April 18, 1961 H. A. MACHLAN ET AL 2,980,076

PNEUMATIC STROKE MOTOR

Filed March 13, 1959 3 Sheets-Sheet 1

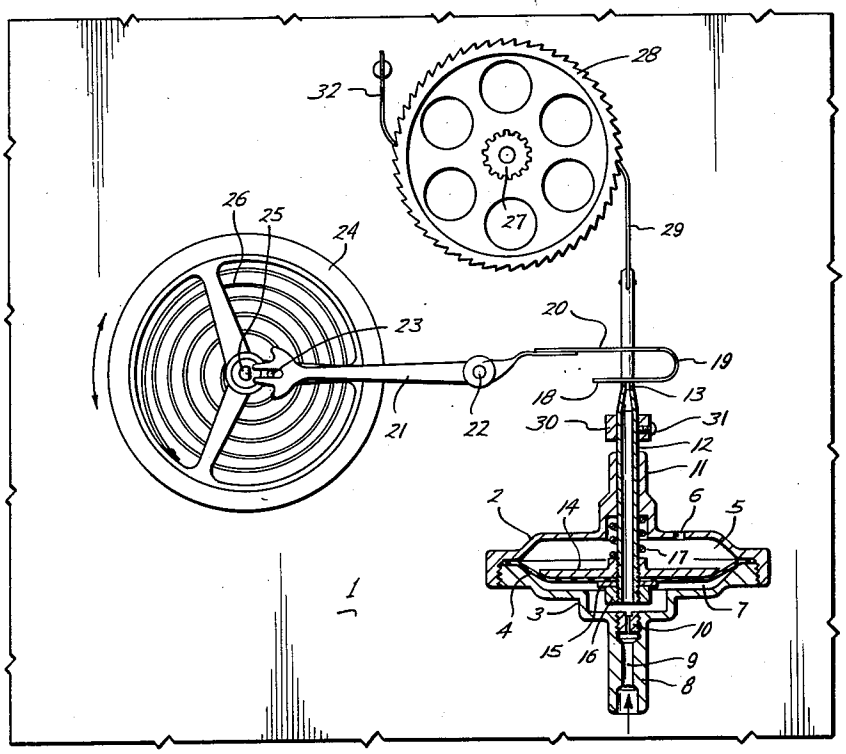


Fig. 1

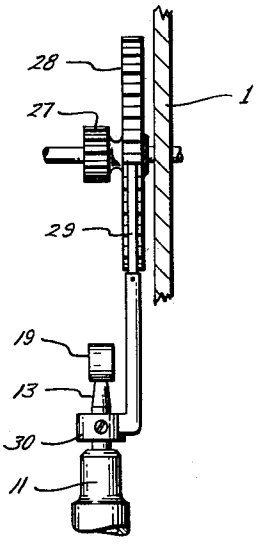


Fig. 2

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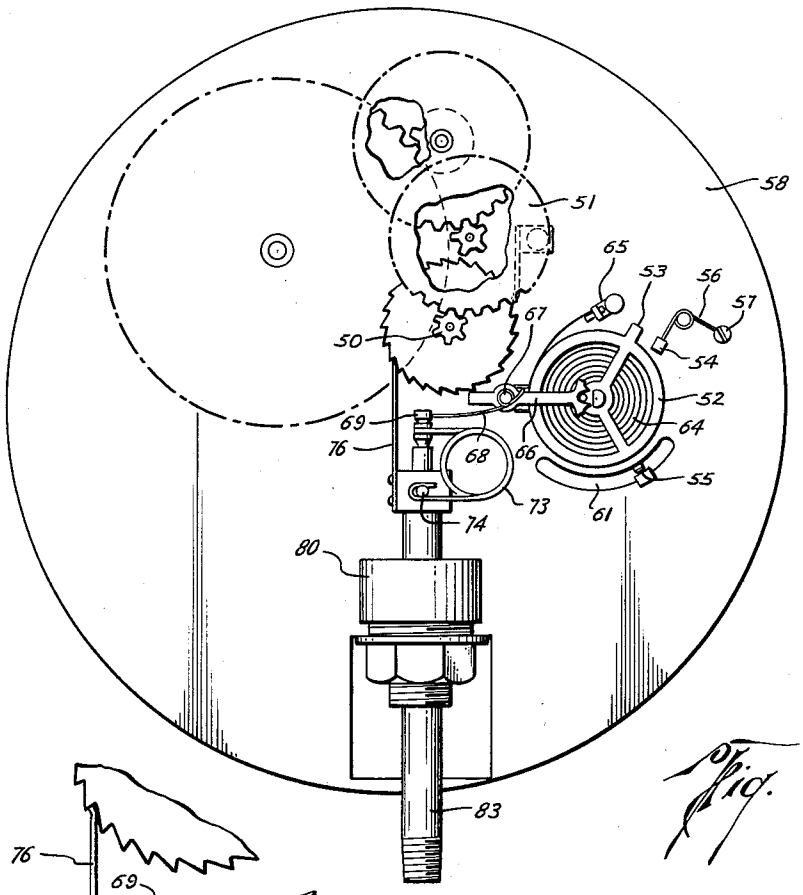


Fig. 3

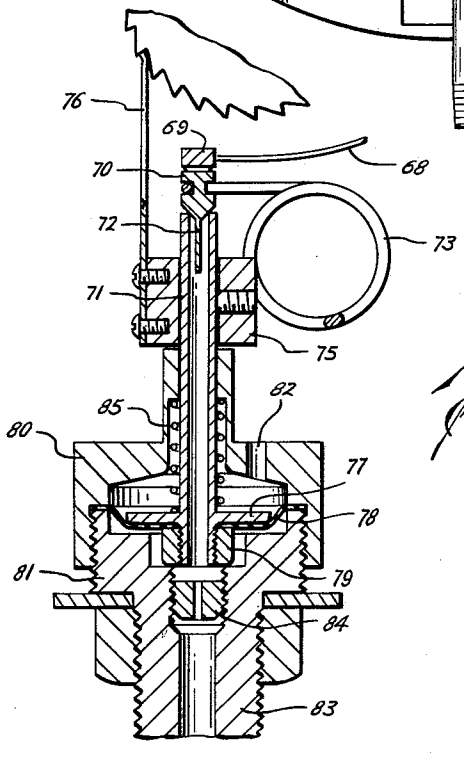


Fig. 4

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Filed March 13, 1959 3 Sheets-Sheet 3

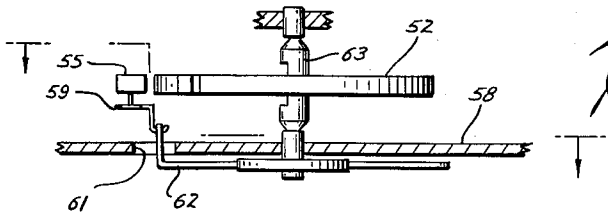


Fig. 5

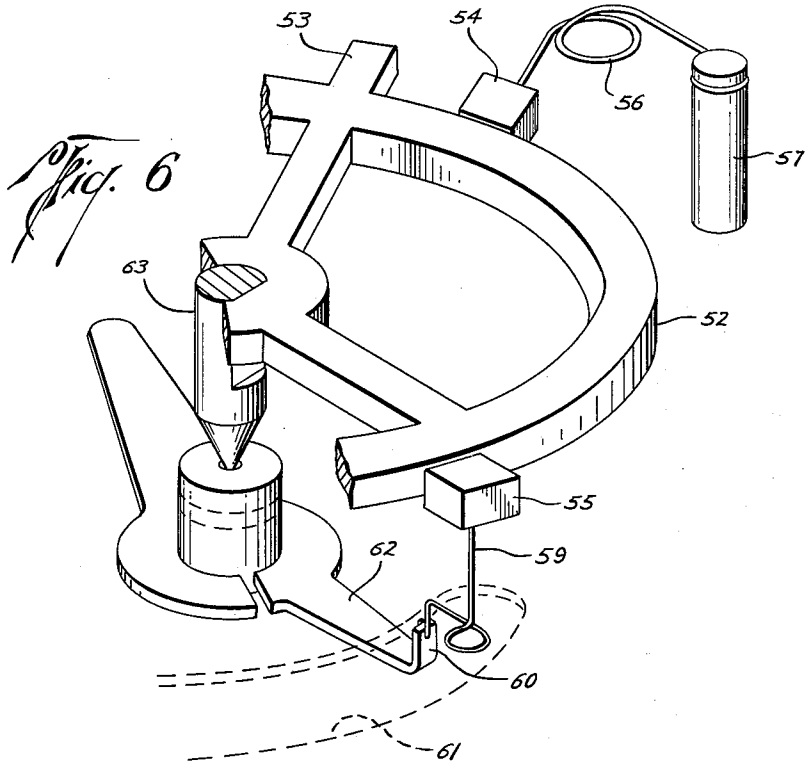


Fig. 6

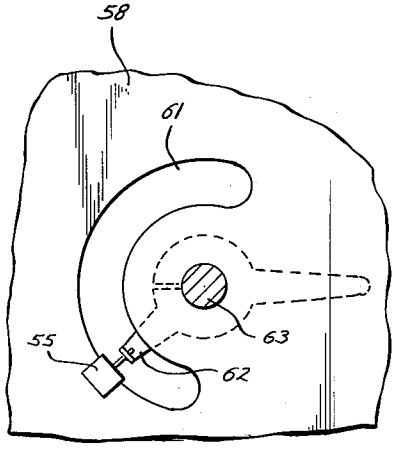


Fig. 7

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2,980,076

PNEUMATIC STROKE MOTOR

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16 Claims. (Cl. 121—48)

This invention relates to fluid pressure motors and more particularly to an improved mechanism especially adapted for installation at a remote or somewhat inacessible location such as an offshore oil well having an available supply of pressure gas as a source of energy for operating a surface controller by which gas injection cycles are timed for intermittent action in the production of well fluids in accordance with gas lift principles.

For intermittent gas lift of well fluids, the conventional controller is a spring powered clock to rotate a timing disc at selected speed and the disc carries a number of spaced pins or cams for successively effecting the periodic opening and closing of a flow control valve according to a set pattern of frequency and duration of gas injection cycles. Such controllers require frequent and usually daily attention and manual winding of the clock power spring. This means the expenditure of manpower seven days each week plus the cost of personnel transportation equipment by either or both land and water to make the round of wells whose number, depending on spacing and accessibility, which one man can service each day often is small. Bad weather, and especially in the case of offshore wells, introduces hazard to personnel and interrupts maintenance trips and well production.

To eliminate need of spring winding visits and provide continuous control of well production by means of a reliable and inexpensive self-acting device for maintaining a controller in operation, is one of the objects of the present invention.

A further object of the invention is to provide an improved gas powered device in which fluid pressure periodically is built up and relieved for driving a motion transmitting linkage to a driven member and wherein motion response actuates a spring return balance weight for alternately sealing and venting a variable volume chamber communicating with a source of pressure gas which furnishes the drive.

Another object of the invention is to provide a cushioned spring blade vent controlling valve arranged to seat over a pressure chamber vent opening through a movable chamber wall and which valve is joined to a balance mass and is propelled by or partakes of movement with the expanding chamber wall during its outward stroke and thereafter at the end of the stroke and due to mass inertia is carried away from the seat and thereby vents the chamber for pressure reduction therein and a resultant chamber contraction and back stroke of its wall, whereupon stored energy in a mass associated spring causes return travel of the spring valve blade and a cushioned reseating thereof to again obturate the chamber vent for repetition of the operational cycle.

A still further object of the invention is to provide a pneumatic pulse motor whose stroke controlling valve linkage includes an inertia member having travel limit stops which are adjustably spaced apart and enable control of the travel range of the inertia member for a variation of beat rate.

Other objects and advantages will become apparent during the course of the following specification with the accompanying drawings illustrating preferred embodiments of the invention and wherein Fig. 1 is a plan view with parts in section of the improved operating mechanism in operative relation; Fig. 2 is a side elevation of a part thereof; Fig. 3 is a plan view illustrating a modified embodiment; Fig. 4 is a view on a large scale and shows the power unit in section; Fig. 5 is a fragmentary sectional view of the balance wheel mounting parts shown in Fig. 3 but with the hairpin spring omitted for the sake of clarity; Fig. 6 is a perspective view on a large scale of portions of the balance wheel and its stop abutments which establish opposite limits of oscillation; and Fig. 7 is a fragmentary detail showing an adjustable stop for the balance wheel.

A typical gas lift installation involves a pressure gas circulation system having a compressor and controls for maintaining delivery line pressure at a stable level and from which line, pressure gas is injected into each well at spaced apart time intervals through a line valve actuated and controlled by a clock or timer known in the trade as a surface controller. The operating mechanism for timing intermittent injection is mounted by and housed within an enclosing box of which a wall portion **1** is illustrated in the drawing.

Fixedly located as by mounting on the wall **1** is a hollow casing shown as made up of a pair of oppositely disposed metal or molded plastic resin cups or domed walls **2** and **3** having their rims screw threaded one on the other. A circular disc or diaphragm **4** of spring metal, rubber or other thin flexible material has its peripheral edge clamped between adjoining faces of the casing cups **2** and **3** and partitions and seals the upper casing space **5**, which is open to atmosphere through one or more ports **6** through the wall of the cup **2**, from the lower casing space **7** and the latter constitutes a variable volume chamber for connection and constant communication with the pressure fluid delivery line from the system compressor or with any other available source of fluid under substantially constant pressure. For making such connection, the casing cup **3** has an integral hollow connector boss or stud **8** whose inlet passage **9** is counterbored and threaded at its inner end to receive an orifice plug **10** having a flow metering opening of predetermined size to fit requirements of a given installation.

Centrally of the upper casing dome **2** is a bearing boss **11** for slidably guiding a reciprocatory post or hollow tube **12**. A substantially friction free and oilless slide fit will be afforded by molding the casing cup **2** of Teflon or, in the alternative, by facing either the tube **12** or the boss **11** with a thin Teflon liner. The slide tube has one end projected exteriorly of and above the casing dome **2** and its inner or lower end passed through the flexible sealing diaphragm **4** to afford an outlet passage leading from the variable volume chamber space **7** for venting the same to atmosphere. The vent passage opens through and is surrounded by an abutment surface and annular valve seat **13** at the outer post terminal. Such terminal opening may be of a restricted outflow controlling area whose size determines the rate of pressure relief in relation to the rate at which pressure fluid is supplied through the inlet orifice **10** for obtaining the desired responsiveness of the device. Outlet area should approximate or be greater than inlet area for quick release of chamber pressure.

Overlying the exterior face of the flexible diaphragm **4** throughout the major central area thereof is a stiff backing plate or circular disc **14** threaded or otherwise fixed on the post **12** and clamped in sealing relation with the diaphragm **4** by a washer **15** held against the under

side of the diaphragm by a nut 16 threaded on the inner terminal of the post 12. A coil spring 17 sleeved on the post and bearing at opposite ends on the cup 2 and the plate 14 yieldably biases the piston-like movable wall assembly in a direction to contract volume of the chamber space 7 and expel pressure gas therefrom through the open vent. Spring strength should be selected to preclude pressure buildup and chamber enlargement whenever the vent is open and spring force also determines opposite travel limits for the movable wall and the range of reciprocation of the post 12.

As seen in the drawing, the pressure chamber vent or opening outlet abutment seat 13 is closed or restricted against pressure gas outflow by an oscillatory valve in bearing engagement with the abutment seat. Although a completely leakproof closure is not a requisite, the vent closure valve as here shown consists of a flat spring metal strip 18 which can bend through an angular range into full bearing engagement on and around the annular valve seat 13 during the outward reciprocatory stroke of the post and the accompanying rocking travel of the oscillatory valve. Flexibility of the spring blade cushions reseating impact on return travel, as will be later described. Spring deflection also absorbs or damps initial push from chamber expansion.

The blade 18 is a free-ended leg of a U-shaped or hairpin strap having its spring bight or return bend 19 joined to the other leg 20, which is riveted or otherwise secured to and forms an extension of one arm of a motion transmitting rock lever 21. This rock lever is for oscillation on a pivoted pin 22 carried by the wall 1 and the opposite lever arm has a bifurcated end to bear on both sides of and to slide radially on a pin 23.

A spoke of a flywheel or balance weight 24 carries the pin 23 and the wheel hub is mounted for oscillation on an axle shaft 25 projected forwardly from the wall 1. A balance spring is positioned inside the wheel rim in the form of a spiral hair or small wire 26 fixed at its outer end to the wheel rim and at the inner end to the stationary axle shaft 25. Action of the hair spring 26 biases the flywheel lightly in counterclockwise direction and urges the lever 21 and the vent controlling valve 18 toward seating engagement with the abutment seat 13. Response of the flywheel in clockwise direction to movement transmitted by the lever 21 on the expansion stroke of the movable chamber wall stores transmitted energy for an inertia action which causes valve overrun or carries the valve blade away from vent closing relation.

Chamber expansion and contraction are utilized for driving control mechanism by harnessing the movable chamber wall to a gear pinion 27 through a ratchet wheel 28 fixed to the gear 27 and rotatably mounted on the wall 1. Similar to the multiplication of force transmitted from a clock spring, the pinion 27 is a part of a step-down gear train coupled to rotate an injection timing controller disc and provides a relatively high torque drive with conversion of high frequency stroke pulsation to slow and substantially uniform controller disc rotation. The ratchet wheel is periodically advanced or projected forward by engagement with its ratcheting teeth by a spring blade dog 29 mounted at its lower end on a collar 30 adjustably fitted to and held by a set screw 31 on the upwardly projecting post 12. If desired, the collar 30 may serve as an abutment stop engageable with the casing guide boss 11 to limit the inward stroke of the movable chamber wall. Outward wall movement transmitted through the collar 30 and the dog 29 turns the ratchet wheel 28 forward with each outward stroke. Reverse ratchet wheel rotation is blocked by a spring detent or check 32 co-operating with the ratchet teeth.

In operation, gas is continuously fed through the metering orifice 10 into the expansion chamber 7. With the chamber vent closed by the valve 18, chamber pressure tends to build up and overcomes resistance presented primarily by the coil spring 17, augmented to some degree by both valve seating force and ratchet wheel load, and lifts the movable wall outwardly. Outward wall movement with chamber expansion is transferred by the post 12 to the ratchet wheel 28 for driving the clock gear train and is directed from post abutment with the spring blade 18 to the flywheel 24 for rotating the same and winding the hair spring 26. Under impetus of flywheel momentum, as chamber wall movement slows down near its outward limit, the light hair spring 26 yields further and the rock lever 21 lifts the valve blade 18 away from its seat 13. The chamber vent now being fully open, permits rapid escape of pressure gas and the elastic force stored in the coil spring 17 assists gas expulsion and acts against reduced chamber pressure for quickly depressing the movable wall and returning the ratchet wheel dog 29. Upon dissipation of forward flywheel momentum, elastic reaction of the light spring 26 reverses flywheel rotation, which swings the spring blade 18 back into cushioned seating engagement with the abutment 13 for again restricting pressure gas outflow through the chamber vent for automatic cycle repetition. Normally, chamber expansion and contraction follow one another at quite rapid rates. Response speed can be regulated by selection of chamber entry and exit flow rates and gas line pressures for any load resistance. In practice and by way of example, satisfactory operation is obtained with an inlet 9 line pressure of from five to ten pounds per square inch, an orifice 10 size of 0.014", a vent 13 size of 0.062" and a pressure chamber 7 diameter of $1\frac{3}{16}$". Delivered pulses are smoothed out and transmitted in high torque form through the power multiplying gear train to the driven timer disc.

A suitable gear reduction train for obtaining high torque with compactness is illustrated in Fig. 3, wherein a ratchet wheel affixed pinion 50 has its teeth in mesh with the teeth of a large gear 51 which in turn has a small pinion fixed thereto for driving a large gear and like gear sets are repeated to provide desired motion reduction which in a production embodiment is on the order of a ratio of about four hundred to one between the ratchet pinion 50 and the final driven element. In such installation the slow speed of the final drive element will be on the order of one-half revolution per hour for an average motor beat rate of two hundred power strokes per minute and with the ratchet wheel completing one revolution in sixty beats.

Control of the beat rate within a desired range, which for practical purposes can be between one hundred eighty and two hundred sixty beats per minute, has been provided for by a variable adjustment of the angle of balance wheel oscillation. As seen in Fig. 3, the rim of the balance wheel 52 carries a radial stop lug projection 53 which, to minimize wear, has flat faces on opposite sides, one for wide area abutment at one limit with a mating flat face of a stop 54 and the other for large area surface contact with the mating flat face on an adjustably mounted stop abutment 55, angularly spaced from the stop 54 to establish the desired location for the opposite limit of wheel travel.

The stop abutment 54 is a small pad positioned in the path of travel of the lug 53 and resiliently mounted on one leg of a spring wire 56 having an intermediate coil and its opposite leg anchored to a rivet pin 57 or other suitable means for securing the spring to the mounting plate 58. The spring mounting cushions impact at the stop faces for both wear reduction and shock absorption to free the associated delicate parts from harmful stress. The other stop abutment 55 also is mounted at the free end of a wire coil 59 (see Fig. 6) and in the path of the balance wheel lug 53. In this case the spring mounted pad 55 is adjustable through a wide angle of as much as one hundred eighty degrees toward and from the companion stop pad 54 and in an arcuate path coincident with that of the balance wheel stop pad 53. For that purpose, the fixed end of the spring wire 59 is secured to

an upstanding ear 60 extending through an arcuate slot 61 in the mounting plate 58 and at right angles to an arm of a manually adjustable lever 62 pivotally mounted at its hub and concentric with the balance wheel and on the side of the plate 55 opposite to that of the balance wheel. Manual shifting of the regulator lever 62 will enable the position of the stop pad 55 to be set in varied spaced relation toward and away from the companion stop pad 54 for regulating the range and frequency of balance wheel oscillation.

The balance wheel hub has its pivoted stem or shaft 63 piloted for oscillation and fixed to the shaft beside the balance wheel is the inner end of a spiral hairpin spring 64 whose outermost end is clamped or wedged to an anchor clip 65 on the mounting plate 58. A pin carried by the wheel in offset relation to its pivotal axis has motion transmitting reception within the forked end of a rock lever 66 fulcrumed on a pin 67 carried by the mounting plate 58. A spring wire has an intermediate coil surrounding the fulcrum pin 67 and has one leg looped over an edge of the rock lever 66 with its opposite end projecting away from the pin in the direction opposite to the forked end of the lever to constitute a resilient lever arm 68. The lever arm 68 terminates in a flat metal disc 69 and has a make-and-break contact with the flat end face of a valve head 70.

This valve head 70 has a tapered seating face engageable with the end of a reciprocatory hollow post 71 for closing a vent passage through the post. A dependent guide stem 72 on the valve 70 of smaller size than the vent passage projects into the passage and is contained therein in all relative positions of the parts. One terminal leg of a spring coil 73 is secured to the valve in any suitable manner, as, for example, by having a terminal eye wrapped around an intermediate neck portion of the valve 70. The other leg of the spring coil 73 terminates in a hooked portion for anchorage to a lateral lug 74 fixed to and movable with the post 71. Conveniently, the mounting lug 74 is carried by a collar 75 secured by a set screw to the post 71 and having projected upwardly therefrom a spring detent or pawl 76 by which outward post movement is transmitted by engagement of the flexible free end of the spring blade 76 with the ratchet teeth of the gear train drive wheel. The coil 73 yields to accommodate seating and unseating of the vent valve 70 under opposing forces thereon. Preferably, the spring coil 73 exerts a slight bias favorable to an unseating of the valve and in opposition to force transmitted through the pad 69 and its carrier spring 68.

At its end opposite to the valve seat, the hollow post is fixed to a movable wall which, as seen in Fig. 4, includes a backing plate 77, a flexible diaphragm 78 and a clamp nut 79, the rim of the diaphragm being held between a post guide bearing cup 80 and a co-operating chambered housing 81 fixed on the mounting plate 58. The housing space on one side of the flexible diaphragm is vented through a wall opening 82 and is at atmospheric pressure at all times and on the other side affords a variable volume pneumatic pressure chamber having a relatively large outlet through the hollow post 71 and a smaller inlet from a pressure source through a hollow stud 83 containing a metering orifice plug 84. A coil spring 85 on the vented side of the movable chamber wall is interposed between the cup 80 and the backing plate 77 and biases the movable wall in opposition to gas pressure to an inward stroke limit afforded by end abutment of the nut 79 with a shoulder in the base of the chambered housing 81. An outward stroke limit is provided either by abutment of the mounting plate 77 with the cup 80 or by compression of the coil spring 85 to close contact of its coils.

In Fig. 4 the movable parts of the power unit are shown at their inward stroke limit. Under the metered feed of pressure gas at substantially constant rate into the pressure chamber and with the vent valve 70 closed, the buildup of pressure impels the post 71 outwardly and indexes the ratchet wheel forward and also transmits motion through the valve and rock lever for swinging the balance wheel 52 in a counterclockwise direction, as seen in Fig. 3, with a winding of the spiral hairspring 64. As the end of the power stroke is reached by the hollow post 71, balance wheel momentum continues the swing of the wheel and raises the lever arm spring 68 at its pad 69 away from contact with the vent valve 70, which thereupon unseats for relief of chamber pressure and outflow of gas exceeding the metered inflow supply. Under force of the coil spring 85, the chamber size is contracted as the movable wall returns toward its inward limit position shown in Fig. 4. Spring winding balance wheel motion continues momentarily and for a short distance beyond the initial valve unseating position until stopped by cushioned flat surface abutment of the wheel carried stop lug 53 with the adjustably set stop pad 55.

When that limit is reached, a rebound and direction reversal of the balance wheel 52 occurs and spring stored energy drives the balance wheel in clockwise direction in Fig. 3 as the spiral spring 64 unwinds with an accompanying rock lever action for returning the lever arm spring pad 69 in follow-up relation to the inwardly moving post 71 until seating contact is made for again closing the vent. Initial return contact of the lever arm spring pad 69 with the vent valve 71 preferably is timed to occur slightly in advance of the time the balance wheel 52 reaches its return limit and continued inertia of the balance wheel is cushioned as by an elastic yielding of bendable lever arm 68 and by the flat abutment of the balance wheel stop 53 with the spring carried abutment pad 54. Instantaneous direction reversals, not necessarily concurrently, of the balance wheel and the outward pulse from the pressure chamber occur for a repetition of the operating cycle.

Balance wheel oscillation range as defined by opposite stop limits controls beat or the rate of motor pulsations and the adjustable setting of the forward stop 50 enables the beat to be increased or decreased within a wide range to fit a particular installation as well as variations from time to time in conditions of use.

While the foregoing description deals with a specific embodiment of a gas powered clock operating motor, the intention is that the invention is of such scope as comes within the following claims.

What is claimed is:

1. In a pressure fluid drive motor, a variable volume chamber having a pressure fluid inlet containing a flow metering orifice, a movable chamber member yieldably biased against fluid pressure thereon within said chamber and movable under fluid pressure in one direction to a given limit, an abutment seat movable with said member and containing a chamber vent passage opening to atmosphere at said abutment seat and vent control means responsive to member movement and comprising a flexible strip engageable and movable in one direction with said abutment seat and covering and restricting said vent passage opening when engaged with the abutment seat and a weighted element connected for movement with the strip to provide inertia for continued strip movement beyond said given limit thereby to unseat the flexible strip and open said vent for chamber pressure reduction and return movement of said member and provided with spring means acting in opposition to said inertia and to effect strip re-engagement with the abutment seat.

2. In a pressure fluid drive motor as in claim 1 wherein said flexible strip is a U-shaped metal spring having one leg connected with the weighted element and its other leg terminating in a free end valving portion which makes resilient engagement with said abutment seat.

3. In a pressure fluid drive motor as in claim 1 wherein said weighted element is a flywheel having a balancing

spring and a pivoted lever transmits motion between the flywheel and the flexible strip and wherein the flexible strip is a metal spring having an intermediate reverse bend between opposite end portions of which one is connected with the lever and the other carries a bearing face engageable with said abutment seat.

4. In a pressure fluid drive motor as in claim 1 together with means to be driven from the movable chamber member, motion transmitting ratcheting mechanism connecting the member with said means to be driven and wherein said vent control means includes a double arm lever, a spring balance wheel connected to one lever arm and a U-shaped spring strip having one end joined with the other lever arm and its other end constituting a free-ended and abutment seat engageable flexible blade.

5. In a pressure fluid drive motor as in claim 1 wherein the chamber vent passage is at least as large as the flow metering orifice of the pressure fluid inlet to the chamber.

6. In a pressure fluid drive motor, a variable volume chamber having a movable wall responsive to chamber pressure increase for moving said wall and expanding chamber space, spring means active on the wall to move the same and contract chamber space with chamber pressure decrease, a pressure fluid inlet connection leading to said chamber and having a fluid pressure controlling orifice therein, a reciprocatory motion transmitting member connected to said wall for movement therewith and provided with a chamber vent opening and a bearing surface adjacent said vent opening and control means operating to open and close said vent opening alternately and comprising an oscillatory balance wheel and a lever having one arm connected for movement with said oscillatory wheel and its other arm constituting a spring blade and co-operating with said bearing surface for make-and-break contact resiliently therewith as controlled by member reciprocation and resultant wheel oscillation through a range exceeding the range of member reciprocation, said blade being active to close said vent opening upon contact with said bearing surface and to open said vent opening whenever said contact is broken.

7. In a fluid pressure drive motor, a pressure fluid expansible chamber having a pressure fluid inlet leading thereto and a movable wall responsive to chamber pressure variation, a chamber vent tube connected for movement with said wall and provided with a valve seat at the tube outlet, an outlet control valve engageable with said seat to close the vent tube and movable therewith upon wall movement in response to chamber pressure increase and spring opposed inertia means connected with the valve and active with inertia from tube transmitted force to unseat the valve and vent said chamber and thereafter to reseat the valve with balance spring recovery.

8. In combination, a chamber having an inlet for substantially constant pressure fluid supply to the chamber and having a valved chamber vent to be opened and closed to control chamber pressure and movable in response to chamber pressure variation, an oscillatory spring opposed inertia member and motion transmitting means between said inertia member and the valved chamber vent and including a flexible spring having a terminal seat engageable with the movable vent to close the same and to be propelled therewith upon chamber pressure increase for driving and storing energy in the inertia member, whose resultant action first disengages said flexible spring from the vent to open the same and enable return thereof upon chamber pressure decrease and thereafter reverses spring travel in follow-up relation with the returned vent and to a resilient cushioned re-engagement therewith.

9. The structure as in claim 8, wherein said spring is a flat blade and its terminal seat is constituted by a flat surface thereof.

10. The structure of claim 8, wherein the terminal seat is a valve disc mounted on the spring and provided with a dependent stem having slide guide reception within said vent.

11. The structure of claim 7, said inertia means being a balance wheel having a stop abutment thereon, a co-operating stop fixed in the travel path of said abutment to establish one limit to the range of wheel oscillation.

12. The structure of claim 11 and means adjustably mounting said stop for range variation.

13. The structure of claim 7 wherein the inertia means is an oscillatory wheel carrying stop abutment means and relatively adjustable stops are positioned in the path of the abutment means and establish opposite oscillation limits therefor and whose adjustment enables beat variation.

14. In a pneumatic stroke motor, a variable volume chamber having a movable wall responsive to chamber pressure and a vent in said wall, a movable vent closure valve bearing on the wall for movement therewith on the pressure stroke, a spring return balance wheel connected for pressure stroke movement with the valve and throughout a range exceeding that of the movable chamber wall, stop means having spaced apart abutments engageable with mating contact abutments on said balance wheel and defining opposite limits of wheel oscillation and means adjustably setting the spacing between the stop abutments for establishing oscillation ranges selectively.

15. In a pneumatic stroke motor, a variable volume chamber having a movable wall responsive to chamber pressure and a vent in said wall, a movable vent closure valve bearing on the wall for movement therewith on the pressure stroke, a spring return balance wheel connected and movable with the valve throughout a range exceeding that of the movable chamber wall, stop means having spaced apart abutments engageable with mating contact abutments on said balance wheel and defining opposite limits of wheel oscillation, means adjustably setting the spacing between the stop abutments for establishing oscillation ranges selectively and an impact cushioning means incorporated in certain of said contact abutments.

16. In a pneumatic stroke motor, a variable volume chamber having a movable wall responsive to chamber pressure and a vent in said wall, a movable vent closure valve bearing on the wall for movement therewith on the pressure stroke, an inertia member drive connected with the valve and movable throughout a range exceeding that of the movable chamber wall, a support mounting said inertia member for oscillation and interengageable stop abutment means on said member and said support limiting the range of member oscillation and including an impact cushioning buffer.

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