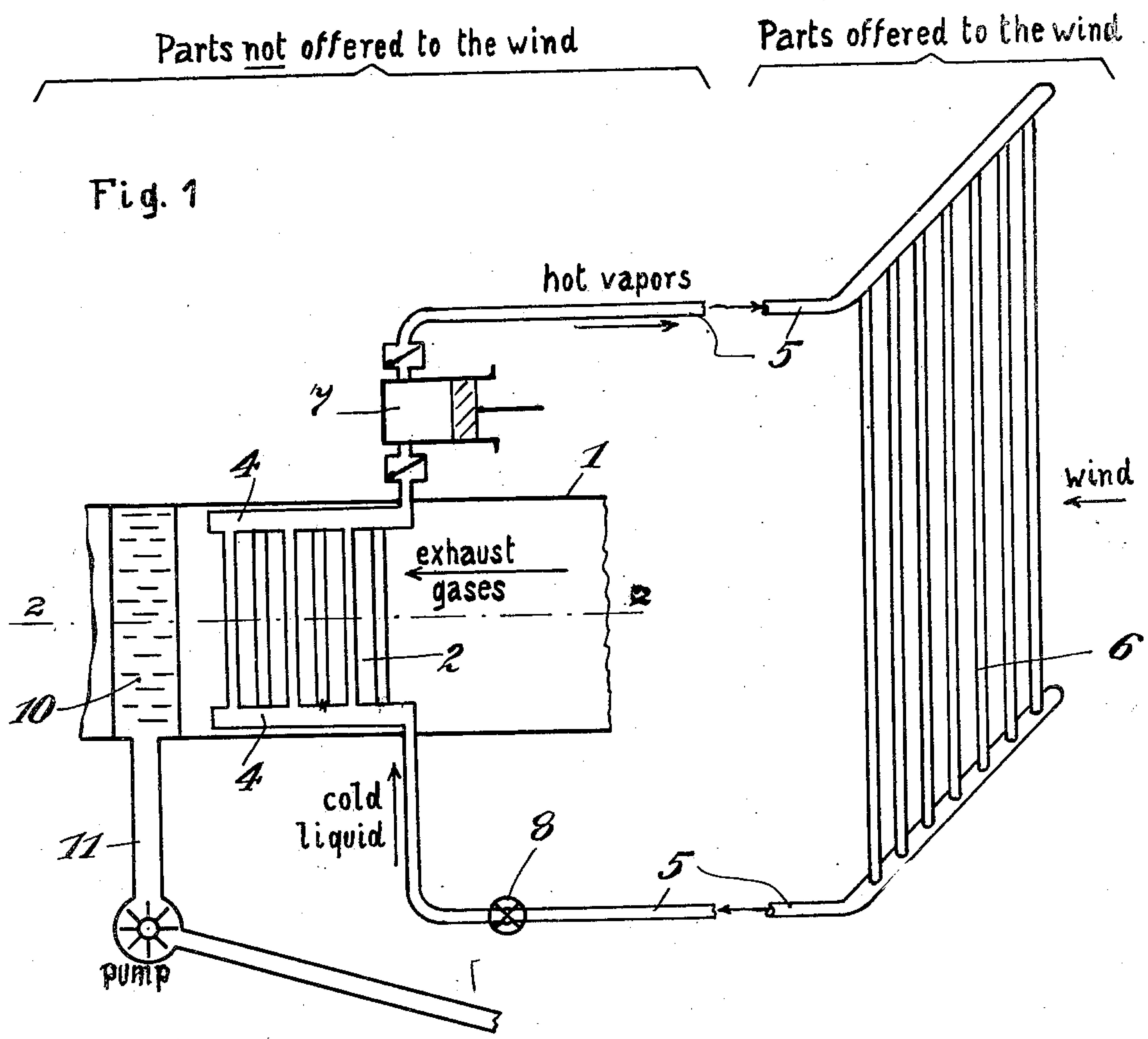
Dec. 20, 1927. 1,653,604

P. SCHRÖDER

CONDENSER FOR AIRSHIPS

Filed June 4, 1926 3 Sheets-Sheet 1

Fig. 1



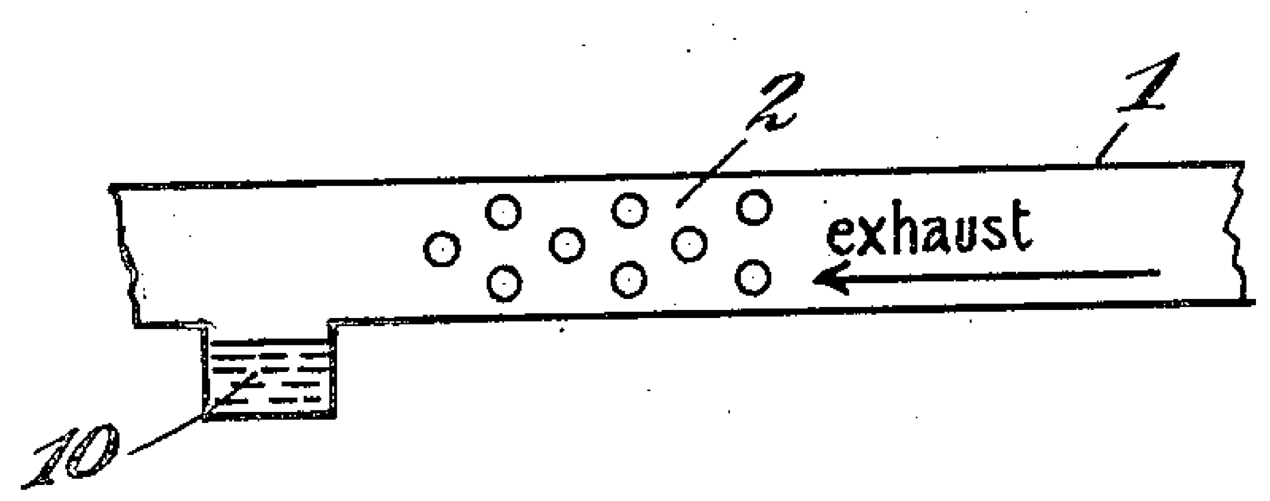


Fig. 2.

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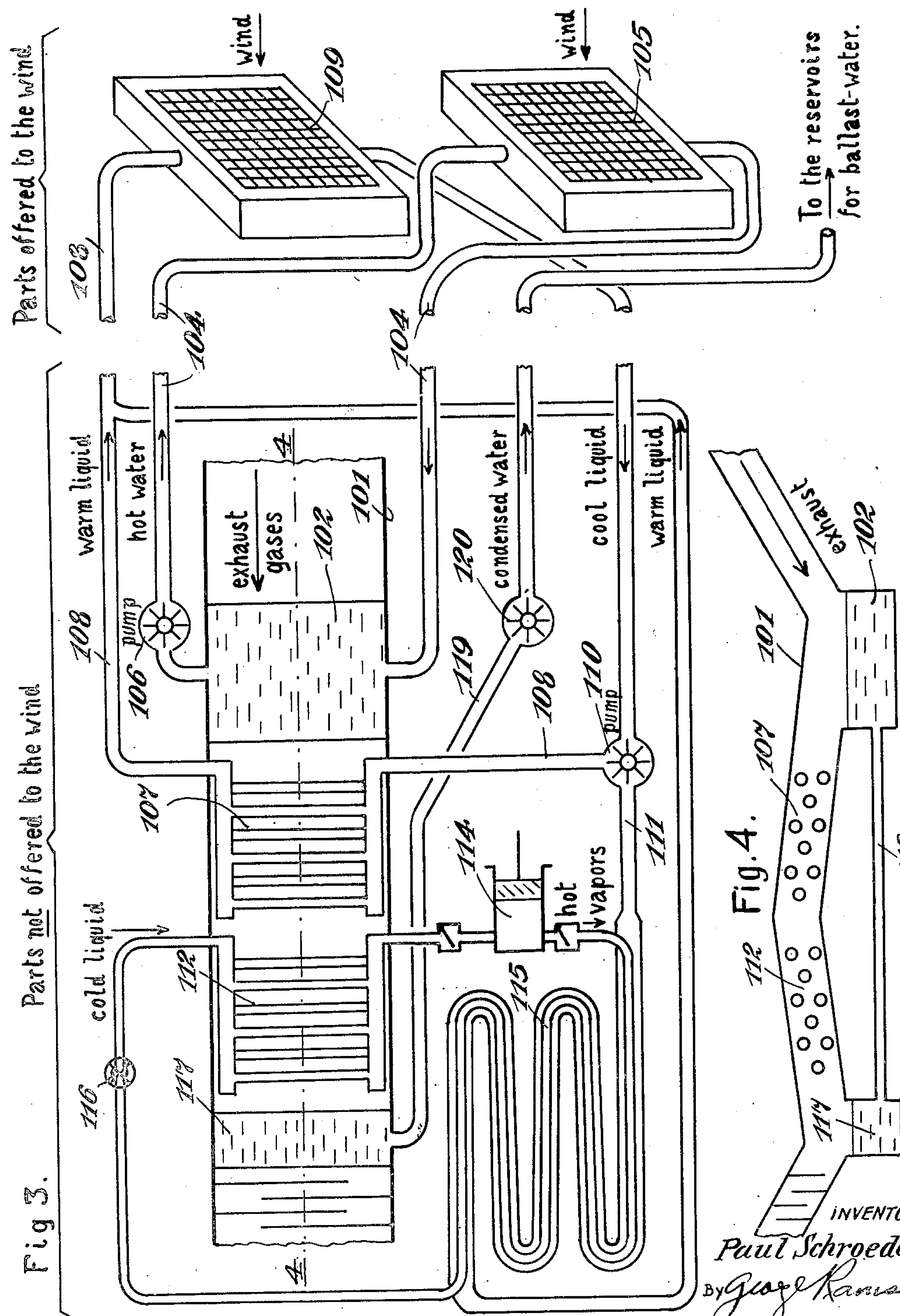

Fig 3.

Fig. 4.

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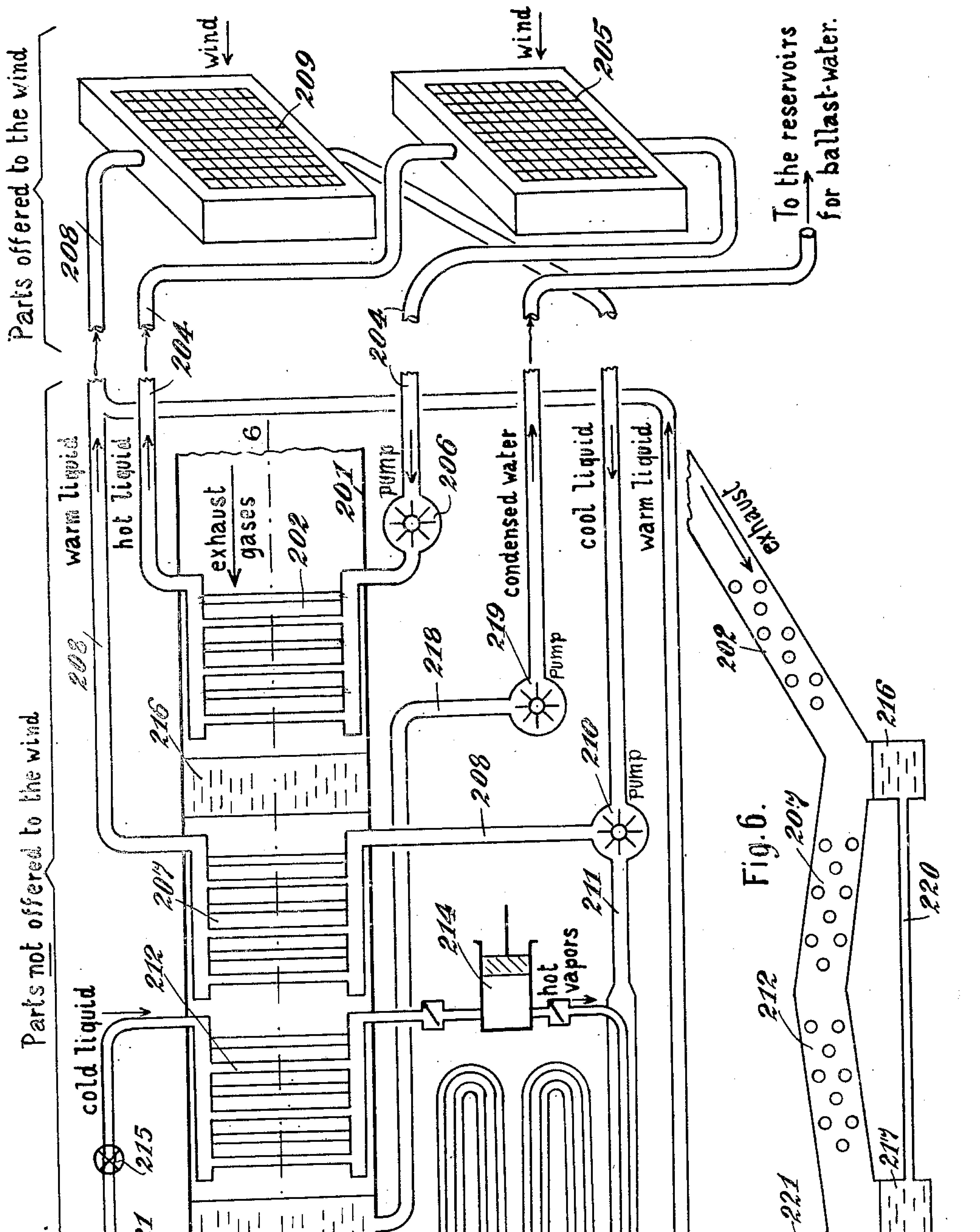

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Patented Dec. 20, 1927. **1,653,604**

UNITED STATES PATENT OFFICE.

PAUL SCHRÖDER, OF STUTTGART, GERMANY, ASSIGNOR TO EXCAELUM CORPORATION, A CORPORATION OF NEW YORK.

CONDENSER FOR AIRSHIPS.

Application filed June 4, 1926. Serial No. 113,616.

The present invention relates broadly to lighter-than-air airships, and more especially to method and apparatus for condensing water vapor in the exhaust gases from internal combustion engines used to propel the ship.

Lighter-than-air airships gradually lose weight in flight due to fuel consumption. It is known that this loss of weight may be compensated by condensing the moisture present in the exhaust gases from the internal combustion engines used in propelling the ship. In the methods heretofore proposed for this purpose, the exhaust pipes have been subjected to the direct cooling effect of the air around the airship. This prior method has been impractical because of the abnormal stresses set up in the exhaust pipes due to large changes in temperature. Furthermore, the direct cooling of exhaust pipes tends to cause soot to be deposited upon the side walls of these pipes, thereby tending to clog and choke the pipes and at the same time to greatly interfere with the cooling operations, because the coating formed on the pipes acts as a heat insulator. Another serious disadvantage of the prior systems is the fact that the air surrounding the ship may be of such a temperature that the exhaust gases cannot be effectually air cooled, and therefore, the water vapor in these gases is lost. This is particularly liable to happen where the ship is flying over hot arid areas, such as deserts, where it is most important and desirable to conserve all water possible.

The present invention overcomes the difficulties of the known prior art by utilizing an intermediate cooling fluid for purposes of heat transfer, which fluid receives the heat from the exhaust gases and dissipates it through air cooled radiators. This fluid should be sufficiently volatile to permit the fluid to be liquefied by compression so that it may be again vaporized and the heat required for evaporation may be withdrawn from the hot exhaust gases. There are fluids which in a liquid state evaporate readily at temperatures considerably lower than that required to properly cool the exhaust gases to obtain condensation of the water therein, and which may readily be reconverted to liquids by pressure and the withdrawal of heat. Examples of such liquids are NH_3, SO_2, CO_2, CH_3CL. According to my invention, such gases may be passed through condenser tubes comprising a grid set across the exhaust conduit in such manner as to be in the path of the exhaust gases. This condenser may be connected in a closed circuit comprising an air cooled radiator exposed to the air outside of the airship, an expansion valve, and a compressor. The refrigerant medium may pass through the expansion valve and expand in the condenser tubes in such manner as to absorb heat from exhaust gases and then be drawn off through the compressor and forced under pressure into the radiating system exposed to the air whereby the heat taken up from the exhaust gases is dissipated to the atmosphere. By means of this arrangement, it is possible to cool the exhaust gases many degrees below that of the surrounding atmosphere and thereby conserve the water vapor which is present in the exhaust gas which otherwise would be lost.

It is recognized that the present invention may be embodied in apparatus and constructions other than those specifically herein disclosed so that the disclosure herewith is to be considered as illustrative and not in the limiting sense.

Fig. 1 diagrammatically illustrates a sectional plan view of a simple form of apparatus for carrying out the present invention.

Fig. 2 is a diagrammatic sectional view on line 2—2 of Fig. 1.

Fig. 3 is a sectional plan view which diagrammatically illustrates a multi-stage system of cooling the exhaust gases.

Fig. 4 is a diagrammatic sectional view on line 4—4 of Fig. 3.

Fig. 5 also diagrammatically illustrates a different multi-stage cooling arrangement from that shown in Figs. 3 and 4.

Fig. 6 is a diagrammatic sectional view taken on line 6—6 of Fig. 5.

Referring now more especially to Figs. 1 and 2, the exhaust conduit 1 is crossed by condenser tubes 2 which are attached to suitable headers 4. These headers are connected by suitable pipes 5 with an air radiator 6 exposed to the air surrounding the ship. The hot pipe line leading from the condenser 2 may be provided with a compressor 7, adapted to withdraw vaporized refrigerant from the condenser and force the same under pressure into a radiator 6. The cool pipe line 5 leading to the condenser from the radiator in which the refrigerant is liquefied may be provided with a suitable expansion valve 8 adapted to control the expansion of the cooling medium as it enters the condenser. Preferably, the medium used in this closed circuit is such as will liquefy under pressure at a relatively high temperature and will assume a gaseous form when the pressure is released, thereby taking up the heat from its surroundings during the expansion cycle. By this means, the exhaust gases may be cooled below atmospheric temperature, where necessary, and the water in the exhaust gases, may be condensed and collected in the trough 10 from which it may be removed by the drain pipe 11 and conveyed to suitable storage tanks to be used for ballast, or as desired.

Referring now more especially to Figs. 3 and 4, a more comprehensive cooling system for the exhaust gases is diagrammatically illustrated and comprises an exhaust conduit 101 crossed by an open trough of preliminary cooling water 102, which trough is connected by suitable pipe lines 104 to an air cooled radiator 105. One of the pipe lines may be provided with a suitable pump 106 to circulate the water through the trough 102 and the radiator 105. The exhaust gases next encounter a condenser 107 which is likewise connected by suitable pipes 108 with an air cooled radiator 109 in such manner as to take up the heat from the exhaust gases and dissipate the same by the radiator located outside of the airship. One of the pipes 108 may likewise be provided with the circulating pump 110, located preferably in the cool pipe, and a by-pass circuit 111 of cooled liquid may lead from the pump into the pipe 108 carrying the warm fluid to the radiator. The by-pass circuit of cooled liquid may be utilized for cooling the liquid or medium in a refrigerating system comprising the third cooling stage encountered by the exhaust gases. This third stage comprises a condenser 112 connected in a closed circuit with a compressor 114, a cooling coil 115, or the like, cooled by the by-pass circuit 111 from the pump 110, and expansion valve 116. The closed circuit for this final stage of cooling preferably includes one of the volatile substances heretofore mentioned which liquefies at relatively high temperature under pressure and which absorbs a considerable amount of heat when expanded in the condenser 112. A second trough 117 is also provided so that the water condensed from the exhaust gases will fall into either trough 102 or 117, and since these troughs are connected by compensating pipe 118, the excess of water in one trough will flow through the pipe 118 into the other trough. Flow through this pipe may be needed to keep trough 102 filled. The hot gases, while being cooled by the water in reservoir 102, vaporize some of the water so that the gases tend to be very humid when they strike the cooling tubes further on in the exhaust conduit. This is desirable because it will cause a maximum amount of condensation on the cooling tubes with the result that the tubes will be drenched and deposited soot effectively washed off. Condensate may run directly back to reservoir 102, but in any event this reservoir will be kept properly filled through equalizer pipe 118. A drain pipe 119 may be connected with one of the troughs, for example, the trough 117, to carry the condensed water to suitable reservoirs (not shown) for storing the water as ballast. The flow of the water through the drain pipe 119 may be controlled or accelerated by the pump 120.

Figs. 5 and 6 diagrammatically illustrate a further modification of the present invention wherein closed systems of cooling mediums provide multi-stages of cooling zones for cooling the exhaust gases from internal combustion engines used to drive a ship. The exhaust conduit 201 is crossed by a plurality of condensers. A first condenser 202 encountered by the exhaust gases is connected by suitable circulating pipes 204 with an air radiator 205 located outside of the airship, and the circulation of the cooling liquid may be accelerated by a suitable pump 206. The next stage of cooling comprises a second condenser 207 likewise connected to circulating pipes 208 with an air cooled radiator 209 located outside of the ship. A pump 210 is adapted to circulate the cooling liquid in this second stage cooling zone and may operate to drive the liquid through a by-pass pipe 211 which leads from the cool circulating pipe to the warm circulating pipe and the cool by-passed liquid may be used to cool a refrigerant used in the third condenser 212, forming the final cooling zone for the exhaust gases. This condenser 212 is connected in a closed system with a compressor 214 for compressing the refrigerant medium and an expansion valve 215 is provided to control the expansion of the refrigerant into the condenser 212. Suitable water troughs 216 and 217 are arranged in the exhaust conduit in such manner that the condensed water will flow into the troughs and may be led to ballast reservoirs (not shown) by drain pipe 218 in which may be provided a pump 219. Preferably, the troughs 216 and 217 are connected by compensating pipe 220 so that the condensed water may be equalized between the troughs. Preferably, baffle plates 221 are provided beyond the refrigerating and cooling zones in order that these plates may receive any globules of water being carried along by the exhaust gases. The exhaust conduit may be provided with inclined bottom portions constructed to drain the condensed water into the troughs 216 and 217 as is illustrated in Fig. 6.

The present invention is designed more especially to produce an efficient cooling of the exhaust gases and may be utilized where a ship is operating at a warm climate or warm atmosphere under which conditions air cooling alone may not sufficiently lower the temperature of the exhaust gases to properly condense the water content thereof. The major portions of the system are located within the airship to avoid added head resistance, and the only exposed parts are the air cooled radiators which are exposed to the atmosphere surrounding the ship.

Having described my invention, I claim:—

1. In an airship driven by at least one internal combustion engine, preliminary cooling means comprising an air cooled radiator adapted to contain a circulating liquid adapted to dissipate a portion of the heat in the engine exhaust gases to the surrounding atmosphere, final cooling means adapted to contain an expansible substance adapted to absorb heat while expanding, conduit means to direct said gases to both of said cooling means, and storage means for the condensate.

2. The method of condensing water vapors present in the exhaust gases from internal combustion engines driving an airship, comprising preliminarily cooling said gases by liquid cooling means, finally cooling said gases by gasifying a volatile substance, and dissipating the heat received by said substance to the atmosphere surrounding said ship.

3. The method of condensing water vapors present in the exhaust gases of internal combustion engines driving an airship, comprising retaining the gases in conduits protected from the outside atmosphere, preliminarily cooling said gases by liquid cooling means, finally cooling said gases by gasifying a volatile substance, dissipating the heat received by said substance to the outside atmosphere surrounding said ship, and collecting and storing the condensate.

4. In an airship propelled by at least one internal combustion engine, an exhaust conduit within the airship, a heat transfer surface positioned to receive heat from gases in the conduit, means to conduct a vaporizing refrigerant to and from said surface, means to compress the vaporized refrigerant, means within the airship to transfer heat from the compressed refrigerant to a cooling liquid, and means to conduct the cooling liquid to a point outside of the airship and dissipate heat therefrom to the surrounding air.

5. The method of recovering water from the exhaust gases of an internal combustion engine propelling an airship, which comprises retaining the exhaust gases in conduits located wholly within the airship, transferring heat from the gases to a vaporizing refrigerant, transferring heat from the refrigerant to a cooling liqud, and dissipating heat from the cooling liquid to the outer air.

6. The method of recovering water from the exhaust gases of an internal combustion engine propelling an airship, which comprises retaining the exhaust gases within the airship, transferring heat from the exhaust gases to a vaporizing refrigerant, retaining the refrigerant within the airship, transferring heat from the refrigerant to a cooling liquid, and dissipating heat from the cooling liquid to the surrounding air.

7. In an airship propelled by at least one internal combustion engine, an exhaust conduit, a radiator outside of the airship adapted to contain a constantly liquid cooling fluid, means to conduct said fluid to and from the radiator from a point within the airship, means to transfer heat from exhaust gases in the conduit to said cooling fluid to initially cool the gases, and means to thereafter transfer heat from the initially cooled gases to a vaporizing refrigerant.

8. In an airship propelled by at least one internal combustion engine; at least two radiators located outside of the airship, one for a preliminary cooling circuit and one for a further cooling circuit; cooling circuits comprising means to conduct constantly liquid cooling fluids to and from the radiators from points within the airship; an exhaust conduit within the airship, means in one zone along the exhaust conduit to transfer heat from the exhaust gases to the cooling fluid of the preliminary cooling circuit; means in another zone along the exhaust circuit to transfer additional heat from the exhaust gases to a vaporizing refrigerant; and means within the airship to transfer heat from the refrigerant to the cooling liquid of the second mentioned cooling circuit.

9. In an airship propelled by at least one internal combustion engine, an exhaust conduit, means to condense moisture from gases flowing through said conduit by cooling the gases with a vaporizing refrigerant, and means to humidify the gases before the moisture is condensed therefrom.

10. In an airship propelled by at least one internal combustion engine, an exhaust conduit located within the airship, a heat absorbing surface within the conduit, means to conduct a vaporizing refrigerant to and from said surface, and a water pan opening into said conduit on the upstream side of said heat absorbing surface.

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