W. C. ANDERSON.

STEAM POWER APPARATUS.

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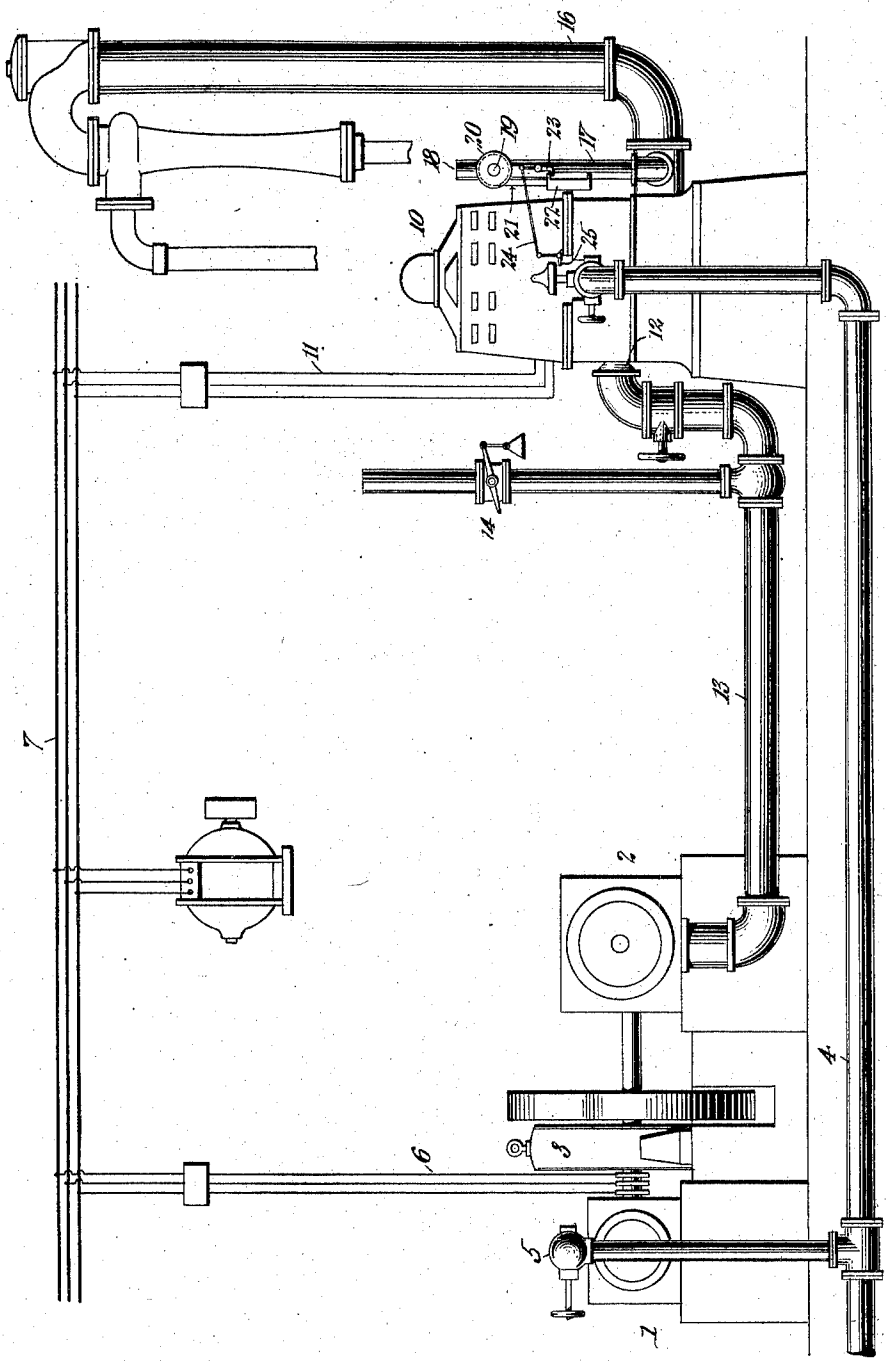
**965,850.** Patented Aug. 2, 1910.




Witnesses:
Frank S. Ober
Anthony

Inventor
Wilbur C. Anderson
By his Attorneys
Rosenbaum & Stockbridge

# UNITED STATES PATENT OFFICE.

WILBUR C. ANDERSON, OF CANTON, OHIO.

## STEAM-POWER APPARATUS.

965,850. Specification of Letters Patent. Patented Aug. 2, 1910.

Application filed January 22, 1909. Serial No. 473,709.

*To all whom it may concern:*

Be it known that I, WILBUR C. ANDERSON, a citizen of the United States, residing at Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Steam-Power Apparatus, of which the following is a full, clear, and exact description.

My invention relates to systems or installations of steam engines and turbines, and includes a number of features by which perfect regulation is secured and high efficiency effected in the power production. The system is also designed to take care of the load during a partial or complete breakdown in any of its units. The matter of high operating efficiency is the most important of these three functions or characteristics and it will be found that attaining such high efficiency is the most prominent characteristic of my invention, the efficiency obtainable being about as high as possible with any steam power apparatus, for reasons which will later appear.

A reciprocating multiple expansion engine is at present more efficient than a steam turbine when operating with steam between high boiler pressures and atmospheric, but a steam turbine is more efficient at low working pressures with a condenser. The reasons for this are well understood and need not be here considered. Accordingly a reciprocating engine having its exhaust connected to a steam turbine constitutes as highly efficient a steam power apparatus as is at present available, the turbine working, say, between pressures of about atmospheric and half a pound or more absolute, determined by the condenser employed. Such operation, however, is not applicable to existing apparatus, but requires new equipment consisting of turbines designed exclusively for low pressures, and in case of the reciprocating engines being shut down for repairs, or other cause, the low pressure turbine cannot be operated at high economy. It is the purpose of my invention to not only provide for all these matters and conditions, but also to provide for carrying the load in case of breakdown of either of the separate units, viz., the reciprocating engine or the steam turbine, separately considered.

In order to make the principles of the invention clear, I will first describe a practical installation suitable to the needs of an electric plant, and in which all of the foregoing matters are provided for.

The drawing illustrates in diagrammatic form a power installation embodying the principles of my invention.

1 denotes a high pressure cylinder and 2 a low pressure cylinder of a compound expansion reciprocating engine directly connected to a generator 3.

4 designates a high pressure steam supply pipe leading from the boiler through which steam passes to the engine through a throttle valve 5 of the high pressure cylinder.

6 denotes generator mains connected to the bus-bars 7 through which the power is distributed to the load. The reciprocating engine is of the ordinary sort in all respects, having the usual variable cut-off appliances by which a constant speed is maintained, regardless of load variations.

10 denotes a high pressure steam turbine which may also be of the ordinary or standard construction in all respects. The essential characteristics of the turbine 10 are first, that it is capable of operating with high pressure steam from the boiler, and, second, that it is so constructed that an auxiliary supply of low pressure steam can be utilized in conjunction with or independently from the boiler. An ordinary two-stage Curtis turbine may be prepared to give these functions or results by the simple expedient of cutting a hole in the shell to admit steam to the second stage of the turbine, assuming that a valve or opening has not already been provided in manufacture. A further prominent characteristic of the turbine is that it has an electrical association with the load of the reciprocating engine. Inasmuch as turbines are ordinarily built with electric generators permanently organized therein, it is merely necessary to connect the electric mains 11 to the bus-bars 7, already described. If the reciprocating engine drives a line shaft or other mechanical load, the turbine mains 11 will obviously be connected to a motor, assisting the drive of such mechanical load.

The exhaust from the low pressure cylinder of the reciprocating engine is piped directly through the opening 12, above described, into the low pressure stage of the turbine, as shown at 13 in the drawing.

14 designates a relief valve, opening at a few pounds gage pressure, which prevents

mounting up of back pressure in the exhaust pipe 13 under any circumstances.

The high pressure steam pipe 4 is connected to the first stage of the turbine 10 in the ordinary manner, this connection being under the control of the usual turbine governor. The particular form of turbine employed is quite immaterial, but this governor, as a factor or element in the entire combination, plays an important part in my invention, as will later appear.

16 is a condenser discharge pipe from the lowest stage of the turbine 10. As a part of the system of regulation, this pipe has a branch 17 open to the air at 18, but normally closed by a valve 19. The valve 19 is adapted to be opened by a drop mechanism in case of undue speed or racing of the turbine. This is simply accomplished by a drum 20 on the valve 19 having a cord 21 with a weight 22, which is normally held from dropping under the influence of gravity by a latch 23. This latch has a link connection 24 with a trigger 25 in the path of the usual automatic stop weight of the turbine, so that when the latter falls to close the usual throttle, it also drops the weight 22 to open the valve 19 and admit air to the condenser discharge pipe 16.

The use and operation is as follows: The reciprocating engine being considered a multiple expansion engine, is adapted to work most efficiently between boiler pressure and pressure about atmospheric. The remaining power of expansion to the condenser has an available power value about equal to that of the engine. The steam being admitted to the turbine direct and not through a governor, the loads on the engine and the turbine will be adjusted automatically and the turbine will be found to carry its part of the load without any live steam at all, as long as the engine governor will maintain the full speed of the engine, the turbine working only on exhaust steam from the reciprocating engine. This condition is automatically maintained because the engine and the turbine share the load together and if the load falls off, a share is taken from the engine and from the turbine together. Therefore the engine does not supply as much exhaust steam to the turbine and the turbine maintains its speed under the diminished load with the less supply furnished. It is not necessary to discuss the electrical relations in the circuit which cause a distribution of the load on all the power units in the same ratio regardless of changing values. The principles governing this are well understood in the art. The system is therefore adapted to operate under ordinary conditions of changing or varying loads and furthermore operates with about as high efficiency as can be obtained by any steam power apparatus. This is because the engine and the turbine both work between the steam pressures to which they are specially adapted. The maintenance of these proper pressures is established without any governor in the exhaust line connection 13 on account of the relation of the electrical loads referred to. This is not only desirable, but is practically essential because an exhaust steam supply is not like a boiler supply, but must be used up or consumed as furnished. It is obvious that the exhaust pipe pressure cannot be easily held back and its energy cheaply stored up as is the case with the boiler supply. It might sometimes happen that the turbine cannot take care of all the exhaust steam furnished. This is an emergency and not a normal condition, but must nevertheless be provided for. It is the purpose of the relief valve 14 to open and relieve any accumulating pressure in the exhaust line 13.

I will now consider various special or emergency conditions which arise in practice and which, of course, must be provided for. An obvious emergency condition is the instantaneous removal of the electric load due to the tripping of a circuit breaker. The governors normally provided in an engine or turbine, of course, close the high pressure steam supplies under these circumstances, but it is evident that all the steam in the exhaust line 13 and in the low pressure cylinder of the engine has a free connection with the turbine and would be sufficient to race the same dangerously. It is to prevent this result that the valve 19 is opened to the atmosphere by the emergency drop 25, the admission of atmospheric pressure to the condenser pipe 16 obviously destroying the vacuum, so that the condenser back pressure substantially balances the steam supply from pipe 13. Thus this contingency is perfectly provided for.

Another contingency is the breakdown of the steam engine. Assuming that something went wrong with the steam engine in any of its valves or parts, it is evident that the entire load will be thrown on the turbine generator. Under these circumstances the turbine governor will act and the high pressure stages of the turbine become available. The capacity of the turbine is multiplied in proportion to the added load imposed, the high pressure stages taking care of the load formerly imposed on the reciprocating engine. The turbine therefore carries the whole load of the power station, and the change is effected automatically and instantaneously by the governor without interruption. Also in case of over-loads, the turbine automatically receives high pressure steam and adds its full capacity to the system. These latter conditions are more or less abnormal and correspond to less efficient power production than the normal working

as first described. Conversely, in case anything should happen to the turbine, the load would be automatically imposed on the reciprocating engine.

What I claim, is:

In combination a reciprocating engine, a high pressure turbine, a live steam conduit connected with a high pressure stage of said turbine, an independent, normally wide-open conduit leading from the exhaust of said reciprocating engine to a low pressure stage of said turbine, a governing apparatus comprising means for controlling the admission of high pressure steam to said turbine, said apparatus also comprising means operating in an emergency to control the admission of low pressure steam to said turbine by admitting air thereto, the air so admitted, by reason of the normally wide-open conduit aforementioned, reducing the mean effective pressure upon the reciprocating engine piston, thereby also reducing the speed of the reciprocating engine as well as that of the turbine.

In witness whereof, I subscribe my signature, in the presence of two witnesses.

WILBUR C. ANDERSON.

Witnesses:

URBAN A. WERNET,

HELEN RALEY.