<u>Hydrogen silicides: Renaissance of a failed discovery?</u>

Peter's trip to the moon

Continuous improvements have reduced the cost of transporting

payload transport into space to such an extent that small solar power plants in low Earth orbit (see under "Geostrategy") have come close to feasibility and economic viability. The large-scale generation of "space solar power" would require a revolution in space technology. An apparently unjustly discarded German discovery about the chemical properties of silicon hydrogens could contribute to this. The story of this discovery and its forgetting reads like a science thriller.

The development of commercial launch systems has greatly reduced the cost of a space launch. NASA's SpaceShuttle, first launched in 1981, still cost about $1.5 billion to launch 27,500 kg into Low Earth Orbit (LEO, about 2 km above Earth). That was $54,500/kg (in 1981 prices).

SpaceX's Falcon 9 - which is Tesla founder Elon Musk's space company - is currently advertising a cost of $62 million to launch 22,800 kg to LEO, or $2,720/kg. Continuous improvements have thus improved the cost of transporting payloads to LEO by at least a factor of 20 within around 40 years.

Depending on which launch vehicle is used, whether astronauts are to be transported in addition to material payloads, what altitudes are to be reached or whether deep space beyond a geostationary orbit is to be targeted, the costs per payload can still be $20,000, $50,000 or even $100,000/kg.

However, technical and economic studies on "solar space power", which the interested community has largely followed so far, demand prices of around 200 dollars/kg payload in order to make "space power" economically advantageous compared to solar power generation on Earth. This is referred to as LCOE (Levelised Cost of Electricity) and compares the generation cost of one kilowatt-hour of electricity from space energy to the cost level of conventional terrestrial energy production or to a desired future price target. The available information on generation costs varies widely and naturally differs with the respective production technology. For example, there is the individual case of a solar power plant in the Nevada desert that allegedly realises a producer price of around 1.5 US cents (0.015 USD). On average, one can currently rather assume 8 to 10 US cents.

This means that "space power" has already become competitive, as a 2018 study by the American National Space Society (NSS) calculated. The starting point is an economic reference model developed by James C. Mankins in 2014 called SPS-ALPHA = Solar Power Satellite via Arbitrarily Large Phased Array), which was revised in 2017 (SPS-ALPHA II). The basic model is supposed to have a power of 1 GW (gigawatt), which is roughly equivalent to a nuclear power plant. Assuming that payload transport is the main factor influencing the generator cost of a space power plant, the NSS study argues:

"As a result of the significant reduction in average module size, mass and cost compared to previous SPS concepts (including the original SPS-ALPHA), the updated concept is much less dependent on "very low cost" ETO (Earth to Orbit; meaning Low Earth Orbit; LH) transportation . As (a graph not reproduced here, L. H.) illustrates, the delivered LCOE rises . . only rises above 10¢ per kilowatt-hour when the cost of ETO transport rises above $5,000 per kilogram. This is a tremendous result. It leads to the conclusion that launch vehicles already in service (e.g. SpaceX's Falcon 9 - at $2,720 per kilogram) could be used now to begin SPS deployment. And with vehicles already in development, SPS ALPHA LCOEs could be reduced below 5¢ per kW-hr. Such vehicles include the expendable Falcon Heavy - priced at $1,650 per kg for LEO (as of August 2016) - or SpaceX's partially reusable Falcon 9, a LEO version of Blue Origin's reusable booster, Reaction Engines Ltd's fully reusable SKYLON concept, or others). To realise a cost of less than 3¢ per kilowatt-hour for the base case, ETO transport is required at less than $800-$1,000 - a far cry from the often-cited $200 per kilogram."

Energy for all

The reduction in payload costs anticipated by the 2017 NSS has not yet materialised on the scale expected. Moreover, solar energy use on Earth is also becoming cheaper, so the LCOE as a measure of competitiveness is falling, or solar power plants on Earth would continue to be "more obvious". A 2018 study by the Fraunhofer Institute for Solar Energy Systems predicts, "By 2035, the LCOE of CSP (concentrated solar power) can drop to values between €5.75 cents/kWh and €6.93 cents/kWh."

However, the authors make the caveat: "For CSP, the decisive factor will be the extent to which CSP installations in markets with high solar radiation are driven forward in the coming years."

In January 2020, market research firm ReportLinker conducted a comparative study for orbital and terrestrial solar power generation.

There is no doubt, therefore, that the 1 GW SPS-ALPHA II will continue to require significant cost reductions in space launchers. However, the real challenge lies in the construction of large-scale facilities of 10 G and above (GW=gigawatt). A target output of around 20 TW of electrical energy or 60 TW of thermal energy (TW=TerraWatt) per year would be the amount of energy needed to enable even each of the soon to be 10 billion citizens of the earth to consume the same amount of energy at low cost per capita as was consumed by an EU European or US American in the year 2000. Cost-effective would mean: 0.01-0.04 USD (2001)/kWh). This is in line with the target of the World Energy Council (WEC). According to a comparative study presented to the WEC Congress in 2001, of all the forms of energy generation even conceivable at the time, only a large lunar solar energy plant offers the corresponding climate-friendly possibility.

But how could the necessary cost reductions in material transport by at least a factor of 10, rather by a factor of 100 to 500, be achieved?

If one follows the NSS study from 2018, from which the current cost figures at the beginning of this text are taken, private-sector management methods in particular have contributed to cost efficiency in space travel up to now. The study states:

"After an initial decline at the beginning of the space age, launch costs (in Western spacefaring nations) have remained very high and relatively constant until recently. High launch costs have been the biggest limiting factor for expanded space exploration and exploitation.

The following factors have been identified as the cause of high launch costs:

1. target: maximum power and minimum weight, originally of ballistic missiles.

2. higher cost of consumables compared to reusable materials

3. high cost of manned space flight

4. high cost of new technology, hardware and software

5. low fault tolerance resulting in intensive design effort and detailed oversight

6. high system complexity, number of parts and number of interfaces.

Commercial launch vehicles saved initial development costs by using (military) rocket designs, but rockets are designed for high performance, not minimal cost. Comparing missiles to aircraft, it seems that reusability is the obvious way to reduce costs." This is the premise currently held by the majority of authors who study the economics of space missions. But the example of the SpaceShuttle does not support this assumption:

Reusable rockets have higher development costs and reduced payloads due to the need for landing fuel. SpaceX's Falcon 9 is reusable and has been reused, but the projected cost savings will at best take place on further flights in the future. Moreover, the costs of remanufacturing were shown to be hardly less than building a new one. Manned spaceflight incurs additional costs for life support systems, higher reliability and adaptation to human passengers. Even recent developments such as Nothern Grunman's Omega rocket or the massive, reusable "New Glenn" from Jeff Bezos' space company Blue Origin seem unlikely to undercut Falcon 9 payload costs much further. After all, commercial and military payloads are expensive. Therefore, customers' tolerance for missed launches is low. Development and production costs increase with the complexity of the system.

The possible technical approaches to reduce launch costs are given by NSS experts "as follows:

1. simplify the vehicle configuration

2. increase vehicle production and launch rates

3. use industrial design and modern production methods (cultural change) for manufacturing and operation

4. optimise for minimum cost

5. reduce the number of parts

6. increase simplicity and design flexibility

7. reduce instrumentation."

As in the past, these optimisation strategies enable continuous improvement. Not only the US, but other spacefaring nations, such as Japan, have made and are making progress with them.

Discreet Japanese

In 2013, the Japanese space agency JAXA sent the "Epsilon" into space for the first time, a launch vehicle that checks itself before launch. Instead of 150 engineers, JAXA now needs only eight experts for launch preparations, which no longer take six weeks, but only one week. An expensive situation centre is also superfluous - two laptops were enough for the launch of the Epsilon. That makes every launch of an Epsilon rocket inexpensive. But the development was also comparatively inexpensive: at around 30 million euros, this rocket cost only a third of the development costs of the previous Japanese "flagship" H2A. However, the Epsilon can also only carry a maximum of 1,200 kg into low Earth orbit.

In May 2020, Japan launched the more advanced H3 launcher on schedule. In the minimum version, the H3 is supposed to be able to deliver 4000 kg of payload to LEO at a cost of 5 billion yen (= 46.6 million USD à 11,650 USD/kg), while the maximum version H3-24 can allegedly deliver 6,000 kg into transfer orbit to the moon or 28,300 kg into Low Earth Orbit. With this, the Japanese want to achieve competitive parity with the Falcon 9 - but they probably won't achieve a better price/performance ratio either.

More ambitious, however, is the combination with the reusable Japanese space glider HTV Kounotori (こうのとり, Kōnotori, "White Stork"). Plans for a first launch in 2025 into deep space, pursued since 2016, speak of payloads in the low double-digit tonnes to reach the moon for the establishment of a Japanese base on the Earth's satellite. When the H3 rocket left for the ISS in May 2020, the Kounotori was already "piggybacking" for the first time. While Americans and also the Chinese usually make quite a fuss about their rocket launches, the Japanese proceed discreetly and silently. In any case, the European public hardly notices how advanced Japanese space technology already is.

But even a load carrier like the White Stork would still be far too weak to realise a large solar power plant on the moon with the required performance.

According to the technical possibilities of the year 2000 - the WEC study by Criswell mentioned above - an estimated 455,000 tonnes of material would have to be installed on the Earth's satellite for the 20 TW complex over a 70-year life cycle of the plant. This would include the cost of a lunar habitat for 4,700 construction and maintenance workers. Even if the raw materials were partly extracted on the moon itself (the ESA has already developed methods for this) and the components could be made lighter, several thousand rocket launches would probably be necessary.

But at least a start is to be made soon: NASA is preparing with international partners to build a manned lunar base for 2024, and individual space nations, such as Japan in particular, also have concrete plans for their own lunar stations with a similar time horizon.

In the NSS analysis of the cost factors, it is noticeable that the improvement of the engines and higher-thrust propellants are not explicitly named as "adjusting screws". Apparently, hopes in this direction are low: the currently most advanced Raptor engine of SpaceX's Falcon rockets uses methane as a propellant for the first time, but a great improvement is not associated with it: rather, it is a practicable variant that delivers an all-round good average value in comparison with conventional engine/fuel combinations. A video from the online magazine "Everyday Astronaut" provides a clear description and explanation. When asked, Professor Dr. Michael Pfitzner from the Institute of Thermodynamics at the Bundeswehr University in Munich was also unable to name a better fuel alternative than methane.

But that was "so far". Now Professor Pfitzner is interested in a new research project on a possibly revolutionary fuel and engine concept. The story is a true scientific thriller, in the last chapter of which the author of this essay has a small part to play:

A fateful publication

The 11th of November in 2000 was the second blackest day in the history of the news magazine STERNS. Before that, the editorial staff had already disgraced itself to the bone with fake Hitler diaries. The cover story of that day with the lurid title "Sensational discovery: SAND - THE OIL OF THE FUTURE - How a German scientist found the solution to our energy problems" turned out to be another journalistic disaster. In the article, Professor Dr. Norbert Auner, then full professor at the Department of Chemistry at the Goethe University in Frankfurt, claimed: >>Cars could perhaps be powered the day after tomorrow by ceramic engines or jet turbines from which sand, rather than exhaust gases, wells up.<<

The starting point for this unusual idea was the production of long-chain silicon hydrogen compounds, so-called silanes. These chemical compounds are similar to the hydrocarbons on which our familiar fuels such as oil and petrol are based. In principle, the carbon atoms (chemical symbol: C) in the silanes are replaced by silicon atoms (Si). However: Until now, long-chain silanes were considered technically unmanufacturable, volatile and highly explosive. In any case, these explosive properties apply to the "low" silicon hydrogen compounds with only a few, i.e. a maximum of three silicon atoms. Auner had allegedly succeeded in producing five millilitres of the "higher" cyclopentasilane Si5H12 and having it tested at the Fraunhofer Institute for Chemical Technology ICT for its thermal properties when burned with oxygen. According to Auner, the silicon involved would not only burn oxygen from the air through a reaction with copper dioxide, but also enable a very strongly exothermic (heat-generating) reaction with atmospheric nitrogen. The STERN article went on to say: >>Power plants for burning silicon, however, would still have to be developed. Most of the energy would be released by combustion with pure oxygen. Nevertheless, Auner relies more on the reaction with nitrogen. Because in addition to heat, this produces a number of economically valuable products. The chemist: "With nitrogen, economically speaking, we turn sand into gold."<<

Rather casually, the STERN article mentioned a "chemist at Cologne University" named Peter Plichta, who had allegedly made the first successful experiments with silane production in the 1950s. However, his ideas for new types of fuels, engines and rocket motors were rejected by the then Research Minister Rüttgers after Plichta "could only present formulas on paper". Since then, the chemist has turned to mathematics. Professor Auer, on the other hand, was celebrated as the actual inventor of silane chemistry, "who has since applied for several patents."

In fact, Plichta, together with the chemist Rolf Guillery, had been able to produce a mixture of higher silanes for the first time in 1968, from which small quantities of stable, oil-like penta- hexa-, hepta- and octasilane could be separated. In an effort to use laboratory capacities for the production of these substances on a larger scale, Plichta had approached the university professor Auner around 1997, who was considered an expert in silicon chemistry and also had connections to large-scale industry. Pure silicon and various silicon compounds, although not the higher silanes in question, had long been in use for industrial applications in semiconductor production, nanotechnology, lubricants, seals and numerous other uses. Silicone is popular for cosmetic surgery. In any case, Auner proclaimed to have invented his own manufacturing process for silanes. For this, he needed elementary (pure) silicon, which is technically extracted from sand (quartz sand SiO2) at around 2000 degrees Celsius.

A false invention

However, the STERN article was quickly criticised by experts, who initially focused on the question of whether the energy-intensive production of pure silicon as a starting point for the further extraction of silicon hydrogens was an energetic process at all that could deliver an additional energy yield in the end. The expensive process of silicon production completely called into question the economic viability and thus the usefulness of silanes as an energy source. Added to this was the realisation that at the time, even if pure silicon were available as a starting material, it was not at all possible to synthesise higher silanes in quantities larger than just a few millilitres. Neither Auner nor Plichta were able to show alternative industrial production routes for silanes at the time that would produce a relevant yield without pure silicon. Once again, STERN was thus convicted of unreflective loudmouthedness.

Equally damning was chemist Plichta's objection that Auner's process for nitrogen combustion did not work at all and "that chemist Auner did not understand something fundamental." ... "The Sterntitel report of 09.11.2000, finally edited by Auner himself, borders chemically on an invention from a madhouse," wrote Pflichta on his website. Other chemists also expressed similar doubts in public comments.

However, Plichta's criticism should not be taken to mean that high-energy nitrogen combustion is not possible, but only that it is achieved by a different chemical process and even releases far higher energies than Auner would even suspect. A year after the STERN report appeared, Plichta published his own book with the unfortunately also inappropriate title "Petrol from Sand". There he described in detail and in an autobiographical style the entanglements whereby Professor Auner had become an incomprehensible plagiarist of his own inventions. A bitter dispute broke out between Auner and Plichta over patenting, both with regard to the production of higher silanes and the procedure and application of combustion with oxygen and nitrogen. In fact, Auner eventually had to withdraw his silane patent applications, mainly because they did not actually work in the end.

On Peter Plichta's website you can read more about this today:

>>(I) had in the meantime worked with the senior assistant Dr. habil. Kornath at the University of Dortmund, the three steps for the preparation of cyclopentasilane according to Auner's instructions were repeated and filmed. It was possible to prove that only phenylcyclopentasilane was produced in the main. This proved that the results (also at the ICT) by Prof. Auner were all wrong. …. (This led to) the finest journal for chemistry "Zeitschrift für angewandte Chemie" (Journal for Applied Chemistry) publishing a book review and the German Research Foundation cancelling Prof. Auner's research funding. This, however, foolishly extinguished the interest in nitrogen combustion that had once flared up. Only the scientific director of the WDR's Jean Pütz took up the matter, and in January

2002 there was a 25-minute report on the chemist Plichta and the use of silanes in future aerospace in the programme "Dschungel".<<

And this is where the author of this essay comes in for the first time.

At K1F Knowledge One Fonds AG, which managed the world's first investment fund for investment in "knowledge" as an asset manager, I was responsible at the time for communication with capital investors. For this, I was constantly on the lookout for "good stories", especially from the knowledge area of patent production, because in the meantime, around 2003/2004, K1F AG had also invented a procedure for computer-based "automatic" patent evaluation. With some delay, I therefore became aware of the WDR report in 2004. The prospect of new chemical fuels seemed tempting, yet the whole Auner-Plichta story remained confusing, incomprehensible and ultimately impossible to assess for outside laypersons. I therefore put this topic aside for myself quite quickly.

"Summa cum laude" for the silanes

One piece of information, however, remained in my memory: Dr. Plichta had a research assistant named Bernhard Hidding. After working with Peter Plichta, he had moved to the Bundeswehr University in Munich and had submitted a diploma thesis there and at the Heinrich Heine University in Düsseldorf in 2004. It was entitled "Investigation of the Suitability of Silanes as Propellants in Aerospace". The examiners were Univ. Prof. Dr. rer. nat. Michael Pfitzner (UniBwMünchen) and Univ. Prof. Dr. rer. nat. Detlef Reiter (HHUDüsseldorf). They assessed the work with "Summa cum Laude", i.e. the highest academic grade. The paper came to the conclusion: >>(Overall, the silanes) could make a decisive contribution to improving combustion efficiency in the sense of NASA, etc."

When I took up the post of head of the state expert commission "Growth and Innovation" at the Hamburg Economic Council from 2011 (until the end of 2013) and the projects on solar energy from space came into my sights, I vaguely remembered Hiddings' thesis and sought contact with him. The young diploma student had become a recognised scientist, who in the meantime even headed a DFG special research area for solar cell research. I also managed to make contact with Professor Dr Pfitzner from the Bundeswehr University. My question at the time was quite general and typically journalistic: "Is there any truth in the miraculous possibilities of silane chemistry or not?" One of my best friends is the chemical process engineer Bernd Neumann. I submitted this question to him as well, along with scientific information, albeit still quite sparse. The research at that time led to the following findings:

1.) The failure of the seemingly revolutionary silane chemistry is probably due in no small part to the person of Dr. Plichta.

Although he is in fact the actual discoverer of the properties of higher compounds of silicon hydrogens, the contact partners who knew Dr. Plichta personally described him as a personality who

- let me put it mildly - was difficult in human dealings. It is therefore not surprising that the ingenious Plichta could, as it were, rail in the background: "Professor Auner is a plagiarist, and a false one at that!", but that simply nobody wanted to listen to him.

2.) Plichta's revolutionary chemistry met with rapid approval and public applause, especially among esotericists of various colours. This made it difficult for serious scientists to deal with the subject seriously without damaging their own reputation.

3.) In addition, Plichta's book "Petrol from Sand" was largely autobiographical. While this makes the story of silane research easy for the reader to follow, it does not correspond to the style that scientists appreciate. In the process, Plichta mixes the silane topic with other inventions such as a new type of space cruiser or mathematical number theory, which even call Albert Einstein's physical findings of space and time into question. So Dr Peter Plichta, who has proven his extensive knowledge through numerous academic degrees, may be one of the few polymaths of our time. But in his book he celebrates his own genius all too often and all too exuberantly for it to really earn him an interested, appreciative readership. Thus Plichta suffered the same fate as many visionary discoverers and inventors: numerous commentaries simply dubbed him a "crackpot". Those who might hastily join this chorus should recall Napoleon's reaction when the invention of the steamship was presented to him: "Let me be spared the nonsense that a ship would move faster if a fire were lit below deck."

4.) Based on Bernhard Hiddings diploma thesis, there was definitely interest in silanes as rocket propellants at the Bundeswehr University and probably also at the University of Stuttgart, which was renowned in the field of rocket technology. However, this interest simply faded away over time. Prof. Pfitzner still gave several lectures at scientific conferences together with Bernd Hidding, but their interest eventually waned. From today's perspective, it can be added that more intensive research probably lacked the actual availability of higher silanes, because no one knew of an (economically) feasible production process. So the research remained purely theoretical.

5.) Although the topic seemed "fundamentally interesting" to some experts, much more research was needed. In the absence of paying clients and other tasks of their own, this meant for my interlocutors: "In any case, I won't look into it any further."

A hapless discoverer

Almost ten years have passed since my involvement with this unusual story at the time. Dr. Plichta even published his book "Petrol from Sand" almost twenty years ago and has not published a new edition since.

Given the importance of "space energy", I have recently revisited silanes in perspective as novel fuels. Only now, too, did I procure Peter Plichta's book on "Petrol from Sand", which made the context of the unfortunate dispute between Dr. Plichta and Prof. Dr. Auner more comprehensible to me. It is not the first time in the history of science that disputes about the authorship of a discovery almost caused the invention to perish. Legendary is the desperate fight of the inventor Charles

Goodyear against a patent plagiarist, who made Goodyear so poor that he could not even pay for the funeral of his child. Without Goodyear's persistent fight for his invention, there would be no vulcanised rubber and thus no car tyres today.

In Plichta's case, too, it can be said: "First he had no luck, then bad luck came along. Around the year 2000, when Dr. Plichta had finally found a functioning synthesis method for large-scale silane production without the diversions via pure silicon, interested investors for a silane factory withdrew because of the patent dispute with Auner.

Plichta's patent was finally registered as "Process for the production of higher silanes with a view to their use as fuel (large-scale synthesis via modified Müller-Rochow process)", PCT: DE 91/03764, filing date: 01.12.2000". On 1 September 2006, the application for a patent on "Pressure syntheses of higher silanes" was filed,

AZ 10 2006 041 605.8 .

Well, patent applications are one thing, but their actual granting, application and production of the chemicals is another matter. Have silane oils been produced anywhere in the world in the meantime? And what about the nitrogen combustion of silanes claimed by Dr. Plichta?

Dr. Plichta has already explained the silane reaction with oxygen and nitrogen in his book. They allow even the layman to understand the chemical processes. According to this, in a hot combustion chamber the silanes would automatically decompose into silicon and hydrogen atoms, which in turn react with both the oxygen (20% air content) and the nitrogen (chemical symbol: N; almost 80% air content) contained in our atmospheric air. The reaction products of the seven-chain heptasilane, for example, are water ($H2O$) and the non-toxic silicon nitride $Si3N4$, a rare crystalline substance that liquefies at high temperatures.

A chemical revolution

For a scientific chemist, the information might not have been enough to overcome professional scepticism. On his personal website, however, Dr. Plichta now reveals further information that is now also of interest to experts:

"A chemical process is used, which burns the injected oxygen of the air with the hydrogen separated from the silane chain, so that a so-called reducing atmosphere prevails. Due to the excess of H atoms, no silicon oxides can be formed. Now, by continuing to burn all the nitrogen fed in to silicon nitride in the excess of silanes - and in the supersonic range - the engine begins to suck, so to speak, because silicon nitride is not gaseous, but forms a kind of droplet-particle mist with the water vapour. Because of the aforementioned noble gas structure of Si 3N 4 , the combustion has an implosion character. To put it in a nutshell: The injected nitrogen is not co-heated as in a normal scramjet process, which would cool the flame, but provides heat during the combustion itself. In the case described here, however, all the nitrogen is burnt along with it. This causes the nitrogen to disappear, leaving behind a large amount of unburnt atomic hydrogen from the silane chain. These in turn build up the pressure in the supersonic combustion chamber. When these H atoms molecular weight (Mg) = l (H_2O Mg = 18, Si_3N_4 Mg = 140) leave the supersonic combustion chamber and enter the Lavalle nozzle, they will experience an enormous increase in velocity because of their very low molecular weight. For the use of hexasilane, the combustion of the 20% oxygen of the air and a corresponding proportion of nitrogen results in the chemical equation

$$2Si_6H_{14} + 7O_2 + 8N_2 \rightarrow 4Si_3N_4 + 14H_2O$$

In order to also burn the residual nitrogen, the following equation applies

$$4\frac{1}{2} Si_6H_{14} + 18N_2 \rightarrow 9Si_3N_4 + 63H$$

In total, the following applies for the input: $6\frac{1}{2} Si_6H_{14} + 7O_2 + 26N_2$

and for the output: $14H_2O + 13Si_3N_4 + 63H$

To calculate the average molecular weight, the combustion products are added up with their molecular weights and divided by the number N=90 of molecules formed.

The average molecular weight is then about 23 and the combustion chamber temperatures are over 3000°C, resulting in a specific impulse that has never been achieved before. In a conventional scramjet burner, the liquid hydrogen must first be vaporised and then broken down into its atomic form. It is then burned with liquid oxidiser. With nitrogen combustion, on the other hand, the released hydrogen is shot out to the nozzle unburned. By dispensing with the oxidation tank and using centrifugal pumps, the payload increases from 3% to over 50%. Since the rocket equation is bypassed, the payload increases to over 75%.

With the procedure presented here at minimum length, thermodynamics is turned upside down, so to speak. Any rocket engineer would try to burn existing free hydrogen atoms with atmospheric oxygen. The secret of nitrogen combustion, however, forces us to use the nitrogen to produce heat, so to speak, and to use the extremely hot hydrogen for propulsion. In the process, of course, the silicon nitride molecules are also accelerated. According to the impulse theorem, they will also provide thrust because of their as yet unimaginably heavy mass.

From the preceding text it follows that the projectile works more and more effectively at ever higher Mach numbers, whereby of course the air envelope at an altitude of about 50 km must not be left. The described suction effect has another thrust unknown in rocket technology so far. In addition to the combustion products, very large quantities of ultra-fast atomic hydrogen escape from the Lavalle nozzle. While the combustion chamber is physically in the state of a standing detonation wave, behind the rocket there is a permanently propelled explosion chamber, which could be described chemically as an "oxyhydrogen chamber". To what extent this permanent explosion wave provides additional thrust can only be hinted at here. In this way, speeds of over 24 Mach become possible,....." (the remainder of the text refers to the discus-shaped missile conceived by Plichta).

As mentioned before, silicon chemistry is a vast and not unknown field. In the search for cheaper production possibilities for pure silicon or for effective lubricants, industrial companies such as SEIKO or Evonik Degussa GmbH (now EVONIK Industries AG) have independently developed production processes for higher silanes (also known as hydridosilanes) in recent years. EVONIK, for example, produces mainly silicon chemistry products at its site in Rheinfelden in Baden-Württemberg and holds about 400 patents in this field. As I was able to find out after some painstaking research, one of them is patent EP 2 135 844 A1, registered by the European Patent Office on 23 December 2009 in Patent Bulletin 2009/52.

"Process for the preparation of higher hydridosilanes".
https://patentimages.storage.googleapis.com/a4/56/9a/ca986e6676a886/EP2135844A1.pdf

I therefore asked EVONIK directly whether the company could make a statement on the reaction described by Dr. Plichta. The answer came by return of post: "Yes, the chemistry of the reaction of the H-silanes with N2/O2 is comprehensible and ok so far."

A second chance for the silanes

I do not want to reproduce here the extensive correspondence between the Bundeswehr University, EVONIK, the company PSC Polysilanchemie GmbH, the BDLI Bundesverband der Luft- und Raumfahrtindustrie (German Aerospace Industries Association) and myself that surrounds this statement. In any case, the result is a seriously renewed interest in the suitability of silanes as rocket fuel or in a research project on this. The remaining scepticism relates above all to the question of whether the reaction product silicon nitrite could clog engine nozzles or stick to combustion chamber walls, or how this could be prevented. In addition to chemists and physicists, engineers and engine experts would therefore have to be involved in the research on an interdisciplinary basis.

In view of the considerable funds that will soon be available for the European Green Deal, there should be sufficient funding for this. That such research should finally be started twenty years after the ill-fated report in STERN magazine is the concern of this essay!

The next hurdle for this will be the German Aerospace Research Centre DLR, which operates a large technical test facility for rocket engines in Lampoldshausen near Heilbronn. There, too, Dr. Plichta's silane idea has already been rejected once, mainly because of concerns about a supposed explosion hazard of these then still unknown substances, and because he simply could not yet produce the higher silanes in relevant quantities either.

Today, silane research could possibly be hindered by the fact that DLR has currently turned to another chemical substance family as a possible new fuel, the ADN ammonium di-nitramides. DLR is working on this in collaboration with the originally Swedish company ECAPS, which was sold to the US company Bradford Space in 2017. DLR is also exchanging information with the Japanese company JAXA. However, a - I confess: superficial - review of the literature on the propellant ADN gives the impression that ADN, which was actually invented in Russia as early as 1959, promises little more than to replace the expensive and highly toxic Hydrazyn in a more environmentally friendly way. Ultimately, of course, it is up to the experts to decide which research strategy is more promising. In any case, I wish the silanes the chance of a solid scientific competition.

P.S.: As of today (25.06.2020), I can already report more on DLR's interests. However, I still reserve this information for selected contacts.

EPILOG: Peter's Ride to the Moon

In 1912, the German author and natural philosopher Gerd Bernhard von Bassewitz wrote the fairy tale 'Peter's Moon Journey'. In it, the children Peter and Anneliese help the one-legged cockchafer Sumsemann fly to the moon to retrieve his lost sixth leg. The fairy tale was adapted as a play for children in the same year and premiered at the Old Theatre in Leipzig. In 1959, my father Theodor Hollweg took on the role of Sumsemann as an actor at the Theatre of the City of Hagen/West, and my mother accompanied me to the performance when I was three years old. I was so thrilled that I insisted on seeing a second performance and refused to go home. I stomped my feet angrily on the forecourt of the theatre and shouted at the top of my voice: "But I want to see Sumsebrumm the cockchafer again!

Ten years later, Neil Armstrong became the first man to set foot on the moon, between 3 and 4 a.m. Central European Time (exactly 3:56 a.m. CET) . My father and I sat spellbound in front of the black-and-white television, which provided only flickering transmission images. For days before, we had been following every detail of the historic moon mission.

So the moon and I already have an intimate relationship. In memory of Peter, Anneliese and the Sumsemann, and in recognition of the achievement of the apparently unjustly misjudged Dr. Peter Plichta, I have therefore given this essay the childlike title "Peter's Moon Journey".

Dr. Plichta has combined his discovery of the properties of silane-hydrogens with construction patents for a hyper-fast disc-shaped space cruiser, which indeed reminds one of the famous "flying saucer". He also described and patented a novel "silane diesel Wankel engine". As STERN reported, Plichta actually also delved into mathematical number theory. There he believes he recognises a "basic code" for the phenomena of the universe in the prime numbers, which is expressed, among other things, in the chemical periodic table. Plichta goes so far as to claim that Einstein's conception of space and time is wrong and that even behind the world visible to man there must be a - mathematically justifiable - hidden universe.

I am not in a position to judge any of these findings. But since Dr. Plichta, who is highly educated in the natural sciences, obviously made an important discovery at least once, shouldn't his other ideas also be seriously examined?

It takes an average of about 25 years for groundbreaking discoveries to become new basic technologies and find practical application. Breathtaking innovations therefore lie dormant in the laboratories of scientists and the workshops of engineers. For example, in August 2018, the online military magazine The-War-Zone reported on a new missile said to have been developed at the Naval Aviation Enterprise, a technology workshop of the US Naval Air System Command. It is a device that can operate both in the air and underwater. Through superconducting effects at room temperature, it displaces all surrounding matter so that the aviator (or diver) can glide virtually weightlessly and manoeuvre with incredible flexibility. The invention seemed so obstruse to the US Patent Office and contrary to all current scientific knowledge ("superconductivity at room temperature does not exist") that the patent was initially rejected. However, the Chief Technology Officer of the Naval Aviation Enterprise, Dr. James Sheehy, assured the patent office in writing that the invention was "operable". The process has puzzled journalists and experts ever since. So if such a "UFO" is already in the realm of the possibly possible, why not, for example, Dr. Plichta's miraculous 20,000 km/h spaceship?

It is not only since the Corona crisis that we have been hearing that Germany must become more "innovative". The know-it-alls rarely explain what they are thinking about in concrete terms - if they are thinking about anything in particular at all. It is therefore time that we at least give the seemingly impossible a real chance.