J. M. HOPWOOD.

METHOD AND MEANS FOR REGULATING OR CONTROLLING MECHANISM.

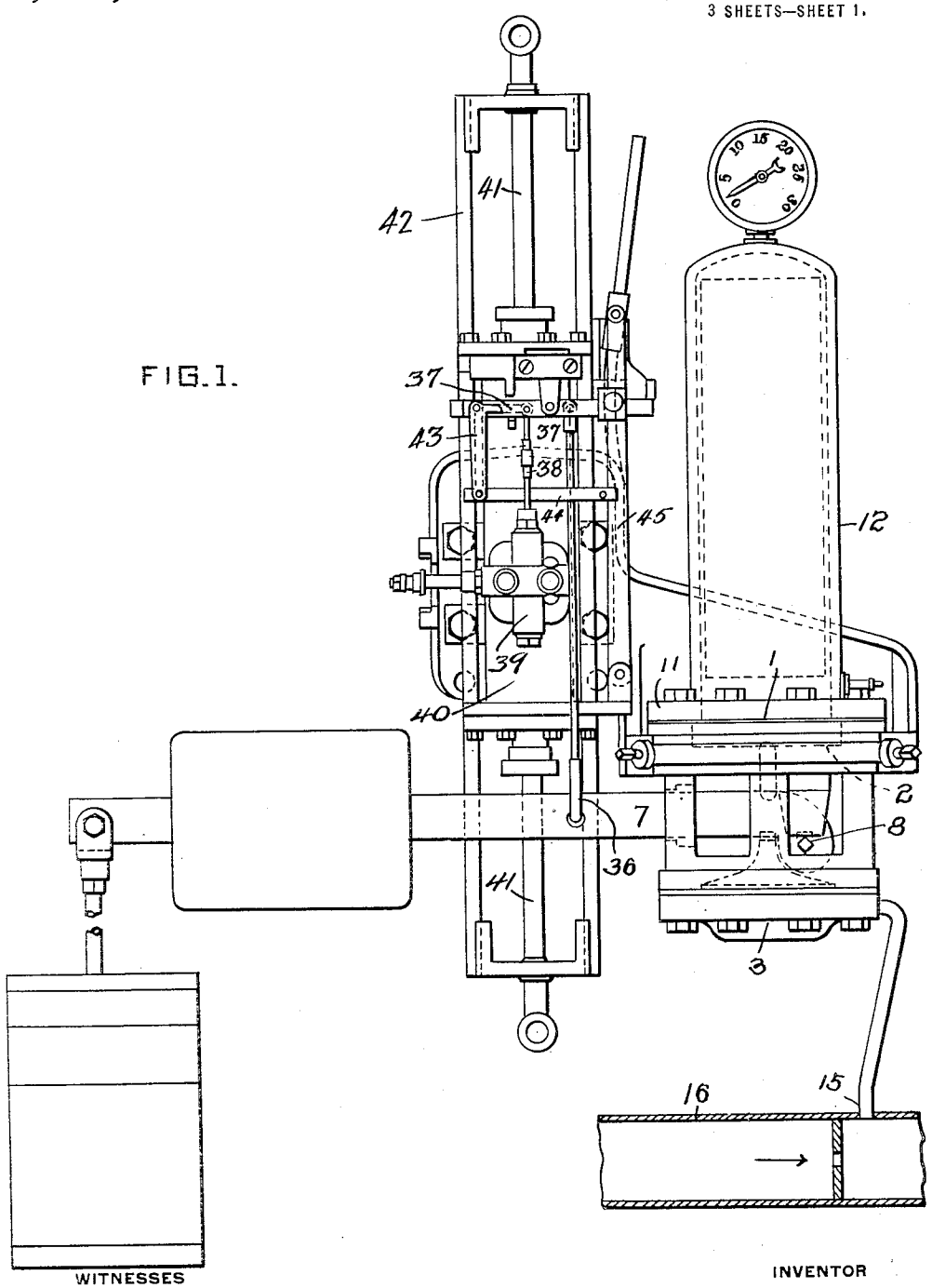
APPLICATION FILED APR. 21, 1919.

1,371,243.

Patented Mar. 15, 1921.

3 SHEETS—SHEET 1.

FIG. 1.



WITNESSES

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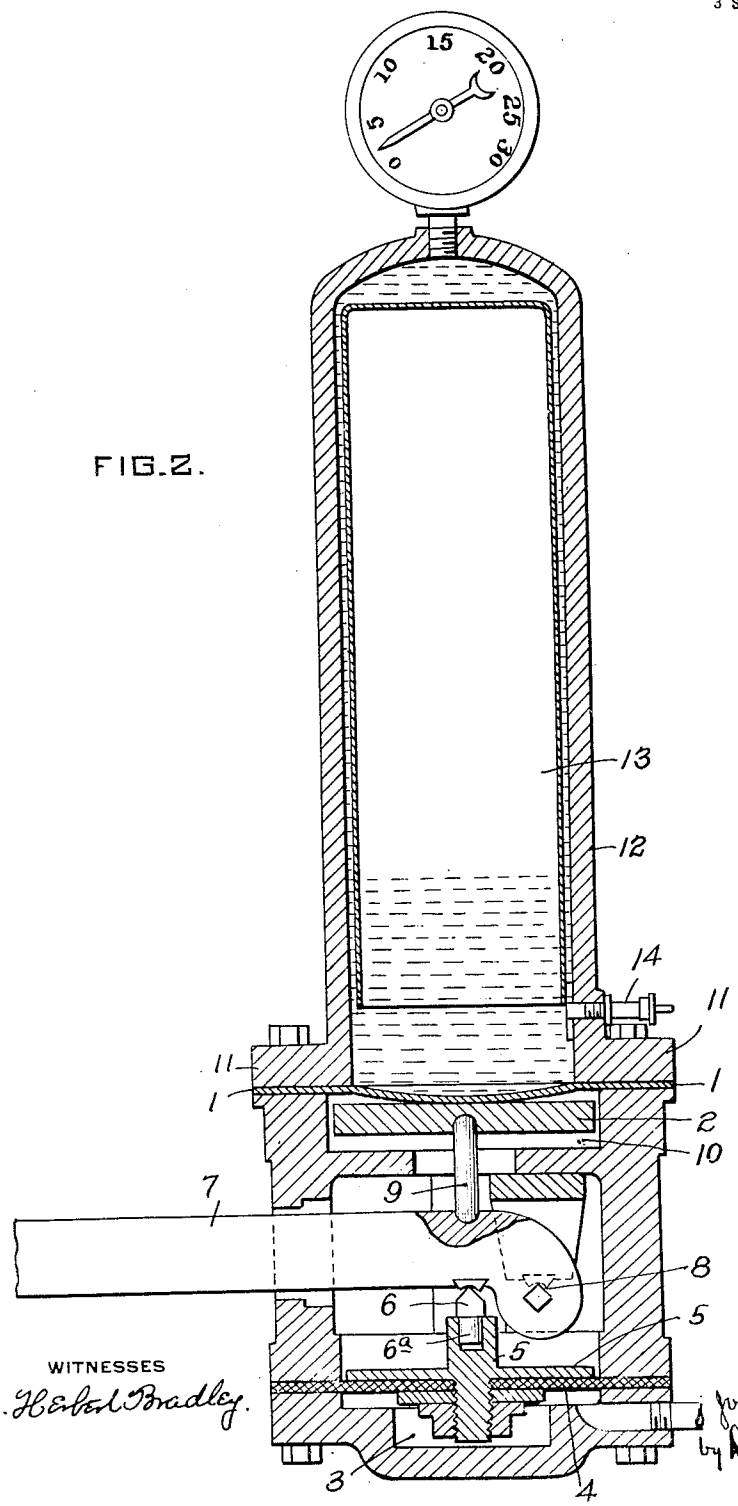
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3 SHEETS—SHEET 2.

FIG. 2.



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3 SHEETS—SHEET 3.

FIG. 3.

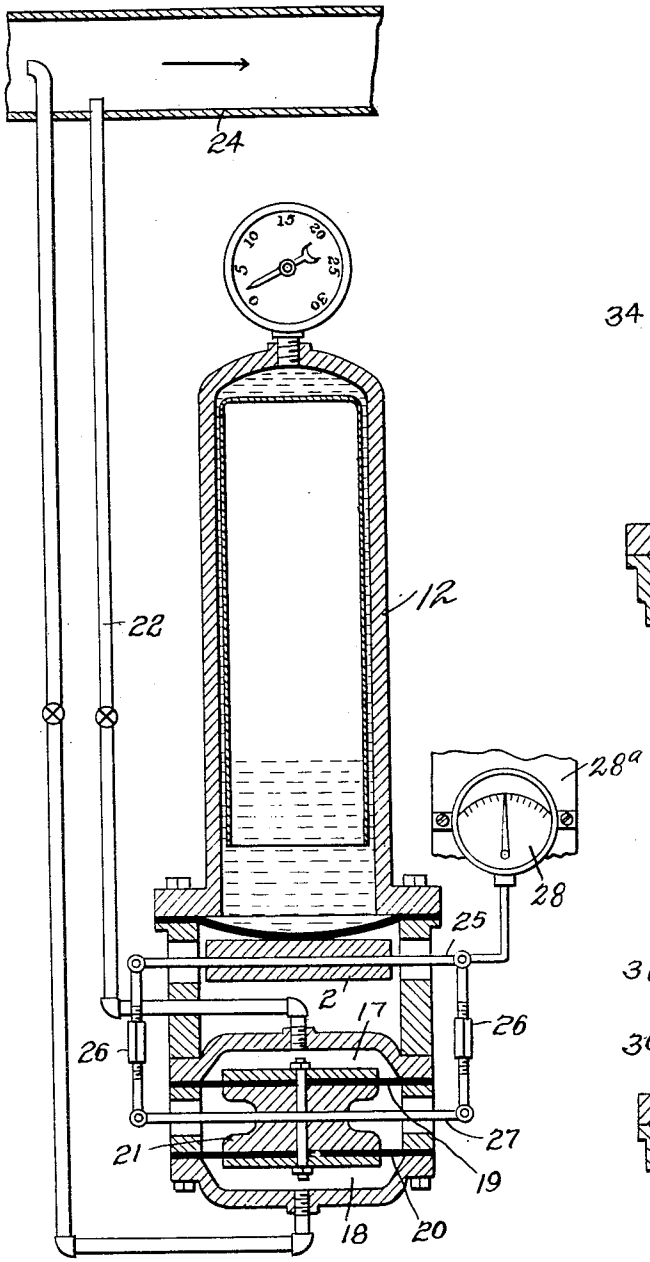


FIG. 4.

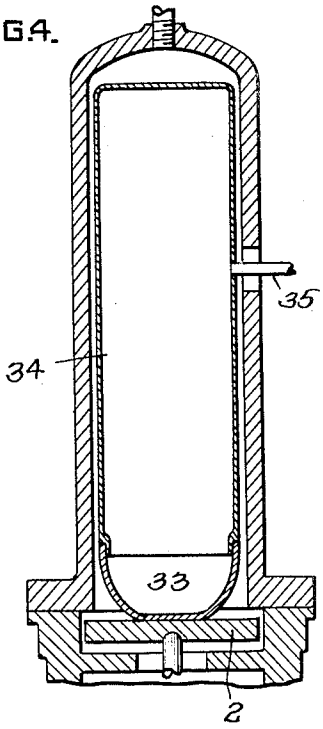
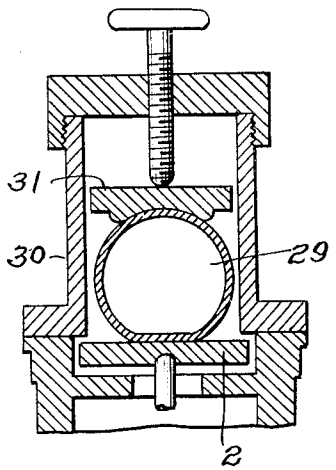


FIG. 5.



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METHOD AND MEANS FOR REGULATING OR CONTROLLING MECHANISM.

1,371,243. Specification of Letters Patent. Patented Mar. 15, 1921.

Application filed April 21, 1919. Serial No. 291,779.

To all whom it may concern:

Be it known that I, JOHN M. HOPWOOD, residing at Dormont, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in Methods and Means for Regulating or Controlling Mechanism, of which Improvements the following is a specification.

In an application filed December 10th, 1917, Serial Number 206,479, I have described and claimed a method of and apparatus for retarding the movement of a regulating or controlling mechanism consisting of a rigid movable member and a flexible member in contact with the rigid member, the exposed surfaces of said mechanism being subjected to oppositely acting pressures and movable on a change of one of said pressures, said method consisting of changing by the movement of the mechanism the area of contact of the flexible member with the movable rigid member an amount proportional to such change of pressure. It has been found in practice that when the pressures acting on opposite sides of the mechanism are small, as for example five pounds more or less, that with a change of even one half ounce in one of those pressures, there will be sufficient movement of the mechanism to operate a transmitting mechanism. But when the oppositely acting pressures are large, as for example, two hundred pounds per square inch, a change of several pounds in one of the oppositely acting pressures will not cause a commercially usable movement of the mechanism.

The object of the invention described herein is to provide for the application of a small pressure to one of the members of such mechanism and of a small percentage of a high pressure to the other member by counterbalancing the large percentage of such high pressure. The invention is hereinafter more fully described and claimed.

In the accompanying drawings forming a part of this specification, Figure 1 is a view showing a construction of mechanism adapted to the practice of the invention; Fig. 2 is a sectional elevation of the portion of the mechanism shown to the right of Fig. 1; Fig. 3 is a view similar to Fig. 2 showing a form of mechanism operative by changes in the rate of flow of a fluid; Figs. 4 and 5 are sectional views illustrating certain modifications.

In the practice of the invention provision is made for subjecting one side of a flexible diaphragm 1 preferably formed of metal, to a predetermined constant but low pressure, as for example five or six pounds per square inch, more or less, while the opposite side of the diaphragm is in contact with a movable rigid or nonflexible member as a disk 2. A pressure generated by heat (as in a steam generator) or other means and which in practice will vary more or less, is so applied to the disk 2 as to act in opposition to pressure on the diaphragm. The pressure applied to the disk and diaphragm are so proportioned that under normal conditions the diaphragm will be somewhat dished so that the area of contact of the diaphragm with the adjacent faces of the disk will be substantially less than that of the entire face of the disk. In case of an increase in the pressure applied to the disk, the latter will be shifted and thereby increase the area of contact of the diaphragm with the disk until the lower but constant pressure acting on the diaphragm will by reason of the increased area of contact between the two members, check the movement of the disk. In case the pressure acting on the disk drops, the pressure on the diaphragm will cause a further dishing of the diaphragm and consequent reduction of area of contact of the diaphragm and disk until the lower pressure on the disk will counterbalance the higher constant pressure acting on a reduced area.

It will be readily understood by those skilled in the art that when the pressures acting on the disk and diaphragm respectively are small, *e. g.*, five or six pounds, a small change in the pressure acting on the disk will produce a substantial movement of the latter *i. e.*, one sufficient to operate a transmitting mechanism.

In order to utilize the sensitiveness of the mechanism when subjected to low pressures as above stated, when using the mechanism in connection with high pressures, provision is made for neutralizing or counterbalancing, in so far as action on the mechanism is concerned, all except a small percentage of the high pressure. A convenient construction to this end consists in connecting the source of high generated pressure

to a chamber having a portion thereof movable, and counterbalancing this high pressure by two pressures one of which will be applied to the movable wall of the chamber through the diaphragm and disk and will be constant and equal to a predetermined small pressure, and the other pressure will be equal to the difference between such predetermined small pressure and the high pressure in said chamber, at its predetermined normal point. In case of an increase of the high generated pressure the disk 2 will be shifted until by reason of the increase in the area of contact of the diaphragm with the disk, the constant pressure on the diaphragm acting through this increased area on the disk will counterbalance the increase in the high generated pressure. In case of a decrease in the generated pressure, the constant pressure on the diaphragm will shift the disk 2 in a direction to reduce the area of contact between the disk and diaphragm until the constant pressure acting on a reduced area will equal as regards effectiveness, the reduction of the high generated pressure.

A convenient means for the practice of the invention consists in connecting a vapor generator or other source of fluid pressure to a chamber 3, one wall of which is formed by a diaphragm 4 to which is secured a plate 5 provided with a knife-edge 6 preferably formed on a removable plug 6^a, as shown in Fig. 2 and adapted to bear on a lever 7. This lever which is fulcrumed at 8, carries a weight or weights sufficient to counterbalance all but a small fraction of the high normal pressure in the generator or other source. As for example, if the normal pressure in the generator or other source and operating on the diaphragm 4 is 250 pounds per square inch, the lever 7 will be weighted to counterbalance 245 pounds of such generated pressure and the additional five pounds required to completely counterbalance the normal generated pressure can be applied to the diaphragm 4 through a strut 9 and lever 7. As shown in Fig. 2, one end of the strut bears the lever and on its opposite end rests a disk 2 arranged in chamber 10, one side of which is formed by a diaphragm 1, preferably formed of metal, and peripherally clamped between the annular wall of the chamber and the flange 11 on the lower end of the shell 12. Within this shell is maintained a pressure sufficient with a predetermined area of contact between the diaphragm and disk to balance the difference between the normal pressure in the generator and that portion of such pressure counterbalanced by the lever. Such pressure would under the conditions mentioned above, be approximately five pounds. In the construction shown, an inverted cup 13 is arranged in the shell which is filled with a suitable liquid, and air is forced through the valve 14 into the cup thereby forming an air cushion normally exerting the required pressure of approximately five pounds per square inch which is transmitted through the liquid to one side of the diaphragm forcing the opposite surface of the diaphragm into contact with one face of the disk 2. In case of an increase of pressure in the generator, the lever 7 will be raised thereby through the strut causing an upward movement of the disk 2 and an increase of the area of contact of the disk with the diaphragm. This movement of the disk and consequent increase of the area of contact between the disk and diaphragm will continue until the constant pressure in the shell will by reason of the increase of surface through which it operates on the disk, counterbalance the increase of pressure in the generator. It will be understood that as the area of contact between the diaphragm and disk increases progressively, the constant pressure in the shell will act progressively to retard and finally stop the movement of the disk, lever and diaphragm 4.

In case of a decrease of pressure in the generator, the action above described will be reversed. The constant pressure on the diaphragm will operate through the disk and will become less effective on the lever and diaphragm 4 in proportion to the reduction of area of contact between the disk and diaphragm as the disk moves down, until the counterbalancing pressures, *i. e.*, those of the weighted lever and the constant pressure operating through a reduced area will equal not 250 pounds but the reduced pressure in the generator.

The mechanism shown in Figs. 1 and 2 will be operative by and in accordance with changes in a static fluid pressure or by and in accordance with changes in static pressure and changes in the rate of flow of the high pressure fluid through a pipe or conduit, dependent upon the connection of the chamber 3 to a generator or a pipe or conduit through which the fluid flows from the generator. As for example, if the chamber 3 be connected to a conduit through a Pitot tube, as shown at 22^a in Fig. 3 or as shown in Fig. 1 through a pipe 15 to a conduit 16 in which is a perforated disk 15^a, the pipe opening through the conduit posterior to the disk and the conduit conducting the fluid from a generator or other source of high fluid pressure, the pressure in the chamber 3 and acting on the diaphragm 4 will vary with changes of static pressure in the conduit and also with changes in the rate of flow of fluid through the conduit. If however the perforated disk 15^a be omitted, the pressure in the chamber 3 will vary only with changes in the static pressure of the fluid.

The mechanism can be adapted to operate only by and in accordance with changes in dynamic pressure or rate of flow of high pressure fluid, as shown in Fig. 3. A suitable construction consists of two chambers 17 and 18, each having a movable wall formed by flexible diaphragms 19 and 20 operatively connected to an intermediate block or disk 21. One of these chambers as 17 is so connected by a pipe 22 to a conduit 24 connected to a source of high fluid pressure that the pressure in said chamber will be substantially equal to the static pressure of the fluid flowing through the conduit 24, while the other chamber as 18 is so connected to the conduit as by a Pitot tube 22^a that the pressure in said chamber will be substantially equal to the total pressure in the conduit, *i. e.*, the static pressure plus or minus (dependent upon the arrangement of the Pitot tube) the pressure due to the rate of flow of the fluid through the conduit. The disk or block 21 is so connected to the disk 2 of the movable device that the constant pressure acting on the diaphragm 1 will oppose the total pressure in the conduit, or in the construction shown will oppose the pressure in the chamber 18. In the arrangement shown, a bar 27 passing through the block 21 is connected by links including the turn buckles 26 to a bar 25 passing through the disk 2.

The pressure in the chamber 17 and that portion of the pressure in the chamber 18 due to the static pressure in the conduit 24 will, of course, balance each other regardless of any change in the static pressure in the conduit; and, in initially adjusting the mechanism for operation, such a constant pressure is established in chamber 12 as will be sufficient, when acting on disk 2 through the diaphragm 1, to maintain, under normal rate of flow in the conduit, the disk and the other parts moving therewith in the position in which all these movable parts are shown in Fig. 3; and there will obviously be no movement of these parts from this position so long as the rate of flow through the conduit remains normal. If however such rate of flow should change, as for example drop, the constant pressure in the chamber 12 and acting on the diaphragm will cause it and the disk 2 to move down thereby progressively reducing the area of contact between the disk and diaphragm, until by reason of the reduction of area, equilibrium is established between the constant pressure on the diaphragm acting on the reduced area and the lower dynamic pressure in the chamber 18. If there should be an increase in the rate of flow, the disk 2 will be forced up causing an increase in the area of contact between the disk and diaphragm 1, until by reason of such increase, the constant pressure in chamber 12 acting on the disk through the diaphragm will counterbalance the increased dynamic pressure in the chamber 18. As the movement of the disk 2 is effected only by and in accordance with changes in the rate of flow and is proportional to each increment of change in such rate, the construction shown in Fig. 3 is especially applicable for use in measuring the rate of flow of steam or other fluids under high pressure and can be so employed by connecting a suitable indicating or registering mechanism 28 to some member moving with the disk 2 as for example the bar 25. This registering mechanism which is secured to a suitable support 28^a can be of any suitable construction whereby the movement of the bar 25 is transmitted to the movable index finger of the mechanism.

In lieu of a diaphragm peripherally held as against movement and subjected to a constant fluid pressure as shown in Fig. 2, a construction similar to that shown in Figs. 4 or 5 may be employed. These constructions include a movable disk 2 and a member having a curved surface adapted to bear upon the upper face of the disk and capable of being flattened to increase the area of contact of the member with the disk. The embodiment shown in Fig. 5 consists of a ball 29 formed of rubber or other suitable resilient material arranged in a shell 30 to bear upon the disk 2. In order to regulate the pressure to be exerted on the disk by the ball, a follower plate 31 is arranged to bear on the ball and is adjusted by a screw or other suitable means to vary the pressure and consequently the area of contact of the ball on the disk.

In lieu of a ball, a tube 34 having at its lower end a spherical portion 33 formed of flexible material and secured to the shell 34 as shown in Fig. 4 may be employed. This tube is provided with an inlet valved pipe 35 for the admission of fluid under pressure dependent on the counterbalancing pressure required.

In order to utilize the movement following a change in the generated pressure, in the construction shown in Figs. 1 and 2 for any purpose such as regulating the supply of fuel and the feed of air to the furnace or the discharge of products of combustion from the furnace, the lever 7, the movements of which will be the same as those of the disk 2, is connected by a rod 36 to a lever 37 on which is mounted a bell crank lever 43 having one arm connected to the stem 38 of the movable member of the valve mechanism indicated at 39. This valve mechanism controls the flow of fluid under pressure to and from the opposite ends of the cylinder 40, which has its piston connected by rod 41 to a frame 42. The bell crank lever 43 has its other arm connected by a link 44 to a pivotally mounted post 45

adapted to be shifted by the frame 42, and thereby reverse the movement of the valve. This transmitting mechanism which is preferred to be employed is fully shown and described in my application Serial No. 254.975, filed September 30, 1918.

In the adjustment of the mechanism described herein for operation, it is first determined how much or what proportion of the pressure on the underside of the diaphragm 4 is to be neutralized, such pressure being equal per unit of area of the diaphragm to the pressure per unit of area which it is desired to maintain in the generator under normal conditions. The weight on the lever 7 is then adjusted to counterbalance such proportion of the pressure on diaphragm 4 so that thereafter only the unneutralized portion of such generator pressure will act on the disk or movable member 2. Fluid under pressure is then admitted into the cup 13 to act through the diaphragm 1 on the block 2 to counterbalance the upward thrust of the strut 9.

The pressure above the diaphragm should be such that the contact area of the diaphragm with the movable member may vary with a change of the upward thrust of the strut whether the change results from an increase or a decrease of the high pressure in the generator.

Neither in the construction of the apparatus nor in the admission of fluid pressure to the cup is any account taken of the area of contact of the diaphragm on the disk or block 2. It is only desired to counterbalance the upward thrust of the strut and this may be effected by so constructing the apparatus that counterbalancing is effected by a low pressure acting on a diaphragm having a large area of contact with the block or a higher pressure and a smaller area of contact between the diaphragm and block.

It will be readily understood from the foregoing that the term "pressure" which when used in connection with fluids generally signifies pounds per unit of area, is not correctly descriptive when referring to the counterbalancing operation and hence the term "force" has been employed to designate the counterbalancing of the thrust of the strut on the block or movable member.

I claim herein as my invention:

1. The method of operating a regulating or controlling mechanism consisting of a movable member and a flexible member in contact with the movable member, which consists in so applying a constant pressure to the flexible member that the two members shall have a substantial area of contact, the one with the other, utilizing this constant pressure and a second pressure to counterbalance a high pressure and by the movement of the mechanism due to a change in the high pressure, changing the area of contact between the members of the mechanism thereby restoring equilibrium between the pressures acting oppositely on the mechanism.

2. The method of operating regulating or controlling mechanism which consists in counterbalancing a predetermined percentage of a predetermined high pressure, applying the unbalanced portion of such high pressure to one side of the movable member of a mechanism consisting of such member and a flexible member in contact with the movable member, applying to the flexible member a constant pressure adapted with a properly proportioned area of contact between the members of the mechanism to counterbalance the percentage of the high pressure applied to the movable member, and by the movement of said mechanism due to a change in the high pressure changing the area of contact of the members of the mechanism and thereby impeding the movement of the mechanism caused by such change of pressure.

3. A mechanism which consists in a chamber having a movable portion adapted to be subjected on one side to a high fluid pressure, means for counterbalancing a portion of the high pressure, and means for counterbalancing the remainder of such high pressure, consisting of a movable disk and a flexible member arranged in contact one with the other so that a movement of one of them will change the area of contact, and means for applying a pressure to the flexible member adapted when the high pressure is normal to supplement the first counterbalancing means.

4. A mechanism having in combination a movable element adapted to be subjected on one side to a relatively high pressure, a yielding means operating on the opposite side of the movable member and adapted to exert thereon a pressure less than the high pressure, a member movable with the said element a flexible member in contact with the movable member, the movable and flexible members being so arranged that on a movement of either, the normal area of contact between them will be varied and means for applying a yielding pressure to the flexible member in a direction to oppose the relatively high pressure on the movable element.

5. A mechanism having in combination a movable element adapted to be subjected on one side to a relatively high pressure, a lever bearing on the opposite side of the movable element and subjected to a pressure sufficient to counterbalance a portion of the relatively high pressure, a movable member, means for transmitting movement interposed between the movable member and the movable element, a flexible sheet peripherally supported in such manner that adjacent surfaces of the sheet and movable

member will be in contact for a portion of the areas of such surfaces and means for applying a constant yielding pressure to the side of the sheet opposite that in contact with the movable member.

6. The method of operating the movable member of a motor mechanism which consists in neutralizing the action of a portion of a normally predetermined but variable pressure, applying a force equal to the unneutralized portion of such variable pressure to one side of the movable member of the motor mechanism, applying to the opposite side of the movable member a force equal to that of the unneutralized portion of the variable pressure and by a movement of the movable member due to a change in the variable pressure restoring the equilibrium between the forces acting oppositely on the movable member.

7. The method of operating the movable member of a motor mechanism which consists in neutralizing the action of a large fraction of a normally predetermined but variable high pressure, applying a force equal to the unneutralized portion of such variable pressure to one side of the movable member of a motor mechanism, applying to the opposite side of said member a force equal to the normal difference between such high pressure and the neutralized portion thereof and by a movement of the movable member due to a change in the high pressure restoring equilibrium between the forces acting oppositely on the movable member.

8. The method of operating a registering or controlling mechanism embodying a movable member which consists in applying to one side of said member variable high pressure, applying to said member two pressures operating to normally counterbalance the high pressure and by a movement of the member due to a change in the high pressure restoring equilibrium between the high pressure and the counterbalancing pressures.

9. The method of operating a registering or controlling mechanism embodying a movable member which consists in neutralizing all but a predetermined portion of a constantly acting but variable high pressure, applying the unneutralized portion of such pressure to the movable member applying an oppositely acting pressure being approximately equal to the unneutralized portion of the high pressure, and by a movement of said member, due to a change in the variable high pressure, restoring equilibrium between the pressures acting oppositely on said member.

In testimony whereof I have hereunto set my hand.

JOHN M. HOPWOOD.