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Chapter 3

Reflection of the Technical Developments of the Group "Raketenflugplatz Berlin-Reinickendorf" in the Literature and Historical Sources*

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Abstract

The group, Raketenflugplatz Berlin-Reinickendorf, led by Rudolf Nebel (1894–1978) was the last of the teams working in Germany as a private organization. It was developing rockets and liquid-propellant rocket engines. For the number of its employees and the amount of rocket designs developed by the group, it stood out from other German rocket engineers, realizing experimental programs and financed by private capital. So, no wonder, that numerous publications on the history of German rocketry to some extent featured the results and the work itself, which was being carried out on Berlin's "rocket launch site." Analysis of the data and conclusions contained in the literature proved that they are often fragmentary, contradictory, and inexact.

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The Literature Review

The history has been reflected in dozens of literature publications. The earliest of these publications date back to the 1930s.[1] The works of German and American authors, such as Werner Büdeler, Frank-Erhardt Rietz, Frank Winter, and Michael Neufeld stand out from other publications for the problems which have been discussed there and historical sources used for these literary works.[2] The source base on which these authors reconstructed the history of the group is shown by numerous published and archival works. Winter is distinguished by using documentary items taken from the archival collections of Willy Ley, Rolf Engel, Wernher von Braun, Herbert Schäfer, Edward Pendray, and also verbal memoirs of some ex-employees of the group. Neufeld considerably extended the range of known historical sources by using documents that throw light on the history of contacts between Nebel and Heereswaffenamt (HWA). Side by side with the materials that have reflected the contracts of the group with the administration of Stadt Magdeburg, Rietz used numerous photo documents, including rare and little-known ones.

The Review of Historical Sources

Hundreds of well-known literature historical sources reflect the history of the group. The majority of these sources consists of written and photo documents. The smaller part is interviews. They are all kept at the Imperial War Museum; Bundesarchiv/Militärarchiv Freiburg (BA/MA); National Air and Space; and the Deutsches Museum. It is not possible to estimate the volume of all the saved technical documentation (working drawings): about 20 working drawings (which are kept at the Deutsches Museum) need some restoration work, and they were inaccessible for this investigation.

It is known that a documentary movie was made at Raketenflugplatz in 1931 (between August and October 1931)[3] in honor of the first anniversary since the day of the opening of the proving ground. This film has been shown in movie theaters as *Ufa Tonwoche Nr. 60.* Probably Nebel had a copy of this film. The location of any copy of this movie is unknown. There are only some known fragments of it and also some sequences of the film that show a launching of the last rockets that were built by the group and was included in the movie *Raketenflug* (1944). (The original version of this movie is kept at BA/MA; copies are private property of different people.)

The search for new historical sources was carried out for 10 years by Karlheinz Rohrwild and gave an opportunity to extend the range of known documentary materials. There are some not so well-known documents, such as the correspondence of Hermann Oberth, located at the Stadtarchiv Gemeinde Feucht; some photo documents, diary notes, and technical drawings that belonged to Herbert Schäfer and placed in the Hermann-Oberth-Raumfahrt Museum not long ago; and a photo album from the personal archives of J. Wagner.

It is necessary to keep in mind that despite the fact that historical sources contain a lot of information that reflects the process and the results of the work of Nebel's group, this information is not full enough. It depends on the nature and role of the documents.

Memoirs

It is necessary to take some facts into consideration: the subjective estimate of the role of authors of the memoirs in described events, and the amount of the information they had about details of events. For example, the memories of von Braun and Ley cannot be full enough (the events of the end of 1932–1933) because von Braun left the Nebel group in the fall of 1932, and Ley did not have strong contacts with the group, because Nebel finally separated himself from Verein für Raumschiffarhrt (VfR). Engel's recollections are also subjective and not full, because from the fall of 1931 he was working with J. Winkler. Nebel's recollections are too subjective, which is already marked in the literature. The recollections of Schäfer for the second part of the 1930s are more interesting, full, and exact, because they were based on his diary notes.

One of the important historical sources is press materials, such as Ley's articles in magazines and his reports in *Mitteilungen des Vereins für Raumschiffahrt,* which took the place of the magazine *Die Rakete. Mitteilungen des VfR* was published from March 1930 until April 1934. *Raketenflug,* published by Nebel, was the official publication of Raketenflugplatz Berlin. It was published from January 1932 until May 1934. Ley's and Nebel's materials are characterized by the publicity orientation and the superficial and brief statement (description) without technical details.

There is a big potential for photo documents, which has not been used yet as much as it could be.

The analysis of the literature of the history of Nebel's group and the study of the whole complex of historical sources led to questions that should be investigated deeper (in detail), such as staff, division into periods of the group's activity and the peculiarity of each period, grounding of the group members in the practical works in the first stage, equipment of the group with machinery and appliances, and basic results of the practical activities of the group.

The Staff Crew

According to Ley, from the summer of 1931 after a successful launching of the first liquid-propellant rockets, the staff grew, and sometimes up to 16 people were busy on the site. "From this time on was quite extensive—the staff grew, sometimes sixteen people were busy out there at the Raketenflugplatz."[4] Probably Ley identified this number of people based on one of the group photos of Raketenflugplatz employees taken in July 1932.[5]

The work at the site paralleled with constructive, creative, and experimental activities also contained some technical paper work, manufacture, and construction work. Based on this fact, it is possible to talk about two basic groups of employees—technical engineering (notice) and auxiliary/subsidiary staff.

Rudolf Nebel and the rocketmen, who had been working from the beginning of the practical work on the site, were the backbone of the group, such as Klaus Riedel (1907–1944), Kurt Heinish (1910–1991), Hans Bermüller, Paul Ehmeye,[6] and Wernher von Braun (1912–1977). There were also Helmut Zoike (1915–) and Wörl among the employees of "the first wave." Later, in April 1932, Hans Hüter (1906–1970) and Herbert Schäfer (1911–1999) joined the group. H. Dix, Werner Dunst, Kurt Prill,[7] and Obering. Richter and Dr. von Ludviger became employees of the group (probably) somewhere in 1931–1932. Some years ago it was learned the name of who was working in the group from 22 March 1932 until 14 December 1932 as an engineer. The question about Rolf Engel's taking part in the work of the group needs particular consideration. He talked about himself as an employee of the group until February 1932, when he started working with J. Winkler. Actually Engel was present on the photos of February, April, and May 1931. But it is difficult to say exactly whether he really was a direct participant in the work or if he was just one of the private visitors who were interested in the proving ground.

While Nebel was responsible for the organization and providing financial support for the group, Riedel was controlling the technical side of the work. The leading part in development of the first models of engines and rockets, which had been working on fuel and successfully passed the tests on the rocket launch site or in the sky, belongs to Riedel also. Hans Hüter made a valuable contribution to the developing of engines with thrusts of about 200 kilograms.

The names of employees from auxiliary parts of the group who were involved in the work from the group Raketenflugplatz Berlin are not as well known. It is possible to recall only some young ladies in the group: Fr. Bela, Fr. Herkt.

Periods of Group Activity

It is not so difficult to determine the final date when the group stopped existing—the summer of 1934. The reasons and circumstances under which it happened were elucidated in the literature and were well known. It was the integrity of the private researches in the program of the work that were being carried out in the Army administration. This integrity was stipulated by the aspiration of servicemen for the monopolization of rocket industry. Such a situation was being partly explained by the necessity of keeping strict confidence.

It is more difficult to answer the question when the history of the group began. It is clear that the history did not begin on 27 September 1930 when the group got its own proving ground suitable for experimental programs, but it was begun much earlier. Probably it might be the beginning of 1930 when Nebel, being formally the representative of Oberth, pursued a course of independent work in the sphere of rocket engineering. According to practical works that were being carried out by the group, there are five basic periods of its activity:

1. from January 1930–June 1930 (the design and manufacture of the first liquid-propellant rocket (model Mirak)
2. from July 1930–end of 1930 (experiments with liquid-propellant rocket engines and rockets of the type Mirak 1 and Mirak 2)
3. from the beginning of 1931–July 1932 (rocket engines with a thrust of 30–60 kilograms, and rockets of the type Zweistaber and Einstaber)
4. from August 1932–September 1933 (developing and testing of rocket engines with thrusts up to 200 kilograms and also the rockets with these engines, projecting of a rocket engine with thrust up to 600 kilograms, and a rocket with carrying capacity up to 100 kilograms for a flight at an altitude of 1,000 meters)
5. from October 1933–spring of 1934 (theoretical work).

During the first months of 1930, Nebel's group consisted of one person and this person was Nebel himself. There are some statements in the literature that Riedel began his practical work with Nebel in the fall of 1929 when they both took part in experiments with liquid-propellant rocket engines that were carried out by Oberth. Riedel, in his brief autobiography, dated the beginning of his work "in a private working staff (work collective) . . . at Raketenflugplatz Berlin." It was 1 October 1929.[8] But at that time there was neither Raketenflugplatz Berlin nor Nebel's group. Riedel probably meant his joining Verein für Raumschiffahrt. K. Riedel's name is seen on correspondence between J. Winkler and

E. Wurm[9] dated from 22 October 1929 to 26 October 1929 and also in the minutes of the conversation among Oberth, Winkler, and Wurm on 3 November 1929.[10] As far as it was possible to understand, they were talking about an interesting suggestion that Riedel had made in written form and which was the reason Winkler asked Wurm to make some arrangements as soon as possible. It is even difficult to guess what kind of offer Riedel had made, but it is totally impossible to connect it to the practical work of Oberth in the fall of 1929. It seems more true to fact that the opportunity to help Oberth with his tests of engine plants was given to Riedel and Heinisch (who also joined the staff of Verein für Raumschiffahrt in October 1929) for the first time in June 1930. The beginning of their own practical work in the sphere of rocket engineering dates to August 1930, when they tested the rocket Mirak (Nebel's design).

How much practical experience in the work with models of liquid-propellant rockets and rocket engines did Nebel have in the beginning of 1930? This question seems strange because in the literature it says that Nebel had taken part in Oberth's work from the beginning. That is why in many literature publications Nebel is called "the first assistant" of Oberth. But a proper investigation of all available historical sources gives another opinion about this question. According to the information from these sources, one can imagine the circumstances under which Oberth carried out his experiments in 1929, the nature and the results of these experiments in another way from that given in the literature publications. The authors have drawn some basic conclusions from their research.

- Although the treaty between Oberth and Ufa about the financial support of his experiments with liquid fuel rockets was officially concluded on 17 July 1929, unofficially Oberth started working in this direction in May 1929. On 15 November 1929 Oberth stopped the work for a while, and this day became the last one in the history of his practical work with Ufa. So this work lasted for about six months.
- There was only one assistant who worked with Oberth during all this time. It was A. B. Scherschevsky. Today there are many reasons which make one doubt the story that he was fired because of his laziness. Reliable sources have the information that he was still busy with the work on 28 October 1929 and after Oberth's departure on 17 November 1929 from Berlin. With Nebel he continued the tests, and he informed Oberth of Nebel's actions in his letter of 1 December 1929, which was signed along with Ley.
- Apparently an unpleasant incident between Oberth and Scherschevsky occurred. The reason for this incident was a reproach spitted out to

Scherschevsky in "his relations with certain people," but it is difficult to say exactly who was meant—Scherschevsky knew a lot of people, not only in Berlin. It is clear, though, that the reason for this reproach was fear of spreading some information about Oberth's works. It is also clear that the incident was settled, because Ley, who initiated the incident (1 December 1929), was convinced of "Shura's recovery" from undesirable relations.

- Parallel with Scherschevsky, Nebel had become the second Oberth assistant on 18 October 1929. It meant that he was working with Oberth for about four weeks and all of Oberth's basic experimental achievements—the development and test of liquid-propellant rocket engines—had been carried out in Nebel's absence.

- During four weeks of the work directly controlled by Oberth at the same time with Scherschevsky, Nebel participated in (1) aerodynamic experiments with small wooden and aluminum models,[11] (2) the start of a powder rocket equipped with a parachute for the purpose of testing the mechanism of its opening on 28 October 1929,[12] and (3) the development of the "experimental rocket No.1/model 2"—one of two high-altitude rockets planned by Oberth[13]—which have gone down in history as "16 *l* rocket." The project and the manufacture of this rocket in some parts was financed by Ufa and (4) included experiments in the sphere of using different kinds of fuel pairs, including benzine and oxygen, methane and oxygen, benzene and nitric acid (it was decided to use benzene and oxygen);[14] and experiments in the sphere of pressurized fuel feed, these tests, which were carried out in special tanks, were accompanied with explosions because of Nebel's mistakes, and they (tests) were not completed.[15] Despite all these preliminary experiments, the project of "experimental rocket No. 1/model 2" consisted of some technical solutions, which were not properly tested—first of all it concerned the fuel feed to combustion chamber (it is no mere chance that Oberth considered an engine the weakest link of the whole construction).

- The relationship between Oberth's assistants (Nebel and Scherschevsky) in the process of work was cool. It is not surprising. Nebel was full of conceit, and Scherschevsky was a much more experienced specialist theoretically (he had an incomplete, but good, higher education—specialty aeromechanics) and practically (the work with Oberth on the experiments that lasted for six months was a good practice).

- During two weeks after Oberth's departure from Berlin, Nebel started active work without official plenary powers. But this work was rather imitating the preparation of the rocket for its start than touching on technical problems. All the arrangements Nebel made at that time, Ley described as "technical nonsense." He meant Nebel's starting unit for the rocket and the design of fuel tanks, which were good for the pressure of 4 atmospheres at a designed pressure of 30 atmospheres in the combustion chamber.
- In December 1929 Oberth was in Berlin again, but the experiments had not recommenced; contrary to the opinion of some authors, the authors of this chapter can insist that the experiments also were not carried out in Stettin in the territory of Second Pionierbatallon, where Nebel had been with experimental equipment waiting for Oberth's arrival. They had not met each other that time, and there was little possibility that Nebel, being totally alone, was engaged in the experiments.
- In the second part of November 1929 there was something strange in Nebel's actions. Ley expressed it, applying to Oberth with the phrase: "He is going to drive you into a corner."

So at the beginning of 1930, Nebel had minimum experience in theoretical and practical questions about liquid-propellant rocket engines and liquid-propellant rockets. But the lack of necessary knowledge was replaced by his desire for being established in the sphere of rocketry. The more so, that Nebel in his situation had drawn a right conclusion from Oberth's works: it was unreasonable to think about a theoretically ideal construction that could be good for a controlled distance flight. It was much better to make an elementary rocket unit with one basic requirement: not blow up, but launch. During only four months (January–April) in 1930, being supported by The Cosmonautic Society, Nebel became one of the well-known rocketmen. In May 1930 Nebel was already on the same level with them because he had his own rocket, which had not been tested, and the promising program of work. Many young people who have been infected by "rocket fever" were interested in this program. They took a great interest in rocketry, so these young people joined Nebel and became the main body of the group.

The first practical lesson of testing the liquid-fuel rocket motors they got from Oberth in July 1930 on the grounds at Chemisch-Technische Reichanstalt. With their own practical experiments and developing their own constructions, they began in August 1930. The man at Raketenflugplatz Berlin undertook numerous experiments. Unfortunately only fragmentary data remains.[16] So the authors saw their task as gathering trustworthy information on Raketenflugplatz experimentation, constructions, and tests.

Here is a tabular summation of the motors and rockets, their tests and flights undertaken at Raketenflugplatz Berlin.

Results of Experiments (August 1930—September 1933)
Rocket Motors

Name	Weight	Fuel	Thrust	Construction Material	Purpose and Tests
Kegeldüse/ Mirak 1 original—Oberth; modified— Nebel	1.5 kilo-grams (kg)	gas 0.25 liter(l) LO_2 1 l	0.4–3.5 kg	heavy copper alloy	in Bernstadt after 20 August 1930 until 11 September 1930
Kegeldüse/ Mirak 2		gasoline 0.25 l LO_2 1 l		heavy copper alloy	Raketenflugplatz in winter 1931 and March 1931
Experimental model	Intermediate stage from Kegeldüse/Mirak to the "egg-shaped" motor. Probably this motor was drawn after Mirak 2 was exploded in the early spring of 1931. There are not any details about its technical data or its tests known.				

Table 1: Motor for Mirak 1 and Mirak 2.

Kegeldüse/Mirak

The combustion chamber, following early ideas by Oberth, was cone-shaped, made of heavy copper alloy. According to earliest descriptions, the combustion chamber of Mirak 1 was without a special lining of any kind.[17]

Name	Length	Weight	Fuel	Thrust	Cool-ing	Construction Material	Purpose and Tests
Motor/ Mirak 3			gasoline 0.25 l LO_2 1 l	8 kg	cooling ribs		Raketen-flugplatz 12 March 1931
0.16/32 the egg; Standard I Constructor —Riedel		250 grams	gasoline 0.3 l LO_2 1 l	25–30 kg for 10 seconds (sec)	static water cooling	Pantal/ Duralumin	Zwei-staber / 1931 Einstaber of the smaller size since March 1931
0.32/64 Aepyornis-Ei Standard II Constructor —Riedel	11 centi-meters (cm)	1.5 kg	gasoline 0.8 l LO_2 3 l	50–60 kg for 20–25 sec	static water cooling (0.5 l water)	Pantal/ Duralumin	Einstaber of larger size at the end of 1931

Table 2: Standard Motors.

Motor/Mirak 3

The third Mirak had a new type of motor, no longer a Kegeldüse.[18] There is not much information about it in the historical sources. The publication of G. E. Pendray, dated May 1931, is without doubt the most important document in this connection. Although it had some "misunderstandings,"[19] the information gathered by Pendray on a trip to Germany in April 1931 contained a lot of details of the earlier constructions of rockets and their motors developed on Raketenflugplatz. According to the unique draft in Pendray's publication, an important change in the motor for Mirak 3 had to do with the shape of the combustion chamber. It was cylindrical, with each end finished in a hemisphere—the so called "egg-shaped." This shape was decided on as a result of tests on the proving stand. It was built of duralumin, with an inner lining of copper. The choke was somewhat greater in the nozzle of this motor than in the others and the ejection tube somewhat longer. The copper lining covered the whole inside, including the nozzle to its end.[20] The motor was expected to develop a thrust of more than 8 kilograms and possibly 10 kilograms and to fire 32 seconds.[21] The amounts of fuel were about the same as in the Mirak 1—namely 1 liter of oxygen and half a liter of gasoline. The nitrogen in the pressure chamber was under a pressure of 10–12 atmospheres; the safety valve at the top of the oxygen tank was set to open at 6 atmospheres.[22] The pressure inside the combustion chamber, due to the greater choke at the neck, was higher than in the Mirak 1–2 and was expected probably to reach 15–20 atmospheres.[23] The other important change in this motor was cooling ribs on its surface, depending on its position. The motor was to be below the bottom of the oxygen tank. It is unclear when the motor was tested. According to Pendray, it had not yet been tested when he was at Raketenflugplatz.[24] It means that the tests of the motor for Mirak 3 took place after 12 April 1931. But a report of Raketenflugplatz itself informed about the test on 12 March 1931. During the testing, the motor burned for about 40 seconds, including 30 seconds constant.[25]

0.16/32[26]

Consuming approximately 160 gallons of fuel per second, it delivered a thrust of approximately 32 (in the main 25–30) kilograms for a period of 10 seconds.

The tests took place after March 1931 on the so-called "large proving stand." The test stand was a heavy angle-iron launching rack, originally built for the Oberth rocket "experimentally rocket No. 1/model 2." It was located outside the earth wall near the workshop building, operated by cable releases from the top floor where the controls were located, directly next to the door that led to the bridge; the person directing the test stood on top of the earth wall and shouted commands. To the right and to the left of the launching rack, tanks for oxygen and for gasoline were buried, each with its separate nitrogen flask for providing pressure. The valves were operated from the top floor, as was the ignition. The latter consisted of an electric primer, which ignited a kind of small powder rocket. It was a powder that produced a low exhaust velocity—and consequently a slight recoil—but a hot flame. This powder rocket jetted its flame across the exhaust nozzle of the rocket motor to be tested; it burned for about half a minute. When it was working full blast, the nitrogen valve that put pressure on the gasoline tank was opened and, at the instant the gasoline jet caught fire, the oxygen was added.

The rocket motor itself was placed inside a large metal container, which was open on top, with a hole in the bottom to fit the nozzle perfectly. A water pipe ran into this container, the water was drained through another pipe welded to a hole near the bottom of the container. The ground crew's last job before scrambling up the hill was to turn on the water; everything else was done from a distance.[27]

> Usually all these precautions were unnecessary and the motors roared through their ninety seconds of testing without mishap, but there were just enough explosions to keep us from getting foolhardy. Once a motor burned through at a faulty place in the welding seam with the weird effect that there were two fire jets, one vertical and one horizontal, the latter carrying a steaming spray of water with it. Another time the whole welding seam broke, the top part of the combustion chamber shot skyward while the jet burned two enormous holes in two sheets of quarter-inch boiler plate that served as blast guards; all in two or three seconds before the man at the controls turned the pressure off . . . But such accidents were rare, usually the motors developed their thirty-two kilograms—seventy pounds—of recoil without even wavering . . . The exhaust velocity of the blast—computed from recoil and amount of fuel consumed—was almost precisely two thousand meters per second . . . After a little practice we could hear and see whether a motor worked perfectly, without even looking at the recording tape. If the sound was that of an enormous waterfall and the flame short and virtually invisible, everything was perfect. If we got machine-gun staccato and bright fire, it was time to duck.[28]

The first test was conducted on the large stand on 12 March 1931.[29] One of the earliest tests with motor 0.16/32 took place probably by the end of March or the beginning of April 1931. Some photos show preparations for the test, its development, and its result—the combustor chamber and the water container burned through. In April 1931 some visitors (Andre-Louis Hirsch on 4 April 1931; Gawain Edward Pendray on 12 April 1931) were presented during these tests. For the first time the 0.16/32 motor delivered a thrust of 30 kilograms on 15 April 1931.[30]

0.32/64[26]

Consuming approximately 320 gallons of fuel per second, it delivered a thrust of approximately 64 (in the main 50) kilograms for periods veering between 20 and 25 seconds.[32] Ley mentioned that the plans for a bigger 0.32/64 motor were drawn up in April 1931.[33] Nebel dated the first test of this motor at the end of 1931.[34] The large test stand was also used for this purpose. There is a film in which the test of this motor was presented.[35]

Name	Length	Weight	Fuel	Thrust	Cooling	Purpose and Tests
Experimental Model			alcohol–water mixtures LO_2		static water cooling	experiments with alcohol–water mixtures in place of gasoline. In winter 1931–32 or early 1932
0.5/96			alcohol–water mixtures LO_2		regenerative cooling	experiments with regenerative cooling. In December 1932

Table 3: Exprimental Motors.

Experimental Model

This model was for experiments with alcohol–water mixtures in place of gasoline. According to information from Ley and Nebel, the first tests with alcohol–water mixtures and liquid oxygen took place in winter 1931–1932 or early 1932.[36] It can be supposed that the motor for these experiments still had water cooling. First of all the problem of the percentage of alcohol and water was studied. In this conclusion a test with 25 percent alcohol and 75 percent water mixture was mentioned.[37] The test stand, the so-called Portable Proving Stand,[38] was used. Ley described it as follows: "It was actually portable, consisting of two small fuel tanks, a small pressure flask and a simple scale. It had been built specifically for demonstrations, to show how a rocket motor behaved . . . There was a lot of testing to be done. Alcohol was tested in place of gasoline."[39]

0.5/96

This motor was for experiments with regenerative cooling.[40] Only a few details about this motor became known. It was built in November 1932. Its construction scheme was shown on drafts. A photo remains, on which the moment of its building is imprinted.

The tests of this motor began in December 1932, including 6, 7, 13, and 16 December. Probably at first, alcohol was used for cooling of the motor,[41] later liquid oxygen. The tests with 40 percent alcohol and 60 percent water mixture or 90 percent alcohol and 10 percent water mixture—the motors burned through. The ideal alcohol–water mixture was 60 percent and 40 percent.

These tests were also conducted on the Portable Proving Stand. Alcohol–water mixtures were tested with internal cooling in mind. The tests proved the point, but an enormous plume of steam was produced.[42]

Name	Length	Weight	Fuel	Thrust	Cooling	Construction Material	Purpose and Tests
1.7/200 Construct—Hüter	44 cm	3.5 kg	alcohol–water mixture 60:40 percent LO_2 50 l	150–200 kg for 20–25 sec	regenerative cooling	pantal/ duralumin	motor for Magdeburger Vorführrakete and other larger rockets. 9 March 1931–1 June 1931
5.1/600 Construct—Hüter	74 cm	7.5 kg	alcohol–water mixture 60:40 percent LO_2 250 l	600 kg for 40 sec	regenerative cooling	pantal/ duralumin	motor for Magdeburger Pilotenrakete. One sample was built, but it never fired.

Table 4: Large Motors.

1.7/200 Motor[43]

Consuming approximately 1.7 kilograms of fuel per second, it delivered a thrust of approximately 200 kilograms for periods ranging between 20 and 25 seconds.[44] The beginning of the technical development was at the end of 1932. Eight samples were built. The first test took place on 9 March 1933 at the Portable Proving Stand. Since 22 March 1933, the 1.7/200 motor was tested at the Proving Stand, designed by H. Hüter to test complete rockets of the larger size with thrusts of 1,000 kilograms. The Proving Stand was built between 17–22 March 1933. Dimensions of the Proving Stand were as follows: length 4 meters, including 2.5 meters above the ground and 1.5 meters under the ground. The construction above ground was on a gigantic scale: 1.835 meters long and 0.705 meters wide. The dynamometer given by Magdeburger Firma Schäfer and Büdenberg was used for a measure of the thrust. Between 25 March and 3 April 1933, a corrugated roof was built over this proving stand. There were 20 tests of the 1.7/200 motor. The other tests took place:

Date	Results
25 March 1933	Explosion during the ignition
3 April 1933	Explosion during the ignition
11 April 1933	Success
12 April 1933	Success
13 April 1933	Success, see diagram 10^{00} P_{max}=121kilograms, Verb.=1.53 kilograms/second
14 April 1933	Success
15 April 1933	Success, see diagram 12^{00} P_{max}=215 kilograms Verb.=2.04 kilograms/second
18 April 1933	Success
19 April 1933	Burn down
20 April 1933	Burn down
21 April 1933	Burn down
22 April 1933	Success
28 April 1933	Success
2 May 1933	Success
8 May 1933	Success
9 May 1933	Success
11 May 1933	Success
13 May 1933	Success
20 May 1933	Success
31 May 1933	Success
1 June 1933	Success

5.1/600[45]

Consuming approximately 5.1 kilograms of fuel per second, it must deliver a thrust of approximately 600 kilograms for a period of 40 seconds. The technical draft made by H. Schäfer was dated 7 March 1933. A technical draft and a photo remain.

Rockets

A summary from Willy Ley—

> We built two Miraks, one Oberth-rocket, more than thirty repulsors and six heavy liquid fuel rockets. The Miraks burned about sixteen times, aside from this approximately 490 ground tests and about 90 shots were made. To this the 6 flights of the heavy rockets have to be added . . . The greatest altitude of a repulsor was about one mile, the greatest distance approximately three miles. The heaviest rocket weighed about 72 kg, the distance is covered about half a km . . . About 75 percent of all the shots were complete successes, in a few of them the parachute broke off, only once a motor exploded in flight.[46]

Name	**Length** centimeters	**Ø** centimeters	**Weight** kilograms	**Tank Construction Material**	**Starts**
Mirak 1	LO_2 tank—30 gas tank—120	8 0.12	3	duralumin	built and tested but not started. Oxygen tank exploded.
Mirak 2				duralumin	built and tested but not started. Oxygen tank exploded
Mirak 3					never completed

Table 5: Mirak.

Mirak 1

In the literature there is a reference that Mirak 1 was built and tested by Nebel and Riedel in June 1930 in Bernstadt.[47] In another publication the fact is maintained that Mirak 1 was constructed and tested by Nebel, Riedel, and Heinisch from June up to September 1930.[48]

It is possible that this is correct. Mirak 1 was constructed by Nebel at the beginning of 1930.[49] Its first drafts were ready in April 1930 (on 17 April 1930 they were sent to Winkler), on the same day the materials were bought for its building.[50] At the beginning of May 1930 (soon after 2 May) the rocket was built[51] (probably in Autowerkstatt A. Förster where the Oberth rocket was put together in March 1930). The earliest public reference of it appeared also in May 1930.[52] The practical experiments with Mirak 1 were made by Nebel, Riedel, and Heinisch in August–September 1930 in Bernstadt, where its construction was perfected and tested (after 20 August[53] up to 11 September[54]). The perfection was connected with the construction of the safety valve.

The earliest public description of its construction and tests escorting with sketches (they were not drawn to scale) appeared one year later in the *Bulletin of the American Interplanetary Society* in the report by G. A. Pendray.[55] According to this report and to later publications of Ley, there was not a safety valve in the Mirak 1. But there are two original drawings of it known, made by Nebel, which showed many details of its construction.

The Mirak 1 was built of duraluminum and consisted of three parts: the upper tank for oxygen, the lower tank for gasoline, and the combustion chamber. The oxygen was forced into the combustion chamber by the pressure of its own gas, which formed quickly whenever the vessel was closed. The gasoline was forced in by carbon dioxide gas, furnished by the small siphon charger at the lower end of the chamber.[56] If the Mirak 1 had not been tied down during its tests, it would have flown. The gasoline was forced in by nitrogen gas.

Mirak 2

This rocket had the same construction as Mirak 1 but was larger. The safety valve at the top was perfected so that it opened at a pressure of 6 atmospheres, which was well within the safety limits of the tank's strength.

Mirak 3

Mirak 3 differed in certain important respects from its predecessors, the principal changes having been made in the construction of the gasoline fuel tank apparatus and the shape and position of the motor. Instead of one lower tank, it had two, so weighed and constructed as to balance each other. One carried the gasoline, the other a charge of nitrogen gas under pressure. A pipe connected the two so that the gas, pressing on the liquid, forced it into the combustion chamber when the valve was opened. The substitution of nitrogen gas for the carbon dioxide charger of the earlier experiments followed a number of tests, which showed the new method to be more dependable and steady. Under this method the full pressure was available at once, whereas by the charger method there was an appreciable lag.

Name	Length centimeters	Ø centimeters	Weight kilograms	Details of Construction	Flights and Altitude
Zweistaber 10 May 1931				consisted simply of two fuel tanks and a rocket motor	10 May 1931. 18.3 meters (m)[57]
Zweistaber 14 May 1931 (Repulsor I; Mirak 2)				same construction but lighter	14 May 1931 (1) 30 m (2) 350 m[58]
Zweistaber 23 May 1931 (Repulsor II; Mirak 3)				four fins and parachute	23 May 1931 60 m
Zweistaber June 1931 (Repulsor III; Mirak 2)				same construction with fins and parachute container but still larger	In June–August 1931 max. 700 m (9 July 1931)
Einstaber or Achsenstaber/small	300	tanks 10			Since August 1931 500–1,000 meters
Einstaber or Achsenstaber /large (Repulsor IV; 4-liter Rakete)	360	tanks 10			Since April 1932 Höhe 1,000–2,000 m

Table 6: Repulsor.

There were about four or five Zweistaber and three or four Einstaber/klein built.[59]

Name	Length	Ø		Flights and Altitude
Magdeburger Vorführrakete	280 cm 15 feet (457) [60]			Wolmirstedt 9 June 1933 failure 11 June 1933 failure 12 June 1933 failure 13 June 1933—2 m 21 June 1933 failure 22 June 1933 failure 23 June 1933 failure 24 June 1933 failure 27 June 1933 failure 29 June 1933 failure
Vierstaber 14 July 1933 11 August 1933	250 cm	75 cm	fairing with fins	10–12 July 1933 on "Lover's Island" (official name on maps is Lindwerder) in Tegeler Lake near Berlin, 14 July 1933—70 m.[61] It rose with terrific velocity to about 3,000 feet, suddenly tilted over, made a few loops, and came down in a power dive, landing some 300 feet from the island in the water. The parachute was ejected at the last moment before striking, thus only minor damage was sustained. On Schwielow Lake, using a motor launch instead of an island, 11 August 1933—80 m. Seems that one valve did not open, horizontal flight, touching water. Sank in steamboat channel, the only dredged and deep section of the whole shallow lake. Rescue impossible.
Vierstaber 21 July 1933	250 cm	75 cm	fairing without fins	On Schwielow Lake, using a motor launch instead of an island, 21 July 1933—100 m. The first try was unsuccessful; the valve burst, but after replacement and refueling the repulsor took off. One oxygen valve failed to open, and the repulsor rose slowly and off balance to about 200 feet (61 m). Landed in water with minor damage.
Vierstaber 5 August 1933	250 cm	75 cm	fairing without fins, valves near the motor	On Schwielow Lake, using a motor launch instead of an island, 5 August 1933—"low altitude."[62] It exploded soon after take-off.
Zweistaber 9 September 1933	400 cm		fairing without fins	Same place, launch from "Startfloß." 1 September 1933—30 m[63] 9 September 1933—"both poor"[64]
Magdeburger Pilotenrakete	8–10 m[65]	1 m		The rocket was supposed to reach an altitude of 1,000 m.

Table 7: Large Rockets.

Magdeburger Vorführakete

A smaller rocket of the same shape as the "Piloted Rocket" was to be built first; except for the size, it differed from the large one only by having its parachute where the large one would have the passenger. The actual work began around 25 December 1932.[66] The city of Magdeburg hurried the rocketmen, and it was agreed to let the big rocket (but not the human-carrying) ascend on 9 June. A large launching rack was built in a cow pasture at Wolmirstedt near Magdeburg. It was 30 feet high. Then a series of mishaps began. The rocket could not be attended to properly as it was so far away from the workshops. On the morning of 9 June it was fired, the rocket began to rise slowly, but before it reached the top of the rack, it began to slowly slide down. The thrust was insufficient, and the reason could not be found. Another attempt two days later was spoiled by a leaky gasket. The motor got only one quarter of the fuel it was supposed to get, the rocket roared for 2 minutes instead of 30 seconds, and people approached to within 10 feet. Of course the rocket did not move. Another test on 13 June also ended prematurely. When the rocket was 6 feet high, a vent screw popped out and the rocket fell back, getting no more fuel. After that new tests had all kinds of little mishaps: once a valve froze tight, another time the ignition capsule was blown out before it ignited the rocket, a diaphragm in the fuel line burst, et cetera. Heavy rains interfered and warped the wooden launching rack, not enough to be noticed, unfortunately. The city accountants had not granted the expenditure of a metal rack. Thus when the rocket finally did take off on 29 June, one of the rollers derailed and became stuck. The rocket just stripped it but took off almost horizontally because of that. Losing altitude rapidly, the rocket made a belly landing 1,000 feet from the rack, the motor still going full blast. It slithered for another 30 feet. It looked totally smashed, but the motor and the tanks were unhurt. Only the casing, fuel lines, et cetera, had been smashed.[67]

Vierstaber

The tanks were made near the motor.

Zweistaber/1 September 1933

This was a new design: two-sticker with long tanks.

Magdeburger Pilotenrakete

The passenger cabin and the fuel tanks were to be one unit, shaped like a huge artillery shell, while the other unit, comprising the rocket motor and the parachute, was a smaller "shell" topping the bigger one. After reaching an altitude of 1 kilometer, the parachute was to be ejected while the passenger—he was not a "pilot" because he did not do anything—was to jump out with his own parachute.

Conclusion

There are many questions which need answers: on the dates of some events, on the technical data, on the work of some persons. The authors have tried to complete the known information and hope this study will be a basis for further research.

Notes

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