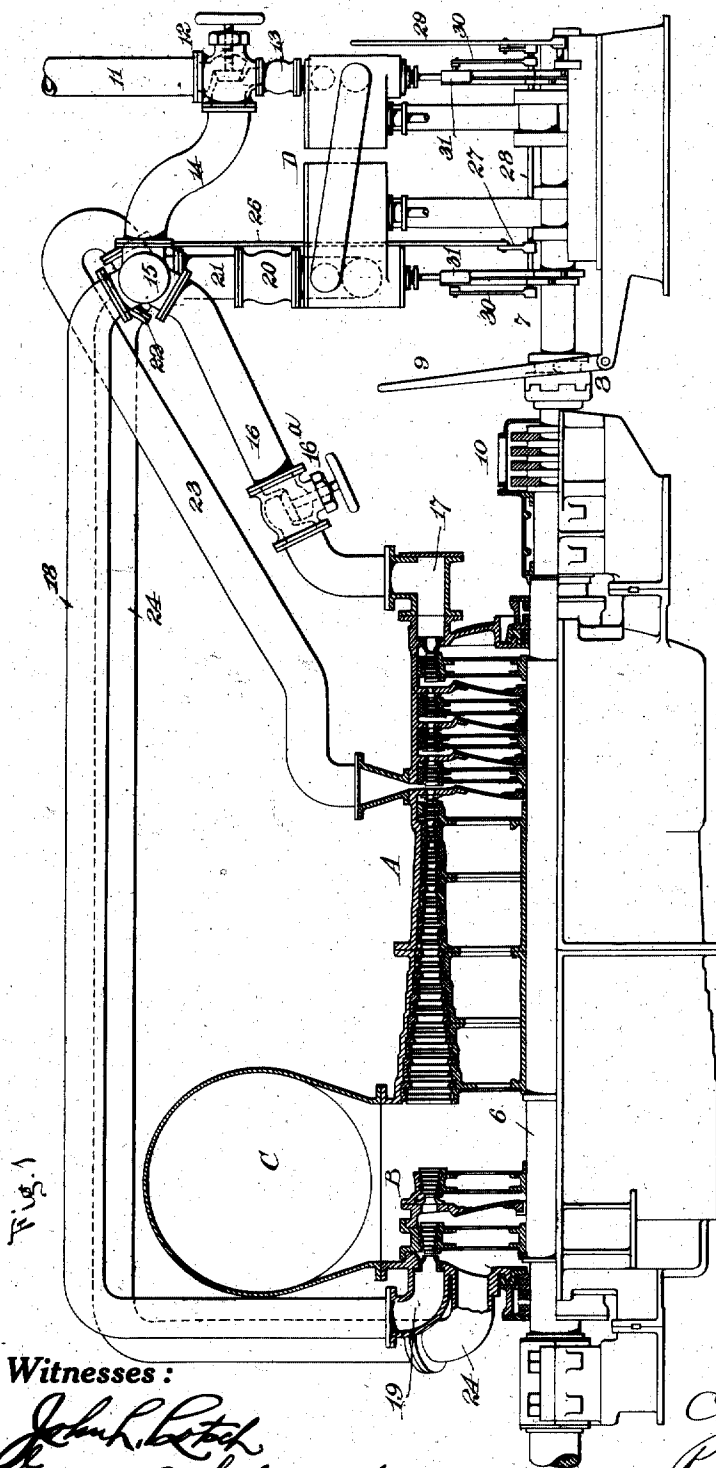


1,008,532.

3 SHEETS—SHEET 1.



Witnesses :

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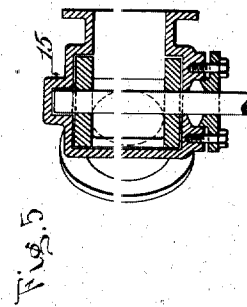
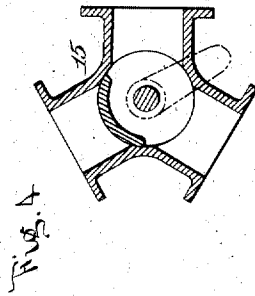
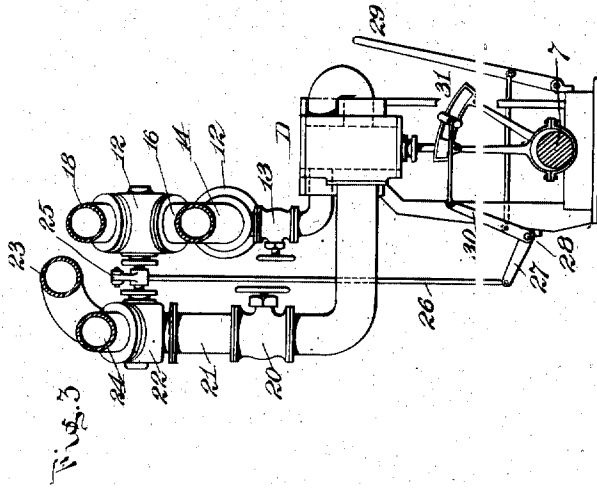
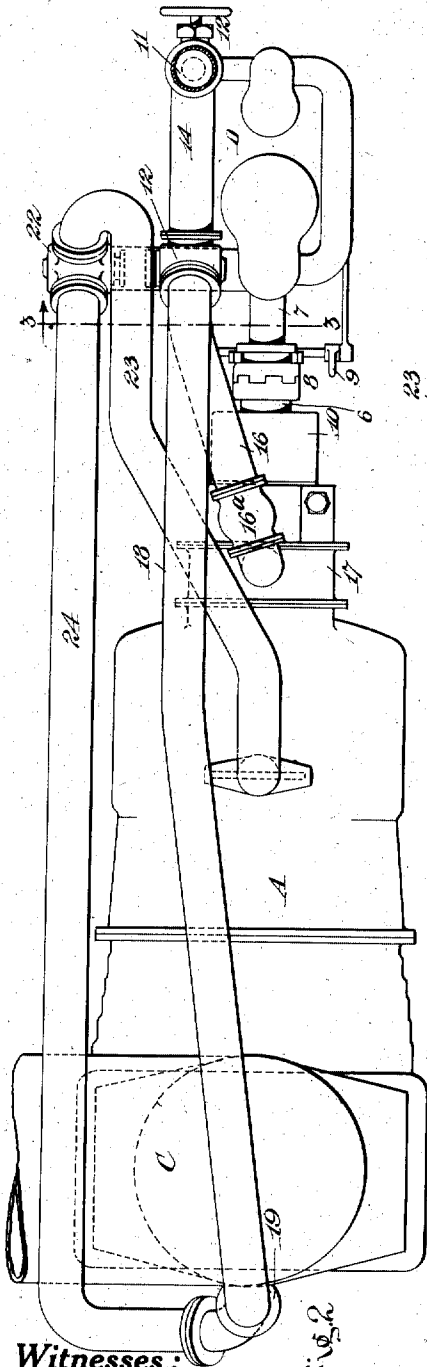
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PRIME MOVER FOR MARINE PROPULSION.
APPLICATION FILED MAY 15, 1911.

1,008,532.

Patented Nov. 14, 1911.

3 SHEETS-SHEET 2.



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3 SHEETS—SHEET 3.

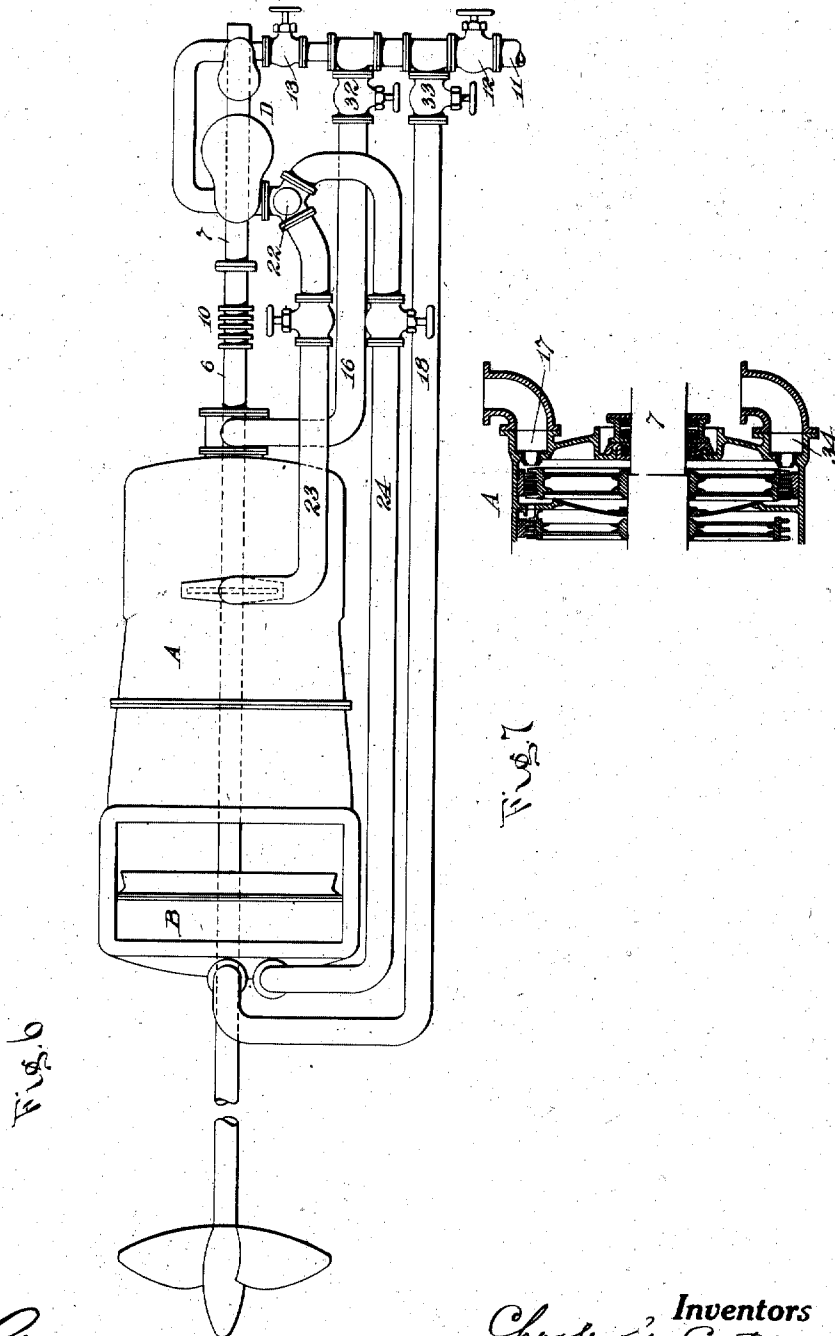


Fig. 6

Fig. 7

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UNITED STATES PATENT OFFICE.

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PRIME MOVER FOR MARINE PROPULSION.

1,008,532.

Specification of Letters Patent. Patented Nov. 14, 1911.

Application filed May 15, 1911. Serial No. 627,114.

To all whom it may concern:

Be it known that we, CHARLES G. CURTIS, a citizen of the United States, residing at New York city, county and State of New York, and RALPH L. LOVELL, a citizen of the United States, residing at Quincy, county of Norfolk, and State of Massachusetts, have invented a certain new and useful Improvement in Prime Movers for Marine Propulsion, of which the following is a specification.

The object of our invention is to produce, for the propulsion of ships, an effective combination of reciprocating engines and steam turbines so as to secure economy of fuel, particularly at cruising speeds.

In carrying out our invention we couple direct to the same propeller shaft a reciprocating engine and a steam turbine taking the steam flow in succession at cruising speeds and adapted to utilize the entire expansion down to a condenser vacuum. For higher speeds a part or all of the steam is by-passed directly from the boiler to the steam turbine, and its complete expansion is utilized therein.

We prefer to use a steam turbine of the stage expansion, impulse type, or one having initial impulse, pressure stages, with partial peripheral steam admission; and preferably also having one or more final drum stages. A turbine of this character which will be adapted to utilize the steam pressure between the exhaust of the engine and the condenser, and will also be adapted to utilize the full expansion of the steam from the boiler pressure to the condenser pressure, can be made with such simplicity of parts and moderate length, that the mounting of it directly on the same propeller shaft with the reciprocating engine is permissible. This combination has the further advantage that a steam turbine having initial impulse, pressure stages, with partial peripheral steam admission, can, practically, be made to utilize the full expansion of the steam at a lower shaft speed than the ordinary reaction turbine with full peripheral admission, and hence not only can a higher propeller speed be secured, but the lower shaft speed is better adapted to the conditions of the reciprocating engine, which, in moderate speed ships, can be kept connected with the propeller shaft so as to furnish power there-

to at all speeds, and in high speed ships need only be disconnected at the higher speeds.

The reciprocating engine employed by us is preferably of the compound or two-cylinder type, a comparatively simple form of engine, and since the full power it is required to develop is less than that necessary to propel the ship at cruising speed, it can be made small and, being provided with large bearings and forced lubrication, can be run with safety at quite high speeds.

In order to make the combination effective, a special relation between the engine and the turbine must be provided. When it is attempted to utilize the full expansion in a turbine of the character referred to, at all speeds and powers, the efficiency of the early stages of the turbine becomes very poor at low speed and small power, on account of the low bucket speed and also because the volume of steam flowing through the turbine is not sufficient to maintain the stage pressures required to secure a high efficiency. In the combination which is the subject of the present invention, the exhaust from the engine is connected with the turbine at an intermediate point of its expansion range so that the steam does not flow through the first stage nozzles, but enters the turbine at a lower point below which the turbine stages can effectively utilize the steam. This connection may be to the shell of the first stage wheel or compartment, or to any of the later stages, even down to the head of the drum stage (when a drum stage is employed), so that the engine will work between the boiler pressure and a pressure which may be for example from 6 to 20 lbs. absolute, while the turbine will utilize the expansion below that point down to the pressure of the condenser vacuum. This is the preferred arrangement. As a modification, a separate set of first stage nozzles, adapted to expand the steam efficiently down to the back pressure, will be employed, to which the exhaust from the engine will be delivered. But this makes necessary the use of a higher exhaust pressure and lower range of energy for the engine, at cruising speeds, which we regard as disadvantageous, in view of the fact that the efficiency of the engine is much higher than the turbine at cruising speeds. Therefore it is desirable to utilize as much of the available energy as

possible in the engine under these conditions without covering too great a range of expansion.

At cruising speeds, the direct supply of steam from the boiler to the first stage nozzles of the turbine will be cut off and the entire expansion utilized successively in the engine and the turbine. For higher speeds live steam will be admitted directly to the first stage nozzles of the turbine, and will result in raising the pressure in the initial stages of the turbine so that the engine will work against a higher back pressure. This back pressure will increase as the flow of steam directly to the turbine is increased, until the full speed conditions are attained, so that, although the speed of the engine is increased, the power which it is called upon to develop is not increased owing to the decreased range of pressure which it utilizes. The engine will be coupled to the shaft by a suitable coupling so that it can be uncoupled at full power if desired, or at any time, for repair or other purpose without interfering with the driving of the shaft by the turbine. Mounted directly upon the same shaft with the engine and go-ahead turbine is also a backing turbine, whose shell may be a continuation of the shell at the low pressure end of the go-ahead turbine, or a separate shell. The backing turbine is likewise and in a similar manner connected with the exhaust of the engine, and also connected directly with the boiler, so that the engine can be used to add to the power of the backing turbine. A change valve is located in the exhaust steam pipe of the engine at the point where it branches to the go-ahead and backing turbines, and this change valve is connected with the link motion of the engine so that the reversing of the engine will simultaneously reverse the connection of its exhaust from the go-ahead turbine to the backing turbine. A change valve may also be used to control the flow of live steam directly to the go-ahead and backing turbines, and this may also be connected with the link motion of the engine, or the live steam connections may be controlled by separate throttle valves.

In the accompanying drawing forming part hereof, Figure 1 is a side elevation and partial section illustrating a compound engine and turbine arranged so as to embody our invention; Fig. 2 is a top view of the same parts; Fig. 3 is a vertical section on line 3-3 in Fig. 2, looking to the right; Figs. 4 and 5 are sectional views of one form of valve which may be employed for changing the flow of steam from the go-ahead to the backing turbine, and vice versa; Fig. 6 is a plan view of a modified arrangement in which the live steam connections to the go-ahead and backing turbine are controlled by separate valves; and Fig. 7 is a view

showing two separate sets of nozzles for the first stage of the turbine.

Referring particularly to Figs. 1 to 5—A is the go-ahead turbine; B is the backing turbine. These may be inclosed in a single casing, as shown, and discharge in opposite directions into the condenser C. Each of these turbines has initial impulse, pressure stages, with partial peripheral admission, and a final drum stage. D is a compound steam engine. The shaft 6, upon which the rotating elements of the turbine are mounted, it will be understood, is connected with the propeller. The shaft 7 of the engine is coupled with the shaft 6 by a clutch 8 of any suitable form, which may be operated by the lever 9. The thrust block for taking the propeller thrust is shown at 10. The pipe 11 is the steam supply pipe from the boiler. The flow of steam through this pipe is controlled by the throttle valve 12, from which there is a connection through the valve 13 to the high pressure chest of the compound engine D. The valve 12 also controls the admission of steam to the pipe 14 which extends to one side of the change valve 15. From the change valve 15 a connection 16, provided with throttle valve 16^a, is made to the steam chest 17 of the go-ahead turbine A; while another connection 18 is made from the change valve 15 to the steam chest 19 of the backing turbine B. The exhaust from the low pressure cylinder of the compound engine passes through the valve 20, and by a pipe 21, is carried to the change valve 22. From this change valve there is one connection 23 extending to the shell of the go-ahead turbine, and entering that shell at the last wheel stage so that the steam flowing through 23 will not pass through the wheel stages of the turbine but will first enter the working passages of the turbine through the nozzles preceding the drum stage. From the change valve 22 there is another connection 24, leading to the first stage shell of the backing turbine, so that the exhaust from the engine does not pass through the first stage nozzles. The change valves 15 and 22 may be of any suitable form of construction, one such form being shown in detail in Figs. 4 and 5. These two valves have their stems connected so that they may be operated simultaneously; an arm 25 on the stem of these valves is connected by a rod 26 with an arm 27 on a rock shaft 28. This rock shaft is moved by a lever 29, and is also connected by arms 30 with the link motion 31 for reversing the steam engine.

It will be understood that when the lever 29 is in one position the link motion will be adjusted to cause the engine to drive forward and at the same time the change valves 15 and 22 will be adjusted to open the pipes 16 and 23 and close the pipes 18

and 24, so that the steam will be delivered to the go-ahead turbine and cut off from the backing turbine. When the lever 29 is in the opposite position, the engine will be reversed and the go-ahead turbine connections 16 and 23 closed and the backing turbine connections 18 and 24 opened.

While the valves permit of different methods of control, it is apparent that the prime mover can be controlled almost wholly by the main throttle valve 12 and the reversing lever 29. Except when it is desired to run the ship for some distance at less than full speed the valves 13, 20 and 16^a will be left open and the speed controlled by the valve 12. When a sufficient distance is to be run at less than full speed to warrant the change, the valve 16^a will be closed more or less, thus cutting down the total power developed by the turbine and, particularly, wholly or largely cutting out the ineffective early stages. When the valve 16^a is set for any desired speed condition, lower speeds can be secured by reducing the steam supply at the valve 12. In reversing, the control is effected entirely by the main throttle valve 12 and the reversing lever 29, the area of the first stage nozzles of the backing turbine being such that when the valve 12 is open, an effective distribution of power between the backing turbine and the engine will be produced.

As shown in Fig. 6, the live steam connections 16 and 18 to the go-ahead and backing turbine may be controlled by separate hand valves 32 and 33, while the connections 23 and 24 from the exhaust of the engine will be controlled by a change valve 22 connected with the link motion of the engine. As shown in Fig. 7, a separate steam chest 34, with nozzles, at the head of the first stage of the turbine, may be used to receive the exhaust steam from the engine, instead of carrying this exhaust to one of the lower stages of the turbine.

It will be understood that the propeller shaft carrying a complete steam utilizing plant may furnish the entire power for driving the ship, or may be used in a two or three-shaft arrangement in which the shafts are independent of each other, each being provided with a complete power equipment of the character described.

What we claim is:—

1. In a prime mover for marine propulsion, the combination of a reciprocating steam engine and a steam turbine, directly coupled to the same shaft, receiving the steam in succession and adapted to utilize the complete expansion of the steam, substantially as set forth.

2. In a prime mover for marine propulsion, the combination with a shaft, of a steam turbine directly coupled thereto having a live steam connection and adapted to

utilize the complete expansion of the steam, and a reciprocating steam engine directly coupled to the same shaft and exhausting into said turbine, substantially as set forth.

3. In a prime mover for marine propulsion, the combination with a shaft, of a steam turbine directly coupled thereto, having a live steam connection and adapted at high powers to utilize the complete expansion of the steam, and a reciprocating steam engine directly coupled to the same shaft and exhausting into said turbine at low powers, said engine being adapted to utilize the steam expansion from the initial pressure to an intermediate pressure, substantially as set forth.

4. In a prime mover for marine propulsion, the combination with a shaft, of a steam turbine directly coupled thereto having a live steam connection and adapted to utilize the complete expansion of the steam, and a reciprocating steam engine directly coupled to the same shaft and exhausting into said turbine at an intermediate point of its expansion range, substantially as set forth.

5. In a prime mover for marine propulsion, the combination of a reciprocating steam engine and a steam turbine having a fixed speed relation and receiving the steam in succession, such turbine having initial impulse pressure stages with partial peripheral admission and a final drum stage, and a direct live steam connection to the turbine, substantially as set forth.

6. In a prime mover for marine propulsion, the combination of a reciprocating steam engine and a steam turbine directly coupled to the same shaft and receiving the steam in succession, such turbine having initial impulse, pressure stages with partial peripheral admission, and a direct live steam connection to the turbine, substantially as set forth.

7. In a prime mover for marine propulsion, the combination of a reciprocating steam engine and a steam turbine, directly coupled to the same shaft and receiving the steam in succession, such turbine having initial impulse, pressure stages with partial peripheral admission and a final drum stage, and a direct live steam connection to the turbine, substantially as set forth.

8. In a prime mover for marine propulsion, the combination of a reciprocating steam engine and a steam turbine having initial impulse, pressure stages with partial peripheral admission, directly coupled to the same shaft, and an exhaust steam connection from the engine to the turbine cutting out the high pressure first stage nozzles, substantially as set forth.

9. In a prime mover for marine propulsion, the combination of a reciprocating

steam engine and a steam turbine having initial impulse, pressure stages with partial peripheral admission, directly coupled to the same shaft, and an exhaust steam connection from the engine to the turbine, cutting out one or more of the initial stages of the turbine, substantially as set forth.

10. In a prime mover for marine propulsion, the combination of a reciprocating engine, a go-ahead steam turbine and a backing steam turbine, all coupled directly to the same shaft, live steam connections to both turbines, and exhaust steam connections from the engine to both turbines, substantially as set forth.

11. In a prime mover for marine propulsion, the combination with a go-ahead steam turbine, a backing steam turbine and a steam engine, of exhaust steam connections from the engine to both turbines, and means subject to a single control for simultaneously reversing the engine and the exhaust connections to the turbines, substantially as set forth.

12. In a prime mover for marine propulsion, the combination with a go-ahead steam turbine, a backing steam turbine and a steam

engine, of exhaust steam connections from the engine to both turbines, a change valve controlling the two exhaust connections and a connection between the change valve and the link motion of the engine, substantially as set forth.

13. In a prime mover for marine propulsion, the combination with a go-ahead steam turbine, a backing steam turbine and a steam engine, of live steam connections to both turbines and to the engine, exhaust connections from the engine to both turbines and means subject to a single control for simultaneously reversing the engine and the live and exhaust turbine connections, substantially as set forth.

This specification signed and witnessed.

CHARLES G. CURTIS.

RALPH L. LOVELL.

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ANGELO CONTI,

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