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PROPELLANTS

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There is little doubt that explosives had their origin in warfare. In the armed conflict between groups of individuals or of states, where each sought and still seeks to impose its will upon the other by force, it was inevitable that arms should grow and flourish. The sling, the bow and arrow, the sword and firearms typify evolution in warfare weapons. As a means of propelling missiles, the gun and gun powder were thought of. The history of explosives, therefore, may be said to begin with black powder.

From the voluminous and conflicting evidence before us, it is almost difficult to trace the black powder back to its origin. According to Halhead (1776) gunpowder has been known in India 'far beyond all periods of investigation'. The other claimants are the Chinese, Greeks, Arabs, English and the Germans.

With the great strides made by science from the fifties of the last century, progress in explosives also kept pace. The discovery of nitroglycerine in 1846 by Sobrero opened up new possibilities. This invention of nitroglycerine, however, remained undeveloped for a long time, excepting for minor use as a remedy for headache in diluted alcoholic solution under the name of glonoine.

It is to the genius of Alfred Nobel (1833-96) that we owe the genesis, and development of explosives based on nitroglycerine. From 1859 onwards, Alfred and his father Emmanuel Nobel busied themselves with experiments on N. G. Eventually in 1862 they erected at Heleneborg, near Stockholm, a small plant where nitroglycerine was manufactured in small quantities. In the two years following, Nobel's efforts were mainly directed towards the introduction of his explosive, called the 'blasting oil', into blasting practice. When these were beginning to look bright, the young manufacturer met with a severe reverse. In 1864 there was a terrific explosion at the plant, resulting in its complete destruction. Alfred's young brother Oscar Emil was killed in the explosion, while his father Emmanual Nobel was severely injured from which he never recovered, dying in 1872. The accident made a deep impression upon the public and consequently caused the Government to forbid the manufacture of nitroglycerine. But Alfred was undaunted, ... 'strong in will'.

Alfred Nobel rented a boat and anchored it at Malrsee and continued his experiments, removed from dwellings, till he was rewarded with the discovery of dynamite, although once again through an act of 'sependiarism'.

The sheet metal cans containing nitroglycerine were packed in Kieselgurh in order to protect them from shock and damage during transportation. When unpacking the cans, it was found that one of them had apparently lost a portion of its oil, and in this way Nobel discovered the absorbing capacity of Kieselgurh for N. G. The capilliary action of the minute diatomaceous particles of the kieselgurh converts nitroglycerine into a cheesy, plastic mass, which hardly shows any exudation and is much more insensitive to shock than free N. G.

However, neither the freezing of N. G., nor its absorption by kieselgurh made it entirely safe or efficient. It was soon discovered for instance, that N. G. in dynamite could be displaced by water and therefore dynamite would be of little use for demolition purposes in water or in wet holes. Improvement over dynamite had to be effected, if N. G. was to be used for blasting purposes. Nobel was revolving these problems in his mind, when chance again favoured him. It was a chance that only an active and alert mind could seize upon and utilise for the benefit of mankind. A small wound on Nobel was dressed with collodion. This gave him the idea of colloidising or gelatinising nitroglycerine with nitrocellulose. Thus arose blasting gelatine that was to be the premier demolition explosive of the world to-day. Its performance was efficient and perfect, as witnessed by the number of factories Nobel established in most countries on the Continent and in America for the manufacture of blasting gelatine. He thereby amassed a big fortune most of which he bequeathed, as we all know, to a trust for the establishment of five prizes, one of which is to be given to a person or society that renders greatest service to the cause of international brotherhood, in the supression or reduction of standing armies, or in the establishment or furtherance of peace Congress. We might pause here for a while, contemplating this great genius and his munificent contributions towards promotion of universal brotherhood.

No less fascinating than the history of nitroglycerine is the history of nitrocellulose which begins in the year 1833. When Bracannot first prepared nitrostarch under the name of xyloidine. In 1838, Pelouze found that xyloidine ignites at 180°C, and burns with a very considerable violence. Paper treated with nitric acid was found to have similar combustible properties and Pelouze believed that these properties might make such materials useful in artillery.

In 1845 Schonbein prepared for the first time Schiessbaumwalle *i.e.*, guncotton from absorbent cotton. There is an amusing story on the discovery of guncotton by Schonbein. It appears that Schonbein, like many other inventors, often used his wife's kitchen for his experiments. One day he was distilling nitric acid and sulphuric acid on the kitchen stove, when the flask broke. He grabbed the nearest thing, his wife's apron, which seemed none the worse for the treatment and hung it up to dry in front of the kitchen fire. Suddenly there was a puff and the apron went up in flames. Being a true Scientist, although perhaps a cowardly husband, he repeated the experiment and discovered that the treatment of cotton with a mixture of nitric and sulphuric acids resulted in a highly inflammable compound but possessing the same physical appearance of the original cotton.

Gunpowder, as already mentioned, was the propellant sine quo non till the rise of smokeless powder, when it completely went out of the field.

In considering development of modern propellants we have to refer to Nobel's work again. In extension of his experiments on blasting gelatine, *i.e.*, of gelatinising nitroglycerine with nitrocellulose, he increased the nitrocellulose content and thus succeeded in producing a fairly horn-like colloid which could no longer be detonated by a blasting cap, but proved to be a very suitable and powerful propellant on account of its slow combustion. After prolonged and intensive research, he fixed upon 40% nitroglycerine and 60% nitrocellulose (part of it guncotton) as the most suitable composition and called it ballistite (1888). This discovery was the most outstanding of the time in the sense that two of the most brisant and sensitive of the explosives in their free state, from being bad masters became good servants in the cause of mankind.

Almost simultaneously, Abel and Dewar discovered that nitroglycerine and guncotton could be better plasticised with the use of acetone. The dough, thus obtained, they caused to be pressed out into sticks or cords, known thereafter as cordite. The first of this series is cordite Mk. 1, introduced by the British Government.

In the South African War, it first came to notice that cordite Mk. 1 was highly eroding to the gun barrels, which was traced to the excessive heat produced by the large amount of nitroglycerine (58%) in the cordite. A modification, under the name cordite M. D., with added mineral jelly and nitroglycerine reduced to 30%, was found to overcome the defect and became so popular with the British Services that the largest industrial venture of the 1914-18 War in Great Britain was the (Propellant) factory at Gretna, its acid-producing capacity exceeding that of the whole country before the war.

To improve further upon cordite M.D. the War Office and the Admiralty, after the first Great War, initiated researches into producing a propellant that would be free from flash and smoke. These researches resulted in cordite which contains carbamite as stabiliser, in place of mineral jelly of the M. D. cordite. Cordite W is superior to cordite M. D. in stability. The Navy uses cordite S.C.,—no solvents are used in its manufacture. In recent times further improvements have been effected, and we have now a great variety of cordites such as, cordite, W.M., A, N, AN, L, NQ, etc., and are available in different sizes and shapes. In U.S.A., on the other hand, nitrocellulose powders in different forms, suitably stabilised, are the standard propellants. Thus N.C.T. is nitrocellulose tubular stabilized with diphenylamine, while the Dupont powder is nitrocellulose coated with dinitrotoluene and graphite. These powders do not contain nitroglycerine. The nitrocellulose powders are generally hygroscopic, causing variation in ballistics and are not so stable in storage as cordite ; they are rather bulky and burn more slowly and more uniformly than cordite and cause less erosion.