April 21, 1953 F. H. RUED 2,635,847

TURBINE JET CONTROLLER

Filed May 31, 1947 4 Sheets-Sheet 1

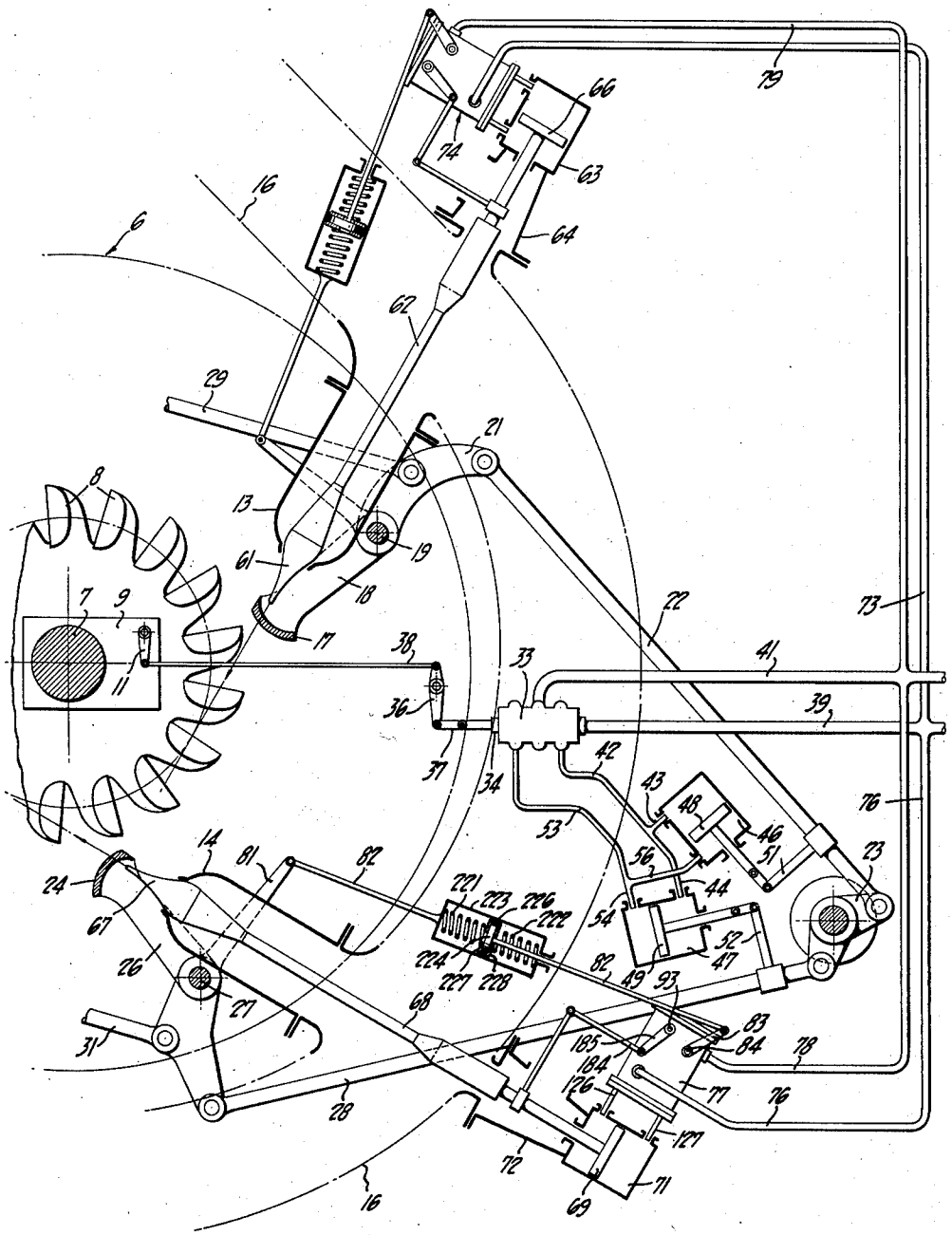


FIG. 1

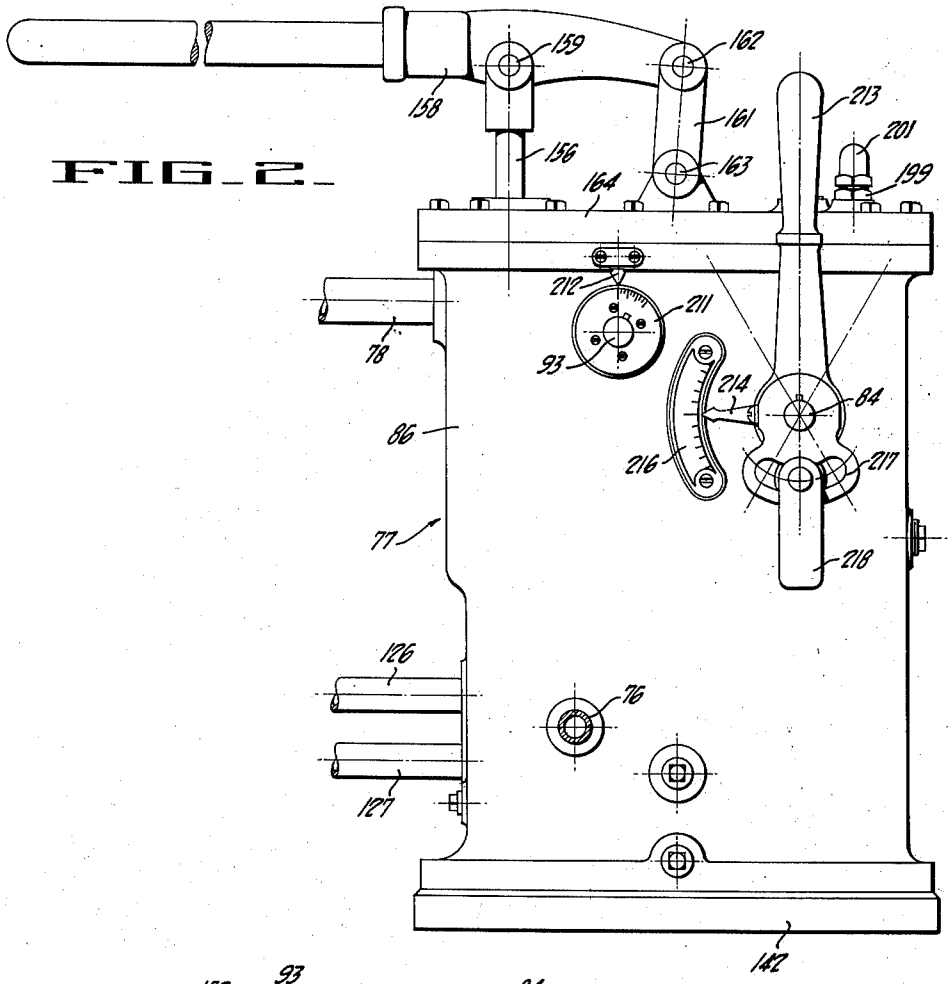
INVENTOR.
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April 21, 1953 F. H. RUED 2,635,847

TURBINE JET CONTROLLER

Filed May 31, 1947 4 Sheets-Sheet 2

FIG_2_



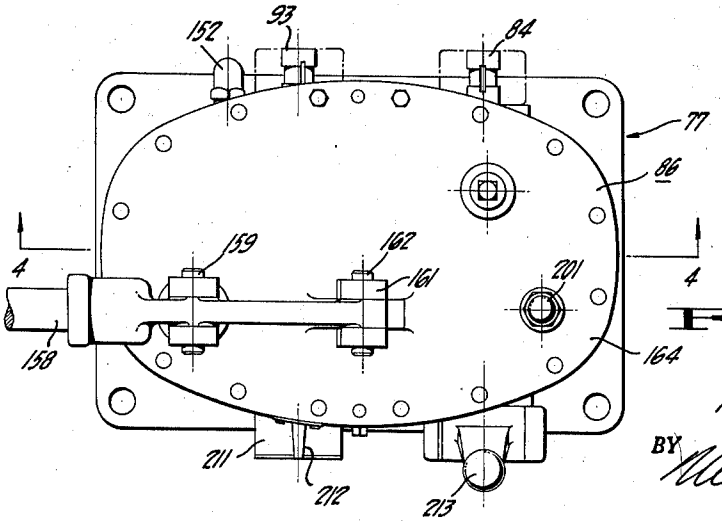


FIG_3_

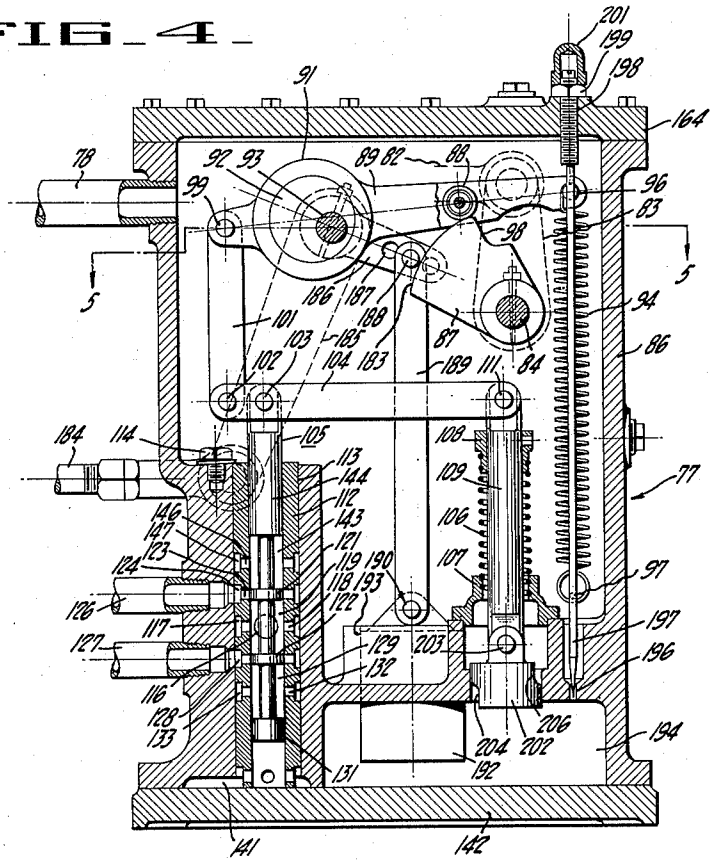
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April 21, 1953 F. H. RUED 2,635,847

TURBINE JET CONTROLLER

Filed May 31, 1947 4 Sheets-Sheet 3

FIG_4_



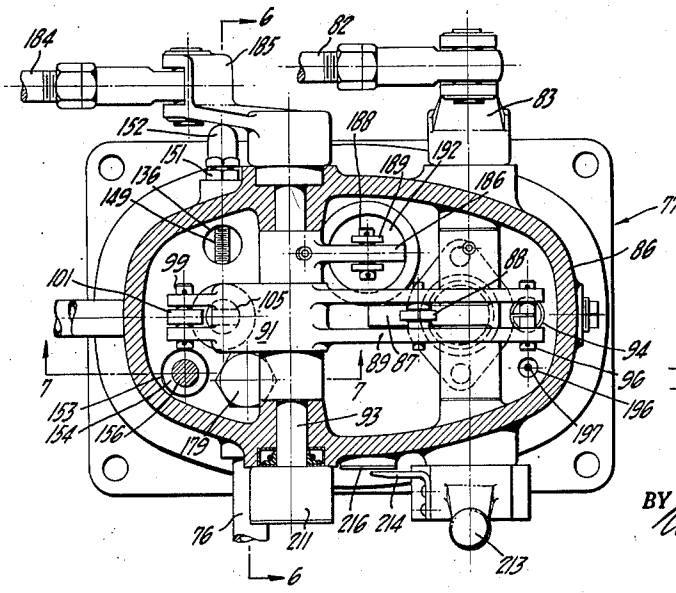


FIG_5_

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April 21, 1953 F. H. RUED 2,635,847

TURBINE JET CONTROLLER

Filed May 31, 1947 4 Sheets-Sheet 4

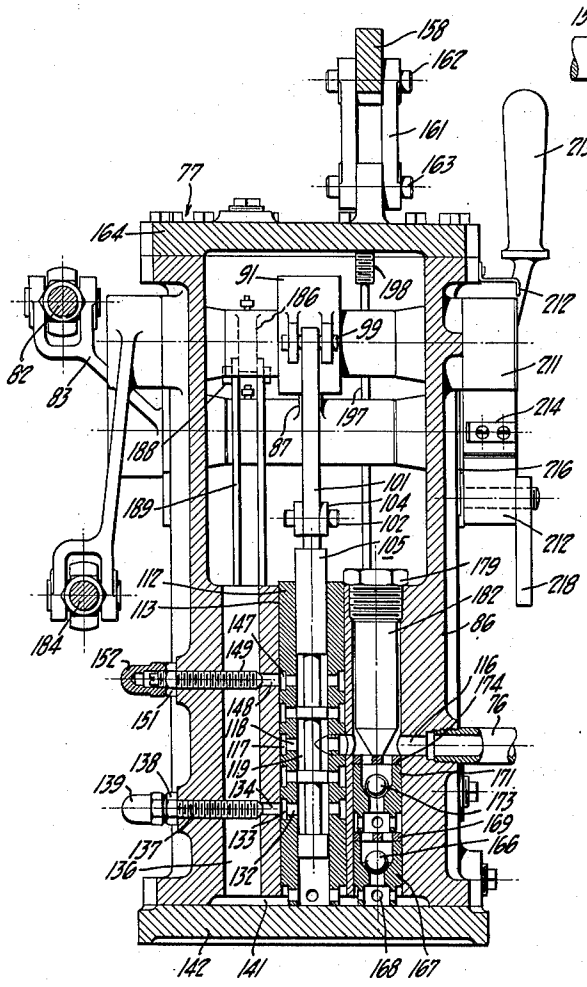


FIG_6_

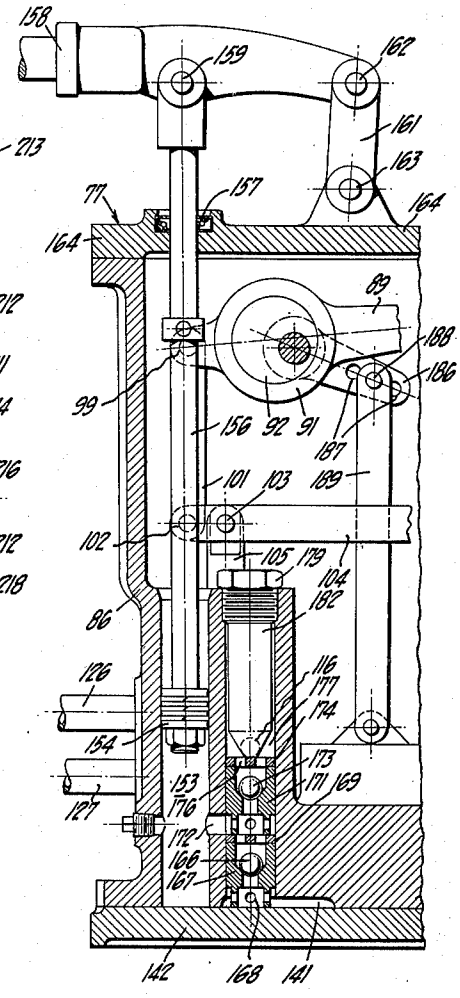


FIG_7_

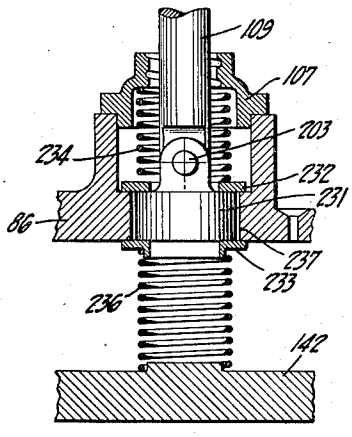


FIG_8_

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Patented Apr. 21, 1953 2,635,847

UNITED STATES PATENT OFFICE

2,635,847

TURBINE JET CONTROLLER

Fred H. Rued, Lafayette, Calif., assignor to The Pelton Water Wheel Company, San Francisco, Calif., a corporation of California

Application May 31, 1947, Serial No. 751,549

4 Claims. (Cl. 253—24)

1

My invention relates to means primarily useful in connection with the operation and control of hydraulic motors, more particularly water wheels of the "Pelton" type in which water under high pressure is discharged through a nozzle onto a rotary bucket wheel.

In some installations it is advisable to provide a water wheel fed by a plurality of jets or nozzles supplied with water through a penstock many hundreds or even thousands of feet in height so that the pressure is considerable. Most often the water wheel is directly connected to an electric generator in turn connected through switching mechanism to an electrical transmission line. Upon occasion the line load is suddenly removed from the generator and the tendency of the water wheel is then to drive itself and the loadless generator in excess of normal operating speeds and at speeds that are dangerous. A problem arises in that it is not possible satisfactorily to shut off the flow of water from the jet in a reasonably quick time, that is, a time short enough to prevent over speeding. A shutdown time of approximately a minute may be required in order to avoid disruptive strains or shocks in the penstock or allied water conduits. On the other hand, it is desirable to remove the effect of the water upon the wheel almost instantly, that is, within a matter of a very few seconds.

It is therefore an object of my invention to provide means for quickly depriving a water wheel of its motor power without producing any disruptive strains in the supplying penstock.

Another object of the invention is to provide a means in multi-jet turbines for depriving the water wheel of motive power from all of the jets instantly or substantially so while slowing the flow in the penstock at a moderate rate.

An additional object of the invention is to provide a means for individually controlling the jets in a multi-jet installation, so far as certain operating characteristics are concerned.

A further object of the invention is to provide in general an improved mechanism for controlling a jet, or the jets, in a turbine.

A further object of the invention is to provide a relatively simple control mechanism for exercising supervisory functions over a hydraulic turbine.

Other objects, together with the foregoing, are attained in the embodiment of the invention illustrated in the accompanying drawings and described in the following description.

In the drawings:

Figure 1 is a diagram showing largely in plan and partly in section a portion of a multi-jet turbine provided with the control instrumentalities of my invention.

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Figure 2 is a side elevation of a control structure incorporated with the mechanism of Figure 1.

Figure 3 is a plan of the control structure shown in Figure 2.

Figure 4 is a cross section the plane of which is indicated by the line 4—4 of Figure 3.

Figure 5 is a cross section the planes of which are indicated by the lines 5—5 of Figure 4.

Figure 6 is a cross section the planes of which are indicated by the lines 6—6 of Figure 5.

Figure 7 is a cross section portions being broken away to reduce the size of the figure and the planes of the section being indicated by the lines 7—7 of Figure 5.

Figure 8 is a cross section of a modified form of centralizing plunger mechanism.

In its preferred form the turbine jet controller of my invention is for use with a turbine having a plurality of jets, and involves a number of deflectors, one for each jet, all actuated simultaneously in response to a speed governor operated by the turbine. Also involved, and preferably installed one for each jet, are needle valves operated by servo mechanisms in response to the position of the deflectors, but at a somewhat slower rate than that at which the deflectors respond to the speed governor. While the servo mechanisms are automatic in general operation they are provided with hand controls for manual operation, if desired.

The turbine jet controller of the invention can be embodied in numerous different forms depending upon the particular performance desired, and depending also upon the particular environment in which it is installed. It has successfully been embodied in the form shown in the accompanying drawings. In the illustrated installation there is provided a hydraulic casing 6, within which is disposed a turbine shaft 7, on which an impulse wheel 8 is mounted. A governor 9 is driven by and is responsive to the impulse wheel 8 and is effective to move a lever 11 in accordance with the speed of the turbine wheel. Ranged round the casing 6, at appropriate intervals, are nozzles 13 and 14, for example, all of them being supplied with hydraulic fluid, usually water under pressure, from the end of a penstock 16 which curls around the casing 6. Each of the nozzles 13 and 14 is effective to release a water jet against the impulse wheel 8.

Associated with the nozzle 13 is a deflector

17 comprising primarily a curved plate formed at the extremity of a lever 18 mounted on and to pivot with a shaft 19. The deflector is movable to occupy one position as shown in Figure 1 entirely intercepting or deflecting the jet normally issuing from the nozzle 13 and to occupy another position at one side of the jet and completely clear of it so as not in any way to interfere with the issuance of a full jet. These motions of the deflector 17 and of the shaft 19 are effectuated through a lever 21 connected by a rod 22 to a main connecting crank 23.

A similar arrangement is provided in connection with the nozzle 14 in that a deflector 24 is mounted on a lever 26 connected to a shaft 27 and also connected by a rod 28 to the rocker crank 23. Motions of the deflector 17 and of the deflector 24 are in unison and are in corresponding amounts. Similarly, there may be additional deflectors (not shown), rods such as 29 and 31 extending to them in order to provide appropriate action of all of the deflectors at once.

The motion of the various deflectors is made responsive to the governor 9. Any excessive speed over a set or predetermined value is immediately effective upon the governor. This is accompanied by corresponding motion of the lever 11 in order to produce quickly, or at a desired rapid rate, a corresponding functioning of the deflectors.

Since the force available from the governor is not sufficient to actuate the deflectors directly, an intermediate or servo mechanism is employed. This is of standard type and involves a main servo valve 33 having a plunger 34 connected through a rocker lever 36 by rods 37 and 38 to the governor lever 11. The body of the valve 33 is supplied with pressure actuating fluid, usually oil, from a suitable source (not shown) through an intake conduit 39 leading back to the source of pressure fluid.

As the valve core 34 is actuated in response to the governor motion, pressure fluid is admitted to or released from the valve body 33 in a corresponding fashion. When the turbine speed is excessive, the valve core 34 is in a position to admit pressure fluid from the conduit 39 into a conduit 42 having branches 43 and 44 extending into hydraulically expansible chambers 46 and 47 sometimes called expansible chamber motors suitably mounted and containing pistons 48 and 49 reciprocable therein. The pressure fluid from the conduits 43 and 44 drives the pistons in such a direction as to move the rods 22 and 28, through intermediate links 51 and 52, in a direction to impel the deflectors into the jets. When the valve core 34 is in an opposite position, pressure fluid is conducted through a pipe 53 having branches 54 and 56 into the opposite end of the hydraulically expansible chambers and then displaces the pistons and ultimately the rods 22 and 28 so as to move the deflectors out of the path of the several jets.

In this fashion, action of the governor lever 11 is promptly followed by a corresponding movement of the deflectors 17 and 24. The position of the governor lever 11 is accurately reflected by a corresponding position of the deflectors within a very few seconds time, the delay of the hydraulic servo mechanism being very slight. Consequently, upon the beginning of over speeding by the turbine, the deflectors 17 and 24 move within a short time into the driving jets and deflect them thereby depriving the impulse wheel of its propulsive water and preventing excessive over-speeding and damage.

While it might sometimes be entirely satisfactory to control the jets solely by means of deflector plates 17 and 24, such action is wasteful of water and does not provide an efficient intermediate range of operation. For those reasons, among others, I provide each of the nozzles 13 and 14 with suitable controlling instrumentalities effective to vary the size or diameter of the respective jets from time to time so that the jets are operated at optimum characteristics for as long as possible, and so that by controlling the jets the deflector plates are called upon to operate only in emergencies and during short periods of time.

Within the nozzle 13 there is provided a needle 61 movable axially in unison with a stem 62 in order to control the size of jet issuing from the nozzle. Since the movement of the needle requires considerable force it is done through the medium of a servo mechanism including an expansible chamber 63 sometimes called expansible chamber motor mounted on a connector 64 secured to the housing 16 and including a piston 66 translatable toward either end of the cylinder 63 to produce a corresponding motion of the needle.

Quite similarly, the nozzle 14 is provided with its own needle 67 connected by a stem 68 to a piston 69 within a cylinder 71 of a hydraulically expansible mechanism sometimes called expansible chamber motor mounted on a connector 72 secured to the casing 16.

In accordance with the invention means are provided for supplying hydraulic actuating fluid to the servo mechanisms 63 and 71 in amounts, and at times, and at rates so as to produce the desired motion of the needles 61 and 67. Preferably each of the needles and its servo mechanism is arranged so that while it may be operated in unison with the others, it is also individually operable. The operating fluid is preferably derived from the same source as that supplying the conduit 39. For that reason the conduit is provided with a branch 73 leading to a controller 74 for the needle 61 and also with a branch 76 leading to a controller 77 for the needle 67. Return lines 78 and 79 connect to the return conduit 41.

Since the controllers 74 and 77 are identical, a description of one of them applies equally to the other. The controller is responsive to an associated one of the deflectors, for example, the deflector 24. Projecting from and fastened to the shaft 27 is a lever 81 joined by means of a compound rod 82 to an actuating lever 83. This is secured to a cross shaft 84 journaled in the casing 86 of the controller 77. Within the casing, a cam 87 (Figure 4) is fastened on the shaft 84. Following the cam 87 is a roller 88 journaled on a compound lever 89, enlarged to provide an eccentric strap 91 encompassing an eccentric 92 fastened on a cross shaft 93 likewise journaled in the casing 86.

In order that the follower roller 88 will at all times abut the cam 87, a coil spring 94 is disposed within the casing and at its upper end is engaged with a pin 96 projecting from the compound lever 89 and at its lower end encircles a pin 97 fastened in the casing. The spring is effective to maintain the roller in contact with the cam even over a relatively abrupt portion 98 of the cam face. The movement of the follower 88 over the cam face produces a corresponding motion of the com-

pound lever 89 and is simultaneously effective to move a pivot pin 99 fast in the lever and engaging a link 101.

Pivot pins 102 and 103 connect a cross lever 104 to the link 101 and to a valve shuttle 105 respectively. Since the cross lever 104 serves primarily as a floating link, and is normally held in a neutral position, it is extended to a movable connection to a normally unstressed coil spring 106. At its lower end the spring is threaded into a cap 107 mounted in the casing 86 and at its upper end is threaded onto a sleeve 108 secured firmly to a plunger 109 connected by a pivot pin 111 to the cross lever 104. With this mechanism, when the spring 106 is in its neutral position, motion of the link 101 is transmitted with substantially no change to the valve shuttle 105.

The valve shuttle is reciprocable within a port sleeve 112 removably secured in a bore 113 in the casing 86 by a fastening stud 114. Leading into the valve structure from the supply conduit 76 is an entrance passageway 116 (Figure 6) formed in the casing 86 and opening into a peripheral groove 117 turned in the sleeve 112 and itself communicating through apertures 118 with a chamber 119 defined between two lands 121 and 122 on the valve shuttle 105. When the valve shuttle 105 is translated into an upper position, for example, it establishes communication then with a plurality of ports 123 leading into an annulus 124, in turn communicating with a conduit 126. This leads to one end of the expansible chamber 71 and consequently subjects the piston 69 therein to fluid under pressure from the supply line 76.

Since there must also be a corresponding connection at the other end of the expansible chamber to a drain line, a return conduit 127 simultaneously communicates through an annulus 128 and associated ports with a chamber 120 defined between lands 131 and 122 on the valve shuttle. Flow is therefore established in this position of the valve shuttle 105 through radial ports 132 and an annular groove 133 to a metering port 134. This port extends into a channel 136 formed in the casing 86 and opening at its top and bottom into the interior of the casing.

The rate of flow through the aperture 134 and consequently the rate at which the piston 69 can be displaced within the cylinder 71 is regulated by a variable screw 137 threadedly engaging the casing 86 and provided with a lock nut 138 and a cap nut 139 to secure it in any selected position. By appropriately setting the screw 137 the maximum rate of opening of the needle nozzle 67 is established at a value to preclude any deleterious pressures or shocks due to too rapid closure of the water outlet. Oil or hydraulic fluid from the cavity 136 finds ready access to the body or fluid within the casing 86 either by overflowing the top of the cavity or by flowing through a discharge passage 141 between the bottom of the casing 86 and a closure plate 142 forming the base thereof.

In an entirely comparable fashion, if the shuttle 105 is displaced downwardly rather than upwardly, pressure fluid is admitted to the conduit 127 rather than to the conduit 126 and return fluid then flows from the conduit 126 and through the apertures 123 into a chamber 143 defined by the land 121 and by the enlarged stem 144 of the valve shuttle 105. From the chamber 143 flow is through apertures 146 and a peripheral groove 147 to a control orifice 148. This is regulated by a screw valve 149 threaded into the casing 86 and provided with a lock nut 151 and a cap nut 152. The speed of operation of the hydraulic mechanism in the closing direction can be regulated to a rate preclusive of excessive forces. By appropriately regulating the screws 137 and 149 with respect to each other, and with respect to any absolute rates dictated by engineering requirements, it is possible to confine the needle nozzle 67 to motions that are satisfactory.

In the event that the supply of hydraulic fluid under pressure through the line 76 should fail, or in the event during starting that there is no supply of hydraulic fluid under pressure, I provide an auxiliary means for furnishing pressure fluid. Built into the casing 86 is a pump barrel 153 in which a pump plunger 154 is reciprocable. The plunger is situated at the lower end of a stem 156 projecting out of the casing 86 through a packing 157. The stem is joined to a hand lever 158 by a pivot 159. A mounting link 161 is connected by a pivot 162 to the lever 158 and by a pivot 163 to the cover 164 of the casing 86.

Hydraulic fluid is supplied to the pump barrel 153 from the interior of the casing 86 through the passageway 141. This affords access to an inlet check valve 166 contained within a removable cage 167 having inlet apertures 168 therein and affording egress through a perforated spacer plate 169 and the lower end of an outlet check valve housing 171 to a passage 172 opening into the barrel 153. An outlet check valve 173 is disposed in the cage 171 and is confined by an outlet plate 174 having perforations 176 opening into a chamber 177 which is in common with the passageway 116. The chamber is closed by a plug 179 threaded into it extended to provide a positioning stem 182 for holding the check valves in assembled relationship.

With this structure when a supply of oil through the duct 116 is not available or is not under pressure, manipulation of the lever 158 draws oil from the interior of the casing 86, passes it through the pump bore 153 and sends it into the same channel 116 that is normally utilized for supply so that the valve shuttle 105 functions in the previously described fashion. The conduit 76 is either closed or is provided with an appropriate check valve in order that the hand pumped fluid will flow only into the valve sleeve 112.

With the described structure, under pressure supplied either by hand or automatically, the position of the deflector 24 and of the shaft 84 is reflected by a corresponding position of the needle nozzle 67. This is accomplished through the servo mechanism comprised of the valve shuttle 105 and the expansible chamber 71. When the deflector 24 moves into or toward the jet under the influence of the governor there is shortly thereafter a closing movement of the needle nozzle 67. The diameter of the jet is thus reduced away from the deflector so that water will no longer be diverted by the deflector. When conditions change, the deflector is then moved either farther into the jet or farther away from the jet. Shortly thereafter there is a motion of the needle nozzle either further to reduce the size of the jet or in the opposite sense to increase the size of the jet in a corresponding amount. In this fashion the needle nozzle and the deflector are always operated in correct relationship with each other; the deflector quickly following the governor for accurate control, the needle nozzle slowly following the deflector to avoid damage.

Under normal operating conditions these mo-

tions of the deflector and needle nozzle are relatively small and really are minor corrections. In emergency there is sudden removal of load from the mechanism to which the turbine wheel 8 is connected. It is essential that the supply of driving fluid to the turbine be quickly and completely interrupted. The governor 9 is immediately affected and moves the various deflectors into the paths of their respective streams despite needle position. This is provided for in the present structure by arranging on the cam 87 in addition to the cam track 98 a further cam track 183.

Under normal conditions, if the needle nozzle reduces the size of the jet in close conformity with the movement of the deflector into the jet, the deflector need move only to the axial center of the jet in order to intercept it completely as at that point the needle has closed. If however, the deflector is called upon suddenly to intercept the entire jet before movement of the needle occurs, it is necessary then for the deflector to traverse not only the radius of the jet but rather its complete diameter. It is for that reason the cam 87 is provided with an overtravel face 183 not effective to produce any particular movement of the needle nozzle but to permit overtravel of the deflector entirely through the unreduced jet.

Under customary operating conditions the servo mechanism for moving the needle nozzle to follow the deflector that in turn follows the governor responsive to the turbine speed tends to make innumerable minor corrections in the needle nozzle position and also tends to hunt; that is, to correct excessively for each variation and continually to oscillate on either side of the desired mean or intermediate position.

In order to preclude excessive hunting and in order to make the movable elements correspond quite closely to the demands upon them, I provide means responsive to the actual movement of the needle nozzle for assisting in regulating it. The needle nozzle stem 68 is provided with a connector 184 responsive to its movement and pivotally connected to a lever 185 fast on the cross shaft 93. Each movement of the needle nozzle is therefore reflected by a motion of the cross shaft 93 and a rotation of the eccentric 92 to produce a corresponding movement of the compound lever 89. Since the cam follower 88 is held against the cam 87 by the spring 94 any motion of the eccentric 92 is immediately reflected in a corresponding movement of the ink 101 and of the valve shuttle 105.

In order to augment this valve shuttle motion and the effects produced by it through its connected servo mechanism I provide on the shaft 93 in addition to the eccentric 92 a lever 186 having a plurality of fastening holes 187 therein. In engagement with any selected one of the holes is a pivot pin 188 connecting the lever 186 to a link 189 depending within the casing 86. A pin 190 connects the link 189 to a plunger 192 reciprocable within a bore 193 extending from the general interior of the casing to a restricted compartment 194 defined between the lower portion of the casing and the bottom plate 142.

The compartment 194 is generally closed without access to the remainder of the interior of the casing except through an aperture 196. Flow through the aperture is regulated in rate or amount by a needle 197 extending through the casing from a screw mounting 198 threadedly engaging the cover 164. The adjustable needle 197 is locked in any adjusted position by a lock nut 199 and cap nut 201. The size of the aperture 196 is regulated by the needle so that the rate of flow out of the compartment 194 is less than that at which flow into the compartment is induced by the depression of the plunger 192. Consequently the pressure within the compartment instantaneously increases with motion of the plunger and is then effective to displace a follower 202. This is a piston-like body movable within a suitable bore within the casing and subject on one side to pressure within the compartment 194 and on the other side to pressure within the interior of the casing.

The plunger 202 is connected by a pin 203 to the lower end of the member 109 so that motion of the plunger 202 is ultimately communicated through the cross lever 104 to the valve shuttle 105. The motion of the plunger 202 is limited after its initial stroke since a channel 204 cut in the plunger admits of free communication between the compartment 194 and the interior of the casing.

Comparably, the plunger 202 travels in a reverse direction from central position in response to a lowered pressure within the compartment 194 due to lifting of the plunger 192 and the inability of adequate liquid to flow back quickly through the aperture 196. After the plunger has traveled more than a fixed amount from central position, further movement is arrested as a groove 205 cut in the plunger affords free access between the casing interior and the compartment 194.

With this mechanism and the spring 106 to urge the plunger 202 into an intermediate or neutral position, and since over a period of time the pressure within the compartment 194 and the interior of the casing can readily equalize, the lever 104 is normally held simply as an intermediary between the link 101 and the shuttle 105. The motion of the shuttle 105 then corresponds almost exactly to the motion of the link 101. Since the motion of the needle nozzle produces not only a rotation of the eccentric 92 to displace the valve shuttle 105 but likewise through displacement of the plunger 192 produces a corresponding motion of the plunger 202, the member 109 and the spring 106 are forced out of neutral position so that the lever 104 augments the effect of the link 101. The result is that the valve shuttle 105 is lifted more than normally it would be. This produces a reduced or slower action of the servo mechanism and reduces the tendency of the nozzle needle to overtravel. Correspondingly, when the valve shuttle 105 is depressed the plunger 192 is simultaneously lifted, a related depression of the plunger 202 results and a corresponding overtravel in the reverse direction of the valve shuttle 105 is produced. Because of the augmented movement of the valve shuttle, hunting is minimized and the needle 67 tends to follow quite accurately the movements of the deflector.

In some instances, the neutralizing or centralizing plunger 202 operated in conjunction with the spring 106 is not sufficiently sensitive or accurate in that frictional restraint upon the piston 202 causes some delay or lag in the centralization of the spring 106. It is believed important to have the cross lever 104 always in a central position when it is not being actuated. For that reason the structure shown in Figure 8 is sometimes utilized in place of that shown in Figure 4. In this instance a piston 231 is secured by the pivot pin 203 to the lower end of the member 109 and is confined in neutral position between a pair of apertured washers 232 and 233. Both

washers are normally urged by a pair of coil springs 234 and 236 against an inturned flange 237 projecting from the housing 86. These springs are preferably pre-stressed. The upper one 234 not only abuts the washer 232 but likewise is in contact with the cap 107. The other spring 236 abuts the bottom cover plate 142 of the housing. With this arrangement, the piston 231 is always held in a central position despite minor variations in friction and inaccuracies in the springs 234 and 236. Motion of the member 109 in either direction always produces a corresponding deflection of one of the two springs. In this fashion the floating lever 104 is always retained in the same neutral position except when due to the operation of the plunger 192 it is displaced either upwardly or downwardly.

By an appropriate adjustment of the mechanism, whenever a movement of the deflector toward the jet is initiated, the needle nozzle then follows promptly thereafter in such a carefully regulated amount that the size of the issuing jet is correspondingly reduced. As the deflector moves slowly toward the jet to intercept it, the jet itself is contracted or is reduced in size so that the deflector never actually enters the water stream.

For all normal regulation therefore, while the deflector is slightly spaced from the jet in an instantaneous position to move immediately into the jet under the influence of the governor in emergency, still the needle nozzle is effective to reduce the jet just in advance of leisurely entry thereinto by the deflector. No water whatsoever is ever deflected or wasted except due to a sudden loss of turbine load or a failure of the mechanism otherwise. In that dangerous instance the deflector does actually intercept the hydraulic jet partially or entirely. This mechanism provides an entirely automatic and accurate non-hunting control for regulating an individual nozzle needle in a multiple jet turbine even though the deflectors are operated simultaneously by the governor.

As an operating and testing convenience, as shown particularly in Figure 2, the shaft 93 is extended to the outside of the casing 86 and carries an indicator wheel 211 located with respect to a pointer 212 so that the instantaneous position of the respective nozzle needle can readily be observed.

In the event that the automatic mechanism is not to be utilized, or in the event a manually controlled position of a nozzle needle is to be established a suitable mechanism is provided. The shaft 84 is extended from the casing 86 and on its projecting portion is provided with a hand lever 213. An indicator needle 214 cooperating with a scale 216 on the casing 86 affords an indication of the position of the lever 213 and remotely of the needle 67. A pierced sector 217 extends from the lever and is clamped in position if desired, by a lever nut 218. After manipulation to set the shaft 84, the lever 213 can be locked in position by rotation of the nut 218. Normally, however, the nut 218 is entirely free so that the lever 213 and the indicator 214 move back and forth during automatic operation of the structure and afford an indication of the motion of the deflector mechanism.

The manual operation or locking of the lever 213 may involve a motion or position not participated in by the deflector 24 in that rotation of the shaft 84 not only revolves the cam 87 to secure a corresponding action of the nozzle needle through the servo mechanism but is also productive normally of a corresponding mechanical motion of the deflector. But the deflector servo structure may not be correspondingly energized by the governor. To permit motion of the lever 23 without corresponding motion of the deflector and vice versa, but in order that the deflector movement normally when the lever 213 is free is as previously described, the connecting rod 82 is not continuous. Rather it is provided with a pair of pre-compressed springs 221 and 222 respectively. These are situated within a housing 223 incorporated in one portion of the rod 82. Both of them abut a disk 224 integral with the other portion of the rod 82. In its intermediate position, the disk 224 is in approximate registry with an inturned flange 226 in the casing 223 and is also abutted by a pair of washers 227 and 228, respectively.

When the lever 213 is free, motion of the lever 81 produces a corresponding movement of the housing 223 and due to the pre-compressed springs 221 and 222 the washers are held against the piston 224 and the rod 82 moves as a unit. But if the lever 81 is held stationary for example, as the lever 213 is rocked, then one or the other of the springs 221 and 222 is compressed while the other one is effective merely to hold its respective washer against the inturned flange 226. In this fashion, while the rod 82 normally acts as a solid connector, it is yieldable under the motion of the lever 213 when the deflector 24 is not correspondingly moved.

The foregoing structure provides in a multi-jet turbine means for simultaneously regulating deflectors in each of the jets in response to the governor not only to provide an intercepting control of the structure especially in emergencies when the impulse fluid must be immediately interrupted, but also to provide a supervisory structure capable of following accurately and without excessive hunting the requirements of the governor so that the size of the jets is economically controlled. Preferably the control is so precise that the deflectors never actually intercept the jets except in emergencies. Furthermore, by the provision of individual controls it is possible not only for the individual needles to follow the particular requirements and idiosyncrasies of the particular nozzles with which they are associated but likewise for an individual needle to be manually closed and held closed. For example, if conditions of operation make it advisable, two of the four jets of the turbine illustrated can readily be cut out of operation completely. Indicators at each particular controlling mechanism show the position of the nozzle needle and of the deflector associated therewith. The individual controllers are mounted quite close to the servo mechanisms they supervise in order that miscellaneous rods, links, and levers which otherwise would be necessary can be entirely dispensed with. Thus, a generally improved control mechanism for turbines has been provided.

I claim:

1. A jet controller for an impulse wheel having a nozzle and needle for establishing a jet for the wheel, an operating expansible chamber motor connected to said needle for moving the same to vary the jet diameter, a deflector, means for supporting the deflector adjacent to the jet for diverting the same when moved into the jet, a servo mechanism connected to said deflector to directly move the same, an operating fluid sup-

ply line connected to the servo mechanism, a speed responsive governor driven by said wheel, a valve in said line for controlling operating fluid for said deflector servo mechanism, means connecting said valve to said governor so that the governor directly controls said servo mechanism to move the deflector toward the jet when the speed of the impulse wheel exceeds a predetermined value, a second operating fluid supply line connected to said needle operating motor, a second valve in said latter supply line for controlling operating fluid for said needle operating motor, a cross lever connected to said second valve, a compound lever connected to said cross lever to move the cross lever and valve attached thereto, means connected to said deflector for moving said compound lever upon occurrence of movement of the deflector toward the jet and thereby move the cross lever and second valve connected thereto for effecting movement of the needle valve toward its closing position, means operatively connected to the needle for moving said cross lever in a direction opposite to that which was effected by the deflector movement thereby to produce a restoring action on the second valve through its connection to the cross lever, and means connected to the needle and to the cross lever for additionally moving said cross lever and the second valve connected thereto in said restoring direction in accordance with movement of the needle valve towards its closing position only when the rate of needle movement exceeds a predetermined value.

2. The combination set forth in claim 1 further characterized in that the means for further moving the cross lever for producing the additional restoring action on the second valve includes a hydraulic compartment, means for displacing fluid therefrom upon movement of the needle toward its closing position, and means responsive to the displaced fluid in said compartment for moving said cross lever in its restoring direction.

3. The combination set forth in claim 1 further characterized in that the means for further moving the cross lever in its opposite direction for producing the additional restoring action includes a hydraulic compartment, means for displacing fluid therefrom upon movement of the needle toward its closing position, means responsive to the displaced fluid in said compartment for moving said cross lever in its restoring direction, and an escape port for said compartment whereby displaced fluid will flow through said escape port to the limit of its capacity and any greater rate of displaced fluid will then effect actuation of said means which is responsive to displaced fluid in the compartment.

4. A jet controller for an impulse wheel having a nozzle and needle for establishing a jet for the wheel, an operating expansible chamber motor connected to said needle for moving the same to vary the jet diameter, a deflector, means for supporting the deflector adjacent to the jet for diverting the same when moved into the jet, a servo mechanism connected to said deflector to directly move the same, an operating fluid supply line connected to said servo mechanism, a speed responsive governor driven by said wheel, a valve in said line for controlling operating fluid for said deflector servo mechanism, means connecting said valve to said governor so that the governor directly controls said servo mechanism to move the deflector toward the jet when the speed of the impulse wheel exceeds a predetermined value, a second operating fluid supply line connected to said needle operating motor, a second valve in said latter supply line for controlling operating fluid for said needle operating motor, means connected to said deflector and second valve for moving the second valve to operate said needle expansible motor in a needle closing direction upon occurrence of movement of the deflector toward the jet; means connected to the needle and to said second valve for moving the second valve, upon occurrence of closing movement of the needle, in a direction opposite to that which was effected by the deflector movement thereby producing a restoring action on the second valve; means connected to said needle and to said second valve for additionally moving said second valve in a restoring direction upon occurrence of closing movement of the needle, and means for rendering said additional restoring movement effective automatically in response to needle movement only when the rate of movement of the needle exceeds a predetermined value.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,613,950	Jackson	Jan. 11, 1927
1,706,812	Pfau	Mar. 26, 1929
1,914,679	White	June 20, 1933
2,158,108	Deglon	May 16, 1939
2,491,059	Ring	Dec. 13, 1949

FOREIGN PATENTS

Number	Country	Date
49,956	Switzerland	Jan. 21, 1910