

May 16, 1939.

H. DÉGLON

2,158,108

CONTROL SYSTEM

Filed May 21, 1937

5 Sheets-Sheet 1

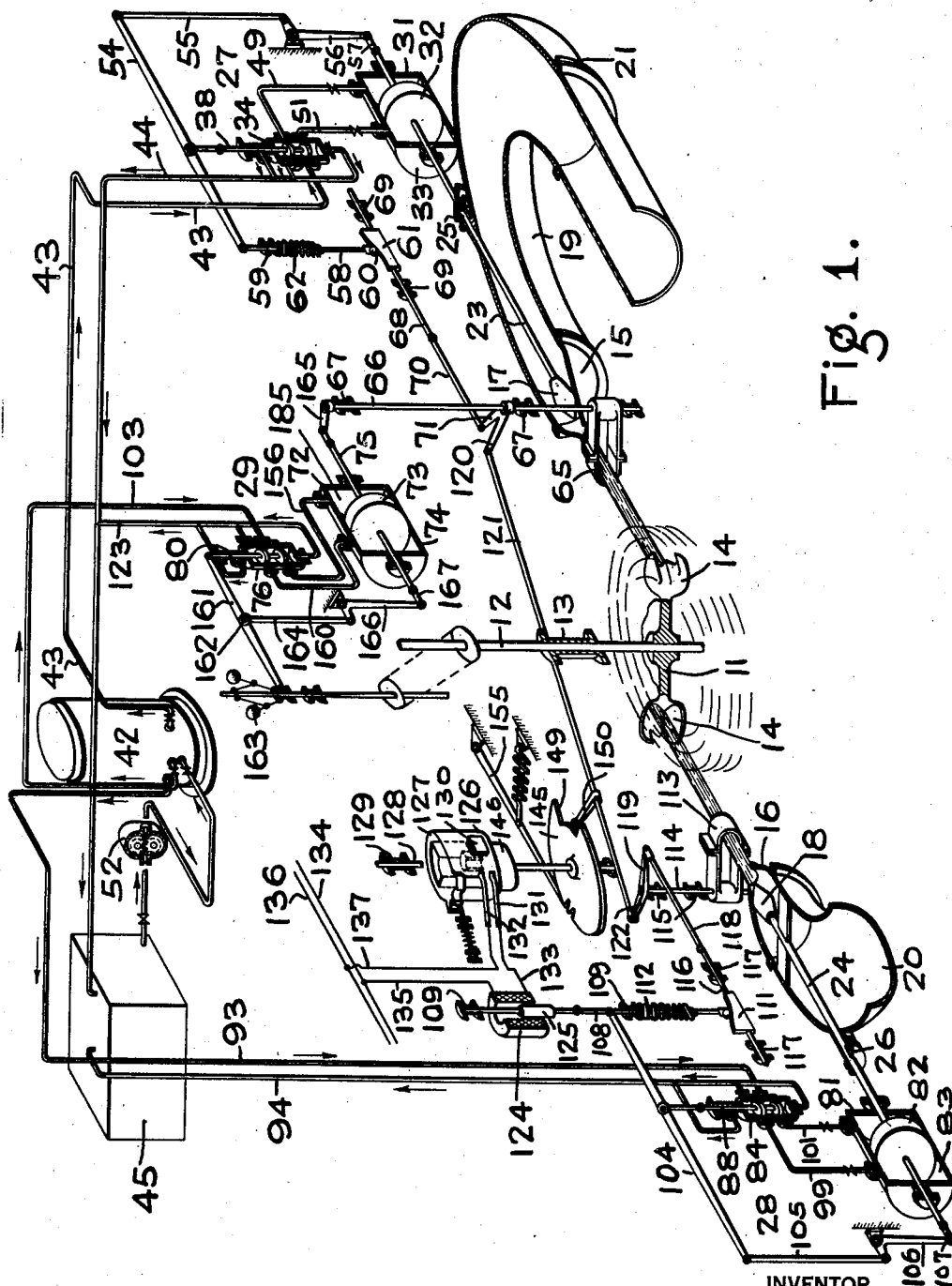


Fig. 1.

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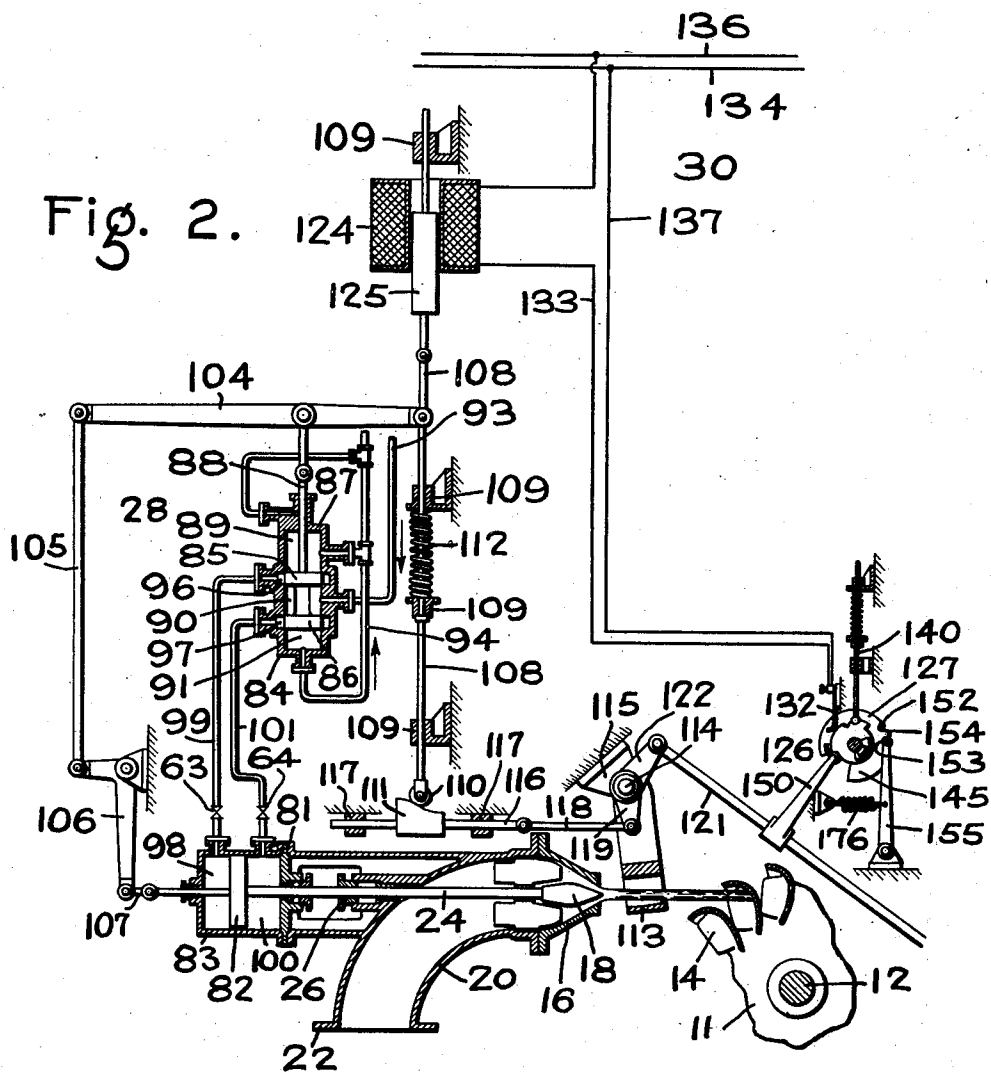
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## CONTROL SYSTEM

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Fig. 4.

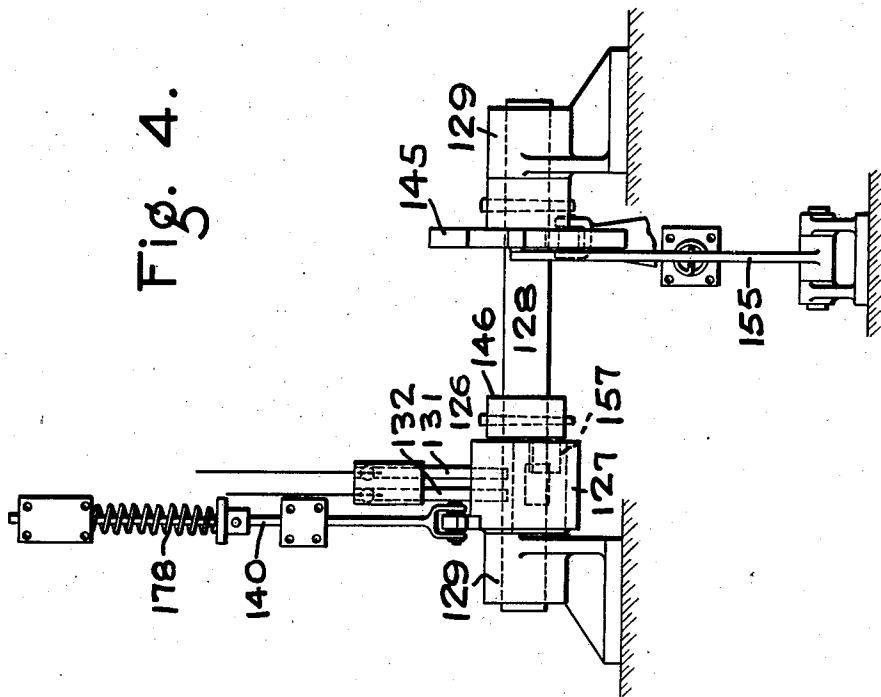
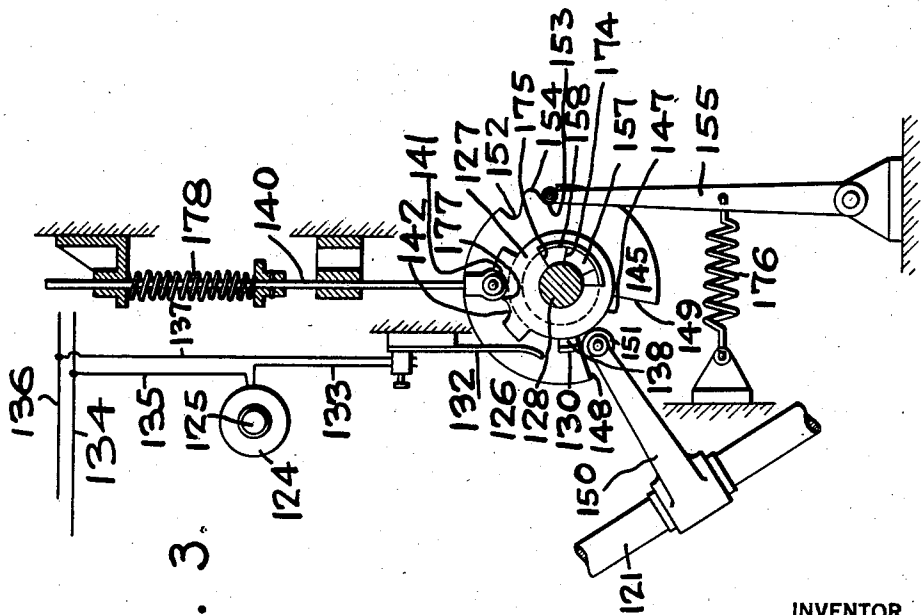


Fig. 3.



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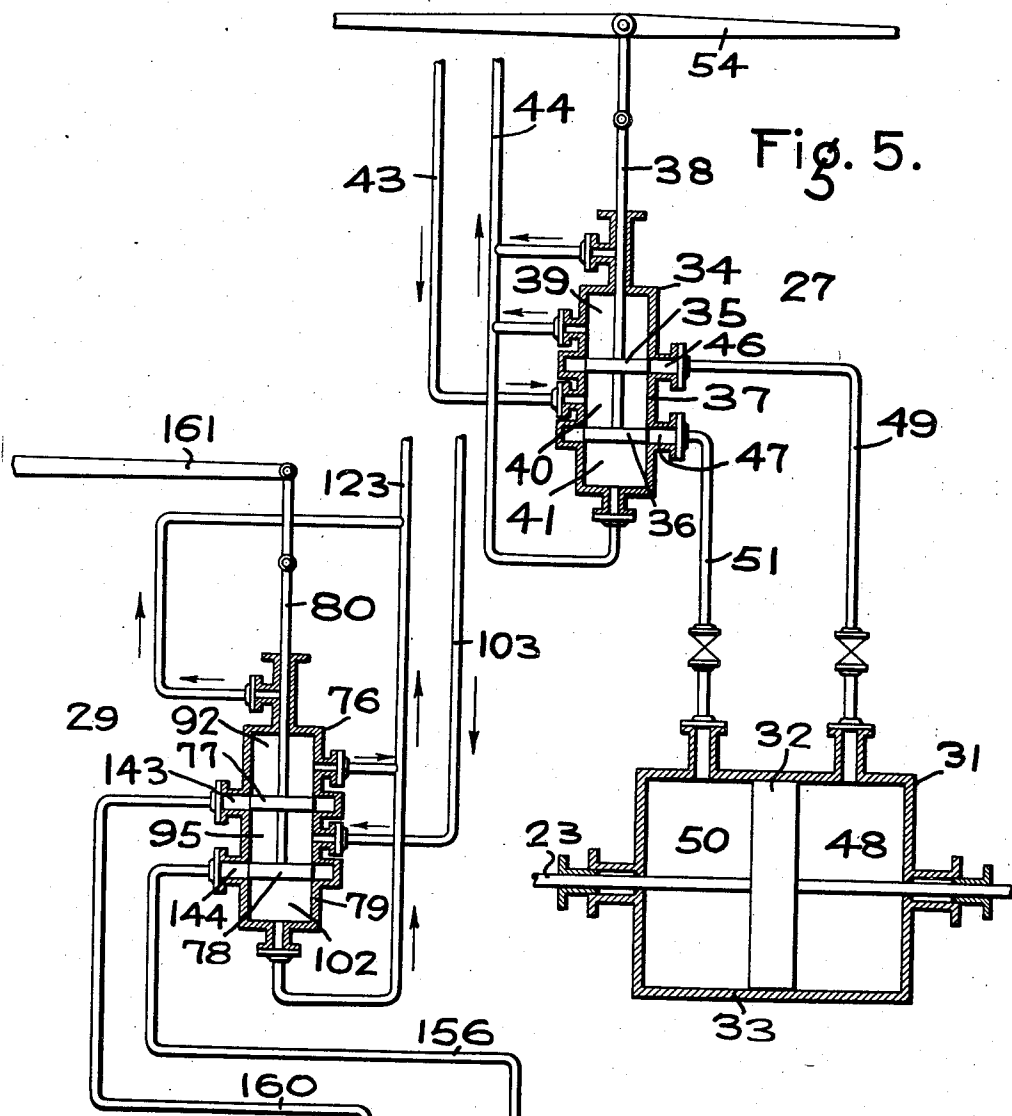
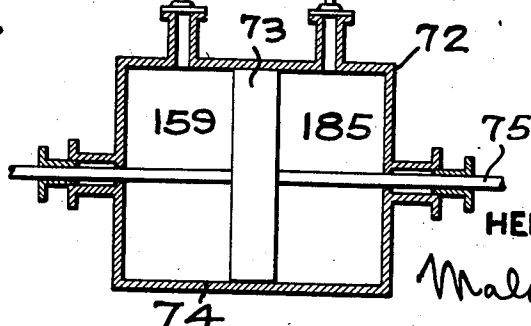


Fig. 6.



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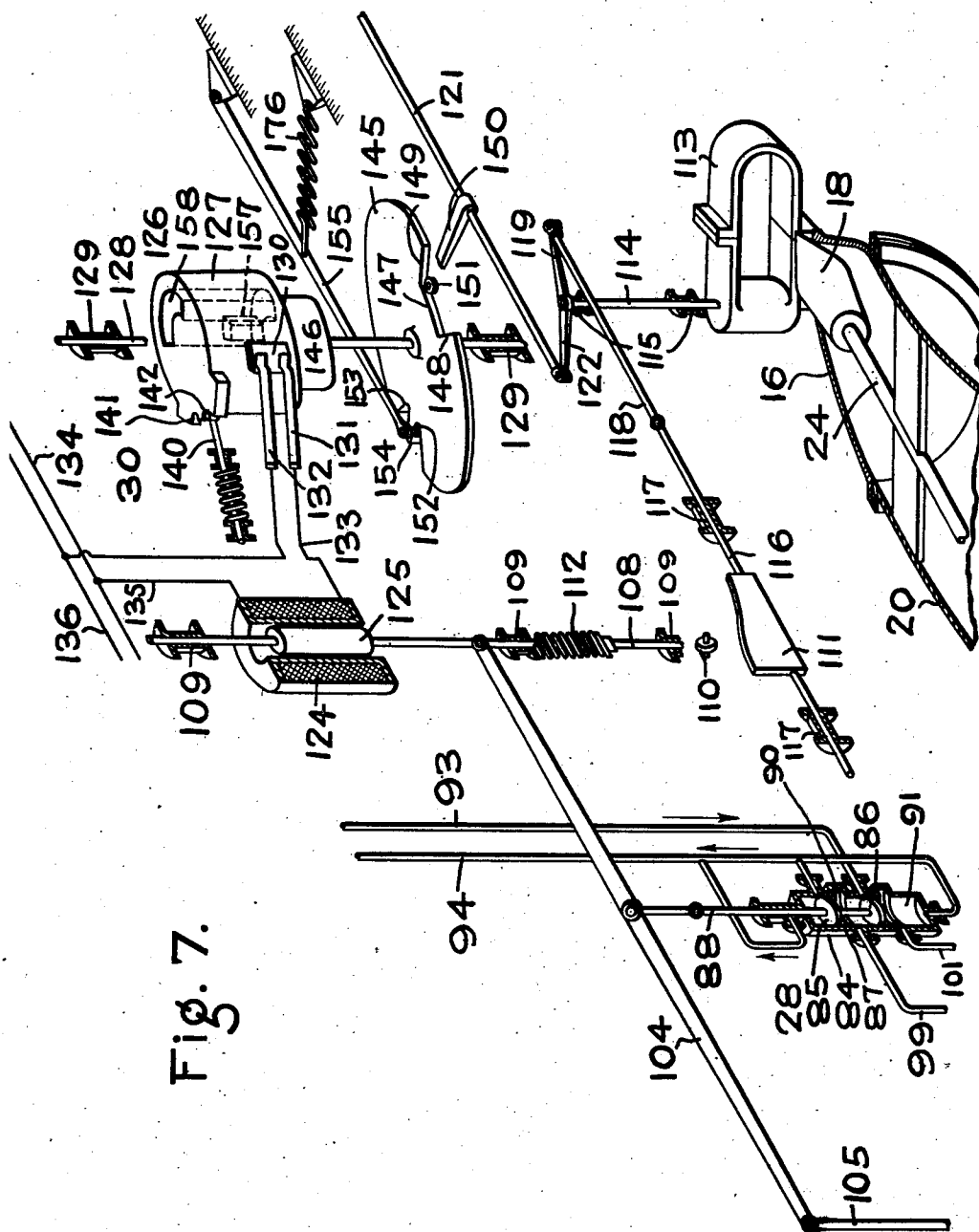
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CONTROL SYSTEM

Filed May 21, 1937

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## UNITED STATES PATENT OFFICE

2,158,108

## CONTROL SYSTEM

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Application May 21, 1937, Serial No. 143,885

5 Claims. (Cl. 137-144)

This invention relates to prime mover control systems. It is particularly applicable to the control of impulse water wheels.

An object of the invention is to provide an improved control system in which the speed of the prime mover and the supply of operating fluid thereto will be properly controlled.

Another object of the invention is to provide an improved control system adapted to be initiated by the operation of a control mechanism, so that all functions necessary for the operation of the control system will be automatically performed.

Another object of the invention is to provide an improved control system for impulse water wheels having two nozzles for supplying operating fluid to the impulse wheels in accordance with the load, in which one of the nozzles constitutes the main nozzle and the other nozzle functions as an auxiliary nozzle which is adapted to operate in conjunction with the main nozzle only when the load is above a predetermined amount.

With the foregoing and other objects and advantages in view, the invention consists in the construction and arrangement of the several parts which will be hereinafter more fully described and claimed.

In the accompanying drawings:—

Figure 1 is a diagrammatic perspective view partly in section of a control system for impulse water wheels constructed according to the present invention, both nozzles of the mechanism being shown in their operative position;

Fig. 2 is a diagrammatic view partly in section of the auxiliary nozzle shown at the left in Fig. 1 and the control mechanism associated therewith;

Fig. 3 is an enlarged elevation partly in section of the portion of the control mechanism of the auxiliary nozzle shown at the extreme right in Fig. 2;

Fig. 4 is a rear elevation of the structure shown in Fig. 3;

Fig. 5 is an enlarged diagrammatic view partly in section of the operating mechanism for the main nozzle shown at the right in Fig. 1.

Fig. 6 is a similar view of the operating mechanism for the deflecting hood of the main nozzle; and

Fig. 7 is an enlarged diagrammatic perspective partly in section of the mechanism for controlling the auxiliary nozzle shown at the left, Fig. 1.

Referring to the drawings, the apparatus may comprise an impulse wheel runner 11, mounted on a shaft 12 journaled in suitable bearings, one

of the shaft bearings being indicated at 13, Fig. 1.

The runner 11 is provided with the usual buckets 14 and a casing (not shown), and opposed nozzles 15, 16 controlled respectively by needle valves 17, 18 are arranged to discharge jets of water against the buckets 14 in the manner clearly illustrated in Fig. 1.

The nozzles 15, 16 are, respectively, secured to nozzle bodies 19, 20, which may be connected with suitable supply conduits by means of flanges 21, 22, respectively, (Figs. 1 and 2).

The needle valves 17 and 18 are, respectively, provided with stems 23, 24 which extend, respectively, through suitable stuffing boxes 25, 26, carried by the nozzle bodies 19, 20, respectively.

In the arrangement of the parts as illustrated in the drawings, nozzle 15 constitutes the main nozzle of the turbine, while the nozzle 16 functions as an auxiliary nozzle which is adapted to operate in conjunction with the main nozzle 15 only when the load on the turbine is above a predetermined amount.

When the turbine is in operation and the load is below a predetermined amount, nozzle 15 alone functions to supply a single jet of water for operating the runner 11. When the load increases to a point above that at which the maximum jet produced by the nozzle 15 is insufficient to take care of the load, mechanism is operated by which the needle valve 18 is opened so that the nozzle 16 will supply an additional jet of water to augment the supply of operating fluid as supplied by the nozzle 15.

As long as the load remains up, both the nozzles 15 and 16 will supply two opposed jets of water as shown in Fig. 1.

When the load decreases to a point below that at which a single jet is sufficient to operate the runner, the mechanism is operated so as to close the nozzle 16, so that the nozzle 15 will function alone.

The single or joint operation of the nozzles 15 and 16 is controlled in such a manner that there is an overlap in the stages during the operation of the turbine when, due to variations in the load, one or two jets of the driving fluid will be supplied to the runner.

Associated with the nozzles 15 and 16 are suitable control mechanisms 27, 28 which are adapted to control the operation of the respective nozzles, and these two control mechanisms are in turn under the control of a control mechanism 29. The three control mechanisms 27, 28 and 29 are so arranged as to automatically control the operation of the turbine, whereby the turbine will

operate in the most efficient manner with one or two jets, irrespective of variations in the load.

As shown in Figs. 1 and 5, the control mechanism 27 may comprise a servo motor 31 including a piston 32 operating in a cylinder 33 and connected to the valve stem 23.

Fluid under pressure may be admitted so as to act on either side of piston 32 and the admission of this fluid may be controlled by means of a distributing valve 34 shown as provided with a pair of piston valves 35, 36 operating in a cylinder 37. The valves 35 and 36 may be operated by means of a stem 38.

The valves 35, 36 divide the cylinder 37 into chambers 39, 40 and 41. Chamber 40 is connected to a source of fluid under pressure, such for instance as pressure tank 42 by a pipe 43, and chambers 39 and 41 are connected by drain pipe 44 to a sump tank 45.

The cylinder 37 is formed with ports 46 and 47. Port 46 is connected to chamber 48 on one side of piston 32 by a pipe 49, and port 47 is connected to chamber 50 on the other side of piston 32 by a pipe 51.

The valves 35 and 36 are shown in their neutral position in which they lap the ports 46 and 47 and thereby cut off communication between the distributing valve 34 and the servo motor 31, through the pipes 49 and 51.

The stem 38 is connected to a floating lever 54 intermediate the ends of said lever.

As shown in Fig. 1, one end of the lever 54 is connected to the portion of the valve stem 23 which extends beyond the cylinder 33, by means of link 55, bell crank lever 56, and link 57.

Connected to the other end of the lever 54 is a rod 58 which is guided in a bearing 59. The free end of the rod 58 is provided with a roller 60 which engages the face of a cam 61, the roller 60 being maintained in engagement with the cam by an expansible coil spring 62, as shown in Fig. 1.

Associated with the nozzle 15 is a deflecting hood 65 which is carried by a shaft 66 journaled in bearings 67. The shaft 66 is rotated or oscillated by mechanism to be hereinafter described so as to cause the hood to swing into or out of the path of the jet produced by the nozzle 15.

Cam 61 heretofore referred to is operated by a rod 68 slidably mounted in bearings 69. One end of the rod 68 is connected to the shaft 66 by link 70 and lever 71, so that when the deflecting hood 65 is oscillated, cam 61 will also be moved.

As shown in Figs. 1, 2 and 7, the control mechanism 28 may comprise a servo motor 81 including a piston 82 operating in a cylinder 83 and connected to the valve stem 24.

Fluid under pressure may be admitted so as to act on either side of piston 82 and the admission of this fluid may be controlled by means of a distributing valve 84 shown as provided with a pair of piston valves 85 and 86 operating in a cylinder 87. The valves 85 and 86 may be operated by means of a stem 88.

The valves 85 and 86 divide the cylinder 87 into chambers 89, 90 and 91. Chamber 90 is connected to the pressure tank 42 heretofore referred to by a pipe 93, and chambers 89 and 91 are connected by drain pipe 94 to the sump tank 45 heretofore referred to.

The cylinder 87 is provided with ports 96 and 97. Port 96 is connected to chamber 98 on one side of piston 82 by a pipe 99, and port 97 is connected to chamber 100 on the other side of piston 82 by a pipe 101.

The valve 85 and 86 are shown in their neutral

position in which they lap the ports 96 and 97 to thereby cut off communication between valve 84 and servo motor 81, through the pipes 99 and 101.

The stem 88 is connected to a floating lever 104 intermediate the ends of said lever.

One end of the lever 104 is connected to the portion of the valve stem 24 which extends beyond the cylinder 83, by means of link 105, bell crank lever 106, and link 107.

The other end of the lever 104 is connected to a rod 108 which is guided in bearings 109.

One end of the rod 108 is provided with a roller 110 which engages the face of a cam 111, the roller being urged toward the cam face by an expansible coil spring 112.

Associated with the nozzle 16 is a deflecting hood 113 which is carried by a shaft 114 journaled in bearings 115. The shaft 114 is rotated or oscillated by mechanism to be hereinafter described so as to cause the hood to swing into or out of the path of the jet produced by the nozzle 16.

Cam 111 heretofore referred to is operated by a rod 116 slidably mounted in bearings 117. One end of the rod 116 is connected to the shaft 114 by link 118 and lever 119, so that when the deflecting hood 113 is oscillated, cam 111 will also be moved.

As shown in Fig. 1, shafts 66 and 114 are connected by a lever 120, a rod 121 and a lever 122, and this leverage system is so designed that actuation of one deflecting hood causes a corresponding operation of the other deflecting hood.

The operation of the valve 84 is controlled either by cam 111 or by an electrically operated mechanism generally designated by the numeral 30.

The electrically operated mechanism 30 may comprise a solenoid 124, the core 125 of which is carried by the rod 108 heretofore referred to. The energization and deenergization of the solenoid 124 is controlled by a switch device 126, comprising a drum 127 loosely mounted on a shaft 128 journaled in bearings 129, (see Fig. 7).

Mounted on the exterior of the drum 127 is a contact plate 130 which is insulated from said drum, as indicated at 138, Fig. 3. The contact plate 130 is adapted to receive a pair of contact fingers 131 and 132 when the drum is in one position.

One terminal of the coil of the solenoid 124 is connected to the contact finger 131 by a conductor 133, and the other terminal of the solenoid coil is connected to a source of current, such as a main line conductor 134, by a conductor 135. The other contact finger 132 is connected to another main line conductor 136 by a conductor 137.

The drum 127 is adapted to be rotated through a limited arc, or to be moved to such an extent that the fingers 131, 132 will engage the contact plate 130 or be disengaged therefrom.

When the fingers 131 and 132 contact with the plate 130 the circuit will be closed through which the solenoid 124 is energized, and when the fingers are disengaged from the plate 130 the circuit through which electric current is supplied to the solenoid 124 will be open, and, therefore, said solenoid will be deenergized.

During the operation of the turbine, when both of the nozzles 15, 16 are open, the solenoid 124 is deenergized and therefore the drum 127 is so positioned that the fingers 131, 132 are disengaged from the contact plate 130, as shown in Figs. 1, 2 and 3. When only the nozzle 15 is

open, the drum 127 is so positioned that the fingers 131 and 132 engage the plate 130 so that the solenoid 124 is energized, as shown in Fig. 7. Therefore, in order to provide means for retaining the drum 127 locked in either of the two above mentioned positions, a suitable locking means is provided, and said locking means may comprise a spring pressed detent 140 adapted to engage either of notches 141, 142 formed on the exterior of the drum 127, as shown in Figs. 3 and 7. The locking mechanism is so constructed as to permit rotation of the drum 127 from one position to the other by the drum operating mechanism, but prevents movement of said drum when its operating mechanism is inactive.

Any suitable mechanism may be provided for operating the drum 127. As shown in Figs. 1, 2, 3, 4 and 7, the drum operating mechanism may comprise a cam 145 fixed to the shaft 128 and a clutch device 146 (Fig. 4) also mounted on the shaft 128 and adapted to actuate the drum 127.

The cam 145 is formed with a notch 147 having end walls 148, 149 spaced a suitable distance apart. Disposed within the notch 147 is the extremity of an arm 150 carried rigidly by the rod 121 heretofore referred to, the end of said arm being provided with a roller 151 for engaging the walls of the notch.

Also formed in the cam 145, is a pair of notches 152, 153, which are separated by a tooth 154. A spring pressed detent 155 is adapted to engage in either of the notches 152, 153 and retain the cam 145 in position.

The clutch device 146 may comprise a collar 156 having a finger 157 projecting therefrom and disposed within an arcuate slot 158 formed in the drum 127 (see Figs. 4 and 7).

The clutch device 146 is so constructed that rotary movement of the cam 145 is transmitted to cause a corresponding rotary movement of the drum 127.

As shown in Figs. 1 and 6, the control mechanism 29 may comprise a servo motor 72 including a piston 73 operating in a cylinder 74 and having a stem 75 extending in both directions therefrom.

Fluid under pressure may be admitted so as to act on either side of piston 73 and the admission of this fluid may be controlled by means of a distributing valve 76 shown as provided with a pair of piston valves 77 and 78 operating in a cylinder 79. The valves 77 and 78 may be operated by means of a stem 80.

The valves 77 and 78 divide the cylinder 79 into chambers 92, 95 and 102. Chamber 95 is connected by a pipe 103 to the pressure tank 42 heretofore referred to, and chambers 92 and 102 are connected by pipes 123 and 44 to the sump tank 45.

The cylinder 79 is provided with ports 143 and 144. Port 144 is connected to chamber 85 on one side of piston 73 by a pipe 156, and port 143 is connected to chamber 159 on the other side of piston 73 by a pipe 160.

The valves 77 and 78 are shown in their neutral position in which they lap the ports 143 and 144 respectively, and thereby cut off communication between the valve 76 and servo motor 72, through pipes 156, 160.

The valve stem 80 is connected to one end of a floating lever 161 provided with a floating pivot 162. The other end of the lever 161 is connected to a fly ball mechanism 163 or other suitable speed responsive means. The fly ball mechanism 163 may be driven from the runner 11

through any suitable connection, indicated in Fig. 1 as belted.

The pivot 162 of the lever 161 is connected to the piston stem 75, by means of a compensating mechanism comprising a link 164, bell crank lever 166, and link 167, as shown in Fig. 1. In this way the distributing valve 76 is governed by the fly ball mechanism 163 and compensating mechanism.

Piston stem 75 is also connected to the shaft 66 by a lever 165, so that when the servo motor 72 operates, movement of the piston 73 in either direction will cause a corresponding rotation of shaft 66. Since the two deflecting hoods 65 and 113 are operatively connected to the shaft 66 the operation of said deflecting hoods will be governed by the servo motor 72.

The sump tank 45 serves as a reservoir for containing a quantity of oil. Oil is pumped from the sump tank 45 by pump 52 (Fig. 1) and delivered to pressure tank 42. From the pressure tank 42 the oil under pressure is carried through the pipes 43, 93 and 103 to the chambers 40, 90 and 95 of the distributing valves 34, 84 and 76, respectively, so that said chambers are normally charged with oil under pressure.

In operation, under load conditions of a predetermined amount only the main nozzle 15 will supply operating fluid to the runner 11. However, when the load is above a predetermined amount, two jets, one from nozzle 15 and the other from nozzle 16 will supply operating fluid to the runner 11, as shown in Fig. 1.

In this position of the device, piston valves 77 and 78, 35 and 36, 85 and 86, of the distributing valves 29, 27 and 28, respectively, are at neutral position, and needles 17 and 18, and the deflector hoods 65 and 113 are at a stand still and out of the path of the jets from the two nozzles 15 and 16.

When the load decreases a predetermined amount, the speed of the runner 11 will increase, thereby increasing the speed of rotation of the fly ball mechanism 163 and causing the piston valves 77 and 78 of the control valve 29 to move downwardly through the resultant operation of the floating lever 161.

When the piston valves 77 and 78 thus move downwardly, ports 143 and 144 will be uncovered, and oil under pressure from the pressure tank 42 is supplied to piston chamber 185 in operating cylinder 74, through pipe 103, chamber 95, port 144 and pipe 156. The oil in chamber 159 is discharged through pipe 160, port 143, chamber 92, and pipes 123 and 44 into sump tank 45. Piston 73 then moves towards the left (Fig. 6) thereby turning shaft 66 and simultaneously turning the deflectors 65 and 113 and moving the cams 61 and 111 through their operating mechanisms which are connected to the deflector operating mechanism as has heretofore been described.

The operation of cam 111 effects an upward movement of piston valves 85 and 86 of the control mechanism 28, and the operation of cam 61 effects a corresponding upward movement of piston valves 35 and 36 of the control mechanism 27.

Oil under pressure is then admitted into chamber 83 from the pressure tank 42, through pipe 93, chamber 90, and pipe 99.

Oil from chamber 100 is discharged through pipe 101, chamber 91, and pipe 94 to the sump tank 45.

Piston 82 then moves stem 24 towards the right (Fig. 1) towards the closing position of needle 18.

Oil under pressure from pressure tank 42, is admitted to chamber 48, through pipe 43, chamber 40 and pipe 49.

Oil from chamber 50 is discharged to the sump tank 45, through pipe 51, chamber 41 and pipe 44, and piston 32 moves the stem 23 and needle 17 to the left toward the closing position of the needle 17.

Meanwhile the rod 121 moves the follower 150 towards the edge 148 of cam 145 (Fig. 7). The spring pressed detent 155 climbs tooth 154. Shaft 128 turns finger 157 of clutch 146 and face 174 of finger 157 comes in contact with face 175 of slot 158 of the drum 127.

After the detent 155 has passed the extreme tip of the tooth 154, the spring 176 (Figs. 3 and 7) forces the detent 155 into the notch 152.

Face 174 of finger 157 which is in contact with face 175 of the slot 158 then snaps the drum 127 and the roller of detent 140 climbs on to the tooth 177.

After the detent 140 has moved across the tooth 177, spring 178 forces the detent 140 into the notch 142, thereby imparting a snap movement to the drum 127 and causing the contact 130 to move into engagement with the fingers 131 and 132 so that the electric circuit is closed through which the solenoid 124 is energized.

When the solenoid is thus energized, its core 125 is pulled upwardly and the roller 110 is lifted from the face of cam 111. The control valve 28 is now governed or controlled by the solenoid 124 and the compensating mechanism comprising the link 105, lever 106 and link 107 connected to the rod 24 of piston 82 and nozzle 18.

Piston valves 85 and 86 in the distributing valve 84 (Figs. 1 and 7) are lifted up and remain in the up position.

Chamber 98 of the servo motor 81 (Fig. 2) remains under pressure, through pipe 99, chamber 90 of distributing valve 84 and pipe 93.

Chamber 100 remains under discharge, through pipe 104, chamber 91 and pipe 94.

Piston 82, by means of the stem 24, moves needle 18 towards the closing position and closes the nozzle 16. The time of this closing is regulated by needle valves 63 and 64 (Fig. 2).

The position of the different parts of the regulating mechanism of the auxiliary nozzle 16 are thus shifted from the showing in Fig. 1 to the showing in Fig. 7 and the turbine operates with only the nozzle 15 open, and will continue to operate thusly until the load increases above a predetermined amount.

When the load is increased above a predetermined amount the speed of the runner 11 will be decreased and the fly ball mechanism 163 will lift up piston valves 77 and 78 of the distributing valve 76 (see Fig. 5).

Chamber 159 of the servo motor 72 is under pressure, being connected through pipe 160, chamber 95, and pipe 103 with the pressure supply tank 42.

Chamber 185 of the servo motor 72 is under discharge, being connected through pipe 156, chamber 102, and pipes 123 and 44 with the sump tank 45.

Piston 73 then moves the rod 121 and mechanism operatively associated therewith, including the deflector hoods 65 and 113, cams 61 and 111, and arm 150 and its roller 151.

Roller 60 on the lower end of rod 58 travels down the face of cam 61, the rod 58 being urged downwardly by spring 62, and lever 54 is pulled downwardly and piston valves 35 and 36 are

moved downwardly in the cylinder 37 of the distributing valve 34 (Fig. 5).

Piston chamber 50 is now supplied with fluid under pressure from the pressure tank 42, through pipe 43, chamber 40 and pipe 51, and fluid in chamber 48 is discharged to the sump tank 45, through pipe 49, chamber 39, and pipe 44.

The piston 32 moves stem 23 and needle 17 toward the full open position.

The arm 150 and its roller 151 which are attached to the rod 121, push the end wall 149 of the notch 147 in cam 145.

The roller of the spring pressed detent 155 climbs the tooth 154 (Fig. 7) of cam 145, and after the detent 155 has passed slightly by the tip of the tooth 154, spring 176, acting on the arm of the detent 155, pulls the detent into the notch 153, thereby imparting a snap movement to the cam 145.

Shaft 128 transmits this snap movement to the clutch device 146.

The spring pressed detent 140 (Fig. 3) climbs tooth 177 and spring 178 forces the detent 140 towards notch 142, thereby imparting a snap movement to the drum 127. The contact plate 130 is thus disengaged from the contact fingers 131 and 132, thereby deenergizing the solenoid 124.

When the solenoid 124 is thus deenergized, roller 110 of the rod 108 is forced by spring 112 into contact with the surface of the cam 111.

The downward movement of the rod 108 imparts a swinging movement to the lever 104.

The piston valves 85 and 86 of the distributing valve 84 which are operatively connected to the lever 104 by stem 88, are moved to the position in which chamber 100 of the servo motor 81 (Fig. 2) is supplied with fluid under pressure from the tank 42 and the fluid in chamber 98 is discharged to the sump tank 45.

Needle valve 18 is then moved by piston 82 towards the left (Fig. 2) to full open position so that additional power is supplied to the runner 11.

The opening time of needle 18 is regulated by needle valves 63 and 64. The piston valves of the distributing valves 34, 76 and 84 keep moving until the needles 17 and 18 are exactly in the same position, then said piston valves are at neutral position, and the complete regulating or controlling mechanism is at a standstill.

This automatic regulating or controlling system can be used for single acting regulation, that is, regulation of needles, or for double acting regulation with relief valves and needles, for a number of jets greater than one, and acting on one or several wheels.

If the jets of a multiple jet turbine are not operated simultaneously at part load but in a proper manner as provided by the invention, the part load efficiency of the turbine is higher than if the jets are working simultaneously.

From the foregoing, it will be noted that by my invention the envelope efficiency curve has a higher efficiency when the load is below a predetermined amount and the number of jets in operation is smaller than the total number of jets. This is due to the fact that the jets in operation are working at higher load and better efficiency. On the other hand, when all jets are in operation for a given load, the load per jet is smaller and consequently the efficiency lower.

Having thus described my invention, what I claim is:

1. In a controlling mechanism, the combination of a controlling element, means for actuat-

ing said element, speed responsive means, a valve device, power means controlled by said valve device, and means actuated by said power means for controlling the operation of the actuating means of said controlling element and comprising a cam operatively connected with said speed responsive means and normally disconnected from said actuating means and electrically actuated mechanism having a cam operated switch device operatively connected with said speed responsive means and having means for engaging said cam for operatively connecting the cam with said actuating means.

2. In a controlling mechanism, the combination of two controlling elements, separate means for individually actuating said elements, a single speed responsive means, a valve device actuated by said speed responsive means, power means controlled by said valve device, means actuated by said power means for controlling the operation of the actuating means for both of said controlling elements and comprising, a cam for each of said controlling elements operatively connected with said power means, means for normally retaining one of said cams disconnected from said actuating means and electrically actuated mechanism having a switch device operatively connected with the cam operating mechanism and having means for engaging said disconnected cam for operatively connecting the same with said actuating means.

3. In a controlling mechanism, the combination of a controlling element, means for actuating said element, a device for controlling the operation of said actuating means, speed responsive means, mechanism for controlling the operation of said control device and comprising a

cam operatively connected with said speed responsive means and normally disconnected from said controlling mechanism and electrically actuated mechanism having a switch device operatively connected with said speed responsive means and having means for engaging said cam for operatively connecting the cam with said control device mechanism.

4. In a controlling mechanism, the combination of a controlling element, fluid pressure operated means for actuating said element, a valve device for controlling the operation of said fluid pressure operated means, speed responsive means, mechanism for controlling the operation of said control valve device and comprising an electrically actuated mechanism having a switch device operatively connected with said speed responsive means and operable thereby, a cam operatively connected with said speed responsive means, and means for connecting and disconnecting said cam with said controlling mechanism.

5. In a control system for a plurality of sources of fluid, a main control means for controlling one source of fluid, an auxiliary control means for the other source of fluid, a governor mechanism, means for selectively controlling the operation of said control means and comprising a cam operatively connected with said governor mechanism and normally disconnected from said auxiliary control means, and electrically actuated mechanism having a cam operated switch device operatively connected with said governor for connecting and disconnecting said cam with said auxiliary control means.

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