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W. J. CLARK.

SYSTEM OF POWER GENERATION AND STORAGE.

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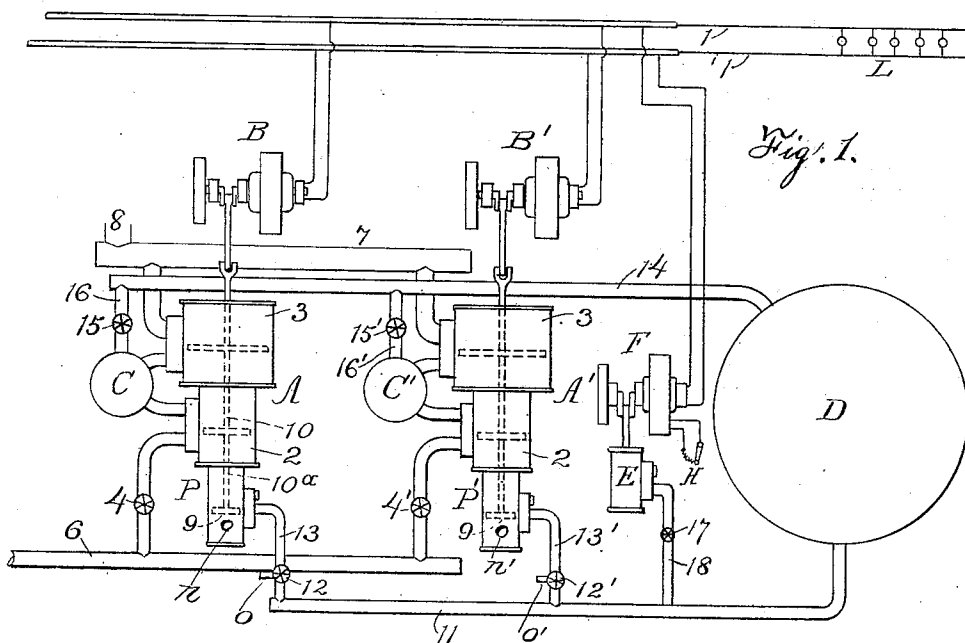
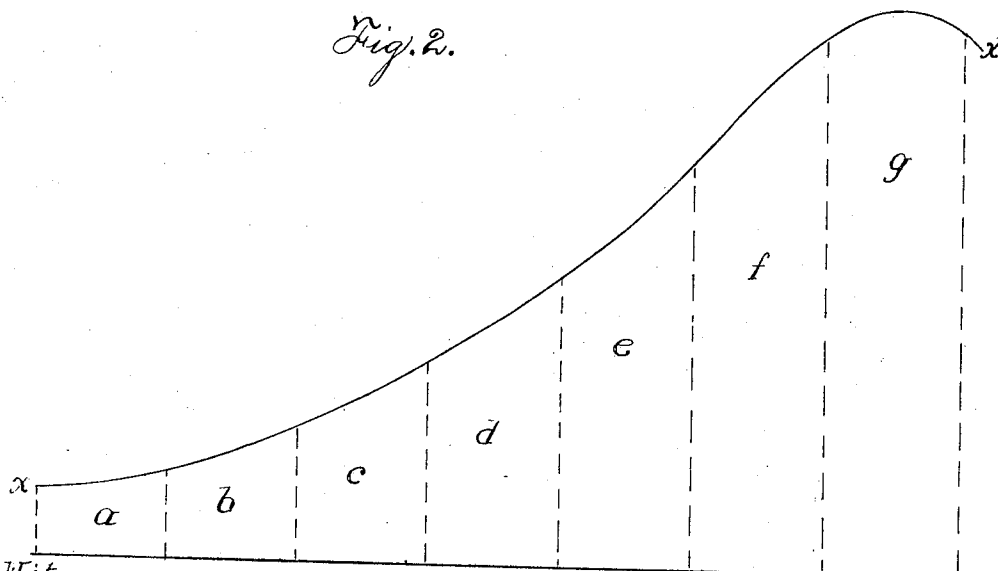


Fig. 1.

Fig. 2.



Witnesses:

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SYSTEM OF POWER GENERATION AND STORAGE.

No. 826,313.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, WILLIAM J. CLARK, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Power Generation and Storage, of which the following is a specification.

This invention relates to improvements in power generation and storage; and its object is to provide a steam-power plant with an auxiliary means of storage of energy in a fluid-pressure reservoir, such fluid being stored under pressure by the superfluous power of the steam-engines of the plant when the load is light and the fluid so stored being delivered to the steam-engines to increase the power of same when the load is excessive. Thus in applying my invention to the usual electric-lighting plant, where a plurality of steam-engines or steam-power units operate dynamos connected in parallel to a working circuit, I provide one or more of the engines with a pump which is brought into operation at times when the load is less than corresponds to the number of steam-power units in operation to compress air into a reservoir, and I also provide means whereby this compressed air may be supplied to the steam-engines as an auxiliary motive fluid under conditions of excessive load—that is to say, at the so-called “peak of the load.”

In the accompanying drawings, which form a part of this specification, Figure 1 is a diagrammatic representation of a steam-power plant with my auxiliary storage means applied thereto. Fig. 2 illustrates a load diagram with the various steps of storage and delivery of compressed air indicated thereon.

The steam-power plant illustrated in Fig. 1 comprises the two steam-engines A and A' and the two dynamos B and B', driven thereby, feeding in parallel into the working circuit 1 1, which includes the load L. Each of said steam-engines will usually be of the compound type, comprising a high-pressure cylinder 2 and a low-pressure cylinder 3, a receiver C or C' being interposed, as usual, in the connection between such cylinders. The respective high-pressure cylinders are connected, through the valves 4 4', with the steam-main 6, and a connection 7 leads from the low-pressure cylinders to the exhaust-stack 8. All the above elements, with the appropriate valves, &c., are of the usual construction and arrangement and need not be fur-

ther described. There may be any number of steam-power elements.

Mechanically connected to each of the steam-engines A or A' is an air-pump P or P', the piston 9 of which may be carried by an extension 10^a of the piston-rod 10 of the steam-engine. These pumps are provided with the usual valves and are connected, through pipe 11, to a fluid-pressure reservoir D, valves 12 12' being interposed in the connections 13 13' between the pumps P P' and the pipe 11. From this reservoir D a pipe 14 runs to both of the steam-engines A A', valves 15 15' being arranged in the respective connections 16 16' between the air-pipe 14 and the engines A A'. The connections 16 16' preferably lead to the receivers C C', intermediate between the high and low pressure cylinders of the steam-engines. It is desirable that the valves 12 12', controlling the outlet of the air-pumps P P', should be three-way valves, which when turned to shut off the connection to the reservoir will open outlets (indicated at o o') to the outer air, so that the pumps will then run freely. The intakes of the pumps are indicated at n and n', respectively.

I will now explain the operation of my invention with the aid of the diagram in Fig. 2, wherein the curved line x x represents the load-curve or curve of power delivered by the engines to the working circuit, it being understood that the operator in charge of the plant watches the load on the external circuit, as shown by suitable indicating means, and manipulates the valves 17 4' 4 15 15' to vary the operation, as hereinafter set forth.

Assuming the load to be at a minimum, so as to be considerably less than the capacity of either of the steam-power units A A', then only one of these units, as A, is connected to the steam-main, and the pump P, connected to such unit, is brought into operation by establishing connection from same through valve 12 with reservoir D, so as to run air under pressure into this reservoir. This condition corresponds to section a of the load-diagram in Fig. 2. When the load increases to a point commensurate with the capacity of engine A, (section b in Fig. 2,) the pump P is disconnected. In Fig. 2 the load is shown increasing continually to a maximum limit, and the capacity of the power plant is therefore increased correspondingly by the following steps: When the load exceeds the capacity of a single engine A, the steam is turned

on to the other engine; but as this gives a power far in excess of the increase of load indicated in section *c* of Fig. 2 both the pumps *P P'* are brought into operation to compress air in the reservoir *D*. As the load increases the pump *P'* may be disconnected, (section *d*,) and then on the further increase of load both pumps may be disconnected, (section *e*.) The steam-engines are now working directly on the load, which absorbs their full capacity. On further increase of the load, which is assumed to occur at a maximum of short duration, termed "peak of the load," the engines would be temporarily overloaded to a dangerous or even prohibitive extent unless their normal capacity is made largely in excess of the usual working requirements. To avoid this, I arrange to deliver the stored air in reservoir *D* to such a point in one or both of the engines *A A'* that the power of such engines is temporarily increased. The pressure in air-reservoir *D* may be maintained at a point above the average working pressure of the low-pressure cylinder, so that when the compressed air from said reservoir is admitted into one or both of the receivers *C C'* it will increase the pressure in the low-pressure cylinder and correspondingly aid the engine in overcoming the excessive temporary load. As is well known, the pressure in receivers *C C'* fluctuates, being equal to the back pressure of the high-pressure cylinder previous to the opening of the entrance-port into the low-pressure cylinder, and upon the opening of the port of the low-pressure cylinder and after the piston in said low-pressure cylinder has commenced its stroke the pressure in the receiver falls off. At this point the compressed air admitted to the reservoir becomes effective in aiding the engine. Thus during the time corresponding to section *f* of Fig. 2 the air-pressure is admitted to receiver *C* of engine *A*, and at the maximum or peak of the load *g* the air-pressure is admitted to the receivers *C C'* of both engines *A A'*. The compressed air mixes with the steam in the receivers, and the mixture passes to the low-pressure cylinder of the engine or engines. The pressure of the compressed air in reservoir *D* is considerably less than that in the boiler and, in fact, should be about equal to the normal back pressure in the high-pressure cylinder, so that there is no tendency of the air to pass through or into the high-pressure cylinder. The air-pump is put out of action whenever the pressure rises above this point. This invention therefore enables a steam-power plant of a given capacity to run temporarily on a load far exceeding such capacity on power stored up during intervals of light load. It also enables the throwing in or out of a steam-power unit without a sudden change in the ratio of power to load, as the difference is largely absorbed in the pump.

I have also shown in Fig. 1 an additional means of storage and modification of load and power relation consisting of an air-engine *E*, capable of acting as a pump or as a motor connected through pipe 18, containing valve 17, to the pipe 11 and the reservoir *D*. Said pump or engine *E* is operatively connected to a dynamo-electric machine *F*, which is connected to the line 11 in parallel with dynamos *B B'*. At times when the load is in excess of the capacity of the steam units then in operation, but not sufficiently so to justify the coupling up of another steam unit, the requisite modification of relation of power to load can be obtained by connecting in this auxiliary apparatus, which in this case acts as an air-motor, operating the dynamo *F* to supply electrical energy to the line, and under the reverse conditions the same apparatus may be used to store compressed air in the reservoir *D* by the action of dynamo *F* acting as a motor to drive pump *E*. In order to effect this change of function of this apparatus, it is only necessary to vary the relative force of the engine *E* and the dynamo-electric machine *F*. Thus I have shown a regulating resistance *H* for modifying the field-exciting current of the dynamo, and thus causing the electromotive force generated in such dynamo to exceed or fall below the line electromotive force, according to whether it is desired to operate as a generator or as a motor.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. In a system of power generation and storage, the combination of a prime mover, the fluid-pressure pump connected therewith, means to store the fluid-pressure generated by the pump, connections from the storage means to the prime mover whereby the fluid-pressure generated may be utilized to assist the prime mover, and an auxiliary fluid-pressure device operating either as a motor or as a pump to assist the prime mover or absorb a portion of the energy generated thereby.

2. In a system of power generation and storage, the combination of a prime mover having a plurality of working cylinders operating at different pressures, a fluid-pressure pump connected to said prime mover, a reservoir connected to said pump for storing the fluid-pressure generated thereby, and the connection of said reservoir to the cylinder of the prime mover working at the low pressure.

3. In a system of power generation and storage, the combination of a plurality of steam-power units, each having a plurality of working cylinders working at different pressures, an air-pump having mechanical connection with one of said units, a compressed-air reservoir connected to said pump and also connected to a steam-power unit at a point

where the working pressure is below the highest working pressure of the steam-power unit, and valves in the connections from said reservoir to the pump and the engine, substantially as and for the purpose set forth.

4. In a power plant, the combination of a steam-engine having a plurality of working cylinders working at different pressures, an air-pump mechanically connected thereto, a compressed-air reservoir connected to said pump, and also connected to said engine at a point where the working pressure is below the highest working pressure of the steam-engine, and valves in the connections from said reservoir to the pump and the engine, substantially as and for the purpose set forth.

5. In a power plant, the combination of a compound steam-engine, an air-pump mechanically connected thereto, a reservoir connected to said pump, and also connected to said steam-engine at a point between the high and low pressure cylinders, and valves

in the connections of said reservoir to the pump and steam-engine.

6. In an apparatus for generating and storing power, the combination of a plurality of prime movers operating by fluid-pressure, a fluid-pressure pump connected with each prime mover and operated thereby, a reservoir connected with said pumps, an auxiliary fluid-pressure device capable of acting either as a motor or as a pump, and means for causing said auxiliary device to absorb a portion of the energy generated by the prime movers and store fluid-pressure in said reservoir when desired, and means for applying the stored pressure to cause said auxiliary device to generate energy to assist the prime movers as desired.

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