F. W. BALLARD.

HYDRO-ELECTRIC POWER PLANT.

APPLICATION FILED JUNE 16, 1909.

958,578.

Patented May 17, 1910.

2 SHEETS—SHEET 1.

Fig. 1

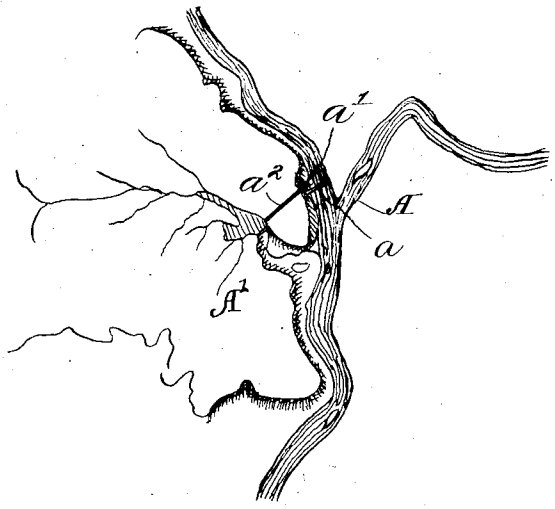

Fig. 2

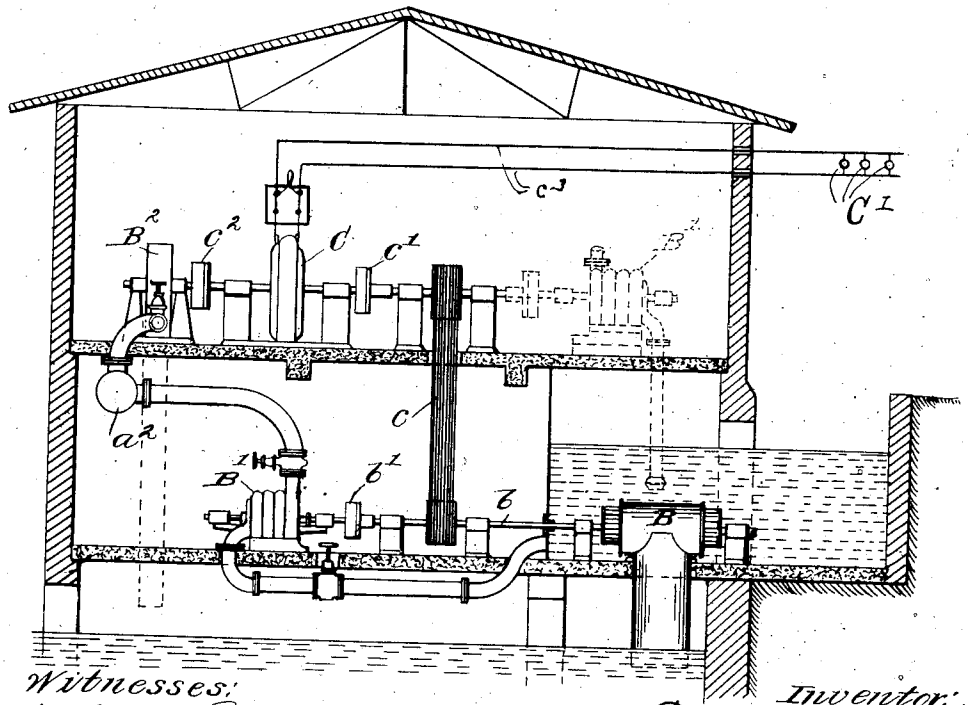

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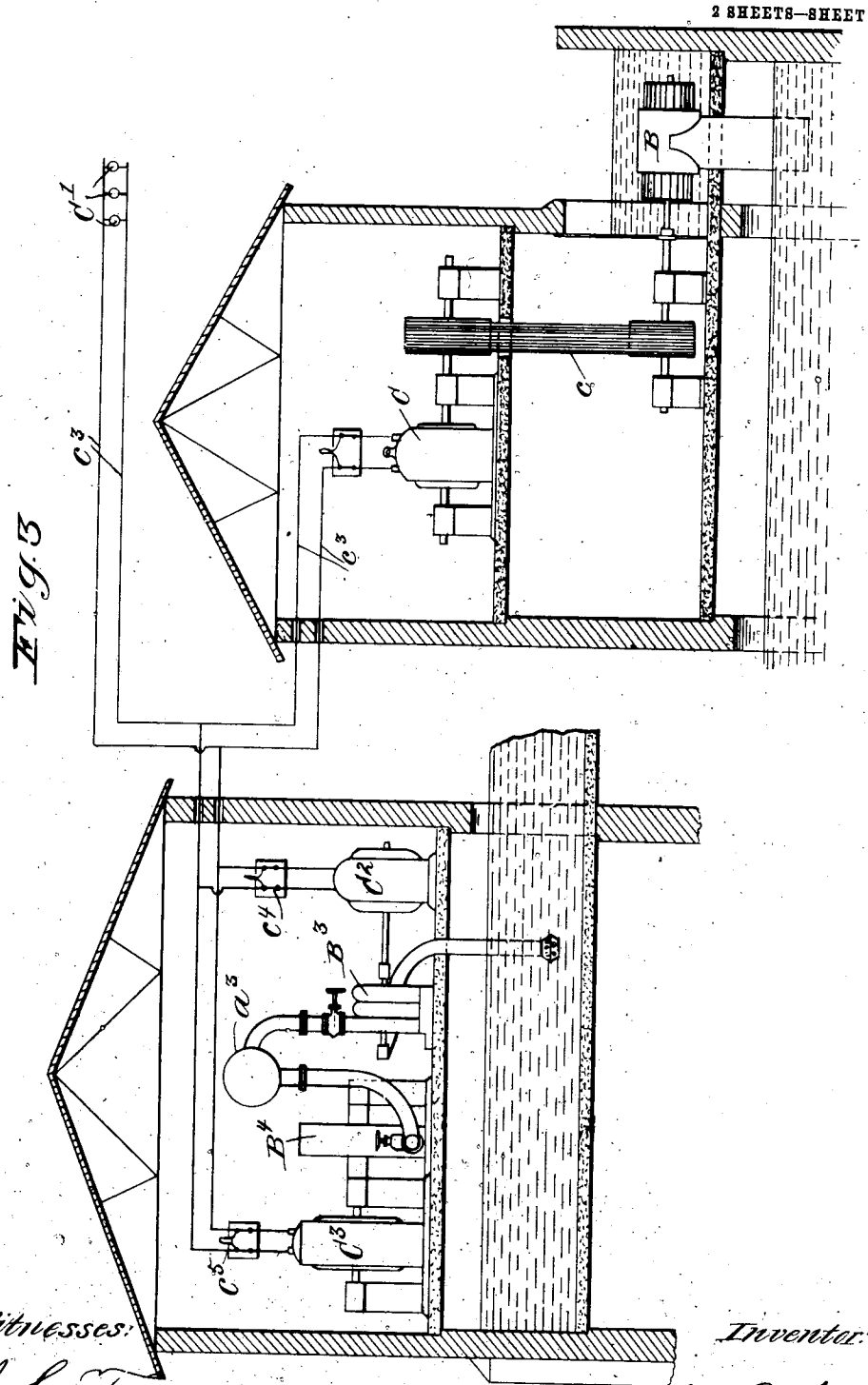
Fig. 3



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UNITED STATES PATENT OFFICE.

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HYDRO-ELECTRIC POWER PLANT.

958,578. Specification of Letters Patent. Patented May 17, 1910.

Application filed June 16, 1909. Serial No. 502,416.

To all whom it may concern:

Be it known that I, FREDERICK W. BALLARD, a citizen of the United States, and a resident of Cleveland Heights, county of Cuyahoga, and State of Ohio, have invented a new and useful Improvement in Hydro-Electric Power Plants, of which the following is a specification, the principle of the invention being herein explained and the best mode in which I have contemplated applying that principle so as to distinguish it from other inventions.

In the development of power from a fluctuating water supply of relatively low head, as for example, from a river or like stream having a gradual fall and limited storage capacity, it often becomes necessary to furnish additional power during low water periods in the summer time, or times of drought, as also in times of flood when the hydraulic installation utilized in developing such power is apt to be "drowned out," that is the available head is very much reduced by the backing up of water in the tail-race. In the prevailing practice, such additional power is generally furnished by a steam auxiliary plant which is objectionable both because of the cost of operation and the large initial expenditure involved in installing such steam plant and maintaining the same in operative condition.

By the present invention I propose to obviate the difficulties heretofore encountered in furnishing such additional power to hydraulic installations of the kind in question, by utilizing any excess of the supply of water at the plant to raise water to a relatively high head and then employing the water thus raised as an auxiliary source of power when such main supply is deficient.

To the accomplishment of this object, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

The annexed drawings and the following description set forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings:—Figure 1 represents topographically a power development system embodying my several improvements; Fig. 2 is a sectional view, more or less diagrammatic in character, representing one approved form of hydraulic installation embodying such invention for use in connection with such system; and Fig. 3 similarly represents an alternative form of installation.

Referring first of all to Fig. 1, the river A there appearing, is of the general class previously referred to, wherein a fluctuating water supply of relatively low head is available for power development purposes. By means of a dam *a* or the like, such relatively low head is utilized in a hydraulic installation located at *a'*. Located on a mountain or high hill in the vicinity of such hydraulic installation is a storage reservoir A', the effective head of which is considerably greater than that of the water in the river at *a*. My method of developing power then, consists as has been indicated, in substantially absorbing the supply normally available at *a* in the generation of power, utilizing any excess of such supply to raise water to such storage reservoir A', and then employing the water thus raised as an auxiliary source of power when the supply at *a* is deficient.

In the plant illustrated in Fig. 2, both hydraulic installations, viz. the one operating at the lower head of the river, and the one operating at the higher head of the storage reservoir, are housed together. A turbine wheel B of the usual type will ordinarily be employed in the first installation, while a Pelton or other impulse wheel operating at high pressure will be used in connection with the supply from the storage reservoir. As shown in said figure of reference, I mount a pump B' of centrifugal type in alinement with the shaft *b* of the turbine, so that by means of a suitable clutch *b'*, said pump may be connected or disconnected as desired. A main a^2 leading from said pump to the storage reservoir A', serves equally to conduct the water delivered by the pump when in operation, and to return such water for use in connection with the impulse wheel B^2 that operates at the higher head of the storage reservoir. Such impulse wheel is conveniently mounted in alinement with the generator which is adapted to be driven from the turbine through intermediate belting *c*, clutches *c'* c^2 being provided between the generator and said turbine and impulse wheel respectively, whereby the generator may be driven by

either or both of said wheels. The centrifugal pump B′ for raising the water to the higher elevation of the storage reservoir may likewise be placed in alinement with the generator if desired, as shown in dotted outline to the right in the figure under consideration. Said pump whatever its location is designed to be operated whenever the full output of the plant is not required. Certain of the generating units, of which one is represented by the generator C just described, are then shut down, and the corresponding pump connected to be operated from the turbine. Conversely, in times of low water, drought, or in times of flood, when the capacity of the hydraulic installation operating at low head, is not sufficient to meet the demands for power, the clutch connecting the impulse wheel with the generator will be closed, the turbine being at the same time disconnected. Water from the main a^2 leading to the storage reservoir is now supplied to such impulse wheel and the generator operated by means of the power which has been stored in such reservoir. In case some power is still available from the turbine wheel, the latter, of course, can be left connected and both sources of power simultaneously utilized. It will be understood, of course, that it is frequently desirable in plants of this sort, to have available an auxiliary power supply for short periods of time during the day when the demand for power might be greater than the capacity of the power plant, in order to meet what is known as the "peak load". When this is the case, the storage reservoir may be drawn upon equally as well as in the instances just discussed.

In the modified form of plant illustrated in Fig. 3, I show the adaptation of my invention to a location where a reservoir cannot be located sufficiently near to the hydraulic installation operating at low head to render feasible the direct pumping of the water from such installation into the reservoir, because of the long and expensive water mains that would be required, and the frictional loss encountered in forcing the water through such distance. Under these circumstances, it is contemplated that it will be more economical to transfer the excess power, that the first installation is capable of developing at times, in the form of electricity to the second installation, and there utilizing such current to pump water to the storage elevation from some local source of supply. Accordingly the two installations respectively operating at the different heads are here shown as separately housed, and may possibly be located a number of miles apart. The low pressure installation consists, as before, of a turbine wheel B connected to drive a generator C, the leads c^2 from the latter being connected both with the translating devices C′, for which it is the object of the plant to supply power, and with a motor C^2 in the second installation. Motor C^2, when connected with leads c^3, is arranged to operate a pump B^3, corresponding with pump B′ of Fig. 1, to raise water through a main a^3 to an adjacently located storage reservoir (not shown). From such reservoir the water thus raised is in turn adapted to be withdrawn through the same main a^3, and supplied to an impulse wheel B^4 connected to drive a second generator C^3 which latter can be connected in the same circuit c^3 as the generator C of the first installation and the motor C^2 of said second installation, when the latter is employed in utilizing the excess power from the first installation. The mode of operation with such modified arrangement of plant will obviously be substantially the same as that previously described in connection with the first form of plant. In utilizing the stored power in the reservoir as an auxiliary, the impulse wheel in the second installation is provided with water under the high head of such reservoir. Under these circumstances, the switch c^4 to the motor is opened and that c^5 to the generator C^3 closed. Current is accordingly transmitted back through the electric circuit, this generator being run, in other words, in parallel with the generator in the first installation to supply power to the electric circuit for the power distribution system. As before, either installation may be here employed by itself, or, if desired, both may be used simultaneously, as the exigencies of the water supply at the first installation may demand; furthermore such second installation is obviously available in case the generators in the first installation are entirely shut down, due to accident or other cause than mere failure of the water supply.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. A power plant comprising a hydraulic installation operable at a relatively low head, a second hydraulic installation operable at a relatively high head, and means for utilizing excess power developed at the first installation to raise water to such relatively high head for use in said second installation.

2. A power plant comprising an electric generator, a hydraulic installation operable at a relatively low head and adapted to drive said generator, a second hydraulic installation operable at a relatively high head and likewise adapted to drive said generator, and

means adapted to be operated by said first installation to raise water to such relatively high head for use in said second installation.

3. The combination with power absorbing means, of a plant for supplying power thereto, comprising a hydraulic installation operable at a relatively low head, a second hydraulic installation operable at a relatively high head, each of said installations being adapted to actuate said power absorbing means, and means adapted to be operated by said first installation to raise water to such relatively high head for use in said second installation.

4. The combination with an electric-supply system, of a power plant for supplying current thereto, comprising current-generating means, a hydraulic installation operable at a relatively low head, a second hydraulic installation operable at a relatively high head, each of said installations being adapted to actuate said current-generating means, and means adapted to be operated by said first installation to raise water to such relatively high head for use in said second installation.

5. The combination with an electric-supply system, of a power plant for supplying current thereto, comprising an electric generator, a hydraulic installation operable at a relatively low head and adapted to be coupled to said generator, a second hydraulic installation operable at a relatively high head and likewise adapted to be coupled to the same generator, and means adapted to be operated by said first installation to raise water to such relatively high head for use in said second installation.

Signed by me this 14th day of June, 1909.

FREDERICK W. BALLARD.

Attested by—
ANNA L. GILL,
JNO. F. OBERLIN.