ORIGINS OF ASTRONAUTICS IN SWITZERLAND+

Alfred Waldis (Switzerland)++

Switzerland has no claim to a pioneering role in astronautics, nor is our country among the leading nations in this field today. Also, Swiss contributions cannot be measured on the scale of those made by larger countries. Yet, on taking a closer look, one discovers some daring and way-breaking thoughts and experiments originated by Swiss scientists and researchers.

The task of setting a date on the origins of modern astronautics can be rather difficult. As part of the natural sciences, astronautics built upon all of the major mathematical, physical, and chemical principles—all closely related to most other branches of research. Two early Swiss scientists, for example, made basic contributions to astronautics: Daniel Bernoulli, a mathematician from Basle, with his principle of flow (Hydrodynamica, 1783), and Leonhard Euler (1726) with his textbook on differential calculus.

Legend has it that each of the famous Bernoullis lived in the hope that he would create an abstract mathematical principle that had absolutely no application. Five of them died disappointed; someone always found good use for every concept they produced. The sixth one, it is said, died happy because he thought he had finally produced a principle that was thoroughly useless. That was the theory of the solution of simultaneous equations (now the basis of so much of our advanced mathematics in daily use all over the world). Whether or not this legend is apocryphal, it does illustrate a point to be kept in mind: any mathematical discovery, in the long run, will likely contribute to the solution of some problems that are the concern of man.

Before reviewing the modest contribution to astronautics made by our small, neutral country, it would be useful to mention the reasons why space technology to this day has not attained its due recognition in Switzerland.

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++Director, Swiss Museum of Transport, Lucerne, Switzerland.

- In larger nations, the development of launch vehicles for artificial satellites and space probes was made possible largely by armament or highly-specialized aeronautical industries. In the period during and immediately after World War II, Switzerland had neither an armament nor an aeronautical industry capable of such a task.
- Aerospace developments in today's leading space nations depended on substantial government grants or subsidies. Switzerland traditionally relies entirely on private industry for applied research. It was not possible, within existing laws, to create a national space program providing the necessary funds for even a modes research program.

In his opening address at the Fourth Congress of the International Astronautical Federation in Zurich in 1953, the well-known Swiss professor of aerodynamics, Josef Ackeret, very accurately summed up the essential considerations for the cooperation of individual researchers and small nations in space projects: "For young enthusiasts the situation is frustrating. While in aeronautics one or a handful of amateurs can by themselves build at least some primitive kind of flying machine with which to experiment, this is all but impossible in astronautics where activities seem to be restricted to 'theoretical hobby craft.' Real development work," Professor Ackeret continued, "can only be realized on a truly large scale. And this scale is bound to be so big that not even the largest companies, let alone private individuals, could embark on the venture. Here, an entirely new form of teamwork is required. Each nation and each individual must fit in a scope within which he can make a useful contribution." These thoughts suggest the limits to the range of space activities in my country to the 1950s.

FIRST STRATOSPHERE FLIGHT

One of the pioneers who tried to widen this dimension was the experimental physicist, Professor Auguste Piccard. Let us examine a few interesting details of Piccard's historic balloon high-altitude flight of May 27, 1931. This event captured world attention in a high-altitude flight for scientific research. Together with Engineer Paul Kipfer, Piccard ascended to nearly 16,000 meters to conduct radiation measurements. The spheric cabin was made of 3.5 mm-thick aluminum plate, and consisted of three forged parts assembled by autogenous welding. Eight vertical supports in the interior formed the frame and supported the crew. Professor Piccard's ascension had its dramatic moments.

At take-off, a sudden gust prematurely swept the balloon out of the hands of the launching crew before the take-off weight was under control and the instruments properly stowed away. Adding to the troubles, the revolving device for the cabin did not work; as a result, the dark outer side was exposed to direct sun light, while the reflecting aluminium side remained in the shade. Temperatures in the upper part of the cabin reached 41° C, while the researcher's feet froze in -10° C. Professor Piccard made the following entry in his log-book: "The situation is serious. There are various dangers. We shall not be able to time our landing as we choose (the valve line had not unwound properly). If there is a leak in the cabin, we shall die of suffocation. It depends on the wind if we drop into the Adriatic to-night or have land below us." Leaks in the cabin actually occurred several times and had to be repaired in a hurry. The scientific measurements were considerably complicated by this fact. At 9 p.m. the cabin carrying the two scientists hit the ice of the Gurge glacier.

AERODYNAMIC CONTRIBUTIONS TO ASTRONAUTICS

In the field of aerodynamics at high speeds, as applied in rocket technology, Professor J. Ackeret has been Switzerland's leading scientist. His basic paper of 1928, "Air Resistance at Very High Speeds," not only gave an excellent survey of the state of this particular field at that time, but suggested a program of future research. Ackeret was convinced that the future of manned flight lay in aerodynamics of highest speeds. It was he who coined the term "Mach Number" in honor of the celebrated physicist, Ernst Mach. Ackeret wrote: "In aerodynamics of higher speeds, the proportion v/a comes up time and again (v = speed of the examined body, or the airflow, respectively; a = speed of sound). A short term therefore seems indicated. Since the well-known physicist Ernst Mach recognized the basic significance of this proportion with particular perception, v/a may justly be termed 'Mach Number.'" "Mach" has been used ever since in scientific language as well as in popular texts.

Ackeret decisively influenced the development of aerodynamics of high speeds with his publications on gas dynamics, aerodynamic forces on wings, boundary layers in compressible flow, and rocket theory. He began to read on rocket technology in 1941-1942. His paper, "Comments on the Rocket Theory" (see references) finally marked Swiss engagement with questions of space. To Ackeret's way of thinking, such a step was a natural conclusion, and he later gave the opening address at the Fourth Congress of the International Astronautical Federation in 1953. In 1956, he published an article on the "Limits to the Attainability of Remote Celestial Bodies." In it he observed: "The majority of the following remarks were written several years ago, but remained in a drawer, since the conditions for attaining high speeds (comparable to the speed of light) seemed to me all too vague." From mathematical-physics he drew these conclusions: "It becomes clear, therefore, that despite the most daring assumptions, we can no longer think of space travel beyond the nearest fixed stars. A journey of this kind would only make sense if it could be hoped to discover and observe unknown planetary systems. Perhaps forms of life—very different from ours—could be found there. Thus, biology could gain from such a discovery. But one must ask whether more is not to be gained by terrestrial research which actually is only on the threshold of exploring life. Astrophysically, the yield would presumably be modest, since 99% of the substance is in the form of gas. An astronomical observatory on the Moon will furnish all the results that can be expected in this regard. So we may have to resign ourselves to the old saying:

"To tread upon the infinite,
keep going in all ways of the finite."

The construction of the first large closed-circuit transonic wind-tunnel at Professor Ackeret's Department of Aerodynamics of the Federal Institute of Technology in Zurich, in 1933-1934, caused a sensation in scientific circles and opened the way for much more work in the field of rocket aerodynamics. Two papers appear representative of the great number of publications: "To the Theory of Aerodynamic Forces on Slim Profiles and Slim Bodies of Revolution," by H. R. Voellmy, and "Of Toroidal Wings," by Z. Plaskowski. Here, K. Iserland's experiments in 1952 with thrust reverse must also be mentioned. He placed a number of semi-toroidal turn-back rings at the end of a rocket nozzle. Before being ejected from the nozzle, the gas jet is set spinning by a circle of revolving blades. As a result of the centrifugal load, the jet spreads out, hits the rings and is turned back by them. If the blades are set in the direction of flow, keeping the jet free of spin, the gas is ejected from the nozzle in a straight line and flows through the centre of the rings, without changing direction (Figure 1).

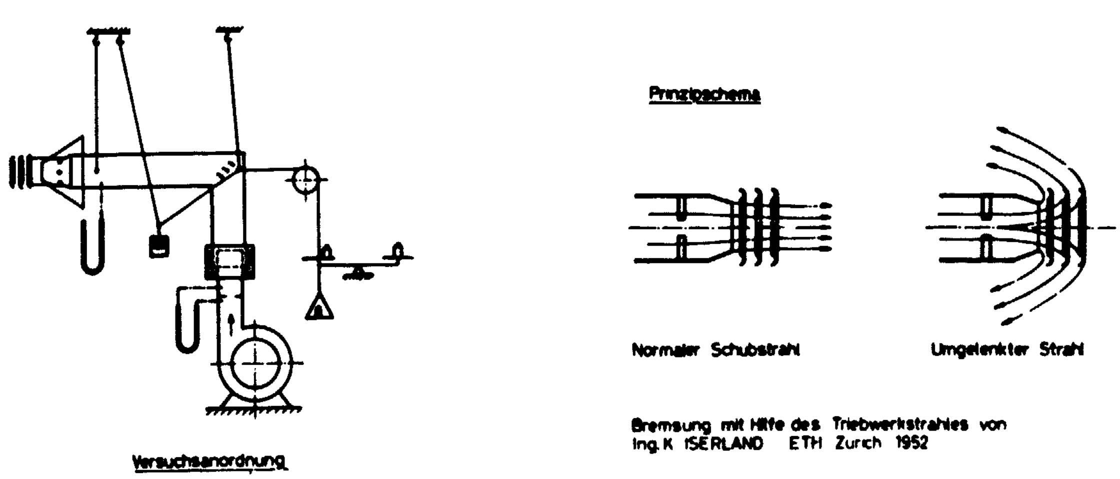
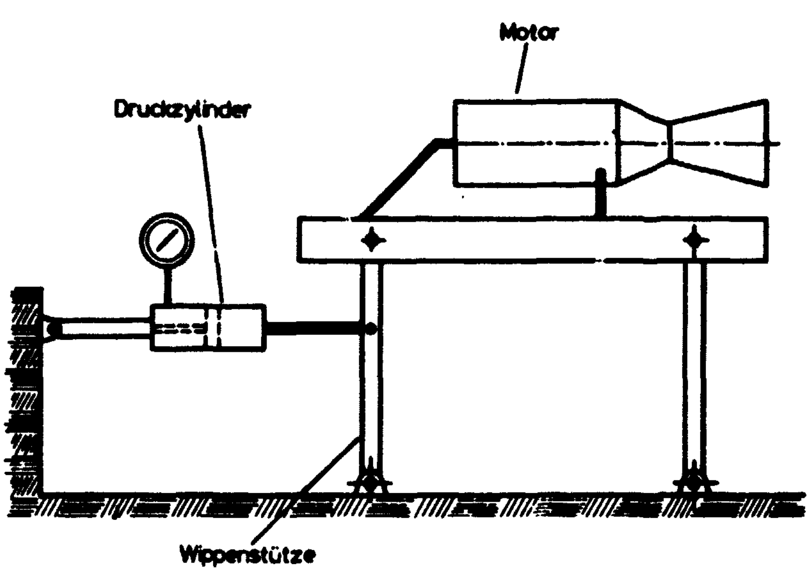


Fig. 1

ROCKET EXPERIMENTS

Another farsighted Swiss pioneer in the field of rocket propulsion was the engineer, Josef Stemmer. After many minor experiments beginning in 1925, he succeeded in 1934 in realizing what he called "a reasonably successful form" of test stand for a reaction thrust engine. In the period between 1934 and 1945, Stemmer build various rocket engines and test stands. The first experimental rocket engine had two combustion chambers and two ejection nozzles. Propellants were injected separately from the nozzle side in the opposite direction of flow. Given very limited funds, Josef Stemmer's experiments had to be carried out on a very modest scale. With the exception of the combustion chambers for the first test stand which came from an old two cylinder Mercedes gasoline engine, all the parts he used, such as combustion heads, injector and ejection nozzles, were home made (Figure 2). His second rocket engine propelled a model airplane. A third



Raketen-Prüfstandschema von J. STEMMER 1945

Fig. 2

was fitted with a mixing injection nozzle and a special cooling jacket. It served to study problems of cooling and fuel. The fourth rocket engine had a changeable combustion chamber and a special coolant supply system. It was used to test ejection nozzles and to determine the duration of gas presence.

Stemmer continued his experiments with flying models and test stands until 1945. In a series of publications entitled "The Development of Rocket Propulsion in a Generally Understandable Presentation" (1945), he proposed a development program intended to be applied on a larger national scale. In 1951, Stemmer was appointed Secretary of the International Astronautical Federation. At the end of the same year, he founded the Swiss Astronautics Association.

SPACE SCIENTISTS

Beginning in 1932, another Swiss scientist, Professor Dr. Jakob Eugster, concentrated his studies of the effects of cosmic radiation. His investigations were first conducted jointly with Victor Hess, who discovered cosmic rays on his balloon flights in 1912. The studies were pursued at Innsbruck (Hafelekar, at 2340 meters altitude, and in the former salt mines of Hall), and, after 1937, at Fordham University in New York. These studies concentrated on the effects of cosmic radiation on unicellular organisms and on healthy and diseased human tissue, and, more recently, in physiological form, with astronauts. Since 1950, a special observation station for biological controls has been operated in the interior of the Simplon tunnel. Professor Eugster used the so-called "sandwich method," in which the objects to be examined--seeds of plants or ova of small animals for instance--were placed in the cavities of a plexiglass screen-plate. This preparation was fixed between two photo-plates with nuclear emulsion. The package was then enclosed in a light protection wrap and transported to high mountains, or attached to stratospheric balloons, or carried to high altitudes by rockets. After exposure, the photo-plates were developed; the traces left in the emulsion helped to evaluate the exact location of the hits in the biological matter. The untiring effort of this scientist is reflected in over 100 original publications.

Alfred Stettbacher involved himself with the chemistry of rocket propellants and the production of explosives, among them the most violent of all, "Pentrinit." In his book on explosives published in 1933, he clearly predicted the use of rockets as long-range weapons "in the next war." Another work, published in 1948, included a chapter entitled, "The Rocket or the Long Range Shot," describing the various rocket propellants and adding comments on rocket ballistics.

After the Second World War, rocket development was taken up by Swiss private industry. At that time, solid propellant rockets of up to 350 m/s speed were considered "high speed rockets." In these developments, one tried to achieve speeds of over 600 m/s, with the result that conventional projectile heads were no longer suitable aerodynamically. Consequently, new forms of solid propellant rockets were developed that could be launched with particularly high precision and with a minimum of air resistance. Initially, fully fixed tail units were used, replaced later by adjustable (flap-back) tail units.

Development of a Swiss remote control rocket started in 1946. Aerodynamic tests with this rocket led to the addition of tail unit surfaces for guidance control after completed combustion, and of longitudinally shiftable wings to control changes of the center of pressure. In the course of wind tunnel tests a special measuring device was developed. It worked on the principle of an analogue computer, and helped to reduce wind tunnel tests to a minimum.

Table I, though incomplete, indicates the activities of Swiss scientists in various astronautical fields. This work indicates some of the state of research and the infrastructure for industrial production of parts, components, and complete structures for use in space. This basic research has enabled Switzerland to produce a high-altitude research rocket, developed by Contraves that reached an altitude of 300 km. Satellite structures have been successfully built, and quite a number of components for space vehicles and rockets prove Switzerland's ability to meet sophisticate requirements in specialized sectors. Most Swiss universities are engaged in some type of space research, if only on a small scale, and thus carry on the effort from modest beginnings.

A great many Swiss scientists who were unable to realize their research projects at home have engaged their knowledge and work in American space programs. Representative of these are Fritz Zwicky, Professor of Astrophysics at the California Institute of Technology, and Dr. H. U. Schürch. Professor Zwicky is known as the "Father of Ultra High Energy Propulsion." He succeeded in 1957 with Project Meteor, in placing the first artificial meteorites in deep space.+ Schürch successfully built a variety of satellite structures.

On the other hand, prominent foreign scientists pursued studies at institutions of higher learning in Switzerland before achieving success in the United States. Among these are Wernher von Braun, who studied with Professor Ackeret at the Federal Institute of Technology (F.I.T.) in Zurich in 1931; Professor R. Bisplinghoff and Dr. John C. Houbolt, who both defended their thesis on technological subjects at our F.I.T. in Zurich. Dr. Bisplinghoff, the Dean at the Massachusetts Institute of Technology, also served in NASA. Dr. Houbolt is known in modern space technology as the "father of the rendezvous technique" used in the Apollo program.

How much Switzerland may contribute in solving aerospace problems in the future remains a question of government support. Today, it does not have a national space

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+See Fritz Zwicky, "A Stone's Throw into the Universe: A Memoir," in this volume - Ed.

program. Our parliament is debating grants for ESRO high altitude research and satellite projects. Despite frequent disappointments, the pioneering spirit--shown by Jakob Bommeli of Zurich who lectured on "A Flight Through the Universe" in 1897--has not left Swiss engineers and scientists. But as long as funds are unavailable for the realization of even modest projects, their activities remain limited.

In conclusion, the author must add here sincere thanks to these who contributed to this report, particularly Engineer Eugen Erni of the Institute of Aeronautical Structure and Lightweight Design of the Federal Institute of Technology in Zurich.

TABLE I

Zusammenstellung schweizerischer Wissenschaftler und Forscher die sich bis in die 50-ziger Jahre mit Raumfahrtforschung beschäftigt haben.

Aerodynamik, Antriebe und Energiequellen	Raketenversuche und Raketenentwicklung	Physik der Atmosphäre Erforschung der kosmischen Strahlung	Raketentreibstoffe
Ackeret	Stemmer	Piccard	Stettbacher
Plaskowski	Industrie:	Kipfer	Brunner
Voellmy	Gerber	Eugster	
Gerber	Voellmy	Waeffler	
Iserland	Iserland	Töndury	
Hösli		Jenny	
Grossmann			
Desmeules			
ETH-Zürich		Universität Zürich	
Institut für Aerodynamik		Physikalisches Institut	
Institut für Physik		Physikalische Anstalt Basel	

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