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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Rocket Assisted Projectile or Gun Boosted Rocket with Supported Propellant Charge

We, ARNOLD INGEMAR MAGNUSSON, of 4, Ringvagen, Grodninge, Sweden, PER TAGE MARKLUND, of 60, Olshammarsgatan, Bandhagen, Sweden, SVEN MALTE BRODDNER, of 65, Tideliussgatan, Stockholm, Sweden, LARS AX, of 13, Stenvagen, Tumba, Sweden, and ROBERT BERT ANDERSSON, of 49, Gallerstagrand, Bandhagen, Sweden, all Swedish subjects, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to rocket technology and particularly to a gun boosted rocket or rocket assisted projectile. In the following description the notation RAP is used. This expression covers rocket assisted projectiles as well as gun boosted rockets, GBR.

A well known method to increase the range of a gun is to supply the round with a rocket which is ignited when the round has left the muzzle of the weapon. Such a combination usually is called an RAP or GBR. The thrust which the rocket delivers will increase the velocity of the projectile and consequently its range.

There are considerable problems in designing a RAP motor. The high acceleration forces experienced by the projectile when it is launched often causes rupture in various components. This is especially so of the solid rocket propellant charge, due to the fact that every known type of solid rocket propellant has rather poor mechanical properties. A crack in the solid propellant charge can cause malfunction of the motor and may also cause explosion of the whole projectile.

In spin stabilized vehicles the solid rocket propellant will experience a high load due

to the centrifugal forces. For a cylindrical charge configuration this means high tensile stresses, especially in the center of the charge. This makes it necessary to use hard types of solid propellant with a high tensile strength. Such types of solid propellant will necessarily become brittle. Consequently the risk of cracks during the launch will increase. Additionally, such types of solid rocket propellant generally have a low specific thrust.

The object of the present invention is to overcome these difficulties. The characteristics of the invention, and other objects thereof will become apparent from the following description with reference to the accompanying drawing, where the invention is shown embodied in 15.5 cm calibre RAP.

The RAP includes a warhead consisting of a conventional shellcase 1 with explosive 2 and fuze 3. The warhead may be of any suitable type and forms no part of the present invention. The rocket motor 4 is separated from the war head by a wall 5 which is covered with a heat insulating layer 6 made, for example, from an asbestos—phenolic laminate. The solid rocket propellant charge 7 is a conventional internal burning cylinder with an insulating lining on the outer surface 8 of the cylinder and on two ends 9. The insulation on the outer surface of the cylinder can be very thin (0.5 mm or less). The charge is a little shorter than the motor chamber so that a space 10 is formed between the charge and the front end of the rocket motor.

Within the central bore in the charge is a central supporting tube 11. The tube is fixed to the rear end 12 of the rocket motor, with a smooth junction to the nozzle 13 of the motor. Throughout its length, the tube has a smaller diameter than the bore in the charge so that a uniform or (as shown) forwardly

widening annular space 14 is formed between the charge and the central supporting tube. The spaces 10 and 14 mean that the charge does not completely fill the internal volume of the motor.

The material chosen for the central supporting tube 11, which is conveniently externally coned, so that its thickness increases forwards the rear end of the chamber, has proved to be of great significance. Good results have been obtained with tubes made of glass-fiber reinforced synthetic plastic, but tubes made of phenolic-asbestos laminate may also be used, as well as tubes made of various metals. The material is selected so that whilst providing adequate mechanical strength, it is consumed during burning of the propellant. Thus organic based materials such as exemplified above are suitable, as well as magnesium alloys and aluminium alloys, are suitable. Combustion of the material used may be used to complement the thrust of the motor. The materials may either be such as to support their own combustion, or such as will react with the gases from the burning propellant charge. An igniter 15 for the rocket motor, incorporating time delay means, may be placed in a cover for the nozzle 16 or, as shown in the example, in a recess in the front end of the motor chamber.

In those cases where the charge needs to be fixed more accurately in the motor, this can be achieved by bonding the outer surface 8 of the charge to the wall of the motor either directly or through the insulating lining. To reduce the shear stresses, the charge should only be bonded for about $1/3$ of its length, the bonded surface being at the rear end of the motor.

The rocket motor of the RAP works, as described briefly, as follows.

When the projectile is launched the acceleration forces will press the charge backwards, consequently the charge is deformed until it receives support from the rear end of the motor, the walls of the motor and the central supporting tube. If those types of solid rocket propellant are used which show sufficient tensile strain, for example composite propellants with carboxy-terminated polybutadiene as binder, no cracks will occur during this deformation.

The compressive stresses of about 1000 bars, which the charge experiences during the launch, will be taken up as a hydrostatic pressure. The charge is subjected to total hydrostatic containment. Virtually incompressible materials, to which class soft types of solid rocket propellants belong, have, when subjected to hydrostatic containment, almost unlimited tensile strength.

When the projectile leaves the gun, the axial acceleration ceases. As a result of its visco-elastic behaviour and the high centrifugal force to which it is subjected due to the spin

of the projectile, the charge will return to its original length, but will then be elongated by the action of centrifugal force until it is supported by the front end of the motor so that even under these conditions the charge is subjected to hydrostatic containment. After this elongation, the space 14 between the charge and the tube appears again and has become larger. This makes it possible for the propellant charge to be ignited by the igniter 15 and to burn radially.

Correct function of the above described RAP has been proved experimentally at accelerations of 15000 g as well as in spin tests at 15000 rpm and was additionally confirmed by an entirely successful test series in a 15.5 cm howitzer. The centrifugal force increases the burning rate of the propellant. The spin also causes a swirling flow which reduces the effective nozzle throat area. The effect of these two factors can be cancelled by an increase in the nozzle throat area dependent on the spin velocity.

WHAT WE CLAIM IS:—

1. A rocket assisted projectile or gun boosted rocket, comprising a rocket motor having a solid propellant charge formed with a central bore and housed in a tubular casing which forms the outer wall of a rocket propellant chamber and is provided with a rear end formed with a central nozzle and a supporting tube extending forwardly therefrom within the bore of the charge, the bore of the tube being in communication with that part of the casing containing the charge, wherein the charge consists of a solid propellant showing a high tensile strain in response to the high axial and centrifugal forces set up by launching, and the supporting tube has a smaller outer diameter than the bore in the charge so as to leave an annular space therebetween, whereby the charge is constrained by axial acceleration during launching to deform so as to receive support from the tube without cracking, but when the axial acceleration ceases can reassume its original shape and consequently form a space between the charge and the supporting tube whereby radial combustion of the charge is rendered possible.

2. A projectile according to claim 1, wherein the length of the charge is less than the length of the rocket chamber, so that a space is formed between the front end of the chamber and the front end of the charge, so that, after launching, the charge is adapted to be elongated by centrifugal forces acting thereon generated by spinning of the projectile, whereby the charge is deformed into supporting engagement with the outer wall and ends of the chamber, and the space between the charge and the supporting tube is enlarged.

3. A projectile according to claim 1 or 2, wherein the outer surface of the charge

widening annular space 14 is formed between the charge and the central supporting tube. The spaces 10 and 14 mean that the charge does not completely fill the internal volume of the motor.

5 The material chosen for the central supporting tube 11, which is conveniently externally coned, so that its thickness increases forwards the rear end of the chamber, has
10 proved to be of great significance. Good results have been obtained with tubes made of glass-fiber reinforced synthetic plastic, but tubes made of phenolic-asbestos laminate may also be used, as well as tubes made of
15 various metals. The material is selected so that whilst providing adequate mechanical strength, it is consumed during burning of the propellant. Thus organic based materials such as exemplified above are suitable, as well as
20 magnesium alloys and aluminium alloys, are suitable. Combustion of the material used may be used to complement the thrust of the motor. The materials may either be such as to support their own combustion, or such
25 as will react with the gases from the burning propellant charge. An igniter 15 for the rocket motor, incorporating time delay means, may be placed in a cover for the nozzle 16 or, as shown in the example, in a recess in
30 the front end of the motor chamber.

In those cases where the charge needs to be fixed more accurately in the motor, this can be achieved by bonding the outer surface 8
35 of the charge to the wall of the motor either directly or through the insulating lining. To reduce the shear stresses, the charge should only be bonded for about $1/3$ of its length, the bonded surface being at the rear end of the motor.

40 The rocket motor of the RAP works, as described briefly, as follows.

When the projectile is launched the acceleration forces will press the charge backwards, consequently the charge is deformed
45 until it receives support from the rear end of the motor, the walls of the motor and the central supporting tube. If those types of solid rocket propellant are used which show sufficient tensile strain, for example composite propellants with carboxy-terminated polybutadiene as binder, no cracks will occur
50 during this deformation.

The compressive stresses of about 1000 bars, which the charge experiences during the
55 launch, will be taken up as a hydrostatic pressure. The charge is subjected to total hydrostatic containment. Virtually incompressible materials, to which class soft types of solid rocket propellants belong, have, when
60 subjected to hydrostatic containment, almost unlimited tensile strength.

When the projectile leaves the gun, the axial acceleration ceases. As a result of its visco-elastic behaviour and the high centrifugal
65 force to which it is subjected due to the spin

of the projectile, the charge will return to its original length, but will then be elongated by the action of centrifugal force until it is supported by the front end of the motor so that even under these conditions the charge is subjected to hydrostatic containment. After this elongation, the space 14 between the charge and the tube appears again and has become larger. This makes it possible for the propellant charge to be ignited by the igniter
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Correct function of the above described RAP has been proved experimentally at accelerations of 15000 g as well as in spin tests at 15000 rpm and was additionally confirmed by an entirely successful test series in a 15.5 cm howitzer. The centrifugal force increases the burning rate of the propellant. The spin also causes a swirling flow which reduces the effective nozzle throat area. The effect of these two factors can be cancelled by an increase in the nozzle throat area dependent on the spin velocity.

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1. A rocket assisted projectile or gun
90 boosted rocket, comprising a rocket motor having a solid propellant charge formed with a central bore and housed in a tubular casing which forms the outer wall of a rocket propellant chamber and is provided with a rear
95 end formed with a central nozzle and a supporting tube extending forwardly therefrom within the bore of the charge, the bore of the tube being in communication with that part of the casing containing the charge, wherein the charge consists of a solid propellant showing a high tensile strain in response to the high
100 axial and centrifugal forces set up by launching, and the supporting tube has a smaller outer diameter than the bore in the charge so as to leave an annular space therebetween, whereby the charge is constrained by axial
105 acceleration during launching to deform so as to receive support from the tube without cracking, but when the axial acceleration ceases can reassume its original shape and consequently form a space between the charge and the supporting tube whereby radial
110 combustion of the charge is rendered possible.

2. A projectile according to claim 1, wherein the length of the charge is less than the length of the rocket chamber, so that a space is formed between the front end of the chamber and the front end of the charge, so that, after launching, the charge is adapted to be
120 elongated by centrifugal forces acting thereon generated by spinning of the projectile, whereby the charge is deformed into supporting engagement with the outer wall and ends of the chamber, and the space between the charge and the supporting tube is enlarged.

3. A projectile according to claim 1 or 2, wherein the outer surface of the charge



is bonded to the wall of the tubular casing, either directly or through a lining.

- 5 4. A projectile according to any of the preceding claims, wherein the space between the supporting tube and the charge widens forwardly.

- 10 5. A projectile according to any of the preceding claims, wherein the supporting tube completely or partly consists of material which will be consumed during combustion of the charge.

6. A projectile according to claim 5, wherein the tube material is organic, an aluminium alloy or a magnesium alloy.

7. A projectile according to any of the preceding claims, wherein the wall thickness of the supporting tube increases towards the rear end of the chamber. 15

8. A rocket assisted projectile or gun boosted rocket, substantially as hereinabove described with reference to the accompanying drawing. 20

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