

June 11, 1929.

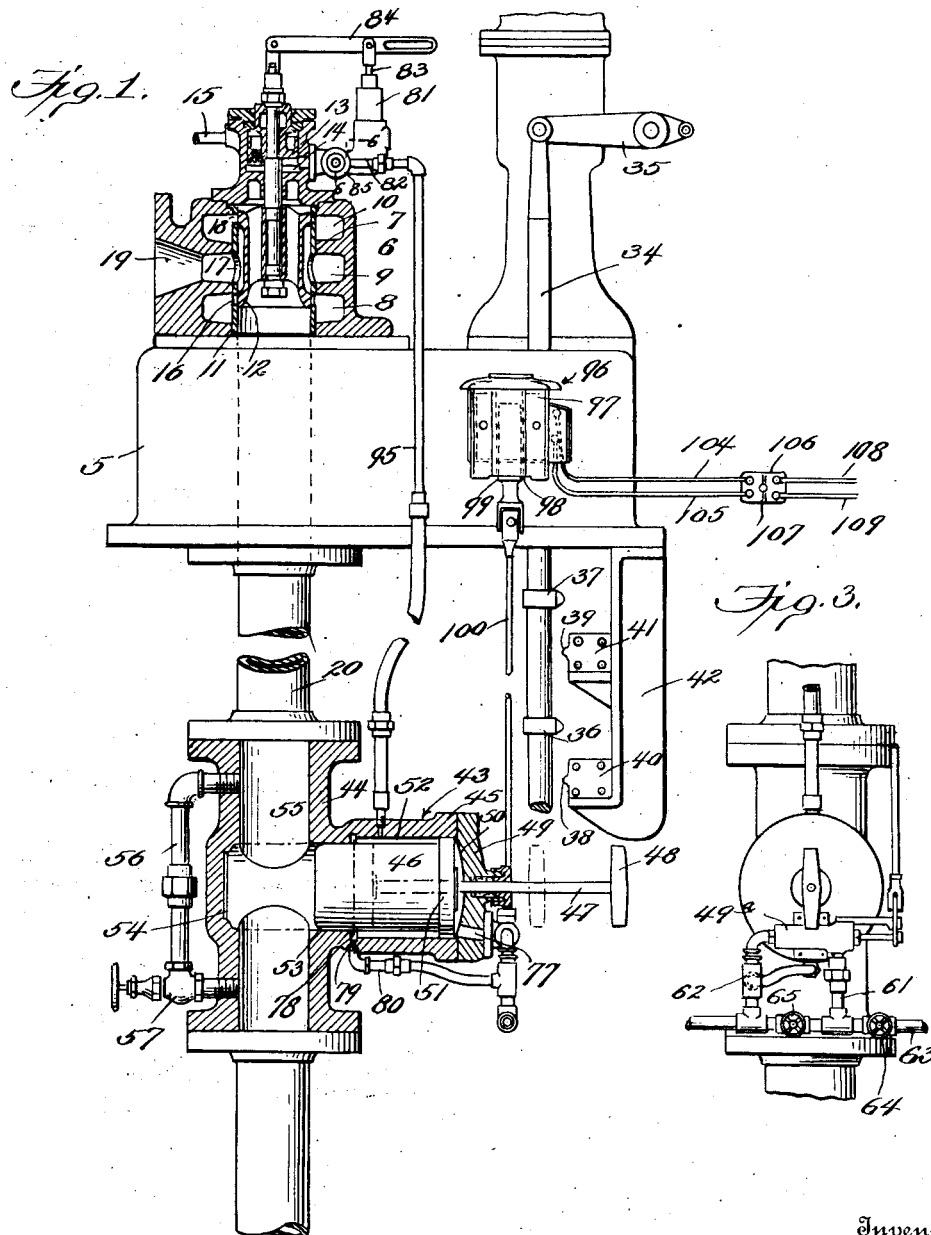
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1,717,071

SHUTTING DOWN MEANS FOR HYDRAULIC TURBINES

Filed May 4, 1925

3 Sheets-Sheet 1



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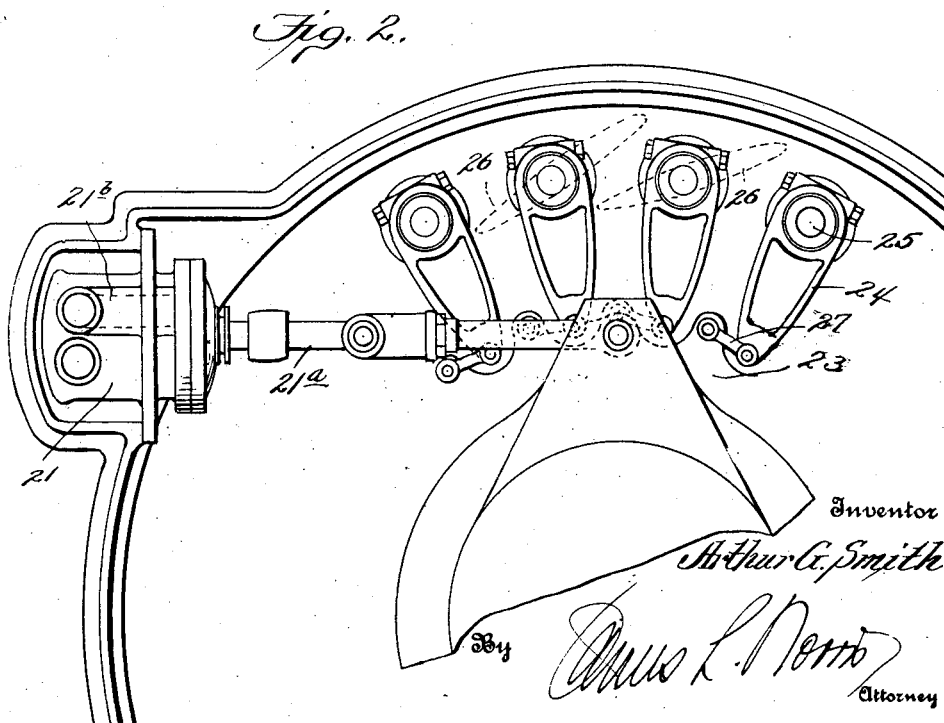
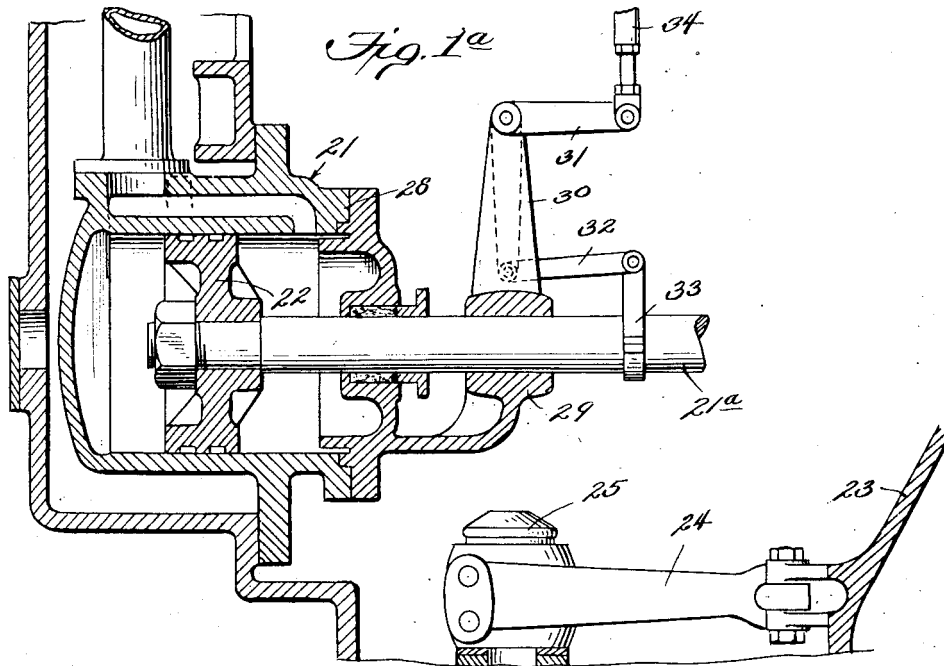
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SHUTTING DOWN MEANS FOR HYDRAULIC TURBINES

Filed May 4, 1925

3 Sheets-Sheet 2



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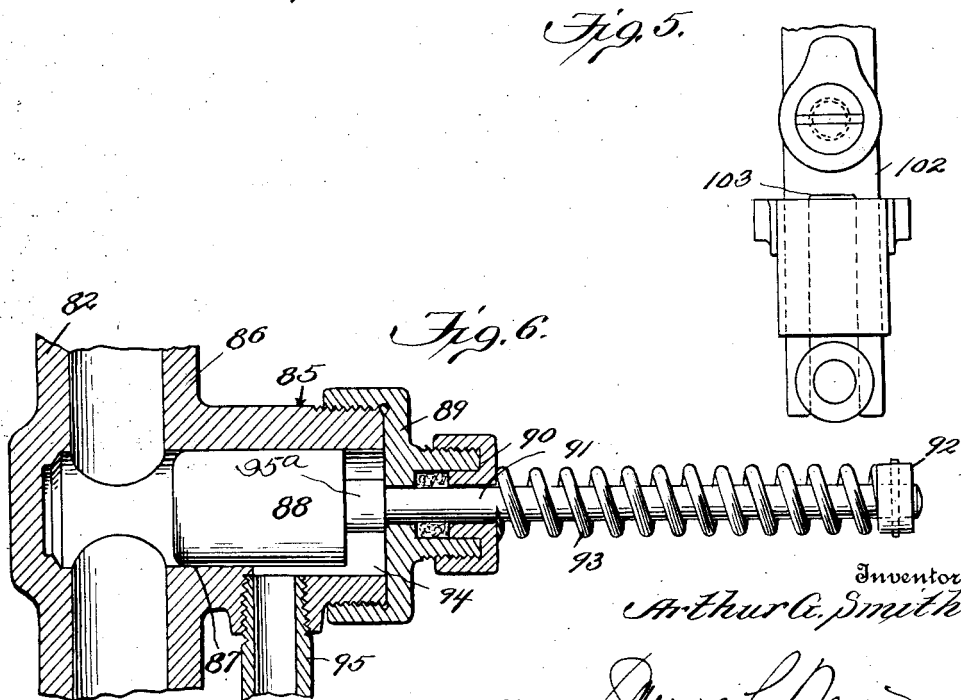
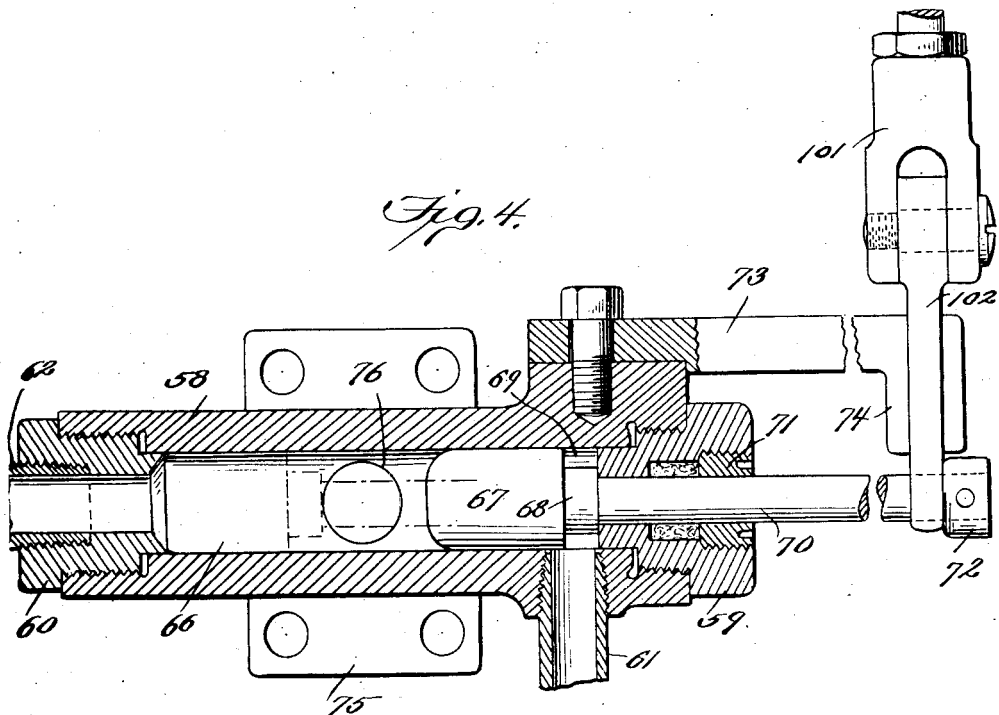
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SHUTTING DOWN MEANS FOR HYDRAULIC TURBINES

Filed May 4, 1925

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

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SHUTTING-DOWN MEANS FOR HYDRAULIC TURBINES.

Application filed May 4, 1925. Serial No. 27,814.

This invention relates to means for shutting down large hydraulic turbines and connected generators, and the primary object of the same is to provide an easily controlled and safe and positively operating organization of elements, including electrical instrumentalities for cooperating with known electrically-controlled contactors mounted in operative relation to some part of the gate mechanism and also cooperating with the usual actuator or governor, to enable an operator to close the gates of and stop a turbine unit from a switch board or some other point distant from the said actuator or governor.

A further object of the invention is to provide means for securing a positive closing of turbine gates regardless of accidents to a generator or the centrifugal governor head that might cause the turbine unit controlled to run away or become difficult to handle by ordinary governor operation, and enable a switch board operator, through electrical connections and elements, to shut down a turbine unit in an emergency by simply closing a switch to energize and actuate a movable electrical part, which effects the result sought through the governor mechanism, instead of performing a series of operations in definite sequence and at the right time, and further, to locate the entire organization or apparatus embodying the features of the invention in a place safe from accident and make it possible, in the event of total failure of the electric current used under normal conditions as the prime operating medium, to trip or actuate the improved mechanism and hold the turbine gates shut as long as there is sufficient pressure in the tanks associated with the governor mechanism.

The invention consists in the preferred construction and arrangement of parts which will be hereinafter more fully described and claimed.

The parts shown in the accompanying drawings, to illustrate one application of the improved features of the invention, are intended for use in connection with an actuator type governor where the centrifugal head and valve gear are mounted on a generator floor and connected by suitable pipes to the hydraulic pistons which moves the gates, but the constructions can be modified without departing from the nature or spirit

of the invention for use on any form of governor. The contactors with which the improved means are operatively associated are mounted on the turbine gate ring or parts operated by the same and have a fixed movement to close a circuit whereby the armature and field switches are opened when the gates are closed to a point which gives zero load on the generator.

In the drawings:

Fig. 1 is a sectional side elevation of the upper portion of a well known form of actuator or governor and cooperating parts, showing the features of the invention applied thereto.

Fig. 1^a is a longitudinal vertical sectional view of the lower portion of the actuator or governor and particularly embodying a servo motor and turbine gate connecting and operating means.

Fig. 2 is a top plan view of a portion of a turbine gate installation, illustrating the parts shown by Fig. 1^a in association therewith.

Fig. 3 is an end elevation particularly illustrating the pilot valve and its connections and supplemental valves and a part of the improved attachment which cooperates with the plunger of said pilot valve.

Fig. 4 is a longitudinal vertical section on an enlarged scale of the pilot valve and part of the improved attachment which directly cooperates with the plunger of said valve and illustrated in side elevation.

Fig. 5 is an end elevation of the outer extremity of the plunger of the pilot valve and the portion of the improved attachment which directly engages therewith and as shown in side elevation by Fig. 4.

Fig. 6 is a section on the line 6-6, Fig. 1, and shown on an enlarged scale.

The parts of the well known actuator to which the features of the invention are applied will be only generally referred to, as they are well understood in the art of hydraulics and such additions as are involved in the features of the invention will be particularly explained in connection with elements of the actuator with which the improved features are directly associated. It will also be understood that the operating fluid is oil which is supplied from pressure tanks connected with the actuator and its cooperating parts and including servo-motors associated with the turbine gate operat-

ing means or ring to open and close the gates by reverse operation thereof. The actuator is also in operative organization with relation to a governor mechanism, not shown in the present instance, but will be of that type usually employed in actuator and governor mechanisms or organizations well known in this particular art. By "actuator" is meant a centrifugal speed control mechanism or device, with the necessary valves and other accessories, that is mounted on a base and separated from the operating cylinders by some distance.

Briefly describing the parts of the actuator organization which are essential to the application and operation of the features of the invention, the numeral 5 designates a suitable support and thereon is an enclosing casing 6 containing a vertically extending chamber 7 with separated ways or ports 8, 9 and 10, partially covered by an inner sleeve or liner 11, in which is disposed a distributing valve 12 connected to an upper relay piston 13 mounted in a chamber 14 over the valve 12 and having an oil pressure supply connection 15. The sleeve or liner 11 has openings or ports 16, 17 and 18 formed therein at different elevations in communication with the ways or ports 8, 9 and 10, the distributing valve 12 being movable in the sleeve or liner 11, and by its particular construction, controlling communication between the interior of said sleeve or liner and the several ways or ports 8, 9 and 10. An inlet 19 is provided in the casing 6 for supply of oil under pressure from one of the pressure tanks or oil pressure sources to the interior of said casing, and continuing from the lower terminal of the chamber 7 is a main pipe 20, supplying pressure to the servo-motors, one of which is shown by Fig. 2 as at 21 and has the usual connection between the plunger 22 thereof and the gate-operating mechanism or ring 23 by means of a plunger rod or stem 21^a. It will be understood that another servo-motor will be associated with the gate-operating means or ring 23 to act in opposition to the servo-motor 21 as shown in Fig. 2. The servo-motor 21 as shown by Fig. 2 is representative of one of two similar motors associated with the turbine gates and has a single piston 21^b which is double-acting in view of the ports at opposite sides of the casing as shown and controls the closing operation of the gates, and the levers 24 connected to the stems 25 of the gates 26, shown in dotted lines, are coupled or attached to the gate ring 23 by the usual form of links 27, so that all of the gates will be uniformly operated either to a closed or open position in accordance with the servo-motor rendered active. The casing 28 of the servo-motor 21 has at one end a bearing support 29 for the plunger rod or stem 21^a, and extending up-

wardly therefrom is a fulcrum support 30, to which is pivoted a bell crank lever 31 having movably attached to one arm thereof a link 32, also movably connected to a coupling yoke 33, secured on the plunger rod or stem 21^a. The remaining arm of the bell crank lever 31 has an upwardly extending rod 34 movably attached thereto and also connected at its upper end to a rocking lever 35 associated with the governor, not shown. On the rod 34 are a pair of spaced contacts 36 and 37 which are adapted to engage cooperating contact points 38 and 39 carried by contact plates 40 and 41 held in position by a frame member 42 depending from the casing 5, as shown by Fig. 1. The contact plates 40 and 41 with their points 38 and 39 and the contacts 36 and 37 on the rod 34 will be suitably connected to the field and armature switch of the generator, not shown, the said contact devices constituting a tripping contact for the field and armature switch and by means of which the field and armature switch or switches, as the case may be, may be opened when the gates are closed to a point that gives zero load on the generator. Installed at a suitable point in the main pipe or conduit 20 is a shut-off valve generally indicated by the reference character 43 and having a casing 44 with a horizontally extending member 45 having a plunger 46 mounted therein and provided with an outwardly projecting stem 47 with a hand grip 48 for manual operation, the latter stem extending through a head 49, which is concaved or recessed as at 50 over an outer enlarged end 51 of the plunger or piston 46. The member 45 has an enlarged chamber 52 of approximately the same diameter as the enlarged outer end 51 of the plunger 46. The member 45 of the casing 44 also has an inner opening 53 of approximately the same diameter as the reduced diametrical portion of the said plunger 46, and opposite this opening the casing has a seat depression 54 for the reception of the inner smaller end of the plunger 46 when the latter is closed. The valve casing 44, by its interposition in the main pipe or conduit 20, has a bore 55 therethrough which continues the bore of the said pipe or conduit 20, and above and below the depression 54 a bypass pipe 56 is connected to and communicates with the bore 55 and has a lower angle valve 57 which is adjustable to give the desired time element of gate closure. Associated with the head 49 of the valve casing 44 and extending transversely across the same in a horizontal plane is a pilot valve 49^a, shown by Fig. 4, comprising a tubular casing 58 having opposite heads 59 and 60. A lower inlet connection 61 is connected to the casing 58 adjacent the head 59 and an outlet connection or constantly open drain pipe 62 is connected to a longitudinal bore in the

head 60. The lower end of the pipe 61 is connected to an oil pressure supply pipe 63 provided with a valve 64, and the lower ends of the pipes 61 and 62 are connected by a pipe having a closing valve 65, the latter pipe beyond the valve 65 being a constantly open drain pipe. The valve 64 is opened to permit oil under pressure at all times to pass into the pipe 61 and from the latter into the one extremity of the chamber 66 of the pilot valve 58 while the valve 65 remains closed. Within the chamber 66 of the pilot valve casing 58 a plunger 67 is mounted to reciprocate and has one end thereof circumferentially reduced as at 68, to provide a port 69 adjacent the upper inlet end of the pipe 61, the plunger 67 having a rod or stem 70 extending outwardly through a suitable packing or gland 71 in the head 59 and having on its outer end a collar or analogous device 72. On the upper part of the end of the casing 58 from which the rod or stem 70 projects is a horizontal bracket arm 73 having a terminal depending angular guide 74 for a purpose which will be presently explained. The casing 58 of this pilot valve is fastened to the lower portion of the head 49 of the member 48 of the valve casing 44 by a suitable bracket plate 75, and extending through the latter and also through the casing 58 into the chamber 66 is a port 76 which registers with the port 77 in the lower part of the head 49, said port 77 opening into the recess or depression 50 in the inner side of the head 49. The chamber 52 in which the enlarged outer end 51 of the plunger 46 has snug sliding movement has at its inner end a drain groove 78, and communicating with this groove by a port 79 through the bottom portion of the casing 44 is a drain pipe 80, which runs to and connects with the drain pipe 62 of the casing 58, and by this means the chamber 52 may be freed of any accumulation of oil therein when the plunger 46 is restored to normal position and avoid any obstruction to the sensitive and complete operation of the said plunger to closing position. Adjacent to the relay valve structure hereinbefore described is an upright pilot valve 81 having a lower pipe connection 82 with the chamber 14 of the relay piston 13, the stem 83 of the said pilot valve being connected to a floating lever 84, also associated with the governor mechanism.

All of the foregoing mechanism except the valve 43 and its cooperating pilot valve 49^a is old in this particular art and has been illustrated to demonstrate the operative relation thereto of the improved features, which have been in part and will now be particularly and additionally described.

The improved features of the invention comprise a plunger valve 85, shown in de-

tail in Figure 6, interposed in the pipe connection 82 between the pilot valve 81 and the relay valve including the chamber 14 and piston 13, the said plunger valve by its disposition as just explained being thereby located in the exhaust line from the relay control valve of the governor. This plunger valve by its operation effects a positive closing movement of the governor and comprises a casing 86 extending out at right angles to the pipe or conduit 82 and having a chamber 87 in which is mounted a plunger 88. The casing 86 is closed at its outer end by a head 89 with a suitable gland or other packing means 90, and through the center of the latter and the head a plunger rod or stem 91 connected to the plunger 88 has movement. On the outer end of the plunger rod or stem 91 is a collar or stop device 92, and between the latter and the head 89 a spring 93 surrounds the said plunger rod or stem, to dispose the plunger 88 in normal position after it has been operated to close the pipe or conduit 82. The chamber 87 adjacent the head 89 is enlarged, as at 94, and the end of the plunger 88 from which the plunger rod or stem 91 projects is diametrically reduced, as at 95^a, to give the enlargement 94 of the chamber 87 the necessary capacity for receiving oil under pressure which is fed thereto in accordance with the operation of the improved features of the invention and as will be presently explained. Connected to the bottom of the casing 86 and opening into the enlargement 94 of the chamber 87 is the upper end of a pipe 95, which is connected and opens into the chamber 52 of the shut-off valve 43. Suitably supported and held in operative relation above the shut-off valve 43 is a solenoid 96, constructed similarly to devices of this type and having magnetic coils 97 around a central bore 98, which is open at the bottom and has a solenoid core 99 freely movable therein. Movably attached to the lower end of the core 99 is a depending rod 100 of suitable length having a bifurcated head 101 at its lower end in which the upper end of a clip or latch fork 102 is secured as shown by Fig. 4, the said latch fork having a bifurcation 103 opening through the lower end thereof and movable on the angular guide 74 at the outer end of the bracket arm 73. The coil or coils 97 of the solenoid 96 have electrical conductors 104 and 105 connected thereto and to a switch board 106, comprising a push button 107, which is operable to close the circuit between the wires or electrical conductors 104 and 105 and other electrical conductors 108 and 109, also attached to the switch board 106 and connected to an electric current supply. This switch board 106 may be located at any position desired at a distance from the actuator and governor mechanism so that it may be

operated to close the circuit and actuate the solenoid for the purposes hereinbefore set forth. It will therefore be seen that the improved attachment comprises the shut-off valve 43 with its cooperative pilot valve 49^a, the plunger valve 85, the pipe 95 running to and communicating with the chamber 52 of the shut-off valve, and the solenoid having the depending rod 100, to the lower end of which the latch fork 102 is attached, together with the electrical connections whereby the solenoid is rendered operative or actuated to move or shift the rod 100. To render the full closing movement of the plunger 88 structurally effective, the wall of the pipe or conduit 82 opposite the chamber 87 in which the plunger valve has movement is preferably formed with a seat or depression 110, and when the plunger 88 is forced across the bore of the pipe or conduit 82, the latter is shut off and the said plunger 88 remains in closed position until relieved of oil under pressure which operates thereon through the medium of the enlargement 94 of the chamber 87 against the resistance of the spring 93.

In setting the improved attachment for operation, the rod or stem 70 of the plunger 67 of the pilot valve connected to the head 49 of the valve casing 44 of the shut-off valve 43 is drawn outwardly and the latch fork 102 is caused to embrace the outer extremity of the rod or stem 70 and to bear against the collar or analogous device 72 to hold the plunger 67 in the position shown by Fig. 4, at which time the reduced extremity 68 of the said plunger will be in engagement with the inner terminal of the head 59 at one end of the valve casing 58 of the pilot valve, and the port 69 will be in communication with the upper inlet end of the pipe 61, and whereby oil under pressure to the capacity permitted by the position of the plunger 67 will fill the said port. The plunger 46 of the shut-off valve 43 will also at this time be disposed in the position shown by Fig. 1 with the enlarged extremity or end thereof close to the depression 50 of the head 49 and to the inlet end of the port 77 also opening into the pilot valve and the main line pipe 20 will then be clear with the gates of the turbine open. When the latch fork 102 is in engagement with the outer extremity of the rod or stem 70, the core 99 of the solenoid will be pulled down or lowered and the plunger valve 85 will have its plunger 88 positioned as shown by Fig. 6 so as to clear the bore of the pipe or conduit 82. The distributing or exhaust valve 12 will also occupy the central position shown by Fig. 1 with its upper and lower rings covering the ports 18 and 16 and, further, the relay piston 13 in the chamber 14 will be disposed as shown by Fig. 1. The parts of the improved attachment and

the several instrumentalities of the actuator and governor control mechanism directly associated with the improved features having been arranged as just explained will permit the governor to normally operate and perform its functions, and the turbine gates will remain open to permit ingress of water to the runner or wheel for driving the turbine shaft. The valve 64 in the oil pressure pipe connection 63 and the valve 65 in the same pipe connection in the preliminary arrangement or adjustment of the parts of the actuator mechanism will be respectively opened and closed and remain in such opened and closed relationship during the normal operation of the turbine runner. In the event of trouble owing to too high speed of the turbine runner or wheel and which would make it difficult or impossible to perform the closing operation of the gates in the normal way, an operator may close the switch 107 and energize the solenoid 96 and cause the core of the latter to be drawn upwardly and thereby at the same time pull upwardly on the rod 100 and release the latch fork 102 from the outer end of the rod or stem 70 of the plunger 67 of the pilot valve, and the oil under pressure behind the plunger 67 will force the latter from the full line position in Fig. 4 to the dotted line position thereof and open the port or passage 76 and permit the oil under pressure to enter the member 45 of the shut-off valve 44 through the passage 77 against the outer enlarged extremity 51 of the plunger 46 and force the latter across the main pipe 20 and close said latter pipe and also open up the pipe 95 for the flow of oil therethrough under pressure from the enlarged chamber 52, the oil passing through the pipe 95 entering the enlargement or port 94 of the plunger valve 85 and forcing the plunger 88 into closed position across the bore of the pipe or conduit 82 against the resistance of the spring 93, and the excess pressure under the enlarged end of the relay piston 13 in the chamber 14 of the relay valve will effect a movement of the said latter piston and force the distributing or exhaust valve 12 upwardly to put the ports thereof into communication with the passages 9 and 10 and permit the oil to flow down through the pipe 20 and bypass by way of the pipe 56 to the servo-motor 21 and actuate the plunger of the latter in a direction to shift the plunger rod 21^a and operate the gate ring and connections for the gates 26 to close said gates and effect a downward movement of the rod 34 to set up engagement of the contacts 37 and 36, respectively, with the contacts 39 and 38, and thus act through the armature and field switches of the generator to open the latter to a point that will give zero load on the generator.

After the emergency operation of the

improved attachment features as just explained has been fulfilled to overcome the irregularity of operation present in the turbine installation in part or as a whole, the several mechanisms, including those of the actuator and governor mechanism with which the improvements are associated, are reset to normal position partially automatically and partially by hand and including the core of the solenoid, which is lowered by the application of the clip or latch fork 102 at the lower end thereof to engage the outer end of the rod or stem 70 of the plunger 67 of the pilot valve. What oil may remain in the chambers of the several valves is drained away and passes off to the sump and thereby frees the chambers or bores in which the valves operate from obstructions to the operation of the plungers of the valves.

From the foregoing it will be seen that the turbine gates will be positively closed regardless of accidents to the generator or centrifugal governor head that might cause the entire turbine unit to runaway or become difficult to handle by ordinary governor operation. As also hereinbefore noted, the improved features enable a switch board operator to shut down a turbine unit during an emergency by simply pressing a button or operating an analogous switch device to energize the solenoid instead of being compelled to perform a series of operations in definite sequence and at proper times.

What is claimed as new is:

1. Shutting down means for hydraulic turbines, comprising in combination with an actuator adapted for association with governor mechanism and turbine gates having means for enclosing the same, of a valve located in the exhaust line from the relay control valve of the governor mechanism, a shut-off valve interposed in the main line between the relay control valve and a part of the gate operating means and having a pilot valve with a projecting plunger rod, and electrically shiftable means having a switch connected thereto and including a movable element separably associated with the plunger rod of the said pilot valve and releasable from the latter by the actuation of the switch to effect a shutting down operation of the gates of the turbine in the event of the necessity of emergent action.

2. In shutting down means for hydraulic turbines, the combination with an actuator having oil pressure connections and operating valves to control the flow of oil under pressure therein and adapted for association with governor mechanism, turbine gates having operating devices including a servo-motor for closing the same connected to the actuator by a main line conduit provided with an automatically operating shut-off valve interposed therein, of a pilot valve

operatively mounted in connection with the said shut-off valve and having a plunger rod movable outwardly therefrom, an electrically operated device having a movable element with holding means connected thereto for engagement with the said plunger rod to maintain the shut-off valve open, a vertically reciprocating rod associated with the gate operating mechanism and having electrical contacts thereon, other contacts adjacent the contacts of the rod, the said contacts being adapted for connection to the switch means of a generator to open the said switch means when the gates are closed to a point which gives zero load on the generator, a plunger valve interposed in the exhaust line relatively to the said relay valve and having a plunger operating to automatically open a pipe connection between the shut-off valve and the said plunger valve, and an electrical attachment having a movable member with a clip attached thereto for engagement with the plunger rod of the said pilot valve, the said electrical attachment having a switch means connected thereto for controlling the supply of current for actuating the said movable member to release the plunger rod of the pilot valve and automatically effect a closure of the turbine gates.

3. A shutting down means for hydraulic turbines including actuator and gate operating mechanism controlled by oil under pressure, combined with a plunger valve interposed in the exhaust line of the actuator and governor and the relay control valve of an actuator, means connecting said plunger valve for supplying oil thereto under pressure from the remaining part of the actuator mechanism, and electrically controlled means having a holding device removably engaging a part of the actuator mechanism when electrically energized to effect an automatic operation and supply of oil to the said plunger valve and an immediate operation of the turbine gate closing devices independently of the series of operations in definite sequence and in proper timed relation required to be performed to effect activity of the actuator mechanism to close the turbine gates.

4. In a shutting down means for hydraulic turbines the combination of a standard turbine wheel actuator consisting of centrifugal speed control device associated with a governor and operated by oil under pressure supplied to the cylinders by a main supply pipe, and comprising automatically operating valves including a valve to control the exhaust of the actuator, mechanism directly and operatively associated with the gates of a turbine and including a servo-motor having a piston connected to the gates, an electrical attachment having a movable member with means connected thereto to engage a

part of and hold open one of the valves, and switch means controlling the flow of current to said electrical attachment and to automatically release the valve engaged by said movable member and actuate the piston of the servo-motor to effect a closing of the gates of the turbine by an automatic operation involving a shut off of the supply of oil to the cylinders of the actuator through the main supply pipe and independent of the usual manual operation usually required to cause the actuator and relatively associated parts to close the turbine gates.

5. In a shutting down means for hydraulic turbines, the combination with the usual form of hydraulic turbine actuator, and gate operating mechanism including a servo-motor and a main oil supply conduit having a shut-off valve and all associated with a governor mechanism of electrical means having a movable rod engaging a part of the said shut-off valve for normally holding the actuator mechanism in set position, the said movable rod being operable through the medium of a switch located at a distance from the shutting down means to energize the said electrical means and release the rod and shut-off valve and effect a change of the oil pressure and an automatic operation of the actuator to close the gates through the servo-motor independent of the manual control of the usual means to effect a closure of the turbine gates.

6. Means for closing the gates of a hydraulic turbine regardless of accidents to a generator or to a centrifugal governor head that might cause the unit to run away or become difficult to handle by ordinary governor operation, consisting in addition to the usual actuator mechanism operating under the force of oil under pressure supplied through a main conduit connected to the actuator and a servo-motor connected to the turbine gates, of shut-off valve mechanism associated with the said main oil supply conduit, and electrically controlled means including a movable member engaging and holding a part of said shut-off valve

in normal set position and operable under emergency conditions to release said valve and a part of said actuator mechanism and instantly set up an activity of the latter mechanism to close the turbine gates through the servo-motor independently of the means of the actuator mechanism ordinarily requiring sequential manual adjustment and operation.

7. Means for closing the gates of a turbine including an actuator to control the speed and power and hydraulic servo-motor means through oil pressure supplied through a main conduit, combined with shut-off and exhaust control valves operatively associated with the said oil conduit and a portion of the actuator, an electrical attachment having a movable element provided with means for engagement with a portion of the shut-off valve to hold the latter valve open and automatically release the latter and control actuation of said exhaust valve, and electrical switch means associated with and operable to energize said attachment for releasing the said element and the shut-off valve to effect closure of the turbine gates through the servo-motor at an interval of emergency independently of the usual manual operation of said actuator.

8. Means for closing the gates of a turbine including an actuator and a main oil supply conduit to control the speed and power and operation of the servo-motor means, valve mechanism associated with the actuator, and a shut-off valve for the main oil supply conduit, said valve mechanism and said shut-off valve having related control operation one by the other, and an electrical attachment having a movable element to engage the shut-off valve to hold the latter in open position and release the same to actuate the said related valve mechanism to effect the gradual closing of the gates of the turbine through the servo-motor independently of the normal operation of the actuator.

In testimony whereof I have hereunto set my hand.

ARTHUR G. SMITH.