A. HOAR.

SUBMARINE.

APPLICATION FILED APR. 30, 1915.

1,172,992.

Patented Feb. 22, 1916.

2 SHEETS—SHEET 1.

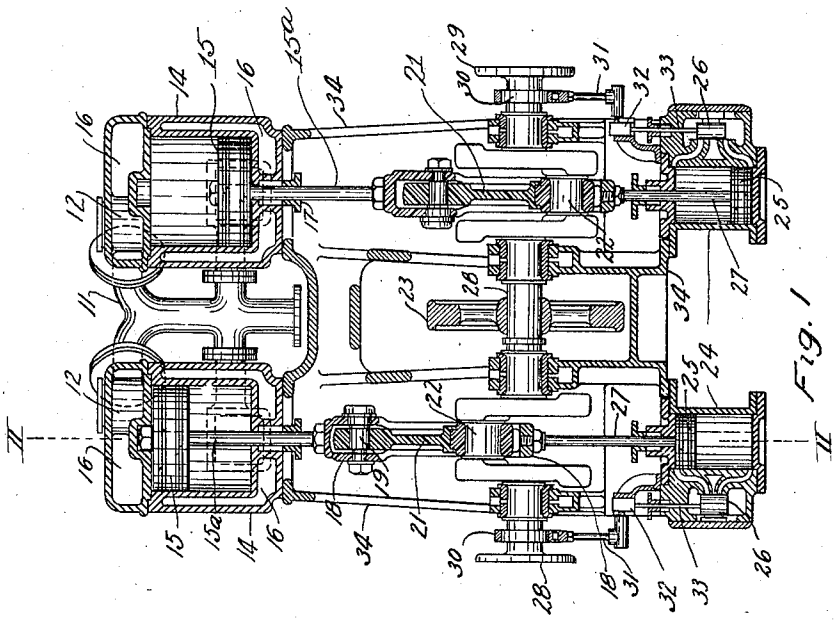


Fig. 1

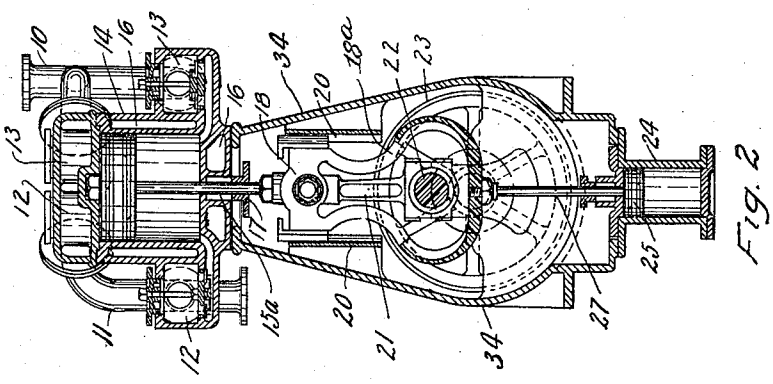


Fig. 2

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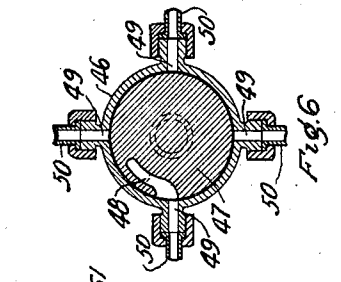


Fig. 6

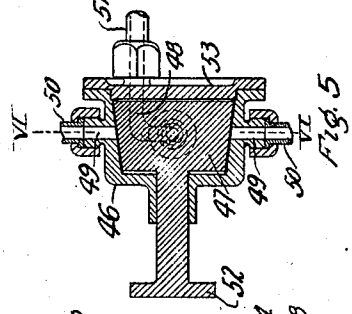


Fig. 5

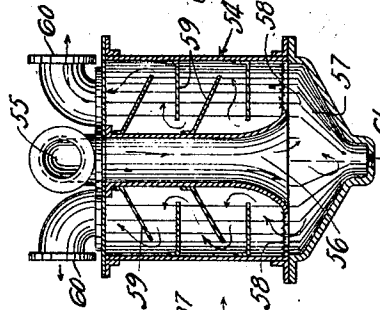


Fig. 4

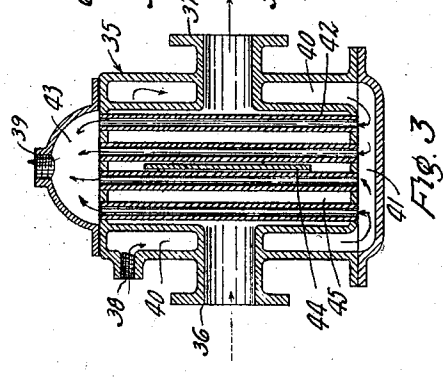


Fig. 3

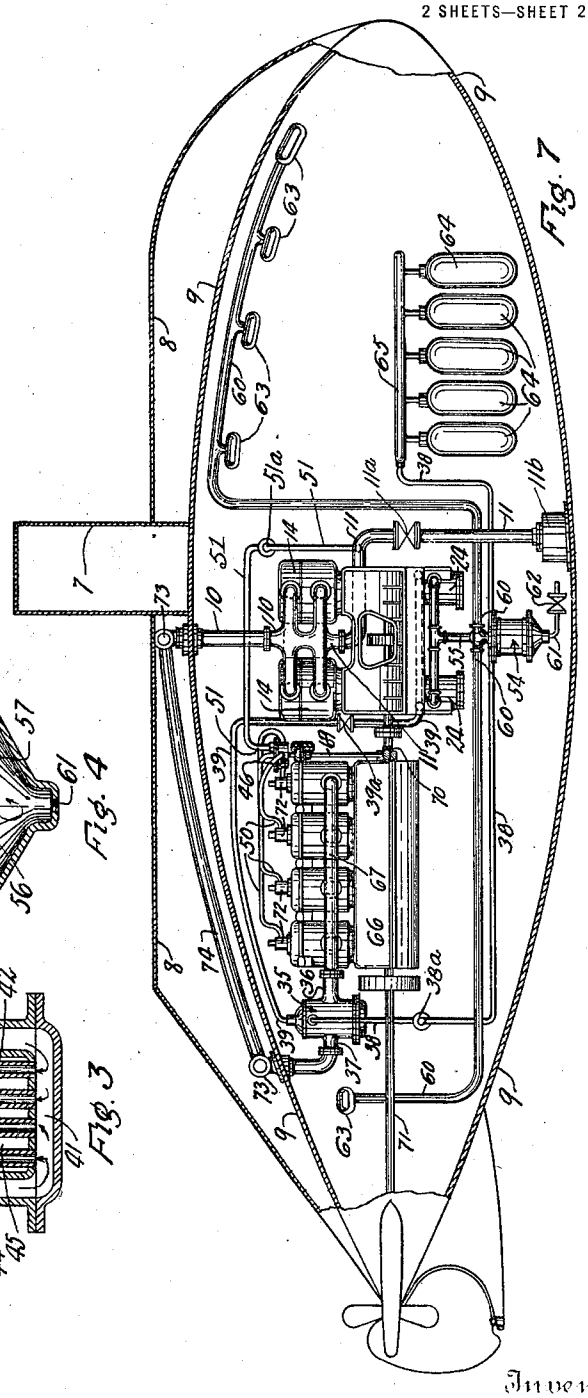


Fig. 7

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UNITED STATES PATENT OFFICE.

ALLEN HOAR, OF LONG BEACH, CALIFORNIA, ASSIGNOR TO ABNER R. NEFF, OF LOS ANGELES, CALIFORNIA.

SUBMARINE.

1,172,992. Specification of Letters Patent. Patented Feb. 22, 1916.

Application filed April 30, 1915. Serial No. 24,963.

To all whom it may concern:

Be it known that I, ALLEN HOAR, a citizen of the United States, residing at Long Beach, in the county of Los Angeles and State of California, have invented certain new and useful Improvements in Submarines, of which the following is a specification.

My invention relates to improvements in propelling mechanisms for submarines, more particularly of that type disclosed in Letters Patent to John M. Cage, No. 1,126,616, dated Jan. 25, 1915, and in applications filed by me March 5, 1915, Serial No. 12,281, and April 9, 1915, Serial No. 20,279, and has for its main object to provide a certain modified form of power plant, involving an exhaust pump similar to that of the said systems, but having for its main difference an air motor attachment for driving it, thus utilizing the mechanical energy contained in the compressed air stored, and conserving for the propulsion of the ship engine-power which was formerly expended in driving the exhaust pump.

My invention also embodies certain detailed improvements as hereinafter will be more definitely pointed out and claimed.

In the accompanying drawings:—Figure 1 is a vertical longitudinal sectional view of the exhaust pump and air motor, embodying my improved construction. Fig. 2 is a transverse sectional view of the exhaust pump and air motor, taken on the line II—II, Fig. 1. Fig. 3 is an enlarged sectional view showing in detail the compressed air heater. Fig. 4 is an enlarged sectional view showing in detail the construction of a combined exhaust muffler and oil separator. Fig. 5 is an enlarged sectional view of an improved combination timing and distributing valve. Fig. 6 is a transverse sectional view of the same taken on the line VI—VI, Fig. 5. Fig. 7 is a vertical longitudinal sectional view of a submarine, showing diagrammatically the embodiment of my improved construction and a general arrangement thereof.

Similar numerals of reference denote corresponding parts in the several views.

In Figs. 1 and 2 showing the combined exhaust pump and air motor in detail, 10 indicates the exhaust intake manifold, 11 indicates the exhaust discharge manifold, and 12 and 13 indicate intake and exhaust valves respectively, of any suitable automatic type. 14 indicates the double acting pump cylinders, 15 the pump pistons, 15^a the pump piston rods, 16 the water jacket, and 17 indicates packing glands. At 18 are shown cross-heads of a special construction, each having a lower hoop-shaped portion 18^a pendant from the wrist pin 19, to which the piston rods 27 of the air motor cylinders 24 are rigidly connected, and to which said cross-heads transmit their motion. The connecting rods 21 and the crank pins 22 revolve within the hoop-shaped portions 18^a of the cross-heads 18, and have an oscillating motion with respect to it. At 20 is shown the cross-head guides, at 23 a centrally disposed fly-wheel, and 34 indicates the engine frame. The motor cylinders 24 are fitted with valve mechanisms consisting of the slide valves 26, the valve rods 33, the valve rod guides 32, the eccentric rods 31, and the eccentrics 30. However, any suitable type of valve mechanism may be substituted in place of the slide valves shown. 28 and 29 indicate flange couplings for connecting to the engine crank shaft.

In Fig. 3 the reference numeral 35 indicates the casing of an air heater, 36 an inlet connection for the exhaust gases directly from the engine, and 37 an outlet connection for the exhaust gases leading to the condenser outside the hull. At 38 is shown a connection for the piping leading from the air storage reservoir, and at 39 is shown a connection for the hot air piping leading to the air motor cylinders 24. 40 is an annular receiver or relay chamber in which the compressed air is first heated by coming in contact with the hot inner walls, from which air passes downward to the bottom chamber 41, and from thence to the tubes 42, which cause the air when passing therethrough to be brought to a correspondingly higher temperature by reason of the comparatively greater heating surface. At 43 is shown an upper air receiving chamber, with which connection 39 communicates, and at 44 is shown a baffle which causes the hot exhaust gases from the combustion engine to circulate throughout the entire chamber 45 before passing out through the pipe 37.

In Fig. 4, I have shown an improved construction of my combined muffler and oil

separating device, wherein the reference numeral 54 indicates the casing of the same, a central inlet connection being provided at 55, for leading the exhaust of the air motor to an inner central tube 56, which in turn conducts it to a chamber 57 in the bottom of the casing 54. Surrounding the tube 56 at its lower end is a screen 58, through which the air must pass in its upward movement around the tube 56 and in the chamber around said tube are a series of baffle plates 59, the chamber containing said baffle plates communicating with outward connections 60 leading to the distributing pipes. At 61 in the bottom of the chamber 57 is shown a connection for draining off the oil deposited therein.

In Figs. 5 and 6, the reference numeral 46 indicates the valve body of my improved gas distributing and timing device, 47 indicates a revoluble valve core, 48 the inlet port therein, 49 the outlet ports, 51 a connection to the main exhaust discharge line 11, (Fig. 7), and 50 connections leading from the ports 49 to the air inlet valves 72 of the combustion engine. At the end of the spindle shaft of the core 47 is a flange 52 for attaching to the vertical time shaft 69 of the combustion engine 66, said shaft 69 being caused to revolve, by means of the spiral gears 70, from the crank shaft 71, as is the usual practice in engines of this type.

In Fig. 7, the reference numeral 7 indicates the conning tower of a submarine, 8 the superstructure and 9 the hull. At 63 are shown ventilating air outlet boxes, at 64 compressed air storage tanks, and at 65 a manifold connection to the tanks 64. An internal combustion engine for propelling the ship is indicated at 66, 67 being the exhaust manifold of the same and 72 the air intake valves. At 73 are indicated the headers of the exhaust gas cooler and condenser, and at 74 the circulating tubes thereof.

A general description of the operation is as follows: Compressed air from the storage tanks 64 is led through the manifold 65 and piping 38 to the reheater 35, the pressure being first reduced, by passage through the pressure reducing valve 38ª, from the storage pressure of the reservoir to any suitable working pressure, say 150 pounds per square inch. The enlarged chamber 40 of the reheater 35 serves to act as a receiver, slowing up the velocity of the air in passing therethrough, and thereby giving it sufficient time properly to be heated. The heat is supplied to the chamber, by passing the exhaust gases (usually found to be at a temperature of about 800 degrees F.) directly from the exhaust manifold 67 through the reheater 35, entering at the connection 36, passing into the chamber 45 which surrounds the air tubes 42, around the baffle 44, and out through the connection 37. The compressed air entering at 38 is first heated by contact with the hot walls of the chamber 45, and then passes down into chamber 41 and up through the hot tubes 42, in which it is exposed to a greater heating surface, to the chamber 43 and out through the piping 39 to the cylinders 24 of the air motor. At 39ª is shown a cut-off valve for regulating the flow of air to the cylinders. After expanding in the cylinders 24 of the air motor and performing all the work necessary to expel the gases in the pump cylinders 14 overboard against the outside water pressure, the air is exhausted from the motor through the piping 55 into the muffler 54 in which the velocity of the air is checked by the enlarged area thereof, and further by the baffles 59. A great part of the oil with which the entering air is laden is deposited in the bottom of the chamber 57 by this sudden checking of its velocity, and the air continuing its course through the screen 58 and the baffles 59, still further is relieved of the particles of oil and moisture held in suspension by the contact and scrubbing action of the baffles 59, the remaining oil being deposited on them and drained off into the lower portion of the chamber, from which it may be drawn off through the connection 61. The expansion and checking of the flow of the air in the muffler 54 causes it to issue from the connections 60 with an even flow and with all periodic explosive noises eliminated. From the muffler 54 the air is led through the piping 60 to the various points of the ship at which ventilation is desired, and is admitted into the interior of the vessel at atmospheric pressure through the outlet boxes 63. The air then is used to support the combustion in the cylinders of the main engines as is done in the Letters Patent to Cage hereinbefore referred to, or may be used to support the combustion in the fire box of the boiler shown in my application, Serial No. 12,281 hereinbefore referred to.

The cycle of operation of this system is completed by passing the exhaust gases, after leaving the reheater 35, through a cooling and condensing apparatus outside the hull, indicated by the headers 73 and the tubes 74, and then by means of the pipe 10 drawing them into the pump cylinders 14, wherein they are compressed to a pressure somewhat above that of the outside water pressure and discharged overboard through the piping 11 and the check valve 11ᵇ. By means of the cooling apparatus outside the hull, using the open sea as a cooling agent, a great shrinkage in the volume of the gas is effected, and thereby a correspondingly smaller pump is needed, and a resultant reduction in the power consumed in its expulsion overboard.

My method of reheating the air and then

using it to perform the work of operating the exhaust pump, accomplishes, first, an economy of energy by regaining a portion of the energy which was originally expended in compressing the air from the atmosphere to the storage pressure; secondly, it affords the full engine power for propulsion submerged plus a certain amount of excess energy regained over that necessary to perform the work of expelling the exhaust gases; thirdly, by utilizing the heat of the exhaust gases for the purpose of reheating the compressed air before use, it serves to regain some of the heat units normally wasted by the engine, and transpose them into useful work in the cylinders of the air motor. The great economy, however, is in the great saving of air used, and therefore a corresponding increase in the radius of action submerged, which I have effected in a manner as follows:—As is well known, internal combustion engines draw into their cylinders considerably more air than is necessary completely to consume in combustion all the fuel injected into the cylinder with it, and analysis of the exhaust gas shows that a large percentage of it is still pure air.

In Figs. 5 and 6, I have shown in detail a device for regulating and distributing a certain portion of these gases after being cooled and purified to some extent, back into the engine cylinders along with a charge of fresh air. The operation is as follows: the core of the valve 47 is revolved within the casing 46 by being attached to the revolving time shaft 69 of the engine by the flange connection 52, thus bringing the port 48 into contact with the outlet ports 49 in rotation and synchronizing with the timing of the opening of the air intake valves of the engine. A portion of the cool exhaust gas is admitted to the valve by the piping 51 leading from the outboard exhaust discharge line 11. In the piping 51 is placed a pressure reducing valve 51ª for reducing the pressure from that of discharge down to say eight or nine pounds, at which pressure it is introduced into the engine cylinders in rotation through the valve 46 and the piping 50, as has been explained. In this manner it is possible to regulate the amount of fresh air admitted to the engine cylinders to say one and one-half times that theoretically necessary to support a complete combustion of the fuel injected therein, which in practice has been shown is the correct amount to secure the best results. It easily will be seen that the amount of air drawn into the cylinders from the interior of the vessel can only be that amount of air which in addition to the amount already in the cylinders completely will fill them, and by my device this is regulated by the amount of exhaust gas admitted. This regulation of the amount of exhaust gas admitted is accomplished by the length of time the ports 48 and 49 cover one another with reference to the length of time of the intake stroke of the engine, or in other words, through that portion of the stroke during which these ports cover one another, and by the pressure at which the gas is admitted, governed at will by the pressure reducing valve 51ª. It will be understood that the above operation applies only to combustion engines wherein a measured charge of fuel is injected, such as in oil engines. With this type of engine, the supply of fuel will be constant and the supply of air will be regulated by the amount of exhaust gas admitted. The air motor may also be used as a starting engine for the combustion engine when starting up or reversing.

While I have shown and described my present invention as applied to a submarine in which the motive power is an internal combustion engine, I wish it to be understood that I contemplate its use in connection with a steam engine and boiler, such as disclosed in my application filed March 5, 1915, Serial No. 12,281, and in this connection, in using the term "combustion power plant" intend that the scope of the same shall be to cover not only internal combustion engines but also steam engine power plants, or in fact any form of engine requiring combustion to create the driving power.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, means for discharging overboard the products of combustion, air storage means, and means driven through the energy of the compressed air in said air storage means for operating said discharge means.

2. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, means for discharging overboard the products of combustion, air storage means, and means driven through the energy of the compressed air in said air storage means for operating said discharge means, the exhaust air from said driving means discharging into the interior of the vessel for the purposes of ventilation and to support the combustion in the power plant.

3. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, an exhaust pump for expelling overboard the burnt gases from the power plant, air storage means, and an air motor driven by the energy of the compressed air in said air storage means for operating said pump, the exhaust air from said air motor discharging

into the interior of the vessel for the purposes of ventilation and to support the combustion in the power plant.

4. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, an exhaust pump for expelling overboard the burnt gases from the combustion power plant, an air motor for operating said pump, and a combined muffler and oil separator receiving the exhaust air from said motor and discharging the air thence into the interior of the vessel for the purposes of ventilation and to support the combustion in the combustion power plant.

5. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, cooling and condensing apparatus for the products of combustion, a pump for discharging overboard the products of combustion, air storage means, and means driven by the energy of compressed air in said air storage means for operating said pump.

6. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, a compressed air reservoir, an exhaust pump for expelling overboard the burnt gases from the combustion power plant, an air motor for operating said pump, said motor being supplied from said compressed air reservoir, and a reheater for receiving and heating the compressed air in its passage between said reservoir and said air motor.

7. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, a compressed air reservoir, an exhaust pump for expelling overboard the burnt gases from the combustion power plant, an air motor for operating said pump, said motor being supplied from said compressed air reservoir, a reheater for receiving and heating the compressed air in its passage between said reservoir and said air motor, and connections between the exhaust manifold of the combustion power plant and the reheater for allowing the hot exhaust gases to be used for heating the compressed air in its passage through the reheater.

8. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, a compressed air reservoir, an exhaust pump for expelling overboard the burnt gases from the combustion power plant, an air motor for operating said pump, said motor being supplied from said compressed air reservoir, a combined muffler and oil separator into which the exhaust from said air motor discharges and from which it discharges into the interior of the submarine for the purposes of ventilation and to support the combustion in the cylinders of the combustion power plant, and a reheater for receiving and heating the compressed air in its passage between the reservoir and the air motor.

9. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, a compressed air reservoir, an exhaust pump for expelling overboard the burnt gases from the combustion power plant, an air motor for operating said pump, said motor being supplied from said compressed air reservoir, a combined muffler and oil separator into which the exhaust from said air motor discharges and from which it discharges into the interior of the submarine for the purposes of ventilation and to support the combustion in the power plant, a reheater for receiving and heating the compressed air in its passage between the reservoir and the air motor, and connections between the exhaust manifold of the combustion power plant and the reheater for allowing the hot exhaust gases of the engine to be used for heating the compressed air in its passage through the reheater.

10. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment, a compressed air reservoir, means for cooling and condensing the products of combustion, and an air motor driven exhaust pump for expelling overboard said products of combustion, said motor being supplied from said compressed air reservoir.

11. In a submarine, in combination, a hull having an engine compartment, a combustion power plant in said compartment for propelling the submarine, cooling apparatus for condensing the products of combustion therefrom, a pump to expel overboard these products of combustion, a compressed air reservoir, an air motor having connections with said air reservoir for driving said pump, means for heating the compressed air in its passage between said reservoir and motor, said means utilizing the heat of the products of combustion from the power plant, and means for cleaning and discharging the exhaust air from the compressed air motor into the engine compartment.

In testimony whereof I have hereunto set my hand this 24th day of April, 1915.

ALLEN HOAR.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."