ASTRONAUTICS

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THE WHY OF LIQUID PROPELLANTS FOR ROCKETS

by Willy Ley

Vice-President German Interplanetary Society

Engineers and so-called specialists often ask me: "Why do you insist on using only liquid fuels for your rockets? They are not as well-known as powder for this purpose. Why not develop rockets to a higher state with powder and then later replace the powder with liquids if needed?"

We (I mean now all of the men at the Raketenflugplatz) only use liquids because we really want to advance rocketry.

It is true that when people hear that our rocket with liquid propellants reaches an altitude of only 3000 feet, and *that* after years and years of scientific calculation, after hundreds and hundreds of tests on the proving stand, and more than a hundred rockets since the founding of the Raketenflugplatz and when people hear that the large factories making pyrotechnics can construct sky-rockets fueled with powder to reach heights of 6000 feet—they don't believe that liquid propellants have a future.

Even scientists cannot understand it, and believe that the first development of rockets can be made with powder as well as liquids. One successful rocket constructor — Reinhold Tiling — is working on powdered fuels, but has told us personally: "When I have finished a good rocket construction and have properly working wings for my rocket I will come to you and use your liquid fuels and your rocket motors."

In order to dispel in rocket concious countries the misunderstanding about the difference between liquid and powdered fuels I will give my reasons for the use of liquids, despite the fact that the excessively cold liquid oxygen, which has hardly even been used before for our purpose, gives so much trouble.

The technical reasons for not using powdered fuels are simple. Powder has an uncontrollable tendency to explode. As Professor Oberth said humorously: "It believes it must explode all at once. From constant use in shells and guns, powdered fuels are only too well-trained to destroy."

Even some of the rockets of Tiling, and he seems to be the best constructor of powdered rockets, exploded completely at the moment of shooting them.

Scientists suggested that it might be possible to separate the combustion chamber from the fuel tanks. In all powdered rocket, it must be said for the benefit of laymen, the combustion chamber and the fuel compartment are one. The powder under pressure lines the surface of the combustion chamber and simply burns away. The suggestion of scientists was that the powder might be brought into the combustion chamber in little cartridges by means of an apparatus like the machine gun.

But such an apparatus would be very heavy and has never been tried out. And besides, who would like to travel on top of a ship filled with powder?

The scientific reasons for preferring liquids to powders are not so simple as the technical ones. Science is always a complicated matter..........for the others. I cannot, therefore, continue the discussion without a few mathematical terms and little formulas, which I will explain.

Everyone will believe me and understand when I say that the altitude a rocket will reach will depend on its velocity. But what determines the velocity? I will start with the first formula.

v (velocity of rocket)=c log (nat) m/ml

c means the velocity of the exhausted gases, *m* is the weight of rocket before burning, ml is the weight after burning. *Log (nat)* means natural logarithm. The formula shows that v increases when c increases. Also that v also increases if m/ml increases. But the increases of v with an increase of m/ml is not a full increase, for it increases only with the logarithm of m/ml. This indicates that the greater influence on the ultimate velocity of the rocket is determined by c. If I make c larger then v will become larger in the same proportion.

If we ask chemists they will tell us that the velocity of exhaust—c—of liquid fuels is much greater than that of powdered fuels. I offer the following list of velocities of exhaust

860	meters/sec	for usual rocket powders
1700	" "	gasoline plus liquid oxygen
2100	" "	best smokeless powder
2200	" "	alcohol plus liquid oxygen
2200	" "	certain kinds of gasoline plus liquid oxygen
4850	" "	hydrogen plus liquid oxygen

At the Raketenflugplatz we burn gasoline and similar liquids with liquid oxygen. Our standard type of reaction motors give a reactive power (called P) of nearly 30 kilograms. The weight of the tested motor including cooling water itself, is about 2 kilos, the gross power is 32 kilos.

The formula for c is

c=P x dm/dt.

dm/dt for one second is the weight of exhausted gases. Of course we don't weigh these gases, but the material before burning. So we know that in a standard motor (of the Series II and III) we have

dm/dt=0.160 kilograms

therefore c=2000 meters/sec

What I have given is the result of two years' work. We consider what we have accomplished of the most importance, greater than reaching an altitude of say 20 miles. Of course if anyone would pay the expenses for such a shot we would be able to do it next week. But for our own purposes we have no need to attempt it because we make our experiments for scientific purposes and not for records.

We are now starting a new series of experiments with other liquids, first with alcohol. We have two reasons for it—we wish to obtain a bigger velocity of exhaust—c—and secondly we wish to solve the problem the cooling of the motor. Little motors can be cooled well enough from the outside; larger motors need other devices. There are different ways to do it, we don't know the best at the moment, but we hope to find it soon.

NEWS OF THE SOCIETY

ROCKET FLYING FIELD DISCOVERED

After considerable search for a field in the environs of New York in which to shoot the experimental rocket constructed by the Society, a place has tentatively been found in the neighborhood of Stockton, N. J. A firing stand will be located on the field and several weeks will be devoted to testing the rocket before it is finally sent aloft. If the tests are successful the rocket will be shot about October 10.

SCHACHNER ASCENDS TO SOCIETY'S PRESIDENCY

Following the resignation of G. Edward Pendray as president of the American Interplanetary Society, Nathan Schachner, formerly vice-president became the society's head. Laurence Manning, first treasurer of the Society was elected vice-president at a recent meeting of the Board of Directors.

Mr. Pendray stated in his resignation that he wished to devote his time exclusively to rocket experimentation rather than to administrative duties. He will carry on as chairman of the Experimental Committee and will actively pursue research on types and designs of rockets.

INFORMAL MEETING TO OPEN 1932-1933 SEASON

The 1932-1933 season of meetings of the Society will be opened by an informal gathering of Society members at the Museum of Natural History in New York on Friday, September 30. After a trial of an informal meeting at the end of the 1931-1932 season, during which open forum for members on rocket problems was maintained, it was decided to make it an occasional interruption of the formal lecture. Meetings will be held monthly hereafter during the coming season.

MEMBERSHIP DUES REDUCED

At a recent meeting of the Board of Directors it was decided to reduce active membership dues and at the same time adjust the dues between active members who lived without the environs of New York. For active members within a radius of 100 miles of New York, membership will be $7.50 yearly instead of $10.00 as heretofore. The fee for active members outside the 100 mile radius will be $5.00 instead of $10.00. Associate membership dues will remain at $3.00.

NEWS OF THE MONTH

PILOTS CAN FLY TEN MILES HIGH WITHOUT DEATH DANGER

Airplane pilots could rise to altitudes of fifty thousand feet, nearly ten miles, without danger of death from the rigorous experience if the nitrogen gas in their bodies is expelled before they leave earth, by breathing oxygen for one hour before the ascent.

Sir Leonard Hill, the eminent British physiologist, will so conclude in a communication to the British scientific journal, *Nature,* as the result of experiments on animals under low pressure conditions.

Previous experiments in France had led to the conclusion that about 45,000 feet was the limit of altitude that can be reached by man with safety, even when oxygen-equipped, unless his whole body is enclosed in a pressure chamber that shields him from the effects of the great height. Death from high altitude might sometimes come the day after the experience, experiments on animals showed.

JAPANESE ASTRONOMERS DENY FINDING NEW "SUN GAS"

Although the Japanese expedition observed the eclipse with practically complete success, members of the party packing apparatus here denied that any new gas in the sun, as widely reported, had been discovered as a result of their photographs. Prof. M. Notsuki and O. Oikawa stated that their negatives were not developed until August 31 and that weeks and months must elapse before they can be interpreted. No announcements are to be expected until the party of three astronomers return to Japan.

Prof. K. Hirayama of Imperial Tokyo University has left for Harvard University to attend sessions of International Astronomical Union. The Japanese astronomers deny giving any newspaper interviews after the eclipse except to report that clear skies, denied other parties, favored their observations.

PICCARD'S FLIGHT DISPELS COSMIC RAY DANGER

Of indirect interest to rocketry is the recent stratosphere flight of Professor Piccard, who rose recently in an airtight aluminum globe attached to a balloon some ten miles or more, exceeding by several hundred feet the height reached by him in his similar flight of last year. It will probably be several months before the data obtained is in available form, but among the interesting points were the uniform temperature obtaining in the stratosphere and the fact that radio messages were sent by him and clearly received on earth. Among the things to be looked forward to with great interest will be fresh light on the density of cosmic rays. One newspaper account quoted Prof. Piccard as remarking that his instruments recorded the impingement of cosmic rays at the ten mile height "like rain on a tin roof". Incidentally, the necessarily primitive artificial atmosphere in the metal sphere worked to perfection for the few hours of flight.

ASTRONOMERS NOTE PLANETARY HEAT INTENSITY

One of the most interesting revelations of the last meeting of the International Astronomical Union came at the meeting of the commission on stellar spectroscopy. Reports by Miss Cecilia H. Payne, of Harvard University, and Dr. C. S. Beals, of the astro-physical observatory at Victoria, Canada, revealed temperatures as high as

75,000 degrees centigrade being located on some of the nearer planets. Miss Annie Jump Cannon, curator of astro-photography at Harvard, assisted Miss Payne in this work.

Dr. Henry Norris Russell, of Princeton University, who presided at this commission, explained that in the extremely hot atmosphere of these planets there were atoms of carbon, oxygen and nitrogen from which all but two electrons have been knocked off. The high temperature was only partially responsible for this condition.

Other meetings discussed astronomical telegrams, wave lengths, longitudinal determinations by means of wireless, the nebulae, stellar spectra, the solar parallax, observations of the small planet Eros (important in determining the distance of the sun) and solar physics.

(Editor's Note: Perhaps the astronomers referred to the temperatures of suns and not planets, as reported.)

WINKLER PLANS NEW ROCKET SHOT

From Berlin comes a vivid account of the preparations for shooting Herr Johann Winkler's liquid-fuel rocket in the near future, on a lonely island, off the German coast.

Herr Winkler's rocket is of the liquid fuel type —using methane and liquid oxygen. He hopes to better by three thousand meters the present record for this class of rocket which is now about 4000 meters. Such a feat would be of the utmost value to rocketry. The experiment has to do with fuels and shell design. The fuel problem is based upon a calculation that one pound of mail from Berlin to New York could be flown under the power of fifty pounds of liquid fuel. This compares very favorably with solid fuels, which for the same work would require about 25,000 pounds of powder, according to Herr Winkler.

The body of the rocket is about seven feet in length and is torpedo shaped. The metal of which it is constructed is an alloy containing aluminum. The net weight of the structure is ten kilograms. The speed is planned to be less than 330 meters per second, but later on Herr Winkler plans another rocket with much higher speed and for that he will experiment with altogether different shapes —one under consideration is a shell tapering to its broadest at the rear. The present rocket will carry some instruments and a parachute will open automatically at the highest point of the flight and lower the empty shell slowly to the water.

There have been no controls provided, and no attempt will be made to aim the rocket. The question of control, in the opinion of Herr Winkler, is a specialized one requiring a series of further experiments to be carried out later.

PACIFIC OCEAN NOT BIG ENOUGH TO FURNISH MATERIAL FOR MOON

The moon didn't come out of the Pacific Ocean basin.

So says D. Artur Neuberg, of Meissen, Germany, in flat contradiction to a widely held theory, that pictures the earth as "carving" the moon out of the Pacific Ocean basin in some remote geological period.

Choosing one of three proposed methods for calculating the total volume of the Pacific Ocean basin, Herr Neuberg arrives at an estimate of approximately 700 million cubic kilometers (167 million cubic miles). But the moon, with a diameter of 3,480 kilometers, has a volume of approximately 22 billion cubic kilometers (5 billion, 240 million cubic miles). The Pacific Ocean basin is therefore about 31 times too small to supply all the material needed to make the moon.

Even if the Pacific, Atlantic and Indian oceans, together with all smaller seas, were scooped out to make the moon, they would not yield nearly enough material. According to Herr Neuberg's calculations, their collective volume is roughly one and one-third billions of cubic kilometers (319,-200,000 cubic miles), or only one-sixteenth that of the moon.

Herr Neuberg sticks to the theory held by another school of geologists, that the earth and the moon were shot off together from the sun as a single egg-shaped mass, which subsequently separated into a larger body, the earth, and a smaller, the moon. He recognizes, however, certain unsolved problems, notably the one presented by the widely different rates of rotation of the earth and its satellite.

ON ROCKETS AND THEIR HISTORY

by Willy Ley

It is often said, and written and printed too that the rocket was invented in China 3000 B. C. I spent three years in studying the history of the rocket and I am sure that the date must be a mistake. I don't know how many years it is in error and who was responsible for it. The oldest date I could find was a Chinese chronicle from the year 1220. It was translated 80 years ago by a French scientist Stanisłas Julien, and referred to the battle of Pien—of the Emperor against the Mongols.

In this battle the first rockets were used (and used in warfare) and it is evident for some reason that the invention of the rocket is based on the old fire arrow.

It seems that Greek philosophers had in olden times the idea that any burning materials would produce a very hot flame if mixed with salt. It is not true that salt produces a hot flame, it produces only a shining yellow flame. But in those days modern theories of heat were unknown and no one could contradict the assertions of the philosophers. The idea must have travelled to the Far East and Chinese pyrotechnicians tried to make use of it.

But they not only used salt (ordinary NaC1), but also saltpeter, common in their country. So they discovered the first powderlike mixtures. It is interesting that not only the old Chinese fire arrows are constructed like the usual arrow (with fins of feathers) but even the Chinese sky-rockets of today have always these feathers, like a rudimentary organ.

From China the new invention came over India to Arabia. It is commonly known that Arabian science was at its highest point in those days. It is a matter of fact, too that the Arabians learned the use and construction of rockets from the Chinese and not the Chinese from the Arabians. The saltpeter in Arabian books is called "snow of China". There are also other materials whose names are ornamented with the words "of China".

At this time was the first use of powder in Europe. The name of its inventor is not known. Perhaps it was Roger Bacon, perhaps the German Friar Bertholdus Niger. But in the books of Roger Bacon and Albertus Magnus we find the first mention of rockets in Europe.

There exists also a very interesting book by an unknown author called "Liber Ignium." The author is called Marcus Graecus (or Marxus with a Greek X). But none knows who this man was, where he lived or when the book was written.

In Europe as in China the first rockets were used in warfare. The German war engineer Konrad Kyeser von Eichstadt (1405) describes it after Arabian works and the Italian engineer Joanes de Fontana (1420) does the same. De Fontana not only used rockets as they were, but he constructed artificial birds, torpedoes and even an automobile propelled by powder rockets. It is not certain that his rocket-car was really constructed but he planned it.

In the year 1721 the second rocket car was invented by the Holland professor, Jacob Wellem s'Gravesande. Some years ago the great Isaac Newton founded the mathematical laws of reaction. S'Gravesande was his pupil and in his book "*Physica elementa mathematica*" he gave demonstrations of the laws of Newton and planned a rocket car built to a fair size to carry men and goods. There even exists an old drawing of such a car. But in his book one cannot find anything about big cars.

The prototype of s'Gravesande's horseless carriage was another apparatus well-known to everybody from lessons in physics: the Areolipile of Heron of Alexandria—a turning cross propelled by steam. Many years after s'Gravesande French engineers tried to construct a flyer (a so-called helicopter) based on the principle. Models were built and made good flights but a large apparatus was only a dream. In the meantime the powder-rockets were brought to a very high standard by General William Congreve and some inventors tried to use the Congreve war rockets for other purposes.

Many of them constructed (only on the paper, it seems, it was too dangerous to do in reality) airships, propelled by rockets; there are a lot of patents of all countries. It is not known to everybody, that one of the murderers of the Czar Alexander II, the Russian engineer Nikolai Iwanowitch Kibaltchitch during the time of his imprisonment at the Peter-Paul Citadel made calculations about a rocket-plane. His manuscripts and his drawings came after the execution to the Governor of St. Petersburg, but the governor ordered to put them to the acts of Kibaltchitch and the plan was at first known after the bolshevist revolution.

After the first success of the Congreve rockets in all European countries Rocket-Corps were founded, but none of them was older than fifty years. The last rocket-corps was that of Austria, it was abolished after the war against Prussia, because it could not fight as expected by its emperor.

The history of the rocket would nearly have ended about at 1900, if not science would have shown a way to accomplishment by the use of liquid propellants. It was first suggested by a Russian Scientist, Konstantin Eduardowitch Ziolkovsky in 1903. Twenty years later appeared the book of the German professor Herman Oberth "Die Rakete du zen Planeteuraumen" (the Rocket into Cosmic Space) in which the first exact rocket-theory was given to science.

CHRONOLOGICAL HISTORY OF THE ROCKET

360 B. C. The famous flying wooden pigeon of Archytas, according to explorers of recent times, is to be viewed as a sort of aero-projectile, representing the oldest type of repulsion machine known. The Roman writer Aulus Gellius actually claims that it was kept suspended by weights "holding it in equilibrium and propelling it by means of blowing of the mysteriously closed-in air". Arthur Fuerst, in "Weltreich der Technik" (*World Empire of Technic Science*) (III, page 298) concluded from this that the pigeon of Archytas in contrast to the usual reader's conception, does not float in the air but was kept sus-

pended on a string by a counter-weight and turned around the support of a string. "The propulsion for the circular motions may have been supplied by steam which, in the form of air pressure, forced its way out of the interior causing repulsion."

1164 A. D. The Chinese general Wei-Sching who lost his life that year is said to have been the first to use mixtures similar to powder for shooting purposes. This statement is not definitely confined, inasmuch as Morrison who published in 1812 the "View of China" did not quote any source. All the so-called more ancient reports about shooting with powder and similar mixtures for shooting (starting with the tale of the inhabitants of Atlantis who are supposed to have known rocket planes (!) up to the army of Alexander the Great when it marched against the Indian king Porus). If there is any truth underlying these reports, it is mostly a confusion with "Feu Gregois", that is, Greek fire, which contrary to many public announcements possessed no oxygen carrier in its composition but was merely a mixture with easily inflamable materials.

1200 ? Probably around this time originated the "Liber ignium ad comburendos hostes" of Marcus Graecus. To judge by the very numerous Hellenic expressions and the occasional use of Arabic words, the well known Latin manuscript is not the original but a copy. As its composer may come into consideration some Byzantine Greek; otherwise the author is unknown. But it is important that the Parisian manuscript writes the word Marchus with the Greek "X". The date of origin cannot be determined, inasmuch as the claim that Mesue, the personal physician of the calif Mamun who was to have cited Marchus Graecus, is wrong, because it should be Dioskorodides. At any event, Albertus Magnus and Roger Bacon have known the "Fire Book". Very decided similarities lead to that conclusion.

Also Hunns Hartlieb, a writer who did a considerable amount of transcribing, refers to the rocket recipe in the "Fire" "Take living sulphur 1 part yellow............2 parts saltpeter (?) 6 parts" (elsewhere he states: 2 parts) That, of course, is nothing but a mistake in writing which Hartlieb was not aware of. The afore-named things are crushed to small pieces and well mixed on a stone and then placed in a long tube. The afore-mentioned tube is then filled and pushed down. Next a small hole is made inside, filled with powder and a small wick is ignited. The tube then would fly up in the air wherever it was directed to.

1232. The first definite mention of explosives containing saltpeter are found in this year in the Chinese chronicle T-Hung-Lian Kang-Mu in the occupation of the town Pien-king (Kai-fung-fu). There is also some mention of the first rockets and similar implements which apparently have developed not from the fire-arrow. St. Julien has translated the passages under consideration which appeared in the "Journal asiatique" (1849) as follows: "Furthermore, 'fire-carrying-arrows' were used by the invaders (Fe-i-ho-tsiang). A substance that would easily catch fire was put on the arrow; the arrow would shoot off straight causing a fire of some ten feet spread. The 'pao' and fire-bearing arrows were very much dreaded by the Mongols."

1240. About this same year, the Arabian savant Abu Mohammad Abdallah Ben Ahmad Almaliqui (from Malaga), also known as Ibn Baithar and Dijjaddin mentions saltpeter under the name of "Snow of China" as a substance known in the Mahommetan West. Regarding its further qualities (also pyrotechnical ones) he does not say anything.

1258. First mention of firecrackers or rockets (*ignis volans or windfire*) at Cologne..

1260. Albertus Magnus in his "De mirabilibus mundi" and Roger Bacon in "Epistola" and "Opus Maius" talk about rockets, their manufacture and distribution. Both authors have drawn on the *liber ignium* by Marchus Graecus; in the case of Albertus the beginning of that particular passage corresponds word for word with the original. The mysterious passage in Roger Bacon: "Sed tamen salis petrae R. VII. PART V. NOV. COBUL. VET..." is to be read as: "recipe vii partes, v novellae coruli v et sulphuris" (Take 7 parts of sulphur, 5 of young hazel (nut) tree wood and 5 of sulphur, and you will provoke thunder and destruction, if you know the art). The anagram reads: Luru vopo vir can utri, which was readily paraphrased to "Luru mope can ubre", so as to read into the words CARBONUM PULVERE.

1280. Around this year Hassan Alrammah, called Nedschm-eddin (Star of Faith) a "Book on Fighting by Horse and with War Machines" in which the first fireworks recipes are given. Among the war weapons is found also a torpedo with rocket propulsion, described as "self transportable and combustible egg."

1379. Muratori states that in the war for Chiozza an invincible tower was set afire by rockets. ("Pure una rocchetta fu tirata nel tetto della torre de si fatto modo, que it tetto s'accese ....". But it may also have been a fire-bearing arrow, due to the fact that the expressions for fire-carrying arrows, rockets and bombs were used interchangeably. The assertion that this was the first mention of rockets in Europe, is false also.

1405. In the war book "Bellifortis" by Konrad Kyeser of Eichstaedt three kinds of rockets are described: the flying, the swimming and those running on strings. Kyeser speaks of a stick for gauging the direction in the case of the flying one, but the sketch down alongside, is wrong; the stick for gauging the direction is shown hanging next to it.

1420. We have preserved from this year a sketch (scrap) book of the Italian engineer Joanes de Fontana which was later published under the title "Bellicorum instrumentorum liber". It describes flying rockets in the form of a pigeon, rockets running in the way of rabbits, as well as a large wagon running on rollers, propelled by three rockets; furthermore, a large wooden rocket torpedo which was given the form of the head of a sea monster and was painted.

1500. In China under the Mandarin Wan-Hu the first experiment of a rocket flight is said to have been undertaken. The reports are that two large kites were connected by a frame with a seat; the whole was lifted by 47 rockets; 47 kulis simultaneously ignited these rockets. An explosion is said to have killed the inventor and destroyed the apparatus.

1550. Around the time, rockets with parachutes are mentioned in various warfare and fireworks books (Count Reinhart von Solms). Furthermore, multiple rockets as well as stickless ones, partly with guiding fins, partly by iron files were made essentially top-heavy.

1557. In this year came out at Frankfurt-on-the Main "Von Geschuetz und Fewrweck, wie dasselb zuwerffen und schiessen, Auch von gruendtlicher zuberaitung allerley gezeugs, vnd rechtem gebrauch der Fewrwerck......... Alles durch Leonhart Fronspergern mit fleiss beschrieben." (About guns and fireworks, how to throw and shoot them. Also concerning an accurate preparation of all sorts of things and the proper use of fireworks,) all described with zeal by Leonhart Fronspergern." Here the rocket is mentioned only as an object for fire works for celebrating: "Roget is das geringst fewerwerck, gemacht as puluer, salitter, schwefel vnd koln, hart eingeschlagen in papier, sol hoch in die lufft fahrn (The rocket is the smallest form of fire works, made out of powder, saltpeter, sulphur and hazel (nut) tree wood (?), tightly packed in paper, are said to shoot high up in the air, and to produce a beautiful fire and to spend its force up in the air, and to disappear there without any damage whatsoever. And even though the rocket is of little effect in itself and blows out quickly, even so much pretty fireworks can be made from it when put together either like a ball or connected like wheels or are thrown out of moerschern (?), they are a decoration to all other fire works and also give action ,and are mainly of this kind that they lift themselves up in the air by their own fire: they require no shooting or any other power.)

1610. The Count of Nassau describes the first under-water-rockets.

1627. Joseph Furttenbach, an architect from Ulm, refers to rockets as battle weapons of pirates in his books Halinitro-Pyrobolia and Architectura navalis.

1668. Cristoph Friederich Geissler shooting off near Berlin rockets weighing 120 pounds, these rockets carry heavy bombs which burn very slowly until they fly downward.

1721. In Leyden appears the 2nd volume of "Physica elementa mathematica" by Jacob Willem s'Gravesende according to Newtonian fundamental principles. Newton was the first one to scientifically formulate the repulsion. As an application, J. W. s'Gravesande proposes to propel a wagon as a result of the propulsion of escaping water vapor. The construction of a large wagon is supposed to have been planned but never materialized.

1783. The Abbé Miollan and Janninet in Paris wanted to direct a very large Montgolfière by letting hot air blow out through a valve. But on the day set for the demonstration of the balloon which had been built with subscription money, it was so hot that the balloon could not be filled all the way and so failed to rise. At least the spectators lost patience and divided among themselves the bits of the balloon with had caught fire. The Abbé Miollan fled with the cash and nothing was ever heard of him again.

1784. Master weaver Ehrgott Friedrich Schaefer in Kohlberg wanted to shoot a saver line over to a stranded ship by means of a projectile. Therefore, he is the father of the idea of the later rocket saving apparatus. The officers of Frederick the Great, however, did not consider this invention for ships stranded as practical.

1798. In Paris experiments with phosphoric rockets are undertaken by citizen Chevalier causing arson.

1799. During the occupation of Seringapatam the English colonel William Congreve, later a general and Sir (inventor of the offset print (?) or pressure (?) The German word "druck" may mean either one) came to know the Indian war rockets. Haidas Ali, prince of Mysore had maintained a reserve of 1200 rocket throwers which were increased by his son Tipu Sahib to 5000. The physical effect of the rockets was not very great but they caused considerable mix-up, particularly among the hostile cavalry.

1804. Sir William Congreve conducts the first experiments in order to introduce war rockets in the English army. The first application of the new weapon proved a failure (Boulogne); the next, however, was a complete success. Kopenhagen was all set afire by 40,000 rockets. Also against Danzig the effect was great. However, in the case of Leipzig the fighting corps of English rocket throwers had but small success.

The largest flying distance of Congreve's rockest averaged 3000 yards. Congreve's late plans to build rockets weighing from 500 to 1000 lbs. were not realized. On the other hand, his regular war rockets were imitated by nearly all European countries; they all formed their own "Rocket Corps", the last of which were not disbanded until 1870. The following countries had rocket laboratories or rocket guns in their artillery. England, Prussia, Poland, Russia, Holland, Switzerland, Greece, Sardinia, France, Spain, Austria, Italy and Sicily.

The rockets were discharged by all armies either from earth walls, out of canon-like and mostly copper discharge barrels or out of ladder-like mountings. Also, shell rockets or stickless models (Hale) were tried everywhere, but the greatest use was made of the original axis-stick-rockets with arson effect.

1806. The pyrotechnician Claude Ruggieri undertakes transports of small animals by parachute rockets. The largest of the animals shot in the air in this manner, was a wether; the proposed rocket flight of a man (on the Mars field near Paris) was prohibited by the police.

1819. The Danish Capt. Schuhmacher constructing signal rockets which could be seen 15 (Danish) miles away.

1821. Capt. Scoresby (on the ship "The Fane") tried out a whale harpoon propelled by a big rocket.

1825. In Paris appears Montgéry's "Traité des fusées de guerre" which are perhaps the most important treatise on contemporary war rocketing, next to Congreve's books, and of the war strategy of the rocket corps. Montgéry in his book also propagated new kinds of rockets, some whose guiding stick forms a powder magazine etc. Also submarine torpedoes are described.

1828. (October 17). In Memel experiments are made by Major Stiehler to use a rocket as rope carrier in the ship's saving apparatus. These were the first experiments of its kind in Germany. Stiehler's predecessors were: Capt. Treugrouse at Helston in 1807 and Dennet at Newport on Wight in 1824. They employed Congreve's war rockets.

1841. In England the first patent on a rocket plane is issued to Charles Golightly. The details regarding the patent are missing, it appears that steam was the driving force.

1842. Engineer Phillips successfully demonstrates a "hélicopère a réaction". Steam was used as the means for propelling.

1846. (Nov. 12) The famous scientict Christian Gottfried Ehrenberg states before a society that the recently invented gun cotton will probably serve in the construction of giant rockets for the transportation of people.

1847. According to a presumption of Dr. F. M. Feldhaus, a project of a repulse plane for gun cotton propulsion dating dating from this year, originates from Werner von Siemens, very likely.

1849. The Russian military engineer Tretesski submits to Prince Wozonzoff in Tiflis (the governor of the Caucasus) a 208 page manuscript on repulsion dirigible air ships.

1856. The French Achille Eyraud was the first one to use the expression "moteur a réaction" for the propulsion of a space ship in a space ship novel entitled "Venusreise" (Trip to Venus).

1850. In the laboratory of Petersburg, extensive experiments are carried on by Col. Konstantinoff which are being put down in writing. Konstantinoff finds that rocket propulsion for large bodies, especially at low speed, is uneconomical.

1866. At the fireworks laboratory in Spandeau extensive experiments were made with light rockets which led to the creation of a standard model of about 350 meters (that is about 1165 feet) rising capacity. The field on which it shed light measured around 700 x 500 meters (that is about 2330 x 1670 feet) and its center from where it was shot off was around 800 meters (2630 feet).

1868. (Dec. 30) In Bremen a rocket apparatus was demonstrated in public for the salvation of ship-wrecked; a rocket weighing 38½ lbs. without a rope, was shot about 3000 feet out.

1873. The Russian general Iwanin wants to operate airplanes by war rockets.

1881. (March 23) The Russian engineer Nikolai Iwanowitsch Kibaltschitsch turns over to the Prison administration the plans he drew while under arrest (in the Peter-Paul Fort?) of an airplane lifted and steered by repulsion. After his execution because of participation in the crime against the head of the state a committee was to examine his plans. However, they were simply attached to the documents and only on March 23, 1918 they were turned over to Prof. Rynin by the Bolshevists, who concluded their technical inadequacy.

1884. The American general Russel Ihayer (Philadelphia) wants to operate an air ship for warfare by compressed expelled air. Emphasis is put on the idea of firing so that also the repulsion of the cannons will help to propel. (!)

1887. At Kiew Fedor Geschwendt publishes a treatise "Die allgeneine Einrichtung eines Luftdampfschiffes" (the general mechanism of an air steamship). It deals with a kite plane driven by steam repulsion, with oval carrying surfaces, which was to attain 260 werst of speed per hour (1 werst equals 1.066 kilometer; equals about 163 miles per hour). A short time previous, Gerschwendt had published a plan for a steam repulsion railway train.

(To be continued in the next issue.)