July 28, 1942. H. DEGLON 2,291,453

IMPULSE TURBINE

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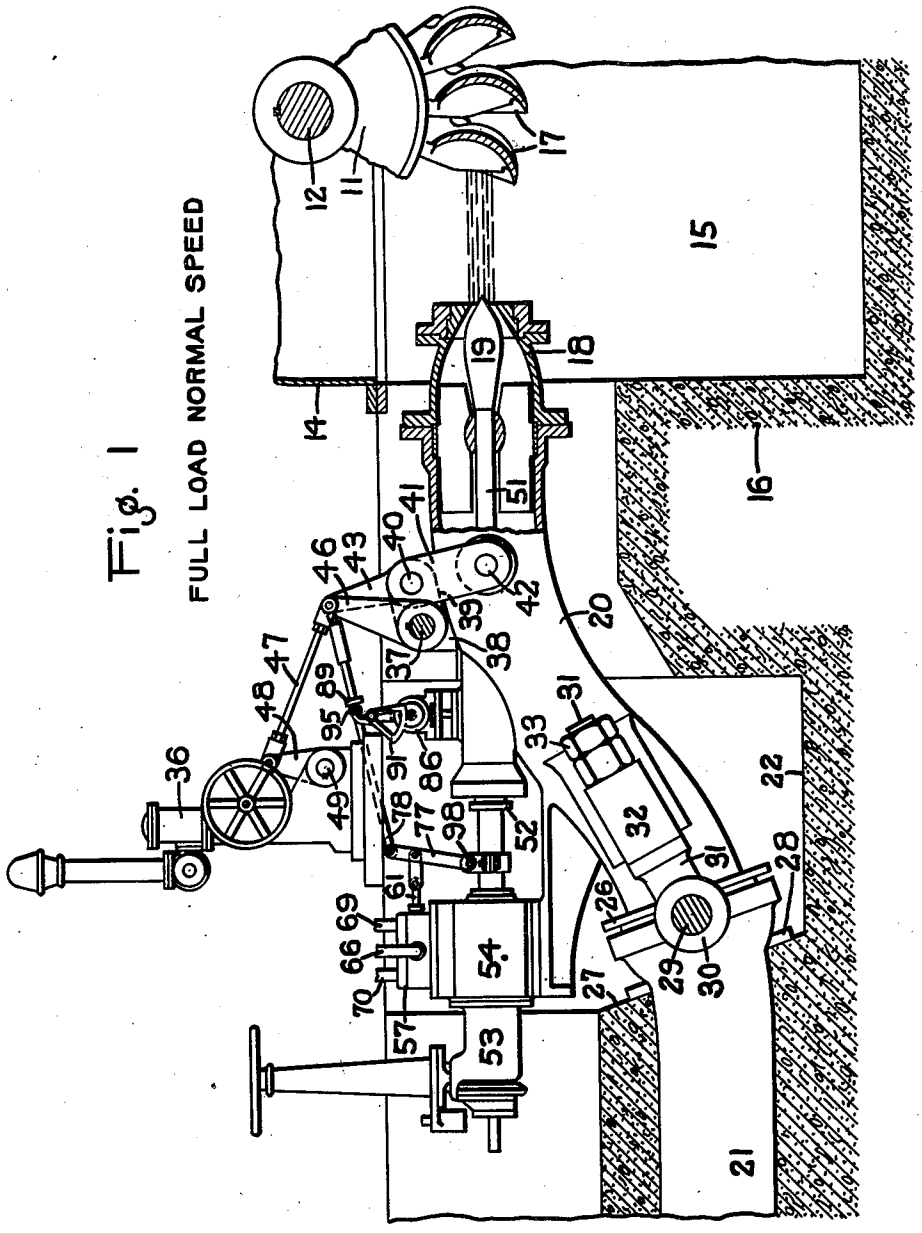


Fig. 1

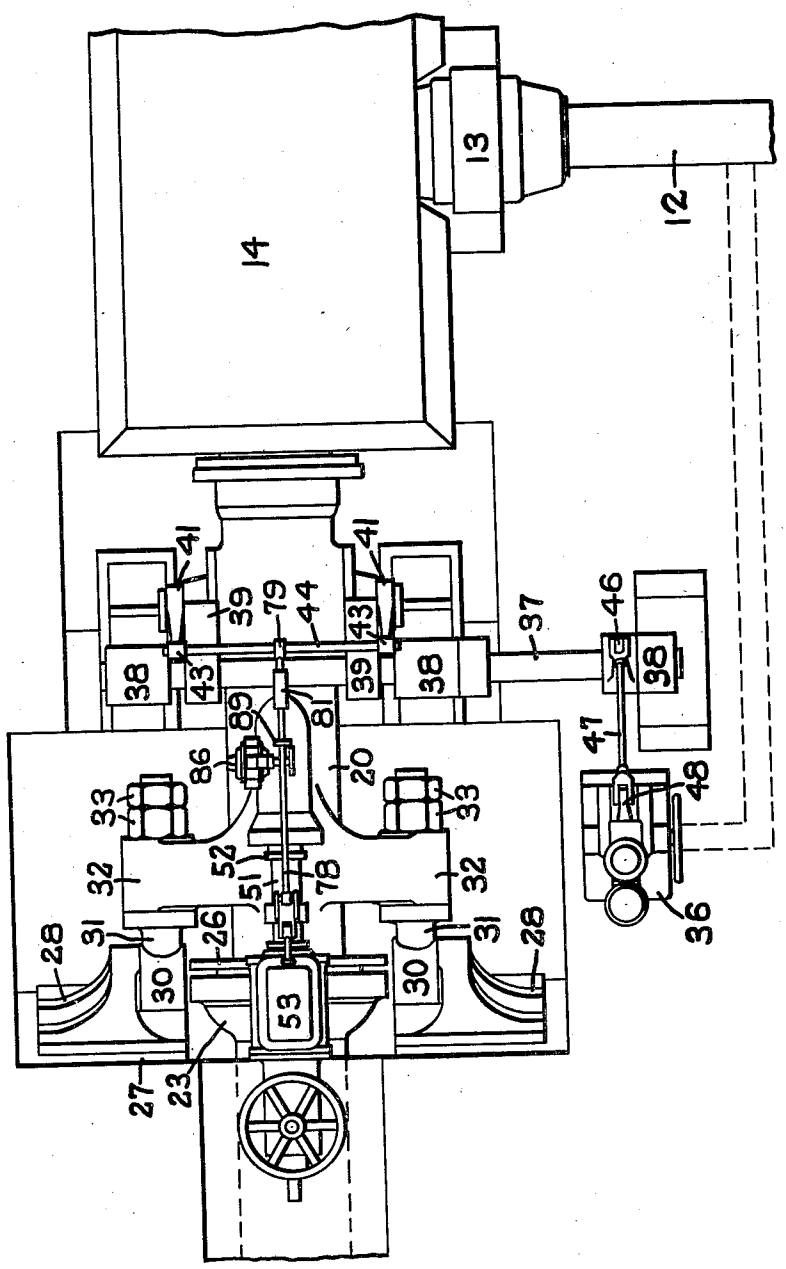
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IMPULSE TURBINE

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Fig. 2



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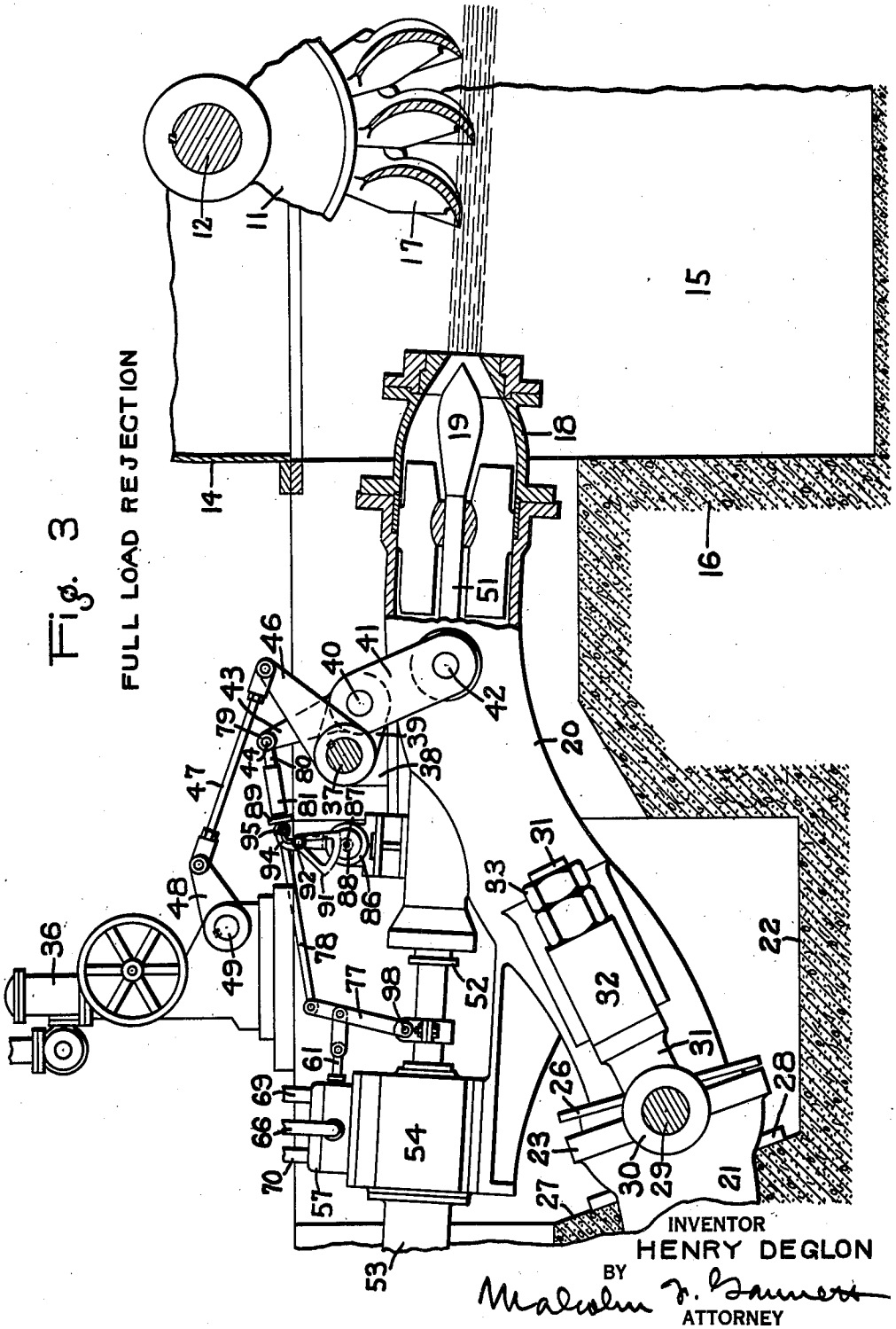
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Fig. 3

FULL LOAD REJECTION



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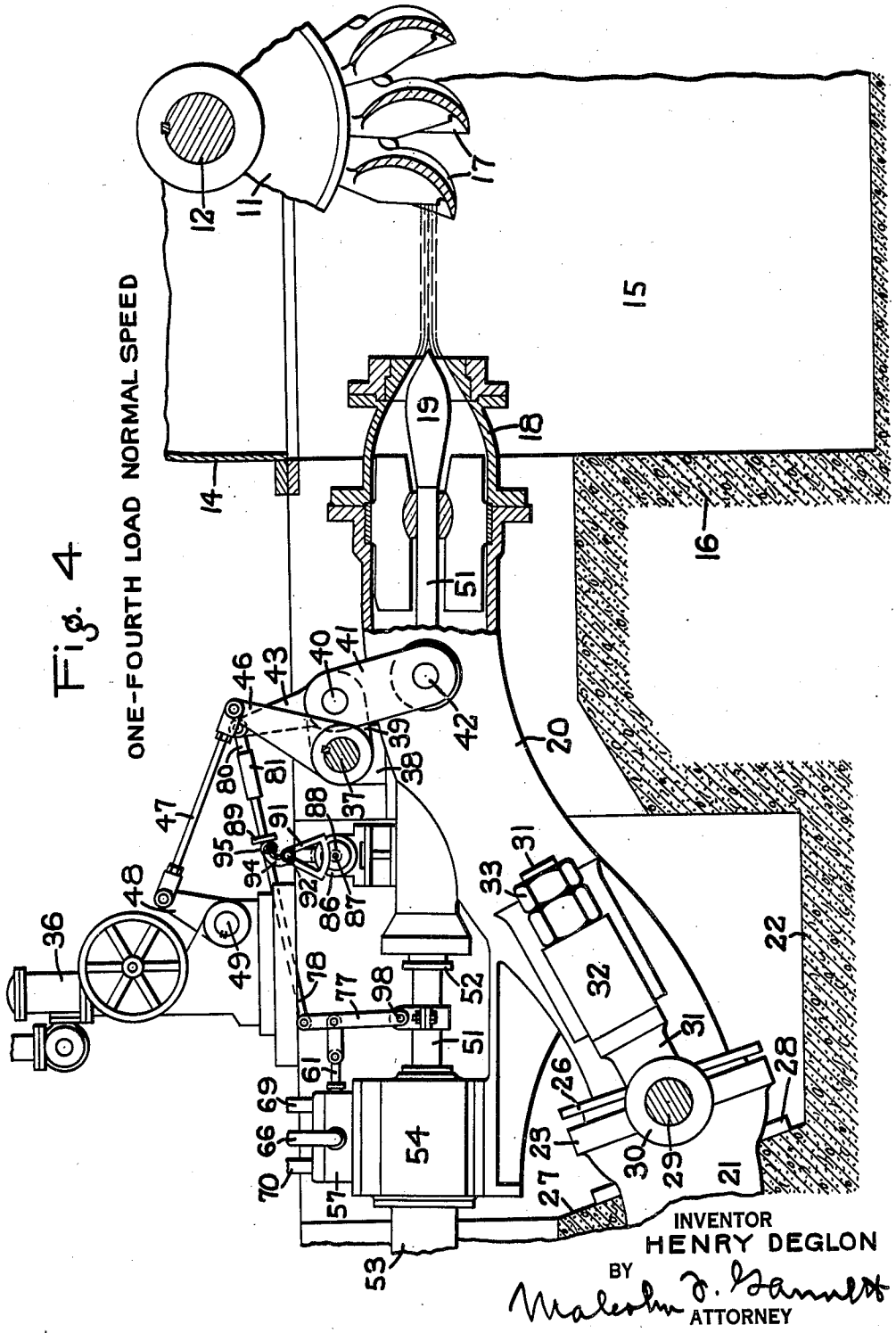
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Fig. 4

ONE-FOURTH LOAD NORMAL SPEED



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Fig. 5

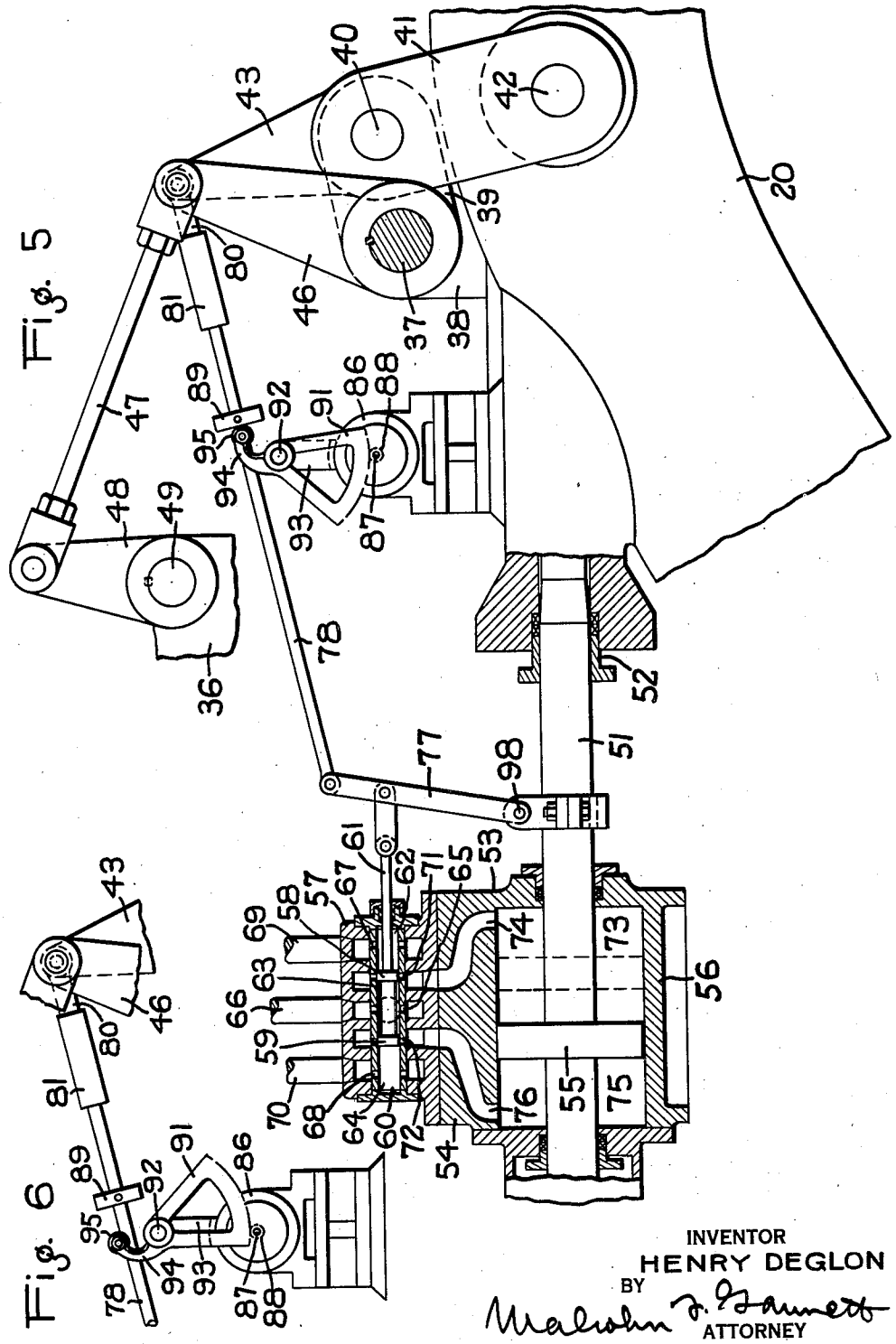


Fig. 6

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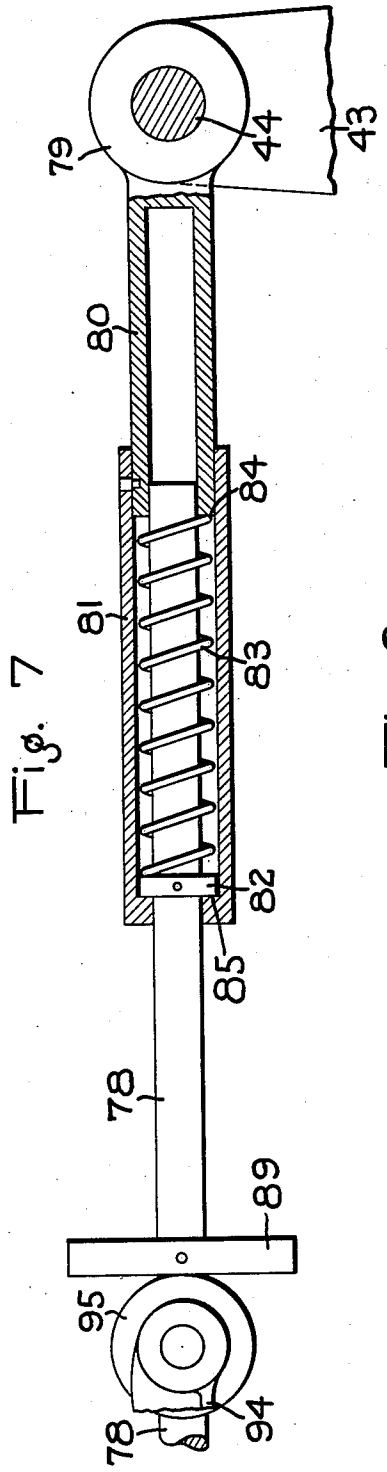


Fig. 7

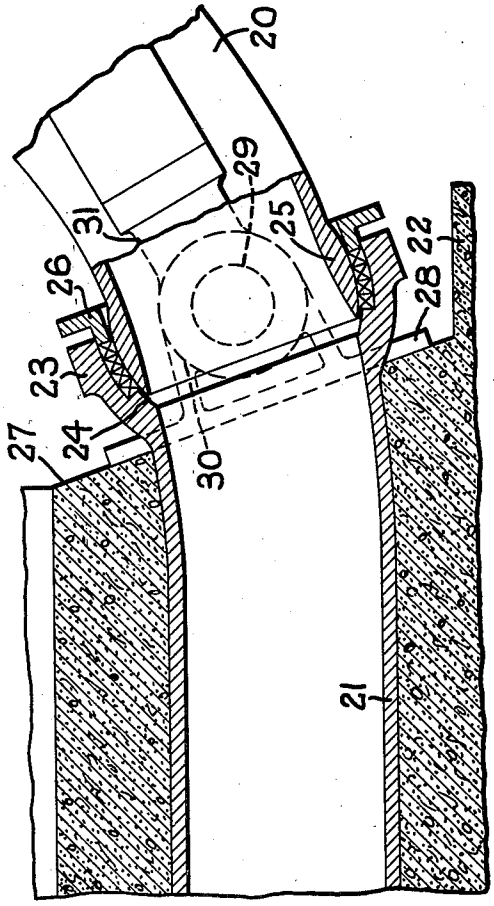


Fig. 8

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2,291,453

UNITED STATES PATENT OFFICE

2,291,453

IMPULSE TURBINE

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Application May 17, 1940, Serial No. 335,750

8 Claims. (Cl. 253—24)

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 system for controlling the supply of operating fluid to the runner of an impulse turbine.

Another object of the invention is to provide an improved control system for an impulse water wheel having a nozzle for supplying a jet of operating fluid to the wheel, in which the position of the jet with respect to the wheel, as well as the size of the jet are varied in accordance with the load on the wheel.

Another object of the invention is to provide an improved mechanism to control the operating fluid for the runner of an impulse water wheel having a nozzle through which a jet of operating fluid is directed towards the wheel, in which the nozzle structure and the controlling mechanism for the jet associated with the nozzle are movable as a unit under control of a governor mechanism responsive to load conditions of the impulse wheel.

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 an elevation, partly in section, of an impulse turbine installation embodying the present invention, the parts being shown in full load normal speed position;

Fig. 2 is a plan view of the structure shown in Fig. 1;

Fig. 3 is an enlarged elevation, partly in section, of a portion of the structure shown in Fig. 1, the parts being shown in full load rejection position;

Fig. 4 is a view similar to Fig. 3, the parts being shown in one quarter load normal speed position;

Fig. 5 is an enlarged elevation, partly in vertical section, of a portion of the needle operating and controlling mechanism;

Fig. 6 is an elevation of a portion of the structure shown in Fig. 5, the parts being shown in another operating position;

Fig. 7 is an enlarged view, partly in section, of a portion of the structure shown in Fig. 5; and

Fig. 8 is a detail view, partly in section, showing the manner in which the nozzle is pivotally connected to the inlet pipe.

Referring to the drawings, the apparatus may comprise an impulse wheel runner 11, mounted on a shaft 12 journalled in suitable bearings, one of the shaft bearings being indicated at 13, Fig. 2.

The runner 11 is enclosed by a casing 14 which may be, in some installations, arranged in the form of a housing over a pit 15 formed in a masonry structure, such as the concrete structure 16 shown.

Projecting into the pit 15 and arranged to discharge a jet of water towards the buckets 17 of the runner 11, is a nozzle 18, controlled by a needle valve 19.

The nozzle 18 is secured to a nozzle body 20 which is adapted to be pivotally connected to an end of a water supply pipe 21 in the manner hereinafter more fully described, so that the jet can be moved in a vertical path with respect to the buckets 17.

The water supply pipe 21 projects into one section 22 of the pit 15, and the extremity of said pipe is formed with a bell-end 23.

The interior of the bell-end 23 is formed with a spherical cavity 24 in which is mounted a correspondingly formed end portion 25 of the nozzle body 20.

The joint between the cavity 24 and the portion 25 may be sealed by means of a packing gland 26.

Mounted on the wall 27 of the pit section 22 and disposed on opposite sides of the pipe 21, are brackets 28.

Each bracket 28 supports a trunnion 29 on which is rotatably mounted the eye 30 of a bolt 31 carried by a boss 32 formed on the side of the nozzle body 20.

The shank of the bolt 31 has mounted thereon nuts 33.

The construction is such that the bolts 31 are detachably connected to the nozzle body 20, so that when the packing gland 26 is disconnected, the nozzle body can be readily assembled and disassembled from the pipe 21.

By disposing the trunnions 29 in the spaced relation shown in Fig. 2, the nozzle body 20 will be rigidly supported for true vertical movement for the purpose to be hereinafter more fully described.

Since the nozzle body is mounted for vertical swinging movement, it is necessary to provide some means for supporting the free end thereof so that the jet will be directed towards the buckets 17 of the runner 11.

In the present instance the nozzle supporting means is arranged so that such supporting means can be operatively connected with a gov-

ernor mechanism, generally indicated at 36, and mounted on the concrete structure 16 in proximity to the nozzle, as shown in Figs. 1 and 2.

Overlying the nozzle body 20 and arranged transversely thereof, is a shaft 37, which is supported by a plurality of bearings 38 mounted on the concrete structure 16.

Fixed to the shaft 37 and disposed at opposite sides of the nozzle body 20, are two arms 39.

Connected to the free end of each arm 39 by means of a pin 40, is the intermediate portion of a link 41. The lower end of the link 41 is pivotally connected by a pin 42, to the nozzle body 20.

Above the pivot 40, the link 41 is formed with a smaller portion 43 which projects upwardly and terminates at a suitable distance above the shaft 37.

Mounted in the upper ends of the portions 43 of the links 41 and arranged transversely of the nozzle body 20, is a rod 44, the purpose of which will be hereinafter more fully described (see Fig. 2).

At a point adjacent the governor mechanism 36, the shaft 37 has fixed thereto one end of an arm 46.

The free end of the arm 46 is connected by a rod 47, to the free end of an arm 48 keyed to an actuator shaft 49 of the governor mechanism 36.

It is to be understood that the governor mechanism 36, which is diagrammatically shown in the drawings, may be of any well known type of mechanism adapted to be used in connection with hydro-electric apparatus for controlling the supply of operating fluid to the runner in accordance with the load. In such apparatus the governor mechanism may be operatively connected with the shaft 12, or otherwise, whereby variations in load will be transmitted to the governor mechanism, the latter then operating, through shaft 49, mechanism by means of which the amount of fluid supplied to operate the runner is varied in accordance with changes in the load.

In the position of the parts shown in Fig. 1, the shaft 49, through the arm 48, the rod 47, the arms 46 and 39, and the links 41, retains the nozzle 18 in such a position that the jet of operating fluid strikes the center of the runner buckets 17. This position of the nozzle 18 is the uppermost position, and when the shaft 49 operates the above described leverage mechanism, the nozzle 18 is swung downwardly about the pivot provided by the trunnions 29. Since the arms 39 and 46 are keyed to the shaft 37, the angular relationship of these arms never changes and consequently said arms constitute bell crank levers which turn about the axis provided by the shaft 37.

The needle valve 19 is formed with a stem 51 which extends through a stuffing box 52 (Fig. 5) carried by the nozzle body 20.

Associated with the needle valve 19 is a control mechanism, generally indicated at 53. This control mechanism is so arranged as to automatically control the operation of the turbine, whereby the turbine will operate in the most efficient manner irrespective of variations in the load.

As shown in Fig. 5, the control mechanism 53 may comprise a servo motor 54 including a piston 55 operating in a cylinder 56 and connected to the valve stem 51.

Fluid under pressure may be admitted so as to act on either side of the piston 55 and the admission of this fluid may be controlled by means of a distributing valve 57 shown as having a pair of piston valves 58 and 59 operating in a cylinder 60. The valves 58 and 59 may be operated by means of a stem 61.

The valves 58 and 59 divide the cylinder 60 into chambers 62, 63 and 64. Chamber 63 is connected to a source of supply of fluid pressure (not shown), through port 65 and pipe 66.

Chambers 62 and 64 are connected, respectively, by ports 67, 68 and pipes 69, 70, to the usual sump tank (not shown) with which apparatus of the present type is usually provided.

The cylinder 60 is provided with ports 71 and 72.

Port 71 is connected to chamber 73 on one side of the piston 55 by a passage 74, and port 72 is connected to chamber 75 by a passage 76.

The valves 58 and 59 are shown in their neutral position, in which position they lap the ports 71 and 72 to thereby cut off communication between the valve device 57 and the servo motor 54.

The stem 61 is connected to a floating lever 77 intermediate the ends of said lever.

One end of the lever 77 is connected to the needle valve stem 51, and the other end of the lever 77 is connected to a rod, indicated generally at 78.

As shown best in Figs. 5 and 7, at a suitable point outwardly from the lever 77, the rod 78 has a disk 89 fixed thereto. The purpose of the disk 89 will be hereinafter more fully described.

Beyond the disk 89, the rod 78 has a telescoping section so arranged that the end portion of the rod 78 farthest from the lever 77 can be telescoped during operation of the apparatus in the manner to be hereinafter more fully described.

The extreme outer section of the rod 78 is formed with an eye 79. The rod 44 heretofore referred to passes through the eye 79, as shown best in Fig. 2.

Extending rearwardly from the eye 79 is a tubular section 80 having an internal bore of a diameter to snugly receive the outer extremity of the rod 78.

Secured to the end portion of the tube 80, is a second tubular member 81 having an internal bore approximately equal to the diameter of the exterior of the tube 80.

The end of the tube 81 opposite to the end thereof which is secured to the tube 80 is formed with a bore 82 to snugly receive the rod 78.

The construction of the tubes 80 and 81 is such that spaced apart bearings are provided for supporting the outer portion of the rod 78. The relation of the tube 81 with respect to the tube 80 never changes, but the disposition of the end portion of the rod 78 within said tubes may change during the operation of the apparatus.

Fixed to the portion of the rod 78 which is disposed within the tube 81, is a collar 82.

Encircling the portion of the rod 78 which is disposed within the tube 81, is an expansible coil spring 83. One end of the spring 83 bears against the shoulder 84 provided by the end of the tube 80 which is disposed within the tube 81, and the other end of said spring bears against the collar 82, thereby retaining said collar normally in engagement with the shoulder 85 provided at the end of the tube 81. In such position the rod 78, as a whole, is in extended position.

During operation of the apparatus the rod 78 is telescoped, and during such movement the tube 80 moves towards the disk 89. At the same

time, the shoulder 85 is moved away from the collar 82 and the shoulder 84 is moved in the same direction towards the collar 82, thereby compressing the spring 83 (see Figs. 3 and 5).

Mounted on the nozzle body 20 is an electric motor 86, the shaft 87 of which carries a pinion 88 having teeth in meshing relationship with the teeth of a sector 91. The sector 91 is pivotally mounted at 92 on a pin carried by a bracket 93.

Fixed to the sector 91 and extending upwardly from the pivot 92, is an arm 94 which has mounted thereon a roller 95 adapted to engage the disk 89 during operation of the apparatus.

Electric current is adapted to be supplied to the electric motor 86, in order to operate said motor whereby the sector 91 is moved from the normal position shown in Fig. 6 to the position shown in Fig. 5 and vice versa.

In Fig. 1 the apparatus is illustrated as functioning in full load, normal speed position. In this operating position of the apparatus the jet from the nozzle 18 is directed towards the pitch diameter of the buckets 17 of the runner, and the needle 19 is in open position. The control mechanism 53 is in the position shown in Fig. 5.

In Fig. 3 the apparatus is illustrated in full load rejection position. That is to say, through the operation of the governor mechanism 36, the nozzle body 20 is swung about the pivot provided by the trunnions 29 so that the free end of the nozzle is moved downwardly. In this way the jet is moved away from the pitch diameter of the runner buckets 17.

In the movement of the nozzle from the position shown in Fig. 1 to the position shown in Fig. 3, since the roller 95 is in engagement with the disk 89, the relative position of the operating rod 78 with the control mechanism 53 remains unchanged, and consequently the needle 19 remains in the same relative position within the nozzle. In this way the size of the jet is not changed.

When it is desired to change the size of the jet, for instance, when there is a condition, such as one-fourth load, normal speed, as shown in Fig. 4, the electric motor 86 operates to move the sector 91 so that the roller 95 is disengaged from the disk 89. Through the action of the spring 83, the rod 78 is moved in the direction in which the floating lever 77 is swung about the fulcrum provided by the pivot 98, from the position shown in Fig. 5 to the position shown in Fig. 4. The distributing valve 57 is then operated to control the fluid in cylinder 56 so that the piston 55 is moved from the full line position to the dotted line position, Fig. 5, thereby partly closing the needle 19.

After the needle has been thus positioned the disk 89 will again engage the roller 95 thereby preventing further movement of the rod 78 and the floating lever 77 will move piston valves 58 and 59 to the lap position shown in Fig. 5, so that the fluid is bottled up in piston chambers 73 and 75, with the result that the needle 19 is held in its adjusted position.

In hydro-electric stations it is customary to provide a suitable switchboard (not shown). In addition to the switches on the switchboard for controlling the operation of the electric motor 86, there are also signal lights for indicating to an operator the relative position of the needle within the nozzle.

From the foregoing, it will be noted that a dual regulation or control mechanism has been provided.

The governor mechanism 36 regulates the relative position of the nozzle with respect to the pitch diameter of the blades of the runner 11, as well as the size of the jet.

For normal operation the entire mechanism is designed to assure a small variation of the pitch diameter between the full load and no load position and to move the jet completely out of the buckets in case of sudden load off (see Fig. 3).

In other words, for slow load on or off, the needle 19 will be actuated by the mechanism to slowly travel from normal speed no load to full load position and vice versa. The nozzle 20 will be oscillated very little and the governor arm 48 will also travel a small fraction of its stroke.

The dual regulation permits for the normal relationship of the mechanism, a very quick load off and a load on as fast as the pipe line pressure variation will permit.

If an instantaneous load on regulation is wanted which is out of the range of flywheel effect compatible with steady regulation, the relationship between the nozzle and the needle position can be changed in such a manner as to have the nozzle opening greater than required for the load. In other words, in Fig. 4, the nozzle is shown in the position in which a partial jet is directed towards the buckets 17.

Should the load suddenly increase, the needle 19 is operated to increase the size of the jet, and the nozzle body 20 is moved so that the jet, or at least a part of the jet, is directed away from the buckets (see Fig. 3). Now, with the jet out of normal pitch diameter position, the apparatus is ready to take an instantaneous increase of load corresponding to the difference between the actual load on the apparatus and the load corresponding to the nozzle opening.

Having thus described my invention, what I claim is:

1. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve, mechanism for adjusting the needle valve to control the amount of fluid delivered by said nozzle, a governor, means operatively connecting said governor with said nozzle for imparting swinging movement to the nozzle and including a bell crank lever, means for connecting the bell crank lever to said needle valve mechanism and including a telescoping rod, and means for actuating said rod independently of said governor to adjust the position of said needle valve with respect to said nozzle.

2. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve, a governor, means for controlling the position of said needle valve within said nozzle, mechanism for swinging said nozzle about its pivot, means operatively connecting said governor with said nozzle swinging mechanism, means operatively connecting said needle valve controlling means with said mechanism, and means for controlling the operation of said last named means so as to permit operation of said needle valve independently of the operation of said governor.

3. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve, a governor, a shaft, a bell crank lever keyed to said shaft, a link connecting an arm of said bell crank lever with said nozzle, means connecting the other arm of said bell crank lever with said governor so that operating movements of the governor are effective through said shaft, said bell crank lever and said link

for moving said nozzle, an arm projecting from said link, mechanism for controlling the position of said needle valve with respect to said nozzle so as to control the amount of fluid delivered from said nozzle and including a servo-motor operatively connected to said needle valve and a distributing valve for said servo-motor, said distributing valve having a stem, a floating lever connecting said valve stem to said needle valve, a rod connected at one end to said floating lever, means connecting the other end of said rod with said link arm, said rod comprising a rigid section connected to said floating lever and a telescoping section formed in the portion of the rod adjacent to said link arm, means for normally retaining the telescoping section of said rod extended, a disk mounted on the rigid section of said rod, a member engageable with said disk to hold the rigid section of said rod and permit telescoping movements of the other section of the rod when the governor operates the bell crank lever to swing the nozzle, and means for actuating said disk engaging member to move said member either out of or into engagement with said disk, said rod being adapted when said member is disengaged from said disk to transmit movements of said governor to said distributing valve to thereby effect a change in the position of said needle valve in the nozzle.

4. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve for controlling the supply of operating fluid, a governor, a shaft, a bell crank lever mounted on said shaft, a link connecting an arm of said bell crank lever with said nozzle, means connecting the other arm of said bell crank lever with said governor so that operating movements of the governor are effective to move said nozzle, an arm projecting from said link, mechanism for controlling the position of said needle valve with respect to said nozzle so as to control the amount of fluid delivered from said nozzle, and including a servo-motor operatively connected to said needle valve and a distributing valve for controlling the operation of said servo-motor, a floating lever connected to said needle valve, a rod connected at one end to said floating lever, means connecting the other end of said rod with said link arm, said rod comprising a rigid section and a telescoping section, means for normally retaining the telescoping section of said rod extended, a disk mounted on the rigid section of said rod, a member engageable with said disk to hold the rigid section of said rod and permit telescoping movements of the other section of the rod when the governor operates the bell crank lever to swing the nozzle, and means for actuating said disk engaging member to move said member either out of or into engagement with said disk, so as to operate the distributing valve to change the position of said needle valve in the nozzle.

5. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve for controlling the supply of fluid discharged therefrom, a governor, a shaft, a bell crank lever keyed to said shaft, a link connecting an arm of said lever with said nozzle, means connecting the other arm of said lever with said governor so that operating movements of the governor are effective to swing said nozzle, an arm projecting from said link, mechanism for controlling the position of said needle valve with respect to said nozzle so as to control the amount of fluid delivered by said nozzle, means connecting said arm with said needle valve mechanism, and means controlling the operation of said connecting means so that said needle valve mechanism can be operated either independently of the governor or simultaneously with the governor.

6. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve for controlling the supply of fluid discharged therefrom, a governor, a shaft, means keyed to said shaft and operated by said governor for moving said nozzle, an arm projecting from said shaft means, mechanism for controlling the position of said needle valve with respect to said nozzle, and including a servo-motor operatively connected to said needle valve and a distributing valve for controlling the operation of said servo-motor, a floating lever connected to said distributing valve, a rod connected at one end to said floating lever, means connecting the other end of said rod with said arm, said rod comprising a rigid section and a telescoping section, formed in the portion of the rod adjacent to said arm, means for normally retaining the telescoping section of said rod extended, a disk mounted on the rigid section of said rod, a member engageable with said disk to hold the rigid section of said rod and permit telescoping movements of the other section of the rod when the governor operates the shaft means to swing the nozzle, and means for actuating said disk engaging member to move said member either out of or into engagement with said disk, said rod being adapted when said member is disengaged from said disk to transmit movements of said governor to said distributing valve to thereby effect a change in the position of said needle valve in the nozzle.

7. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve, a governor, a shaft, a bell crank lever keyed to said shaft, a link connecting an arm of said bell crank lever with said nozzle, means connecting the other arm of said bell crank lever with said governor so that operating movements of the governor are effective for moving said nozzle, mechanism for controlling the position of said needle valve with respect to said nozzle, and including a servo-motor operatively connected to said needle valve and a distributing valve for controlling the operation of said servo-motor, a rod connected at one end to said distributing valve, means connecting the other end of said rod with said link, said rod comprising a rigid section and a telescoping section formed in the portion of the rod adjacent to said link, means for normally retaining the telescoping section of said rod extended, a disk mounted on the rigid section of said rod, a member engageable with said disk to hold the rigid section of said rod and permit telescoping movements of the other section of the rod when the governor operates the bell crank lever to swing the nozzle, and means for actuating said disk engaging member to move said member either out of or into engagement with said disk, said rod being adapted when said member is disengaged from said disk to transmit movements of said governor to said distributing valve.

8. In a device of the type described, a nozzle mounted for vertical swinging movement and having a needle valve for controlling the supply of fluid discharged therefrom, a governor responsive to load conditions, a shaft, a bell crank lever keyed to said shaft, a link connecting an

arm of said bell crank lever with said nozzle, means connecting the other arm of said bell crank lever with said governor so that operating movements of the governor are effective for moving said nozzle, mechanism for controlling the position of said needle valve with respect to said nozzle, a rod connected at one end to said mechanism, means connecting the other end of said rod with said link, said rod comprising a rigid section and a telescoping section formed in the portion of the rod adjacent to said link, means for normally retaining the telescoping section of said rod extended, a disk mounted on the rigid section of said rod, a member engageable with said disk to hold the rigid section of said rod and permit telescoping movements of the other section of the rod when the governor operates the bell crank lever to swing the nozzle so that such governor movements are ineffective on said needle valve, and means for actuating said disk engaging member to move said member out of engagement with said disk, so that movements of said governor may be transmitted to said mechanism to thereby effect a change in the position of said needle valve in the nozzle.

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