July 1, 1941. W. J. BESLER 2,247,595

MARINE PROPULSION SYSTEM

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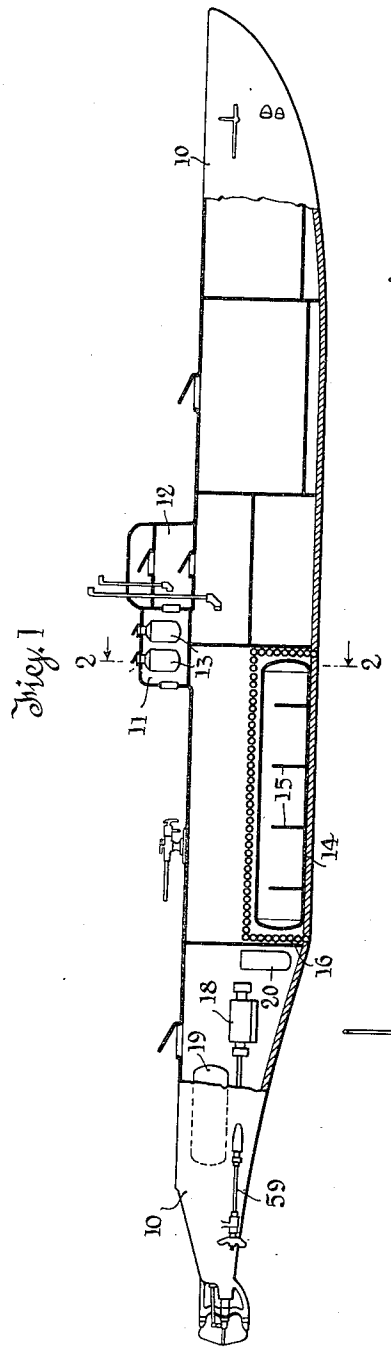

Fig. 1

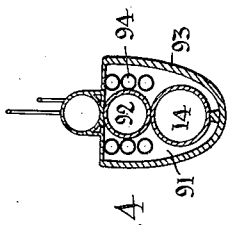

Fig. 4

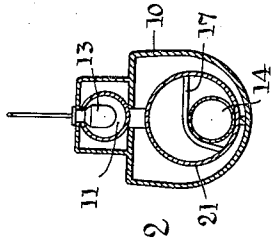

Fig. 2

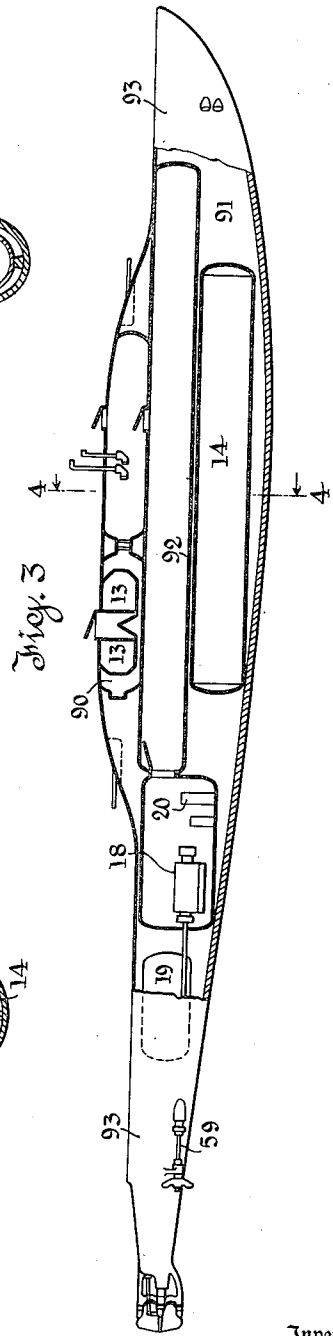

Fig. 3

Inventor

William J. Besler

By

Attorney.

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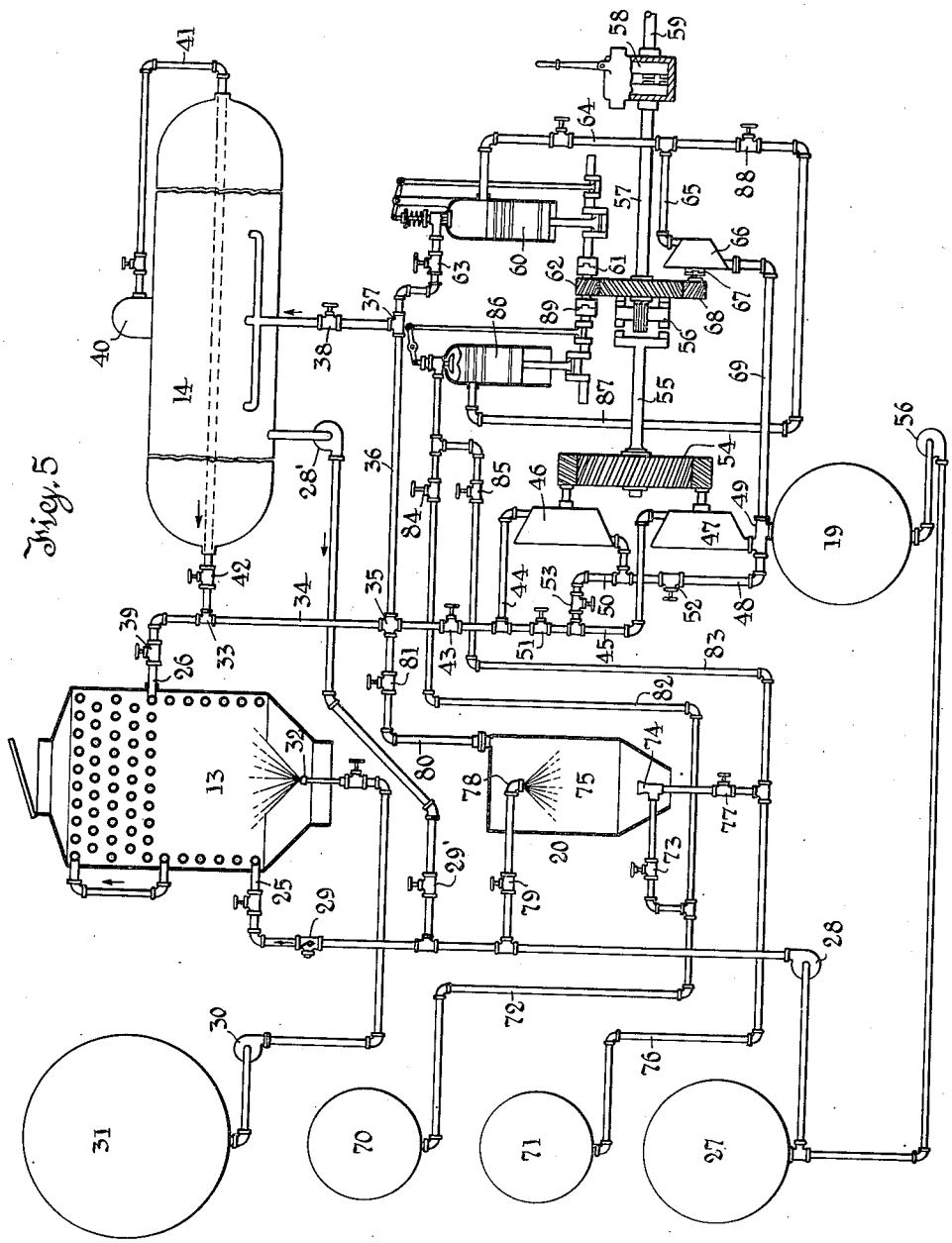
Fig. 5



Inventor
William J. Besler

By

Attorney.

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MARINE PROPULSION SYSTEM

William J. Besler, Plainfield, N. J.

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3 Claims. (Cl. 60—6)

This invention relates to marine propulsion systems and particularly to apparatus for the propulsion of submarine vessels. The invention relates more specifically to apparatus for the surface and underwater propulsion of submarine vessels by the use of high pressure steam. The term high pressure is intended to mean pressures up to or above the order of two thousand pounds per square inch.

The propulsion of submarines on the surface by steam has been accomplished heretofore. It has also been known to provide submarines with compressed air reservoirs to supply air for the operation of internal combustion engines while the vessel is submerged.

According to the present invention, a submarine propulsion system is provided which has all the well-known advantages incident to steam-turbine drives for marine vessels. The instant invention involves the use of a steam boiler operated when the vessel is on the surface, accumulators for storing energy in the form of liquid under high pressure and heat, and a steam turbine or engine or combination turbine and reciprocating engine for propulsion of the vessel both on the surface and when submerged. It also contemplates the emergency use of a combustion device operable when submerged, if necessary, to produce steam for operating the submarine and/or its auxiliaries.

It is the object of this invention to provide an efficient propulsion system for submarines permitting the utilization of a steam turbine drive for both surface and submerged maneuvers.

It is a further object of the invention to provide a steam propulsion system for submarines which requires a minimum amount of space and weight per horsepower, and which does not involve the use of heavy electrical apparatus.

It is another object of the invention to provide a steam propulsion system for submarines adapted to be operated under water, from energy accumulators containing a hot liquid under high pressure, and to provide means for charging said accumulators rapidly and efficiently.

It is another object of this invention to provide a steam generating plant for submarine vessels which may be disposed within or without the pressure hull, in order to accommodate balance, disposition of bulk, or convenience of control in the design of armed submarine vessels.

It is the further object of this invention to provide a submarine propulsion system which vastly increases the utility of this type of vessel due to increased speed, increased cruising range, rapid recharging rates, and increased space for fuel and munitions.

A further object of the invention is the provision of submarine propulsion apparatus which may be compactly installed and located so as to minimize discomfort to the crew due to fumes and heat, and to provide more space than heretofore for control and munition equipment.

Another object of the invention is the provision of a steam propulsion system for submarine vessels having the steam boilers and accumulators outside of the main pressure hull thereby permitting the use of a smaller diameter, more easily streamlined pressure hull which is better able to withstand greater depths and sudden pressures due to depth or aerial bombs.

Other objects and advantages of this invention will be readily apparent from the following description of the embodiments of the invention illustrated in the accompanying drawings in which:

Figure 1 is a diagrammatic elevation view, partly in section, of a submarine provided with my improved propulsion system.

Figure 2 is a sectional view taken on line 2—2 of Figure 1.

Figure 3 is a diagrammatic elevation view, partly in section, of a modified form of submarine construction embodying my invention.

Figure 4 is a sectional view taken on line 4—4 of Figure 3.

Figure 5 is a diagram illustrating the interrelation and the interconnections of the various elements in my improved propulsion system.

Referring to Figure 1 of the drawings, for the purposes of illustration, a submarine pressure hull is indicated by the numeral 10. The pressure hull 10 is provided with the usual compartments for the crew, control, supplies and armament. A compartment 11 is provided immediately abaft the conning tower 12 and within the pressure hull 10, for housing one or more (two shown) boilers or heaters 13. A relatively large tank or series of tanks or pressure vessels 14, hereinafter referred to as an accumulator, is located within the pressure hull 10. The accumulator 14 may be provided with suitable baffles 15 to restrict or prevent excessive surging of the liquids stored therein. The accumulator 14 may also be provided with a water jacket 16 or other form of effective thermal insulation to limit the loss of heat from the accumulator to the compartments within the hull. The accumulator insulation is preferably in the form of pipes 17.

shown in Figure 2, through which sea water may be circulated by suitable means.

The turbine and pump compartment, located aft is provided with suitable steam turbines and/or other kinds of engines, indicated generally by the numeral 18, connected through clutches and gearing for rotating the conventional propeller shaft or shafts 59. A condenser 19 is situated in the turbine compartment. Auxiliary apparatus including pumps, generators, blowers and the like may also be located in the aft compartment.

An oxygen-hydrogen combustion apparatus 20, described hereinafter, may also be installed in the turbine compartment. As shown in Figure 2, the submarine hull 10 is provided with inner walls 21, containing the various compartments, and the space between the hull and the walls 21 may be used for buoyancy and storage tanks.

My improved propulsion system and apparatus will now be described in detail. Referring to Figure 5, the boiler or fluid heater 13 is provided with an inlet 25 and an outlet 26 for the fluid to be heated. The boiler 13 is preferably of the continuous-flow, once-through high pressure type which is strong, light-weight in construction and which heats up rapidly. Duplicate heaters suitably cross-connected are preferable. A fluid, e. g., water, is supplied to the heater 13 from feedwater supply or storage tank 27 by pump 28. The water is pumped into the heater through check valve 29 and the inlet connection 25. Fuel, preferably in the form of hydrocarbon fuel oil, is forced by the pump 30 from storage tank 31 to the burner 32. Suitable forced draft apparatus (not shown) may be used to promote fuel combustion in the conventional manner. The boiler draft pipe for exhaust of combustion products extends to the outside of the compartment, and is provided with water-tight closures for use when submerged, it being understood that the boiler 13 is not operated when the submarine is propelled underwater. The heater outlet 26 is connected through T 33, pipe 34, fitting 35, pipe 36, T 37, and charging valve 38 to the accumulator tank 14. A stop valve 39 is provided adjacent the heater outlet 26. A dome 40 at the top of the accumulator 14 is connected by a superheating or evaporating pipe 41 extending through the interior of the accumulator and connected to the fitting 33 through a valve 42. The accumulator 14 is also connected through pump 28' and valve 29' to the boiler inlet connection to provide positive means for circulation of water in the accumulator through the boiler 13. The fitting 35 is connected through throttle valve 43 and lines 44 and 45 to two steam turbines designated 46 and 47, respectively. The low pressure or exhaust side of each turbine is connected to the condenser 19 by pipe 48 and fitting 49 respectively. Turbine 46 may be a high pressure turbine, and turbine 47 a low pressure turbine for operation as a multi-stage or compound unit. The turbines may have separate shafts, as shown, or be arranged on the same shaft. A cross connection 50 is provided between the low pressure side of turbine 46 and the line 45 extending to the high pressure inlet of turbine 47. By opening valves 51 and 52 and closing valve 53, turbines 46 and 47 can be connected to operate in parallel. By opening valve 53 and closing valves 51 and 52, the steam turbines are connected in series for operation at high and low pressure respectively. Both turbines are connected by suitable reduction gearing 54 to the driven shaft 55. The latter shaft is connected by clutch 56 to shaft 57, and through a reversing mechanism 58 to the propeller shaft or shafts 59. A pump 56 is provided for delivering the condensate from condenser 19 back to the feedwater supply tank 27. The feedwater tank or tanks may be relatively small in size since the accumulator remains at all times at least partially filled with water. Where several accumulator tanks are provided, they may be interconnected with the feedwater tank whereby a discharged accumulator tank may serve as an additional feedwater tank when necessary.

A cruising engine shown diagrammatically at 60 is connected by a clutch 61 and reduction gearing 62 to the shaft 57. The cruising engine 60 may be of the reciprocating piston type and is connected through a steam throttle valve 63 to the fitting 37. Exhaust steam from cruising engine 60 is led by pipes 64 and 65 to a cruising or low pressure turbine 66. A clutch 67 and reduction gearing 68 connect the cruising turbine to shaft 57. The low pressure side of the cruising turbine is connected by pipe 69 and fitting 49 to the condenser 19.

Auxiliary steam generating and propulsion apparatus is provided for use in emergencies so that a submarine will not be entirely out of commission if the regular boiler accumulator turbine system becomes exhausted or inoperable. The emergency system depends upon an oxygen storage tank shown at 70, and a hydrogen storage tank shown at 71. The oxygen tank 70 is connected by line 72 and throttling valve 73 to a burner 74 in an auxiliary combustion chamber 75. The hydrogen tank 71 is likewise connected to the burner 74 by line 76 and valve 77. The burner 74 is of the mixing nozzle type which permits a proper mixture of hydrogen and oxygen to be burned within chamber 75. Water may be added to the combustion chamber by means of an atomizing nozzle 78 connected through valve 79 to the feedwater line extending from pump 28 to the boiler 13. By means of water added through the nozzle 78, the products of combustion can be desuperheated to the required temperature, and the resulting steam lead through line 80 and valve 81 to fitting 35 in the main steam piping. The steam generated in the oxygen-hydrogen combustion chamber 75 may be used to recharge the accumulator 14 through valve 38, and/or to drive the main turbines 46 and 47, or the cruising engine 60.

Extensions 82 and 83 on the lines 72 and 76 from the oxygen and hydrogen storage tanks lead through stop valves 84 and 85 to the internal combustion cruising engine 86. The exhaust steam from combustion engine 86 is connected by line 87 and stop valve 88 to the inlet 65 of the cruising turbine 66, where its remaining pressure may be utilized. Combustion engine 86 is connected by clutch 89 and reduction gearing 62 to the shaft 57.

The operation of the above-described propulsion apparatus is as follows: The submarine is operated on the surface by steam generated in the boilers 13 and led directly to the main turbines 46 and 47 or to the cruising engine 60 and cruising turbine 66. At any time while the submarine is at the surface, the boilers 13 may be utilized to charge the accumulator 14 through valve 38. The accumulator may be charged by admitting steam into the accumulator tank or tanks partially filled with water, or may be charged by using pump 28' to circulate water

from the accumulator through the boiler 13 by way of valve 29 and inlet connection 25. Energy is stored in the accumulator 14 in the form of hot water at high temperature and correspondingly high pressure. The hot water may be accumulated at pressures up to or above the order of three thousand pounds per square inch. Present engineering practice indicates accumulator operation over a range of pressures extending from two thousand pounds to the condenser pressure. For propulsion when submerged, the boilers 13 are closed down and the stack hatches closed. Steam is bled from the accumulator 14 by dome 40 into pipe 41 extending through the accumulator to fitting 33 in the main steam header. Steam is thus supplied for operating the turbines and/or engines as in surface propulsion. Exhaust steam is condensed in the condenser 19 and returned to the feedwater tank 27 for re-use when the submarine rises to the surface and boilers 13 resume operation.

When first submerged, the submarine may be propelled by using turbines 46 and 47 in series as high pressure and low pressure turbines, respectively. During the final stages of accumulator utilization, valves 51 and 52 may be opened and valve 53 closed to allow expansion across both turbines in parallel directly into the condenser 19.

After the accumulator becomes discharged, the submarine may be brought to the surface and the water remaining in the accumulator recharged by use of the heaters 13. The system described contemplates a power plant the boilers or heaters of which are capable of developing up to or even more than ten thousand horsepower. An accumulator designed to store ten thousand horsepower hours of energy may therefore be recharged within an hour when utilizing the full capacity of the boilers. An accumulator of the above capacity would be approximately 110 feet long and 10⅔ feet in diameter if one tank is provided. Four tanks 5½ feet in diameter could be used for similar capacity. It is also possible for a submarine with a partially or completely discharged accumulator to rise to the surface and completely recharge the accumulator in a relatively short interval of time.

The oxygen-hydrogen combustion device 20 is provided for the generation of steam for use when the accumulator is discharged and the tactical situation precludes rising to the surface for accumulator recharging. The internal combustion engine 86, operable on oxygen and hydrogen from tanks 70 and 71 provides means for propulsion in event of failure of the main steam propulsion system.

The submarine may be propelled either on the surface or when submerged by the main turbines or the cruising engine and turbine. It consequently has the advantage of high speed operation for all maneuvers.

The modified submarine construction shown in Figures 3 and 4 contemplates location of the heater units 13 and the accumulator 14 in compartments 90 and 91 outside of the pressure hull 92 and within the outer hull 93. In this arrangement, the pressure hull 92 has to accommodate only the relatively small high power driving turbines and engines 18 and the control and living quarters, and hence the vessel may be more fully streamlined. The small diameter pressure hull 92 saves materially in hull weight, and through greater strength, provides safer operating and living compartments. Buoyancy may be secured by separate small tanks or chambers 94 (see Fig. 4) within the outer hull 93 but outside of the pressure hull 92.

The advantages of the above-described system for the steam propulsion of submarine vessels are numerous and fundamental. The elimination of storage batteries and heavy electrical apparatus permits the installation of increased horsepower boilers. The use of heat accumulators permits the utilization of the same driving turbines and engines for submerged as well as surface maneuvering. The increased space provided by elimination of a separate power plant for submerged operation results in increased range due to the use of large accumulators. The elimination of storage batteries and internal combustion engines provides better living compartment conditions for the submarine crew, since it does away with all sources of poisonous and noxious fumes. The relatively large accumulator tanks provide an additional safety feature in that the tanks may be quickly blown and extra buoyancy promptly obtained. The use of the heat accumulator likewise provides a convenient source of heat for heating the compartments and for cooking. The ability of the high pressure boilers 13 to rapidly recharge the accumulators likewise is an important advantage in tactical maneuvers. The fact that the heaters and accumulator may be positioned outside of the pressure hull provides a stronger submarine construction better able to withstand great depths and sudden pressures encountered in marine warfare.

Other advantages of my improved propulsion system will be readily apparent from the description thereof. Obviously, many variations in the nature and arrangement of the elements described will be apparent to those skilled in the art of marine propulsion. The scope of this invention contemplates the installation of any equivalent apparatus and arrangement within the scope of the following claims.

I claim:

1. In apparatus for the propulsion of submarine vessels, the combination comprising a high pressure steam boiler, steam engines and means connecting said engines with said boiler for operation of the engines by steam from said boiler for the propulsion of said vessel on the surface, an accumulator for the storage of heated water under pressure, means for charging said accumulator from said boiler, means for operating said engines with steam furnished by said accumulator when the vessel is submerged, and means including a combustion chamber for generating steam for operating at least one of said engines when the vessel is submerged and said accumulator discharged, steam being generated in said combustion chamber by the combustion of gases therein.

2. In apparatus for the propulsion of submarine vessels, the combination comprising a high pressure steam boiler, steam engines and means connecting said engines with said boiler for operation of the engines by steam from said boiler for the propulsion of said vessel on the surface, an accumulator for the storage of heated water under pressure, means for charging said accumulator from said boiler, means for operating said engines with steam from said accumulator when the vessel is submerged, a combustion engine for the propulsion of said vessel submerged when said accumulator is discharged, and means connecting the exhaust of said combustion engine to one of said steam engines for

operating the same in conjunction with said combustion engine.

3. In apparatus for the propulsion of submarine vessels, the combination comprising a high pressure steam boiler and a source of fuel for heating said boiler, steam turbines and means connecting said engines with said boiler for operation of the engines by steam from said boiler for the propulsion of said vessel on the surface, a reciprocating type steam cruising engine also operated by steam from said boiler for propulsion of said vessel on the surface, a heat insulated accumulator for the storage of highly heated water under pressure, means for charging said accumulator from said boiler, means for operating said turbines with steam furnished by said accumulator when the vessel is submerged, means including a combustion chamber for generating steam for operating said cruising engine and turbines for the propulsion of said vessel submerged when said accumulator is discharged, and a combustion engine for the propulsion of said vessel submerged when both said steam turbines and cruising engine are inoperative.

WILLIAM J. BESLER.