

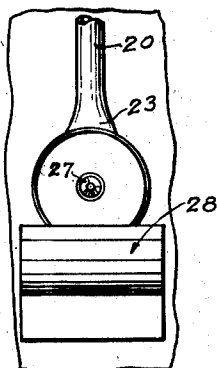
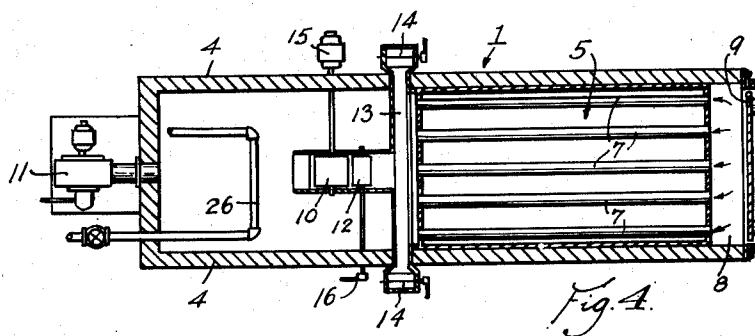
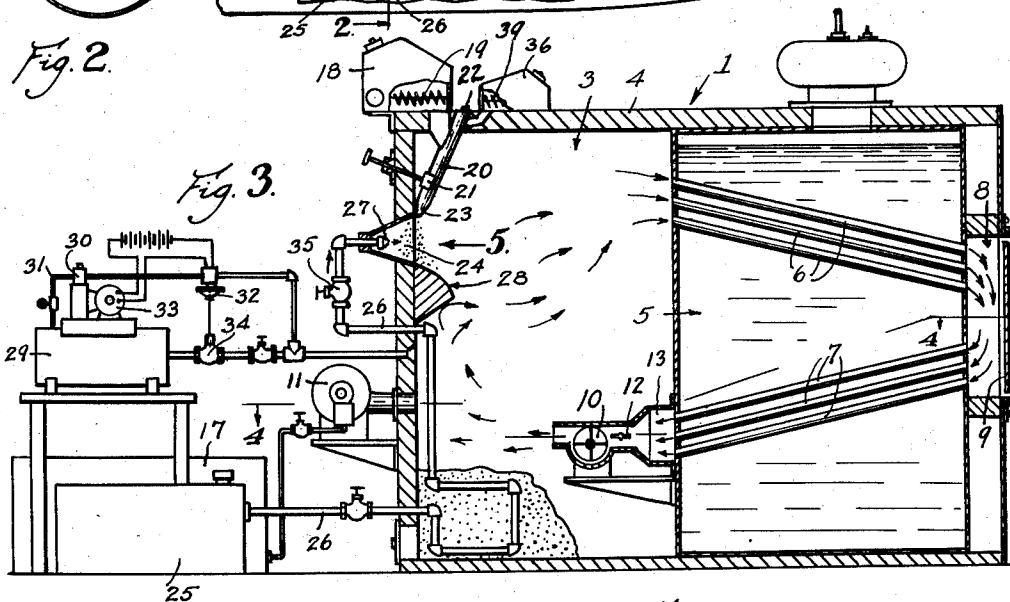
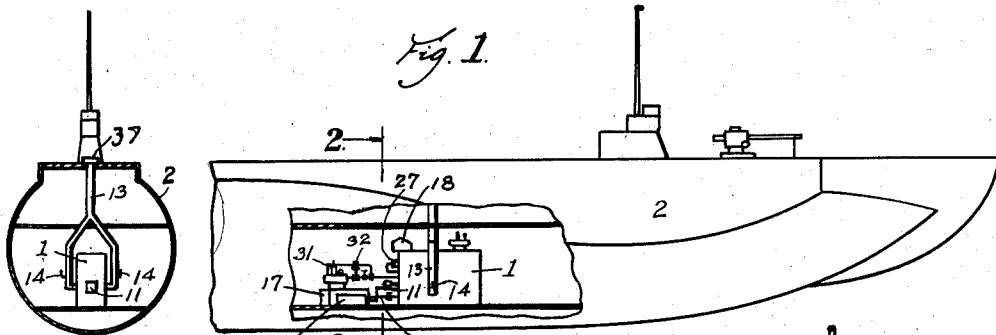
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POWER PLANT

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POWER PLANT

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My invention relates to submersible boats, and it relates more particularly to the propulsion of said boats while they are under water. The power supply for submersible boats, commonly called submarines, has heretofore consisted of electric storage batteries for use under water, and internal combustion engines for propulsion on the surface and to charge said storage batteries. This method of propulsion involves the disadvantage of great weight and cost of storage batteries of sufficient capacity to propel the submarine even relatively short distances under water, and it has been necessary to provide internal combustion engines of sufficient power both to propel the boat on the surface and at the same time charge the storage batteries. As used in warfare, this dual power requirement has not been adequately met even by the large engines commonly used, since, on the surface, great speed and a high charging rate for the batteries are often simultaneously demanded. Furthermore, dangerous gases result from the charging of said batteries, and said gases are sometimes produced during discharge under water.

The principal object of my invention is to provide a steam power supply for submarines that may be used both under water and also upon the surface thereof. I achieve said object by providing a boiler and firebox therefor wherein oil or coal may be burned while the boat is upon the surface of the water, and wherein a fuel such as aluminum, which results in a solid product of combustion, may be burned under water. Although it is well known that finely divided aluminum will burn readily and thereby produce a large amount of heat, the utilization of aluminum as a fuel for producing steam encounters many difficulties, and said difficulties are magnified where it is required that the same boiler be also useful for burning oil.

In boiler furnaces heretofore used, the heat of combustion has been transferred to the boiler walls, and the water and steam therewithin, mainly by convection; the products of combustion being gaseous serve to convey the heat to said walls. In addition to the heat transferred by convection, there has been a certain amount of heat transferred by radiation from the combustion and absorption by the boiler walls. The latter method of heat transfer, however, is inadequate by itself.

When aluminum is used as a fuel, no gaseous products of combustion are produced, the aluminum oxide produced being a solid. It does not

appear to be feasible to bring said aluminum oxide into direct contact with the walls of a boiler adapted also to burn oil thereby to transfer its heat by convection. I, therefore, introduce an inert gas, such as nitrogen or helium into the firebox when aluminum is being burned, and I circulate said inert gas in such a way that it first comes in contact with the hot aluminum oxide and then circulates through the boiler in much the same way as do the products of combustion of oil. The circulation of said inert gas, however, differs from that of the products of combustion of oil in that the former is recirculated whereas the latter passes out to the atmosphere after once passing through the boiler. Said inert gas thus serves as a special medium for the convection of heat from the aluminum oxide to the boiler walls.

A further object of my invention is to provide means first for mixing finely divided aluminum with oxygen at a temperature above the kindling point thereby to produce finely divided aluminum oxide, and then passing an inert gas such as nitrogen through or past said aluminum oxide while the latter is falling under the force of gravity and thus sufficiently scattered to be intimately in contact with said gas. It will be apparent that, with my invention, an additional heat transfer step is involved, compared with the ordinary oil burning process, that is, the heat of combustion must first be transferred from a solid to a gas, and thereafter transferred from the gas to the boiler wall. On the other hand, in ordinary boilers, the heat of combustion is primarily present in the gaseous products of combustion, and it need only be transferred to the boiler wall. The transfer of heat from the aluminum oxide to the nitrogen thus presents a new problem which I prefer to meet by directing a stream of nitrogen in a generally upward direction, intermixing it with the falling, finely divided aluminum oxide.

A further object of my invention is to provide means for preheating the aluminum and the oxygen with which it is to combine thereby to aid complete combustion thereof. I achieve said result by passing said aluminum and said oxygen through conduits within the combustion chamber. Said materials are thus in condition for immediate combustion when they are mixed. I desire that combustion take place immediately, rather than after the aluminum has fallen an appreciable distance, in order to facilitate the transfer of heat from the aluminum oxide to an inert gas, as hereinbefore described.

A further object of my invention is to provide means for maintaining a constant, predetermined pressure of an inert gas within a boiler firebox, for the purpose aforesaid. I prefer to use nitrogen as said inert gas, and said nitrogen may be originally produced merely by allowing the oxygen of air to combine with the aluminum, leaving substantially pure nitrogen as a residue. However, when the boiler is to be used with oil as a fuel, I prefer to reclaim the nitrogen within the firebox and, later, use it again rather than to introduce air into the firebox each time the change is made from oil to aluminum fuel. The reason for this preference is that the oxygen in the air coming in contact with the boiler walls at the extremely high temperature produced by burning aluminum will have a deleterious effect thereon due to oxidation of the material of which said boiler walls are made. I prefer to use a slight deficiency of oxygen in the combustion of aluminum, and to keep the firebox substantially free of oxygen at all times. However, it is not necessary that the nitrogen be absolutely pure, and since nitrogen combines with aluminum to a certain extent, it will be necessary to introduce fresh air from time to time to maintain the pressure of nitrogen.

I prefer to maintain the gaseous pressure within the firebox at the same value as that in the boiler room exterior of said firebox or at a lesser value, thereby preventing the seepage of gas through any cracks that may exist in said firebox into the boiler room. The aforesaid means for maintaining a constant predetermined pressure within said firebox will serve to achieve this result without an interchange of gases from within and without the firebox if the pressures are of the same value. However, in some cases, it may be preferable to use some other gas, such as helium, and it is then that the aforesaid means for maintaining constant pressure are most useful.

Other objects and advantages of my invention will be discussed with reference to the accompanying drawing, in which:

Fig. 1 is a fragmentary side elevation of a submersible boat, a portion thereof being shown broken away to disclose the arrangement of a power supply embodying my invention therein;

Fig. 2 is a transverse section taken on the line 2-2 in Fig. 1;

Fig. 3 is a large scale, more or less diagrammatic vertical section through the power supply shown in Fig. 1;

Fig. 4 is a horizontal section taken along the line 4-4 in Fig. 3, and

Fig. 5 is an enlarged detail view taken in the direction of the arrow 5 in Fig. 3.

Boiler 1 may be disposed in any suitable way within the hull of submarine 2. It will be understood that my invention is concerned with the production of heat by combustion, and the transfer of said heat to a boiler. It is not concerned with the utilization of that heat thereafter; the energy from the boiler may be used to propel the submarine by purely mechanical means, or it may be converted to electricity as an intermediate step in the well known manner. Likewise, the medium in the boiler may be either water or mercury. However, my invention is particularly adapted to the generation of steam at high temperatures such as are common in the so-called high pressure boilers wherein superheated steam is generated at a pressure in the neighborhood of 2000 pounds per square inch, and at a tempera-

ture in the neighborhood of 1000 degrees Fahrenheit.

Said boiler may be constructed in the ordinary way, comprising a firebox 3 having walls 4 made of some refractory material such as fire brick, and being heat insulated. The details of said walls are not shown, since the construction is well known. Similarly, boiler 5 is suitably heat insulated, and the metal parts thereof may be made of a suitable molybdenum alloy that will have great strength at high temperatures. I provide two courses of flues 6 and 7 forming a return path so that the inert gas may circulate from said firebox, through flues 6 to compartment 8, thence back to said firebox. Of course, additional courses of flues could be provided so that said gas would pass lengthwise of said boiler several times before finally returning to the firebox. Compartment 8 is provided with a removable door 9, through which said flues may be cleaned when necessary.

Blower 10 is adapted to draw said inert gas downward through flues 7 and force it upward through the firebox and downward through flues 6, as is shown by the arrows in Fig. 3. When oil burner 11 is used, damper 12 is closed and the products of combustion travel upward through firebox 3, downward through flues 6, downward through flues 7 thence upward through bifurcated stack 13, dampers 14 then being open. The upper end of said stack must be provided with a suitable cover to keep water out when the submarine is submerged. Covers of this kind are well known to those familiar with submarine construction, hence it is not described in detail herein. Blower 10 is driven by motor 15, preferably located outside firebox 3, and damper 12 is provided with a handle 16 extending outside said firebox. Oil burner 11 may be of any well known type, and it is adapted to draw oil from tank 17 and to supply air for combustion thereof.

Hopper 18 is adapted to contain a quantity of finely divided aluminum which may be fed therefrom by screw feed 19. Conduit 20 leading from said hopper into firebox 3 is provided with a valve 21 for controlling the flow of aluminum there-through, with a removable cover 22 at its upper end to facilitate cleaning said conduit. Inasmuch as combustion of said aluminum will take place near the lower end of said conduit, it will be subject to a high temperature and it should be made of some suitable refractory material such, for example, as silico-carbide. Silico-carbide in the form of infusorial earth, may be mixed with a temporary binder, such as glue, and molded to the proper form. It should then be heated to a high temperature in an oxidizing atmosphere for several hours.

I prefer slightly to flatten the lower end of said conduit, forming a flat nozzle 23 adapted to spray the aluminum downward across the mouth of a conical chamber 24. Oxygen from tank 25 may be released through pipe 26 terminating in nozzle 27 into the apex of said chamber, there to be mixed with the aluminum from nozzle 23. Pipe 26 may, if desired, pass through firebox 3 in order to heat the oxygen therein, and I prefer it to pass through the accumulation of aluminum oxide at the bottom of said firebox, thereby utilizing some of the residual heat of said oxide. Below chamber 24, I provide a shoulder 28, made of some suitable refractory material, to disperse the aluminum oxide falling thereon, and also to deflect the stream of inert gas from blower 10, directing said stream toward flues 6.

I deem it important that the velocity of the inert gas where it comes in contact with the aluminum oxide shall be low enough that said oxide will not be carried thereby into the flues. Said carrying of said oxide may be furthermore prevented by causing the stream of inert gas to swirl, changing its direction sharply. To this end, I direct the stream of gas from blower 10 backward so that it will be deflected sharply upward, then I provide said shoulder to again deflect it sharply forward. The following upward movement of said inert gas is at low velocity, and the aluminum oxide has ample opportunity to settle out.

Tank 29 is adapted to receive the aforesaid inert gas under pressure to vary the gaseous pressure within firebox 3. Compressor 30 is adapted to draw gas out of said firebox and to force it into said tank under pressure through pipe 31. Diaphragm switch 32, which may be of any well known type, is adapted to open a circuit to stop motor 33 which drives compressor 30 when the pressure in firebox 3 falls below a certain predetermined value. If said pressure should be further reduced, said diaphragm switch is adapted to open valve 34 to release gas from tank 29 into said firebox until the pressure therein again reaches said predetermined value. Thus, if the pressure in said firebox becomes too high, gas will be pumped out therefrom, into tank 29. Or if the pressure in said firebox becomes too low, gas from said tank will be released to increase the same. It will be apparent that, instead of the aforesaid diaphragm switch used to switch off motor 33 and also to open and close valve 34, two pressure control valves might be used, one to switch said motor off when the pressure in firebox 3 becomes lower than a certain predetermined value, and another to open valve 34 when said pressure reaches a slightly lower predetermined value.

I prefer to use finely divided aluminum as fuel for several reasons. First, the oxidation of aluminum results in a large amount of heat while the specific heat of the product of combustion is relatively low. This results in a high temperature of combustion, a feature that is of particular importance where high temperature boilers are used. It would be difficult to transfer heat from low temperature combustion to a boiler at, say, 10,000 degrees Fahrenheit. For example, among those substances whose products of combustion are solids and hence may be used as fuels for a submerged submarine, the combination of iron and sulphur has been proposed. But the heat of combustion of these substances is so low that the withdrawal of only a small fraction thereof reduces the temperature of the iron sulphide to that of the boiler. As a practical matter, there is serious difficulty in transferring heat to a boiler unless the temperature of the products of combustion is considerably above that of the boiler.

A further advantage of aluminum as a fuel for submarines is that it gives a large amount of heat for a given weight of fuel, considering the weight of both the aluminum and the oxygen to be combined therewith. This permits a submarine to have a greatly increased under-water cruising range, compared to present practice, and said cruising range may be uninterrupted whereas present submarines must come to the surface frequently to charge their batteries.

A further advantage of aluminum as a fuel is that the resultant aluminum oxide is a very good

conductor of heat. The heat produced in the center of the particles of said oxide, therefore, very quickly flows to the surface thereof, where it is taken up by the inert gas hereinbefore described. This feature makes it possible to transfer heat from the solid product of combustion to a gas in a reasonably small firebox.

However, there is another metal, namely, magnesium, whose properties resemble in many ways those of aluminum and which may be satisfactorily used as fuel for a submarine. Since magnesium ignites at a lower temperature than does aluminum, I prefer to use it as kindling material, burning a small quantity of it at first to heat the firebox and conduit 20 about the kindling temperature of aluminum, after which aluminum may be supplied instead of magnesium. When this method of kindling is employed, no special ignition device is necessary, a small piece of burning oily waste being sufficient to kindle the magnesium. However, if it is not desired to use magnesium as a kindling means for the finely divided aluminum, an electric igniter (not shown) similar to those employed on oil burners may be provided in chamber 24 to ignite said aluminum.

The operation of my invention is as follows: When the submarine is to be propelled under water, preferably a small quantity of magnesium in a finely divided state is fed from hopper 36 through conduit 20 and ignited in any convenient way, valve 21 being adjusted to control the flow thereof, and valve 35 being opened to supply oxygen for combustion. Dampers 14 and cover 37 will be closed when the boat is submerged, and damper 12 will be open. Blower 10 is started to circulate nitrogen through the flues of the boiler, and diaphragm switch 32 is adjusted to maintain the pressure of said nitrogen at the proper value. When the temperature within the firebox is sufficiently high, aluminum is substituted for the magnesium by starting worm 19 in hopper 18 and stopping worm 39 in hopper 36. When the submarine comes to the surface, the supply of aluminum may be shut off by means of valve 21, and that of oxygen by valve 35. Motor 15 should be cut off to stop blower 10, damper 12 then is closed and dampers 14 opened. Then, oil burner 11 may be started to energize the boiler in the ordinary way.

Although the principal advantages of my invention are in the longer under-water cruising range of the submarine, and the lower first cost and weight as compared to a storage battery installation, another advantage of great practical importance arises from the availability of steam for forcing water out of the submersion tanks instead of compressed air heretofore used. At present, when it is desired to raise the submarine so that its periscope may be used, water is forced out of the submersion tanks by compressed air which mixes with the water and leaves a wake that is highly visible to airplanes for a period of several hours. On the other hand, if steam is used to force the water out of said submersion tanks, no visible wake will result, a matter of considerable importance in the operation of submarines.

While I have described my invention as being adapted for use with submarines of the ordinary type, I deem it also applicable to smaller types of submarines approaching the present torpedoes in construction. Also, whereas I have described the use of aluminum or magnesium, separately, as fuels, it will be apparent that, under certain

conditions it might be preferable to use a mixture of the two substances, the ready combustibility of magnesium thereby aiding the combustion of aluminum.

Another expedient that may be useful under certain conditions, either to kindle aluminum or to aid in the burning thereof, is to amalgamate the small particles of aluminum with mercury. If the freshly cut surface of a particle of aluminum be covered with a thin layer of mercury, the formation of aluminum oxide on said surface will be largely prevented. The particle then will oxidize at a lower temperature than would a similar particle whose surface was covered by aluminum oxide, the latter substance being highly refractory so that even a thin layer of it serves, to a certain extent, as a heat insulator for the aluminum inside. Inasmuch as the layer of aluminum oxide that forms on the surface of aluminum particles at ordinary temperatures is extremely thin, I deem it preferable to utilize un-amalgamated aluminum in general. However, amalgamated particles could be somewhat larger, and the oxidation of the mercury would produce a substantial amount of heat; so the use of mercury will be feasible if its price be low enough.

I claim:

1. The method of generating steam in a boiler having a firebox comprising burning in said firebox a combustible mixture of oxygen and a material which when burned gives off non-gaseous products of combustion and applying the heat of combustion thereof to said boiler by admitting a substantial quantity of an inert gas into said firebox, discharging said products and producing flow thereof in one direction and producing circulation of said gas past said burning substance in a direction substantially contra to the flow thereof and through said boiler, thereby utilizing said gas as a transfer agent for transmitting the heat of combustion of said material to said boiler.

2. The method of generating steam in a boiler having a firebox comprising burning in said firebox a combustible mixture of oxygen and a material which when burned gives off non-gaseous products of combustion and applying the heat of combustion thereof to said boiler by admitting

a substantial quantity of an inert gas into said firebox, discharging said products and producing flow thereof in one direction and producing circulation of said gas past said burning substance in a direction substantially contra to the flow thereof at a velocity less than that at which said discharged products are flowing and through said boiler, thereby utilizing said gas as a transfer agent for transmitting the heat of combustion of said material to said boiler.

3. In a power plant, including a boiler, a firebox for the latter, a burner in said firebox, means for supplying oxygen to said burner, means for supplying a comminuted combustible material to said burner, the products of combustion of which material are non-gaseous, means for directing said products along a path in said firebox, and means for directing a stream of inert gas contra to said path of movement of said non-gaseous products at a velocity less than that which would deflect said non-gaseous products from said path.

4. In a power plant, including a boiler, a firebox for the latter, a burner in said firebox, means for supplying oxygen to said burner, means for supplying a comminuted combustible material to said burner, the products of combustion of which material are non-gaseous, means for directing said products along a path in said firebox, means for directing a stream of inert gas into proximity with said non-gaseous products, and means for deflecting said stream of inert gas obliquely across said path of non-gaseous products as said stream moves into proximity with said path.

5. In a power plant, including a boiler, a firebox for the latter, a burner in said firebox, means for supplying oxygen to said burner, means for supplying a comminuted combustible material to said burner, the products of combustion of which material are non-gaseous, means for directing said products along a path in said firebox, and means including a chargeable gas retaining reservoir having devices for directing a stream of inert gas into proximity with said non-gaseous products, thereby to convey heat from said products to said boiler.

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