April 30, 1963 E. F. CHANDLER 3,087,451

REACTION AUTOMOTOR

Filed March 1, 1960 2 Sheets-Sheet 1

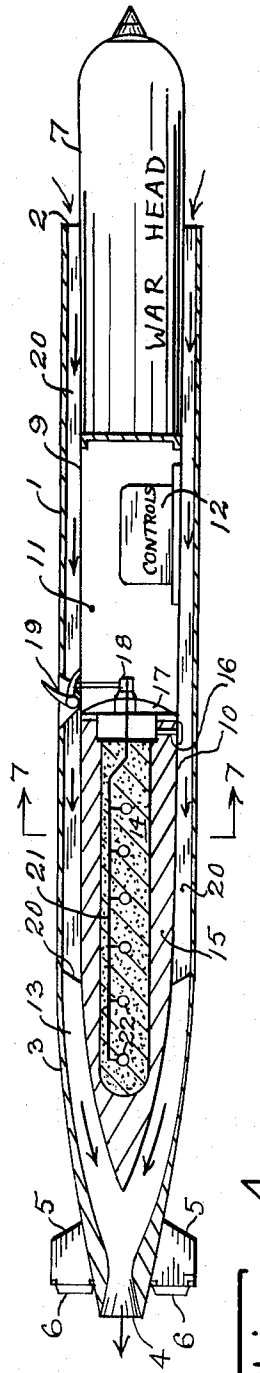


Fig. 1

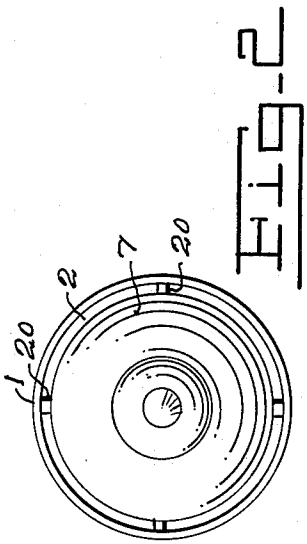


Fig. 2

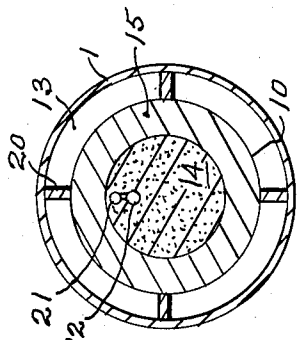


Fig. 7

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REACTION AUTOMOTOR

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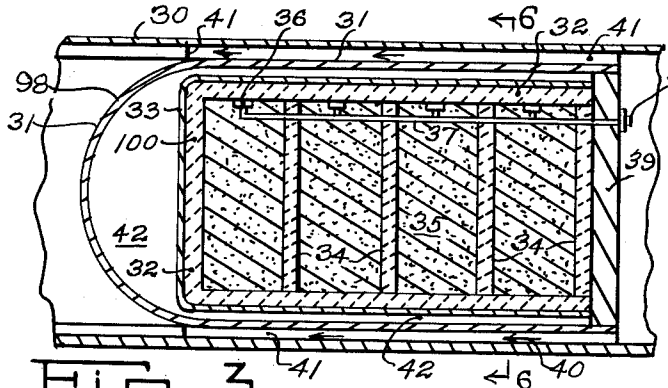


Fig. 3

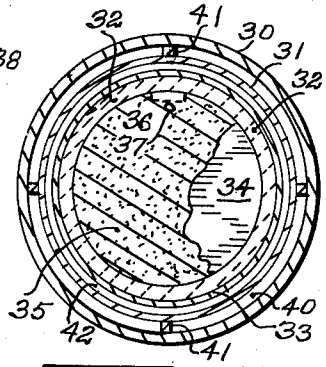


Fig 6

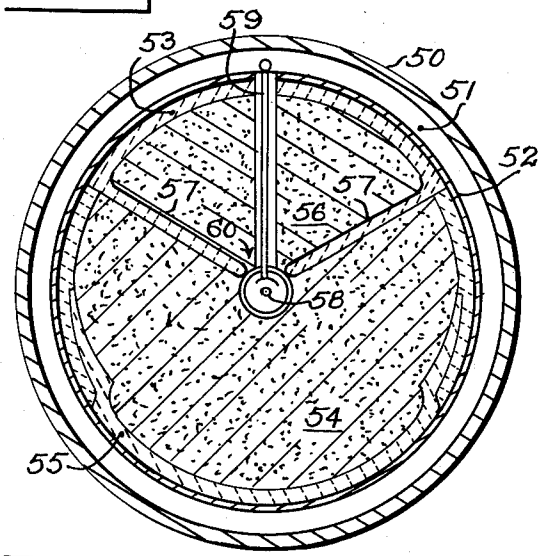


Fig. 4

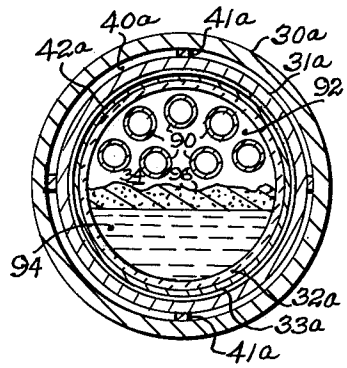


Fig. 8

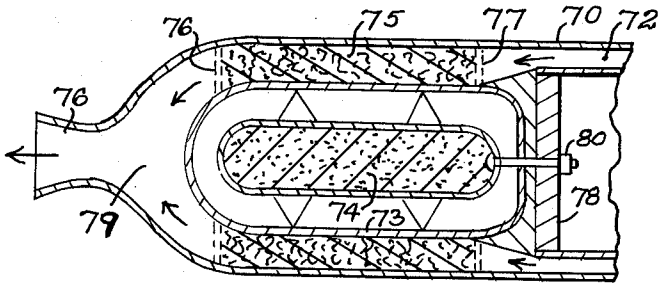


Fig. 5

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3,087,451

REACTION AUTOMOTOR

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4 Claims. (Cl. 114—20)

This invention relates to jet propelled missiles.

An object of the invention is to provide missiles of the ram-jet type, of improved construction.

Another object of the invention is to provide aerial projectiles and missiles of the hydro-jet and similar forms of weapon, and also to provide automotive weapons of novel design, of the torpedo and hydro-bomb types.

A further object of the invention is to provide self-propelled or rocket type missiles for driving of which power is generated by heat released by the exothermic reaction of a self contained compound or of a nuclear fission reaction, or in fact by any suitable source of energy adapted to function in a substantially closed chamber and having the novel characteristic also of practically no loss of weight during or after the reaction.

Another object of the invention is to provide a novel and improved missile of the character described, in which, as a result of the inconsequential or zero loss of weight therein, it does not have its buoyancy changed during its run, and in which as a consequence its trim is not disturbed.

Still a further object of the invention is to provide a novel and improved weapon of the type described, which is simple in construction, inexpensive to manufacture, and adapted to be rapidly produced in non-specialized plants during an emergency.

Still another object of the invention is to provide a weapon of the type described, which may be stored indefinitely, being very stable, and hence ready for immediate use at all times, since it does not deteriorate in storage.

A further object of the invention is to provide a novel missile, in which no operating mechanism is involved in the power plant, and in which no pumps need be employed.

Other objects and advantages of the invention will become apparent from the following description of a preferred embodiment thereof as illustrated in the accompanying drawings, forming a part hereof, and in which,

FIGURE 1 is a longitudinal sectional elevation of my missile.

FIGURE 2 is a right end elevation of the missile shown in FIGURE 1.

FIGURE 3 is a fragmentary sectional longitudinal elevation similar to that of FIGURE 1, but showing one method of loading a plurality of individual charges in the heat releasing unit, and for actuating the same, illustrating only a portion of a torpedo.

FIGURE 4 is a transverse sectional elevation of a portion of a torpedo, showing a modification with means for prolonging the reaction period, showing an initiating charge and a main charge.

FIGURE 5 is a fragmentary longitudinal sectional elevational view showing another modified form of the invention as applied, a portion of a torpedo being shown only.

FIGURE 6 is a transverse sectional elevation taken on plane 6—6 of FIGURE 3.

FIGURE 7 is a transverse sectional elevation taken on plane 7—7 of FIGURE 1.

FIGURE 8 is a transverse sectional elevation taken on plane 6—6 of FIGURE 3, but showing a modified form of the invention, and the Thermit reaction having taken place.

Considering first the requirements for successful operation of a submarine automotive missile such as a torpedo, several features are of primary importance. For example, ther is the need for generating power within a relatively restricted casing or envelope, a large portion of which must be devoted to controls and to the explosive warhead. Accordingly it will be seen that a product or compound which may be caused to react within a closed chamber to generate heat affords ideal means for generating steam to energize a propulsion jet by indirect heat exchange by evaporation of water from the surrounding medium through which the torpedo is moving. The steam issuing from the power jet provides considerable thrust, expanding and dissipating in the water, and hence leaving no tell-tale wake behind the weapon, which would otherwise facilitate its being spotted by the enemy and its course plotted. Evasion of such a torpedo would be difficult if not impossible.

Without intending to limit the scope of the present invention and with the understanding that any source of energy adapted to meet the conditions as herein set forth may be employed in practicing the inventive idea, a product of the type commercially known as "Thermit" is, by way of example, selected to illustrate a preferred form of the invention, since it affords a potentially feasible source of energy for driving the torpedo. The exothermic reaction being self-contained, and substantially without evolution of gas, there is substantially no loss in weight, and consequently the buoyancy of the missile and weight distribution is not changed during its run, and its trim is not disturbed.

Of prime importance is the fact that practically no operating mechanism is involved in the power plant and no pumps need be employed. A weapon of the kind described is simple in construction, inexpensive to manufacture, and adapted to be rapidly produced with non-skilled labor in non-specialized plants during an emergency. Further, it may be stored indefinitely, ready for immediate use at all times, and is not subject to deterioration during such storage.

Thermit is an example of a heat source in which metallic oxides are reduced by powdered aluminum and is well adapted for the present purpose. Such a compound or mixture, upon ignition, reacts exothermically, giving a temperature of about 2700 to 3600 degrees centigrade with a B.t.u. release of about 1500 per pound of the product. The reaction is rapidly completed and it is therefore desirable in order to increase the time during which the power plant is to be active, to utilize a plurality of charges which are caused to react progressively and/or to provide means for automatically, preferably by gravity, causing the reactive materials to be fed to the reaction zone, thereby prolonging the reaction period. In this manner it is possible to establish a suitable mean operating condition with a fairly even B.t.u. release at a consistent temperature for evaporating the water passing in a relatively thin film over the exterior of the chamber housing the reaction.

During the reaction, the molten metals resulting flow downwardly by gravity within the ceramic envelope containing the thermic charge, the slag rising to take its place. Partition means may be provided to substantially retain the molten metal against possibly troublesome shifting, as later described herein. While heat is radiated from the entire surface of the said container, the greater concentration of heat and hence the greater radiation, due to the accumulating molten metallic mass, is from the lower portion of the said container. This condition may be compensated for by employing a horizontal, substantially cylindrical heat releasing container over which the film of water is caused to pass, and if necessary, increasing the thickness of the water film in contact with the lower half of the surface of the cylinder in order to increase its heat

absorbing action relative to the portion passing over the upper half.

While the intention herein is to disclose a preferred embodiment of the invention, it is to be understood that, having set forth the principle of operation, and the objects intended, wide modifications and changes both in the design of the apparatus and the source of heat provided or employed may be resorted to without departing from the spirit and scope of the invention.

Reference has been made to the employment of the atomic energy resulting from nuclear fission in a suitable reactor as a possible source of heat useful for the purpose specified, and while particular reference is made specifically to exothermic reactions of the order of Thermit and the like, it is desired to point out that for certain reasons fully recognized by those skilled in the art, the employment of atomic heat is especially well adapted for the use described, and may be employed in practicing the invention without any substantial change in or departure from the disclosure thus shown herein. Certain protective conditions to be met when applying atomic powered means to manually operated automotors are by the nature of the present use as proposed, eliminated or at least greatly minimized.

In order to understand clearly the nature of the invention, reference may now be had to the drawings, in which like numerals denote similar parts throughout the several views.

As seen in FIGURE 1, there is a diagrammatic illustration of a submarine torpedo embodying a possible form of the invention. The torpedo includes an outer hollow shell **1**, open at **2**, to permit water to enter in the direction of the arrows. The body has a tapered afterbody **3** terminating in a jet-forming nozzle **4**. The body also has tail vanes **5** carrying horizontal and vertical steering rudders **6**, there being four such vanes in the example shown. Within the outer shell and spaced therefrom is the war head **7** which has a rear bulkhead or wall **8** with rearwardly projecting flanges, to which is connected the tapering inner body **10**. The space **11** may carry suitable gyro-steering means, depth and diving gear unit **12** for automatically controlling rudders **6**, or wave-responsive means if homing and/or remote guiding is employed. As is well known in the art, such stabilizing means are employed as are needed for maintaining the desired horizontal path as established by the depth gear, preset or otherwise controlled to cause the weapon to travel the desired distance below the surface of the water, at the desired depth.

The inner body **10** is formed preferably to provide an expanding water channel **13** between it and the shell portions **1** and **3** for passage of the water through the nozzle **4**. A suitable chamber **14**, of ceramic material, carries the heat generating charge, which may be of any suitable heat producing nature, between which and the steel shell **10**, may be a suitable material of a heat insulating nature **15**, through which the heat of the reaction penetrates to evaporate the water in channel **13**, forming a steam jet in this passageway as explained.

An emergency gas vent **16** to channel **13**, may be added as a precaution for use when the charge in chamber **14** is of a nature which would be expected to product a gas on reaction, and such gas would have to be vented. It may be pointed out however, that with a true Thermit reaction, such vent would not be used or needed, as gas would not be expected from this type of particular reaction in the preferred form. A bulkhead door **17** permits access to the heat charge chamber. At **18** is shown an ignition or firing mechanism operated by the latch **19**, which may be tripped on launching the weapon in any well known manner. A plurality of narrow longitudinal metal strips **20** afford water channels and serve to hold the members together, connecting between outer shells **3** and **1** and member **10**, for example.

One method of launching would be to project the weapon into the water, having started the reaction, so that the water entering at **2** by ram-action would be swept back, vaporized by the intense heat at **14**, and expelled at high velocity through nozzle **4** as a power jet. The weapon as schematically shown would be especially adapted for a run of limited duration at extremely high speed in hydro-bombing and in submarine destroying tactics. This is because the heat reaction system as indicated is uncontrolled in this embodiment and hence fast acting with a relatively sudden release of considerable heat, resulting in a very rapid steam generation and a greatly accelerated burst of power for a comparatively short period.

A modern torpedo is capable of a speed of over 4000 feet per minute and a jet propelled projectile of the order described herein is capable of higher speeds than the modern propeller driven weapon. Accordingly, operating as described above, the jet propelled missile, without controlling the heat release rate, as herein described, for shots of longer duration, would have an effective range of from about 1500 to 2500 yards which, in view of the high speed attainable, is sufficient for many types of combat operations. By controlling the time period over which the heat of the generator may be effectively employed, as by successively reacting a series of charges, by nuclear chain reation or other suitable means, the range of submarine automotive missiles, as contemplated by this invention, may be extended as far as it is practicable to effectively direct them by automatic steering or remote guiding, thereby greatly increasing the use and advantages of the target tracking or homing type of projectile.

Compositions of the Thermit type are ignited at the top of the mass preferably, the reaction progressing downwardly, and accordingly, as indicated in FIGURE 1, the horizontally disposed charge **14**, which in the referred form is Thermit, may be ignited simultaneously or progressively at several points **22**, as by a fuse or other suitable means **21**, actuated by the firing mechanism **18** suited thereto. A convenient way to activate the exothermic charge is by a small powder ignition charge actuated by means **18**, and as this takes place upon launching, the projectile or torpedo, the small amount of gas evolved from this ignition of this ignition charge, may be vented through vent **16** when used, for example, into channel **13**, or otherwise as desired during the brief launching period and thereby dissipated actually before the projectile starts its run through the water.

Referring now to FIGURE 3, it is seen that this is intended to illustrate one method of loading a plurality of individual charges in a heat releasing unit and actuating the same in a manner to prolong the total time during which the effective heat may be utilized. The outer shell of the missile is shown at **30**. Within the outer shell **30** is positioned the heat-transfer shell **31** containing a ceramic cartridge **32**, which may or may not be enclosed in a suitable metallic jacket **33**. The cartridge **32**, which may be circular in cross-section, is divided into a plurality of equal spaces, or spaces of varying capacity, as required, by partitions **34**, the spaces containing the charges **35** of suitable reactive agents. Means **36**, associated with each charge is for the purpose of detonating, igniting or otherwise activating the charge, depending upon its nature, and said means may be connected to means **37** which may be an electric cable, fuse or other means whereby, when firing is initiated at the means **38**, one or all of the individual charges may be put into action, that is either individually, sequentially, or together, according to various embodiments of the invention.

A suitable bulkhead **39** may serve as a removable closure for the cartridge. Water, preferably by ram-jet action, is caused to flow as at **40**, in any suitable manner, to insure effective heat transfer thereto, as by equipping the exterior surface of **31** with fins **41**. Some of these fins may be in metallic contact with the inner side of

shell **30** and thereby act to support **31** within the shell **30**, while other of the fins may be shorter to increase the radiation to the flowing water stream. Increasing the number of such fins which contact the outer shell may serve to dissipate to the surrounding sea water excessive and/or un-required heat. The space **42** around the cartridge **32** may contain a suitable heat insulating and/or controlling medium or the same may contain a heat storing and/or heat releasing substance such as a metallic fibrillar mass or a metal which is adapted to melt within the temperature ranges contemplated and thereby modify the heat release from the said reaction or reactions.

Referring further to FIGURE 3, it is seen that the partitions **34** also serve to substantially retain the molten metal resulting from the Thermit reaction, within their respective compartments, and thus avoid troublesome shifting or substantial displacement which would or might otherwise cause erratic movement of the missile.

Referring now to FIGURE 4, there is seen a schematic cross section of a means for prolonging the reaction period wherein a reaction is initiated and subsequently fresh reactive material is fed to the reaction spot or zone to maintain and/or accelerate the reaction. In this figure, **50** is the outer shell of which the numeral **51** shows the water space and **52** may be a steel jacket within which are positioned a ceramic liner **53** composed of segmental portions to permit expansion, without cracking, under intense heating. A primary charge **54** is carried by the ceramic portion **55**, which is formed to serve as a retainer, in the case of Thermit, for the molten material or metal resulting from the reaction.

Above the primary charge **54** is the secondary charge **56**, supported on the sloping portions **57**, and retained by the ignition or actuating element **58**, having a fuse or other means **59**, which leads to the firing mechanism. When the means **58** is actuated, the charge **56**, which may be in granular form, is permitted to flow through the opening **60**, preferably by gravity, to join and react with the activated charge **54**, in a well known manner.

As previously pointed out, when Thermit is employed as the heat source, the molten metal resulting flows to the bottom of the retort or cartridge, and is surmounted by the resulting slag. In a marine projectile, this molten metal lowers the center of gravity and tends to prevent rolling of the weapon, thereby aiding in its stabilization. Further, the partitioning, as seen in FIGURE 3, further aids in confining this molten metal against undue shifting, aiding in stability.

FIGURE 5 illustrates diagrammatically how novel constructional features may be employed, without complexity of installation or elaborate controls, to increase the efficiency of heat transfer in the device, by interposing means in the path of the flowing fluid for greatly extending the exposed area of the heating surface in contact with the fluid, yet without retarding the overall flow rate through the duct.

In FIGURE 5, the outer shell **70** terminates in a nozzle **71**. The fluid duct is shown at **72**. A closed container is seen at **73**, and has positioned therein the charge holder **74**, the space **95** being suitable to contain an inert gas, such as nitrogen, for example, or other suitable insulating or/and heat release governing means. At **75** there is preferably a metallic fibrillar heat transfer medium having suitable characteristics for effective heat transfer to the fluid flowing therethrough, without substantially impeding its flow in this passageway. It will be noted that the space occupied by the fibrillar mass **75** is of greater volumetric capacity than the duct, the purpose being to compensate for flow resistance by increasing the flow area in this portion of the duct, and to otherwise utilize the advantages of this method to the fullest. **76** and **77** represent suitable retaining means for **75**, such as screens or perforated metal walls, through which the fluid may freely flow. **78** may be a removable door affording access to the interior of the container, etc.

A suitably formed space **79** may serve for the accumulation of the highly heated fluid on its way to be discharged by the power jet **71**. **80** represents means for initiating the heat producing reaction in **74**.

It will also be understood that a device similar to that shown in FIGURE 1, or the modifications shown in the other views, may be employed as a primary or auxiliary propulsion device for attachment to ships below the water line, for propelling the same. In such case, of course, the explosives indicated in the war head end of the unit will not be used. Such propulsion units may also be employed for providing strong initial thrust for ships which must get under way on short notice without waiting to get up steam on their regular engines, and also where sudden acceleration in speed is needed at any time. Means may be provided for disconnecting the auxiliary power plant propulsive device from the vessel when used up. In all cases mentioned herein, it is understood that the unit has the advantage of not leaving a wake. Thus from a true Thermit type of reaction, as taught herein, this feature results from the fact that the steam power jet is uncontaminated by combustion products, so that there is no wake indicating the path of the weapon in the water, or the path of the vessel it may aid in propelling where used in that modification of this invention as mentioned herein. In the presently disclosed system, the ram jet delivered water being heated is at no time in direct heat exchange relationship with the products of combustion, there being an intervening wall therebetween, allowing only the heat to pass therethrough, and thus producing a pure steam power jet, the steam being totally adsorbed in the ambient water, leaving no telltale wake. This has particular advantages when used in torpedo or submarine propulsion work, avoiding visual tracking from the surface, for example.

Referring to the modification shown in FIGURE 8, it is seen that this sectional view is similar to that of FIGURE 6, in that it is taken for convenience only, at substantially the same plane as **6—6** of FIGURE 3. The outer casing **30*a*** is the same as casing **30** of FIGURE 3 and 6, and all similar parts are shown with similar identifying numerals, followed by the suffix "*a*."

The embodiment of FIGURE 8 differs from that of FIGURES 3 and 6, however, in that means is provided for conducting the water not only through the annular passageway **40*a*** between the outer and inner casings **30** and **31**, as in FIGURE 6, but also for conducting the water through a series of water tubes **90** which extend right through the inside chamber **92** of the ceramic cartridge **32*a***, longitudinally. It is seen that these water tubes **90** are all located well above the central portion of the chamber **92**, so that they will be out of contact with the molten metal **94** and slag **96** thereabove, which result from the Thermit reaction. FIGURE 8 thus shows the stage at which the Thermit reaction has taken place, the molten metal and slag resulting therefrom. The intense heat from the molten metal and slag heats up the water tubes **90** and the water therein, to a high degree, and aids in providing the reactive thrust from the jet nozzle at the rear end of the propulsion device.

The water tubes **90** will extend longitudinally from the leftward end wall **98** of the casing **31** shown in FIGURE 3, which they penetrate, and thence rightwardly through the left end of the casing **33** and the ceramic end wall **100**, through the partitions **34** and thence rightwardly through the wall **39**, so that water from the right of wall **39** will be able to flow leftwardly through said water tubes **90** as seen in FIGURE 3, and toward the jet nozzle **4** seen in FIGURE 1. The relative quantity of the thermit charge **35** is chosen so that when the reaction has taken place, the molten metal and slag will be substantially below the water tubes **90**.

According to another modification, it is understood that the Thermit charge may also be fed into the reaction chamber inside the casings **15** and **32**, for example,

in batches or stages, from a storage compartment disposed within the hull of the device, to be reacted as such batches or stages are fed in.

The Thermit Process is well known in the art, as mentioned hereinabove. As an example, for illustrative purposes only, the following are typical Thermit charges and reactions, suitable for use in carrying out the invention.

(*a*) Dry ferric oxide reduced by powdered aluminum.

$$Fe_2O_2 \text{ plus } 2Al = Al_2O_2 \text{ plus } 2Fe$$

$$\frac{-195{,}600 \text{ plus } 392{,}600}{\text{plus } 196{,}600 \text{ calories}} \text{ (Heat release)}$$

(*b*) Black cupric oxide reduced by aluminum.

$$3CuO - 2Al = Al_2O_3 \text{ plus } 3Cu$$

$$\frac{-3(37{,}700) \text{ plus } 392{,}600}{\text{plus } 279{,}500 \text{ calories}} \text{ (Heat release)}$$

Although I have described my invention in specific terms, it is understood that various changes may be made in size, shape, materials and arrangement without departing from the spirit and scope of the invention as claimed.

I claim:

1. In a reaction propelled marine projectile, a jet forming nozzle, water inlet opening means, duct means constructed and arranged to convey water from said water inlet opening means to said nozzle, said projectile having a water-tight closed chamber within itself, outer surface wall means in said projectile defining said closed chamber and disposed in the path of said water flowing through said duct means, and means for heating said outer surface wall means to a degree sufficient to evaporate said water to generate steam, said steam issuing from said projectile nozzle, and producing a reactive thrust for propelling said projectile.

2. A ram jet missile comprising a missile body, an outer shell enclosing a portion of said body and spaced therefrom to form an annular duct terminating in a nozzle, inlet opening means in said duct through which said fluid from the surrounding medium is adapted to flow through the said nozzle, and means within the said body for expanding and driving the said fluid out through said nozzle as a propulsive power jet, the said means comprising a substantially gas-tight container positioned in and in spaced relation to the said duct in contact with said fluid therein, a compound carried inside said container and adapted upon actuation to interact exothermically, without loss of weight, and means for actuating said reaction to produce substantial heat for heating said fluid, said compound being free of direct contact with said fluid.

3. A missile comprising an elongated body, power jet means carried at one end of said body, duct means in said body and having an opening for the admission of fluid from the surrounding medium so that said fluid is conveyed to said jet means, a closed container positioned within said duct means and sealed against entry of any fluid into said container, a chemical reaction zone within said container, dry granular chemical means in said chemical reaction zone and constructed and arranged to react to produce substantial heating without substantially an evolution of gas therewithin, a quantity of said chemical means stored elsewhere within said elongated body, means for intiating the reaction of said chemical means in said chemical reaction zone to produce intense heating of said container and of said fluid in flowing contact therewith, and thereby producing a continuous reactive propulsive thrust from said jet means, and means for supplying said stored chemical means to said reaction zone during said reaction to continue the reaction and maintain the operation of said power jet means and its propulsive thrust.

4. The construction according to claim 2, wherein said compound is an exothermically reactive compound which when reacted produces molten metal, and wherein said container is compartmented with some of said compound in each compartment thereof, whereby, upon reaction, said molten metal produced is confined to its own one of said compartments and blocked from passage to another compartment.

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