

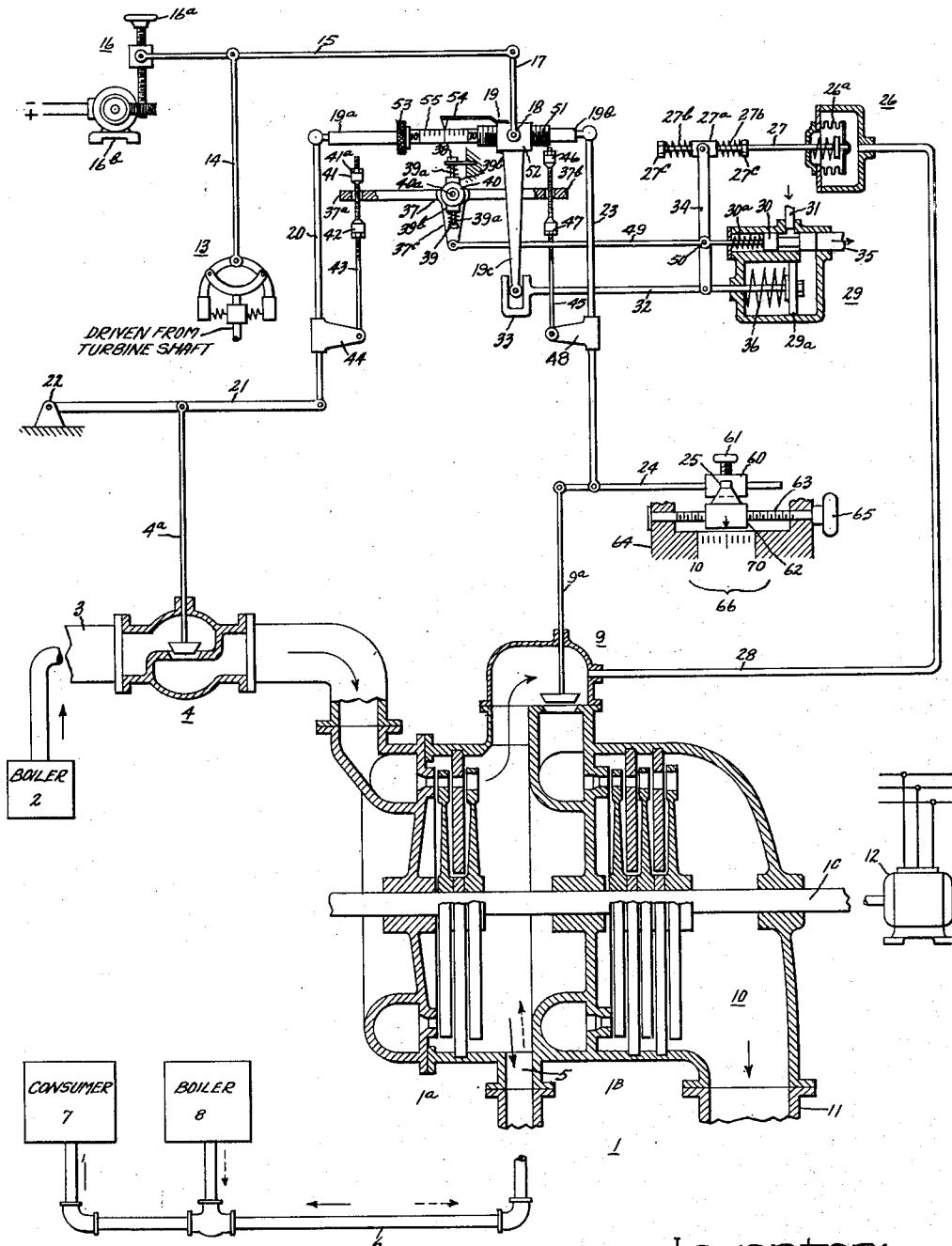
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GOVERNING MECHANISM FOR EXTRACTING TYPE TURBINES

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GOVERNING MECHANISM FOR EXTRACT-
ING TYPE TURBINES

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This invention relates to a governing system for an elastic fluid turbine of the extraction type, having an inlet valve for controlling the admission of motive fluid to a high pressure turbine section in series flow relation with an extraction valve for admitting steam to a low pressure turbine section, the interaction of these two valves determining the energy output of the turbine rotor and the rate of flow of elastic fluid taken from the turbine casing through an extraction opening located between the high pressure turbine section and the extraction valve. The invention constitutes an improved governor of the so-called "three-arm" type, and is a further improvement of the three-arm governing mechanism disclosed in United States Patent 2,095,860, patented October 12, 1937 on an application of F. R. Ericson.

With extraction governors of the three-arm type previously known, it has been necessary to make a number of adjustments in the various linkages in order to alter the desired pressure to be maintained at the extraction opening over a wide range without introducing substantial deviations from the theoretical optimum operation of the governor. Such adjustments could not be made while the machine was in operation. Furthermore, the earlier three-arm governing systems have included means for preventing "overtravel" of the steam valves in the closing direction, in order to provide proper operation and prevent mechanical damage to the linkages connecting the various components of the system when hydraulic servo-motors are employed to actuate the valves. It has since been found desirable in certain applications to also provide means for limiting over-travel of the valves in the opening direction.

The objects of the present invention are to provide an extraction turbine governor of the type described in which the tendency of the steam control valves to overtravel is prevented in the opening direction as well as in the closing direction, while, by means of a minimum number of readily made adjustments, the extraction pressure may be conveniently varied over a wide range without shutting down the machine and without re-adjusting the overtravel preventing mechanism.

Other objects and advantages will be apparent to those skilled in the art from the following description taken in connection with the accompanying drawing in which the single figure is a diagrammatic representation of an elastic fluid

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turbine having an improved three-arm governing mechanism in accordance with the invention.

Referring now more particularly to the drawing, the invention is illustrated as applied to an elastic fluid turbine 1 supplied with motive fluid from a high pressure boiler 2 through a conduit 3 containing a high-pressure inlet valve 4. The turbine 1 includes a high-pressure section 1a and a low-pressure section 1b, each including one or more nozzle diaphragms and bucket-wheels. Intermediate the high and low-pressure sections is an extraction opening 5 communicating with a conduit 6 arranged to deliver motive fluid at an intermediate pressure to any suitable consumer, indicated diagrammatically at 7, and to which additional steam may be supplied by a low-pressure boiler 8. Flow of motive fluid through the low-pressure turbine section 1b is regulated by an extraction valve 9. Fluid discharged from the low-pressure section 1b into exhaust hood 10 may pass to a discharge conduit 11 thence to a condenser or to some still lower pressure turbine element, which may be on the same shaft 1c of turbine 1 or may constitute a separate turbine in series flow relation with turbine 1. Rotor 1c is connected to a suitable load output device indicated diagrammatically as an electric generator 12.

It will be appreciated by those familiar with prime movers of this type that the turbine 1 is intended to perform two important functions: (1) generation of mechanical shaft power for driving the load 12, and (2) supplying steam at a desired intermediate pressure to a consumer 7, which may represent some industrial process or heating system. The auxiliary low-pressure boiler 8 is arranged to supply steam to the consumer 7 when the demand for process steam exceeds that which can be supplied by the high-pressure boiler 2. The low-pressure boiler 8 also supplies steam through the extraction opening 5 to the low-pressure section of the turbine when the demand for mechanical load output from the rotor 1c exceeds that which can be obtained from the boiler 2. The flow arrows shown in the drawing indicate that the consumer 7 will ordinarily always receive fluid, at a constant pressure but at a variable rate determined by the operation of the consumer, the low-pressure boiler 8 may or may not supply steam to the conduit 6 depending on the requirements of the consumer 7 and the mechanical load 12, while boiler 2 always supplies steam to conduit 3, with the result that the net flow through extraction opening 5 may be either from the turbine casing to

the consumer 7 or from the boiler 8 into the turbine 1. Such an arrangement permits generation of process steam in the boiler 2 at high pressure and temperature levels for maximum thermal efficiency, the high-pressure turbine section 1a serving to reduce the pressure to the value required by the consumer 7 while deriving useful energy for the consumer 42 in the process. The low pressure or extraction valve 9 is automatically positioned by the governing system so as to maintain a preselected pressure at the extraction opening 5 regardless of the demands of the consumer 7 and load device 12.

The governing system shown in the drawing includes a number of component parts common to the three-arm regulating systems used in the past, as illustrated in the above-mentioned patent to Ericson 2,095,860, also the later patent to Ericson et al. 2,111,420, patented March 15, 1938. These common elements include a speed sensitive device responsive to the speed of rotor 1c and illustrated diagrammatically as a centrifugal governor 43 adapted to be driven at a speed proportional to that of the turbine shaft, as by any suitable gearing (not shown). Governor 43 actuates a link 44 pivotally connected to an intermediate point of a lever 45 fulcrumed at one end on a speed adjusting or "synchronizing" device 16, which may be actuated either by a manual hand-wheel 16a or a remotely actuated positioning motor 46b. The other end of lever 45 is connected by a link 47 to the intersection or "common point" represented by the pivot 48 of a floating three-arm lever indicated generally at 19. The first arm 19a of this three-arm lever is arranged to actuate the high-pressure inlet valve 4 by means of a link 20 pivoted to a lever 21 supported on a fixed fulcrum 22, the valve stem 4a being connected to an intermediate point of the lever 21. The second arm 19b of the three-arm lever positions the extraction valve 9 by means of a link 23 connected to an intermediate portion of a lever 24 connected to the stem 9a of the extraction valve. The other end of lever 24 is supported on a fulcrum 25 which is ordinarily fixed. The third arm 19c of the floating three-arm lever is arranged to be positioned in accordance with the extraction pressure intermediate the high and low pressure sections of the turbine by means of a pressure responsive device indicated generally at 26 as including a bellows 26a arranged to position a rod 27 in accordance with extraction pressure communicated through a conduit 28 to the device 26. Rod 27 does not position the arm 19c directly, but acts through the medium of a hydraulic servo-motor indicated generally at 29 and including a pilot valve 30, with a small biasing spring 30a to take up lost motion in the pivots, arranged to control the admission of motive liquid through conduit 31 from a suitable source, for instance a pump (not shown) driven from the turbine shaft, to the hydraulic motor piston 29a. Piston 29a has a rod 32 carrying a guide member or yoke 33 engaging a spherical portion at the end of lever arm 19c in such a manner that vertical movement of the three-arm lever 19 is permitted under the action of the speed governor 43, while transverse movement of the yoke 33 produces rotational movement of the lever 19 about the common point 48. Rod 27 positions the pilot valve 30 by means of a lever 34, and a restoring action is produced on the pilot valve 30 by reason of the fact that lever 34 is also pivotally connected to the rod 32. This combination of elements constitutes a well-known

hydraulic servo-motor arrangement, and it will be readily appreciated that movement of pilot valve 30 to the right effects supply of motive liquid from conduit 31 to power piston 29a, the resulting movement of piston 29a to the left against the bias of spring 36 restoring pilot 30 through lever 34 so that the supply of motive fluid is discontinued. Likewise movement of pilot 30 to the left permits motive liquid to drain to conduit 35, piston 29a being then caused to move to the right by the spring 36, while the lever 34 again restores pilot 30 to the aligned position shown in the drawing.

The above-described conventional elements of this governing system are equivalent to the various arrangements shown in the above-mentioned Patents 2,095,860 and 2,111,420, and it will be appreciated by those familiar with extraction governors of this type that the function of the speed governor 43 is to hold the turbine rotor speed constant, at a value selected by the synchronizing device 16, by imparting translational movement to the three-arm lever 19 in a vertical direction, while the extraction pressure responsive device 26 produces rotational movement of the three-arm lever about the common point 48. Translational movement in a vertical direction moves both valve stems 4a, 9a in the same direction simultaneously so as to vary the flow through the high and low pressure elements and change the load output thereof, while rotational movement of the three-arm positions valve 4, 9 in opposite directions in order to keep the extraction pressure constant. The above elements and their method of operation have been sufficiently described in the previous patents so that more detailed description here seems unnecessary.

The present invention includes a special arrangement for preventing overtravel of the valves 4, 9 in both the opening and the closing directions. This has been found desirable in order to provide proper operation of the governor and to prevent deformation of the mechanical parts of the various linkages which might occur if the powerful hydraulic motor 29 tried to move either of the valves in the closing direction when the valve disk was already against its seat member, or conversely tried to move the valves farther in the opening direction beyond the maximum open position. The arrangement for effecting this overtravel limiting function is as follows.

A second "three-arm lever" indicated generally at 37 is supported adjacent the first three-arm lever 19. Lever 37 is not "free floating" in the same sense as lever 19, being suspended resiliently from a fixed bracket 38 by means of a through-bolt or rod 39 having a pair of springs 39a, 39b interposed between a hub portion 40 of lever 37 and fixed abutments at both ends of the rod 39. With this arrangement, the stiffness of the springs 39a, 39b is sufficient that the axis of the hub portion 40 is ordinarily fixed in space, but may move a limited amount translationally in a vertical direction when compelled to do so by interaction of the various components of the system. It will of course be obvious that other types of resilient supports might be employed to maintain the hub 40 ordinarily fixed, while permitting certain yielding under overloads to prevent deformation of the levers and links.

The first arm 37a of the floating lever 37 is adapted to be engaged by a pair of normally fixed, but adjustable, stops 41, 42, each of which may be in the form of a cylindrical member having a bore threaded so as to be adjustable on a threaded

rod 43, the latter being pivotally connected to a bracket or abutment 44 fixed to the link 20. The threaded stops 41, 42 may be provided with a lock nut, as indicated at 41a to hold them firmly in a desired position. While this adjustable stop arrangement may take many mechanical forms, perhaps the simplest in that shown in the drawing, in which the threaded rod 43 projects freely through a hole in the end of arm 37a, with sufficiently generous clearances that the arm will not bind on the rod due to the angularity which will occur between the arm and the rod in normal operation.

The opposite arm 37b of the second floating lever is similarly arranged relative to the threaded rods 45 carrying adjustable stops 46, 47 and pivoted to abutment 48 which is connected so as to move with the link 23.

The third arm 37c of the second floating lever is pivoted to a link 49, which at its other end is connected to the pivot 50 of lever 34. Thus it will be seen that vertical movement of rods 20, 23 may under some condition of operation cause one of the adjustable stops 41, 42, 46, 47, to engage the respective arms 37a, 37b, so as to rotate the three-arm lever 37 about the fulcrum 40a, with the result that the rod 49 exerts a restoring effect on the pilot valve 30, thus modifying the action of the hydraulic servo-motor 29.

It may be noted that the link 34 is not connected to rod 27 by a fixed pivot but through a "bottled spring" arrangement consisting of a sleeve 27a loosely surrounding rod 27 and having trunnions pivoted in the forked end of lever 34. A pair of stiff coil springs 27b are interposed between the sleeve 27a and spaced abutments 27c on rod 27. With this arrangement, the springs 27b ordinarily hold the sleeve 27a in substantially fixed relation relative to rod 27, but some relative movement therebetween is permitted when the other components of the system compel such displacement. This bottled spring arrangement, and the similar spring suspension for the three-arm lever 37, prevent deformation of the linkages.

The arrangement for permitting adjustment of the extraction pressure during operation of the turbine includes (a) an adjustable arrangement by which the relative effective lengths of the arms 19a, 19b of the floating three-arm 19 can be readily varied; and (b) means for readily adjusting the effective length of the lever 24.

The first of these adjustments is made possible by the fact that the arms 19a, 19b are in the form of a single rod having an intermediate threaded portion 51; while the third arm 19c is provided with an end portion 52 having a transverse bore threadedly receiving the rod portion 51. With this arrangement, the arm 19c can be shifted longitudinally, so as to change the length of arm 19a relative to 19b, by rotating the member 19a, 51, 19b about its own axis by means of an adjusting hand-wheel 53. In order to permit this rotational movement, the connection between the end of the arm 19a and rod 20 and also that between arm 19b and rod 23, are not ordinary pivoted joints but are ball and socket connections permitting both angular movement of the arms 19a, 19b relative to rods 20, 23 and also rotational movement of the arms 19a, 19b about their own axis.

To facilitate adjustment of the arm 19c on the threaded portion 51, an indicator arm 54 is fastened to the end portion 52 of arm 19c and carries a pointer cooperating with a scale 55 marked

on the rod 19a. This scale may conveniently be calibrated and marked to read directly in pounds per square inch gage pressure at the extraction opening 5 in turbine 1.

Although difficult to show clearly in a two dimensional drawing, it will be understood that the three-arm lever 19, links 20, 23 are in a plane nearest the observer, the second three-arm lever 37, rods 43, 45, 49 are behind, all so arranged that the upper ends of rods 43, 45 will not interfere with the free floating movement of the three arm 19, and the lower stop 47 on rod 45 will not engage the link 49.

The second adjusting feature, for varying the effective length of the lever 24, consists of an adjustable fulcrum, as follows. The pivots 25 are in the form of trunnions fixed to a cylindrical member 60 through the bore of which is slidably disposed the end of rod 24. Sleeve 60 may be clamped to rod 24 in various adjusted positions by means of a thumb screw 61. Trunnions 25 are carried in a U-shaped bracket secured to a block 62 which is arranged to travel transversely on a lead-screw 63 rotatably carried in a fixed support 64 and turned manually by the hand-wheel 65. Engagement of the flat bottom of block 62 with the adjacent surface of the fixed support 64 may be relied upon to prevent rotation of block 62 as the lead-screw turns. Then by loosening the locking screw 61, the hand-wheel 65 can be manipulated to move pivot 25 longitudinally of rod 24 until the indicating mark on the block 62 is opposite the desired extraction pressure on the scale 66, which scale may be marked on an adjacent surface of the fixed support 64. With this arrangement, the fixed fulcrum 25 may be readily adjusted so as to vary the effective length of lever 24, and thereby alter the rate of movement of valve stem 9a for a given change in position of the floating three-arm 19. It will be understood that the equivalent means for altering the lever ratio may also be employed.

By means of only these two simple adjustments, my improved regulating system may be readily changed during operation of the turbine so as to vary the extraction pressure at the port 5 without introducing substantial deviations from the theoretical optimum operation of the governor. Thus changes in the pressure requirements of consumer 7 may be conveniently met by a very simple adjustment of the regulating system.

The operation and use of the system is as follows. Ordinarily, the adjustable stop 46 will be set so that it just touches the upper surface of lever arm 37b when valve 9 is in the fully closed position, and the pilot valve 30 is aligned, as in the drawing, so that no liquid is bled from or supplied to the hydraulic motor 29, and with the piston 29a in its extreme right-hand position, as shown. With this adjustment, the operation is as follows: Assume that the turbine is operating with the high-pressure inlet valve 4 wide open, the extraction valve 9 closed and piston 29a in its extreme left-hand position, which means that the flow through the high-pressure turbine section and out the extraction opening 5 is just sufficient to satisfy the mechanical load called for by the speed governor 13 and the extraction demands of the consumer 7 as controlled by the pressure responsive device 26. Suppose, now, that the load output requirements on the turbine shaft 1c decrease so that the rotational speed tends to increase. The increased speed of the governor 13 will cause it to pull rod 14 down-

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wardly so that lever 15 pivots about its fixed left-hand end and link 17 causes the floating three-arm lever 19 to begin to descend. Since the adjustable stop 46 was already in contact with the upper surface of lever arm 37, any movement of link 23 downwardly immediately causes the stop 46 to effect clockwise rotation of the three-arm lever 37 about its fulcrum 40a. This clockwise movement causes link 49 to move pilot valve 30 to the left, lever 34 allowing this movement due to the bottled spring arrangement, so that operating liquid is bled from the hydraulic motor 29 through drain conduit 35. This causes piston 29a to move to the right, and the guide member 33 acting on the three-arm lever 19c causes the latter to rotate counterclockwise about its pivot point 18, with the result that the arm 19b rises to its original position and in doing so raises stop 45, releasing pressure on lever arm 37b, permitting pilot valve 30 to return to its original aligned position by movement of piston 29a to the right. While these actions have been described in sequence in order to illustrate the operation, it will be appreciated that they actually occur simultaneously so that the net effect of the adjustable stop 46 has been to cause the right-hand end of lever arm 19b to remain fixed in space. Thus, there is no tendency for the extraction valve 9 to move in the closing direction past the fully closed position, and the forces exerted by the powerful hydraulic motor 29 are not permitted to deform any of the links or levers by trying to force the extraction valve past its closed position.

The effect of the adjustable stop 47 will be seen from the following. Assume that the inlet valve 4 is fully closed, with steam being supplied into the extraction opening 5 from the low-pressure boiler 8, the extraction valve 9 being wide open so that the steam flow from the boiler 8 through the low-pressure turbine section 1b is just sufficient to satisfy the mechanical load requirements of the device 12, the governor 13 again holding the speed constant at a desired value. With these conditions, the adjustable stop 47 is brought up until it just touches the underside of the lever arm 37. This stop will now prevent overtravel of extraction valve 9 in the opening direction in the following manner. Assume that the output load on the turbine shaft 1c increases, so that the speed tends to decrease. The speed governor 13 then causes the rod 14 to move upwardly so that lever 15 rotates counterclockwise about its left-hand end, the link 17 causing the floating three-arm lever 19 to rise. Any movement upwardly of the right-hand end of lever arm 19b causes the stop 47 to engage the underside of lever arm 37, causing the latter to rotate counterclockwise about its pivot point 40a, with the result that link 49 causes pilot valve 30 to move to the right. This permits operating liquid to be supplied from conduit 31 to the piston 29a with the result that guide member 33 moves to the left and the floating three-arm lever 19 rotates clockwise about its common point 18. As before, the net effect of these interactions is that the right-hand end of lever 19b remains in its original position. In other words, the valve stem 9a does not tend to move in the opening direction past the fully opened position; but this call for increased shaft output is satisfied by clockwise rotation of the floating three-arm 19 so as to partially open the inlet valve 4. Steam from the high-pressure boiler 2 then flows through the

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turbine section 1a to satisfy the demand for increased mechanical shaft output.

In this manner, the stops 46, 47 prevent overtravel of the low-pressure extraction valve 9 in both the opening and the closing directions.

With respect to the inlet valve 4, the function of the stop 41 is as follows. Suppose high-pressure valve 4 is fully closed and steam is being admitted through extraction opening 5 with the valve 9 wide open and stop 41 adjusted to just touch the upper side of lever 37a. If, now, the shaft load output and speed should change so as to cause link 17 to lower the common point 18 of floating three-arm 19, any resulting downward movement of link 20 will cause the stop 41 to rotate the lever 37 counterclockwise about its pivot 40a. This causes pilot valve 30 to move to the right, again admitting operating liquid to piston 29a so that floating three-arm 19 is rotated clockwise about point 18, with the result that arm 19a is returned to its original position. In other words, the effect of the stop 41 is to prevent any further net movement downward of the valve stem 4a. Thus, overtravel of the valve 4 in the closing direction is prevented. Similarly, the adjustable stop 42 may be positioned so as to engage the underside of lever arm 37a in order to prevent movement of valve stem 4a in the opening direction when the valve 4 is already fully open and the extraction valve 9 is fully closed.

Experience with regulating systems incorporating the invention has disclosed an important advantage of the adjustable stops 41, 42, 46, 47, in that the "speed regulation" of the governing system remains exactly constant for all modes of operation, with the turbine operating with steam supplied from the high-pressure boiler 2 or from the low-pressure boiler 8, and regardless of whether or not any steam is flowing through the low-pressure turbine section 1b. It will be understood by those skilled in the art that the "speed regulation" of a turbine is the change in speed which occurs from full load to no load, this change being ordinarily about 4 per cent of the normal rated speed. This speed change is that required for effective operation of the speed responsive centrifugal governor 13. For a number of reasons which need not be described in detail here, it is very desirable that this regulation always be of the same magnitude regardless of the method of operation of the turbine.

As indicated above in the description of the apparatus, the extraction pressure which the governing system will maintain is varied by changing the relative effective lengths of the lever arms 19a, 19b. In order to increase the extraction pressure, the hand wheel 53 is rotated to cause arm 19c to shift to the right on the threaded portion 51, thus increasing the rate of movement of the inlet valve stem 4a for a given movement of the extraction valve stem 9a. In order to make the system operate properly, it is also necessary to make an accompanying adjustment in the effective length of the lever 24. When increasing the extraction pressure, the fixed fulcrum 25 must be moved to the right so as to increase the effective length of the lever 24. Thus, by simple manipulation of the hand wheels 53, 65 the operator of the turbine can very readily adjust the extraction pressure in accordance with changes in the requirements of consumer 7, and this change may be easily made while the machine is in operation. Another very important advantage of the arrangement is that such changes in the extraction pressure setting do not necessitate

any further changes in the restoring mechanism for overtravel prevention. In this sense, the overtravel prevention mechanism is "self-adjusting," working properly regardless of changes in the extraction pressure adjusting mechanism.

Heretofore, in cases where a wide range of adjustment of extraction pressure at port 5 was required, it has been necessary for the manufacturer of extraction turbines having three-arm governing system, as known to the prior art, to provide at least three complete alternate designs of governing system in order to permit all the various methods of operation of which my single improved system is capable. With the prior arrangements, it was necessary to shut down the machine and have an expert familiar with the governor make extensive alterations, even to the extent of purchasing certain re-designed parts, in order to alter the extraction pressure. With the present invention, a single governing system is capable of a great variety of modes of operation and permits ready adjustment, by comparatively unskilled operators, of the extraction pressure without even stopping the turbine.

While only one representative embodiment of the invention has been disclosed herein, and that in very diagrammatic form, it will be readily appreciated by those skilled in the art that a great variety of modifications of the mechanical means employed may be made. For instance, instead of using a simple direct-acting mechanical linkage connecting the arm 19a of the floating three-arm 19 with the high-pressure inlet valve 4, a hydraulic servo-motor may be interposed in order to provide the necessary force for actuating the inlet valve 4. Likewise, the speed governor 13 may operate through a hydraulic relay instead of directly through the mechanical link 14, as shown, for instance, in Fig. 1 of Ericson Patent 2,095,860. The extraction valve 9 may also be operated by a hydraulic servo-motor arrangement. Such servo-motors are obviously equivalent to the simple mechanical links shown in the drawing, and since they are so well known in the art, it seems unnecessary to further complicate the present disclosure by including such arrangements.

It will also be understood that in some applications it may not be necessary to provide the overtravel limiting function for either the valve 4 or the valve 9, for either or both directions of movement. In such applications, one or more of the adjustable stops 41, 42, 46, 47 may be omitted. Thus, if it is found not necessary to limit the overtravel of valve 9 in either direction, the abutment 48, rod 45, with the stops 46, 47 and the associated lever arm 37b may be omitted entirely from the arrangement. The remaining arm 37a with its associated stops 41, 42 will still operate precisely as described above. Instead of actually removing the stops not needed, they may be merely "backed off" so that under no conditions will they engage the associated arm of the three-arm lever 37.

It should also be noted that the invention is applicable to more complicated extraction turbines having successive turbine sections in series flow arrangement with an extraction opening between each adjacent pair of sections, as illustrated in the Ericson et al. Patent 2,111,420. The application of the improvements constituting the present invention to such extraction governors produces a regulator of enormous complexity; and it is believed that the description of such a complete system is unnecessary

here because such uses of the invention will be apparent to those familiar with such governors and the prior patented art.

In view of the great variety of modifications to which the invention is amenable, I desire it to be understood that the appended claims are intended to cover all such modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a governing system for an extraction turbine having a floating three-arm lever for coordinating movement of a high-pressure inlet valve and a lower-pressure extraction valve, first linkage means connected to a first arm of the lever for positioning the inlet valve, second linkage means connected to a second arm of the lever for positioning the extraction valve and servo-mechanism adapted to position the third arm of the lever in accordance with changes in extraction pressure and including extraction pressure sensing means adapted to position pilot means controlling a motor, the combination of means for automatically limiting movement of the turbine valves comprising second lever means adapted to produce a restoring action on said pilot means, and stop means connected to move with said first and second linkages and adapted to engage said second lever whereby the servo-motor is prevented from moving the valves beyond a predetermined limiting position.

2. In a governing system for an extraction turbine having a floating three-arm lever for coordinating movement of a high-pressure inlet valve and a lower-pressure extraction valve, first linkage means connected to a first arm of the lever for positioning the inlet valve, second linkage means connected to a second arm of the lever for positioning the extraction valve and servo-mechanism adapted to position the third arm of the lever in accordance with changes in extraction pressure and including extraction pressure sensing means adapted to position pilot means controlling a motor, the combination of automatic limit means comprising second lever means adapted to produce a restoring action on said pilot means, and stop means connected to move with said first linkage and adapted to engage said second lever whereby the servo-motor is prevented from moving the high-pressure inlet valve beyond a predetermined limiting position.

3. In a governing system for an extraction turbine having a floating three-arm lever for coordinating movement of a high-pressure inlet valve and a lower-pressure extraction valve, first linkage means connected to a first arm of the lever for positioning the inlet valve, second linkage means connected to a second arm of the lever for positioning the extraction valve and servo-mechanism adapted to position the third arm of the lever in accordance with changes in extraction pressure and including extraction pressure sensing means adapted to position pilot means controlling a motor, the combination of automatic limit means comprising second lever means adapted to produce a restoring action on said pilot means, and stop means connected to move with said second linkage and adapted to engage said second lever whereby the servo-motor is prevented from moving the low-pressure extraction valve beyond a predetermined limiting position.

4. In a governing system for an extraction turbine having a floating three-arm lever for coor-

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minating movement of a high-pressure inlet valve and a lower-pressure extraction valve, first linkage means connected to a first arm of the lever for positioning the inlet valve, second linkage means connected to a second arm of the lever for positioning the extraction valve and servo-mechanism adapted to position the third arm of the lever in accordance with changes in extraction pressure and including extraction pressure sensing means adapted to position pilot means controlling a motor, the combination of means for automatically limiting movement of the turbine valves comprising a second three-arm lever adapted to produce directly a restoring action on said pilot means, first and second stop means connected to move with said first linkage and adapted to engage opposite sides of a first arm of the second three-arm lever whereby the servo-motor is prevented from moving the high-pressure inlet valve beyond predetermined limiting positions in both the opening and the closing directions, and third and fourth stop means connected to move with said second linkage and adapted to engage opposite sides of a second arm of the second lever means whereby the servo-motor is prevented from moving the extraction valve beyond predetermined limiting positions in both the opening and closing directions, the third arm of the second three-arm lever means being connected to produce the direct restoring action on said pilot means.

5. In a governing system for an extraction turbine having a first high-pressure inlet valve and a second lower-pressure extraction valve, the combination of a floating three-arm lever for coordinating movement of the valves and including means for altering the relative effective lengths of the first and second arms, first linkage means connected to the first arm for positioning the inlet valve, second linkage means connected to the second arm for positioning the extraction valve, the second linkage including variable ratio lever means for altering the rate of change of extraction valve position with change in three-arm lever position, whereby through suitable adjustment of the floating three-arm lever and variable ratio means the extraction pressure may be adjusted, servo-mechanism adapted to position the third arm of the floating lever in accordance

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ance with changes in extraction pressure and including extraction pressure sensing means constructed and arranged to position pilot means controlling a servo-motor, and means for automatically limiting movement of the turbine valves comprising second lever means adapted to effect a restoring action directly on said pilot means, first adjustable stop means connected to move with the first linkage and adapted to engage a first portion of the second lever means, and second adjustable stop means connected to move with the second linkage and adapted to engage a second spaced portion of the second lever means, whereby through adjustment of said stop means the servo-motor may be prevented from moving the valves beyond predetermined limiting positions.

6. In a governing system for an extraction turbine having a first high-pressure inlet valve and a second lower-pressure extraction valve, a floating three-arm lever for coordinating movement of said valves, the first linkage means connected to the first arm for positioning the inlet valve, second linkage means connected to the second arm for positioning the extraction valve, and servo-mechanism adapted to position the third arm in accordance with changes in extraction pressure and including extraction pressure sensing means, said floating three-arm lever including means for changing the effective length of the first arm relative to the second arm, and at least one of said linkages including variable ratio lever means for altering the rate of change of valve position with change in three-arm lever position, whereby through suitable adjustment of the floating three-arm and the variable ratio means the extraction pressure may be adjusted.

CARL E. SEDERQUIST.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,154,533	Moss	Sept. 21, 1915
2,095,860	Ericson	Oct. 12, 1937
2,098,803	Harris	Nov. 9, 1937
2,111,420	Ericson	Mar. 15, 1938