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HISTORY OF ROCKET PROPULSION

NEWNES

9d.

PRACTICAL MECHANICS

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Rocket Propulsion

Its History and Development

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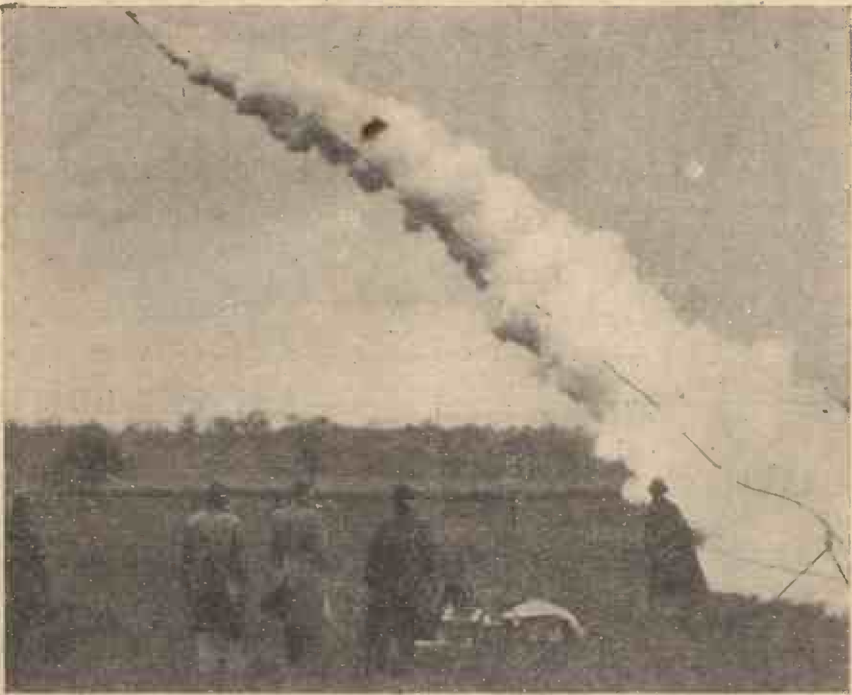


Schermuly multiple rocket electrically fired. Range 350yds. with 1in. circ. line.

Introduction

BEFORE commencing upon the survey of rocket development, it is desirable, on the outset, to define the two *reaction* systems — "*true-rocket*" and "*thermal-jet*." The former, "true-rocket," is the simplest type of thermodynamic engine comprising a pressure-tight chamber, with an escape orifice, containing, or fed with a fuel with oxygen bearing content either as an integral part or as a separate component. There are two distinctive types of rocket motor. The earliest and most familiar is the powder fuel rocket, where the combustion chamber serves also as the fuel store. Examples of this type are the display ("firework") rocket; the rocket life-line, and the A.A. Battery rocket projectile. There are, however, obvious limitations governing the use of this rocket system—namely, the constantly changing chamber volume, and the limited period of reactive effort. The other rocket motor embodies a combustion chamber distinctly remote from the fuel, this being contained separately and supplied at a controllable rate, thus ensuring *constant* chamber volume, and a period of firing far exceeding that of the former. This motor form generally employs a liquid fuel, with oxygen (liquid) as the "supporting" element for combustion, but the "cartridge" fuel injector and certain variants of this system employing solid or paste fuel components come under the same category. In the other reaction system, the thermodynamic engine employs a solid or liquid fuel, burnt in a medium of highly compressed air *inducted from the atmosphere*. This is the "thermal-jet" reaction means, with which we are not concerned in this history.

The principle of *reaction* is common to both "true-rocket," and "thermal-jet" systems, tractive motion being effected by virtue of the reaction of the exhaust efflux on the producing plant, in accordance with Newton's Third Law of Motion.

It is obvious from the foregoing that, whereas the "thermal-jet" propulsion plant is limited for operation to the bounds of atmosphere (due to the need for inducting air to support combustion), the "true-rocket" motor is capable of penetrating the atmosphere, to operate in space itself. Indeed, once free of atmosphere, the rocket would operate at highest efficiency since the atmosphere has a "damping" effect acting to reduce the velocity of the exhaust gases. It is the mass velocity of the exhaust efflux that determines the reactive effort.

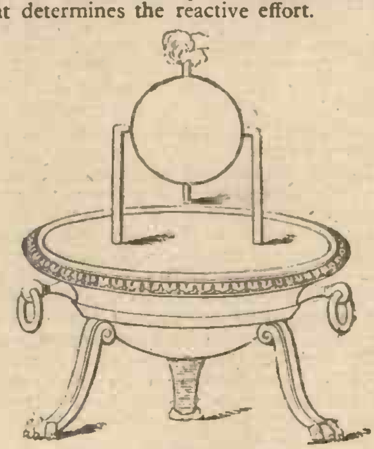


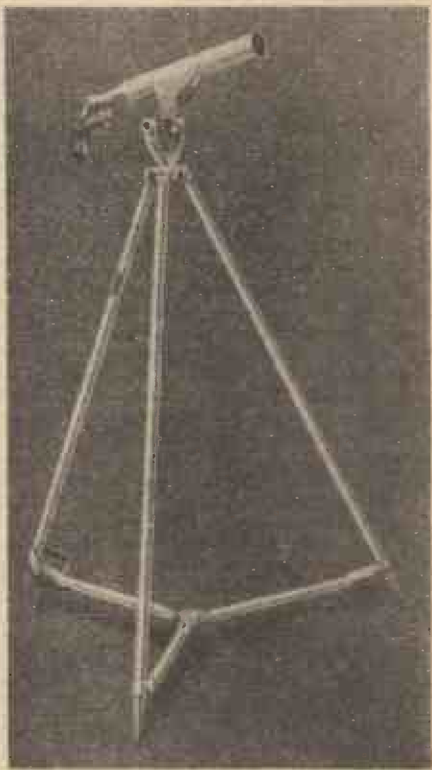
Fig. 1.—Hero's "æolipile."

It is of interest to note that the reaction principle was actually first demonstrated at the beginning of the Christian era by the Alexandrian philosopher, Hero. The apparatus employed, known as the *æolipile* (Fig. 1) consisted of a hollow sphere, into which were fitted two right-angle tubes on opposite sides. This was centrally mounted and free to revolve on two supports, one of which was hollow, to permit steam, generated in a "boiler" positioned below and supported over a fire, to flow into the sphere and out at high pressure through the escape tubes, thereby setting up a reactive force to rotate the vessel.

Finally, as a caution, it is desirable to point out that rocket experiments in time of war are an offence against the Defence Regulations. Formula relating to fuel compositions contained in this article series are included solely to illustrate the trend of development.

The Beginning

It is known that the origin of pyrotechnic compounds dates back to well before the B.C. era. A feasible theory of the evolution of combustible mixtures is held to be in the use of saltpetre (found in abundant natural supply in China and India), for which certain primitive Eastern tribes probably first found a use in the curing of meat. It is likely that the first discovery of the substance as a combustible was during the process of



The Schermuly pistol rocket apparatus.

cooking, a small amount perhaps being accidentally dropped on the fire and, as the result, a sudden observed conflagration. The next step would appear obvious in the adoption of the newly found substance for fire-making, and wood being the first known combustible, the natural inclination would therefore be to combine the two. However, man at that period possessed no means whereby wood could be reduced to a workable medium, at least in any quantity, to obtain a comparatively uniform mixture, but

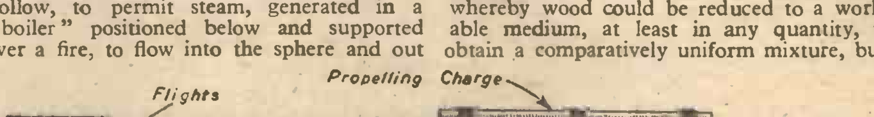


Fig. 2.—Chinese "rocket" arrow (A.D. 1220).

some further consideration, no doubt, would suggest the utility of partially burnt wood, and ultimately, in later development, charcoal.

Whether or not sulphur, or brimstone, was later incorporated in the mixture is uncertain, but it is established that a composition known as "Chinese Fire" (which contained the two base substances previously mentioned) was employed in the East long before the Christian era. An allied compound developed in Greece at about the same time was "naphtha," probably a composition of brimstone, pitch, resins, fats, and possibly crude saltpetre.

It is likely that these substances were first used in war as an incendiary weapon—being contained in clay balls, or small bamboo tubes, ignited and flung at the enemy. It might well have been in this way that a primitive "grenade" developed, as the result of explosions caused by confinement of the burning mixture. However, in all probability, the early "gunpowder" substances were not recognised as propellant medium until after the birth of Christ. It is conceivable that the first indication of propulsive effect came as the result of filling incendiary compound into bamboo rods, which ignited and used against the enemy as "javelins," or "arrows" (fired from the bow) might well have been observed to propel themselves, due to the reactive effect of the burning mixture. Thus it is probable that, in further course of time, the "fire-arrows," as the incendiary rods were later termed, developed into the "rocket-arrows" (Fig. 2), to which reference is made in a Chinese document of the year 1220 A.D., describing their use against the Mongols during the battle of Pieping.

Roger Bacon

Roger Bacon, an English monk, in the year 1242, first made known the composition of true gunpowder: Saltpetre 41.2; charcoal 29.4; and sulphur 29.4. It should not be considered, however, that the ingredient proportions then given have remained unchanged until the present day. The modern gunpowder affords an interesting comparison in this respect, approximating to: Saltpetre 75.0; charcoal 15.0; and sulphur 10.0. As previously mentioned, compounds of similar character to gunpowder had been employed in the East from almost the dawn of recorded history, and in consequence, Bacon cannot be credited as the discoverer of gunpowder. However, he undoubtedly played a considerable part in its development, and greatly enhanced its power by careful attention to the ingredient proportions of the composition and also by the purification of saltpetre.

Further Developments

Credit for further early development is due to a certain German engineer, K. Kyeser von Eichstaedt, who concluded with success many rocket experiments, using varying proportionate gunpowder mixtures, in the year 1405. Some fifteen years later, an Italian, Joanes de Fontana, is held to have conducted similar tests, and is even reputed to have designed a rocket chariot.

In the middle 1400's, the rocket was employed somewhat extensively as a weapon of war, being used against the English in the defence of Orleans in 1429; during the siege of Pont-Andemer in 1499; against Bordeaux in 1452, and Gand in the year following. A technical paper, entitled "Treatise upon several kinds of War-Fireworks," published in France in the year 1561, describes the use of rockets in the previously mentioned campaigns, and suggests a rocket case of varnished leather, as an alternative to the paper and bamboo cases used up to that time. Towards the close of the century, the rocket projectile was employed against cavalry, and also for sky illumination purposes. A document by Hanselet, written in 1630, contains references to rockets bearing a form of grenade, apparently intended to produce a similar effect as the modern light shrapnel shell.

Operating No. 2 rocket hand-fired pistol. Range 250 yds.

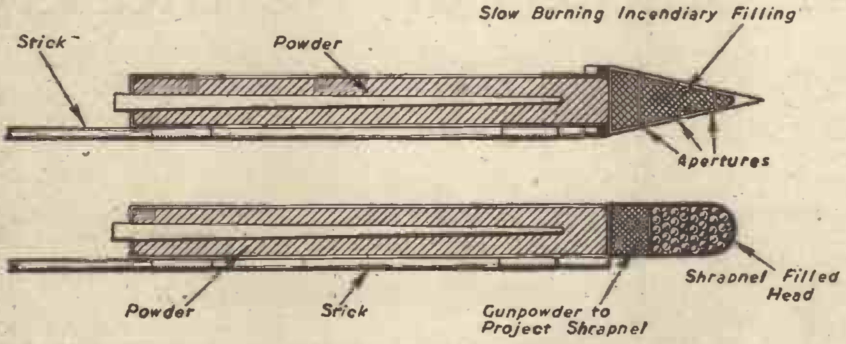


Fig. 3 (Above).—Congreve rocket (early 1800) and (below) a shrapnel anti-troops rocket.

Historical references exist which indicate a large scale use of rocket projectiles against Philippsburg in 1645, during the Thirty Years War, and accounts suggest that they played a substantial part in bringing about the eventual downfall of the city.

A treatise, published in 1650, "Great Art of Artillery," by C. Siemienowitz (Poland), contains a reference to a work of some 90 years earlier on the use of "fireworks" for military purposes, which is said to have given details of rockets up to 100lb., describing their construction.

Experiments carried out in Berlin in 1688 record rocket projectiles of gunpowder composition: Nine parts potassium nitrate (saltpetre); four parts sulphur; and three parts charcoal. The cases were of wood, linen covered for strength, the finished rockets being of 50lb. and 120lb. capable of carrying explosive charges of some 16lb.

It is significant to note, in passing, that as early as 1710, the use of rockets for "firing to the moon," was suggested by a Frenchman, Cyrano de Bergerac.

In the book "Asiatic Researches" (Vol. 3), published in the late 1700's there is given an account of the battle of Paniput (India),

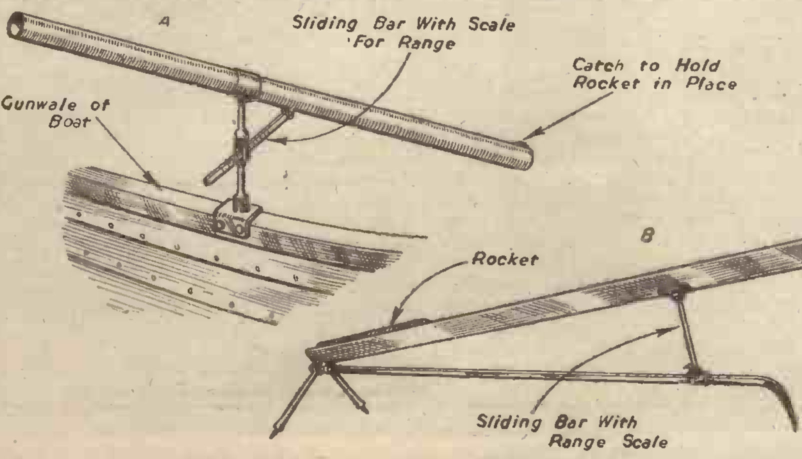


Fig. 4.—A rocket launching tube for use on boats, and (below) a launching trough for land use.

in 1761, in which the following paragraph is included: "As the Rohillas had a great number of rockets, they fired vollies of two thousand at a time, which not only terrified the horses by their dreadful noise, but did so much execution also, that the enemy (the mahrattas) could not advance to the charge."

According to accounts of the India campaigns, rockets were also used extensively against the British cavalry, towards the close of the eighteenth century. It is reported that the rockets employed were iron-cased, 8in. long and 1½in. in diameter, with a spiked nose, and balanced by a bamboo, or iron rod "stick" approximately 8ft. in length. The projectiles were hand thrown by specially trained "rocketeer" troops. Such was the effect of the Indian rocket weapon that militarists returning to England suggested the development of rocket artillery for the British Army.

English War-rockets

Experiments were commenced at the Royal Laboratory, Woolwich, in the early 1800's, by General Desaguliers. It was about the same time that Col. William Congreve, an artillery authority of some standing, first became interested in rocket artillery, and commenced a private investigation of composition proportions, and case efficiencies. As the result of subsequent experiments, Congreve obtained permission to use the laboratory at Woolwich, and there constructed several military rocket projectiles which when tested proved highly satisfactory, and realised practical application, with varying success during the European wars of the early nineteenth century. During the Napoleonic Wars, incendiary rockets, designed by Congreve, played a conspicuous part in the fall of Boulogne, in 1806, and also in the devastation of a portion of the French fleet, the projectiles being fired in salvoes from twenty-four specially constructed "projector" boats, which were conveyed to the scene of engagement by parent vessels. The rockets used, intended primarily for marine warfare, contained a liquid incendiary substance within a sharp-pointed nose, which on impact squeezed out a light through a number of radial holes drilled in the rocket head, liberally coating the target with fire. The pointed nose enabled the projectiles to stick to whatever they hit, and the devastation that such weapons were able to inflict on the all-wooden sailing vessels of that period, for instance, is easy to imagine. A year previous, Congreve had actually gone out with naval vessels, intending to witness his rockets in action against the French flotilla then anchored at Boulogne, only to be disappointed, weather conditions at the time of engagement being such to prohibit their use.

In 1807, rocket projectiles, once more, proved their worth, both on land and afloat, in the siege of Copenhagen, playing a considerable part in the city's downfall. The projectiles used were 32 pounders, capable of bearing explosive or incendiary charges ranging from 8 to 20lb. for a maximum distance of two miles, some 120,000 being used in the assault. Congreve is credited with the introduction of iron-cased rockets in 1808, although certain reports suggest their use earlier, possibly in the Boulogne attack two years previous. The rocket case was of iron sheet, gunpowder filled, the complete projectiles weighing up to 24 pounds, including a charge of either explosive or incendiary composition (Fig. 3). Launched from inclined iron tubes (Fig. 4), and guided by the conventional balancing "stick," tests proved that ranges of over two miles were easily attainable with rockets of the larger type.

In the year 1810, the first important technical paper on the subject of rockets was published, "On the Motion of Rockets," by W. Moore, London, which contained a mathematical investigation of rocket motion and trajectories.

(To be continued.)

Motor Chief on Roads to Be

OUR road engineers must have more vision, scope and encouragement to tackle the problem of traffic in an imaginative and logical way, Sir Miles Thomas, vice-chairman of the Nuffield Organisation, told the Engineering Industries Association in the course of a luncheon address, "Britain's Future Lies With Engineers," in Birmingham.

Nobody would imagine, he said, that it would be either safe or serviceable to carry gas and water through the same pipe. So with roads: it was illogical to make urgent, purposeful, high-powered vehicles fraternise with mercurial pedestrians and volatile cyclists on the same strips of roadway. Safety would only come through segregation; and only by that means would we get the real, time-saving advantages that the development of the automobile could provide, plus the degree of human safety in travel that we simply must attain.

Invasion Ships Off Normandy Coast

This photograph, taken as Allied invasion ships approached the coast of Normandy, shows a Rhino ferry, loaded with trucks and ambulances, leaving a tank landing craft for the beaches.