Jan. 2, 1934. J. LELL 1,941,845

MEANS FOR THE OPERATION OF PUMPING ACCUMULATOR PLANTS

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Fig: 1.

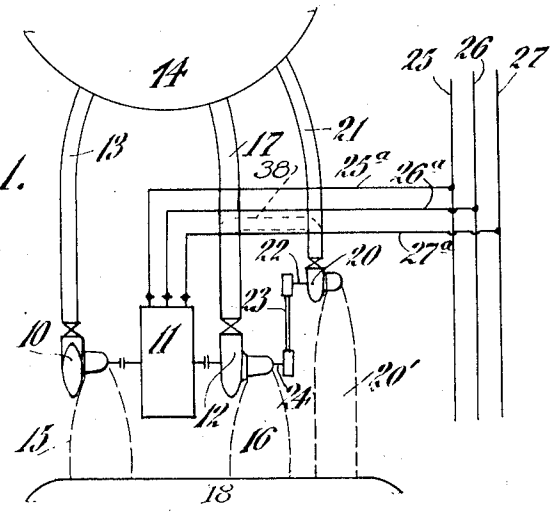


Fig: 2.

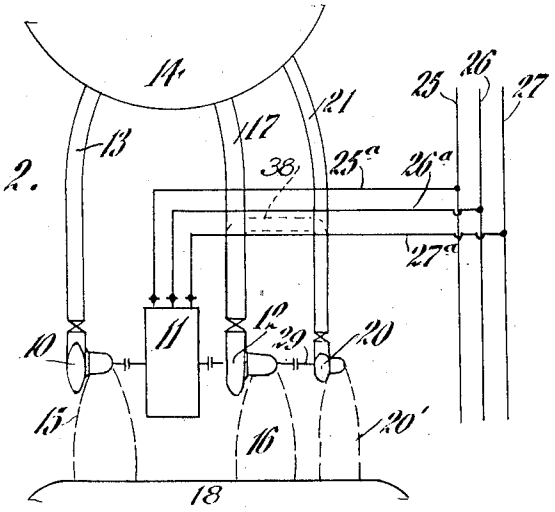
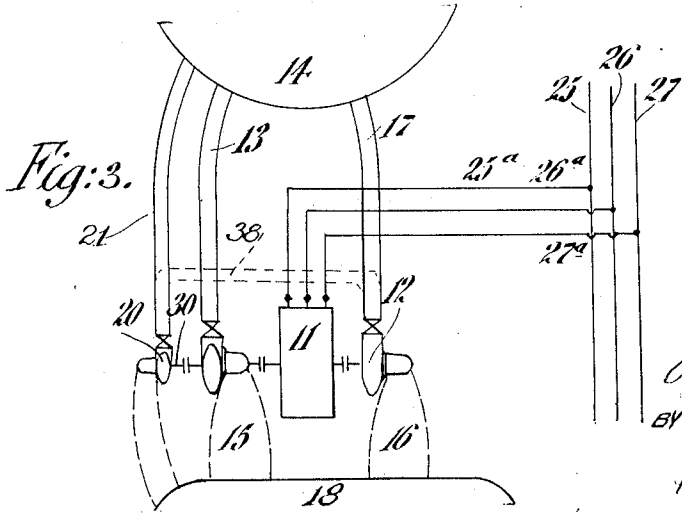


Fig: 3.



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Fig. 4.

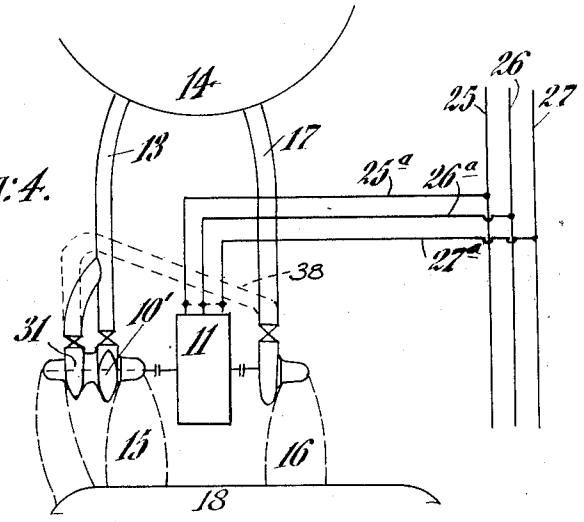


Fig. 5.

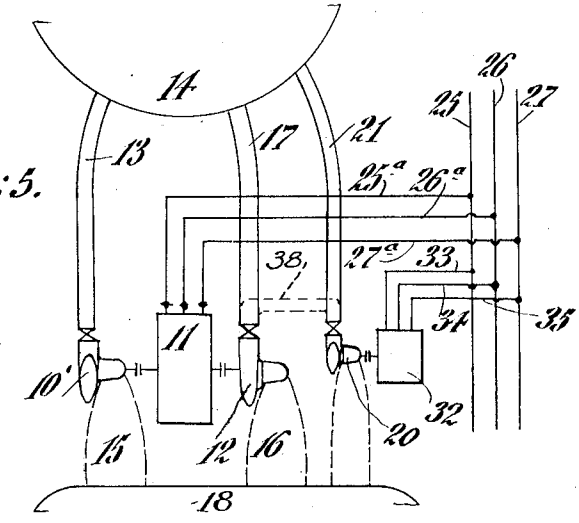
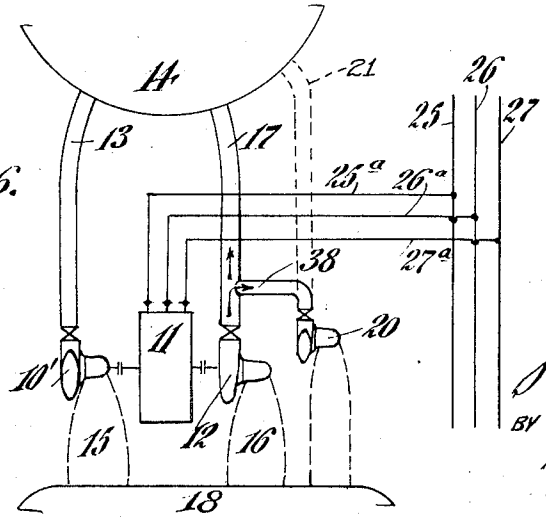


Fig. 6.



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UNITED STATES PATENT OFFICE

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MEANS FOR THE OPERATION OF PUMPING ACCUMULATOR PLANTS

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Application June 15, 1931, Serial No. 544,426, and in Germany June 23, 1930

5 Claims. (Cl. 290—4)

This invention relates to pumping accumulator plants. It is known that such plants consist, generally, of a turbine operated by water received from a suitable head, an electrical machine driven by the turbine to generate electrical energy and which at the same time can function as a motor for the production of mechanical power, and a pump which is driven by this motor to pump water into the upper reservoir, (which serves as a pressure head), from a lower reservoir (as, for instance, the tail water of the turbine), at times when there is an extra supply of electrical energy, whereby such water, pumped to the upper reservoir may, by direct action, serve to drive the turbine and thus to generate power.

With the described arrangement, it has been found that at certain times the pump does not perform its full office in the system because it is not driven to capacity due to the lower power in the circuit or net; and while it may be possible to maintain the pumping action at less than capacity, this lessened action must be accomplished by regulating the power, which is done, as a rule, by decreasing the flow openings in the pump or, by partly closing a valve in the pressure conduit, that is, by throttling down the pump. It is known that by such methods of regulation great energy losses result, and that the control appliances are subjected to considerable strains which frequently give rise to vibrational shocks to the pump, and these readily transform themselves into important injuries to the entire plant. Furthermore, by such methods of regulation, the motive power for operating the pump and hence the ability of the pump to maintain the system decreases accumulatively with each downwardly throttling action. It is quite essential to operate the pump at all times, when it is being operated, at its full capacity in order not to subject the entire plant to damage and costly decrease in efficiency.

Various proposals to solve this difficulty and to maintain the quiet operation of the pump, have met with little success.

The object of the invention is to provide methods and means to overcome these difficulties.

For this purpose, the invention consists in combining with pumping accumulator plants, means to maintain constant the pumping efficiency of the pump, and the novel method consists in so cooperatively operating the assembled mechanical elements to maintain constant the working efficiency of the pump of the pumping accumulator plant.

The invention will be further described in connection with certain embodiments thereof shown in the drawings, and finally claimed in the appended claims.

In the accompanying drawings:—

Figure 1 is a diagrammatic view of a pumping accumulator plant, showing one embodiment of my invention applied thereto;

Figures 2 to 6 show similar views, each presenting a different embodiment, and the embodiment shown in Fig. 6 may be applied in the manner shown in Figures 1 to 5.

Similar characters of reference show corresponding parts throughout the various views.

Referring to the drawings and more particularly to Figure 1, the known pumping accumulator plant consists of a turbine 10, a generator and motor 11, and a pump 12. The turbine 10 is coupled to the generator 11, and the generator-motor 11 is coupled to the pump 12. The turbine 10 is connected with a supply conduit 13, leading from a supply reservoir 14, and is connected with a tail water conduit 15 discharging into the tail water reservoir 18. The pump 12 is connected with a conduit 16 leading to the tail water reservoid 18, and is also connected with a conduit 17 through which water is supplied to the reservoir 14. Such an arrangement of known parts is shown in each of the drawings.

In Figure 1, one embodiment of my invention is shown in that a supplementary turbine 20 is provided which receives its water supply from the upper reservoir by a conduit 21 and is connected by a tail water conduit 20' with the reservoir 18. By suitable power transmission mechanism 22—23—24, mechanical energy is transmitted from the turbine 20 to the pump 12, so as to compensate for any deficiency in power resulting from less than full electrical energy in the circuit or net 25—26—27, connected to drive the motor 11, by conductors 25*a*, 26*a*, and 27*a*. Any suitable power transmission means may be substituted for the disclosed transmission parts 22—23—24. In this case, the turbine 10 can be uncoupled from the generator 11; or it may remain coupled for idle operation.

In Figure 2, the additional turbine 20 receives its water supply through the conduit 21. In this example, however, the shaft of turbine 20 is made common with the shaft of the pump 12; that is to say, the turbine 20 and pump 12 have a common shaft which is indicated at 29. Whatever deficiency may exist in the electrical power circuit 25—26—27, and in the effect upon the motor 11, is made up by the effect of the additional turbine

20, all in a manner as described in connection with the example shown in Figure 1.

Instead of placing the additional turbine upon a shaft common with that of the pump, the additional turbine 20 may be arranged upon the main turbine shaft 30, as shown in Figure 3, whereby to aid the effect of the main turbine, and as the pump shaft is coupled to the turbine through the intermediary of the generator-motor shaft, the full effect upon the pump shaft and hence the full working effect of the pump are attained. Instead of having the two turbines separate from each other, the special turbine may be made as a part 31 of the main turbine 10', as shown in Figure 4.

In another embodiment, the special turbine 20 is again arranged free of the main turbine, and is now connected with an additional generator 32, either by a common shaft or any other mechanical transmission and the additional generator supplies its generated power to the circuit 25—26—27, as shown in Figure 5, thereby augmenting the power of the same, and the joint power then operates the motor 11 and hence the pump 12 at its full pumping capacity. The conductors 33—34—35 of the additional generator supply the additional power into the supply net and thus augment the power supplied to the generator 11.

In the foregoing embodiments, the additional turbine is supplied with water pressure through a conduit 21 connected with the upper reservoir 14.

The additional turbine 20 may be supplied with water directly from the pump 12 by means of a branch pipe 38, connected with the conduit 17 at or near the discharge of the pump into said conduit 17, as shown in Figure 6. The power generated from this additional turbine 20 may then be transmitted: either, as shown in Figure 1, by having the turbine 20 separate from the pump shaft but connected by suitable intermediate means; or, as shown in Figure 2, by having the additional turbine shaft common with the pump shaft; or, as shown in Figure 3, by having the additional turbine shaft common with the main turbine shaft; or, as in Figure 4, with the two turbines combined; or, as in Figure 5, with the additional turbine combined with an additional generator, These arrangements are not specially shown, as they may be fully comprehended from an inspection of Figures 1 to 5, in connection with Figure 6.

When the special turbine is formed as a part of the main turbine as stated, these turbines can be arranged in the form of two or more separate turbines connected with each other. The subdivision of energy necessary to make up the deficiency, is so arranged that the energy deemed necessary to be covered is brought into being either from the smaller or the larger additional turbine, or from the entire main turbine, depending upon the amount of additional energy required, taking the smaller turbine when there is a relatively small deficiency or the larger turbine when there is a relatively large deficiency. In each case that particular turbine or combination of turbines, is used, whether larger or smaller, which will produce the required amount of energy with the best results as to efficiency. Thus the fluctuations in the electrical energies applied to the motor of the pump can be compensated by the use of the turbine or combination of turbines just described. As the danger of corrosion does not exist in turbines even when operated at considerably less than their full load, the main turbine when divided into single turbines can take over the fluctuations of the system without harm. On the other hand, such fluctuations acting directly upon the pump would be distinctly injurious.

By the invention described there can be provided an operative condition, by which the pump receives a constant motive power and can operate at all times at its best efficiency.

It is thus seen that the invention provides a method and means for covering by means of an additional or special turbine, the energy which is not available from the power net to drive the pump at full capacity, this turbine being fed by the water of the upper reservoir, or from the pressure produced by the pump, and thereby the pump is supplied with the energy necessary to operate it at all times at full load.

It is of course known that in plants of this kind, the pump is usually operated from the electrical circuit during the night or at such times when surplus power is available from the transmission or distribution lines, that is, when the power is cheap. Usually, when the main turbine operates to generate electrical power in the generator to supply the transmission or distribution lines, the pump is not pumping. At such times when the pump is being operated to pump, and the electrical energy of the circuit is too low to give the pump its full pumping capacity, then the before-described invention comes into effect.

I have described various embodiments of my invention, but other embodiments will make themselves apparent to one skilled in the art. The principle of the invention is the maintenance in a pumping accumulator plant, of a constant motive power upon the pump to operate it at all times at full load by the instrumentality of the means described, as defined in the appended claims.

I claim:

1. In a pumping accumulator plant comprising a pump, a generator-motor operating said pump and supplying electrical current to power lines, and a turbine operating said generator-motor; an additional water turbine supplied by said pump and operatively connected therewith to compensate for deficiency in the power net, to operate said pump at substantially full load, and thereby maintain maximum operating efficiency of the pump.

2. In a hydro-electric accumulator plant having a turbine operated generator-motor and a pump operated by said motor; an additional turbine adapted to be coupled with the pump and operable to compensate for the deficiency in current supply for the generator-motor upon occasions of heavy demand to thereby operate the pump at maximum capacity and water supply connections between both of said turbines of a common water head.

3. In a pumping accumulator plant comprising a turbine, generator-motor, and pump, the combination therewith of an additional turbine supplying a power sufficient to make up the deficiency between that needed to operate the pump at substantially full load and that of the power net which operates the motor, in which the added turbine is operated directly by the water pressure produced by the pump.

4. In a pumping accumulator plant comprising a turbine, generator-motor, and pump, the combination therewith of an additional turbine supplying a power sufficient to make up the deficiency

between that needed to operate the pump at substantially full load and that of the power net, which operates the motor, in which the additional turbine is axially displaced from the pump and operatively connected by mechanical means with one end of the pump shaft.

5. In a pumping accumulator plant comprising a turbine, generator-motor, and pump, the combination therewith of an additional turbine supplying a power sufficient to make up the deficiency between that needed to operate the pump at substantially full load and that of the power net which operates the motor, in which the main and additional turbines are united to form independently controllable twin turbines driving a common shaft.

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