Sigvard Strandh

WILHELM TEODOR UNGE

A Swedish Pioneer in Rocketry

During the 1890's Wilhelm Unge (1845-1915) perfected the military rocket, and made many important contributions to modern rocket technology.

Introduction

In 1892, more than seventy years ago, a concern with the original if somewhat mystifying name, the Mars Co, was formed. The object of this firm was to develop, manufacture and utilize the inventions and designs of Captain Wilhelm Teodor Unge.

At first Unge concerned himself with problems relating to the techniques of artillery but in due course he devoted himself to one particular idea, the development of the ancient rocket principle and its practical application. He first became engaged in this in the 1880's and he spent the rest of his life in its pursuit.

Today Unge's life is almost a forgotten chapter and yet the contributions which he made undoubtedly merit him a special place among the originators of modern rocket technology.

Wilhelm Unge was born in Stockholm in 1845. He studied at the College of Technology (Teknologiska Institutet), the forerunner of the present Royal Institute of Technology (Kungl. Tekniska Högskolan), and graduated as a naval egineer in 1866. He subsequently decided upon an army career and joined the Uppland Regiment, in due course he was appointed to the Military College, after which he joined the General Staff. In this latter post he became increasingly interested in technical questions and it is hardly an exaggeration to claim that he acted more as a technical consultant than a regular officer on the General Staff. He made several inventions at this time, including an instrument for measuring distances, which he called the *Telemeter* and which was subsequently adopted as a standard instrument in the armies of all the Scandinavian countries.

It is difficult to say exactly when Unge first became taken with the rocket idea, but it was probably sometime around the beginning of the 1880's. Discussions were going on at this time concerning the fate of the antiquated military rocket, while the latest artillery innovation, the long-range rifle-barrelled gun, had just made its appearance. There was also much speculation over the possibility of further increasing the range of artillery pieces and these factors, coupled with the advent of new explosives, including Nobel's dynamite, were all fuel for the imagination.

Origins of rocketry

The type of rocket which is used today in its most elementary form for firework displays has existed as long as powder itself. Several inventors of powder—and rockets too—are named in the literature.

It is more likely that powder was discovered accidentally by an unknown 'inventor' cooking his food over the fire. Salpeter from the ingredients of his meal might have been mixed with coal in the ashes so that he observed how it sparkled and kindled the fire. Be that as it may, it is quite certain that the art of making powder was cherished in ancient China long before the Christian era. In the hands of able pyrotechnicians, powder was used to entertain emperors and princes with firework displays. Chinese Scrolls reveal that there were also rockets, which in the pictorial language of the era were described as 'Flying arrows of flame'. Neither were these used exclusively for princely celebrations. The flying fire could burn and destroy, and it was in just this capacity—as an aerial incendiary—that it was used in Chinese warfare. From China the rocket came in due course westwards by way of India, Persia and the Arabs to Europe. The term *Greek Fire*, describing powder during the Middle Ages, seems to indicate that powder entered Europe by way of Greece.

During the Middle Ages various military technicians were engaged in rocket projects. The Italian *de Fontana* produced plans in the fifteenth century for a rocket torpedo and a rocket-powered tank and several other inventors had much the same ideas. In practice they were all familiar with Newton's third law of motion on power and counterpower, action and reaction, and this same law is the basis of our missile and rocket engines today. Rockets were constructed and used during the Middle Ages, though there are no definite grounds for assuming that they actually experimented with rocket-powered vehicles at this time. On the other hand we do know that in the eighteenth century various individuals diverted themselves with physics disputations demonstrating rocket-powered models. Many of these were beautifully decorated with brass and fitted with glass receptacles which were drawn out at one end to form a propulsion nozzle. A spirit lamp was used to boil water in this receptacle, the nozzle was sealed by lacquer and when this melted a jet of steam was ejected and the small vehicle thrust forward. In other words both theoretically and experimentally at this time they were familiar with the principle of rocket power. There is an unconfirmed story furthermore that the Dutchman *s'Gravesande* built a steam jet vehicle of this type in the 1720's, though it is difficult for a modern technician to credit that such a jet contrivance can have functioned without ballbearings for the wheels and a smooth asphalt road for it to run on.

In the field of rockets there was probably a little more scope, although the powder available at the time was extremely ineffective.

The progress of chemistry in the eighteenth century brought about improved and more powerful powders and towards the turn of the century Sir William Congreve produced a much improved military rocket which in various versions was rapidly adopted by the armies of different countries. The English used the Congreve rocket during the siege of Copenhagen in 1807 and the *Star Spangled Banner* describes the rockets during the attack on Fort McHenry in 1812: ". . . rocket's red glare, the bombs bursting in air."

Berzelius introduced the Congreve rocket in Sweden

The Congreve rocket was introduced into Sweden under curious circumstances. The rocket was well known enough to the Swedish public after the British attack on Copenhagen and the newspapers were filled with frightening descriptions of the "secret weapon" and of how the incendiary rockets had razed a twelfth of Copenhagen to the ground with considerable loss of life and personal property, while the attacking ships had lain far out in the roads. On the other hand very little was known of the technical aspects of these rockets; of the chemical composition of the propellant and the incendiary of the warhead. This had yet to be revealed by the famous Swedish chemist, J. J. Berzelius.

The latter facts emerged in Sweden following a dramatic political event on the home front. In the summer of 1810 Crown Prince Karl August died suddenly during a military parade at Kvidinge near Lund in southern Sweden. The heir to the throne was something of a public symbol for a happier future after a prolonged period of war and political unrest. There was great dismay and consternation over Karl August's totally unexpected death and rumours soon began to circulate that he had been poisoned. In order to settle the matter for once and all Berzelius and M. af Pontin, the court physician, were dispatched to carry out a post mortem. The journey from Stockholm to Lund took four days and on their arrival they found that the Medical Faculty at the University had already performed a post mortem and established that the Crown Prince had died a natural death.

Berzelius now decided to take the opportunity to visit friends in Copenhagen; friends from whom he had been separated during the war years. He was particularly anxious to visit the physicist H. C. Örsted who at this time was engaged in a study of acoustics. Having

found Örsted, Berzelius in due course made contact through his host with various Danish officers and, of course, the conversation inevitably turned to the siege of Copenhagen and the Congreve rockets. The Danish military authorities had retrieved various types of rocket cases and Berzelius studied these with great interest. The warhead was made of cast iron with a sharp conical nose, while the phosphorous incendiary developed a tremendous concentration of heat. The suffocating smoke from the incendiary unit was likewise a predominant feature of the descriptions of the Congreve rockets. Berzelius took the materials with him to Stockholm where he was able to analyse the composition of both the propellant and the incendiary unit. He subsequently contacted the Swedish military authorities and in the spring of 1811 the Royal Academy of Military Sciences appointed a commission, the purpose of which was to arrange tests with Congreve incendiary rockets and examine their military scope. Several variants of such rockets were made and tested but as time passed nothing positive was achieved. Even though Berzelius and his colleagues succeeded in improving the performance of the rockets it seems, nevertheless, that the Royal Academy of War Science had great difficulty in convincing the military authorities in Sweden of the practicability of the new weapon.

The progress of Swedish rocketry was hastened, meanwhile, through the war in Europe. In 1812 Britain established a Field Rocket Corps which was used in the 1813 campaign against Napoleon, in which Sweden also participated. The Swedish rocket corps was attached to troops under the command of the Crown Prince, Karl Johan, and at home further experiments in improving the rockets were carried out by Berzelius and his colleagues.

The rocket was the weapon of the moment. In Sweden the rocket corps set up in 1832 became the Fireworks Corps in 1845 and used Congreve rockets for its exercises. Despite all the improvements which were made, however, these rockets really were little better than glorified fireworks even as late as the 1870's. The driving charge in its case, accompanied by some form of warhead, usually an incendiary, was attached to a stick or cane which was meant to stabilize it in its flight. But the accuracy was very poor. Attempts were made with wings, and even to make the rocket rotate, but no real stability was achieved, chiefly because of lack of speed on account of poor quality fuel. In fact it looked as if the rocket as a weapon was doomed.

The influence of Congreve's rockets on space thinking

Yet there is little doubt that the rockets of this period—the first decades of the nineteenth century—appealed greatly to the imagination of the general public. They were beginning to recognize already the opportunities that existed for reaching tremendous speeds with powder charges used as propellants.

Congreve's contribution to modern rocketry, both technically and in the fields of war application, have become somewhat obscured today, and yet he above all deserves to be called the "Grandfather of Space Technology." As has been indicated previously Congreve's rockets were to be used almost all over the world and this factor—so widely publicized through the medium of the press—was undoubtedly a tremendous source of inspiration to this realm of science. The rocket became a reality for inventors and technicians alike, and a vehicle for the imagination of poets and dreamers.

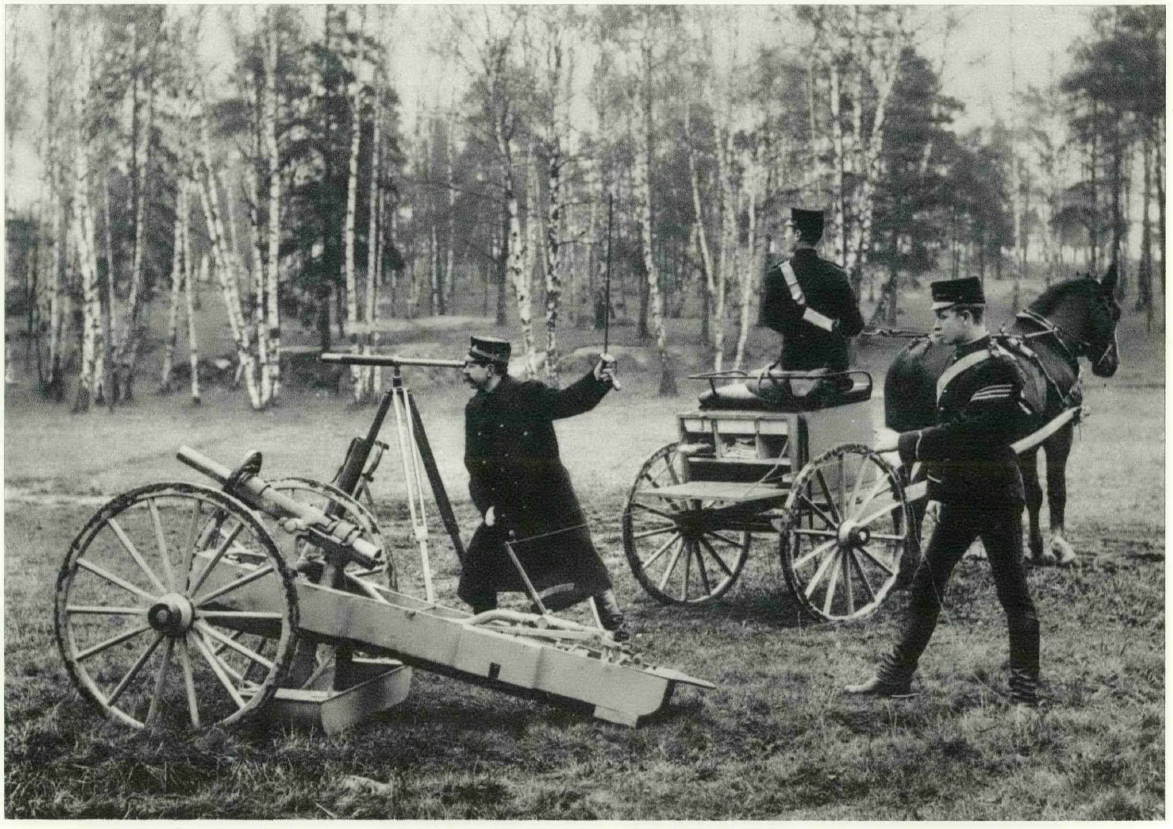
The technical possibility of being able to fly rapidly through the air, which had suddenly become a reality through the advent of Congreve's rockets, became consciously etched in the minds of the public. A typical manifestation of his was the fact that Stephenson named his steam locomotive the "Rocket." Before the famous race at Rainhill in 1829—when the Swedish-American inventor John Ericsson also competed with his "Novelty"—Stephenson had promised that his locomotive would be able to travel at twice the speed of a mail coach. Nevertheless the steam engine was still an extremely dangerous innovation in the eyes of the public and to claim such speeds was altogether too much for one newspaper correspondent, who wrote that the claim was "silly and ridiulous, it may just as well be safer to ride on a Congreve war rocket than to trust our lives to such a machine." Meanwhile Stephenson who obviously had an eye for the value of PR activities duly called his locomotive the "Rocket."

Congreve also more than likely gave science fiction its first rocket-powered take-off, and this was just about the time when the practicability of the military rocket was being questioned. We need only mention here Jules Verne's classic "From the Earth to the Moon," published in 1865. The same year Dumas published his highly imaginative essay on rocket travel while the French scientist Camille Flammarion wrote his famous "Les mondes imaginaires et les mondes reels" which included descriptions and speculations on the planets in our solar system.

New vistas were being opened towards the universe.



Wilhelm T. Unge.

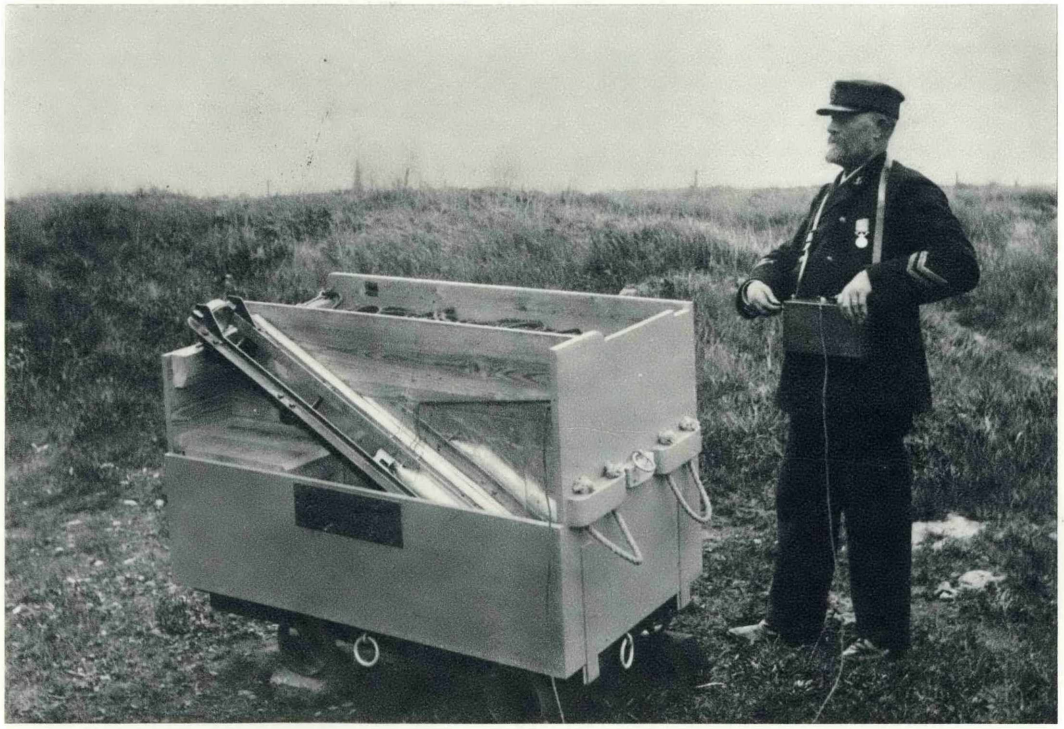


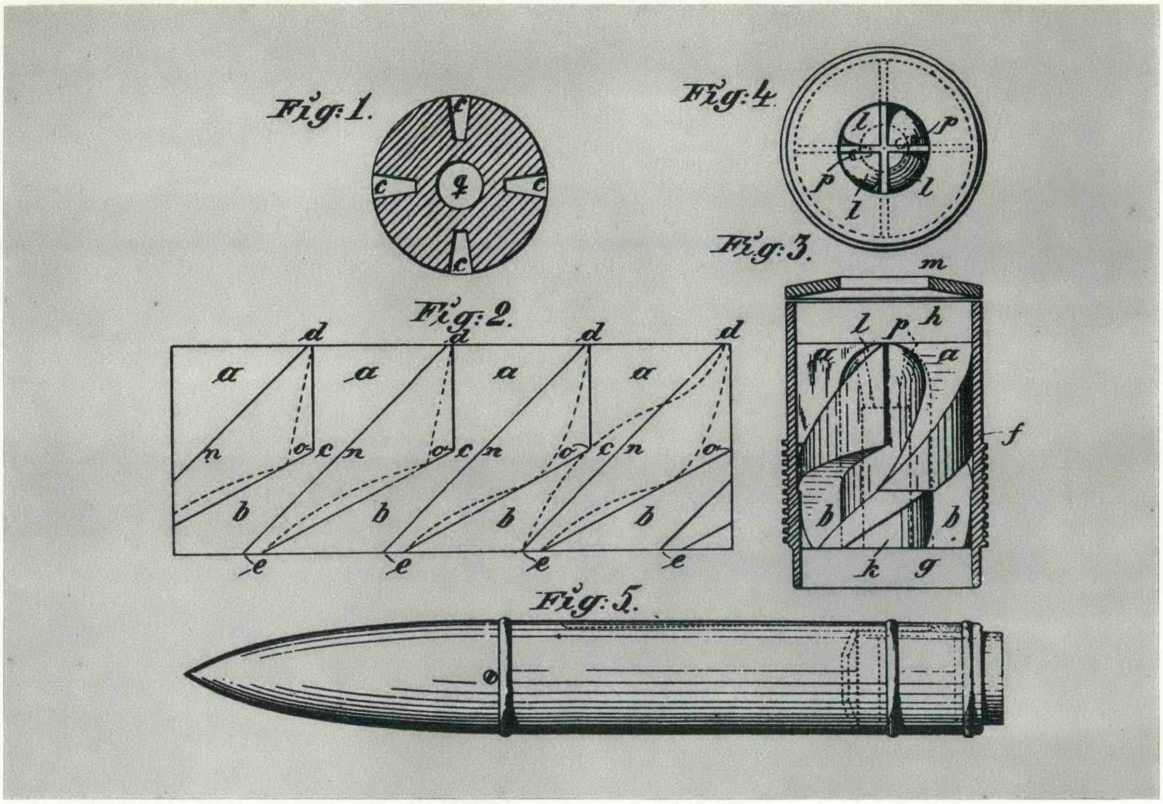
Test firing with Unge's pneumatically rotated rocket.



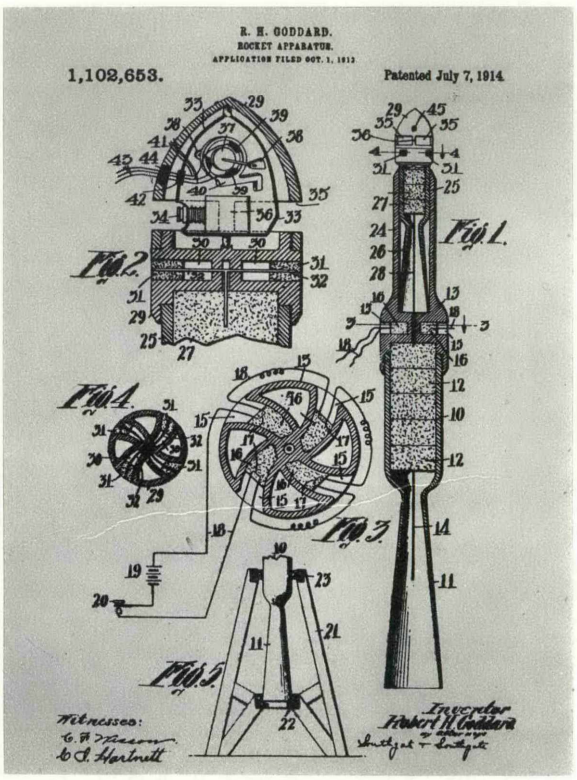
Experimental firing ramp for Unge's "flying torpedo."

Unge's life saving rocket.





Self-rotating rocket, patented in Sweden by Unge 1896.



Robert Goddard's self-rotating rocket, U.S. patent 1914.

W. T. Unge and Alfred Nobel

It was probably as a result of all this that Wilhelm Unge began to consider the idea of a rocket-powered artillery projectile. He had in mind a sort of shell for the new long-range rifled artillery piece. This shell would be fitted with a rocket that would take over at the moment when it reached its highest point of trajectory. In this way, he claimed, tremendous range could be achieved.

Unge succeeded in interesting Alfred Nobel in this project and with Nobel as the financier he designed a "rocket shell." In fact this invention was no more than simply a rocket contained in a shell case and fired off from a gun. The firing mechanism which would ignite the rocket at the most favourable point of trajectory was somewhat primitive meanwhile. Several trial shots were made with the "rocket shell" at Bofors—at least once in the presence of Nobel—but the results were very discouraging. This was undoubtedly the fault of the mechanical firing device and with the electrical aids available today the outcome would quite certainly have been otherwise.

Wanted: a new rocket propellant

Collaboration with Nobel, however, brought Unge into contact with the then current problem of explosive techniques. One of the principal tasks of explosives manufacturers and weapons designers at this time was to find a safe method of firing a shell, the warhead of which contained a high-explosive substance. Such shells were still very sensitive to jolts or shocks and many an unsuccessful attempt had been made to fire a projectile loaded with Nobel's dynamite or blasting gelatine from an ordinary gun. Here various types of propellants had been tried out but the sensitivity of the substance in the warhead still meant that the shell might easily explode while still in the gun barrel. Various complicated gun designs were proposed to neutralize this risk but they were still far from a definite solution to the problem. One method that was tried out was to use compressed air to project the shell and the US military authorities spent several million dollars on what they called "dynamite guns." Barrel explosions with this type of compressed air gun were very rare but generally speaking the effectiveness of the system was poor: the best results obtained gave a muzzle velocity of only 150 ft/sec and a maximum range of two miles, while accuracy was equally inadequate.

Alfred Nobel was extremely interested in these questions and there is no doubt that he must have discussed them with Wilhelm Unge in connection with their "rocket shell" experiments. It is equally likely that the entire problem, including the experiences of the Americans

with their "dynamite guns," served to increase Unge's conviction over the future of the rocket as such. In the matter of carrying a high-explosive warhead the rocket has a definite advantage over both conventional guns and those powered by compressed air: the initial movement is gentle and smooth instead of abrupt and jolting. The rocket slides away and is carried forward with a comparatively slow-burning powder charge which continues to accelerate it until it has burned out. A gun shell on the other hand, from the moment it leaves the muzzle, is exposed to both gravity and atmospheric resistance.

Unge was convinced that the advantages of the rocket were such that it could totally replace artillery as a weapon, and because of this he devoted all his efforts to ironing out the shortcomings of the weaon which had already been condemned out of hand by the military authorities. The first problem he tackled was producing a sufficiently powerful propellant in order to compete with long-range artillery, and here the resources of the Mars Co. combined with Nobel's experts were harnessed for the purpose of developing just such a propellant. A long series of experiments resulted in an improvement of Nobel's earlier invented ballistite and this propellant proved to be far superior to all previous ones. The Tekniska Museet in Stockholm has preserved the original rocket shell by which "ballistite" was first successfully fired, and according to Unge's notes the date was the 18th September 1893. The first shot was made from the heights near the Mars Co's workshops in Stockholm at Östermalmsgatan 67, later to become the site of the Engelbrekt Church. The hills and fields nearby were still open countryside in the 1890's, but were subsequently developed, and have now become a fashionable quarter of the capital known as "Lärkstaden."

The next problem to be solved: stability

The classical rocket was stabilized in flight by a stick or rod in the same manner as the firework rocket of today and the combat rockets of the rocket corps used the same principle. But the mechanical vibrations in the stick combined with the continuous shifting of the centre of gravity in the system rocket-stick resultated in an indeterminate trajectory. Furthermore, shortcomings in the powder charge; uneven packing, cracks, damp and so on, could lead to irregular burning of the charge and consequently an erratic course. The result was poor accuracy and the rocket was thus reduced to the status of a terror weapon.

It was not until the middle of the nineteenth century that a new

method was introduced for stabilizing rockets in flight. In 1846 an American, William Hale, attempted to apply the same principle for the rocket as for stabilizing a rifle bullet in flight, i.e. to set the rocket rotating. Hale contrived to set a rocket revolving on a longitudinal axis by putting diagonally set metal vanes in the exhaust nozzle. This was a great advance and the idea spread rapidly despite the persisting general opposition to rocket weapons at this time. In England Hale's rocket was improved upon and this system continued to be used until 1905.

It soon emerged, meanwhile, that Hale's rotating rocket still did not result in any notable improvement in accuracy and Wilhelm Unge claimed that this was simply because the rate of rotation was too low. The relationship between the axial traction power and the tangential components for rotation had to be such that the range was not seriously affected by the set of the vanes. He then developed a "torpedo gun" where the rocket began rotating before leaving the barrel and where subsequently the rate of rotation increased through an improved version of Hale's diagonal vanes. The gun was equipped with an outer barrel fixed to the carriage, with another, movable, barrel inside which could rotate on an axel attached to the rear end of the outer, fixed barrel. Several different versions of this "rotational gun" were patented by Unge (Swedish patent No. 5556, 1893) including one where the inner barrel was rotated with the aid of a "rocket turbine" of the same simple nature as the "Catherine Wheel" firework. This version was intended for use in the field. A spring-powered version was also tried out where the inner barrel was concent rically enclosed in a spiral spring which could be wound up by hand and was subsequently released at the moment of firing. For naval vessels and fortresses Unge had in mind a steam-powered rocket gun with a pulley attached to the inner barrel. He devoted a great deal of time and thought to finding a suitable source of power for his rocket gun; the internal combustion engine was still in an early stage of development and there were numerous manifest disadvantages to the steam engine.

Unge designed an interesting power mechanism specifically for test shots with the rotational gun, where he used a combination of compressed air and hydraulics. Water was pumped into a sealed container so that the air was compressed to a considerable pressure, a valve was now opened whereupon the resultant jet of water was directed

on to a water turbine wheel attached to the movable inner barrel. This pneumatic (or rather pneumatic-hydraulic) system gave extraordinarily good results both in terms of the rate of rotation and operating reliability. It was also equipped with an automatic firing device consisting of a centrifugal relay which switched on an electric firing circuit when the required rate of rotation had been achieved. Different versions of the rotational gun were patented in varous countries between 1893 and 1896.

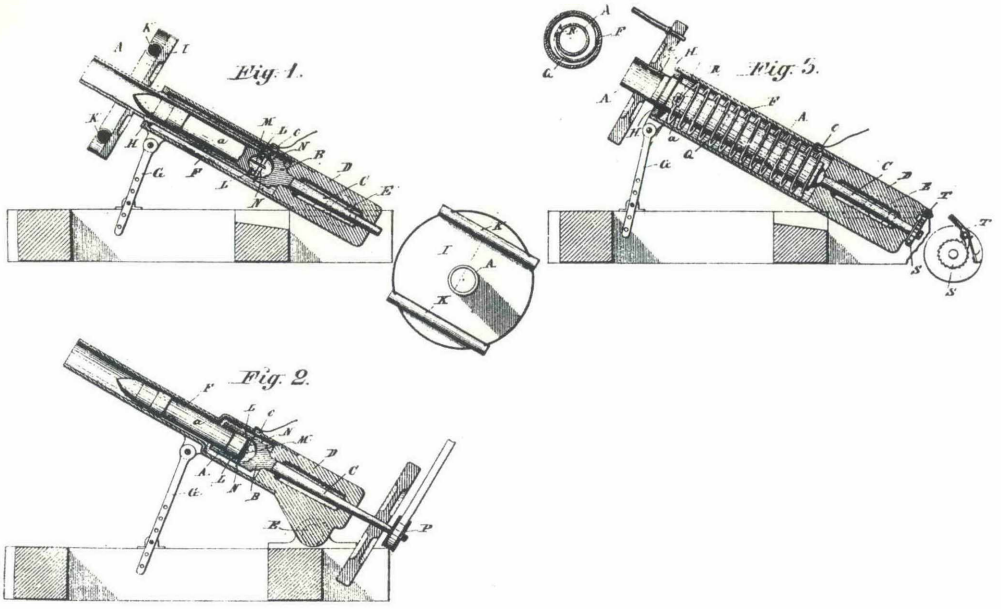
The rotational gun led to considerable improvements in trajectory stability, thus eliminating the worst obstacle, but it soon became obvious that there was much to do yet before Unge's rocket could hope to compete with conventional artillery in the matter of accuracy. Only the very highest rotation rates of the pneumatic-hydraulic rocket gun gave anything like acceptable results, and even so only on condition that the rocket propellant burned in the most favourable manner. The test shots were very discouraging and Unge was all but prepared to give up in the face of the apparantly irreconcilable problems.

Between times, however, he busied himself with designing a life-saving rocket and here he had a certain amount of success. Possibly influenced by this he embarked upon yet another desparate attempt to solve the elusive stability problem, this time by reverting to the steering stick principle of the ordinary firework rocket. He tried several versions of this but was finally forced to conclude that neither was this the answer.

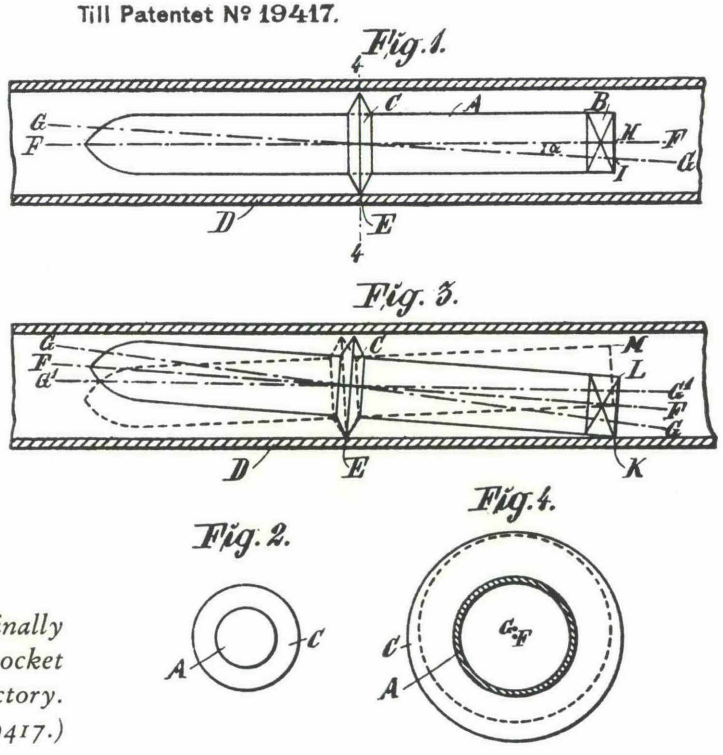
Unge was not to be outdone, however, and in due course he once again began to grapple with the question of stability, this time along two specific lines; first by seeking a new method for increasing the rate of rotation and second by endeavouring to establish in detail what change in symmetry and centres of gravity the rocket was subjected to in flight. He designed a new type of turbine which with the help of the exhaust gases gave a greatly increased rotational rate. This enabled him to drop the problem of rotation and concentrate instead upon giving the rocket's turbine free scope as soon as possible after the starting instant.

It is interesting to note at this point that the well-known inventor of the fast-running steam turbine, Gustav De Laval, joined the board of the Mars Co. at about the same time as Unge developed his idea for the improved rocket turbine.

Unge also experimented in facilitating the rocket's take-off, hasten-



Unge's rotational rocket gun. Fig. 1: "Catherine Wheel" model. Fig. 2: Steam engine powered (P-pulley). Fig. 3: Spring-powered model. (Swedish patent no. 5556.)



The balancing ring finally solved the problem of rocket stability in its trajectory. (Swedish patent no. 19417.)

ing at the same time the function of the rotation turbine by introducing a special initial charge which also fired the propellant. The barrel of the rocket gun was redesigned so as to give direct release to the exhaust gas of the rocket propellant through the turbine to accelerate the rotation as quickly as possible (Swedish patent no. 10036). The barrel could now be simplified into a number of cylindrically arranged guide rods, i.e. a rocket projector. Test shots with the new firing system gave encouraging results, though the rocket, or aerial torpedo as Unge called it, still had a tendency to make sudden rapid changes of direction while in trajectory. But Unge was prepared for this from previous shots and this time, furthermore, he was aware of the reason. The explanation for the rocket's apparently capricious deviations proved to be perfectly simple: in the barrel or the launching projector the rocket had to follow the geometrical central axis, but as soon as it left this compulsory guidance it began to rotate around its own central line through its centre of gravity. These two central axes seldom coincided and the change-over could result in abrupt swings which were exaggerated the greater the rotational rate was, and also on account of lack of symmetry in the rocket's mass, for example the nature of the propellant charge or imperfections in the rocket case. Unge now found a method to co-ordinate the two rotational axes while the rocket was still accelerating in the projector. He fitted a balancing ring around the rocket through the plane of equilibrium. This ring was able to rotate freely around the rocket case. It was made of a relatively soft material, copper or brass, and the wedge-shaped profile of the ring was worn down during take-off so that the loss of mass caused the geometrical rotation axis to coincide completely with the rocket's centre of gravity by the time it left the projector.

Final success of the aerial torpedo

An extremely difficult problem had now been solved, simply and brilliantly. The balancing ring combined with the rapidly rotating exhaust turbine represents the true emergence of Unge's aerial torpedo. In the test shots it was found that the precision of the rocket was excellent and Unge was now ready to proceed with his long-cherished plan to produce an accurate long-range aerial torpedo.

During 1904 and 1905 he held the patent on the balance ring in most west European countries and also in the USA, and now that he had achieved the desired degree of accuracy, the Mars Co. proceeded with series production of the new aerial torpedo.

After over 10 years of feverish work Wilhelm Unge had finally arrived at a technically satisfactory solution; his aerial torpedo was completed. Unge's dodged determination and technical brilliance had enabled him to overcome every obstacle and his dream of transforming the ancient rocket into a modern weapon had been realized. In a lecture on his invention he proudly and quite justifiably pointed out that in terms of accuracy his aerial torpedo and the nineteenth century rocket weapons bore the same relationship to each other as a modern artillery piece and the ancient assault catapult.

The Mars Co's "rocket range" outside the workshop was no longer adequate and the test shots with the new aerail torpedo were transferred to the Marma artillery range, some fifty miles north of Stockholm. Through successive improvements of his propellants Unge now achieved a range of over five miles and with a degree of accuracy that was every bit as good as the conventional artillery then in existence. According to the carefully kept reports from these test shots Unge seems to have gone to great trouble to study and analyse the rocket's trajectories. At this time, however, the instruments and measuring methods were extremely poor and the conclusions he was able to reach from changes and variations in the design of the rocket were only of a very general nature. One of the principal difficulties was establishing the exact point of impact at the end of such longdistance shots. Despite the delight and enthusiasm which is manifest in his notes after he had solved the major problems, he did not attempt to increase the already remarkable ranges that he had achieved and one cannot help thinking what tremendous advantages he would have derived had he had at his disposal the radio communication aids for longe-range observations of rocket trajectories which we possess today.

The aerial torpedo in series production

At the same time as the experimental shots were going on at the Marma range, series production of the aerial torpedo was begun at the Mars factory. Unge was extremely anxious to utilize the results of the experiments through practical improvements in the design of his torpedo and while he was engaged in this, negotiations were also begun with interested and prospective buyers. Unge himself was the mainspring of the concern and as such he had to handle all these various matters. In present day terminology he was managing director, research chief, head designer and sales manager, and despite the fact that he undoubtedly hade very little time over for publicizing

his invention, interested parties soon began to approach him, principally from the central European countries. News of the revolutionary qualities and performance of the aerial torpedo had spread rapidly. Highly encouraged by this Unge now did his best to interest the Swedish military authorities in his invention but they were completely indifferent to it and neither did it help when the Swedish Inventors' Association submitted an indignant protest to the National Defence Department over its lack of initiative, this was signed among others by Gustav Dalén and Alrik Hult.*

Three calibres, 10 cms, 20 cms, and 30 cms, were standardized in the manufacture of the flying torpedo. They were assembled and furnished with warheads by Mars while the different components, excepting the balancing ring and certain minor details, were made by other, larger factories.

The following table shows the details of the standard models:

				Projector:	
Calibre	*Length*	*Warhead*	*Total weight*	*length*	*weight*
10 cms	0.9 m	2 kg	17 kg	2.5 m	64 kg
20 cms	1.55 m	12 kg	134 kg	3.7 m	235 kg
30 cms	2.45 m	40 kg	420 kg	7.0 m	710 kg

Unge and his colleagues went to great pains to make the "ballistite" propellant into an effective and above all storable product. After Nobel's death Unge got into contact with the Skånska Bomullskrutfabriks AB Concern in Landskrona and embarked upon a period of extremely productive collaboration with their gunpowder factory in Annelöv. The main problem was to find a method of preventing the propellant from shrinking and to bring about the most regular possible combustion. Unge's notebooks, several of which are extant, are filled with computations, sketches for propellant presses, reports on tests and analyses of formulae for binding agents. If the propellant charge shrinks during drying it cracks, no matter how closely packed it is, and the combustion area increases abruptly in the cracks. This results in accelerative effects in flight or even a full-scale explo-

* The President of the Swedish Investors' Association in the early 1890's was the famous balloonist S.A. Andrée. Gustav Dalén later became famous for his inventions of automatic navigation beacons and was awarded the Nobel Physics Prize in 1912. Alrik Hult, a prolific Swedish investor, was well-known for his Archimedes out-board engine and many other inventions.

sion. Unge felt that the ideal situation would be for the propellant charge actually to swell somewhat after it had been installed in the rocket. Finally he discovered an organic substance which, when mixed into the charge, gave it the correct properties. This meant that the aerial torpedoes could be stored for years in the open air without harm to the propellant. The composition of this final propellant was kept a secret for some years.

The difficulties involved in getting a solid propellant rocket motor to burn evenly and steadily without sudden accelerative thrusts or explosions has engaged the attention of many rocket designers since then. It is reputed, for example, that the manufacturer of the rockets for *Fritz von Opel's* famous experiments in Germany with rocket-propelled vehicles (1928-1929) encountered the same type of problems. The designer of von Opel's rockets, F. W. Sander, who had also worked with signal and rescue rockets some thirty years later came to the same conclusion as Unge, i.e. that the propellant charge must be packed very hard and mixed with a binding agent which prevents it from drying out and splitting.

Unge was also extremely interested in the practical aspects of his aerial torpedo. For several years around the turn of the century he was engrossed in computations and speculations on the actual application of the weapon. He continued to modify the simple projector and various easily managed versions were tried out.

A versatile weapon

At about this time airships and, not much later, motor-powered aircraft began to emerge and Unge soon realized that these machines would have great scope in warfare. He considered that the aerial torpedo was well suited as an anti-aircraft weapon and in order to give his rockets the maximum possible mobility he decided to mount the projector on motor vehicles; another innovation of the age. He was of the opinion that the most suitable calibre for AA purposes would be 10 cm. and less. He also went into the practicability of the aerial torpedo as an aerial warfare weapon, i.e. between one airship and another, pointing out the superiority of the rocket insomuch that it was almost entirely recoilless. Nevertheless as we well know it was not until the later stages of the last war that rockets were used for AA purposes.

Unge likewise worked out full-scale plans for torpedo boats with aerial torpedoes, to be used for attacking other naval units, "armour piercing" and for attacks against isolated inland targets. Unge argued

that on account of the minimal weight of the projectors the fire power of such vessels would be much greater than that of corresponding ships armed with conventional naval guns.

For field purposes Unge designed various types of projectors mounted on carriages. For the smaller calibre rockets these shooting devices were easy to transport, simple to aim and accurate. The now thoroughly tested aerial torpedo was demonstrated on various occasions before foreign military delegations at the Marma range and at this time Mars were delivering their torpedoes to many countries.

Krupp interested

After all the setbacks, business seemed to be flourishing at last; flourishing so well, in fact, that the arms magnate Friedrich Krupp of Essen, Germany, began to show an interest in Wilhelm Unge's aerial torpedoes. After extensive negotiations in 1908 the Krupp concern purchased Unge's patents and remaining stock of torpedoes and equipment. Test shots were made at Krupp's testing ground in Meppen after certain modifications to the projector and it is probable that experiments continued with Unge's torpedoes during the subsequent years, although Krupp never began actual production of them. There might be a simple explanation for this. The gun business developed splendidly as the first world war approached and there seemed no point in interfering with either the production programme or the existing market of Krupp's established products.

Wilhelm Unge and his associates in the Mars Co. persistently attempted to get a clear idea of Krupp's plans, but without success. Mars were presumably principally interested in settling their financial business with Krupp since only a preliminary payment had been made on the agreed purchasing sum since Krupp had taken over the patent rights. In 1910 Krupp admitted that his concern had ceased experimenting with Unge's aerial torpedo, the excuse being that the desired accuracy could not be attained with the weapon. Naturally enough Unge was hardly inclined to believe this and his scepticism was further strengthened when it emerged that only a few months previously Krupp had taken out a number of German patents for modifications on Unge's designs. Unge became increasingly convinced that the Krupp concern had purchased the Mars patents principally in order to neutralize a potential technical competitor to the conventional field artillery piece. Such a move was hardly unusual in big business policy manoevres, but it must have been a bitter pill for Wilhelm Unge to see his life's work absorbed and effaced in this way.

There is every indication, nevertheless, that Krupp's technicians continued to work upon Unge's basic ideas long after the project had been officially dispensed with. It is probable that these experiments ceased during the first world war, but were resumed again later. During the 1920's the leading ballistic specialist at Krupp's, Professor Otto von Eberhard, indicated in his notes that they continued to experiment with stability and trajectory problems and that Unge's ideas were still applied. Furthermore one can well imagine that there must have been close co-operation between the Krupp rocket engineers and those groups of rocket enthusiasts wich emerged in Germany towards the close of the 1920's. One indication of this is perhaps that the early rockets tested at the *Raketenflugplatz* in Berlin were powered by ballistite, the smokeless, "double-base" propellant introduced by Wilhelm Unge and Alfred Nobel in the early 1890's.

It is quite possible that Wilhelm Unge's pioneering achievements in rocketry here have gone—if not directly, then by devious routes—via the *Raketenflugplatz* group and Peenemunde to Cape Kennedy in Florida, USA.

Wilhelm Unge, early pioneer in rocket technology

Wilhelm Unge was far ahead of his time in many respects. He was possessed with a great idea at an early stage; an idea which was to dominate his entire life and activities—to perfect the rocket of antiquity. Thanks to his brilliant, technical knowledge and his tenacious determination to overcome every conceivable obstacle he succeeded admirably in solving his problems and achieving his end. It was only his unfortunate efforts to collaborate with Krupp which resulted in his pioneering contributions being forgotten by posterity.

Unge died in Stockholm in 1915 and the Mars concern was subsequently dissolved, despite the efforts of various of the board members to continue his work.

Unfortunately, apart from his many patent documents, Unge published but little. We know nothing, for example, of his opinions on the civil use of rockets, beyond the fact that this dreams touched upon the realms of science fiction. The Mars Co. undoubtedly derived its name from the God of War, but one can well imagine that Unge had space and the planets in mind, even though his technical realism deterred him from speculating publically on such matters. But from what we do know of him there is no doubt whatsoever that he was in the same category as those scientists and designers who are commonly regarded as the pioneers of modern rocket technology. Unge was

more or less contemporary with the Russian Konstantin Ziolkovsky and more than 20 years before the American Robert Goddard.

Such a complex and diversified field as modern rocket technology can hardly be referred back or attributed to one particular individual and just as Ziolkovsky and Goddard both made their own specific contributions, so did Wilhelm Unge through his early pioneering work.

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