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GOVERNOR APPARATUS

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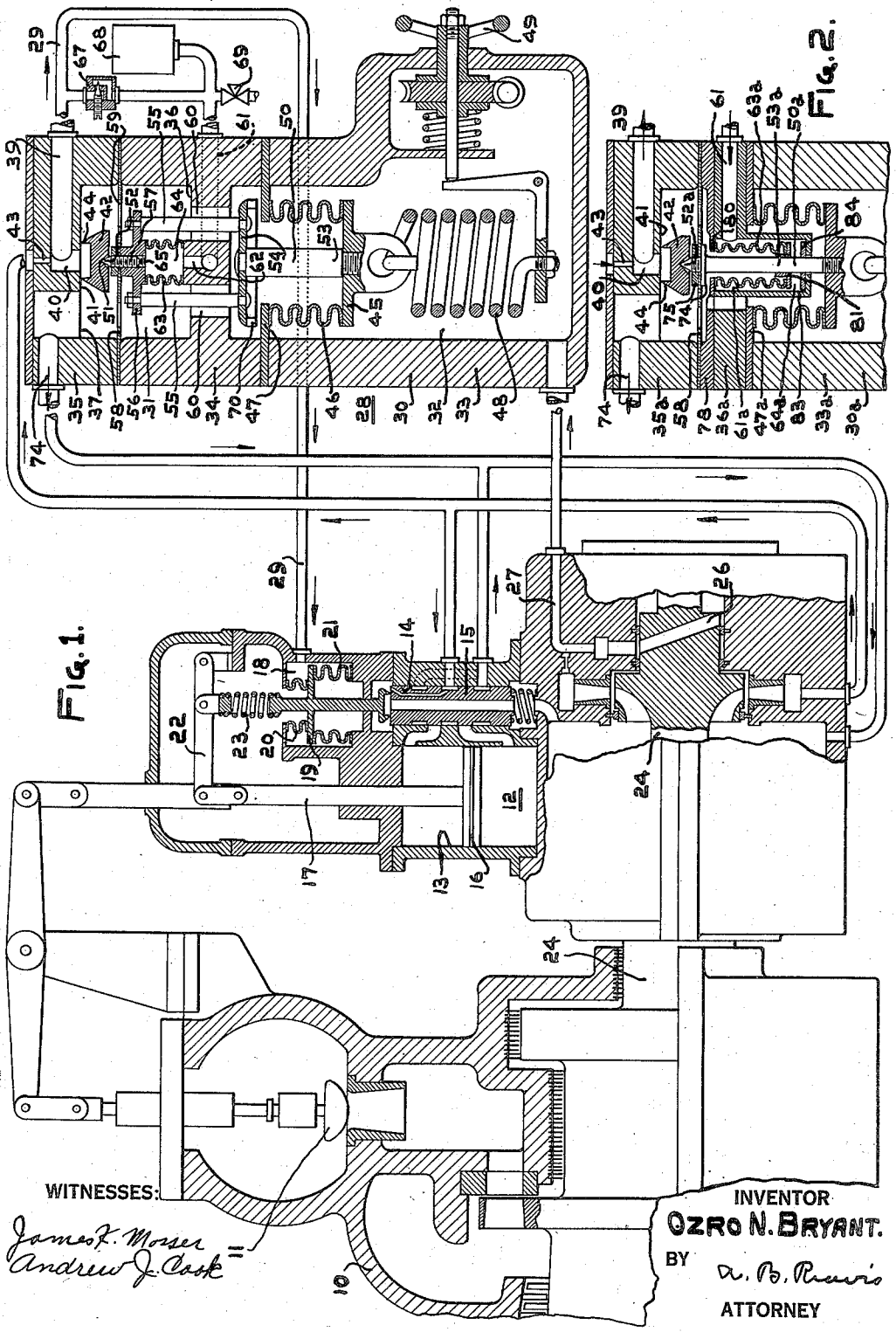


Fig. 1.

Fig. 2.

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GOVERNOR APPARATUS

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My invention relates to a governing system of the pressure transformer type which is operative in response to a change in primary or controlling force to provide a change in secondary or transformed fluid pressure in predetermined relation with respect thereto and it has for an object to provide apparatus of this character which is durable, substantially frictionless, relatively simple in design, and economical to build and operate.

A further object of my invention is to provide apparatus of the above character including means to secure operation such that the regulating percentage is reduced or eliminated.

A further object of my invention is to provide a pressure transformer wherein the magnitude of transformed fluid pressure is determined by an escape port with a valve in covering relation with respect thereto, the valve being positioned by a primary controlling force and by the force of transformed fluid pressure acting thereon.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a sectional view showing my improved pressure transformer applied to govern a steam turbine; and,

Fig. 2 is a view, similar to Fig. 1, but showing a modified form of the transformer.

Referring to the drawing more in detail, the turbine apparatus, the admission valve, and the servo-motor for controlling the latter will be referred to first in order to make the operation of the transformer clearer.

In Fig. 1, there is shown a steam turbine 10 having an admission valve 11 operated by a servo-motor, at 12, the servo-motor including operating and pilot valve cylinders 13 and 14, the pilot valve cylinder having the pilot valve 15 therein controlling the admission and exhaust of suitable motive fluid to opposite sides of the operating piston 16 carried by the rod 17, the latter being connected, by suitable linkage, to the admission valve.

The pilot valve 15 is operated by means of a pressure-responsive device 18 having a pressure space defined by the movable abutment 19 and the cooperating bellows elements 20 and 21.

Follow-up mechanism is arranged between the operating piston and the piston valve to bring about restoration of the latter to neutral position in consequence of movement of the operating piston. To this end, the operating piston rod 17 is connected, by means of a lever 22, to one end of a spring 23, the other end of the latter being connected to the pilot valve, as is well known in the art.

Referring now to the means for developing a primary or controlling force which is utilized by the pressure transformer to secure a transformed fluid pressure for application to the pressure-responsive device 18, any suitable means may be used to provide this force, for example, the turbine spindle 24 is shown as having a suitable impeller 26, which supplies oil under pressure to the passage 27, the fluid pressure varying substantially as the square of the speed.

The passage 27 supplies oil under impeller pressure to the pressure transformer, at 28, the latter operating, in response to change in impeller pressure to provide a change in transformed oil pressure in predetermined relation with respect thereto and supplying such transformed oil pressure by means of the passage 29, to the pressure responsive device 18.

The pressure transformer, at 28, includes a body structure 30 having upper and lower chambers at 31 and 32. As shown, the body is comprised by stacked sections 33, 34 and 35, the intermediate and top sections having transverse walls 36 and 37. The sections are clamped together by any suitable means, for example, bolts (not shown). The upper chamber 31 is a part of the exhaust or drain space and the lower chamber is connected to receive fluid under primary or impeller pressure.

The upper transverse wall 37 has a radial passage 39 terminating in an axial discharge port 40 and the discharge end of the latter is bounded by a flat or seat surface 41 with which cooperates the cup valve 42.

The interiors of the pressure-responsive device 18, the passages 29 and 39 and the port 40 constitute a transformed fluid pressure space to which oil is supplied by any suitable means such that the magnitude of pressure in the space will depend upon the annular escape orifice provided by the cup valve 42 cooperating with the seat 41. For example, an orifice 43 is shown for supplying the space from any suitable source.

Referring now to the means for applying forces to the cup valve 42 to regulate the annular, radially-directed, escape orifice defined between the sharp annular edge 44 and the flat seat 41, it will be obvious that the force of transformed oil pressure acts on the cup valve 42 in such a direction as to tend to increase the flow area of the annular orifice. This force is opposed by a suit-

able primary or controlling force such that the annular orifice is regulated to secure a transformed oil pressure in predetermined relation to the primary controlling force.

Referring now to the primary controlling force, by way of example, the body 30 is shown as provided with the lower chamber 32 in communication with the impeller passage 27, such chamber being separated from the chamber 31 by a structure comprising an abutment 45 connected by the bellows 46 to the inwardly-projecting annular plate 47 clamped between the body sections 33 and 34. The force of impeller pressure applied to the downwardly-facing piston area provided by the abutment 45 is opposed by means of the load spring 48 whose lower end is connected to suitable speed change apparatus 49, as is well known in the art.

The abutment 45 is arranged to apply the resultant of the forces acting thereon by any suitable thrust structure, at 50, to the cup valve 42, the cup valve preferably having a conical seat 51 cooperating with the conical tip 52 of the thrust structure to provide a point bearing.

From the structure so far described, it will be apparent that, if a change in primary pressure or force occurs, incident, for example, to a change in load of the turbine, such force is transmitted to the cup valve 42 to regulate the annular escape orifice such that the transformed oil pressure changes in predetermined relation with respect to the primary force or pressure change, the force of transformed oil pressure acting on the cup valve in opposed relation to the resultant of the force of the load spring and of the primary pressure or controlling force.

Preferably, the thrust structure, at 50, is comprised by a central post 53 having its lower end attached to the abutment 45 and having its upper end attached to the cross bar or plate 54 secured to the lower ends of rods 55 whose upper ends are connected to the plate 56 carrying the central stem 57 whose upper end is provided with the conical tip 52. In addition to the stem 57 being connected to the plate 56, it serves to clamp the diaphragm 58 in place with respect thereto, the outer edge of the diaphragm being clamped between the body sections 34 and 35. The diaphragm serves to center the thrust structure and provides for movement thereof without friction.

The intermediate transverse wall 36 has openings 60 through which the rods 55 extend, the wall being provided with a passage 61 communicating with a central and upwardly-directed port 62. A bellows 63 has its lower end attached to the wall 36 and its upper end attached to the plate 56, the bellows providing a pressure space, at 64, communicating with the port 62 and the passage 61, and the piston or abutment area 65 provided on the plate 56 and encompassed by the bellows 63 being preferably opposed and equal to the piston area of the cup valve encompassed by the annular orifice.

While the passage 61 communicating with the pressure space, at 64, may be connected to the drain space, at which time it exerts no effect on the transformer, I prefer to have it connected to the transformed oil pressure space so that pressure may be applied to the piston area or abutment 65 in lagging relation with respect to the transformed oil pressure applied to the cup valve, the lagging pressure providing for speed correction, in whole or in part, incident to change in load.

The passage 61 is shown as connected to the transformed oil pressure space by means of a conduit 66 having an adjustable orifice 67. An accumulator, for example, an air bell 68, is arranged between the orifice and the space, at 64. the passage 66 is also provided with a valve 69 which is adjustable to vary communication of the conduit 66 with the exhaust space or drain. With the valve 69 closed, then the full effect of lagging pressure is applied to secure isochronous operation. On the other hand, as the valve 69 is opened to place the space 64 in communication with the drain space, the maximum pressure obtainable in the space, at 64, becomes less and less, with the result that the speed correction becomes less and less until finally, with the space, at 64, in communication with the drain and communication with the transformed oil pressure space cut off, the governing apparatus operates with its full percentage of regulation.

Movement of the apparatus for the purpose of varying the transformed oil pressure is very small so that the apparatus is essentially a force transmitting, utilizing, and transforming one without substantial movements of any kind. It is desirable, therefore, to provide means to limit the downward movement, or determine the position at least, of the thrust structure, at 50. Therefore, the transverse plate 54 as shown is provided with an edge 70 having close clearance with respect to the upper surface of the plate 47.

The oil escapes from the annular orifice defined by the cup valve 42 into the space, at 31, containing the diaphragm 58 having openings 59 providing continuity of the space. The space also includes the passages 60, the space above the plate 47, and the interior space of the bellows 46. As the outlet 74 is at the top, the space will be maintained filled with oil, and, since the impeller space 32 is also filled with oil, high frequency vibrations will be damped.

In Fig. 2, there is shown apparatus having the same operating principles as that already described but wherein there is shown a further modification of the structure. In this view, the thrust structure, at 50*a*, has a single stem 53*a* whose upper end carries the conical pin 52*a*, the diaphragm 58 being clamped in place between a flange 74 and a nut 75. The body structure 30*a* has upper and lower parts 35*a* and 33*a* held in place by clamping screws (not shown), the parts clamping a composite annular plate structure including the plate 36*a* and the upper and lower plates 78 and 47*a*, the plates being arranged in superposed relation.

The upper plate 78 has a central opening 80 through which the stem 53*a* extends and a bellows encompasses the stem and has its upper end attached to the plate 78, the lower end of the bellows being connected to an abutment 81 carried by the stem. The intermediate plate 36*a* has a passage 61*a* which communicates with the central opening thereof through which the bellows extends, the plate having a depending cup 83 whose bottom 84 has sealing relation with respect to the stem.

It will, therefore, be seen that the space at 64*a* between the cup 83 and the movable structure including the abutment 81 and the bellows 63*a*, functions to achieve the same purpose as the pressure space, at 64, already described.

In all forms of the invention, the cup 42 preferably has a sharpened annular edge 44 cooperating with the flat seat 41 to define the annular orifice; and, in order that the flow characteris-

tics may be kept uniform so as to avoid pulsations of transformed pressure or disproportionate changes in the latter, I prefer to limit the minimum orifice width. Preferably, the orifice width should not be less than ½ of the thickness of the edge 44. By having the apex of the conical seat or bearing 51 spaced below the seat 41, it will be apparent that the hydraulic reaction of fluid escaping from the annular orifice tends to keep the edge 44 in parallel relation with respect to the seat so that a uniform circumferential discharge of fluid occurs. Assuming that the cup should tilt so as to define a minimum orifice width at one side and a maximum at the other, the increasing hydraulic reaction provided by the region of maximum width gives a force tending to tilt the cup so as to equalize the orifice width. Thus the cup inherently tends to seek a position so as to define an annular orifice of uniform width. Also, I prefer to distribute the mass of the cup so that the latter has stable equilibrium with respect to the pivot point 52, this result being secured by having the center of gravity of the cup located below the point of support.

From the foregoing, it will be apparent that I have devised a transformer wherein there are no wearing parts such as control edges which tend to become rounded and thereby lose sensitivity. The movement required is inconsequential and the means of support provide for frictionless operation such that the provision of special friction reducing means is unnecessary. Vibration is substantially avoided because, not only are all of the parts firmly attached to the large bellows subject to impeller pressure, but the interior spaces, at 31 and 32, filled with oil, serve to secure a substantial damping effect. Furthermore, the relation of component parts is such that close tolerances and clearances are not required with the result that manufacture, assembly and operation are facilitated. Aside from these advantages, the apparatus operates without any hydraulic reaction in the direction of applied forces, this effect being due to the radially-directed escape orifice which cannot under any condition give a component of force in an axial direction such as would be the case with a piston valve having sharp land edges controlling sharp-edged cylinder ports. As the cup valve is inherently stable with respect to its point of support and is designed to provide a self-righting hydraulic moment, the escape orifice will tend to maintain a uniform annular escape area. Furthermore, as the cup operates to give a transformed pressure without high frequency pulsations the life of deflectable parts, such as bellows elements, is increased.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including means providing an enclosed space in communication with the pressure-responsive means and having an escape port whose exit end is bounded circumferentially by a seat extending radially from the latter, means for maintaining fluid under pressure in said space, and a member arranged in overlapping relation with respect to said seat to cover the exit end of the port and to cooperate with the seat to define an escape orifice; and means for applying said force to said member in a direction opposed to that of force of space pressure applied thereto.

2. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose exit end is bounded circumferentially by a seat extending radially from the latter, means including an orifice for supplying fluid under pressure to said space, and a member arranged in overlapping relation with respect to said seat to cover the exit end of the port and to cooperate with the seat to define an escape orifice; means for applying said force to said member in a direction opposed to the force of space pressure applied thereto; and means responsive to temporary prime mover speed change incident to load change to reduce the change in speed due to load change.

3. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose exit end is bounded circumferentially by a seat extending radially from the latter, means including an orifice for supplying fluid under pressure to said space, and a member in overlapping relation with respect to the exit end of the port and cooperating with the seat to define an escape orifice; means for applying said force to said member in a direction opposed to that of the force of space pressure applied thereto; means providing a passage having one end communicating with said space and including an accumulator; and means associated with the other end of the last-named passage and responsive to fluid pressure thereof to apply a force to the covering member acting in the same direction as said first force in order to effect speed correction of the prime mover incident to change in load.

4. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose outlet is bounded by an annular seat, means for maintaining fluid under pressure in said space, and a member in covering relation with respect to the outlet end of the port and cooperating with said seat to define an annular escape orifice; means for applying said force to said member in a direction opposed to that of the force of space pressure applied thereto; means providing a piston area or abutment for said member equal

to and in opposed relation with respect to the piston area thereof bounded by the annular orifice; means providing a pressure chamber for the first abutment or piston area; and means including a passage communicating with said space and an accumulator cooperating with the passage to provide for lagging of changes in pressure in said chamber relative to pressure changes in said space.

5. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose outlet end is bounded by an annular seat, means for maintaining fluid under pressure in said space, and a cup in covering relation with respect to the outlet end of said port and having a sharp annular edge cooperating with said seat to define a radially-directed annular escape orifice; a member having point bearing contact with the cup; and means for applying said force to the member.

6. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose outlet end is bounded by an annular seat, means for maintaining fluid under pressure in said space, and a member in covering relation with respect to the outlet end of said port and cooperating with said seat to define an annular escape orifice; a thrust member having point bearing contact with respect to said cup; a flexible element for centering said thrust member; and means for applying said force to said thrust member in a direction opposed to that of the force of space pressure applied to said covering member.

7. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose outlet end is bounded by an annular seat, means for maintaining fluid under pressure in said space, and a member in covering relation with respect to the outlet end of said port and cooperating with said seat to define an annular escape orifice; a thrust member having a point bearing contact with respect to said covering member; means for centering the thrust member; means providing a piston area on the thrust member in opposed relation to the piston area provided by the covering member and bounded by the annular orifice and equal to the latter piston area; means providing a pressure chamber for the first piston area; and means including a passage communicating with said pressure space and providing for the lagging of change in pressure in said chamber relative to change in pressure in said space.

8. In a governing system, pressure-responsive means; means providing a force which varies in response to change in speed; means for transforming changes in said force into changes of fluid pressure and for applying the latter to the pressure-responsive means; said transforming means including structure providing an enclosed space in communication with the pressure-responsive means and having an escape port whose outlet end is bounded by an annular seat, means for maintaining fluid under pressure in said space, and a cup in covering relation with respect to the outlet end of said port and having an annular edge cooperating with said seat to define an annular escape orifice; a member having point bearing contact relation with respect to said cup; a diaphragm for centering said member, said membe rhaving a piston area equal to and in opposed relation to the piston area provided by the cup and bounded by the annular orifice; means providing a pressure chamber for the first piston area; a passage affording communication between the chamber and said transformed fluid pressure space; means providing an orifice for said passage; an accumulator communicating with the passage between the orifice and the pressure chamber; and means for applying said force to said member in a direction opposed to that of the force of space pressure applied to the cup.

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