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Chapter 1

Dr. Irene Sanger-Bredt: A Life for Astronautics*

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Introduction

Irene Bredt (b. 1911 at Bonn, Germany) obtained in 1937 her Doctorate in Physics; in the same year, she became a scientific researcher at the German Research Center for Aviation at Trauen, led by Prof. Dr. Eugen Sanger. Soon, the young but efficient Dr. Bredt became the first assistant of Dr. Sanger who later married her in 1951. During the 1973-1976 period, Dr. Bredt was in correspondence with Prof. Dr. Zagnescu of Romania and helped him to familiarize Romanian readers with Prof. Sanger's life and achievements.

Concerning Dr. Bredt's own career, there were three main periods of her activity: the 1937-1942 period when she was a researcher in charge of thermogasdynamical problems of liquid fuel rocket engines at Trauen; the 1942-1945 period, when she was a senior researcher in charge of ramjet in-flight test data at Ainring; and in addition, she was then the co-author of the Top Secret technical report entitled, "A Rocket Engine for a Long Range Bomber," finished in 1941

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and edited in 1944. During the post World War II period, she was a scientific counselor, or Director, at various civil and military institutions, universities, etc. Dr. Sänger-Bredt helped her husband develop many scientific works including the ramjet thermodynamic theory, Sänger's photon rocket theory, the establishment of the International Astronautical Federation (IAF), and the International Academy of Astronautics (IAA), the latter in 1959. In 1970, Dr. Sänger-Bredt was honored with the Hermann Oberth Gold Medal for her own impressive scientific contributions.



Figure 1: Dr. Sänger-Bredt (1911-1983) – German-born mathematician, physicist, and rocket pioneer, who greatly contributed to the Sänger-Bredt Antipodal Bomber, also called the “Silver Bird,” a forerunner of the Space Shuttle (Smithsonian Institution Photo 75-2921).

An Unconventional Youth

Irene Reinhild Agnes Elisabeth Bredt was born on 24 April 1911 of a very prominent family of scientists of the German province of Rhenania. Her first education was undertaken at Cologne where she obtained a diploma. As a schoolgirl, the young Irene read a story entitled *Little Peter's Travel to the Moon* and she also saw the movie *Frau in Mond (A Woman on the Moon)*, produced in 1929 by the Ufa company in Berlin. Prof. Dr. Hermann Oberth was the technical director of the film [Ref. 1].

In such conditions, unconventional for a girl, she was very excited when she saw, in an old hangar under the suspension bridge of Cologne, one of the rocket cars of Fritz von Opel; with this car, named the *Opel-Rak 1*, on April 12, 1928, the driver Kurt Volkhart attained a speed of 100 km/hr in eight seconds using, for such record-speed, twelve [gunpowder—ED.] rockets manufactured by the engineer F. W. Sander [Ref. 1].

Irene's imagination was very impressed and she subsequently bought a book dealing with firework rockets. But she already dreamed [of rockets—ED.] for other purposes.

Unfortunately, in the period of her higher courses at the Universities of Cologne, Freiburg, and Bonn, she almost forgot these ambitious dreams of her youth. She [was occupied with—ED.] passionately preparing for her Doctorate in Physics at the Friedrich-Wilhelm University. Her thesis was "The Roentgen Spectra of Rare Earths." Her Professors-examiners, Drs. Kannen and Füchtbauer, were very satisfied and awarded her a brilliant school mark (*Magna cum laude*) in 1937.

For her first job, the young Dr. I. Bredt received three offers, but she preferred the fourth—received from the Research Center for Aviation at Trauen. Somebody advised her, "...Possibly it would be a matter of rockets." [The subject of rockets was then not considered an important or "respectable" one for academics.—ED.] But such a prospect excited her imagination and she arrived at Trauen entirely set to take on this job.

In her first interview, she made the naïve declaration: "...But I know what you do here—rockets!" Nonetheless, Dr. Sängner, the Chief of the Center, approved her employment and from that moment, the young and beautiful Dr. Bredt became his devoted contributor [Ref. 9].

The Trauen Period: 1937-1942

In 1937, at Trauen, Dr. Sängner thus received two very capable assistants to his projects: Irene Bredt, with a doctorate in physics, and the engineer Count Helmut Philip Georg Alexander Rudolf von Zborowski, born at Theresienstadt on Eger (on August 21, 1905) of a very old Bohemian family [Ref. 1]. Having a good experience with the Bayerische Motorenwerke at Munich (during 1934-1937), von Zborowski very soon became the chief of the Test Rig* for the big

* At the end of 1938, Bayerische Motorenwerke obtained a contract from the German Luftwaffe for reactive propulsion applied to missiles and aircraft. Von Zborowski was invited to build, at Zuhldorf, ten test rigs for rockets fuelled with alcohol and nitric acid. After the war, he worked in France.

1,000 kN thrust rockets. On the other hand, Dr. Bredt, as a scientific researcher, was in charge of the thermodynamic calculations of the combustion of liquid fuelled rocket engines with or without the presence of the weight forces. She was especially charged with solving [thermodynamic—ED.] problems of alcohol combustion in liquid oxygen (primed by Zn diethyl) [*sic*] in some rocket variants.

Dr. Bredt's first task was to familiarize herself with Dr. Sänger's study entitled "Gaskinetik sehr grosser Fluggeschwindigkeiten" ("Gas Kinetics of Very High Flight Velocities"), to be undertaken under a contract with the Zentrale für Wissenschaftliches Berichswesen, or ZBW (Central Office for Scientific Reports). The result of Dr. Sänger and Dr. Bredt's collaboration was a technical report having the above mentioned title and which appeared in May 1938. Thus, this was the start of the collaboration of these two exceptional scientists. We have to remember that Sänger and Bredt determined for the first time in this study, the formula and numerical values for the aerodynamic forces affecting spacecraft at altitudes where the atmosphere cannot be regarded as a continuous medium. Also, this study was mentioned by Dr. H. S Tsien in his report entitled "Super Aerodynamics—Mechanics of Rarefied Gases"* that was translated into English by NACA (in May 1950 as Technical Memorandum No. 1270) [Ref. 5].

In order to solve the theoretical thermogasdynamic problems of liquid fuelled rocket engines tested on the test rig at Trauen, Dr. Bredt's second scientific task was to understand the main research objectives of the Center, as follows:

- Projects for a large rocket engine of 1,000 kN thrust
- Tests carried out for various rocket engine variants
- The semi-ballistic plane project.

To become integrated in such new scientific undertakings, Dr. Bredt studied Dr. Sänger's paper, published in February 1933, under the title "On the Construction Principles and Performance of Rocket Planes," which appeared in the *Deutsch-Österreichische Tages-Zeitung* (the *German-Austrian Daily Paper*). Later, Dr. Sänger detailed this concept in his book *Raketenflugtechnik* (*Rocket Flight Technology*) which was published by the R. Oldenbourg Publishing House, also in 1933 [Ref. 2].

On February 1, 1936, Sänger entered into a contract with the Deutsche Versuchsanstalt für Luftfahrt, or DVL (German Research Establishment for Aviation), in Berlin-Aldershof, the subjects of which were: (1) A proposal for the creation of a Research Institute for Rocket Technology; and (2) a research program for liquid propellant rocket engines [Ref. 6]. The result of this contract was

* *Journal of Sciences*, VIII, No. 12, p.653, Cal Tech, 1945.

the establishment, beginning in February 1937, at Trauen, on the Lündenbergh Heath, of the Rocket Research Center (its camouflage name was the Flugzeugprufstelle Center for Aircraft Testing). It was subordinated to the Luftfahrtforschungsanstalt 'Hermann Göring'— or LFA (the Research Institute for Aviation—Hermann Göring).

Another result was the design in October 1938 at Trauen, of a steel model (1:20 scale) of a supersonic glider plane.* (Because of its dome-shaped body profile and flat bottom, Dr. Sänger's assistants, including Dr. Bredt, nicknamed it the "flat iron.")

Before the liftoff of this plane, also baptized "the Silver Bird," and to save fuel weight, Dr. Sänger proposed to accelerate it to a velocity of about 500 m./sec. by means of a rocket-driven launch sled sliding on a straight horizontal steel rail having a length of several kilometers. Thus, it became necessary to obtain knowledge about the amount of dynamic friction between the sliding surface and the upper face of the rail. This was one of Dr. Bredt's contributions.

She understood that at very high sliding velocities and at a subsequent high negative acceleration of braking, she had to ensure a reliable dynamic floatation of the sliding surfaces by choosing a suitable geometry of the lubricating gap and also, a qualified lubricant. For such extreme operating conditions, there were no reference data in the scientific literature at that time. Also, there appeared the opinion that it would be impossible to control the frictional heat and, consequently, the realization of the entire catapult arrangement became doubtful.

At the beginning, Dr. Bredt intended to collect proven values for dynamic friction and lubricating procedures from specialists at the Institut für Technische Strömungsforschung (Institute for Technical Research of Flows) at Berlin. But there, the highest sliding velocity obtainable on the test rig was limited to a fraction of the required value at Trauen. As a consequence, and helped by Dr. Bredt, Dr. Sänger designed a new kind of spiral test rig, the model being a stainless [steel—ED.] bullet, fired at a velocity of about 800 m/sec (243 ft/second).

The experiments were carried out in 1939 and demonstrated the possibility of this new horizontal launching pad construction and able to accommodate velocities as high as 500 m/sec. [1,640 ft/sec], if the rails would be carefully finished and lubricated.

The relationship between Dr. Sänger and the young Dr. Bredt was, in 1939, a scientific collaboration. But, in their free time, in the remote Oertze Valley, they created their own separate dream world, totally different from the realities of World War II, which broke out that September.

* Dr. Sänger's Reich patent No. 411/42.

They spent their free time together along the traces of the popular heath through the fen-country in dreaming twilight, listening to wood-pigeons and heath cocks, gathering mushrooms, devouring the science fiction stories of Hans Dominik, and tasting red wine in tin cups—if they didn't prefer to work voluntary overtime in order to accelerate the development of the "Silver Bird." [Ref. 6] In their excursions to the Zoo Park in Trauen, Dr. Bredt took with her, her favorite fox terrier dog.

But at the end of 1939, the Luftwaffe orders became clear: the entire work must be dedicated to the war objectives [Ref. 9]. With some added chapters, dealing with bomb trajectories, impact ballistics, and offensive measures, the study on the first single stage to orbit (SSTO) Rocket Plane—the "Silver Bird"—having a launch weight of 100 tons [220,000 lb or 99,792 kg] and a combustion chamber pressure of 100 atm (with the assumption of semi-ballistic trajectories and a specific impulse of 400 seconds [Ref. 6]), became a new military and top secret technical report, entitled, *Über einen Raketenantriebe für Fernbomber* (*A Rocket Drive [i.e. Rocket Engine—ED.] for a Long Range Bomber*) [Ref. 3]. This unique technical document was created by Sänger and Bredt in 1941 and was submitted for approval on December 3, 1941 to the LFA Hermann Göring and, after this, to be forwarded to the Reichluftfahrtministerium (State Ministry for Aviation) in Berlin. The answer arrived in autumn 1942: the authors had to stop their work on the development of the 1,000 kN thrust rocket engine.

Dr. Sänger and his main contributors were allowed to continue their scientific work on ramjet propulsion, but under the leadership of the Deutsche Forschungsanstalt für Segelflug, or DFS (German Research Institute for Gliding Flight) at Ainrung.

The Ainrung Period

To understand Dr. Bredt's preoccupations in that period, we must remember the Deutsche Wehrmacht [(German Army)—ED.] General Staff visit in 1940 to Trauen. The subject of this visit was to define the ways for a German superiority in the air war. Then, Dr. Sänger suggested equipping German fighter planes with ramjets. This suggestion was accepted and Dr. Sänger consequently rapidly initiated a ramjet project. The test ramjet was installed on the fuselage of an old Dornier Do-217 obtained by Captain-pilot Paul Spremberg, a specialist from the Rheinmetall Company [Ref. 9].

Weighing 12 tons, the old Do-217 had a ramjet tube on its dorsal part. With Spremberg and Sänger at the controls, this plane performed the first in the history

of aviation—a half-an-hour flight of an airplane with such an engine. The spectacular successful ramjet was 6 m long and a diameter of 1.5 m. The flight test was reported directly to Berlin. But, the participants in this experiment were rewarded with a reprimand—because the Research Office of the Ministry of Aviation had not approved of such a flight.

Dr. Sänger, and Bredt as his first assistant, were transferred to Ainring (the province in Upper Bavaria) to continue their work under the different leadership of Prof. Walter Georgi, Director of the OFS. There, Dr. Bredt was promoted to Senior Researcher at the Special Propulsion Center of the Institute and she became in charge of evaluating the ramjet aircraft's performance.

In one of her papers, Dr. Bredt uncovered the real motivation of this order—"punishment," that referred to Dr. Sänger's immediate superior in the LFA to stop [i.e. divert his attentions from—ED.] his work on the development of the 100 ton thrust rocket motor for the "Antipodal Bomber." [the "Silver Bird"—ED.] [Ref. 6]

At the Ainring Institute, Dr. Sänger and Dr. Bredt convinced Dr. Georgi to print, on September 22, 1944, a very short variant of their report, that is, a secret excerpt of the *Raketenantrieb für Fernbomber*. Their tenacious preoccupation for this edition was determined by: (1) The scientific value of this first elaboration on the basis of a new aerodynamics of rarified gases, where the forces of an in-flight space plane were entirely different; and (2) their priority concerning a new solution of the de-orbiting of a space plane using a semi-ballistic flight technique later known as "Ricochet-tier" flight, when the space plane ricocheted from the denser layers of the atmosphere, like a stone flung at a flat angle across the water surface. In this way, it could obtain gliding flight paths that were several times longer than the range obtained using mere aerodynamic descent [Ref. 6].

Also, Bredt appreciated that: "...some of the 70 distributed copies of this secret report on rocket propulsion for long distance bombers had fallen intact into the hands of the Allies..." [Ref. 6]

Dr. Bredt also helped Sänger to develop a contract and complete the calculations on the thermodynamic theory of the ramjet engine. She was placed in charge of working up a flight schedule and recording the performances obtained by the Do-217 equipped with a functioning ramjet engine and piloted from the Hörschung Airport by Paul Spremberg.

This courageous pilot had climbed very fast (from 10 to 30 minutes) at 7,000 m and reached 1,500 m. Dr. Georgi's representative, Fritz Stamer—the first man who piloted a rocket plane (in 1928)—was completely astonished. [In 1928, Stammer test flew a glider equipped with Sander solid-fuel rockets—ED.]

In 1944, Dr. Bredt helped Dr. Sänger to elaborate his technical report for the Ministry of Aviation in Berlin: using the ramjet engine results, he demonstrated the possibility of supersonic flight. (Someone from Berlin having probably a high position, wrote the following judgement of Dr. Sänger's report: "What kind of imbeciles! At such a speed, it will not be possible to fly, nor to aim at a target..." [Ref. 9] No comment.)

The Post World War Two Period

Being residents in the French zone of occupation of post-war Germany, Drs. Sänger and Bredt were celebrated and invited (in 1946) by the French Ministry of Aviation to work as scientific researchers at the Aeronautical Arsenal of France, at Paris-Chatillon [Ref. 9]. This old Arsenal later became SFECMAS under the leadership of the Société Nationale des Constructions Aéronautiques (SNCA du Nord—or Northern National Society for Aeronautical Constructions).

Up to 1954, Irene Sänger-Bredt (as mentioned, she married Dr. Sänger in 1951), was also a consulting engineer to the French rocket manufacturing company MATRA at Paris, Billancourt division. Together with her husband, Dr. Sänger-Bredt suggested rocket combustion chambers with cooling channels. They also conceived an under pressure air mixer for combustion gases of the burners and rockets. Furthermore, they proposed a device able to utilize the Doppler effect for a precise determination of the burning gas temperature and speed. Also, they jointly developed a theory of the injection with a nozzle with wrinkles, a hypothesis on the appearance of a luminescence in the burning process, a theory on the explosion of solids, and they studied the reactions of the thermal nuclei.

Dr. Sänger-Bredt helped her husband to carry out the scramjet aerospace transporter concept, dedicated by its discoverers to the future of air traffic. Dr. Sänger tackled the problems of future commercial transports as an intermediary field between aviation and astronautics and demonstrated that the solution will be by international cooperation. Also helped by his wife, Dr. Sänger discovered the principle that assured the successive growth of the aircraft's speeds to those of future spacecraft.

In that period, we must remember the following studies and scientific papers, elaborated by Dr. Sänger with his wife's cooperation:

- *Gemischtauf bereitung on Stationaren Feuerungen (A Mixer for Preparing Static Burning Chambers)*, Paris, 1948.
- *Ionisation und Lumineszenz in Flammen (Ionization and Luminescence in Flames)*, Paris, 1949.
- *Thermodynamik der Überschall-Gerät stoss diffusors (Thermodynamics of Supersonic Nozzles Having Right Shock Waves)*, Berlin, 1954.
- *Stationars kernverbrenung in Raketen (Stationary Nucleus in the Burning Processes inside the Rocket Engine)*, Vienna, 1955, et al.

In 1952, Sänger's family came back to Germany, Dr. Sänger being in charge for creating, at Stuttgart-Pfaffanweld, the new German Institute for Physics and Reactive Propulsion. As it was detailed in an earlier paper, the concept of photon rocket propulsion belongs to Dr. Sänger, helped by Irene Sänger-Bredt. After a joint paper titled *Zur Strahlungs Physik der Photonenstrahlantriebe (On the Physics of Radiations for Photon Emission Propulsion)* carried out in 1957 (at Munich), Dr. Sänger edited the 1959 fundamental work on this subject, *Zur Richtprobleme der Photonanstrahlantriebe (On the Principles of Photon Emission Propulsion)*. The two scientists concluded that this unconventional rocket could be a future space engine.

In the 1951-1958 period, Sänger-Bredt was the external professor at the Aerodynamic Faculty of the Institute of Technology in Chromepoy-Madras, in South India. As a Deputy Scientific Director of the Pfaffenwald Institute (1954-1962), she also expanded the research schedule of the Institute and participated in its reconstruction. From 1963 to 1972, she served as an external engineer counselor for spacecraft at Junkers Inc. (today, MBB-Munich). In all these periods, Dr. Sänger-Bredt published many scientific papers and books.

Sänger-Bredt's Honorary Functions

Sänger-Bredt's honorary positions included the following:

- Scientific Director, member of the Scientific Council of the German Society for Rockets and Spacecraft (1958-1967)
- Scientific Director for publishing *Raumfahrtforschung* (1959-1973)
- Founder member of the International Academy of Astronautics (1959)

- Member of the *Astronautica Acta* Council (1960-1965)
- Member of the German Society for Rockets and Spacecraft Council (1960-1969)
- Member of IAA and IAF Committees for publications (1961-1970)
- Member of DGF Culture Commission, ZLDI Committee, and Eurospace (from 1961)
- Member of the IAA Committee on History and Development of Astronautics (from 1963)
- Member of the *Flugwelt Review* Editorial Committee (1963-1968)
- Member of the Editorial Committee of the *Advances in Space & Technology Review*, Huntsville, Alabama (from 1964)
- Member of the Edition Council of the journal *Flugwissenschaft* (from 1957)
- Member of the DGLR and the *Raumfahrtforschung* journal committees from 1967)

In addition, Dr. Sanger-Bredt was an honorary member of the following scientific institutions:

- The Swiss Astronautical Society, Zurich
- The Space Research Society, Germany
- The German Society for Rockets and Spacecraft, Stuttgart
- The Hermann Oberth and Wernher von Braun Society, Hanover
- The German Society for Aircraft and Spacecraft, Cologne
- The International Academy of Astronautics

In 1970, she was honored with being awarded the Hermann Oberth Gold Medal for her impressive scientific activities. Dr. Sanger-Bredt was a very active woman in other areas as well; she loved architecture and gardens, antiquities, target shooting, and research into pre-history.

Conclusions

Dr. Irene Sanger-Bredt's impressive contributions to space science may be summed up as follows:

- She contributed to Eugen Sanger's foundation of a new aerodynamics of high altitudes where the distances between air molecules are suitable only for a space plane.
- She worked together with Dr. Sanger on the rocket-powered Long Range Antipodal Bomber project, laying the foundations of the Single Stage To-Orbit (SSTO) technique of launch vehicles.
- She directly contributed to a new de-orbiting method for a space plane in helping work out calculations for the ricocheting of Sanger's Antipodal Bomber on high atmospheric layers.
- She helped Dr. Sanger elaborate upon ramjet and photon rocket theories and also opened up the possibilities of the scramjet engine.
- She was an active founder of the International Academy of Astronautics.

Acknowledgements

The authors devote this paper to the memory of Prof. Dr. Eugen Sanger and Dr. Irene Sanger-Bredt and presented it in 1999, 35 years since the edition of their famous study entitled *Zur Richtprobleme der Photonenstrahlantriebe (On the Principle of Photon Emission Propulsion)*.

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