April 6, 1943. A. C. D'ARCEY 2,315,775

CONTROL VALVE

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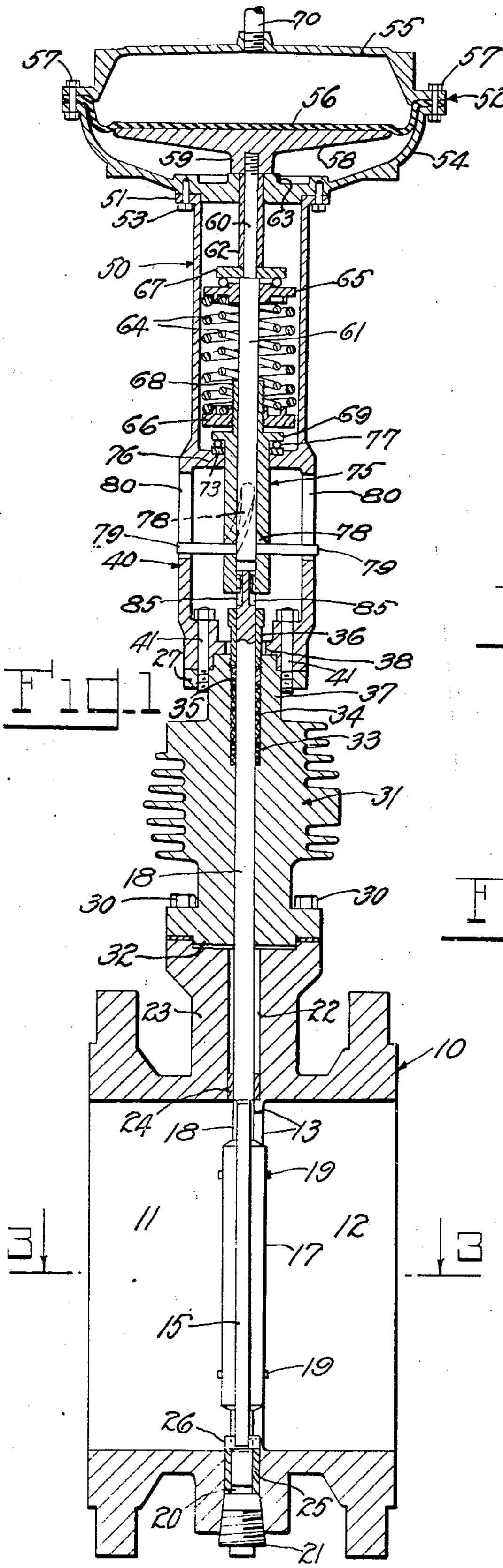


Fig. 1

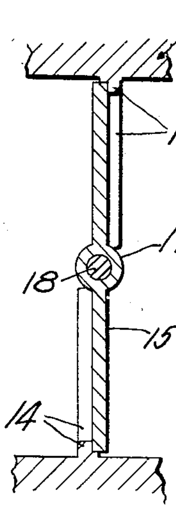


Fig. 3

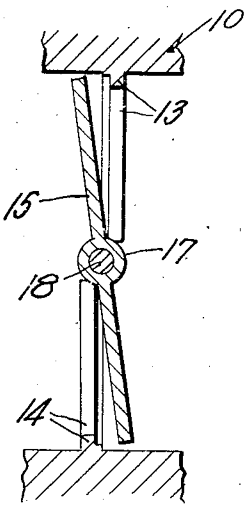
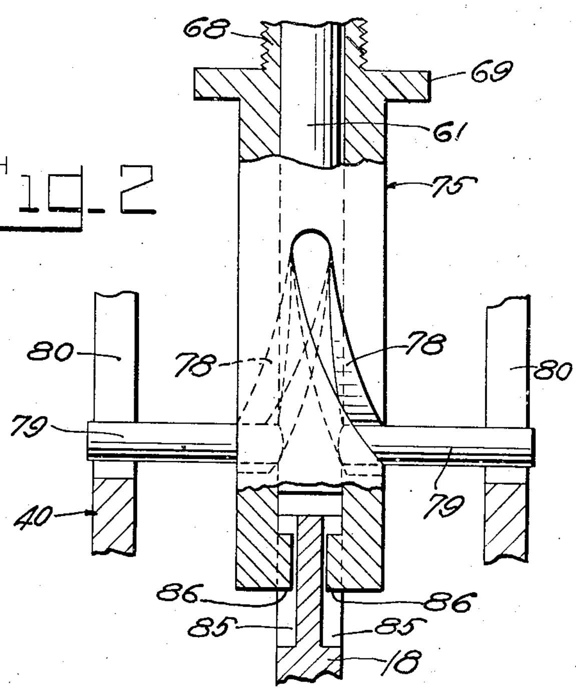


Fig. 4

Fig. 2



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Atty

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CONTROL VALVE

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15 Claims. (Cl. 137—139)

This invention relates to valves for the control of fluids and particularly concerns an improvement in control valves of the type wherein a rotary valve member is employed to govern flow through the valve and wherein the valve member is operated by a motor driven reciprocating member in response to variations in the value of a power medium.

More specifically, the invention is adapted for use in connection with butterfly valves in which a rotatably mounted valve disc or flapper is positioned in respect to a valve port by means of a reciprocatable element, such as the stem of a diaphragm or piston, and the invention relates particularly to improved means for converting the reciprocatory movement of the motor stem to a predetermined rotary movement of the flapper, whereby improved results in valve operation may be obtained, especially under conditions of high temperature.

In connection with many kinds of process control, it may become necessary for butterfly valves to be subjected to widely varied temperature conditions, and it is not unusual for the valve body, through which the controlled fluid flows, and for the operating parts immediately associated therewith to be subjected to temperature changes of 1000° F. or more. Where accurate control is demanded, therefore, the valve must be adapted to function satisfactorily throughout a wide range of temperature variation.

To provide satisfactory operation under exacting conditions of process control, it is desirable that lost motion of the working parts be substantially eliminated in order that the port opening may be varied in accordance with the demand of the system, and further in order that an undesirable fluttering of the valve disc or flapper, resulting from lost motion, be avoided. I have found, however, that where lost motion is reduced to a minimum the operation of the valve is impaired by reason of temperature changes. In valves of standard construction, it has become the practice to use certain well-known materials for the essential valve parts which have become standardized by the trade because of their wear and corrosive resisting properties. A type of material commonly required is stainless steel and, therefore, it has been the practice to manufacture certain parts, such as the flapper stem or shaft, of a form of stainless steel suitable to the conditions. When it is noted that the coefficient of expansion of stainless steel is substantially .00001 inch, per inch of shaft length, per degree F. of temperature change, it will be understood that a 10-inch length of shaft subjected to a 1000° F. rise in temperature will increase its length by $\frac{1}{10}$ inch. For example, in a valve having a diaphragm or piston travel of 2 inches for imparting a 90° turn to the flapper between closed and full open positions, the error developed in the rotary position of the flapper in respect to the reciprocatory position of the stem would be approximately 5 per cent. In other words, when the diaphragm or piston is at a given position in its range of travel, as determined by a condition responsive instrument or the like, the rotary position of the flapper will have an error of substantially 4½ degrees which may seriously affect the accuracy of control, particularly when there is little or no flow demand, as when the valve is operating close to or on its seat. Furthermore, the parts may be subjected to considerable strain and the flapper may have a tendency to stick and thus impair the operation of the valve.

It is an object of this invention to provide a valve which will function equally well under low and high temperature conditions.

It is another object of this invention to provide a valve which will have substantially no lost motion, so that the valve opening demanded by the motor is strictly adhered to by the flapper.

It is still another object of this invention to provide means, in conjunction with a simple form of mechanism, whereby a given linear movement of a motor driven element imparts proportional rotary movement to a flapper irrespective of temperature changes, and whereby the flapper is free to rotate between full open and closed positions to provide the port opening required in exact accordance with the demand.

It is still a further object of this invention to provide a valve which is not subjected to additional stresses due to the thermal expansion of valve parts.

These and other objects of my invention will be more fully understood from the following description when taken in connection with the accompanying drawing in which:

Fig. 1 is a vertical section of a butterfly valve embodying my invention, the flapper being shown in closed position;

Fig. 2 is an enlarged view, partially in section, of a portion of the mechanism shown in Fig. 1;

Fig. 3 is a horizontal section taken on line 3—3 of Fig. 1; and

Fig. 4 is a view similar to Fig. 3 showing the flapper in partially open position.

Having reference to the drawing, there is shown at 10 a butterfly valve body of standard flanged construction which is adapted for connection with piping, not shown, in which fluid flow is to be governed. The body 10 is provided with the usual inlet and outlet chambers 11 and 12 respectively which, as herein shown, are connected by a port defined by semi-circular seating portions 13 and 14 disposed at opposite sides of the port. Means for controlling flow through the port may be in the form of a flapper 15, comprising a disc shaped member having an enlarged portion 17, through which is an opening for receiving a flapper shaft 18 which may be secured to the flapper by means of pins 19. The shaft 18 projects into a recess 20 at the lower end of the body having a closure plug 21, and extends through a bore 22 with which the upper portion 23 of the body is provided, suitable guide bushings 24 and 25 respectively being supplied within which the shaft is free to rotate. A collar 26 is set into the lower portion of the flapper at the axis of the shaft 18 which engages the upper surface of the guide bushing 25 and serves to determine the vertical position of the flapper within the port. The parts are preferably so arranged that when the flapper 15 is in closed position, as shown in Figs. 1 and 3, the circumferential edges of two opposite side faces of the flapper engage the seating portions 13 and 14 to provide a relatively tight shut-off.

Secured to the upper portion 23 of the body by means of studs 30 is an air cooled bonnet 31 having a cylindrical portion 32 which projects into a corresponding recess in the body portion and serves to center the bonnet in respect to the axis of shaft 18. Located axially of the bonnet 31 is an opening through which the shaft 18 extends, said opening being enlarged at 33 to receive suitable packing 34 and a gland 35 with its gland nut 36, the last mentioned member being threaded into a cylindrical extension 37 with which the bonnet 31 is provided. The gland nut 36 is centered in an opening 38 in the lower portion of an intermediate yoke 40 which is recessed to receive the cylindrical extension 37 and is secured to the bonnet 31 by a flange 27, with which the bonnet is provided, and by studs 41.

The intermediate yoke 40 supports a cylindrical spring case 50, herein shown integral therewith, having a flange 51 at its upper end to which a motor generally indicated at 52 is secured by studs 53. The motor 52 may comprise a pair of flanged members 54 and 55 and a diaphragm 56 secured at its edge between the flanges by means of bolts 57. Engaging the lower side of the diaphragm is a button 58 having a centrally disposed boss 59 which is threaded to the reduced end 60 of a diaphragm stem 61, the latter being provided with a combined stem guide and spacer 62 which is slidably mounted in a suitable opening in a boss 63 on the lower diaphragm chamber member 54. Within the spring case 50 is a multiple spring 64 which is retained between an upper spring button 65 and a lower spring button 66, the former being engaged by a thrust bearing race member 67 which is in turn engaged by the stem guide 62 and the latter being threaded on a sleeve member 68, more fully hereinafter to be described, within which the diaphragm stem 61 is slidably mounted and which together with its flange 69 serves as a thrust member for the lower spring button 66. Suitable stops for limiting the movement of the diaphragm 56 are provided by the diaphragm button boss 59, which engages the boss 63 on the lower chamber member 54 to limit its downward movement, and by upper race member 67, which engages the lower surface of chamber member 54 to limit its upward movement. The upper diaphragm chamber member 55 and diaphragm 56 serve to define a pressure chamber to which operating fluid under pressure may be admitted through a suitable pipe connection 70, it being understood that the diaphragm is biased downwardly on an increase in pressure and is biased upwardly on a decrease in pressure under the influence of the spring 64. While I have herein described a form of reciprocating motor, it will be understood that any well-known type of motor may be employed for the purpose of affording a reciprocating motion to the stem 61 in response to changes in controlled condition value.

Means for translating a reciprocatory movement of the diaphragm stem 61 to a predetermined rotary movement of the flapper shaft 18 may be in the form of a cylindrical member 75 having an opening therein within which the lower end of the valve stem is received. The cylindrical member 75, which may be conveniently referred to as a motion translating member, is rotatably mounted in a guide member 76 at the juncture of the intermediate yoke 40 and the spring case 50, and is provided with ball bearings 77, of which the flange 69, referred to above, forms the upper race member, and a washer 73 in the guide member 76 forms the lower race member. The motion translating member 75 is provided with a pair of oppositely disposed semi-spiral slots 78 through which pins 79 secured to the stem 61 extend, the outer ends of the pins being received within vertical slots 80 formed in the intermediate yoke member 40. The spiral slots 78 are so arranged that when the stem 61 moves between its uppermost position and its lowermost position, under the influence of changes in pressure in the diaphragm chamber as opposed by the spring 64, the cylindrical member 75 together with the spring assembly, including multiple spring 64 and associated spring buttons 65 and 66, is rotated 90°. The lower end of the cylindrical member is connected with the shaft 18, in a manner to be described, so that when the stem 61 is at the lower end of its travel, the flapper disc 15 engages the seats 13 and 14 and the valve is closed, and when the stem moves to the upper end of its travel, the flapper is rotated 90° to its open position to provide maximum flow through the valve body 10.

I have found that this construction is a practical means for transmitting movement from the reciprocating stem 61 to the rotary shaft 18 without substantial lost motion between the parts. Furthermore, adequate power may be delivered to the flapper by a relatively light motor for, by means of the slot-pin arrangement, a considerable mechanical advantage may be afforded in favor of the motor. Furthermore, I have found that a flapper member positioned in this manner does not flutter under turbulent flow conditions as is characteristic of many types of construction due to lost motion defects.

In practice, I preferably use a relatively large pitch on the cylindrical member for the purpose of obtaining a considerable mechanical advantage in favor of the motor so that small unit variations of diaphragm pressure will be responded to. Because of the multiplication of power, there is a possibility of damaging either the flapper, or shaft, or both, unless the downward movement of the diaphragm is limited when the flapper seats. It has been the practice, therefore, when the valve is assembled, to apply pressure to the diaphragm until it reaches its lower limit of travel as determined by the engagement of diaphragm boss 59 with lower chamber member boss 63. With the shaft 18 at the rotary position corresponding to the vertical position of the diaphragm stem 61, the flapper 15 is adjusted in relation to the shaft until it is tightly in contact with the port seats 13 and 14. The flapper is then secured to the shaft by the pins 19. The parts are preferably so arranged that the pins 79 are not at the ends of the spiral slots 78 both when the flapper is seated and when it is in open position in order that the diaphragm stops may serve as the sole limits of diaphragm movement.

While the construction hereinabove described is a practical means of operating the flapper by a reciprocating motor without lost motion, it does not lend itself to temperature changes. When the shaft 18 is rigidly secured to the cylindrical member 75, the established relative position of the parts is varied by changes in temperature due to the expansion and contraction of the shaft as hereinabove set forth. In the example cited above, if the mean average temperature of a 10-inch length of shaft is raised 1000° F. a $\frac{1}{16}$ inch increase of stem length will move the cylinder 75 in relation to the diaphragm stem 61 and will rotate the cylinder 75 and with it the shaft 18 and flapper 15 in a counter-clockwise direction, as viewed in Figs. 3 and 4, thus, varying the position of the flapper in respect to the diaphragm stem. If the flapper is in its seated position, as shown in Fig. 3, it will be rotated substantially 4½ degrees to a position corresponding to that indicated in Fig. 4 wherein the valve, herein disclosed, is shown substantially at a 4½ degree opening. Therefore, while the valve can be closed by the motor under certain temperature conditions as, for example, the temperature at which the valve is assembled, it cannot be closed by the motor under higher temperature conditions and a flow varying with the increase in temperature will occur. Thus, when the process demand calls for a control of flow requiring the valve to be at or in close proximity to its seat, the valve will fail to function as intended and undesirable results will be obtained.

In order to overcome the difficulties outlined above, I provide a splined connection, more clearly shown in Fig. 2, between the flapper shaft 18 and the cylindrical member 75 in the form of oppositely disposed slots 85, provided in the wall of the shaft in parallel with the shaft axis, and key members 86 correspondingly placed on the inner wall of the cylindrical member which are adapted to be received within the slots in the shaft. The key members make a close sliding fit with the slots so that while no torsional lost motion is permitted, the parts are free to have independent axial movement without imparting rotary movement to the cylindrical member and flapper. By means of this arrangement, I have eliminated both the compressional and torsional stress which would otherwise occur under changes in temperature of the controlled fluid. I regard this arrangement combined with the cylindrical member 75 as an important development in the art, for I am able to obtain a direct straight-through connection from the motor stem 61 to the flapper shaft 18, the parts being axially aligned and of compact, simple construction. This device may be designed for any mechanical advantage required by the flow conditions, without a tendency to over-stress the parts or to vary the rotary position of the flapper in respect to the reciprocatory position of the motor stem. Furthermore, I have avoided the use of a plurality of pivotally mounted members for operatively connecting the motor to the flapper, such as lever arms, links and the like, and therefore, have eliminated the lost motion effects which are inherent to devices of that type.

While I have herein described in detail a preferred form of device embodying my invention, it is to be understood that the individual parts may be modified without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable valve member cooperating with said port, a rotatable driven member in operative connection with said valve member, a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, and means providing for axial expansion of at least one of said rotatable members while maintaining the rotary position established by the power device.

2. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable valve member cooperating with said port, a rotatable driven member in operative connection with said valve member, a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, and means providing for axial expansion of said driven member while maintaining the rotary position established by the power device.

3. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable valve member coöperating with said port, a rotatable driven member in operative connection with said valve member, a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, and means between said motion translating member and said driven member providing for axial expansion of said driven member while maintaining its rotary position as established by the power device.

4. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable valve member cooperating with said port, a rotatable driven member in operative connection with said valve member, a rotatable non-

reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, and means including a sliding connection in parallel with the axis of rotation of said driven member providing for axial expansion of said driven member.

5. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable valve member cooperating with said port, a rotatable driven member in operative connection with said valve member, a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, and means including a key and slot connection providing for axial expansion of said members while maintaining the rotary position established by the power device.

6. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a rotatable flapper cooperating with said port, a driven member rotatable about its longitudinal axis connected with said flapper, and a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, one of said members having a slot therein disposed in parallel with the axis thereof and another of said members having a part in engagement with said slot forming an axially sliding rotary driving connection providing for axial expansion of said members.

7. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a driven member having a longitudinal axis about which it is adapted to rotate, a valve member rotatable with said driven member to govern flow through said port, a rotatable non-reciprocatory motion translating member having an axis aligned with the axis of said driven member in operative connection both with said reciprocatory element and said driven member for converting linear movement of the former to rotary movement of the latter, and means providing for axial expansion of at least one of said rotatable members while maintaining the rotary position established by the power device.

8. In a valve for governing the flow of fluids having a body defining a passage including a port, a power device having a non-rotatable reciprocatory element movable in response to variations in magnitude of a power medium, a driven member having a longitudinal axis about which it is adapted to rotate, a valve member rotatable with said driven member to govern flow through said port, a rotatable non-reciprocatory motion translating member in operative connection both with said reciprocatory element and with said driven member for converting linear movement of the former to rotary movement of the latter, the axes of said reciprocatory element and rotatable members being coincident, and means providing for axial expansion of at least one of said rotatable members in respect to another.

9. In a valve for governing the flow of fluids having a body defining a passage including a port, the combination with a power device and a rotatable valve cooperating with said port, of means for transmitting movement from said power device to said valve, including, a reciprocatory member operated by said power device, a rotatable driven member in operative connection with said valve, and a rotatable cylindrical member into which said reciprocatory member and said driven member extend, one of said members having a spiral slot therein, another of said members having a part cooperating with said slot and the other of said members being in operative connection with said cylindrical member whereby linear movement of said reciprocatory member is converted to rotary movement of said driven member, and means providing for axial expansion of at least one of said rotatable members while maintaining the rotary position established by the power device.

10. In a butterfly valve for controlling the flow of fluids having a body defining a fluid passage including a port, the combination with an element reciprocatable in response to variations in operating pressure, a support on said valve body on which said element is mounted having a slot therein extending longitudinally in the direction of movement of said element, and a part carried by said element extending transversely of the axis of movement thereof, of a plurality of members, including, a flapper member rotatable to control the flow of fluid, a rotatable shaft member in operative connection with the flapper member to impart rotary motion thereto, a member in operative connection with the shaft having a slot therein positioned adjacent to the first slot but being inclined relatively thereto, the part carried by said reciprocatable element engaging within said two slots whereby movement of the element will cause said part carried thereby to move longitudinally along said slots and thereby rotate the shaft member, and means providing for axial expansion of one of said plurality of rotatable members in respect to another while maintaining the rotary position established by said operating pressure responsive element.

11. In a butterfly valve for governing the flow of fluids including a body defining a port having oppositely disposed semi-circular seating portions, a power device including a reciprocatory element movable in response to changes in operating pressure, a non-rotatable stem reciprocated by said power device, a flapper rotatable for engagement with said seating portions to effect closure of said port, a rotatable shaft to which said flapper is secured, a rotatable non-reciprocatory motion translating member in operative connection with said stem and with said shaft for converting linear movement of the former to rotary movement of the latter, and means providing for expansion of said rotatable shaft while maintaining the position of the flapper in respect to said port which is established by the power device.

12. In a butterfly valve for governing the flow of fluids having a body defining a passage including a port, a power device including a reciprocating element movable in response to variations in fluid operating pressure, a stem reciprocated by said element, a flapper rotatable to govern flow through said port, a rotatable shaft to which said flapper is secured having an axis

coincident with the axis of said stem, a motion translating member comprising a rotatable cylinder having an axis coincident with the axes of said stem and shaft one end of which is associated with said stem and the other end of which is associated with said shaft, a yoke secured to said body on which said power device is mounted having a slot therein extending longitudinally in the direction of movement of said stem, said cylinder having a slot in the wall thereof positioned adjacent said first slot but inclined relative thereto, a part carried by said stem engaging within said two slots whereby linear movement of the stem will cause said part carried thereby to move longitudinally along said slots and thereby rotate the cylinder, and a rotary driving connection between said cylinder and said shaft including means providing for axial expansion of said shaft while maintaining the rotary shaft position established by the power device.

13. In a butterfly valve for governing the flow of fluids having a body defining a passage including a port, a power device including a reciprocating element movable in response to variations in fluid operating pressure, a stem reciprocated by said element, a flapper rotatable to govern flow through said port, a rotatable shaft to which said flapper is secured having an axis coincident with the axis of said stem, a motion translating member comprising a rotatable cylinder having an axis coincident with the axes of said stem and shaft one end of which is associated with said stem and the other end of which is associated with said shaft, a yoke secured to said body on which said power device is mounted having a slot therein extending longitudinally in the direction of movement of said stem, said cylinder having a slot in the wall thereof positioned adjacent said first slot but inclined relative thereto, a part carried by said stem engaging within said two slots whereby linear movement of the stem will cause said part carried thereby to move longitudinally along said slots and thereby rotate the cylinder, said cylinder and shaft comprising a pair of rotary driving members one of which has a slot in parallel with the axis thereof and the other of which has a part which cooperates with said slot to provide for axial expansion of said shaft.

14. In a butterfly valve for governing the flow of fluids having a body defining a port, a power device including a structure defining a pressure chamber one wall of which is formed by a flexible diaphragm, yielding means urging said diaphragm in a direction opposed by pressure in said chamber, a stem reciprocated by said diaphragm, a flapper rotatable to effect closure of said port, a rotatable shaft to which said flapper is secured, a motion translating member in operative connection with said stem and with said shaft for converting linear movement of the former to rotary movement of the latter, a stop for limiting the valve closing movement of said diaphragm to a position at which said port is closed by said flapper, and means provided for expansion of said rotatable shaft while maintaining the position of the flapper in respect to said port which is established by said diaphragm.

15. In a butterfly valve for governing the flow of fluids including a body defining a port having oppositely disposed semi-circular seating portions, a power device including a structure defining a pressure chamber one wall of which is formed by a flexible diaphragm, yielding means urging said diaphragm in a direction opposed by pressure in said chamber, a stem reciprocated by said diaphragm, a flapper rotatable for engagement with said seating portions to effect closure of said port, a rotatable shaft to which said flapper is secured, a motion translating member in operative connection with said stem and with said shaft for converting linear movement of the former to rotary movement of the latter, a stop for limiting the valve closing movement of said diaphragm to a position at which said seating portions are engaged by said flapper, and means provided for expansion of said rotatable shaft while maintaining the position of the flapper in respect to said port which is established by said diaphragm.

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