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STARTING AND LUBRICATING SYSTEM FOR PORTABLE POWER PLANT

Filed July 23, 1958

2 Sheets-Sheet 1

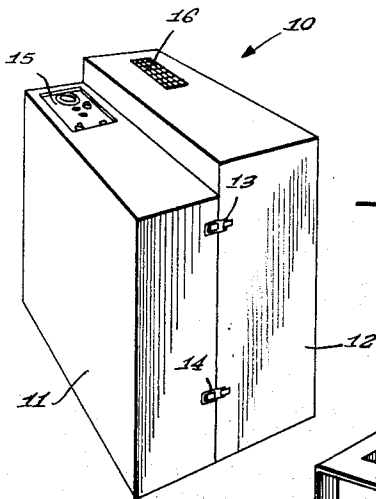


FIG. 1

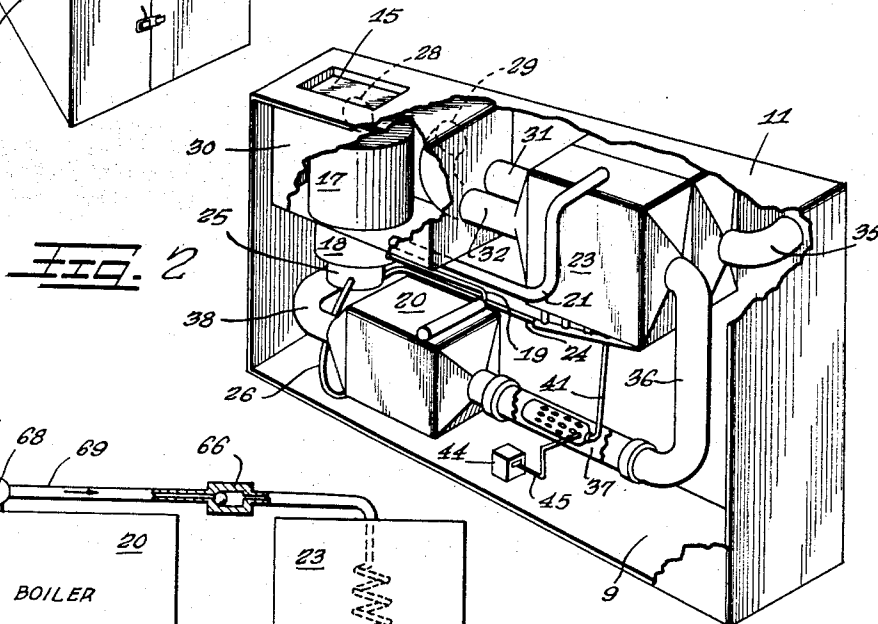


FIG. 2

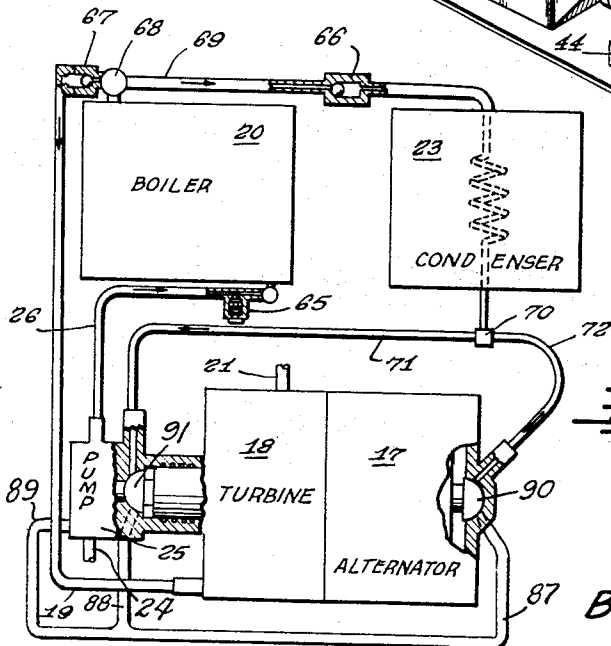


FIG. 5

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2 Sheets-Sheet 2

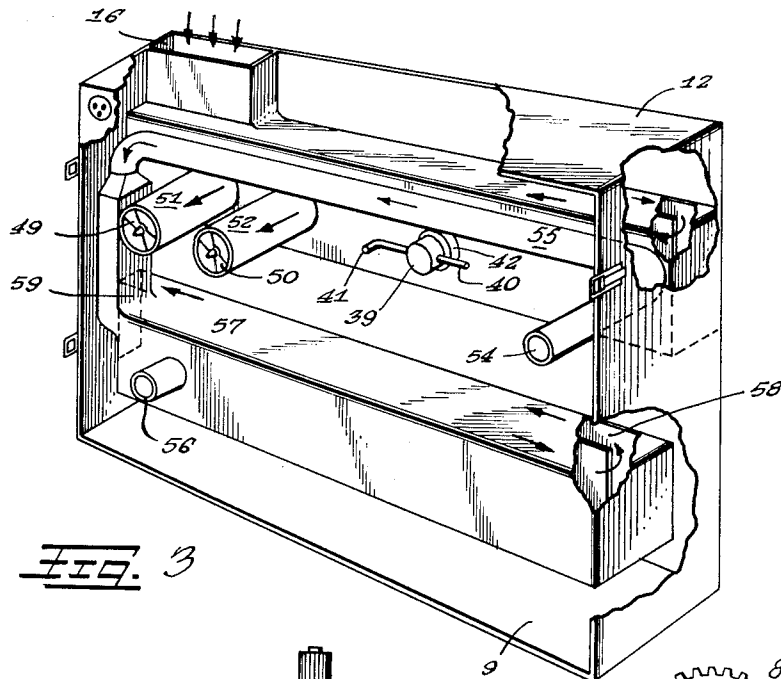


FIG. 3

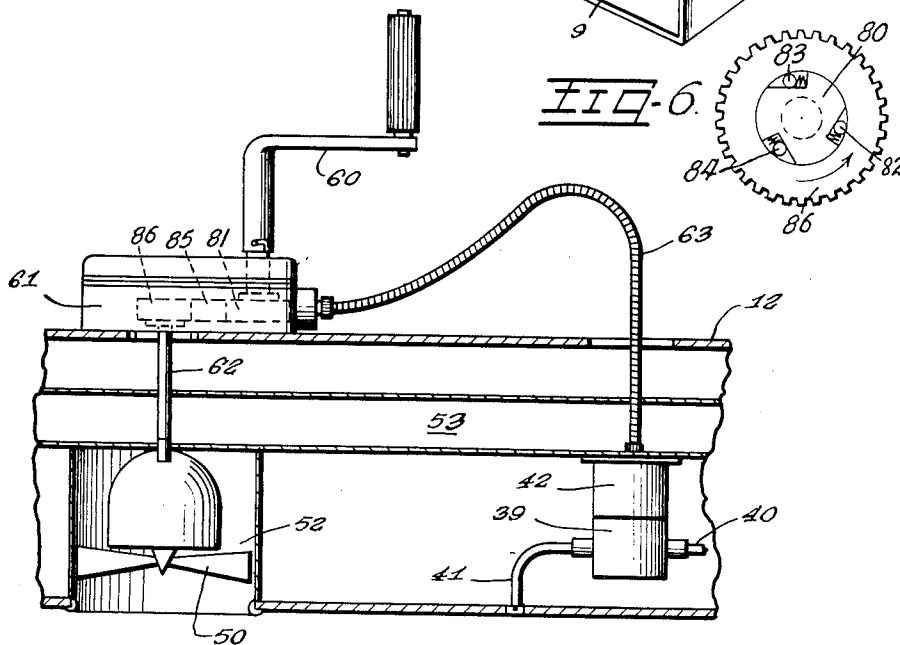


FIG. 4

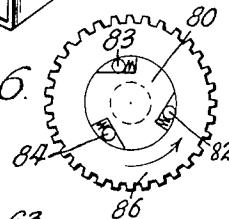


FIG. 6

FIG. 4

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STARTING AND LUBRICATING SYSTEM FOR PORTABLE POWER PLANT

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5 Claims. (Cl. 290—2)

This invention relates to a starting and lubricating system for a portable electric power generating apparatus. More particularly, this invention relates to a starting and lubricating system for an alternator set, the turbine drive of which is powered in operation by a mercury vapor Rankine cycle and the lubrication of which is achieved by the mercury used in the closed cycle.

The present invention is particularly adapted for use in a two-piece light weight silent packaged alternator set operating on the Rankine mercury cycle to efficiently produce about 2½ kilowatts of electric power from a package weighing slightly over 100 pounds and having its components housed in a package about the size of a conventional suitcase. The package is conveniently constructed to have two separable sections which may be connected together by quick disconnect or slip fit connections, one section containing the power package itself and the other section containing a muffler or silencing device and associated controls. The separability of the two sections facilitates the ready portability of the apparatus and renders it particularly suitable for military or commercial field use at such installations as advanced missile bases.

It is a feature of this invention to provide a hand operated means for starting or initiating the operation of the alternator set to thereby further enhance its adaptability for field use by rendering it independent of other auxiliary power supplies. It is another feature of this invention to provide a lubricating system for such an alternator set utilizing the mercury which is used in the Rankine cycle and thereby permitting the complete sealing of the mercury circuit in the power package section.

It is therefore an object of this invention to provide a starting and lubricating system for a small portable silent alternator set.

It is a further object of this invention to provide a starting and lubricating system for an alternator set driven by a turbine operating on a mercury vapor Rankine cycle wherein the mercury is also used as a lubricant.

Other objects, features and advantages of the present invention will be more fully apparent from the following detailed description taken in connection with the accompanying drawings in which like reference characters refer to like parts throughout and wherein:

Figure 1 is a perspective view showing the two-piece package or housing of the alternator set, in assembled relation.

Figure 2 is a perspective view partly broken away showing the interior of the power package portion of the unit of Figure 1.

Figure 3 is a perspective view partly broken away showing the interior of the silencing or muffler unit of the package of Figure 1.

Figure 4 is a sectional view with parts in elevation showing the starting mechanism of the present invention.

Figure 5 is a diagrammatic view showing the lubricating system of the present invention.

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Figure 6 is an elevational view showing the overriding clutch mechanism which is attached to the blower fan of the present invention.

Turning now to the drawings, there is shown in Figure 1 a housing or package 10 for the alternator set. The housing 10 comprises two separable sections or individual housings 11 and 12 respectively, the section 11 housing the power plant itself and the section 12 housing an associated silencing unit and the starting apparatus. Each of the packages 11 and 12 consist of a light weight box preferably lined with a sound absorbing material 9 of honey comb construction. Each box shell may consist of metal, wood, plastic or any other suitable material. The units 11 and 12 are fastened together by trunk type clamps 13 and 14 or by any other suitable quick disconnect or slip fit fastening means. A control panel 15 may, if desired, be disposed in a recess in the top of the power package unit 11, and a groove air inlet opening 16 may be positioned in the top of the silencing unit 12.

The power package 11 is shown in greater detail in Figure 2. The power package includes an alternator 17 which is directly driven by a turbine 18 using mercury vapor as the operating fluid. Mercury vapor enters the turbine 18 through a pipe or conduit 19 which connects the outlet of a boiler 20 to the inlet of turbine 18. The outlet of turbine 18 is connected by a pipe 21 to the inlet end 22 of a condenser 23.

During its passage through the condenser 23, the mercury vapor is changed to a fluid which flows through a pipe conduit 24 to the inlet of a mercury pump 25. Alternator 17, turbine 18 and pump 25 are integrally mounted on a common shaft so that the energy supplied to the turbine 18 by the incoming mercury vapor drives the alternator, the turbine and the pump. The mercury fluid leaves the pump 25 at an increased pressure and flows through conduit or pipe 26 to the inlet of boiler 20. The fluid mercury is vaporized in the coils of the boiler by the heat energy supplied thereto. The resulting mercury vapor then flows through pipe 19 to the inlet of the turbine 18 to complete the Rankine cycle.

As noted above, turbine 18, alternator 17, and pump 25 are mounted on a common shaft and preferably operate in hydrostatic mercury bearings to enable the complete mercury system to be positively sealed from the atmosphere. The entire mercury system is thus contained in the power package 11. However, the air which is used to condense the mercury vapor and to vaporize the fluid mercury in the boiler enters and leaves the power package through the detachable silencing package 12. The air enters the power package 11 through dual ducting comprising the inlets 28 and 29. Inlet 28 discharges into an enclosed housing 30 which surrounds the alternator. This portion of the air flow serves as a cooling medium for the alternator and leaves the housing 30 at relatively low pressure through a duct 31. Duct 32 is directly attached to inlet 29. Both ducts 31 and 32 are connected to supply the cooling air to the condenser 23 which is divided by an interior partition into two sections, duct 31 feeding the air to one section and duct 32 feeding air to the other section. From the divided condenser part of the air is ducted back to the atmosphere through a conduit 35 which transports the air to the silencing package and thence back to the ambient atmosphere. The air from conduit 32 is ducted at relatively high pressure through conduit 36 into a combustion chamber 37 connected to the boiler 20. The divided condenser is used so that the warm condenser exit air in duct 36 may be utilized in the combustor and boiler, this air being derived from that portion of the condenser forming the inlet end for hot mercury vapor. From the combustion chamber 37 the heated air flows through the boiler 20 and is then ducted through a conduit 38 back

through the silencing package 12 and thence to the atmosphere.

A fuel pump 39 (preferably mounted in the silencing package 12 as shown in Figure 3) has fuel supplied to it through a conduit 40 from any convenient source. The pump supplies this fuel to combustor 37 which heats the air being supplied to boiler 20. Pump 39 is preferably driven by an integrally mounted motor 42, electrical energy for which is supplied during operation from the alternator 17. A storage battery 44 is connected by cable 45 to the spark plugs or other ignition system of the combustor 37. Output from the alternator 17 may be derived through any convenient cable connection to the exterior of either of the packages, this cable connection not being shown in the drawings.

The power package 11, which as noted above is structurally a light weight box preferably lined with sound absorbing material of honeycomb construction, is connected in use to the similarly constructed silencing package 12 by the trunk type clamps 13 or any other suitable fastening means. Either of these packages may contain control panel, the fuel pump, the blower fan, the condenser fan, and/or the starting system. In any event, all connections between the power package and the silencing package are either quick disconnect or slip fit and are automatically engaged when the packages are fitted together.

This automatic engagement may more readily be seen by comparing Figure 3, which is a cut-away perspective view of the silencing package, with the structure discussed above in connection with Figure 2. The silencing package 12 is a detachable self-contained muffler designed to silence the combustor and component noise of the power package. It consists primarily of muffling ducts and material and, as shown in Figure 3, also contains the boiler and condenser fans, the fuel pump and the starting system.

It will for example be noted that the section of the fuel pipe 41 shown in Figure 3 mates with the section of the pipe 41 shown in Figure 2 through a quick disconnect coupling. Similarly, a power take-off may be positioned on the silencing unit to derive electrical power from the alternator 17 to operate fans 49 and 50 during the normal operation of the apparatus. Blower fan 49 is positioned in a conduit 51 whereas the condenser fan 50 is positioned in a conduit 52. Conduits 51 and 52 are outlets from a re-entrant or tortuous air conduit 53, the other end of which is connected to the air inlet 16. The fans 49 and 50 are positioned in the outlets of conduits 51 and 52 which mate respectively with the air inlets 28 and 29 in the power package unit. Thus, air from the inlet 16 is circulated through the conduit 53, a portion of this air being driven by fan 49 through conduit 51, inlet 28, alternator chamber 30, conduit 31, condenser 23, conduit 35, and thence back to the silencing unit through the inlet 54 of a conduit 55. The other portion of the air from conduit 53 is driven by fan 50 through air inlet 29, conduit 32, condenser 23, conduit 36, combustor 37, boiler 20, conduit 38, and thence back through an air inlet 56 which connects to an extension 57 of the conduit 55. The conduit 57 has a re-entrant or reversed section 58 which leads to an air discharge 59 in the end wall of package 12. The re-entrant or reversing shape of conduits 53, 57, 58 and the generally tortuous nature of the entire air path also serves to provide baffles which further muffle or silence the noise generated by the operation of the power plane. The duct work in the silencing package 12 thus serves in cooperation with sound absorbing material 9 within the package to provide a muffling action for the noise of the combustor and components of the power package.

As noted above, the fuel pump 39 and the combustor fan 50 are driven by their respective integral motors during the operation of the apparatus by power generated by alternator 17. The input energy to the system is of

course supplied during its operation by the fuel supply to combustor 37. In order to start this self-sustaining cycle of operation, however, it is necessary to first build up sufficient pressure in the mercury vapor in boiler 20 to drive the turbine 18. For this purpose there is provided a gear box 61 and a detachable or collapsible crank 60. The gear box may be integral with or detachable from the housing and may be used either on the power package or the silencing package depending upon where the combustor fan and the fuel pump are located. In the preferred embodiment illustrated, the fuel pump 39 and combustor fan 50 are located in the silencing package 12 and the gear box 61 is mounted at the rear of the package 12 as shown in Figure 4. Gear box 61 drives the fan 50 through a direct coupling shaft 62 and drives the pump motor 42 and pump 39 through a flexible shaft 63. The principle or mode of operation of the starting operation is as follows: When the crank 60 is turned manually, the fan 50 and fuel pump 39 which are connected to the gear box as noted above are rotated at proportionately greater speeds depending upon the gear ratios. This then feeds air to a portion of the condenser and to the combustion chamber and boiler. It also injects fuel into the combustion chamber which is ignited by a spark plug or any other suitable igniting means which may be controlled or energized from a storage battery 44. Once the ignition has been made, the hot air starts to vaporize the liquid mercury in the boiler. The mercury is held in the boiler by an automatic valve 65 (best seen in Figure 5) at the inlet end of the boiler and by two pressure valves 66 and 67 at the exit end. When a predetermined pressure has been reached, pressure valve 66 opens to allow mercury to flow from header 68 through conduit 69 to the condenser 23 and thence to a T connection 70 where the liquid mercury is divided between the two lines 71 and 72 leading to the alternator bearing 90 and the pump and turbine bearing 91. This assures the bearings of lubrication before rotation starts. When a second predetermined pressure greater than the bearing valve pressure has been reached, the main turbine valve 67 opens to permit mercury vapor to flow through line 19 to the turbine 18 to start the rotation of the unit. The rotation of the turbine drives the pump 25 and as soon as this pump builds up a predetermined amount of pressure, the valve 65 at the inlet to the boiler is opened. The mercury is now cycling. However, cranking is preferably continued until the alternator has built up sufficient speed to operate the fan 50 and fuel pump 39. At this time, the fan motor takes over and an over-riding clutch 80 relieves the cranking while an automatic kick-out relieves the fuel pump permitting the motor 42 to drive pump 39. The system is then self-sustaining and the crank may be disengaged.

During cranking, the gear 81 acts through the gear 85 to rotate the gear 86 in a counterclockwise direction as shown in Figure 6. The spring-mounted balls, 82, 83, and 84, are frictionally urged by gear 86 into a wedging relationship between the clutch wheel 80 and the circumscribing gear 86, thereby creating a driving connection between said clutch and said gear. The clutch wheel 80 is fixedly attached to the fan shaft 62 so that cranking as indicated will cause the fan 50 to rotate. As the fan motor gains speed, it rotates the clutch wheel 80, through shaft 62, in a counterclockwise direction as shown in Figure 6. The balls, 82, 83, and 84, are then frictionally urged out of wedging relationship and the clutch wheel 80 turns freely within the gear 86. The crank 60 is thereby freed of rotational connection with the fan, and it may be disengaged. Any of a variety of overriding clutch means may be used in place of the means heretofore set forth. The details of operation of the clutch 80 are not of the essence of the present invention.

It will of course be understood that the liquid mercury circulated through lines 71 and 72 to the bearings is collected and recirculated to the pump 25 which returns it

through line 26 to boiler 20 along with the mercury used in the operating cycle per se.

Return lines 87 and 88 are provided to transport the lubricating mercury from the alternator bearing 90 and the pump and turbine bearing 91. The mercury is transported into the pump 25 through line 89 for reuse in the system.

Briefly then, the operation of the starting and lubricating system is as follows: While cranking, the boiler 20 heats the mercury, vaporizing it and increasing the pressure. This high pressure opens valve 66 allowing mercury to flow through the condenser 23 where it is liquified and then flows through lines 71 and 72 to lubricate the bearings of the alternator, turbine, and pump. At a still higher pressure, valve 67 opens allowing mercury vapor to reach the turbine via line 19 and start the operation of the alternator. Since the mercury pump 25 is also operated by the turbine 18, it too begins to go into operation at this time. Once the pump 25 has built up enough pressure, it opens check valve 65 leading to the boiler, thus delivering liquid mercury to be vaporized and used in the boiler. As soon as the alternator 17 has built up sufficient speed to drive the boiler fan motor and fuel pump motor, automatic kick-out apparatus permits the alternator to take over in the manner described above and the crank handle may be disengaged.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention as defined by the following claims.

I claim as my invention:

1. In power generating apparatus of the type comprising an electrical generator and a pump both connected to be driven by a turbine, a combustor and a boiler connected to supply the vapor of an operating fluid to drive said turbine, a condenser connected to receive said vapor from said turbine, said pump being connected to supply said operating fluid from said condenser to said boiler, a fuel pump connected to supply fuel to said combustor and a blower connected to supply air to said condenser and said combustor, said fuel pump and said blower each having a motor driven by said generator during the normal operation of said apparatus, the improvement comprising starting and lubricating apparatus including means independent of said generator for driving said blower and said fuel pump, means responsive to a first predetermined pressure in said boiler to circulate said operating fluid to lubricate the bearings of said generator and said turbine, and means responsive to a second predetermined pressure higher than said first predetermined pressure to admit the vapor of said operating fluid from said boiler to said turbine to drive said turbine and generator.

2. In power generating apparatus of the type comprising an electrical generator and a pump both connected to be driven by a turbine, a combustor and a boiler connected to supply the vapor of an operating fluid to drive said turbine, a condenser connected to receive said vapor from said turbine, said pump being connected to supply said operating fluid from said condenser to said boiler, a fuel pump connected to supply fuel to said combustor and a blower connected to supply air to said condenser and said combustor, said fuel pump and said blower each having a motor driven by said generator during the normal operation of said apparatus; the improvement comprising starting and lubricating apparatus including means independent of said generator for initially operating said fuel pump and said blower, first and second pressure responsive valves in the outlet from said boiler, a third pressure responsive valve at the in-

let to said boiler, said first pressure responsive valve being positioned in a line supplying said operating fluid through said condenser to the bearings of said generator and said turbine, said second pressure responsive valve being positioned in a line connecting said boiler to supply said operating fluid to drive said turbine, said third pressure responsive valve being positioned in a line connecting said pump returning said liquified operating fluid from said condenser to said boiler, said first pressure responsive valve being set to open at a first predetermined pressure to supply said operating fluid to lubricate said bearings, said second valve being set to open at a second predetermined pressure greater than said first predetermined pressure to supply operating fluid to drive said turbine, said third pressure responsive valve being set to open at a predetermined pressure greater than said second predetermined pressure to return said operating fluid to said boiler.

3. In power generating apparatus of the type comprising an electrical generator and a pump both connected to be driven by a turbine, a combustor and a blower connected to supply mercury vapor to drive said turbine, a condenser connected to receive said vapor from said turbine, said pump being connected to supply liquid mercury from said condenser to said boiler, a fuel pump connected to supply fuel to said combustor and a blower connected to supply air to said condenser and said combustor, said fuel pump and said blower each having a motor driven by said generator during the normal operation of said apparatus, the improvement comprising starting and lubricating apparatus including manually operated means to initially drive said blower and said fuel pump, means responsive to a first predetermined pressure in said boiler to supply liquid mercury to the bearings of said generator and said turbine, means responsive to a second predetermined pressure in said boiler greater than said first predetermined pressure to supply mercury vapor to drive said turbine, and means responsive to a third predetermined pressure to supply liquid mercury from said mercury pump to said boiler to complete said normal cycle of operation.

4. In electrical power generating apparatus of the type comprising a generator connected to be driven by a turbine operated in a mercury vapor Rankine cycle, the improvement comprising, means independent of said generator to initiate said Rankine cycle, first mercury vapor pressure responsive means to circulate liquid mercury to the bearings of said generator and said turbine at a first predetermined pressure, second mercury vapor pressure responsive means to admit mercury vapor to drive said turbine at a second predetermined pressure greater than said first predetermined pressure.

5. In electrical power generating apparatus of the type comprising a generator connected to be driven by a turbine which in turn is driven by the vapor of an operating fluid carried through a Rankine cycle, the improvement comprising, manually operated means to initiate said Rankine cycle, first pressure responsive means to circulate the liquid phase of said operating fluid to lubricate the bearings of said generator and said turbine at a first predetermined pressure, and second pressure responsive means to permit the completion of said Rankine cycle to operate said turbine at a second predetermined pressure greater than said first predetermined pressure.

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