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POWER SYSTEM

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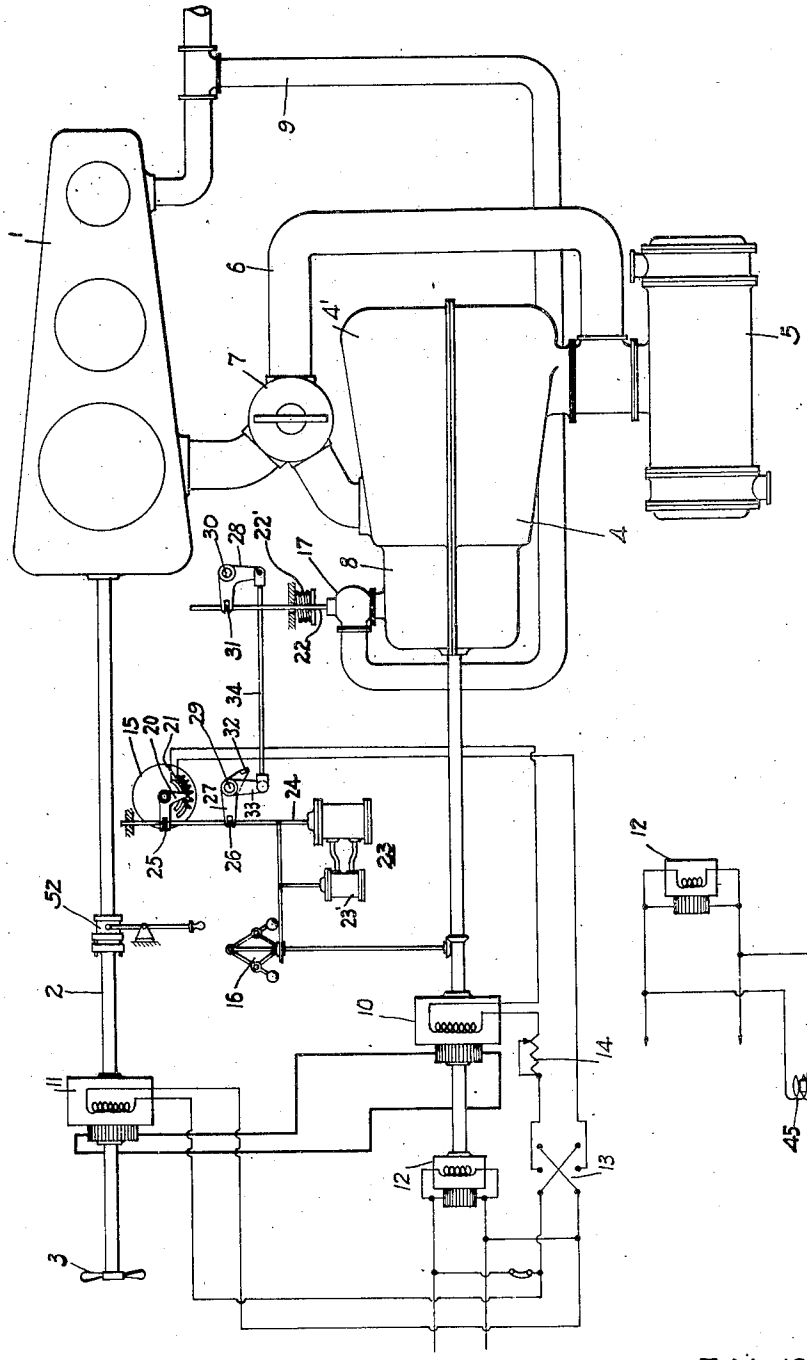


FIG. 1.

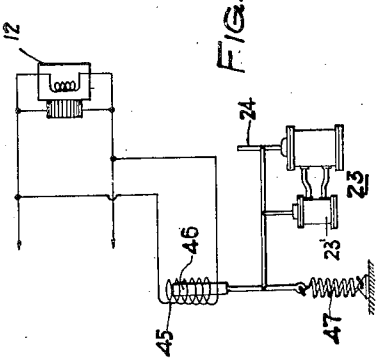


FIG. 2.

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UNITED STATES PATENT OFFICE

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POWER SYSTEM

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This invention relates to power systems of the kind in which a prime mover such as a reciprocating steam engine if utilized to operate a main drive and is assisted by a second prime mover, as for example a steam turbine using the exhaust steam of the first mentioned engine. Power systems of this kind have been proposed for the propulsion of ships, both the reciprocating engine and the turbine being coupled to the main drive or propeller shaft, the engine directly and the turbine through suitable gearing.

An object of the invention is to render the speed of the second prime mover independent of the speed of the main drive so that it may be used to drive auxiliary apparatus at a substantially constant speed. An additional advantage of the invention is that the efficiency of operation of the second prime mover is improved in cases where this consists of a turbine or other engine whereof the efficiency decreases considerably below certain speeds.

According to the invention a power system of the kind set forth is provided wherein the second prime mover is coupled to the main drive by variable power transmission means and is also required to supply power for driving an auxiliary load, and governor means is provided responsive to the speed of said second prime mover, and adapted to vary the ratio of said power transmission means so as to decrease the load thereon due to the main drive when the speed tends to decrease below a predetermined limit. The same or a second governor may further be provided adapted to increase the supply of motive fluid to the second prime mover when the speed thereof tends to fall below a predetermined limit and the load thereon due to the main drive has been reduced by variation of the power transmission ratio to a predetermined extent.

The variable power transmission means may comprise a direct current electric generator arranged to be driven by the second prime mover and connected electrically to a direct current propulsion motor operatively associated with the main drive, the governor means for varying the load on the second prime mover being arranged to vary the resistance of the generator field windings in order to keep the speed of the generator and second prime mover substantially constant when the speed of the latter tends to vary, for example due to variations in the supply of exhaust steam coming from the first prime mover.

The second prime mover preferably comprises a steam turbine adapted to receive the exhaust steam from the first prime mover and also arranged to receive steam from another source. A mixed pressure turbine may advantageously be employed for this purpose, the high pressure portion being normally inoperative, but being brought into action when the supply of exhaust steam to the turbine is insufficient to maintain the speed thereof above a predetermined value and the load thereon due to the main drive has already been reduced a predetermined amount by variation of the power transmission ratio.

The speed at which the second prime mover and any auxiliary machine connected thereto is driven may thus be maintained substantially constant at all times irrespective of variations in the speed of the main drive or the quantity of motive fluid exhausted from the first prime mover. If the auxiliary load upon the second prime mover comprises an auxiliary generator a supply of electric power at a constant voltage may be obtained.

The invention is illustrated in the accompanying drawing, wherein:

Fig. 1 is a diagrammatic representation of a marine installation arranged according to the invention; and,

Fig. 2 is a diagram illustrating an electrical governing arrangement that may be employed in carrying out the invention.

Referring more particularly to Fig. 1, a first prime mover 1, represented as a triple expansion reciprocating engine is coupled to a main shaft 2 for driving a propeller 3, and is adapted to deliver its exhaust steam to the low pressure section 4' of a mixed pressure turbine 4, which in turn exhausts to a condenser 5. A bypass 6 and a valve 7 are provided, whereby, when desired, the supply of exhaust steam from the engine 1 may be shut off from the turbine and delivered directly to the condenser 5. The turbine 4 is also pro-

vided with a high pressure section 8 adapted to receive live steam through a pipe 9 from a suitable source, which in the example shown is constituted by the main steam supply to the engine 1. The turbine 4 drives a direct current generator 10 which is adapted to deliver electrical energy to a direct current motor 11 connected with the shaft of the propeller 3. An auxiliary generator 12 is also adapted to be driven by the turbine 4 and supplies electrical energy for various purposes on board the ship, including the excitation of the generator 10 and the motor 11. A switch 13 is provided for reversing the electrical connections of the field windings of the motor 11 and generator 10 and variable resistances 14, 15 are also inserted in the field winding of the generator 10. Suitable circuit breakers and such like auxiliary devices incidental to the convenient operation of the arrangement may be provided in the circuits, as will be readily apparent to those skilled in the art.

The turbine 4 is further provided with a governor 16 which may be of well known centrifugal type and is adapted to control the operation of a governor valve 17 for regulating the admission of live steam to the high pressure section 8. The governor 16 is also adapted to regulate the amount of resistance inserted in the field circuit of generator 10 by the rheostat 15. Any suitable mechanism whereby the governor 16 controls the operation of the governor valve 17 and rheostat 15 in the desired manner is provided.

One suitable form of mechanism for carrying out the necessary coaction between the governor 16, the rheostat 15, and the governor valve 17 is illustrated by way of example in Fig. 1 of the accompanying drawing, this mechanism being employed in conjunction with an oil relay operated governor system, which is a well known manner of associating a centrifugal governor with the devices which it controls. The rheostat 15 is shown as of the cylindrical type in which the resistance in circuit may be progressively increased or decreased by movement of an arm 20 over a plurality of contacts 21. The valve 17 is adapted to be opened and closed by raising and lowering a spindle 22. An oil relay 23 is provided and arranged to be controlled in well known manner by a pilot valve 23′ connected to the governor 16 so as to impart up or down motion to a rod 24 each time the governor speed tends to decrease below or to rise above predetermined limits.

In Fig. 1 the parts are shown at about the mid position. Falling speed of the turbine causes the governor 16 to admit oil to relay 23 in such a way as to raise the rod 24. In the example given, the motion of the rod 24 is imparted to the rheostat arm 20 by a pin 25 and to the governor valve through a pin 26, bell cranks 27 and 28 rotatable on fixed shafts 29 and 30, a pin 31 on the spindle 22, an arm 33 and a link 34, all suitably situated in regard to the operating parts. The bell crank 27 is provided at one end with a stop 32 adapted, when the crank 27 has been sufficiently far rotated in a clock-wise direction, to engage with the arm 33, which is pivotally mounted on the shaft 29, and to impart to it any further clock-wise rotation of the crank 27. Such further rotation is in turn transmitted to the bell crank 28 through the link 34, pivoted to the ends of the arm 33 and the bell crank 28 and results in the valve spindle 22 being raised to open the valve 17. The latter is opened against the action of a spring 22′, so that in the event of the bell crank 27 being rotated in a counter-clockwise direction the spring will cause the valve operating mechanism and the valve itself to follow up the movement of the stop 32. The rollers or pins 25, 26 and 31 may be adjustably mounted in order to provide for adjustment between the various parts of the mechanism.

The plant is adapted to operate as follows:

Assume the plant to be working at full power and the governor valve 17 closed, the propeller shaft 2 is then driven directly by the engine 1 and the turbine is driven entirely by the exhaust steam delivered to the turbine section 4′, the power of which is utilized to supply electric energy in both the propulsion system 10, 11 and the auxiliary system of the generator 12. If now, any reduction in the speed of the reciprocating engine is made, there will result a diminished supply of exhaust steam to the turbine, the speed of which will fall.

The governor 16 responds to the fall in speed and controls the relay 23 to effect operation thereof raising the rod 24, so imparting clock-wise rotation to the bell cranks 20 and 27. The rotation of the crank 20 will result in the insertion of a greater amount of resistance 15 in the field circuit of the generator 10, but as yet the stop 32 will remain out of engagement with the arm 33. This reduction in output is continued until the load on the turbine is such that with the steam quantity then available, the desired constant speed of the turbine is substantially maintained. At this point, the governor 16 for the time being comes to rest.

Any subsequent reduction in exhaust steam quantity results in the repetition of the above process until finally the output of the generator 10 is reduced to zero. The quantity of exhaust steam then available is employed solely for the purpose of maintaining the output of the auxiliary generator 12.

It will be appreciated that, so long as the motor 11 is excited and rotating, the output of the generator 10 will be zero, not when its field is zero, but when its generated electro-motive force is insufficient to circulate

current around the circuit comprising its own armature, that of the motor 11 and also the interconnecting cables and switch gear. A reduction of the excitation of the generator 10 below the point in question will result in electrical energy being supplied from the motor 11, acting as a generator, to the generator 10, acting as a motor. The latter will, therefore, add its motive power to that of the turbine 4 to drive the auxiliary generator 12, at the required speed. This will continue under the control of the governor 16 until the combined power so obtained is insufficient to maintain the required speed.

At or about this point, the stop 32 engages the arm 33. Any further rise of the rod 24, due to the action of the governor 16 in response to further decrease in the turbine speed, now produces a corresponding rise of the spindle 22, through the clock-wise rotation of the bell cranks 27 and 28 and movement of the link 34 to the left. The governor valve 17 admits live steam to the high pressure section of the turbines 4, which is then governed by the governor 16 in a conventional manner for constant speed steam turbines.

With increase in the speed of the reciprocating engine 1 and consequent increase in the supply of exhaust steam to the turbine 4, the above operation is carried out in the reverse sense as will be readily understood.

It will be apparent to those familiar with governing systems that numerous modifications of the control system described above may be employed in effecting the governing action in accordance with the present invention.

The control system described above enables a substantially constant speed of the turbo-generator set to be maintained so that the voltage of the auxiliary generator 12 may also remain substantially constant. This latter effect may be produced by the use of an electrical governor in place of a centrifugal governor, for example by an arrangement such as illustrated in Fig. 2.

In Fig. 2, we show an electrical form of governing mechanism, which acts in response to the voltage of the auxiliary generator 12 to maintain the same substantially constant. A coil 45 is connected to the leads of the generator 12 and exerts a magnetic pull upwardly on a plunger 46 in opposition to the force of a spring 47. The plunger 46 is connected to the relay 23, which operates the variable resistance 15 and the valve 17 in the same manner as in the embodiment first described.

Upon a decrease in the voltage developed by the generator 12, the plunger 46 moves downwardly under force of the spring 47. The relay 23 is controlled to move the rod 24 upwardly, similarly to a decrease in speed in the embodiment shown in Fig. 1, for first decreasing the load on the turbine and then admitting live steam thereto in order to maintain substantially the desired voltage of the generator 12.

Conversely, upon an increase in voltage, the increased magnetic pull moves the plunger 46 upwardly. The relay moves the rod 24 downwardly to effect reverse operation as will be readily understood.

It will be appreciated that the arrangements above described permit of reversing the direction of rotation of the main engine 1 and the propeller 3, the electrical connections of the motor 11 and the generator 10 being reversed by the switch 13. Also when the main engine 1 is not working the turbine may be supplied with live steam by the pipe 9 for the purpose of supplying auxiliary electric power by the generator 12, the circuits of the generator 10 and motor 11 being suitably disconnected and the speed of the turbine being controlled by the governor in the conventional manner.

From the foregoing it will be apparent that the invention provides a power system of the kind referred to in which substantially constant speed of the second prime mover or turbine is maintained by governor means which adjusts the load on one of two generators in accordance with the available supply of exhaust steam for operating said prime mover, and when the load of that generator is reduced substantially to zero and the supply of exhaust steam no longer suffices for the load of the second generator, admits an appropriate amount of live steam to the prime mover so as to maintain the speed, and incidentally the output voltage of the second generator.

It is preferable, when applying the invention to practice to make provision for uncoupling the main engine 1 from the propeller shaft and for rendering inoperative the means for relieving the turbine of propulsion load. A disengageable coupling 52 may be provided for this purpose. The turbine may then be used alone in an emergency to drive the propeller, with the main engine out of action. In such event the turbine would be supplied with steam entirely by pipe 9 and the admission of steam may be controlled by the governor or governors associated with valve 17 within the fully open and fully closed positions of said valve.

While in the above description an electrical form of variable power transmission means between the second prime mover and the main drive has been described, it will be evident that the invention is not limited in this respect, but that other forms of variable power transmission means may be employed.

While we have shown our invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and mod-

ifications, without departing from the spirit thereof, and we desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What we claim is:

1. In a power system, the combination of a first prime mover coupled to a main drive, a second prime mover coupled to the main drive by variable power transmission means and also supplying power for an auxiliary load, and governing means for maintaining the speed of the second prime mover substantially constant comprising means responsive to the speed of the second prime mover for varying the power transmitted by said power transmission means so as to vary the load thereon due to the main drive.

2. In a power system, the combination of a first prime mover coupled to a main drive, a second prime mover coupled to the main drive by variable power transmission means comprising an electric generator driven by the second prime mover and an electric motor operatively associated with the main drive and electrically connected to the generator, said second prime mover also supplying power for an auxiliary load, and governing means for maintaining the speed of the second prime mover substantially constant comprising means responsive to the speed of the second prime mover for varying the power transmitted by said power transmission means so as to vary the load thereon due to the main drive.

3. In a power system, the combination of a prime mover, means for supplying motive fluid from a variable source to said prime mover, means for supplying motive fluid to said prime mover from a second source, said prime mover normally receiving only the motive fluid from said variable source, a driven machine connected to the prime mover and driven thereby, means for applying additional load to the prime mover and for varying said load in response to the speed thereof to maintain the same substantially constant, and means for admitting motive fluid from said second source when the supply from the variable source is insufficient to maintain the speed of the turbine.

4. The combination with a prime mover receiving a variable quantity of motive fluid and driving a direct current generator and a driven machine, of means for governing the speed of the prime mover comprising means for varying the load on the generator by varying the field excitation current of the generator in response to the speed of the prime mover.

5. The combination with a prime mover receiving a variable quantity of motive fluid and driving an electric generator and a driven machine, of means for governing the speed of the prime mover comprising means for varying the load on the generator by varying the generator field strength in response to the speed of the prime mover.

6. In a power system, the combination of a first prime mover coupled to a main drive, a second prime mover coupled to the main drive by variable power transmission means comprising an electric generator driven by the second prime mover and an electric motor operatively associated with the main drive and electrically connected to the generator, said second prime mover receiving the exhaust from the first prime mover, means including and controlled by a regulating valve for supplying other motive fluid to the second prime mover, and means for governing the speed of the second prime mover comprising a governor responsive to the speed thereof, means controlled by the governor for varying the strength of the generator field, and connecting means between the governor and the regulating valve including a lost motion connection, said governing mechanism operating, upon decrease in speed, to decrease the strength of the generator field and to take up the lost motion in said lost motion connection, and, upon further decrease in speed after said lost motion is taken up, to open the regulating valve through said lost motion connection.

7. In a power system, the combination of a prime mover receiving a variable quantity of motive fluid, said prime mover being coupled to a main drive by variable power transmission means and also supplying power for an auxiliary load, and governing means for maintaining the speed of the prime mover substantially constant comprising means responsive to the speed of the prime mover for varying the power transmitted by said power transmission means so as to vary the load thereon due to the main drive.

In testimony whereof, we have hereunto subscribed our names.

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