H. F. LIEDTKE.

TURBINE GOVERNOR.

APPLICATION FILED APR. 30, 1912.

1,035,713.

Patented Aug. 13, 1912.

2 SHEETS—SHEET 1.

Fig. 1.

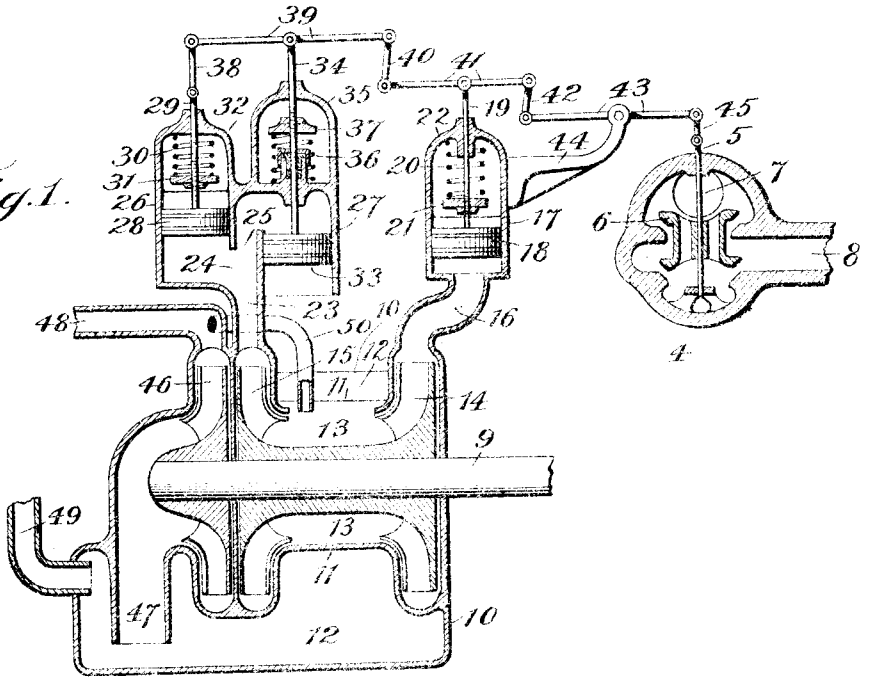
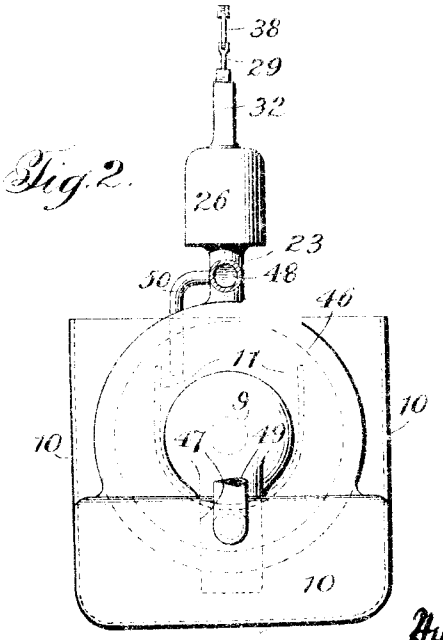


Fig. 2.



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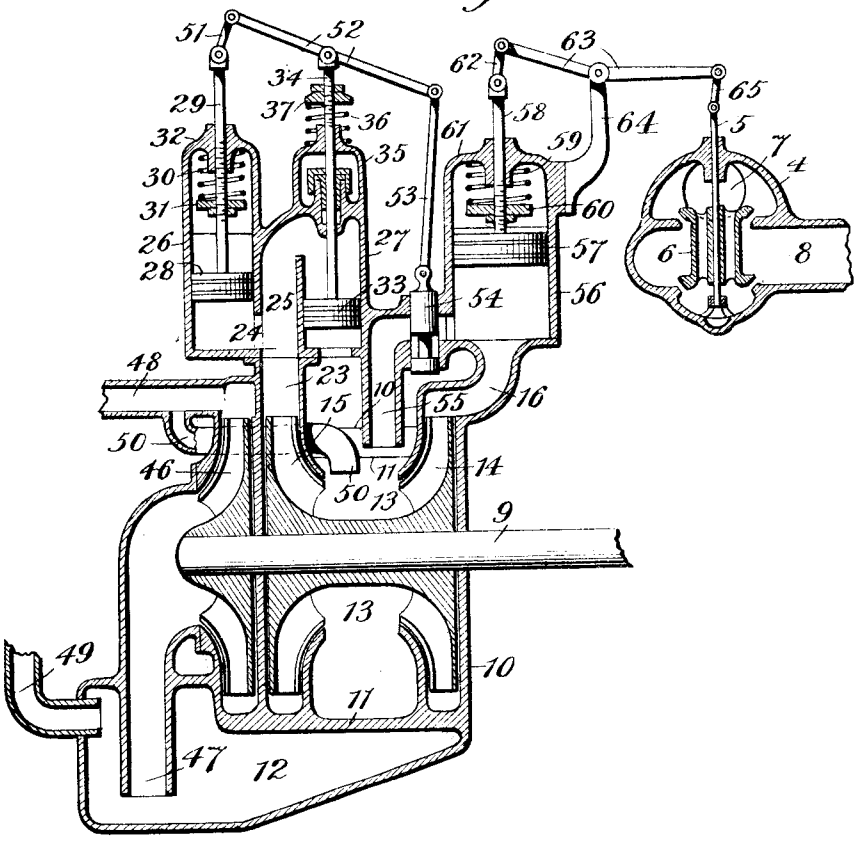
2 SHEETS—SHEET 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

HUGO F. LIEDTKE, OF WILKINSBURG, PENNSYLVANIA.

TURBINE-GOVERNOR.

1,035,713. Specification of Letters Patent. Patented Aug. 13, 1912.

Application filed April 30, 1912. Serial No. 694,175.

To all whom it may concern:

Be it known that I, HUGO F. LIEDTKE, a citizen of the United States, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Turbine-Governors, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to that class of governors in which difference in the pressure of fluid caused by pumps whose speed is responsive to variation of speed of the motor governed is relied upon to effect the governing action.

The governor comprises one or more centrifugal pumps whose speed varies with the speed of the motor, such, for example, as a turbine-engine, with which it is associated, and it makes use of the principle that the fluid pressure developed by centrifugal pumps varies directly as the square of their rotative speed. Means are provided whereby this variation of fluid pressure directly or to a greater degree affects the power-regulating devices of a motor, such as the valve or valves of a fluid-pressure turbine or the timer of an internal-combustion engine, with the result that the power-controlling devices to a greater degree are responsive to speed variation than if they were dependent directly upon speed variation for their movement necessary to alter the power of the motor to accommodate greater or less loads, and that slight variation of speed is reflected in the power-controlling devices in time to prevent marked variation of speed, in order that the motor may be maintained at practically uniform speed.

When read in connection with the description herein, the details of construction and arrangement of parts of the invention, and the principles involved therein, will be apparent from the accompanying drawings, forming part hereof, wherein preferable embodiments of the invention, as applied to a steam-turbine, are disclosed, for purposes of illustration.

While the devices shown herein now are considered to represent the best embodiments of the invention, it is to be understood that they merely are illustrative of the principles thereof, that the several instrumentalities employed in carrying out the invention can be variously organized within the limits prescribed by the claims hereinafter without departing in the least from the nature and spirit of the invention, that it is not the intention to be limited necessarily to the precise delineations herein in interpretations of the claims, and that the invention is susceptive of use with other devices than that with which it is shown here in association.

Like reference-characters refer to corresponding parts in the views of the drawings, of which—

Figure 1 is a sectional view; Fig. 2 is an end view; and Fig. 3 is a sectional view of another form.

Having more particular reference to the drawings, and particularly to Figs. 1 and 2, 4 designates a valve-chest of a fluid-pressure turbine; 5 a valve-stem projecting outwardly of the valve-chest; 6 a valve on the stem within the chest controlling admission of fluid from a fluid-supply passage 7 to an inlet 8 to the turbine; and 9 a shaft rotated in any suitable manner at a speed uniform with the speed of the turbine, the shaft preferably, but not necessarily, being an extension of the rotor shaft of the turbine.

For the purpose of altering the position, with respect to its seat, of the valve 6, which is mentioned herein as typical of a control element of any motor, and thereby controlling the power of the turbine, this invention provides a governor that now will be described.

A casing 10 is positioned conveniently with respect to the turbine, and it has therein another casing 11, whereby a lower reservoir 12 and an upper reservoir 13 are formed. The shaft 9 extends through the upper reservoir, and it has thereon within the reservoir centrifugal pumps 14 and 15. A pipe 16 extends upwardly from pump 14 to a casing 17 below a piston 18 contained in the casing. The piston has thereon an upwardly-extending piston-rod 19. Above the piston a downwardly-acting spring 20 is interposed between a screw-threaded adjustable abutment 21 on the piston-rod and a yoke 22 on the casing, which yoke serves as a guide for the piston-rod. A pipe 23 extends upwardly from pump 15, and it leads to passages 24 and 25 opening, respectively, into piston-casings 26 and 27. The passage 24 leads into casing 26 below a piston 28 contained therein, and this piston has thereon an upwardly-extending piston-rod 29. Above the piston a downwardly-acting spring 30 is interposed between a screw-

threaded adjustable abutment 21 on the piston-rod and a yoke 32 on the casing, this yoke serving as a guide for the piston-rod. The passage 25 leads into casing 27 above a piston 33 contained therein, and this piston has thereon a piston-rod 34 extending upwardly through the top of the casing and through a guide-yoke 35 on the casing. An upwardly-acting spring 36 is interposed between a screw-threaded adjustable abutment 37 on the piston-rod and the head of the casing. The arrangement is such that under influence of increase or decrease of fluid pressure in the casings 26 and 27 the pistons therein move in opposite directions.

A link 38 is pivotally connected to the upper end of piston-rod 29 and to the end of a link or lever 39 pivoted intermediate its ends to the upper end of piston-rod 34; at its other end link or lever 39 is pivotally connected by a link 40 with one end of a link or lever 41 pivoted intermediate its ends to the upper end of piston-rod 19; and link or lever 41 at its other end is pivotally connected by a link 42 with one end of a link or lever 43 pivotally supported intermediate its ends by a bracket 44, the other end of the link or lever 43 being connected by a link 45 with the valve-stem 5.

The fulcrum of the link or lever 39 at its place of connection with piston-rod 34 of piston 33 is a movable one, piston 28 connected with one end of this link or lever and piston 33 move in opposite directions to each other upon occurrence of either fluid condition later mentioned, and, therefore, the operating end of the link or lever 39 connected with the link or lever 41 has a much greater motion than it would have if the fulcrum were fixed; and, in turn, the fulcrum of the link or lever 41 at its place of connection with the piston-rod 19 being a movable one and piston 18 of that rod being arranged to move in a direction opposite to movement of its end connected with link or lever 39, movement of its other or operating end is increased by movement of piston 18.

The reservoirs 12 and 13 are filled with any suitable liquid, preferably lubricating-oil. When the shaft 9 is rotated, the pumps 14 and 15 will draw liquid from the reservoir 13 and force it, respectively, into pipes 16 and 23 and thereby maintain fluid pressure against the pistons 18, 28, and 33 in a direction opposite to the action of their respective springs, and as the pistons are moved under the influence of this pressure movement will be imparted to the valve 6 through the instrumentality of links 38, 39, 40, 41, 42, 43, and 45 and valve-stem 5.

The piston-springs are so tensioned, by adjusting the screw-threaded abutments 21, 31, and 37, that they will hold the pistons against movement under the influence of fluid pressure developed by the pumps when the valve is in the proper position to admit sufficient fluid to the turbine to drive it at the desired speed under normal load. When the speed of the turbine increases, because of less load or for any other reason, the fluid pressure developed by the pumps will be increased in accordance with the speed, the pistons will be moved against the tension of their springs, and the valve moved to admit less fluid to the turbine; and when the speed falls below normal, the fluid pressure developed by the pumps also falls in accordance with the same principle of hydraulics and the springs will move the pistons and thereby the valve in a direction to admit more fluid to the turbine.

The operative parts of the governor function as multiplying devices to make, and the principles involved in the governor make, the valve delicately sensitive to speed variation; that is, the degree of alteration of valve position is greater than if it depended directly on the variation of speed of the turbine. It will be seen that, when the speed only slightly varies, the fluid pressure on the pistons will be varied to a greater degree and the valve moved in response to movement of the pistons to a greater degree than that directly dependent on speed variation. For example, if the speed is increased, the pistons 18 and 28 will be moved upwardly and the piston 33 downwardly under the influence of the increased fluid pressure. Now, if the valve were connected with any one of the pistons so as to have equal movement therewith, the valve movement would be in accordance with the increase of speed; but, as the other two pistons are connected so as to give further movement to the valve through the instrumentality of the lever-links, the susceptibility of the valve to speed variation further is accentuated.

Assuming that the links or levers 39, 41, and 43 are pivoted centrally between their connections with other links, and that the pressure is altered under the influence of speed variation so that each of the pistons is moved one-eighth inch: Then the piston-rod connected with the end of lever 39 will move the other end one-eighth inch and the piston-rod connected centrally of the lever will impart an additional movement of two-eighths inch, and a total movement of three-eighths inch is given to the end of the lever and thereby to the end of lever 41, and the piston-rod connected centrally of lever 41 will impart an additional movement of two-eighths inch to the end of that lever that is connected with the valve, whereby the valve will have a movement of five-eighths inch. By changing the relative lengths of the levers, a multiplying factor as high as fifteen or twenty may be obtained, if desired. Therefore, it will be seen that the valve is

responsive to speed variation from both the multiplying factors of fluid pressure from the centrifugal pumps and from the arrangement of a plurality of pistons and the lever-links that are themselves responsive to that pressure.

For the purpose of supplying oil to the bearings of the turbine and of keeping the upper reservoir filled with oil, a centrifugal pump 46 is positioned on shaft 9 exterior of that resevoir. A suction-pipe 47 extends from the lower reservoir 12 to this pump, a discharge-pipe 48 leads from the pump to the bearings, a return-pipe 49 from the bearings leads to the reservoir 12, and a pipe 50 leads from pipe 48 to the upper reservoir 13; and the pump, while in motion, keeps lubricating-oil in circulation through these pipes. A sufficient amount of oil to keep the upper reservoir full flows from pipe 50, and overflow from this reservoir returns to the lower reservoir.

Referring to Fig. 3, the arrangement and operation of governor-casing 10, inner casing 11, reservoirs 12 and 13, centrifugal pumps 14 and 15, pipes 16 and 23, passages 24 and 25, piston-casings 26 and 27, piston 28, piston-rod 29, spring 30, abutment 31, yoke 32, piston 33, piston-rod 34, yoke 35, spring 36, abutment 37, and the oil-circulating system comprising the pump 46 and pipes 47, 48, 49, and 50, are substantially the same as disclosed by Figs. 1 and 2. However, in this form, instead of pistons 28 and 33 in coöperation with another piston imparting their motion directly to the turbine-valve, these pistons are employed to control, through the instrumentality of a link 51, link or lever 52, and link 53 a valve 54 of a discharge-pipe 55 leading from a piston-casing 56 to the reservoir 13. The pipe 16 of pump 14 leads into this piston-casing, and above the places of entrance and discharge there is in the casing a piston 57 having thereon a piston-rod 58 extending upwardly. Above the piston a downwardly-acting spring 59 is interposed between a screw-threaded adjustable abutment 60 on the piston-rod and a yoke 61 on the casing. A link 62 is pivotally connected to the upper end of piston-rod 58 and to the end of a link or lever 63 pivoted intermediate its ends on a bracket 64, and link 63 is pivotally connected at its other end with the valve-stem 5 by a link 65. In this embodiment of the invention, the pistons 28 and 33 move in response to speed variation in substantially the same manner as in the form shown by Figs. 1 and 2, but their movement results in movement of the valve 54, whereby resistance to flow of liquid through pipe 55 is altered and the amount of pressure on piston 57 correspondingly altered. For example, if in response to increase of speed of the pumps piston 28 is moved upwardly and piston 33 downwardly, the valve 54 will be moved downwardly to further close the passage through pipe 55, resistance to flow of liquid through that pipe is increased, fluid pressure against piston 57 is increased both by the accelerated action of pump 14 and restriction of flow from the piston-casing 56, and piston 57 moved upwardly and the turbine-valve thereby moved toward closed position. When the speed of the pumps decreases, the movement of pistons 28 and 33 is in opposite directions to that of increase, the valve 54 is moved to open further the passage through pipe 55, resistance to flow of fluid through the pipe is thereby decreased, fluid pressure against piston 57 is decreased both by the less pressure derived from pump 14 and the less resistance to flow from the piston-casing 56, the piston 57 is moved downwardly under the influence of spring 59, and the turbine-valve thereby moved away from closed position to admit more fluid to the turbine.

It will be seen that the principle of multiplying the movement of the turbine-valve in response to speed variation by the variation of the pressure in the piston-casings in accordance with the square of speed and by the action of a plurality of pistons is employed in this, as well as in the other, form; for the piston 57 connected with the turbine-valve is moved, not only in response to the variation in fluid pressure in its casing caused by variation of speed of the pump 14, but also in response to the further variation in pressure caused by movement of valve 54.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A governor comprising a source of fluid pressure responsive to speed variation, a member arranged to control a power-regulating device, associated with said member a plurality of pistons susceptive of movement under influence of said source of fluid pressure to move said member in one direction in response to one kind of speed variation, and means whereby said member is moved in the opposite direction in response to another kind of speed variation.

2. A governor comprising a source of fluid pressure responsive to speed variation, a member arranged to control a power-regulating device, associated with said member a plurality of pistons susceptive of movement under influence of increase of fluid pressure from said source to move said member in one direction, and means whereby said member is moved in the opposite direction on decrease of fluid pressure.

3. A governor comprising a source of fluid pressure responsive to speed variation, a link arranged to control a power-regulating device, a plurality of pistons connected

with said link and susceptive of movement under increase of fluid pressure from said source to move a portion of said link in one direction, and means whereby said portion of said link is moved in the opposite direction on decrease of fluid pressure from said source.

4. A governor comprising a source of fluid pressure responsive to speed variation, a lever fulcrumed intermediate its ends and having one end arranged to affect a power-regulating device, and means arranged to move the other end of said lever in one direction and its fulcrum in the opposite direction upon variation of fluid pressure from said source.

5. A governor comprising a source of fluid pressure responsive to speed variation, a lever arranged to have one end affect a power-regulating device, a member movable in one direction under the influence of increase of fluid pressure from said source and connected with said lever at its other end, a member movable in the opposite direction under the influence of increase of fluid pressure from said source and on which said lever is fulcrumed intermediate its ends, and means whereby said members on decrease of fluid pressure from said source are moved in directions contrary to those movements imparted on increase of pressure.

6. A governor comprising a source of fluid pressure responsive to speed variation, a link arranged to control a power-regulating device, connected with said link a plurality of pistons of which one is arranged to be moved in one direction and another in an opposite direction under influence of increase of fluid pressure from said source to move a portion of said link in one direction, and means whereby said portion of said link is moved in the opposite direction on decrease of fluid pressure from said source.

7. A governor comprising a source of fluid pressure responsive to speed variation, a lever fulcrumed intermediate its ends and having an operating end, means arranged to move the other end of said lever in one direction and its fulcrum in the opposite direction upon variation of fluid pressure from said source, a piston susceptive of movement upon variation of fluid pressure from said source, a link connected with said piston and arranged for connection with a power-regulating device, and means whereby movement of the operating end of said lever affects movement of said link.

8. A governor comprising a source of fluid pressure responsive to speed variation, a lever having an operating end, a member movable in one direction under influence of increase of fluid pressure from said source and connected with said lever at its other end, a member movable in the opposite direction under the influence of increase of fluid pressure from said source and on which said lever is fulcrumed intermediate its ends, a piston susceptive of movement upon increase of fluid pressure from said source, a link connected with said piston and arranged for connection with a power-regulating device, means whereby movement of the operating end of said lever affects movement of said link, and means whereby said members and piston on decrease of fluid pressure from said source are moved in directions contrary to those of movements imparted on increase of pressure.

9. A governor comprising a source of fluid pressure responsive to speed variation, a link, a plurality of pistons connected with said link and susceptive of movement under influence of increase of fluid pressure from said source to move a portion of said link in one direction, another piston also susceptive of movement under influence of increase of fluid pressure from said source, a link connected with said last-mentioned piston and arranged for connection with a power-regulating device, means whereby movement of said first-mentioned link affects the movement of said last-mentioned link, and means whereby said links on decrease of fluid pressure from said source are moved in directions contrary to those imparted on increase of pressure.

10. A governor comprising a source of fluid pressure responsive to speed variation, a link, connected with said link a plurality of pistons of which one is arranged to be moved in one direction and another in the opposite direction under influence of increase of fluid pressure from said source to move a portion of said link in one direction, another piston also susceptive of movement under influence of increase of fluid pressure from said source, a link connected with said last-mentioned piston and arranged for connection with a power-regulating device, means whereby movement of said first-mentioned link affects the movement of said last-mentioned link, and means whereby said links on decrease of fluid pressure from said source are moved in directions contrary to those of movements imparted on increase of pressure.

In testimony whereof I affix my signature in presence of two witnesses.

HUGO LIEDTKE.

Witnesses:

JAS. E. SWISSHELM,

JAMES G. STORER.

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Correction in Letters Patent No. 1,035,713.

It is hereby certified that in Letters Patent No. 1,035,713, granted August 13, 1912, upon the application of Hugo F. Liedtke, of Wilkinsburg, Pennsylvania, for an improvement in "Turbine-Governors," an error appears in the printed specification requiring correction as follows: Signature of patentee to the specification was erroneously printed "Hugo Liedtke," whereas it should have been printed *Hugo F. Liedtke;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of September, A. D., 1912.

[SEAL.]

C. C. BILLINGS,

Acting Commissioner of Patents.