March 9, 1954 E. W. PATTERSON 2,671,356

PNEUMATIC TIME COMPENSATOR

Filed Feb. 8, 1952 3 Sheets-Sheet 1

FIG. 1.

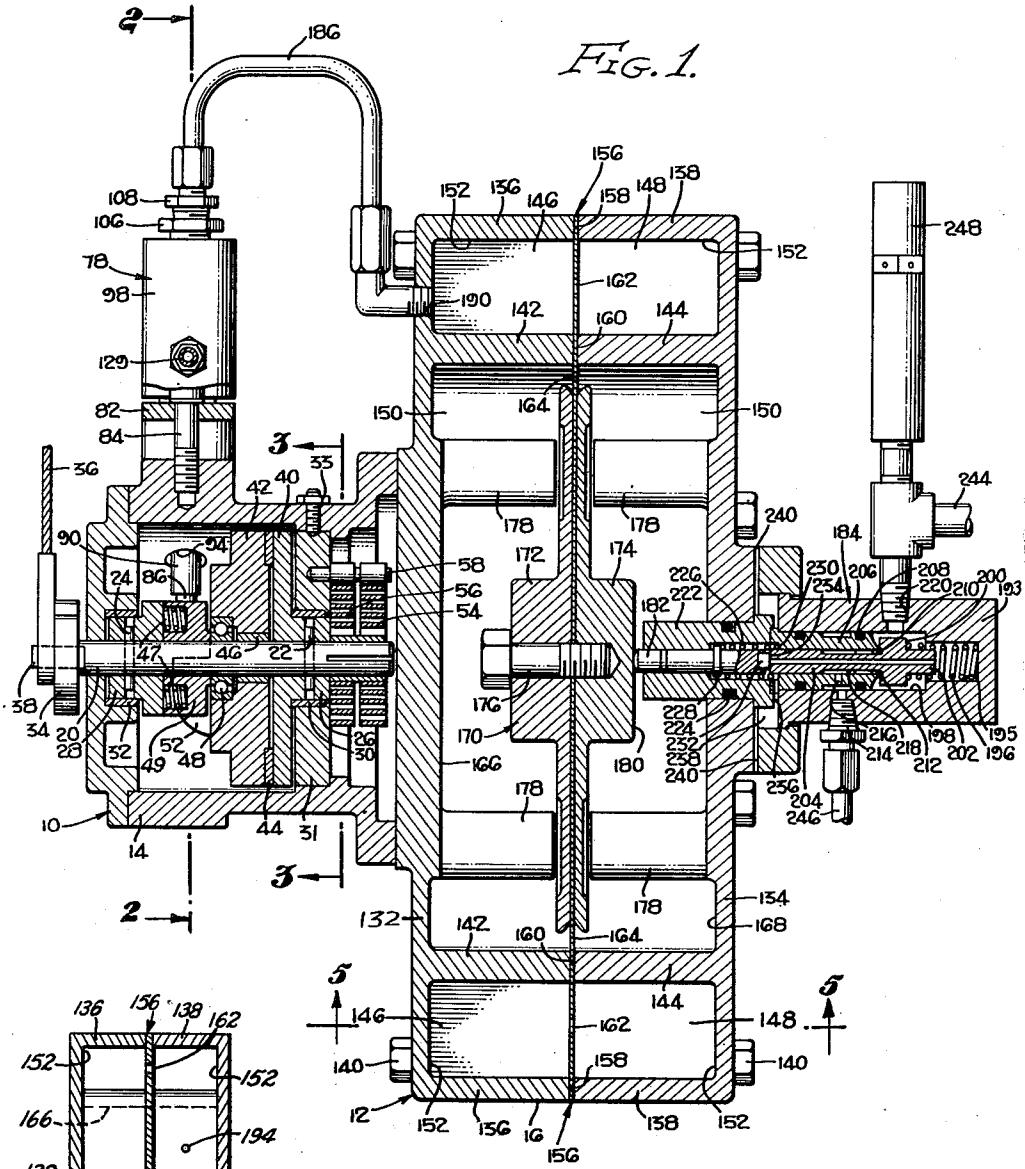


FIG. 5.

EDGAR W. PATTERSON,
INVENTOR.

BY

ATTORNEY

March 9, 1954 E. W. PATTERSON 2,671,356

PNEUMATIC TIME COMPENSATOR

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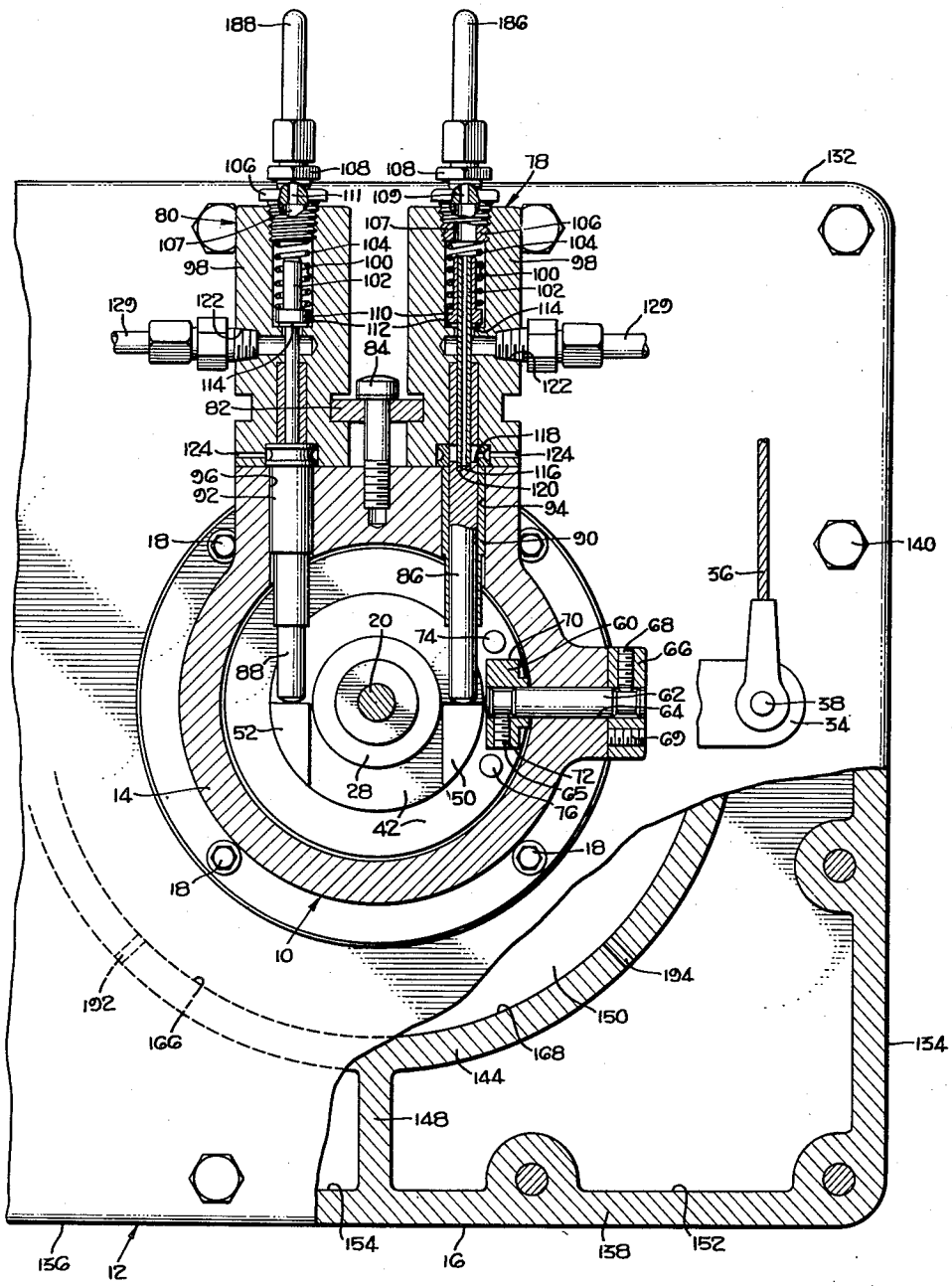


FIG. 2.

EDGAR W. PATTERSON,
INVENTOR.

BY

ATTORNEY

March 9, 1954 E. W. PATTERSON 2,671,356

PNEUMATIC TIME COMPENSATOR

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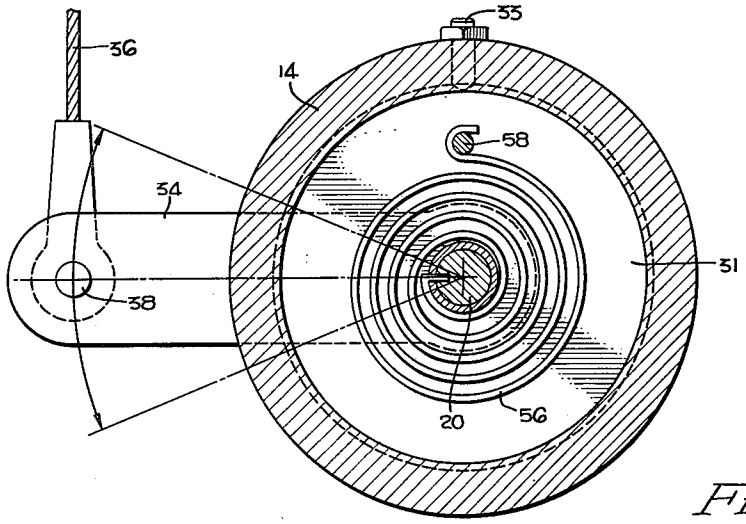


FIG. 3.

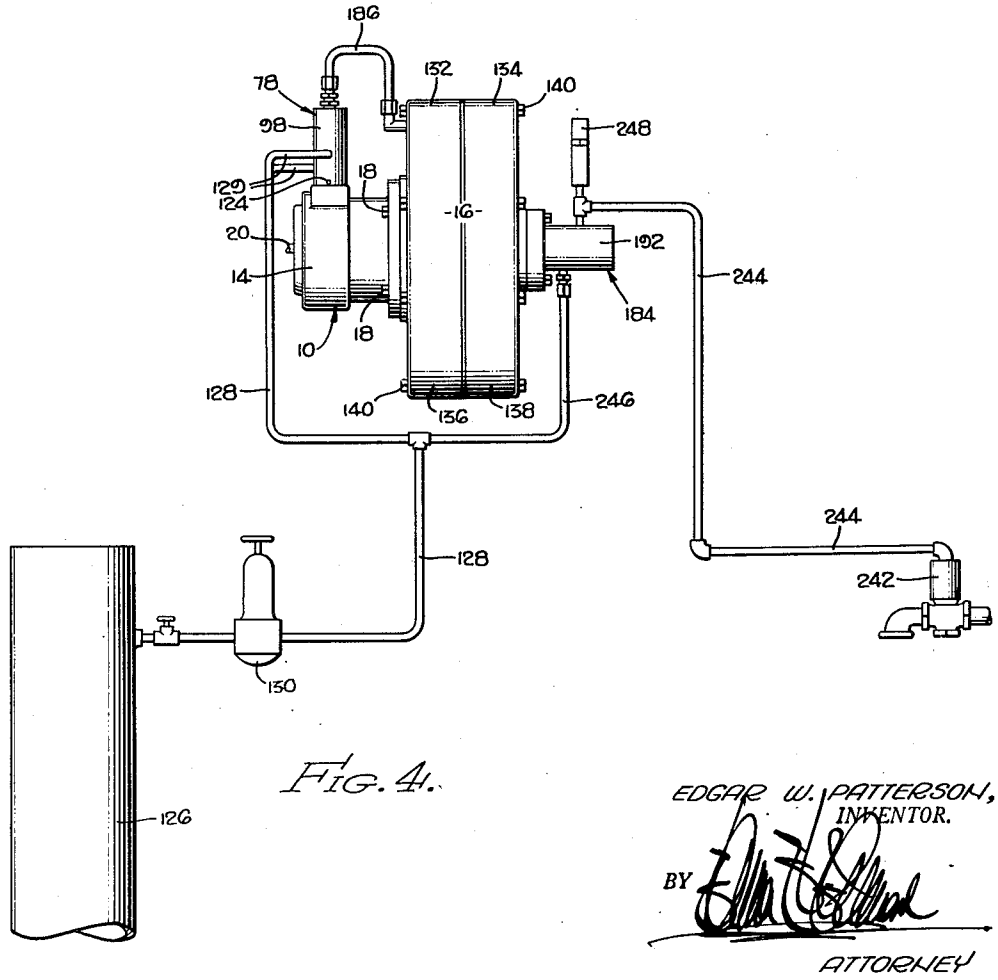


FIG. 4.

EDGAR W. PATTERSON,
INVENTOR.

BY

ATTORNEY

Patented Mar. 9, 1954

2,671,356

UNITED STATES PATENT OFFICE

2,671,356

PNEUMATIC TIME COMPENSATOR

Edgar W. Patterson, Downey, Calif.

Application February 8, 1952, Serial No. 270,660

23 Claims. (Cl. 74—589)

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The present invention is an improvement on my co-pending application Serial No. 129,233 for Hydraulic Time Compensator, filed November 25, 1949, now Patent No. 2,651,945.

My invention relates to balancing systems for machines utilizing reciprocal motion, and more particularly to apparatus for measuring and subsequently automatically causing the time interval to become equal for both of the one hundred eighty degree (180°) half cycles, or the up and down or forward and backward movements of an oscillating or reciprocating machine such as an air balanced pumping unit for oil or water wells. Such an air balanced pumping unit is disclosed in one of my prior patents, Reissue No. 20,287, March 9, 1937.

Although a balancing system such as the above mentioned one described in my Reissue Patent No. 20,287, March 9, 1937, will normally maintain a substantially constant torque on the prime mover of an oil well pumping unit or other reciprocating unit, changes in the load on the reciprocating member cause variations in the torque on the prime mover during different parts of the cycle of the reciprocating unit and thus cause variations in the time which it takes for the reciprocating unit to move through each half-cycle. These variations in the load cause stresses throughout the unit which lead to a shortening of the life of the unit.

Consequently, it is an object of my invention to produce a time compensator which reacts to deviations in the time intervals for the half-cycles of a reciprocating unit in such a way that the load on one of the half-cycles is substantially equalized to the load on the other half cycle.

Another object of my invention is to produce a time compensator which reacts to deviations in the time intervals of the half-cycles of an air balanced pumping unit in such a way that the balancing pressure is adjusted to that pressure which will substantially equalize the well load and hence equalize the time intervals of the half-cycles of the pumping unit.

Another object of my invention is to produce a time compensator which will automatically maintain a substantially constant torque on the prime mover of an air balanced pumping unit for oil or water wells.

Another object of my invention is to produce a time compensator which will accurately measure the half-cycle time intervals of a reciprocating unit and balance these time intervals in accordance with such measurement.

Another object of my invention is to produce

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a time compensator which utilizes air to measure the half-cycles of a reciprocating unit and to actuate a balancing device in accordance with such measurement.

Another object of my invention is to produce a pneumatic time compensator of the character described which can be adjusted to compensate to any poundage over or under a perfect balance, within reasonable values, so that the compensator can be used for any type of pumping wherein an off balance may be desired.

A further object of my invention is to produce a pneumatic time compensator of the character described which may utilize air supplied from the balancing system of an air balanced pumping unit, or other source of supply, to adjust the air pressure within said air balancing unit so that the down and up strokes of such pumping unit are properly balanced.

Other objects and advantages of my invention will be apparent from the following description and claims, the novelty consisting in the features of construction, combination of parts, the unique relations of the members and the relative proportioning, disposition and operation thereof, all as is more completely outlined herein and as is particularly pointed out in the appended claims.

In the accompanying drawings, forming a part of the present specification,

Figure 1 is a sectional view of my invention showing both the pressure control unit and the compensator unit.

Figure 2 is a side elevation, partly in section, along the line 2—2 in Figure 1, showing the details of my pressure control unit.

Figure 3 is a sectional view along the line 3—3 in Figure 1, showing my spring valve action return mechanism.

Figure 4 is a plan view of my invention.

Figure 5 is a sectional view along the line 5—5 in Figure 1.

Referring to the drawings, my pneumatic time compensator comprises two principal elements, a pressure control unit 10 and a compensator unit 12.

My pressure control unit 10 is primarily contained within a housing 14 which in turn is secured to a compensator unit housing 16 by means of bolts 18.

Centrally positioned within pressure control unit housing 14 is an input shaft 20. Integrally attached to input shaft 20 by means of pins 22 and 24 are a pair of annular collars 26 and 28, respectively. Collars 26 and 28 are journalled

in bearings 30 and 32, respectively, to permit input shaft 20 to freely rotate within pressure control unit housing 14. Bearing 30 is mounted within a disc 31 which is clamped in position in housing 14 by set-screw 33.

Integrally attached to the outer end of input shaft 20 is a crank arm 34, the other end of arm 34 being pivotally connected to a flexible link cable 36 by means of crank pin 38 which is pivotally connected to the walking beam of an oil well pumping rig, or to any reciprocal member of a reciprocating unit which is to be balanced (not shown).

I provide a flange at one end of my collar 26 to form a clutch plate 40 which is operatively connected to a second clutch plate 42 by means of a clutch facing 44 which may be mounted free on either of the clutch plates 40 or 42. My clutch plate 42 is freely rotatable about input shaft 20, being mounted on bushing 46 and ball bearings 48.

I provide a constant clutch pressure on clutch facing 44 by means of compression springs 47 which are compressed between collar 28 and a tubular member 49 that is slideably mounted on shaft 20. Tubular member 49 transmits the constant force of springs 47 to clutch plate 42 through bearing 48.

I provide a pair of valve operating lugs 50 and 52 which are integrally mounted on the back of clutch plate 42. As best illustrated in Figure 2, these lugs are preferably so disposed about the central axis of input shaft 20 that a straight line will intersect the tops of both lugs and the center of input shaft 20. Lugs 50 and 52 are normally kept in their extreme clockwise position in Figure 2 by one or more clock springs, such as clock springs 54 and 56 shown in Figure 1. One end of springs 54 and 56 is affixed to shaft 20 and the other end is anchored to a pin 58 supported by disc 31. I maintain the correct tension in my springs 54 and 56 by adjusting disc 31, which may be rotated by loosening screw 33.

As an alternative embodiment of my invention I sometimes provide a link rod in place of my flexible cable 36 to connect my crank arm 34 with the reciprocal unit (not shown) to be balanced. In this construction of my invention the link rod which replaces flexible cable 36 positively moves the crank arm downward as well as upward, so that my return-action clock springs 54 and 56 are unnecessary and may be omitted from the structure.

I limit the amount of rotation of my plate 42 by an eccentric stop-lug 60 which is mounted on one end of a shaft 62 that is rotatably mounted in a passage 64 in one side of my housing 14. A set screw 65 in my eccentric stop-lug 60 prevents relative motion between stop-lug 60 and shaft 62.

Mounted outside of my housing 14, on the outer end of shaft 62, is a circular head 66 which is locked in position on shaft 62 by means of a set screw 68. I manually turn my circular head 66 until my eccentric stop-lug 60 is properly positioned within the housing 14 and then I lock my circular head 66, and hence my shaft 62 and my stop-lug 60, against rotation by tightening up a set screw 69 in my circular head 66 which is adapted to abut against the outside of housing 14.

The upper and lower sides of my eccentric lug 60 form faces 70 and 72, respectively, which are adapted to respectively engage a pair of stop-

pins 74 and 76 that are integrally mounted on the back of my clutch plate 42.

Reciprocal motion of the walking beam or other reciprocating element (not shown) will cause reciprocation of flexible cable 36 and consequently it will cause oscillation of crank 34 and input shaft 20.

Taking the starting point as the position shown in Figure 2, upward movement of flexible cable 36 will cause upward movement of crank arm 34 and hence it will cause counterclockwise movement of input shaft 20. Clutch plate 40, which is integrally attached to shaft 20, will have the same counterclockwise angular movement as the shaft 20.

As this counterclockwise movement of clutch plate 40 is commenced, clutch plate 42 will be moved counterclockwise because of the operative connection between clutch plates 40 and 42 through the clutch facing 44. This counterclockwise movement of clutch plate 42, and the consequent raising of lug 50 and lowering of lug 52, will continue until stop-pin 76 engages face 72 of eccentric stop-lug 60. This engagement of pin 76 and face 72 will completely arrest the counterclockwise movement of clutch-plate 42 and the upward and downward movement of lugs 50 and 52, respectively. Any further movement of shaft 20 and clutch plate 40 in a counterclockwise direction will not carry clutch plate 42, but will cause slideable engagement between clutch plates 40 and 42 through clutch facing 44, whereby clutch plate 40 will be free to move counterclockwise to the limit of its oscillation.

When flexible cable 36 begins to move downward in accordance with the commencement of a new half-cycle of oscillation, shaft 20 and clutch-plate 40 immediately commence to move clockwise under the influence of springs 54 and 56. Plate 40 then picks up plate 42 in the manner hereinbefore described, and plate 42 will rotate clockwise until its motion is arrested by contact between stop pin 74 and face 70 when the lug 50 is at its lowest point and lug 52 is at its highest point. At that time, there will be sliding friction between the clutch plates 40 and 42, whereby clutch plate 40 will be permitted to rotate under the influence of springs 54 and 56 until the downward motion of cable 36 ceases.

In like manner, as soon as my flexible cable 36 begins to move upward from its lowest position, clutch plate 40 immediately commences to move counterclockwise. Plate 40 then picks up plate 42 and the two will rotate together until the motion of plate 42 is stopped by contact between stop pin 76 and face 72 of stop-lug 60. Plate 40 will continue to rotate alone until its direction of rotation is reversed.

In this manner, lug 50 will be up and lug 52 will be down for an interval of time substantially equal to the length of time that flexible cable 36 is moving from the bottom to the top of its stroke, and lug 50 will be down and lug 52 up for an interval of time substantially equal to the length of time that flexible cable 36 is moving from the top to the bottom of its stroke.

In order to adjust my pressure control unit 10 so that the amount of movement of lugs 50 and 52 above a horizontal center line through shaft 20 will be exactly equal I merely loosen set screw 69 and turn circular head 66 until faces 70 and 72 of my eccentric stop-lug 66 are equidistant from the respective stop-pins 74 and 76. Another adjustment of eccentric stop-lug 60 may

be made to cause one of the lugs 50 and 52 to move farther above a horizontal line through the center of shaft 20 than the other lug.

I use the portion of my apparatus which I will hereinafter describe to measure the above two time intervals, and to readjust the balancing load on the reciprocating unit in accordance with that measurement.

A pair of two way air valves, 78 and 80 are affixed to the top of the pressure control unit housing 14 by means of a plate 82 which is affixed to both of valves 78 and 80 and a bolt 84 which clamps valves 78 and 80 to the top of pressure control unit housing 14 by connecting said housing 14 and plate 82. It is to be understood that any other suitable means for attaching valves 78 and 80 to housing 14 may be used.

Extending downwardly from valves 78 and 80 are a pair of actuating stems 86 and 88, respectively, which are slideably mounted in a pair of sleeves 90 and 92 that are inserted in vertical passages 94 and 96 through housing 14.

My two-way air valves 78 and 80 are similarly constructed, each being provided with a valve body 98 having a vertical bore 100 wherein a tubular valve element 102 is slideably mounted. Compression springs 104 are disposed within the upper portion of bores 100, being kept within bores 100 by contact with outlet port adapters 106 which contain two-way air ports 107 therein. Springs 104 abut against the tops of tubular valve elements 102 and urge elements 102 downward.

Threadedly mounted in the upper portions of adapters 106 are tubular bolts 108 which contain orifices 109 and 111 that are adapted to control the amount of air which is permitted to pass into and out of two-way air valves 78 and 80, respectively.

When valve elements 102 are in their normal positions as shown in Figure 2, annular flanges 110 in the upper portions of elements 102 are seated on valve seats 112 by the downward force from springs 104. I provide sealing rings 114 between flanges 110 and valve seats 112 to prevent air from passing therethrough when flanges 110 are seated on valve seats 112.

Still considering the position of valve elements shown in Figure 2, lower faces 116 of valve elements 102 are in contact with upper faces 118 of actuating stems 86 and 88. Sealing rings 120 are disposed between faces 116 and 118 to prevent air from passing between them when they are in contact.

By this arrangement, when my actuating stems 86 and 88 and my valve elements 102 are in the position shown in Figure 2, air will be blocked, by the seating of flanges 110 on valve seats 112, from passing through valves 78 and 80 by entering valves 78 and 80 at air pressure input points 122 and leaving valves 78 and 80 at two-way air ports 107.

A further result of this position of stems 88 and valve elements 102 is that air will be blocked by the seating of faces 116 upon faces 118, respectively, from passing through valves 78 and 80 by entering valves 78 and 80 at two-way air ports 107, passing lengthwise through tubular valve elements 102 and leaving valves 78 and 80 through bleeder passages 124.

When lug 50 is raised and lug 52 is lowered, in the manner heretofore described, my actuating stem 86 and its corresponding valve element 102 are raised, and my actuating stem 88 is lowered leaving its corresponding valve element 102 suspended, by engagement between annular flange 110 and valve seat 112, in the position shown in Figure 2. This will permit compressed air to flow into valve 78 through compressed air inlet port 122, upward through vertical bore 100, between annular flange 110 and valve seat 112 and out of valve 78 through two-way air port 107 and orifice 109. Air will be prevented from leaving valve 78 through bleeder passage 124 by continuous engagement between face 118 of actuating stem 86 and face 116 of the corresponding valve element 102.

At the same time, air will be prevented from flowing through valve 80 from its air pressure input port 122 to its two-way air port 107 by engagement between flange 110 and seat 112 of valve 80. However, air will be permitted to bleed through valve 80 by entering valve 80 through orifice 111 and two-way air port 107, passing down through the center of tubular valve element 102, passing between face 118 of actuating stem 88 and face 116 of the corresponding valve element 102, and then passing out of valve 80 and into the atmosphere through bleeder passage 124.

Thus, when my shaft 20 is rotated counterclockwise in Figure 2, compressed air will pass out of valve 78 through its two-way port 107 and orifice 109 and air will pass into valve 80 through orifice 111 and its two-way port 107. Similarly, when shaft 20 is rotated clockwise in Figure 2, compressed air will pass into valve 78 through orifice 109 and its two-way port 107 and air will pass out of valve 80 through its two-way port 107 and orifice 111.

Compressed air may be provided at air pressure input ports 122 by a connection between ports 122 and any conventional source of air pressure. However, in the preferred embodiment of my invention in which my pneumatic time compensator is utilized in connection with an air balanced reciprocating system, main air vessel 126 of the air balancing system is connected to pressure input ports 122 by means of a pressure line 128 which branches into a pair of lines 129. Since only a very low pressure is necessary to operate my time compensator, a pressure reducer 130 is interposed in line 128.

Having explained the operation of my pressure control unit 10, I will now describe my compensator unit 12. Compensator unit housing 16 comprises two preferably rectangular sections, 132 and 134, having laterally extending flanges 136 and 138 on their respective circumferences. Sections 132 and 134 are so relatively positioned that flanges 136 and 138 oppose each other, and sections 132 and 134 are clamped together by means of bolts 140.

Disposed on sections 132 and 134 of compensator unit housing 16 are tubular flanges 142 and 144, respectively, which are centrally positioned in inter-opposing relationship on sections 132 and 134 inside of the respective flanges 136 and 138.

Flanges 136 and 142 are connected at both the bottom and the top of section 132 by a centrally located vertical metal web 146, and similarly flanges 138 and 144 are connected at both the bottom and the top of section 134 by a centrally located metal web 148. Metal webs 146 and 148 are so disposed in sections 132 and 134 that they oppose each other.

When my compensator housing sections 132 and 134 are clamped together by bolts 140 to form the compensator housing 16 a central chamber 150 is formed inside of the tubular flanges 142

and 144. A second chamber, primary chamber 152, is formed to the right of metal webs 146 and 148 between flanges 142 and 144 on the inside and flanges 136 and 138 on the outside. A third chamber, primary chamber 154, is formed to the left of metal webs 146 and 148 between flanges 142 and 144 on the inside and flanges 136 and 138 on the outside.

I provide a sheet 156 of pliable material which is clamped between compensator unit housing sections 132 and 134. Sheet 156 forms an air sealing gasket 158 between lateral flanges 136 and 138. A similar air sealing gasket 160 is formed by sheet 156 between tubular flanges 142 and 144. Sheet 156 is perforated as at 162, between flanges 142 and 144 on the inside and flanges 136 and 138 on the outside so that the right and left hand chambers 152 and 154, respectively, remain undivided.

The portion of sheet 156 which passes through central chamber 150 forms a flexible diaphragm 164 that bisects central chamber 150 into two secondary air chambers, 166 and 168, disposed respectively in housing sections 132 and 134.

Centrally mounted on my diaphragm 164 is a valve actuator 170 which comprises two portions, 172 and 174, that are clamped on opposite sides of diaphragm 164 by means of a bolt 176. The peripheries of the two portions 172 and 174 of actuator 170 are bevelled adjacent to diaphragm 164 to prevent injury to diaphragm 164 upon movement of the diaphragm due to a change in the relative air pressures of chambers 166 and 168. A plurality of stop-lugs 178 are formed on both sides of chamber 150 and extend inward toward the center of chamber 150. The ends of lugs 178 are spaced a small distance from the opposite sides of valve actuator 170 when actuator 170 is in its normal or central position as illustrated in Figure 1. These lugs limit the amount of lateral movement of valve actuator 170 so that injury to diaphragm 164 will be prevented.

Portion 174 of my actuator 170 is provided with a front face 180 which is centrally positioned within chamber 168 and which abuts against one end of a valve actuating stem 182. Actuating stem 182 is utilized to actuate a two-way air valve 184 in much the same manner that my actuating stems 86 and 88 are used in connection with my valves 78 and 80. Valve 184 is considerably more sensitive than valve 78 and 80, so that movement of actuating stem 182 a small fraction of an inch will be sufficient to operate valve 184.

My orifices 109 and 111, associated with valves 78 and 80, respectively, are respectively connected to right and left hand primary chambers 152 and 154 through a pair of two-way air lines 186 and 188 and a pair of two-way ports 190.

During the half-cycle of operation of the reciprocating unit which is to be balanced when actuating stem 86 is up and actuating stem 88 is down, compressed air will flow from air vessel 126, through two-way air valve 78 in the manner heretofore explained, and hence into right-hand primary chamber 152 of the compressor unit through air line 186.

At the same time the two-way air valve 80 will permit air to flow into it and out at bleeder passage 124, whereby air will be permitted to bleed out of left-hand primary chamber 154 through air line 188 and two-way air valve 80.

I provide a small orifice 192 between my left-hand primary chamber 154, and my secondary chamber 166, and a corresponding small orifice 194 between my right-hand primary chamber 152 and my secondary chamber 168.

Thus, when air is permitted to flow into my right-hand primary chamber 152 by movement of actuating stem 86 to the upward position in the above manner, the resulting small increase of the pressure within right-hand primary chamber 152 will cause a corresponding even smaller increase in the pressure in secondary chamber 168 due to the passage of a small quantity of air through orifice 194.

Similarly, when air is simultaneously permitted to flow out of my left-hand primary chamber 154 by movement of actuating stem 88 to the downward position in the above manner, the resulting small decrease of the pressure within left-hand primary chamber 154 will cause a corresponding even smaller decrease in the pressure in secondary chamber 166 due to the passage of a small quantity of air through orifice 192.

By thus using my dual chamber system of having a pair of primary chambers 152 and 154 and a corresponding pair of secondary chambers 166 and 168, I minimize the pulsation factor at diaphragm 164. This is necessary in order to prevent constant oscillation of my actuator 170 and hence of my valve actuating stem 182.

Although the preferred embodiment of my invention has this dual chamber system, it is to be understood that my primary chambers 152 and 154 may be omitted and suitable results will still be obtained. However, if only a single pair of chambers, such as chambers 166 and 168, were used, these chambers 166 and 168 would have to be approximately 10 times as large as is necessary when I use both my primary and my secondary chambers.

Similarly, during the other half-cycle of operation of the reciprocating unit which is to be balanced, actuating stem 86 will be down, and actuating stem 88 will be up, whereby air will be admitted to primary and secondary chambers 154 and 166, respectively, and air will be exhausted from primary and secondary chambers 152 and 168, respectively.

The amount of air that is admitted to secondary chambers 166 and 168 during the respective half-cycles depends on the amount of pressure at air pressure input ports 122, the size of the orifices 109 and 111 in the two-way air lines 186 and 188, respectively, on the length of time that the valves 78 and 80 permit air to flow to primary chambers 152 and 154, on the size of orifices 192 and 194, and the relative sizes of my primary and secondary chambers.

The air pressure supplied to air pressure input ports 122 is maintained at a substantially constant value by means of pressure reducer 130 in the preferred embodiment of my invention, and since the sizes of orifices 109 and 111, and 192 and 194 remain constant, the only variable of the above factors is time.

Thus, if the half-cycles of operation of the reciprocating unit are of identical duration, two-way air valves 78 and 80 will admit air to the respective primary chambers 152 and 154 for the same time interval and they will also allow air to bleed out of the respective primary chambers 152 and 154 for the same time interval, whereby the same pressure will be maintained within each of my primary chambers 152 and 154. In turn,

this causes equal pressures to be maintained in secondary chambers 166 and 168.

However, if the upward half-cycle of operation of the reciprocating unit is longer than the downward half-cycle, then two-way air valve 78 will admit compressed air to primary chamber 152 for a longer portion of each complete cycle than two-way air valve 80 will admit compressed air to primary chamber 154, and also valve 78 will permit air to bleed out of primary chamber 152 for a lesser time than valve 80 will permit air to bled out of chamber 154. In turn, this will cause a gradual increase in the air pressure within secondary chamber 168 over the air pressure within secondary chamber 166, whereby diaphragm 164 will move to the left in Figure 1. This causes actuator 170 to move to the left as an integral part of diaphragm 164 whereby front face 180 of actuator 170 will move away from valve actuating stem 182 to the left.

On the other hand, if the downward half-cycle of operation of the reciprocating unit is longer than the upward half-cycle, air valve 80 will admit compressed air to primary chamber 154 for a longer portion of each complete cycle than two-way air valve 78 will admit compressed air to primary chamber 152 and also valve 80 will permit air to bleed out of primary chamber 154 for a shorter period of time than valve 78 will permit air to bleed out of primary chamber 152. This will cause a gradual increase in the air pressure within primary chamber 154 over the air pressure within chamber 152, which in turn will cause a small increase in the air pressure within secondary chamber 166 over the air pressure within secondary chamber 168. This pressure differential between secondary chambers 168 and 166 will cause diaphragm 164 and actuator 170 to move to the right in Figure 1 so that valve actuating stem 182 will be permitted to move to the right.

Only a slight difference in the air pressures within secondary chambers 166 and 168 is necessary to cause actuation of valve actuating stem 182, but a sufficient difference in pressure is required so that merely momentary changes in the time required for the half-cycles of the reciprocating unit will not be sufficient to actuate valve 184. The time interval between the first instant the reciprocating unit becomes unbalanced and when valve 184 is actuated is determined by the pressure which is admitted to air pressure inlet valves 122 by the sizes of orifices 109, 111, 192 and 194, by the relative sizes of my primary and secondary chambers, and by the difference in pressure between secondary chambers 166 and 168 which is necessary in order to actuate valve 184. Although the air pressure supplied at ports 122 is one of the variables which must be controlled, any suitable amount of pressure may be used which properly corresponds with the other factors such as sizes of my orifices.

The air pressure which I supply at ports 122 may be less than atmospheric pressure. A source of such a partial vacuum which is generally readily accessible is the intake manifold of a combustion engine. If the pressure at ports 122 is less than atmospheric pressure I cross my air lines 186 and 188 so that valve 78 is connected to primary and secondary chambers 154 and 166, respectively, and so that valve 80 is connected to primary and secondary chambers 152 and 168, respectively. This construction causes diaphragm 164 to move in the same direction as indicated above for a corresponding movement of flexible cable 36.

Valve 184 functions similarly to valves 78 and 80, but is considerably more sensitive to a small shift in the position of valve actuating stem 182 than valves 78 and 80 are to movement of their respective actuating stems 86 and 88. The outer portion of valve 184 consists of a valve body 193 having a small cylindrical chamber 195 in its outer end to receive a coil spring 196 and a large cylindrical chamber 198 through most of its length which is adapted to receive the working parts of the valve.

The exposed end of spring 196 engages an annular flange 200 of tubular valve element 202, the outer end of valve element 202 being disposed within the coils of spring 196.

Shank 204 of tubular valve element 202 is slideably mounted within a sleeve 206 which tightly fits in the inner portion of large cylindrical chamber 198. A sealing engagement is effected between sleeve 206 and chamber 198 by means of sealing rings 208.

Flange 200 of valve element 202 is urged into sealing engagement with valve seat 210 provided at the outer end of sleeve 206 by means of the spring 196 when the actuating stem 182 is in the position shown in Figure 1. A sealing ring 212 completes the seal between flange 200 and seat 210. In this position of valve element 202, air will not pass through valve 184 in the usual manner by entering valve 184 at air pressure input port 214, passing through passages 216 in sleeve 206, passing along passage 218 provided by the reduced diameter of a portion of shank 204, passing between flange 200 and seat 210 and then out of valve 184 through two-way air port 220.

Actuating stem 182 is slideably mounted within a sleeve 222 which is centrally disposed through compensator unit section 134. A sealing ring 224 is disposed between sleeve 222 and section 134. Stem 182 is urged toward actuator 170 by a coil spring 226, one end of spring 226 engaging a flanged portion 228 of stem 182 and the other end of spring 226 engaging a shoulder 230 in the end of sleeve 206.

A sealing pad 232 is affixed to the outer end of actuating stem 182 in order to provide a seat for the inner end 234 of tubular valve element 202, so that when the actuating stem 182 and valve element 202 are in the position shown in Figure 1, air will not be permitted to bleed through valve 184 by entering valve 184 through two-way air port 220, passing inward through the tubular valve element 202, passing between sealing pad 232 and end 234 of valve element 202 and then passing out of valve 184 into the atmosphere through passage 236, chamber 238 and clearance 240.

When my actuating stem 182 is moved to the right in Figure 1 by movement of my actuator 170, flange 200 will become spaced from seat 210, whereby air will be permitted to flow through valve 184 from air pressure input port 214 to two-way air port 220. This air is conveyed to an unloader device 242 (see Figure 4) by means of an air line 244 whereby unloader 242 will be so actuated as to retain the balancing pressure at the value which it then has.

On the other hand, when my actuator 170 is moved to the left in Figure 1, actuating stem 182 will be moved to the left by the compression of coil spring 226 so that stem 182 will remain in

engagement with surface 180 of actuator 170. Although my spring 196 will prevent air from entering the system through air pressure input port 214, air pressure will be released from unloader 242 by being permitted to flow into valve 184 through line 244 and two-way air port 220, through the center of tubular valve element 202, between sealing pad 232 and end 234 of valve element 202, and then pass out of valve 184 into the atmosphere through passage 236, chamber 238 and clearance 240. By thus removing pressure from my unloader 242, the unloader will permit the balancing pressure to be raised.

It can thus be seen that whenever the upward half-cycle of the reciprocating unit becomes longer in duration than the downward half-cycle, which would be the case in an oil well pumping rig when the load becomes too heavy for the balancing pressure that is being used, pressure control unit 10 will provide more air to chamber 168 than to chamber 166 in compensator unit 12, whereby actuator 170 will move to the left, so actuating my valve 184 that valve 184 will release pressure from unloader 242 to cause the balancing pressure to be raised.

However, whenever the reciprocating unit is in an overbalanced condition and the downward half-cycle of the reciprocating unit is longer in duration than the upward half-cycle, pressure control unit 10 will provide more air to chamber 166 than to chamber 168, whereby actuator 170 will move to the right, so actuating my valve 184 that valve 184 will apply pressure to unloader 242 to cause the balancing pressure to remain at the value which it then has.

Air pressure is supplied to port 214 by means of line 246 which is connected to pressure line 128 between reducer 130 and valves 78 and 80.

I provide a set pop valve 248 in line 244 between valve 184 and unloader 242. Set pop valve 248 will dissipate or exhaust any excess balancing pressure from the pumping unit balancing system after a given interval of time has elapsed from the time of introduction of the additional pressure into the air balancing system in the manner described above. It will simultaneously keep sufficient air pressure from valve 184 exposed against unloader 242 to maintain unloader 242 in proper operating condition.

The use of set pop valve 248 allows the air balancing system to be in an overbalanced condition, after pressure is released from unloader 242 through valve 184 because of a greater pressure in chamber 166 than in chamber 168, for a sufficient time to enable pressure control unit 10 to equalize the pressures within chambers 166 and 168. At this time actuator 170 will be in its central position, as illustrated in Figure 1, and set pop valve 248 will then automatically reduce the pressure in the balancing system to the properly balanced state. Pressure control unit 10 will thereafter merely maintain equal pressures within chambers 166 and 168, and valve 184 will remain in its normal position as shown in Figure 1.

During the normal use of my pneumatic time compensator in connection with a reciprocating unit I adjust eccentric stop lug 60 so that the reciprocating unit is substantially perfectly balanced. However, by proper adjustment of my eccentric stop-lug 60, I am able to compensate to any poundage over or under a perfect balance, within reasonable values. Thus, my pneumatic time compensator may be used for any type of pumping wherein either a substantially perfect balance or an off balance is desired.

It is to be noted that although my preferred embodiment is used in connection with an air balanced reciprocating unit, it can be connected with a system which is balanced by other means than air, such as a pumping system which is balanced by moveable weights.

Further, it is to be understood that other devices can be used in place of my two-way air valve 184 for enabling unloader device 242 to be actuated by movements of actuating stem 182. For example, in certain applications of my invention wherein it may be advantageous to use electricity instead of air as the secondary actuating medium, it would be a simple matter for one skilled in the art to substitute an electric make and break contact device for two-way air valve 184 whereby a clutch could be moved into and out of engagement, in turn causing an air compressor to supply and discharge air respectively precisely in the same way that my two-way air valve 184 supplies and discharges air.

It is also to be understood that any suitable dual, two-way air valve system and associated operating mechanism may be utilized in place of my preferred pressure control unit 10 without departing from my present invention.

The simplicity, accuracy and compactness of my invention contribute to make it a highly useful and desirable commercial item.

It is to be understood that the form of my invention herein shown and described is my preferred embodiment and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of my invention, or the scope of the appended claims.

I claim:

1. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit, an air pressure connection between said pressure control unit and said compensator unit and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

2. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit, an air pressure connection between each of said valves and said compensator unit and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

3. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, each of said air valves having an input port, an output passage and a two-way port, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said input ports, a compensator unit, an air pressure connection between each of said two-way ports and said compensator unit and an output member on said compensator

unit which is operatively connectable to means for balancing said machine.

4. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of pressure chambers, an air pressure connection between said pressure control unit and each of said chambers and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

5. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit including a pair of pressure chambers, air pressure connections between said valves and said pressure chambers, respectively, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

6. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, each of said air valves having an input port, an output passage and a two-way port, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said input ports, a compensator unit including a pair of pressure chambers, air pressure connections between said two-way ports and said chambers, respectively, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

7. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of pressure chambers, an air pressure connection between said pressure control unit and each of said chambers, a pressure differential responsive member separating said pressure chambers and an output member on said compensator unit operatively connected to said pressure differential responsive member, said output member being operatively connectable to means for balancing said machine.

8. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit including a pair of pressure chambers, air pressure connections between said valves and said pressure chambers, respectively, a pressure differential responsive member separating said pressure chambers and an output member on said compensator unit operatively connected to said pressure differential responsive member, said output member being operatively connectable to means for balancing said machine.

9. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of pressure chambers, an air pressure connection between said pressure control unit and each of said chambers, a diaphragm separating said pair of pressure chambers and an output member on said compensator unit operatively connected to said diaphragm, said output member being operatively connectable to means for balancing said machine.

10. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves, each of which is operably connected to an air valve actuating stem, the respective said actuating stems being operatively connectable, by means of a pair of operative connections having a substantially 180 degree relative phase difference, to a reciprocating member of said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit, an air pressure connection between each of said valves and said compensator unit and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

11. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves, each of which is operably connected to an air valve actuating stem, the respective said actuating stems being operatively connectable, by means of a pair of operative connections having a substantially 180 degree relative phase difference, to a reciprocating member of said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit including a pair of pressure chambers, air pressure connections between said valves and said pressure chambers, respectively, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

12. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of primary pressure chambers, each of which is pneumatically connected to a respective secondary pressure chamber, an air pressure connection between said pressure control unit and each of said primary chambers and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

13. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and each of said valves, a compensator unit including a pair of primary pressure chambers, each of which is pneumatically connected to a respective secondary pressure chamber, air pressure connections between

said valves and said primary chambers, respectively, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

14. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of primary pressure chambers, each of which is pneumatically connected to a respective secondary pressure chamber, an air pressure connection between said pressure control unit and each of said primary chambers, a pressure differential responsive member separating said secondary pressure chambers and an output member on said compensator unit operatively connected to said pressure differential responsive member, said output member being operatively connectable to means for balancing said machine.

15. A pneumatic time compensator for a reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit including a pair of primary pressure chambers, each of which is pneumatically connected to a respective secondary pressure chamber, an air pressure connection between said pressure control unit and each of said primary chambers, a diaphragm separating said secondary pressure chambers and an output member on said compensator unit operatively connected to said diaphragm, said output member being operatively connectable to means for balancing said machine.

16. A pneumatic time compensator for an air balanced reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of controlling air pressure connected to said pressure control unit, a compensator unit, an air pressure connection between said pressure control unit and said compensator unit, and an output member on said compensator unit consisting of a two-way air valve.

17. A pneumatic time compensator for an air balanced reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of controlling air pressure connected to said pressure control unit, a compensator unit including a pair of pressure chambers, an air pressure connection between said pressure control unit and each of said chambers, a pressure differential responsive member separating said pressure chambers, an output member on said compensator unit consisting of a two-way air valve, and an operative connection between said pressure differential responsive member and said two-way air valve.

18. A pneumatic time compensator for an air balanced reciprocating machine including a pressure control unit actuated by synchronous reciprocal motion from said machine, a substantially constant source of controlling air pressure connected to said pressure control unit, a compensator unit, an air pressure connection between said pressure control unit and said compensator unit, an output member on said compensator unit consisting of a two-way air valve, an unloader device operatively connectable to air balancing means for balancing said machine, a source of unloader air pressure connected to said two-way air valve and an air connection between said two-way air valve and said unloader device.

19. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves, each of which is operably connected to an air valve actuating stem, an alternately rotating shaft mounted in said pressure control unit and alternately rotated by synchronous reciprocal motion from said reciprocating machine, a pair of reciprocally mounted lugs mechanically interconnecting said shaft and the respective said actuating stems, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit, an air pressure connection between each of said valves and said compensator unit and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

20. A pneumatic time compensator for a reciprocating machine comprising a pressure control unit including a pair of air valves, each of which is operably connected to an air valve actuating stem, an alternately rotating shaft mounted in said pressure control unit and alternately rotated by synchronous reciprocal motion from said reciprocating machine, a lug carrier rotatably mounted substantially concentrically with said shaft, a clutch connection between said shaft and said lug carrier to permit said shaft to oscillate at a greater amplitude than said lug carrier, a pair of lugs mounted on said lug carrier, an operative connection between said lugs and the respective said actuating stems, a substantially constant source of air pressure, an air pressure connection between said source of pressure and said pressure control unit, a compensator unit, an air pressure connection between each of said valves and said compensator unit and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

21. A pneumatic time compensator for a reciprocating machine including a compensator unit, a substantially constant source of air pressure, means for alternately connecting said source of pressure to said compensator unit for substantially the time periods of the respective half cycles of the reciprocal motion of said machine, and an output member on said compensating unit which is operatively connectable to means for balancing said machine.

22. A pneumatic time compensator for a reciprocating machine comprising a compensator unit including a pair of pressure chambers, a substantially constant source of air pressure, means for alternately connecting said source of pressure to the respective said chambers for substantially the time periods of the respective half cycles of the reciprocal motion of said machine, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

23. A pneumatic time compensator for a reciprocating machine comprising a compensator unit including a pair of pressure chambers, a substantially constant source of air pressure, means for simultaneously connecting said source of pressure to one of said chambers and opening a bleed passage from the other of said chambers to the atmosphere for substantially the time

period of one half cycle of the reciprocal motion of said machine and for simultaneously connecting said source of pressure to said last mentioned chamber and opening a bleed passage from said first mentioned chamber to the atmosphere for substantially the time period of the other half cycle of the reciprocal motion of said machine, and an output member on said compensator unit which is operatively connectable to means for balancing said machine.

EDGAR W. PATTERSON.

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