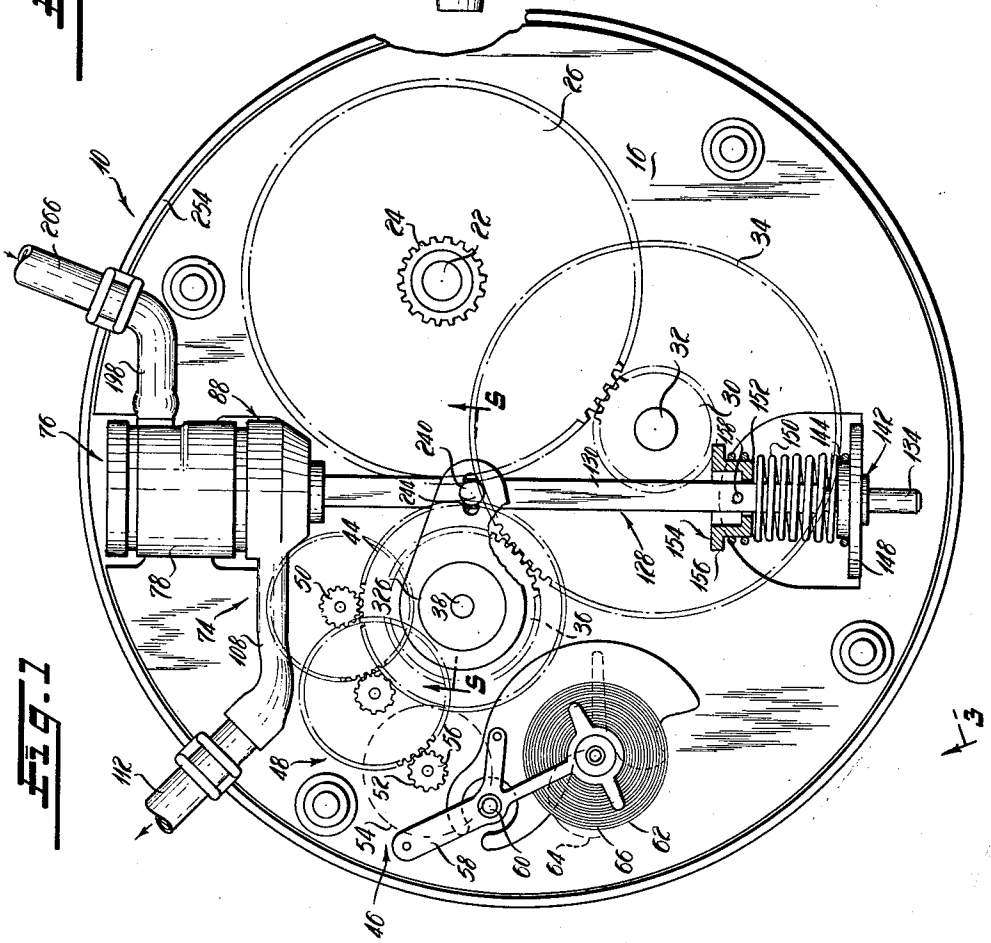


FIG. 1

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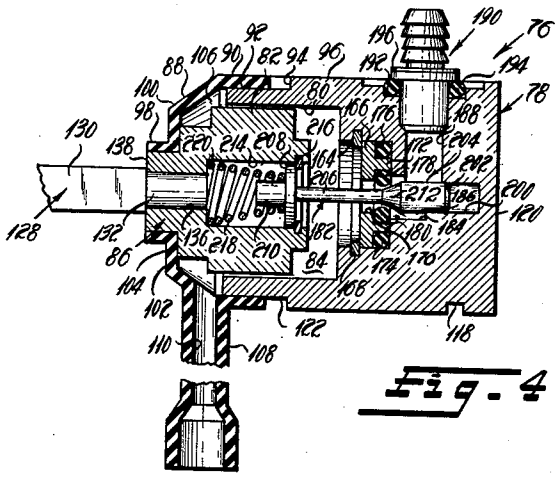


Fig. 4

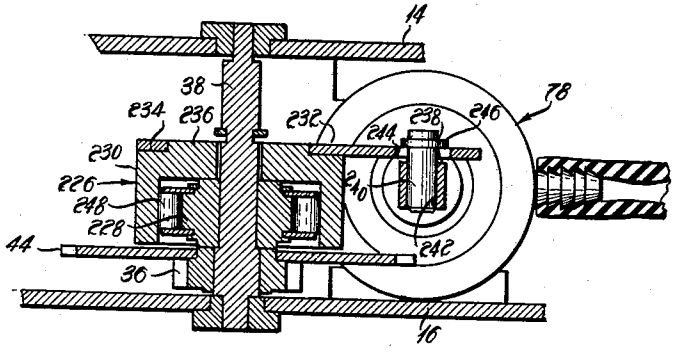


Fig. 5

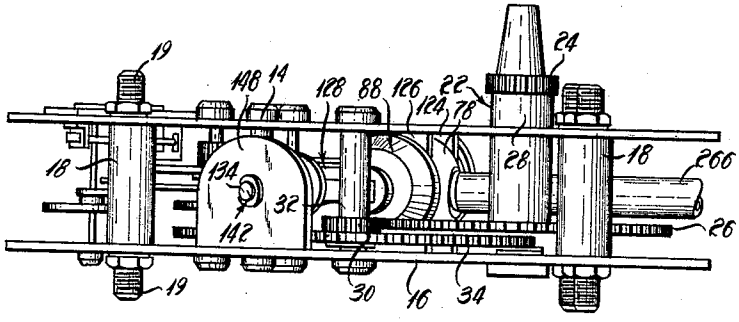


Fig. 3

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3,082,596

PNEUMATIC TIMED DRIVE

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Filed Oct. 16, 1959, Ser. No. 846,876
20 Claims. (Cl. 60—7)

This invention relates to a pneumatically powered timed drive mechanism and is particularly related to an escapement controlled spring powered drive utilizing intermittent power impulses of an automatically operable, pneumatic motor arranged as a compact unitary device for storing energy in the spring.

This application is a continuation-in-part of our copending application Serial No. 656,434 filed May 1, 1957.

As disclosed in said copending application Serial No. 656,434, one field of use of the present invention is for powering condition recording charts. The charts which are adapted to be driven by the present invention are conventionally either strip or circular charts and are normally driven in timed relationship with a recording device. A use of such charts is to record conditions of flow through pipe lines over selected periods of time. Such charts also can be used to provide a permanent record of electrical power flow through various machines or to record the continuing conditions for any factors of which permanent records are desired.

The present invention generally contemplates a unitary pneumatic power component basically consisting of a cylinder block with a reciprocable piston and internal valving directly cooperating with the piston for applying torque to an escapement mechanism and an output drive. In accordance with the present invention, the output drive is coupled to the escapement mechanism so that the rate of rotation of the drive is controlled thereby. The pneumatic power component is coupled to a source of fluid for firing the piston in one direction so as to stress an external spring, close the internal valving and move a drive member of a one-way clutch in its free rotating direction. The spring biasing force then returns the piston and moves the one-way clutch member in its driving direction to apply torque to the output drive under the control of the escapement mechanism. When the escapement mechanism has permitted a full return of the piston, the internal valving is automatically opened and the firing process is repeated.

The specific embodiment of the present invention disclosed herein contemplates a more compact, efficiently organized, easily assembled and repairable pneumatic powered time drive mechanism wherein all of the drive parts are safely enclosed within a cover assembly but are readily accessible for service. The present invention further contemplates a time drive mechanism and a self-contained pneumatic motor unit driving the mechanism and having a piston reciprocable in an open ended cylinder that is sealed by means including a special retainer boot which seals the open ended cylinder with the piston to prevent escape of working fluid into and around the drive and time escapement mechanism thereby precluding corrosion of the component parts of the drive mechanism when corrosive working fluids are used to power the motor unit.

The present invention further contemplates a motion converter including a pin and slot connection to convert the linear movement of the piston of the unit motor into rotary movement to thereby facilitate rotation of an output shaft. The components of the pin and slot connection cooperate with a specially formed planar surface of a piston rod connected to the piston to prevent the rod and the piston from turning to any appreciable degree.

By preventing the piston from turning the seal retaining boot sealingly engaging the piston and the cylinder block of the motor unit is maintained against being twisted or excessively stressed so as to preserve and lengthen its operating life.

Accordingly, a primary object of the present invention resides in the provision of a novel pneumatic powered timed drive mechanism which is compact, simple and inexpensive in construction and has relatively few parts.

Another object of the present invention resides in the provision of a novelly supported and easily assembled pneumatic timed drive assembly.

A further object of the present invention resides in the provision of a novel pneumatic powered timed drive mechanism having an automatically operable self-contained pneumatic motor unit operable to stress a spring and store energy for rotating a drive shaft under the control of an escapement wherein all the component parts are supported between two spaced frame members and wherein at least one frame member is provided with integral formations which structurally support and align the component parts of the pneumatic motor unit and the energy storing spring of the drive assembly.

Still another object of the present invention resides in the provision of novel timed drive assembly powered by a self-contained pneumatic motor unit having fluid inlet and outlet connections wherein the motor unit is sealed fluid-tight to prevent escape of fluid from the motor unit to the components of the timed drive assembly, thereby preventing corrosion of the timed drive assembly components when a corrosive fluid is used to power the motor unit.

Still another object of the present invention is to provide a novel pneumatic timed drive mechanism including a rotatable output shaft driven by a self-contained automatically operable pneumatic motor unit having a reciprocable power member wherein a motion converter mechanism including a pin and slot connection is provided for operatively connecting the reciprocable power member to the rotatable output shaft to transmit a driving torque for rotating the output shaft.

Another object of the present invention resides in the provision of a pneumatic timed drive mechanism as in the preceding object wherein the power member is connected to a piston rod having a specially formed surface cooperating with the component parts of the pin and slot connection to prevent the piston rod from turning in its bearings to any appreciable degree.

Further objects and advantages of the present invention will become apparent as the description proceeds in connection with the drawings, wherein:

FIGURE 1 is a front elevation partly in section of a pneumatic timed drive mechanism incorporating a preferred embodiment of the invention with the front support plate and the front cover plate removed;

FIGURE 2 is a right-hand side elevation of the timed drive mechanism of FIGURE 1 with a portion of the cover plate assembly broken away to show the component assembly;

FIGURE 3 is a plan view substantially along line 3—3 of FIGURE 1 with the cover plate assembly removed;

FIGURE 4 is a section along line 4—4 of FIGURE 2 illustrating the pneumatic motor unit of the timed drive mechanism; and

FIGURE 5 is a section along line 5—5 of FIGURE 1 illustrating the motion converter connection between the piston rod of the pneumatic motor unit and the components of the torque output gear train.

Referring now to the drawings and more particularly to FIGURES 1–3 wherein the construction embodying the principles of the present invention are shown, the

reference numeral 10 generally designates a pneumatic drive assembly adapted for powering a recording chart and having a support frame structure 12.

The support frame structure 12 comprises parallel flat-sided front and back support plates 14 and 16 held in spaced-apart parallel relation by a plurality of parallel shouldered spacer rods 18. Spacer rods 18 are provided with reduced diameter threaded opposite end sections 19 (FIGURE 3) which extend through apertures formed in plates 14 and 16 and threadedly receive nuts 20 for rigidly securing the support plates 14 and 16 and rods 18 in a unitary frame. The general outline of support plates 14 and 16 are substantially identical and are preferably round as shown in FIGURE 1.

An output shaft 22 journalled adjacent its ends in support plates 14 and 16 extends beyond the front plate 14 and terminates in a drive pinion 24 which is adapted to be drive connected to a component to be driven, as for example a chart sprocket or cable pulley of a recording chart (not shown).

In order to apply a drive torque to the output shaft 22, a gear 26 is fixedly secured through a coil type unidirectional clutch 28 onto the shaft. The unidirectional clutch 28 may be omitted if desired but is normally used to provide a safety factor to facilitate rotation of the output shaft 22 independently of the other components of the drive assembly 10. When coil clutch 28 is omitted, gear 26 is directly fixed to shaft 22 as by a set screw or other suitable means.

A small gear 30 meshing with gear 26 is fixedly secured as by a press fit to a cross arbor 32 which is journalled adjacent its opposite ends in support plates 14 and 16 in downwardly parallel spaced relation to output shaft 22 as best shown in FIGURES 1 and 2. Rearwardly of small gear 30, a large gear 34 is fixedly secured to arbor 32 and meshes with a small gear 36 fixedly secured to a drive arbor 38. As best shown in FIGURE 5, the drive arbor 38, extending in spaced parallel relation to cross arbor 32, is journalled adjacent its opposite ends in plates 14 and 16.

In order to control the rate of rotation of the arbor 38 and hence the output shaft 22, a power gear 44 fixedly secured to arbor 38 is coupled, as best shown in FIGURE 1, to an escapement mechanism 46 of conventional clock construction. The escapement mechanism 46 comprises a time gear train 48 having a gear 50 at one end of the train meshing with power gear 44 and a pinion gear 52 at the opposite end of the train as best shown in FIGURE 1. The gear 50 and pinion 52 are interconnected by intermeshing gears and pinions common to clock construction. The pinion 52 and escape wheel 54 are mounted on an arbor 56 and a pallet 58 is secured to an arbor 60 pivotally supported between the front and back plates 14 and 16 of frame 12. Operation of the pallet 58 is regulated by a balance wheel assembly 62 in a manner common to a mechanism of this type, and a regulator 64 is connected with the balance wheel 62 to control its rate of movement.

By this structure, it will be appreciated that the rotation of the arbor 38 and the output shaft 22 will be in accordance with a timed rate as permitted by the escapement mechanism 46. The timing of the escapement 46 can be adjusted by the regulator 64 coacting with an escapement hair spring 66 of the balance wheel assembly 62.

Driving power for arbor 38 is obtained from a pneumatically power driven mechanism 74 which comprises a pneumatic motor unit 76 having a cylindrical block housing 78, one end of which is formed with an open end cylindrical bore 80 as shown in FIGURE 4. With continued reference to FIGURE 4, a reciprocable piston 82 is received in the cylindrical bore 80 with a free sliding fit and there is no seal between the relatively reciprocating surfaces of the piston and the cylinder. By this construction, a minute annular clearance space is

provided around the reciprocating surface of the piston 82 to permit an intentional slow leakage or escape of operating fluid from the expansible working chamber 84 behind the piston 82 and to the exterior of the block 78.

The rod end of piston 82 terminating in a reduced diameter section 86 extends beyond the edge of cylindrical bore 80 and is received in a flexible one-piece gas retainer boot 88 preferably of rubber or other suitable flexible rubber-like synthetic material. Retainer boot 88 is tightly fitted in annular sealing contact with the reduced diameter section 86 of piston 82 and is provided at its other end with a skirt 90 that is adapted to fit tightly over the reduced diameter end section 92 of cylinder block 78 in sealing contact therewith and in spaced relation to the annular shoulder 94 formed between the cylinder block end section 92 and the cylindrical body portion 96 of block 78. The transition between the boot skirt 90 and the axially annular end section 98 is formed by a frusto-conical section 100 and a radially extending annular section 102 which sealingly bears against an annular shoulder 104 of piston 82.

By this construction, it will be appreciated that the retainer boot 88 permits reciprocal movement of piston 82 and seals the outer surface of cylinder 78 with the end of the piston. The radial portion 102 of boot 88 restrains the annular boot section 98 from slipping to the rear of the piston 82 as the piston is moved to its forward position partially beyond the edge of bore 80.

The retainer boot 88, with its frusto-conical section 100 adjacent the outer edge of cylinder bore 80 and in outwardly spaced relation to piston 82, forms a chamber 106 with the piston 82 and the cylinder block 78. Fluid escaping past the piston 82 from the expansible chamber 84 collects in chamber space 106. A laterally extending tubular conduit 108 integral with boot 88 forms an outlet passage 110 communicating with fluid collection chamber 106. The tubular conduit 108 is adapted to connect to the exterior of the drive assembly 10 by a tube 112 to either vent the fluid collected in chamber 106 to the atmosphere or to return it to a fluid sump (not shown).

By this structure, it will be appreciated that fluid entering the expansible chamber 84 is prevented from escaping into the interior of the drive assembly 10 and the component parts of the drive assembly particularly the timed escapement are not effected by any corrosive properties of the fluid utilized to fire the piston. Furthermore, the fluid used to power the motor unit 76 can be reclaimed by returning it to a suitable sump, thereby preventing the loss of the fluid.

In order to simplify the assembly of the motor unit 76 with the other components of the drive assembly 10, two spaced tabs 114 and 116 (FIGURES 2 and 3), integrally formed with the back plate 16, are bent to extend in parallel relation inwardly between the support plates 14 and 16 and at right angles thereto. The upper tab 114 is adapted to extend into an annular groove 118 provided in the cylinder block body portion 96 adjacent the end face 120 and the lower tab 116 is adapted to extend into a groove 122 formed between the annular shoulder 94 and the exposed edge of the retainer boot skirt portion 90. Both tabs 114 and 116 are of similar configuration and have arcuately formed edges corresponding to the radius of curvature of the annular grooves 118 and 122 so as to contact the bottom surfaces thereof.

The front support plate 14 is similarly provided with a pair of integrally formed tabs 124 and 126 which are opposite the tabs 114 and 116 respectively and extend into the annular grooves 118 and 122 on the opposite side of the cylinder block 78.

By this construction it will be appreciated that the cylinder block 78 is rigidly held in spaced relation between the opposed inner faces of support plates 14 and 16 by the tabs 114, 116, 124 and 126.

Extending in parallel spaced relation between the sup-

port plates 14 and 16 is a piston rod 128 which is provided with body portion 130 having a substantially square cross section as shown in FIGURE 4 and opposed cylindrical end sections 132 and 134 as shown in FIGURES 4 and 1 respectively. The width and height of the squared piston rod portion is appreciably greater than the diameter of the cylinder sections 132 and 134.

The cylindrical rod section 132 is press-fitted into a bore 136 formed coaxially in piston 82 so that the squared body portion shoulders on the exposed end face 138 of piston 82 as shown in FIGURES 1, 2 and 4, the cylindrical end section 134 at the other end of piston rod 128 projects with a sliding fit through an apertured boss 140 of piston rod guide bushing 142. The boss 140 integrally depends from a flat-sided annular spring guide flange 144 and projects with a press fit through an aperture 146 formed in a tab 148. The tab 148 formed integrally with the back plate 16 is bent to project inwardly between and perpendicularly to the plates 14 and 16 in parallel relation to the tabs 114, 116, 124 and 126 adjacent the piston end of rod 128.

Opposing the outward movement of piston 82 is a coil tension spring 150 (FIGURES 1 and 2) mounted concentrically with piston rod 128 and seated at one end over the spring guide flange 144 in bearing relation against the top face of tab 148. The other end of coil spring 150 is seated over a boss portion 152 of spring follower 154 and bears against the bottom face of a radially extending annular flange 156 formed integrally with boss 152. The spring follower 154 is provided with a squared aperture to receive the squared body portion 130 of piston rod 128 and is fixedly secured thereto as by set screw 158.

As a result of this novel tab support structure, it will be appreciated that the assembly of the power unit 76 on the support plates 14 and 16 is easily and readily accomplished and that the tabs 114, 116, and 148 of back plate 16 facilitate perfect alignment of the component parts of the motor unit 76, including the cylinder block 78, the piston rod 128, the guide bushing 142 and the power coil spring 150.

The support plates 14 and 16 with their integrally formed tabs being preferably formed of substantially rigid metal, may be fabricated by a stamping and bending operation.

In order to supply fluid to the expansible chamber 84 for firing the piston 82, a counterbore 164 is formed in the base of the cylinder bore 80 and receives a valve seat retaining ring 166 which is held in place within the counterbore 164 by a snap ring 168 as shown in FIGURE 4. With continued reference to FIGURE 4, the retaining ring 166 has a central aperture 170 and an axially projecting annular flange 172 which abuts the end wall of counterbore 164. An O-ring 174 is disposed over the outer periphery of the flange 172 and against a shoulder 176 on retaining ring 166, and being slightly distorted between the flange 172 and the cylindrical wall of the counterbore 164, provides a fluid-tight seal between the valve seat retaining ring 166 and the counterbore 164. An inner annular shoulder 178 disposed between flange 172 and retaining ring aperture 170 provides a seat for an inner O-ring seal 180 which constitutes the seat for valve assembly 182.

At the base of the counterbore 164 a further counterbore 184 of smaller diameter provides an inlet chamber 186 and extends to intersect an inlet passage 188 which extends radially to the exterior of the cylinder block 78. An inlet hose fitting 190 projects into the passage 188 and is fixedly secured to the block 78.

The exterior end of passage 188 is counterbored to form a recessed seat 192 which receives an O-ring seal 194. The O-ring seal 194 is held in position on the seat 192 by an annular shoulder 196 extending radially from the fitting 190 and provides a fluid-tight seal between the exterior surface of the fitting 190 and the cylinder block 78 so as to prevent leakage of fluid therebetween and

thereby to provide a sealed fitting with the end of an air or fluid pressure hose 198.

A still further blind counterbore 200 is formed at the base of inlet chamber 186 and provides a generally guiding coaction with the enlarged end 202 of a movable valve member 204.

As shown in FIGURE 4, the relative dimension between the valve member end portion 202 and the counterbore 200 is such to provide a small annular clearance, but at the same time to provide a guided relationship between block 78 and the movable valve member 204. This small annular clearance space permits valve movement without a fluid lock occurring in the blind bore 200.

The valve member 204 includes an integral stem portion 206 coaxial with the end portion 202, a guide flange 208 adjacent the opposite end of stem portion 206 and a spring seat boss 210 extending coaxial with the guide flange 208.

The valve end member 202 has a diameter of larger dimension than the inner diameter of O-ring 180 and the stem 206 has a diameter of smaller dimension than the inner diameter of O-ring 180. The transition between the end 202 and the stem portion 206 is a frusto-conical seating surface 212 adapted to engage and seal against the surface of O-ring 180 when valve member 204 is axially shifted to a valve closed position. The stem portion 206 extends axially through the O-ring 180 and the aperture 170 in the valve seat retaining ring 166 and coaxially projects into a counterbore 214 formed on the inner side of piston 82 coaxial with bore 136. The guide flange 208 is positioned within the piston counterbore 214 and is retained for limited movement relative to piston 82 by a retaining ring 216 positioned in an annular groove adjacent the open end of counterbore 214. A valve spring 218 is concentrically disposed in the piston counterbore 214 and is seated over boss 210 on the guide flange 208 of valve member 204, thus exerting a biasing force tending to force the movable valve member 204 out of the piston counterbore 214 to a position where flange 208 is engaged against the retaining ring 216. The end of the spring seat boss 210 constitutes an abutment which limits the relative telescoping movement of the movable valve member 204 and the piston 82 by engagement against the end of the piston rod cylindrical section 132 which terminates in a plane with the piston end wall 220.

Referring now to FIGURES 1 and 5, a unidirectional clutch 226 is mounted coaxially with the arbor 38 and has a driven member 228 fixedly secured to the arbor 38 and a driving member 230 mounted for free rotation on the arbor 38. Clutch 226 is a conventional miniature roller clutch as, for example, the roller clutch described in the United States Patent to E. F. Ayers et al. No. 2,633,951.

An apertured flat-sided freely wheeling clutch arm 232 press-fitted on an annular shoulder 234 provided on the end face 236 of the clutch driving member 230 extends transversely of the arbor 38 and overlies the squared central piston rod portion 130 in substantially parallel spaced relation to the face 238 of the squared piston rod portion 130. A pin 240 press-fitted into a through cross bore 242 formed along the transverse in the piston rod 128 and perpendicularly to the flat surface 238 of the piston rod squared portion 130 extends beyond the face 238 and passes through a slot 244 formed in the arm 232. A retaining ring 246 (FIGURE 5) positioned in an annular groove formed in the pin 240 adjacent the end extending through the slot 244 secures the arm 232 to the pin 240.

By this construction, it will be appreciated that the pin and slot connection permits the free wheeling clutch arm 232 of the unidirectional clutch 226 to rotate in either direction depending upon the reciprocal movement of the piston rod 128. The flat surface 238 of the square piston rod body portion 130 cooperates with the bottom face of the clutch arm 232 to prevent the piston rod 128 from turning except as provided by the space between the arm

232 and piston rod portion 130 and the play between the retainer 246 and the top face of arm 232 as viewed from FIGURE 5. Rotational movement of the piston 82 is thereby also restrained and distortion of the gas retainer boot 88 by rotation of the piston 82 is consequently substantially eliminated thereby preserving the life of the boot.

As viewed from FIGURE 1, the movement of the clutch arm 232 in a counterclockwise direction under the biasing force of power spring 150 causes the driving member 230 of clutch 226 to also rotate in a counterclockwise direction. In the counterclockwise direction, the driving clutch member 230 engages the driven clutch member 228 through rollers 248 (FIGURE 5) to thereby cause counterclockwise rotation of the arbor 38, the rate of which being governed by the escapement mechanism 46 as hereinbefore described.

Clockwise movement of the clutch arm 232 against the biasing force of power spring 150 rotates the driving clutch member 230 in the same direction. This motion releases engagement of rollers 248 and permits a reverse overrunning between the driving clutch member 230 and the driven clutch member 228. Thus, it will be appreciated that there is no movement imparted to the arbor 38 by the clutch arm 232 whenever the latter is rotated in a clockwise direction. However, by rapidly and intermittently tensioning the power spring 150, a substantially constant drive force will be realized through the unidirectional clutch 226 to arbor 38 and therefore an essentially constant rotation of output shaft 22 under the control of escapement 46 occurs.

Referring now to FIGURES 1 and 2, a dust cover assembly 250 houses the drive assembly and comprises opposed cover plates 252 and 254 which are substantially identical in shape and have opposed annular skirts 256 and 258 so as to enclose the assembly 10 with the pinion and of output shaft 22 projecting beyond the front cover 252. Pressed between the adjacent edges of the skirts 256 and 258 is an annular resilient dust seal 260 preferably of rubber and provided with an enlarged head portion 262 sealingly overlapping the outwardly facing marginal edges of the skirts 256 and 258 to prevent contamination of the component parts of the drive assembly 10 by dust, dirt or foreign particles.

In order to rigidly secure the cover plates 252 and 254 together, apertures aligned with the shouldered rods 18 are formed in the plates. The threaded end sections 19 extend through the apertures and threadedly receive nuts 264 so that the plates are fixedly secured on rods 18 between the nuts 20 and nuts 264.

By this construction, the drive assembly 10 is completely enclosed within cover assembly 250 except for the protruding ends of output shaft 22, rods 18 and fluid inlet and outlet lines 266 and 112. The cover plates 252 and 254 may be separately removed by removal of nuts 264 to permit ready access to the drive assembly 10.

Operation

When the drive assembly 10 is mounted on a chart recording mechanism, the pinion end 24 of output shaft 22 is connected to the chart mechanism input member (not shown) and air or a suitable gas is supplied through pressure line 266 to to the drive assembly hose fitting 198 at a nominal pressure of approximately 20 p.s.i. This places the motor unit inlet chamber 186 under pressure and when the movable valve element 182 is in an unseated position, the pressurized gas is allowed to pass through valve port 170 around valve stem 206 to the expansible motor chamber 84. The resulting pressure increase in chamber 84 causes piston 82 and the piston rod 128 to move outwardly swinging the free wheeling clutch arm 232 about the axis of arbor 38 in a clockwise direction and urging the follower 154 against the power spring 150 to stress the spring against its seat on the tab 148.

During this movement of piston 82, the valve stem guide 208 is engaged by retaining ring 216 pulling the valve member in the outward direction of piston movement until the frusto-conical portion 212 seats against the O-ring 180 shutting off the pressurized gas supply to motor chamber 84. This is a very rapid action and simultaneously with the firing of the piston 82, the power spring 150 is stressed.

As soon as the valve 182 closes and the pressure in chamber 84 begins to decrease by escape of fluid to chamber 106, piston 82 starts its return movement under action of the power spring 150 through the follower 154 and piston rod 128. Leakage of the gas from motor chamber 84 occurring through the annular clearance between piston 82 and the cylindrical bore 86, allows the piston 82 to be axially shifted to its starting position. During the return movement of piston 82, the valve 182 remains in closed position, being held by gas pressure in chamber 186 and in the counterbore 200 so as to act on the end of valve element 202. However, valve spring 218 will be compressed as the piston 82 returns to its initial position, and when the end of the piston rod cylindrical section 132 fixed in piston 82 engages the spring retaining boss 210 on the movable valve element 182 or the stress of the spring 218 becomes great enough to counteract gas pressure on the end of valve element 202, the valve element 182 will be axially moved to unseat from the O-ring seal 180 thereby permitting gas again to be admitted under pressure to the expansible motor chamber 84. Opening of the valve 182 permits the gas pressure across the movable valve element 182 to equalize and valve spring 218 will extend to fully open valve 182, rapidly admitting gas through the now wide open port 170 into the motor chamber 84, causing piston 82 to again rapidly fire and the aforedescribed intermittent motor cycle will be repeated.

As described, when the piston 82 fires, piston rod 128 will be reciprocably moved with the piston to stress the power spring 150 and rock the free wheeling clutch arm 232 in its free wheeling direction about the axis of arbor 38. When piston 82 starts its return stroke under the force of energy stored in spring 150, the arm 232 also starts a return oscillation to rotate the clutch driving member 230 in a torque driving direction causing rollers 248 to engage the clutch driven member 228 supplying rotational power to the arbor 38 which being connected through gears 36, 34, 32 and 26 to the output shaft 22 and through gear 44 to the escapement 46, will supply rotational power at a timed rate to the output shaft 22. During the extremely short interval of time when piston 82 is being fired and power is not being applied to the arbor 38 through the one-way clutch 226, there is sufficient stored up momentum energy in the gear train to maintain power to the escapement and output so in effect there is no time lag in the rotation of output shaft 22.

Firing of the piston 82 is a repetitive operation. The cycle time varies with the supply gas pressure being shorter for lower pressures and longer for higher pressures. A unit can be designed to operate under pressures within a range, e.g., an approximate range of from 15 to 25 p.s.i., and accuracy of the drive will not be affected by pressure variations within this range. Travel of piston 82 is also related to supply gas pressure and cycle time. The shorter the cycle time, the less the piston travels as travel is related to the force of the valve spring 218, which is necessary to open valve 182 against supply gas pressure. It will be appreciated therefore that the operating range of the drive has a force balance relationship. It is therefore possible to vary the gas supply pressure, the spring constant of the main spring and the spring constant of the valve spring to effect a change in the range of the drive to suit particular application needs as disclosed in said copending application Serial No. 656,434.

Gas consumption in this drive assembly occurs only during the firing operation on piston 82 which occurs at intervals governed by the escapement; thus it is readily seen that the power unit has a low gas consumption. This is an important feature particularly in installations where a large number of pneumatic drive assemblies are installed which feasibly might place a large burden on gas supply equipment.

By providing for the gas retainer boot 88, the gas used for powering the piston 82 is prevented from being uncontrollably dissipated to the atmosphere and can be returned to a suitable gas holder (not shown) by conduit 112 to thereby preclude the loss of gas being utilized.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. In a fluid powered drive mechanism having a rotatable member, a unidirectional drive device operatively coupled to said rotatable member and actuatable to rotate said rotatable member only in one predetermined direction, a motor unit operable to furnish power for actuating said unidirectional drive device and having a reciprocable power member, means operatively coupled to said power member for normally biasing said reciprocable power member in one direction and including resilient power storage means and a reciprocable member movable with said power member, and automatic means contained within said motor unit providing for movement of said power member against the biasing force of said resilient power storage means operable to store energy therein alternately with permitting the energy stored in said power storage means to move said power member in said one direction; motion converter means comprising a rockable driven member and a pin and slot connection drivingly interconnecting said reciprocable member and said rockable driven member to rock said driven member by the reciprocal motion of said power member, said unidirectional drive device drivingly connecting said rockable driven member to said rotatable member to rotate said rotatable member in said predetermined direction when said driven member is rocked a first direction by said reciprocal member and to disengage from said rotatable member when said rockable driven member is rocked in a direction opposite to that of said first direction.

2. In a fluid powered drive unit having a rotatable member, a unidirectional drive device operatively connected to said rotatable member and actuatable to rotate said rotatable member only in one predetermined direction, power storage means, a pneumatic motor unit having a reciprocable power member movable in one direction by fluid pressure to store energy in said power storage means, connection means including a reciprocable member movable with said reciprocable power member for operatively coupling said power member to said power storage means, and automatic fluid control means contained within said pneumatic motor unit for controlling the transfer of energy to and from said power storage means by alternately permitting application of fluid pressure to move said power member in said one direction to store energy in said power storage means and by releasing fluid pressure applied to said power member thereby permitting energy stored in said power storage means to be released to move said power member in the opposite direction; motion converter means comprising a rockable driven member and a pin and slot connection drivingly interconnecting said reciprocable member and said driven member to rock said driven member in opposite directions, said pin and slot connection including means forming an elongated slot in said rockable member and a rigid pin fixedly connected to said reciprocable member and projecting through said slot, said unidirectional drive device drivingly connecting said rockable driven member to said rotatable member to rotate said rotatable member in said predetermined direction when said driven member is rocked in a first direction and to disengage from said rotatable member when said rockable driven member is rocked in a direction opposite to that of said first direction.

3. In a fluid powered drive unit having a rotatable member, a unidirectional drive device drivingly connected to said rotatable member and actuatable to rotate said member only in one predetermined direction, and a pneumatic motor unit operable to furnish power for actuating said unidirectional drive device and having a reciprocable power member movable in one direction by fluid pressure; motion converter means comprising a reciprocable drive member operatively connected to said power member, a rockable driven member drivingly connected to said drive device, and a pin and slot connection drivingly interconnecting said reciprocable drive member and said rockable driven member, said unidirectional drive device drivingly connecting said rockable driven member to said rotatable member to rotate said rotatable member in said predetermined direction when said driven member is rocked in a first direction by said reciprocal member and to disengage from said rotatable member when said rockable driven member is rocked in a direction opposite to that of said first direction; biasing means operatively connected to said reciprocable drive member to bias said reciprocable drive member and power member in a direction opposed to the force of said fluid pressure; and automatic control means contained within said motor unit for alternately permitting application of fluid pressure to move said reciprocable power member and drive member in said one direction against the biasing force of said biasing means and releasing the pressure applied to said power member thereby permitting said biasing means to move said reciprocable power and drive members in the opposite direction whereby said rockable driven member is rocked through said pin and slot connection.

4. In a fluid powered motor unit, a cylinder member having an open-ended bore; a reciprocable member mounted for axial movement in said bore and defining an expansible chamber with said cylinder member at the inner end of said bore; means in said cylinder member providing a pressure fluid inlet communicating with said expansible chamber for introducing pressure fluid into said chamber to move said reciprocable member outwardly toward the open end of said bore; a resilient member enclosing the open end of said bore in surrounding sealing engagement with said reciprocable and cylinder members but permitting limited axial movement of said reciprocable member, said resilient member defining an exhaust chamber with said cylinder and reciprocable members adjacent the outer open end of said bore; means establishing fluid communication between said chambers; and conduit means in fluid circuit communication with said exhaust chamber for removing fluid collected therein.

5. In a fluid powered motor unit, a cylinder block having a fluid inlet and an open-ended bore; a piston mounted for axial movement in said bore with one face exposed adjacent the outer end of said bore and forming an expansible chamber with said cylinder block at the inner end of said bore; means in said cylinder block providing controlled communication between said inlet and said expansible chamber; resilient means enclosing the open end of said bore in sealing engagement with the outer surfaces of said cylinder block and said piston but permitting limited axial movement of said piston and forming an exhaust chamber with said piston and said block; means establishing communication between said chambers, and passage means communicating with said exhaust cham-

ber and connected to a fluid exhaust conduit means for removing fluid from said exhaust chamber.

6. In a fluid powered motor unit, a cylinder member having an open-ended bore; a piston member mounted for axial movement in said bore and defining an expansible chamber with said cylinder member at the inner end of said bore; means providing a pressure fluid inlet communicating with said expansible chamber for introducing pressure fluid into said chamber to move said piston member outwardly towards the open end of said bore; resilient means enclosing the open end of said bore in fluid-tight sealing engagement with the outer surface of said cylinder member and said piston but permitting limited axial movement of said piston in said bore, said resilient means defining a closed space with said piston and cylinder members; said piston member being freely received in said bore to form a clearance space therewith to continually pass fluid from said expansible chamber to said closed space; exhaust fluid circuit means communicating with said closed space to remove fluid therefrom; and pressure fluid circuit means communicating with said inlet for introducing pressure fluid thereto and including conduit means connected to said inlet and means sealingly engaging said conduit means fluid-tight with said cylinder member.

7. In a fluid powered motor unit, a cylinder member having an open-ended bore; a reciprocable piston freely mounted for axial movement in said bore and defining an expansible chamber with said cylinder member at the inner end of said bore, said piston having a radially extending annular shoulder adjacent the open end of said bore and facing away from said chamber; means in said cylinder member providing a pressure fluid inlet communicating with said expansible chamber for introducing pressure fluid into said chamber to move said piston member outwardly towards the open end of said bore; a unitary resilient retainer boot enclosing the open end of said bore with said piston but permiting limited axial movement of said piston, said boot defining a closed space with said piston and said cylinder member and comprising an axially extending end skirt section surrounding the periphery of said cylinder member in fluid-tight sealing engagement therewith, an axially extending annular end section of appreciably smaller diameter than said skirt section and surrounding the periphery of said piston in fluid-tight sealing engagement therewith adjacent said annular shoulder, a section intermediate said end sections cooperating with said annular shoulder to limit the outward axial movement of said piston beyond the open end of said bore, and a tubular section defining a passageway communicating with said closed space for removing fluid from said space.

8. In a fluid powered drive mechanism, two spaced-apart support plates; a motor unit having a cylinder block and a power member mounted for axial movement in said block; and means for rigidly mounting said motor unit between said plates comprising: means providing at least one annularly extending groove in said block, formations integral with said plates and extending into said groove, and means for rigidly maintaining said plates in spaced-apart position with said formations positioned in said groove in engaging contact with said block.

9. In a fluid powered drive unit, two spaced-apart support plates; a motor unit having a cylinder block, a power member mounted for axial movement in said cylinder block and a piston rod member connected to said power member and extending beyond said cylinder block; and means for rigidly mounting said motor unit between said plates and for aligning said cylinder block, said piston member and said piston rod member comprising: means providing at least one annularly extending groove in the outer surface of said block, first formations integral with said plates and extending into said groove in engaging relation with said block, at least one second formation integral with one of said plates and extending between said plates in predetermined spaced parallel relation to at least one of said first formations, guide means associated with said second formation providing a bearing surface for said piston rod member and means for rigidly maintaining said plates in spaced-apart position with said first formations in engagement with said cylinder block.

10. In a fluid powered drive mechanism, two parallel spaced-apart support plates; a motor unit having a cylinder block of substantially cylindrical shape, a piston member mounted for axial movement in said block and a piston rod connected to said piston member coaxial with said cylinder block and extending therebeyond; and means for rigidly supporting said motor unit between said plates and for maintaining the alignment of said piston rod and said piston member with said cylinder block comprising: means providing at least two axial annular grooves in said cylinder block, first parallel tabs integral with each of said plates and extending perpendicularly with said plates into said grooves, said first tabs having arcuate edges cooperating with said cylinder block and corresponding to the contour of said grooves, a second tab integral with one of said plates and extending perpendicularly between said plates in spaced relation to said first tabs, said second tab having an aperture coaxially receiving said piston rod, guide means in said aperture cooperating with said piston rod to provide a bearing surface therefor, and means for rigidly maintaining said plates in fixed spaced position with said first tabs positioned in said grooves in engagement with said cylinder block.

11. The fluid powered drive mechanism defined in claim 9 wherein a resilient member concentric with said piston rod member is provided for biasing said piston rod member toward said cylinder block and seated at one end on said second formation.

12. The fluid powered drive mechanism as defined in claim 11 wherein said resilient member is supported in concentric relation with said piston rod member by said guide means and by means secured to said piston rod in spaced relation to said guide means.

13. The fluid powered drive mechanism as defined in claim 12 wherein said resilient member comprises a coil spring and said guide means comprises a guide bushing having radially extending flange portion positioned on said second formation, said spring being snugly seated over said flange portion.

14. In a fluid powered drive mechanism having an enclosed casing, two spaced-apart support plates in said casing; a motor unit disposed in said casing, said motor unit having a cylindrical cylinder block with an open-ended bore and means providing a radially extending annular shoulder adjacent the open end of said bore, and a piston member mounted for axial movement in said bore; fluid inlet and exhaust conduit means arranged to be connected to said motor unit for respectively transmitting fluid to and from said motor unit for operating said motor unit; said piston member forming with said cylinder block an expansible chamber at the inner end of said bore and in controlled communication with said inlet conduit means; and means for rigidly supporting said motor unit between said plates comprising: means providing at least one annular groove in said block, formations integral with each of said plates and extending into said groove, and means for rigidly maintaining said plates in spaced-apart position with said formations positioned in said groove in engaging contact with said block, said means providing said groove including a resilient boot member enclosing the open end of said bore in fluid-tight peripheral surrounding relationship to said piston member and having a skirt portion axially surrounding said block in predetermined axial spaced relationship to said shoulder thereby cooperating with said shoulder to form said groove, said boot member cooperating with said piston member and said cylinder block to form a fluid ex-

haust chamber with means providing fluid communication between said fluid exhaust chamber and said expansible chamber, said boot having a single outlet opening connected to said fluid exhaust conduit means and forming therewith a fluid exhaust circuit which is isolated from the interior of said casing for conveying exhaust fluid from said exhaust chamber to the exterior of said casing.

15. In a fluid powered timed drive mechanism having a casing and a fluid powered motor unit disposed in said casing and having a cylinder member with an open-ended bore and a power member mounted for axial movement in said bore with one face exposed to the interior of said casing, said power member being freely received in said bore to provide a clearance space between the cooperating relatively reciprocable surfaces of said power and cylinder members for permitting fluid passage from one end of the power member to the other end thereof; the combination with means providing a fluid circuit for transmitting fluid through said casing and through said motor unit to power said motor unit and for preventing escape of fluid into the interior of said casing.

16. In a fluid powered drive mechanism having a rotatable output member; a pneumatic motor unit having a cylinder member with an open-ended bore formed therein, a power member mounted for axial movement in said bore, a reciprocable member operatively nonrotatably coupled to said power member for movement therewith, means including power storage means providing reciprocable movement of said power member, a resilient member enclosing the open end of said bore in surrounding sealing engagement with said power and cylinder members but permitting limited axial movement of said power member; and motion converter means drivingly interconnecting said reciprocable member and said output member for converting linear motion of said reciprocable member to rotate said output member, said motion converter means cooperating with said reciprocable member to prevent said reciprocable member and said power member from turning about their longitudinal axes.

17. The fluid powered drive mechanism as defined in claim 16 wherein said motion converter means comprises a rockable driven member and a pin and slot connection drivingly interconnecting said driven member and reciprocable member whereby linear motion of said reciprocable member rocks said driven member, a unidirectional drive means connecting said driven member to said output member to enable said output member to be rotated in a predetermined direction by rocking said driven member only in one direction.

18. The fluid powered drive mechanism as defined in claim 17 wherein said reciprocable member is rigidly connected at one end to said power member coaxial with said bore and is provided with an intermediate section having a planar surface extending beyond said cylinder member and a cylindrical end section opposite said one end; and guide means slidably receiving said cylindrical end section and providing a bearing surface to permit axial movement of said reciprocable member, said driven member having a surface abuttingly cooperating with said planar surface to substantially prevent rotation of said reciprocal member on said bearing surface thereby substantially preventing said power member from being rotated and said resilient member from being twisted.

19. In a fluid powered drive mechanism, two spaced apart rigid support plates having opposed inwardly directed surfaces; a motor unit having a cylinder block and a power member mounted for axial movement in said cylinder block; and means for rigidly mounting said motor unit between said plates comprising: groove means formed on said block and opening outwardly toward said inwardly directed surfaces, formations integral with said plates and interfittingly extending into said groove means, and means rigidly maintaining said plates in predetermined spaced apart relationship with said formations positioned in said groove means in engaging contact with said block to retain said block against movement relative to said support plates.

20. In combination, a casing, a rotatable member extending through at least one wall of said casing, and a drive assembly enclosed in said casing for rotating said rotatable member in a predetermined direction and comprising: a fluid powered motor unit having a cylinder block formed with an open-ended bore, a piston member mounted for axial movement in said bore, said block having a cylindrical section adjacent the open end of said bore, means providing a radially extending annular shoulder in the external cylindrical periphery of said section, a resilient boot member enclosing the open end of said bore in fluid-tight surrounding and contacting engagement with said piston member and having a skirt portion peripherally engaging the cylindrical periphery of said section with an endless fluid-tight fit and in predetermined axially spaced relationship to said shoulder to cooperatively form with said shoulder an annular groove, two spaced apart support plates fixed one on each opposed side of said motor unit, formations integral with said plates and extending into said groove in engaging contact with said cylinder block to support said motor unit between said plates, conduit means extending from beyond said casing and communicating with the interior of said cylinder block for delivering pressure fluid to said motor unit for displacing said piston, passage means in said motor unit for exhausting fluid delivered to said motor unit to a chamber formed by said boot member in cooperation with said cylinder block and said piston member, said boot member having a single port opening, exhaust conduit means connected to said port opening and extending beyond the exterior of said casing, a reciprocably mounted rod member fixedly secured to said piston and extending beyond said motor unit, a unidirectional drive device operatively connected to said rotatable member and having a rockable drive member, said unidirectional drive device drivingly connecting said rockable drive member to said rotatable member to rotate said rotatable member in a predetermined direction when said drive member is rocked in a first direction and to disengage from said rotatable member when said rockable drive member is rocked in a direction opposite to that of said first direction, pin and slot motion converting means operatively connecting said rockable drive member with said rod member, said rockable drive member being arranged to cooperate with said reciprocable rod member to prevent said rod member and said piston member from turning about their longitudinal axes, and means including a power spring cooperating with said piston member to cause reciprocation of said rod member to thereby rock said rockable drive member and thereby rotate said rotatable member in said predetermined direction.

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