The present invention relates to a projectile which is to be fired from a barrel at supersonic velocity and which is provided with a propulsion unit that becomes operative after firing. Such a projectile is herein referred to as a "supersonic barrel-fired projectile carrying a propulsion unit."

With conventional firearms, the projectile has imparted thereto a kinetic energy which enables it to cover the distance to the target against the action of air resistance and gravity. The firing range depends inter alia on the muzzle velocity and the weight of the projectile. With equal muzzle velocities and equal air resistances, a heavy projectile travels further than a light one. The reaction to the acceleration which the projectile is given in the barrel is the recoil of the weapon. With equal muzzle velocities and other equal circumstances, the heavy projectile produces the greater recoil. With conventional firearms, the gases from the powder discharge forwardly. The gun crew does not have to leave the firing position when the projectile is fired. It is thus possible to effect rapid reloading and a continuous feeding of automatic loading devices.

On account of the high initial supersonic velocity, the flight of the projectile is stable from the start and thus the accuracy of firing is good. It is however decreased in proportion as the kinetic energy of the projectile is absorbed by the air resistance and thus the accuracy in flight decreases. Consequently, the time of flight of the projectile increases relatively quickly as the range becomes longer, so that when firing against moving targets, aim-off errors occur to an increasing degree as the range increases. Firing becomes pointless when the projectile velocity no longer exceeds the target velocity to a sufficient extent or falls below it. It is clear that only projectiles having a high velocity throughout their flight, i.e., projectiles with their own propulsion unit (self-propelling projectiles), permit firing against high-speed targets to be effective.

With self-propelling projectiles, the propellant gases are discharged rearwardly. In cases where the projectile is not fired from a barrel so that the propulsion unit must also be responsible for launching the projectile the gun crew must take cover on firing and this has a deleterious effect on the rate of fire. Such self-propelled projectiles have a low initial velocity and the target accuracy is therefore restricted unless there is remote control of the flight of the projectile. The propulsion units of such self-propelled projectiles must not only supply the power for overcoming air resistance and gravity, but also the power for the total initial acceleration upon launching. Furthermore, energy must be supplied sufficient to accelerate the propulsion unit itself and the weight of fuel serving for the acceleration.

Rapid and accurate firing against rapidly moving targets at ranges which are greater than, for example, those of the modern machine guns and automatic guns is only possible if a projectile fired at normal muzzle velocity is given its own propulsion unit which enables the projectile to maintain its muzzle velocity as far as the target or even for this velocity to be increased. The power of the projectile propulsion unit and the weight of fuel to be accelerated in this case only have to be substantially sufficient in order to overcome the gravity of the earth and air resistance during the time of flight, while the initial acceleration is provided by the gun.

An artillery shell of conventional type is made as heavy as possible, not only for the purpose of conveying the largest possible amount of explosive to the target, but also for the purpose of enabling the shell to overcome the air resistance by means of its kinetic energy over a long trajectory and in addition to exert an armour-piercing action on hitting the target. If now a self-contained propulsion unit and not the weight of the projectile is used to enable the latter to overcome the air resistance and if other means, for example a hollow charge, is used for the armour-piercing effect, the firing range and the piercing power place no direct demands on the weight of the projectile. The weight requirement for propellant and hollow charge is smaller than that mass with an old-type projectile which is equivalent in the respects just indicated. Consequently, such a projectile can be lighter in weight. With an equal muzzle velocity, the rearward thrust is smaller and the recoil shorter, this always being desirable for example for the weapons used on ships and tanks. Alternatively, with an equal rearward thrust, it is possible to achieve a higher muzzle velocity and thus a greater accuracy in firing.

Experiments with shells having a self-contained propulsion unit have already been carried out. If the self-contained propulsion unit is arranged on the base of the shell, the point of application of the forwardly propelling force when the propulsion unit becomes operative is considerably behind the centre of gravity of the shell, which centre of gravity can be considered as the point of application of the forwardly propelling force resulting from the kinetic energy. Thus, these projectiles became unstable in flight when the propulsion unit became operative.

On the other hand, projectiles of the type in question have also already been proposed in which the propellant charge for the self-contained propulsion unit that becomes operative after firing is arranged in the projectile body near the centre of gravity of the projectile and the gases formed by the burning of this propellant charge are exhausted through a plurality of rearwardly directed nozzles opening laterally on the projectile body. The efficiency of this self-contained propulsion unit operating as a rocket motor with thrust nozzles is however obviously very poor. Moreover, it is only with a relatively large projectile that a sufficiently large combustion chamber and the necessary nozzles with their connecting ducts can be arranged in a satisfactory manner in the projectile body.

According to the present invention there is provided a supersonic barrel-fired projectile, comprising a fusiform projectile body, a nose and a tail on said body, a propellant charge of solid fuel arranged in annular form on the outside of the body in the region of the largest cross-section thereof, and a ring of priming composition, for
igniting the solid fuel, situated on the outside of the body, the distance between said nose and the solid fuel being slightly greater than the distance between said nose and the priming composition, whereas the distance between said nose and the centre of gravity of the projectile is still greater.

On account of the construction just indicated, it is possible to dispense with both a separate combustion chamber and thrust nozzles in the projectile body; it thus becomes possible for even small projectiles to be provided with their own propulsion unit in a simple manner and at relatively low expense. The position of the ignition point which is chosen in this case also guarantees that the expansion of the propellant gases takes place wholly or at least partially between the outside wall of the front tapering section of the fusiform projectile body and the shock wave emanating during flight with supersonic velocity from the nose of the projectile. The gas expansion not only has a thrust effect owing to the rearward flow of the gases caused by the high pressure zone in front of the projectile, but also a lower order of propellant and quantity thereof, can so influence the shock wave that the Mach angle of the shock wave is altered to a value corresponding to a smaller projectile velocity. In this way, the resistance opposing the projectile is reduced and the projectile velocity will decrease less rapidly than when the same propellant is not used. The trajectory of the projectile thus becomes flatter and longer under the action of the existing kinetic energy.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made to the accompanying drawing, which shows a longitudinal sectional view of a projectile. The illustrated projectile has a nose, a tail and a region of maximum diameter between the nose and the tail at which a propellant fuel is burnt. The surface of the projectile between the region at which the fuel is ignited and the tail is completely smooth, that is to say that there are no driving bands or other irregularities in that part of the projectile surface. The centre of gravity of the projectile is on the longitudinal centreline of the projectile and between the planes indicated by the references X and Y, that is to say the centre of gravity is behind the region at which ignition of the fuel takes place but well forward of the tail. The exact position of the centre of gravity will, of course, depend upon the dimensions of the projectile and the specific gravities of the various parts thereof so that it is not necessary and would in fact be misleading, to specify the exact position of the centre of gravity in the projectile.

In the drawing, there is shown a fusiform projectile body 1 which must have a thick wall in its rearward portion, especially in the case of fixed gun ammunition, in order to withstand the gas pressure in the barrel. There is provided a driving band 2 for co-operation with the gun barrel rifling to produce rotation of the projectile. 3 is a primer composition which consists of pyrotechnic materials and which is initially ignited, upon firing, by the gun powder, and then in its turn ignites solid fuel 4 which serves as propellant and is arranged as a ring in an annular recess, which also contains the primer composition on the outside of the body 1. 5 is a tail unit for increasing the stability of the projectile in flight. This tail unit is inclined to the direction of flight in order to maintain in flight the rotation produced before the projectile leaves the muzzle. The tail unit can be comparatively small, since it is completely in the flow of the propellant gases. 6 is the explosive charge, which can be of conventional type, and 7 is the cartridge case. It is of course also possible for solid propellant compositions, for example those of infantry rifles or machine guns, to be equipped with the additional propulsion unit previously described in order to increase the efficacy of these weapons. The projectile described above is distinguished from the previously known types of projectiles by the fact that it has the form of a closed solid or hollow body which is tapered towards the front and rear ends, inside which body is a solid core of an explosive charge of molecular type, and on the outside which is a priming composition situated in the region of the largest cross-section and disposed in front of the centre of gravity of the projectile, while to the rear of this composition, seen in the direction of flight, there is a propellant charge consisting of a solid fuel.

The projectile shown in the drawing is provided at its rearward end with a tail unit which is disposed in the gas stream of the propulsion jet and which serves to stabilize the projectile in flight, such tail unit being so shaped that it imparts a rotation to the projectile.

It is to be noted that the expression "projectile" used in the previous description is to cover any body for flight in atmosphere at supersonic velocity.

It will be apparent from the drawing that the ring of priming composition 3 is situated at a location which is on the outside of the projectile body in the region of the greatest diameter thereof. It is adjacent to the solid fuel in the body and is between the latter and the nose of the projectile and closer to said nose than to the tail of the projectile measured along the longitudinal axis of the projectile. The distance between the nose and the solid fuel is therefore slightly greater than the distance between the nose and the priming composition, whereas the distance between the nose and the centre of gravity of the projectile is still greater.

I claim:

1. A supersonic barrel-fired projectile, comprising a fusiform projectile body, a nose and a tail on said body, a propellant charge of solid fuel arranged in annular form on the outside of the body in the region of the largest diameter thereof, and a ring of priming composition, for igniting the solid fuel, situated at a location which is on the outside of the body in the region of the greatest diameter thereof and is adjacent to the solid fuel and is between the latter and said nose and closer to said nose than to said tail, measured along the longitudinal axis of the projectile.

2. A projectile according to claim 1, and further comprising wall portions of said body defining an annular recess extending around the outside of said body in the region of the greatest diameter thereof, the solid fuel and the priming composition being disposed within said recess.

3. A supersonic barrel-fired projectile, comprising a fusiform projectile body, a nose and a tail on said body, a propellant charge of solid fuel arranged in annular form on the outside of the body in the region of the largest cross-section thereof, and a ring of priming composition, for igniting the solid fuel, situated on the outside of the body, the distance between said nose and the solid fuel being slightly greater than the distance between said nose and the priming composition, whereas the distance between said nose and the centre of gravity of the projectile is still greater.

4. A supersonic barrel-fired projectile, comprising a fusiform projectile body, a nose and a tail on said body, a propellant charge of solid fuel arranged in annular form on the outside of the body in the region of the largest cross-section thereof, and a ring of priming composition, for igniting the solid fuel, situated on the outside of the body, the distance between said nose and the solid fuel being slightly greater than the distance between said nose and the priming composition, whereas the distance between said nose and the centre of gravity of the projectile is still greater, the entire part of the projectile body between the fuel and said tail having a completely smooth external surface.

5. A supersonic barrel-fired projectile, comprising a fusiform projectile body, a nose and a tail on said body, a propellant charge of solid fuel arranged in annular form on the outside of the body in the region of the largest diameter thereof, and a ring of priming compo-
situation, for igniting the solid fuel, situated at a location which is on the outside of the body in the region of the greatest diameter thereof and is adjacent the solid fuel and is between the latter and said nose and closer to said nose than to said tail, measured along the longitudinal axis of the projectile, the entire part of the projectile body between the fuel and said tail having a completely smooth external surface.

6. A projectile according to claim 1 and further comprising wall portions of said body defining an annular recess extending around the outside of said body in the region of the largest cross-section thereof, the solid fuel and the priming composition being disposed within said recess.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,067,685

December 11, 1962

Günter Ludwig

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 3 and 13, and in the heading to the printed specification, line 6, for "Spindex", each occurrence, read -- "Sfindex" --.

Signed and sealed this 20th day of August 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents
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