



USE OF MATERIALS FOR THE ACCELERATION  
OF MASSES AND DRIVING DEVICES FOR  
EMPLOYING THOSE MATERIALS

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This invention relates to use of materials for the acceleration of masses and driving devices for employing these materials and to a method of accelerating a mass.

10 It is known to use a mass (which is accelerated) as a resilient, namely yielding part of the tamping or blocking (~~Vordammung~~) of an expansion chamber in which rapidly expanding reaction gases are generated once, or periodically, for example by burning-off (deflagration) of a propellant powder (for firing a projectile from a  
15 weapon barrel) or by the combustion of liquid propellant (for example for linear or rotatory motion of a piston in an Otto or Diesel engine). The mass that is to be accelerated does not, however, have to be a rigid, projectile-shaped or piston-shaped construction part; it may also be a mass of fluid which reacts inertly to dynamic  
20 stressing as in the case of the water reaction motor.

In the interests of favourable thermodynamic efficiency, for the acceleration of a mass by the expansion of an reaction gas bubble (tamped or blocked by the mass that is to be accelerated) it is  
25 desirable that the chemical reaction in the reaction chamber produces the seemingly steepest possible pressure rise in the reaction gas bubble then expanding in energy-rich manner with the least possible amount of materials being used, which materials should be as uncritical as possible with respect to their magazine safety, their  
30 handling safety and their functional safety. Numerous reaction partner groups have been tested to increase the reaction-gas energy density and the amount of reaction gas related to the amount of the reaction partners used.

35 However, in fact, in cases where a noteworthy rise in the amount of energy-rich reaction gas has been achieved, always reaction partners were used which were not practically suitable in the final

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analysis for economical (commercial) reasons or for technological reasons, namely because, for example, specific substances needed for the reaction are not available to a large-scale extent or at a viable price or because of the toxicity or perhaps because the readiness of  
5 reaction (danger of spontaneous ignition) of the reaction partners would make scarcely fulfillable, unrealistic, safety demands on the storage and handling of the materials.

Accordingly, an object of the present invention is to remedy or  
10 reduce the urgent need for energy-rich expanding reaction gas bubbles, which can be obtained technologically uncritically with a seemingly very steep pressure rise and which can accrue from economically (commercially) easily available reaction partners.

15 According to the present invention there is provided use of a complex metal hydride and acid reagent which is sprayed onto the metal hydride presented in lumpy consistency, for the pulse-like generation of expanding reaction-gas bubbles in, or fed to, a chamber for the acceleration of masses, aqueous fluid being provided for the dynamic  
20 tamping or blocking of the reaction-gas bubbles.

Further according to the present invention there is provided a driving device for carrying out the use according to the immediately preceding paragraph, comprising a complex metal hydride presented in  
25 lumpy consistency and a holder therefor, and comprising an acidic reagent, the driving device having an expansion chamber for the acceleration of masses, which chamber is defined in part by, or blocked by, a yielding aqueous fluid, such that masses can be accelerated by the expanding reaction-gas bubbles as a reaction of  
30 said bubbles against the aqueous fluid, and in which device an injection nozzle for injecting said reagent is directed towards the holder and at a surface part of the metal hydride.

Still further according to the present invention there is  
35 provided a method of accelerating a mass comprising:-

- a) introducing an acid onto a metal hydride;

- b) allowing one or more expanding gas bubbles produced from the reaction between the acid and metal hydride to enter a chamber having a mass to be driven or accelerated, said chamber being defined in part by, or blocked by, an aqueous fluid;

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- c) driving or accelerating the mass by the gas bubble or bubbles, as a reaction of said gas bubble or bubbles against the aqueous fluid.

10 Still further according to the present invention there is provided a gas bubble drive comprising a metal hydride and acid reagent and means arranged to introduce the acid onto the metal hydride, said metal hydride and acid comprising reacting partners which produce gas bubbles on contact with one another, the drive being  
15 for propelling a mass, for example a solid or fluid piston or projectile, present in use in a gas bubble expansion chamber of the drive, said expansion chamber being defined in part by, or blocked by, a yieldable aqueous fluid.

20 One of the decisive reaction partners can be accordingly a complex metal hydride (for example, sodium borohydride or sodium tetrahydroborate (formula  $\text{NaBH}_4$ )) which is supplied on a large scale by relevant chemical concerns (such as Bayer AG, Leverkusen or Merck AG, Darmstadt) to the chemical industry as a versatile usable reduction  
25 and hydrogenizing agent. This very reactive boron compound with a high content of chemically combined hydrogen is powdery in a raw state but is compacted in the ambient atmosphere into lumpy pieces which also may be pressed into specific shapes. These materials are normally held for the suspension of the pulverised material in a  
30 solvent, which is chosen depending on the purpose of use, for example for the reduction of organic compounds or of inorganic salts, or in the chemistry for the reduction of disturbing impurities into inactive forms, which then no longer have to be expressly separated out in a costly manner from the actual process material.

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Differing from the use of the said materials for previously known purposes, the present invention recognises that the sodium

borohydride (indeed corroding on the skin, but not critical in other ways with respect to possible health risks or risks of spontaneous ignition) which in its powdery-lumped form is stable at temperatures below 0°C and above 100°C or other metal hydride, is quite particularly well suited for allowing, in simple equipment along with dosed spraying on of acid reagent, a reaction gas bubble to be obtained which, by reason of its extremely steep pressure rise with energy-rich expansion, is quite particularly suitable for the driving or acceleration of masses relative to constructively or dynamically tamped (blocked) expansion chambers. In accordance with the use, in accordance with the present invention, of this material, merely - in the presence of of an aqueous reaction partner - a relatively small

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amount of higher-concentrated acid reagent (equally suitable as reagents are more especially mineral acids, organic acids or suspensions of acid salts) needs to be sprayed - dosed in amount and periodic time delivery - onto the metal hydride that is to be supplied into the expansion chamber and which metal hydride is for example shaped into a rod and thereby easily holdable. The sprayed-on jet of reagent wets a region of the metal hydride which is of a relatively large area but which is constructionally delimitable by way of the jet guidance, and penetrates in this region also into the porous structure thereof. This leads to the sudden onset of the large-volume formation of reaction gas, which can easily be influenced in its intensity by appropriate control of the jet and more especially which jet can also be interrupted and again started up afresh. However, also for example the metal hydride of the formula  $\text{KBH}_4$  (potassium borohydride) is very advantageously usable; even if its handling is not quite so uncritical.

The reaction product, upon spraying the borohydride with aqueous hydrochloric acid, is practically pure hydrogen of exceptionally high combustion energy density, and with an amount of gas which is three to four times the yield of conventional explosive and propellant charge agents of munitions technology. The amount of gas can additionally be raised by over 10% if, in the course of the spontaneous formation of the hydrogen, this is also combusted forthwith; by an oxygen carrier being sprayed on along with the reaction acid. It is particularly advantageous to spray the borohydride presented in solid consistency, with aqueous nitric acid, because this then at the same time serves as an oxygen carrier for the combustion of the hydrogen arising upon the spontaneous reaction.

A trace addition of metals, more especially copper, acts catalytically and contributes to the further increase both in the energy density and the amount of combustion gas.

In any case, the use of metal hydride, water and acid reagent appear to represent the ideal reaction partners for a bubble

generator, by reason of the large and energy-rich reaction-gas volume of the highest efficiency; in which respect for the gas generator a particular further advantage of practical importance is that quite readily, and immediately with the combustion (increasing the efficiency further) of the hydrogen accruing in a great amount, a friendly environment driving system - on the basis of uncritically available and manipulable reaction partners - is achieved, with which system a closed combustion cycle process can be realised in a technically uncritical and versatile useful manner.

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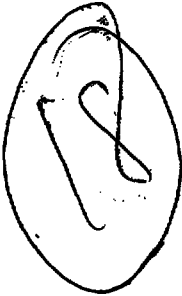
The water reaction motor for water vehicles needs, for intermittent mode of operation, an oscillating valve body for the periodic closure of the inlet, for the respective water-column or water-piston ejection reverse to the direction of movement of the water vehicle. The requirement of such an oscillating valve body calls for considerable constructional expenditure and considerably restricts the amount of water ejection and thus the vehicle speed which can be achieved with such a water reaction engine.

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To be considered as a possible further disadvantage in the case of that previously known device is the fact that the combustion procedures taking place in or behind the valve body can lead only to a very moderate thermodynamic efficiency of the device, because, by reason of the restricted working frequency of the valve body, in each case, over comparatively long timespans relatively large amounts of heat are emitted from the combustion chamber into the water flowing out.

In accordance with the present invention with comparable driving devices a considerable improvement in efficiency and higher ejection frequencies with a mode of operation which is more insusceptible to trouble may be achieved.

It is important that both the heat loss (detrimental to efficiency) to the fluid and the constructional problems and restrictions, in operating technology respects, of a mechanical



oscillating valve body can be avoided in that, for the separation of a fluid piston that is to be exhausted and for the ejection thereof, the expanding effect of a reaction gas bubble (initially relatively small and highly compressed) is utilisable if (by reason of the shape in the neighbourhood of the expansion chamber in the interior of the device) during the expansion of this bubble a dynamic tamping (blocking) relative to the relatively inert and incompressible inflowing fluid mass takes place. The exceptionally rapidly ensuing expansion of the gas bubble leads to the portioning off of a fluid piston from the inflow with dynamic tamping (blocking) reverse to the piston exhaustion direction; and by reason of the exceedingly rapid rise in gas pressure, with poor heat transference conditions at the boundary interface of the gas bubble to the surrounding fluid, there results only an extremely low heat loss from the gas bubble into the fluid and therefore a high thermodynamic efficiency.

The sequence of reaction gas bubbles can be produced in the interior of the driving device, directly in the expansion chamber itself, by the reaction substances being introduced there and being caused to react with one another. However, provision can also be made for operating the gas bubble generator periodically outside the interior of the driving device and for introducing the reaction gases (in each case after a predeterminable minimum pressure has been exceeded) by way of a shock-wave-tubelike flow duct into the expansion chamber. By way of the periodicity of the gas bubble expansion, coordinated to the inflow conditions of the fluid into the driving device, the exhaustion frequency - and thus the quasi-continuous speed of the device relative to the fluid surrounding or flowing therethrough - can be influenced. Because, with a rise in speed, the resistance forces stemming from the fluid rise exponentially, it can be advantageous to raise the energy content of the gas bubbles (for example by way of dosing the materials reacting with one another) proportionally with the frequency of the gas-bubble production, so that a speed variation over a large operating range is

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achievable.

The driving device is particularly suitable equally as a propulsion mechanism for surface watercraft or as a driving mechanism on bodies travelling underwater, both for the initial acceleration and for maintaining or increasing the speed of travel after some other initial acceleration; in which respect in these cases the surrounding water itself represents the fluid. The driving device can, however, also be used in a fixed mode, for example as a driving unit in the flow of a hydrodynamic machine.

Whereas, for example in the case of underwater travel bodies, more especially for reasons of cavitation formation at the conventional screw drive, specific speed limits (of the order of magnitude of up to 30 m/s) cannot readily be exceeded, with a driving device in accordance with the present invention (without moving construction parts in the drive itself) without problems in the water, double the previous speed is achievable, and by coordination of the geometry of the driving device to the recurrence frequency and the energy content of the gas bubbles the speed may be raised still further; and handling problems with respect to risks of accident in propeller regions appear completely abolished. A further rise in efficiency and relative speed is, by coordination of the fluid to the behaviour of the expanding gas bubbles, possible more especially when the driving device is a constituent part of a closed flow circulation (for example of a stationary plant) in other words contrary to the factors in the case of a watercraft - and moreover the fluid is to be fed separately and can therefore be optimised with respect to the driving reaction.

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The present invention will now be described, by way of example only, with reference to accompanying simplified, diagrammatic drawings which are approximately true to scale, in which:-

FIGURE 1 shows a gas generator in accordance with the present invention having rigid construction tamping or blocking of its



reaction-gas expansion chamber; it takes into account special features regarding different instances of use;

FIGURE 2 shows a second gas generator in accordance with the present invention having dynamic tamping or blocking of the reaction-gas expansion chamber;

FIGURE 3 shows a fluid-piston driving device in accordance with the present invention in the form of a fast-running (fast-moving) thrust element with the gas generator arranged outside its gas-bubble expansion chamber;

FIGURE 4 shows consecutive phases of operation (FIGURE 4a to 4f) of the driving device;

FIGURE 5 shows a qualitative time diagram regarding pressure and movement cycles, corresponding to the operation in accordance with FIGURE 4;

FIGURE 6 shows an example of bubble generation directly in the expansion chamber;

FIGURE 7 shows a modified driving device in accordance with the present invention similar to that in accordance with FIGURE 3 on a body which travels underwater;

FIGURE 8 shows a further driving device in accordance with the present invention which is modified as compared with FIGURE 3, used in the cyclic process of a hydrodynamic machine.

FIGURE 1 shows, in axial longitudinal section, a gas-bubble generator 1 having an injection nozzle 2 for injecting, for example,



an acid 3. The nozzle 2 opens out in a reaction-gas expansion chamber 4 opposite a holder 5 for a rod 6 made, for example, of sodium borohydride ( $\text{NaBH}_4$ ). The expansion chamber 4 is enclosed or defined in a constructionally rigid manner by a wall 7 and by a piston 9 which is displaceable upon the expansion of the reaction gas 8 to enlarge the expansion chamber 4. When piston 9 has experienced a desired displacement by reason of the pressure of the expanding reaction gas 8, an outlet pipe 10 can be opened (for example directly through the piston 9 itself) for the removal of the relaxed (expanded) reaction gases 8 or - depending on the constructional factors - for the further relaxation (expansion) of the still expanding reaction gases 8. In FIGURE 1 outlet pipe 10 flows into a fluid 19 which flows through thrust element 12.

The piston 9 may be a lifting piston guided oscillatingly or reciprocatingly (in the manner of a conventional Otto engine), in a cylinder in the form of the wall 7, or in the case of an appropriately adapted construction the piston could also be a rotational piston.

The piston 9 can be thought of as (or could comprise in an alternative arrangement) a projectile which is to be accelerated, as a result of the expansion pressure of the reaction gas 8, out of a weapon barrel (in the form of the wall 7) in the direction of the arrow 11, i.e. the piston (projectile) is to be fired from a barrel. The "piston" (9) could also be any other arbitrary component which on the one hand closes off an expansion chamber for the gas 8 and on the other hand (as a result of the expansion of the gas) is to be moved with great initial acceleration and thrust force in the direction of the arrow 11 when, by reason of some external influence, a metal hydride is wetted by acid 3.

It could be arranged for the piston 9 to work in the direction of the arrow 11 against an elastic restoring force - for instance against a counter-pressure spring (not shown in the drawing) - so that by reason of appropriate displacement of the piston 9 the line from the expansion chamber 4 into the outlet pipe 10 is freed (open) only when,



in the course of reaction-gas development in the expansion chamber 4, a pressure is built up which exceeds the counter-pressure acting contrary to the direction of the arrow 11.

5        The idea in FIGURE 1 is to create an expansion-gas shock wave which is introduced with the seemingly steepest possible pressure wave front into a diffuser 13 filled with aqueous fluid; so that the reaction gas 8 not only induces a channel or duct in the fluid, but displaces fluid with a large-area phase limit (boundary) (along with  
10 dynamic tamping towards the diffuser inlet). For this, the outlet pipe 10, connected into the system only upon a specific minimum pressure of the reaction gases 8 at the expansion chamber 4 thereof, is dimensioned as a so-called impulse pipe, i.e. for example as a pipe which is extremely thin in relation to its length.

15        Feeding of the injection nozzle 2 with acid 3 from a storage container 14 is effected by way of a conveying mechanism (which can be installed as an independent pump or be realised by a pressurised storage-container) and by way of a timed and dosing valve ~~(TAKT)~~ 16.

20        The sodium borohydride 6 can be subsequently continuously delivered or supplied into the holder 5 directly as a rod by means of an advance or feed mechanism 17, in order to be wetted, in an edge region of the expansion chamber 4 for gas-formation from reaction with  
25 an aqueous acid 3 from the injection nozzle 2 - or from reaction with an acid as well as with water injected from an additional water jet. However, the sodium borohydride 6 may be made available in a lumpy-granular (granular mass) state, in other words in a form similar to a granulate, and the granulate-like sodium borohydride may then be  
30 compacted, only through a functional link with the advance mechanism 17, by means of an extruding mechanism 18, into the compact mass standing opposite the injection nozzle 2.

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A different usage of the gas-bubble generator 1, for driving devices, is shown in FIGURE 2. The surface part of the sodium borate 6, to be acted upon with acid 3 from the injection nozzle 2 is now surrounded by an aqueous fluid 19. Through the mass of the fluid 19, inert in relation to the expansion energy of the reaction gases 8, a dynamic tamping or blocking of the reaction gases 8 takes place in a gas bubble 20; the tail of a piston 9 or the like configured in a flow-favourable manner is supported directly (on the bubble) - or is supported by way of a kind of sabot.

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Piston 9 is, therefore, accelerated in the direction of the arrow 11 by the expanding gas bubble 20 which is, however, supported dynamically relative to the fluid 19.

15 The basic shape, shown in axial longitudinal section in FIGURE 3, of a fluid-piston driving device 101, which in accordance with one aspect of the present invention is a thrust element ~~(ZELLE)~~ is a substantially nozzle-shaped structure configured in a flow-favourable manner between a fluid inlet portion 102 and an exhaust pipe portion 20 103, which pipe portion 103 is longer by comparison than inlet 102 but which in relation to the diameter of device 101 is nevertheless still relatively short. Formed to the rear of the inlet portion 102 is a fluid entry nozzle 104; said nozzle shaped structure has an internal cross-section which is initially narrowed relatively early and then 25 widened less sharply again to a wider diameter than inlet 102. The outer cross-sectional configuration of portions 102 and 103 can correspond to that of the driving device 101 itself, and may for example be circular, annular or ring-segment-shaped. Considered from the inlet 102, the cross-section widening again behind the entry 30 nozzle 104 acts as a diffuser 105, the largest cross-section of which then merges into the exhaust pipe 103 which is profiled in a flow-favourable manner. The inner space along the transition from the diffuser 105 to the exhaust tube 103 serves as an expansion chamber 106, as will be explained in yet more detail below. Into this chamber 35 106 there opens (if a separate gas generator 108 is provided outside the expansion chamber 106) at least one shock-wave-tubelike (i.e. very

thin or narrow in relation to its length) flow duct 110; which duct 10 is always connected by way of a pressure-limit valve 124 (see FIGURE 8) to the generator 108 briefly, whenever the reaction gases in generator 108 exceed the minimum pressure, in order to transfer the gases, as a compressed gas bubble 115 having a steep pressure wave front, into the expansion chamber 106.

If the driving device 101 is not a fixed or motionless arrangement, but is, in fact, intended to move through the surrounding fluid 111, more especially for example through water, then also the exterior of the driving device 101 can be designed in a flow-favourable manner, for example by the provision of a jacket 112.

The driving device 101 and thus its entry nozzle 104 move relative to the fluid 111 in such an orientation that the fluid 111 enters in the dynamic pressure direction 113 through the entry nozzle 104 into the diffuser 105, as shown in FIGURE 4a. When the fluid column 114 has also filled the interior of the exhaust part 103 - at least substantially (see FIGURE 4b), a relatively small but severely compressed energy-rich reaction-gas bubble 115 is caused to expand in the chamber 106.

The gas bubble is expanded in the fluid column 114 practically in explosion-like manner, compared with or against the tamping/blocking action of the relatively inert mass of the surrounding fluid 111. By reason of the cross-sectional tapering in the diffuser 105, the tamping action is the greatest in a direction contrary (reverse) to the dynamic pressure direction 113.

Therefore, the greatest growth component of the expanding gas bubble 115 lies approximately coaxially in the exhaust pipe 103, in the exhaust direction 116 (FIGURES 4c-4d); with the result that in the transitional region from the diffuser 105 to the exhaust pipe 103 a fluid piston 117 is separated off from the fluid column 114 and is forced in the dynamic pressure direction 113 out of the exhaust pipe 103 into the surrounding fluid 111. The mechanical supporting

reaction is effected by way of the expanded gas bubble 115 against the tapering cross-section of the diffuser 105, on account of which reaction the driving device 101 is moved relative to the surrounding fluid 111 in the driving direction 118 (in other words contrary to the inlet or dynamic pressure direction 113 (FIGURE 4e)); which movement promotes the re-filling of the interior of the driving device 101 with a fluid column 114 (FIGURES 4f-4a). Now the procedure can be repeated by making available a further compressed expansion-gas bubble 115 in the chamber 106 (FIGURE 4b-4e).

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As shown in FIGURE 5, by means of simplified time diagrams, the fluid 111 enters at a relatively constant inlet speed  $V_{113}$  into the inlet 102. When the driving device 101 is filled with the fluid column 114 at the point in time  $t_{114}$ , the gas bubble 115 is made available in the expansion chamber 106. In chamber 106 there takes place, with the expansion of the bubble 115, a very steep rise in the pressure  $p_{106}(t)$  which flattens briefly at a maximum. The steep pressure rise and the inert mass of the fluid 111 flowing through the entry nozzle 104 compel, by reason of the expansion of the enclosed gas bubble 115, along with a decrease in the pressure  $p_{106}$ , a separation of the fluid piston 117 from the fluid column 114 with an increasing exhaust speed  $v_{114/117}(t)$ .

The expansion properties of the gas bubble 115 and the diameter and short length of the exhaust pipe 103 are, preferably, coordinated with one another in such a way that the fluid piston 117 emerges as straight as possible from the rearward opening 119 of the exhaust tube 103 (FIGURE 4e), upon reaching its maximum speed  $v_{117}$ .

Such coordination is preferred because a build-up of the underpressure or backpressure in chamber 106 is thus prevented, so that a suction effect (reducing efficiency) on the fluid piston 117 that is to be pushed out or exhausted from the device 101 is avoided. Similarly, in the interests of favourable efficiency the geometry of the entry nozzle 104 and the periodic preparation of expanding reaction-gas bubbles 115 are, preferably, coordinated to one another



in such a way that the next successive filling of the exhaust tube 103 with a fluid column 114, and then the severing (portioning off) and exhausting of the fluid piston or body 117 takes place so rapidly that the fluid piston 117 leaving the exhaust opening 119 passes into a cavity or space in the fluid 111 or at any rate into an underpressure (backpressure or low pressure region), and therefore has to displace seemingly as little as possible of the inert mass of the fluid 111 at the rear of the driving device 101.

Thus, the fluid 111 flowing through the exhaust tube 103 is periodically accelerated by means of the expansion-gas bubbles 115 in such a way that a pulsating (pulsed), but practically compact jet (subsequently the fluid piston 117) is ejected; the thrust reaction impulses of the jet lead to the movement of the driving device 101 relative to the fluid 111. In this respect, a particularly favourable thermal and mechanical efficiency occurs, because only individual, highly-compressed gas bubbles 115 react with the surrounding fluid 111 and in each case only over extremely short timespans; and because the tamping action of the expanding bubbles 115 on the fluid column 114 makes any mechanical valve design superfluous (i.e. the pressure action during the ejection of the fluid piston 117 does not work against a moving mechanical system) there ensures directly by way of the tamping action of the fluid 111 itself an impulse transfer to the interior of the driving device 101, in the region of the transition from the exhaust pipe 103 to the diffuser 105.

The relatively high thrust impulses can be achieved with relatively small amounts of reaction partners, or materials (Reaktionen - partnermergen) which are caused to react with one another periodically either directly in the expansion chamber 106 or else in a separate gas generator 108.

A favourable plot of pressure  $p_{106}(t)$  (with regard to the initially desired steep pressure flank) may be provided by the rich (greater) volume and highly compressed reaction gases which accrue upon the reduction of metal hydrides (previously not used for propellant charges), with acid reagents and water, as explained above.



The addition of a gas generator 108 that is to be operated independently is thus superfluous if, in accordance with FIGURE 6, a bar or rod 107 of, for example, sodium borohydride is advanced into the expansion chamber 106 and sprayed periodically with, for example,  
5 nitric acid from a nozzle 109.

Through the expansion frequency of the bubbles 115, the acceleration achievable with the driving device 101, and thus the speed  $v_{114/117}$  relative to the fluid 111, can be varied. Of course,  
10 the resistance forces exerted by the fluid 111 rise with the square of the speed  $v_{117}$ . Therefore, it is advantageous, for an increase in speed, to increase not only the frequency of bubbles 115, but also the energy content thereof, i.e. for example to increase the amount of propellant or acid made available in each case for the gas generation,  
15 in order to overcome the resistance forces which increase in a speed-dependent manner. With a fixed bubble frequency and fixedly preset mass of reaction partners used for the bubble formation, in contrast there occurs a specific maximum speed  $V_{117}$ , as taken into account in FIGURE 5.

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With the thrust element shown as the driving device 101 in accordance with FIGURE 7 a travel body 125 is accelerated underwater. The driving device 101 can be arranged coaxially with body 125 and be arranged to extend around and behind the tail 126 thereof (as shown in  
25 FIGURE 7), so that an annular slot geometry results for the entry nozzle 104 and the diffuser 105.

More advantageous is, however, a grouping together of several thrust elements, arranged peripherally side-by-side or end to end,  
30 with the cross-section of circular-ring-segments being on the travel-body tail and, for example, with a central gas generator 108 for all the segments in the body 125. The shock-wave flow ducts 110 then lead from the valve 124 to the expansion chambers 106 - unless the propellants are caused to react directly in accordance with FIGURE 6  
35 in the chambers 106.

As shown in FIGURE 8, for a relatively slow-running fixed



hydrodynamic machine, the driving device 101 can also be used (instead of being designed as a free-running or co-running thrust element in accordance with FIGURES 3, 6 or 7) in a closed fluid circuit 120, in which circuit for example for the movement decoupling a paddle wheel 122 rotating about a shaft 121 is arranged close behind the exhaust pipe 103 of the thrust element. A filter 123 serves for separating impurities from the fluid 111 prior to return of the fluid into the thrust-cell or element driving device 101. The build-up of reaction residues can, however, be kept very low if (in accordance with the above example) a reaction product is produced from the gas bubbles 115 which is for example like the fluid 111 - water.

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CLAIMS

1. Use of a complex metal hydride and acid reagent which is sprayed onto the metal hydride presented in lumpy consistency, for the pulse-like generation of expanding reaction-gas bubbles in, or fed to, a chamber for the acceleration of masses, aqueous fluid being provided for the dynamic tamping or blocking of the reaction-gas bubbles.  
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2. Use as claimed in Claim 1 with a rod, suppliable into the chamber, as the metal hydride.  
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3. Use as claimed in Claim 1 or Claim 2 in which water is used for wetting at least that region of the metal hydride which is sprayed with acid reagent.  
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4. Use as claimed in Claim 1 or Claim 2 in which the metal hydride is sprayed with aqueous acid reagent.
5. Use as claimed in any one of the preceding claims in which there is used a trace addition of catalytically acting metal, for example copper, in addition to the reagent.  
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6. A driving device for carrying out the use as claimed in any one of the preceding claims, comprising a complex metal hydride presented in lumpy consistency and a holder therefor, and comprising an acidic reagent, the driving device having an expansion chamber for the acceleration of masses, which chamber is defined in part by, or blocked by, a yielding aqueous fluid, such that masses can be accelerated by the expanding reaction-gas bubbles as a reaction of said bubbles against the aqueous fluid, and in which device an injection nozzle for injecting said reagent is directed towards the holder and at a surface part of the metal hydride.  
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7. A device as claimed in Claim 6 in which that surface part of the metal hydride which is acted upon by reagent, introduced by way of the injection nozzle, extends into an expansion chamber in which said part of the metal hydride is surrounded by the aqueous fluid.  
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8. A device as claimed in Claim 6 or 7 in which that surface part of the metal hydride which is to be acted upon from the injection nozzle is arranged at the edge of the expansion chamber which is blocked by the aqueous fluid.

9. A device as claimed in Claim 8 in which the expansion chamber is blocked by means of a piston.

10. A device as claimed in Claim 9 in which the piston is a dischargeable projectile.

11. A device as claimed in Claim 8 in which the expansion chamber is blocked by a mass which is relatively inert or sluggish as compared with the expanding reaction gas bubble.

12. A device as claimed in Claim 11 in which the expansion chamber is situated in a thrust element from which a reaction gas bubble exhausts a fluid piston.

13. A device as claimed in Claim 11, in which the reaction chamber is connected by way of a shock tube to a thrust cell or element, from which reaction gas pushes out a fluid piston.

14. A device as claimed in Claim 12 or 13, in which a periodically operable gas generator is connected by way of a limit pressure valve and a shock-wave flow duct to the expansion chamber.

15. A device as claimed in Claim 12, having a direct feed of the reaction partners (metal hydride and reagent) into the expansion chamber.

16. A device as claimed in Claim 14 or 15, which is a substantially nozzle-shaped structure configured in a flow-favourable manner as a free fast-running thrust cell.

17. A device as claimed in Claim 11 which is arranged on an underwater travel body.



18. A device as claimed in any one of Claims 12 to 15 which is arranged in a closed fluid circuit.
19. A driving device as claimed in Claim 18, which is arranged in front of a blade wheel of a hydrodynamic machine.
20. A method of accelerating a mass comprising:-
- a) introducing an acid onto a metal hydride;
  - b) allowing one or more expanding gas bubbles produced from the reaction between the acid and metal hydride to enter a chamber having a mass to be driven or accelerated, said chamber being defined in part by, or blocked by, an aqueous fluid;
  - c) driving or accelerating the mass by the gas bubble or bubbles, as a reaction of said gas bubble or bubbles against the aqueous fluid.
21. A method as claimed in Claim 20 in which the acid is sprayed onto the metal hydride.
22. A method as claimed in Claim 20 or 21 in which the metal hydride is in a lumpy or solid condition, for example in the form of a rod.
23. A method as claimed in any one of Claims 20 to 22 in which the expansion chamber is blocked by the mass to be driven or accelerated.
24. A method as claimed in Claim 23 in which the mass is yieldably biased in a direction contrary to the driving or accelerating force of the gas bubble or bubbles in the chamber.
25. A method as claimed in Claim 23 or Claim 24 in which the mass is a piston.
26. A method as claimed in Claim 25 in which the piston is itself a fluid.





27. A method as claimed in Claim 20 and substantially as herein described with reference to FIGURE 1, FIGURE 2, FIGURE 3, FIGURES 4 and 5, FIGURE 6, FIGURE 7 or FIGURE 8 of the accompanying drawings.

28. A gas bubble drive comprising a metal hydride and acid reagent and means arranged to introduce the acid onto the metal hydride, said metal hydride and acid comprising reacting partners which produce gas bubbles on contact with one another, the drive being for propelling a mass, for example a solid or fluid piston or projectile, present in use in a gas bubble expansion chamber of the drive, said expansion chamber being defined in part by, or blocked by, a yieldable aqueous fluid.

29. A drive as claimed in Claim 28 in which the metal hydride is in the form of a solid rod and the chamber is blocked by a blocking means in the form of a piston or projectile.

30. A drive as claimed in Claim 28 or 29 in which the expansion chamber is a thrust element from which a fluid piston is exhausted by a reaction gas bubble in order to propel the element forwards in a fluid medium or alternatively for use in a fluid circuit, for example of a hydrodynamic machine.

31. A drive as claimed in Claim 28 and substantially as herein described with reference to FIGURE 1, FIGURE 2, FIGURE 3, FIGURES 4 and 5, FIGURE 6, FIGURE 7 or FIGURE 8 of the accompanying drawings.

32. A method or device substantially as herein described and illustrated with respect to each of the accompanying figures.

33. A device or method as the case may be as claimed in any one of Claims 20 to 32 in which the metal hydride is sodium borohydride ( $\text{NaBH}_4$ ) and the acid is a mineral acid, organic acid or acid salt.

34. A device or method as the case may be as claimed in Claim 33 in which the acid is hydrochloric or nitric acid.

