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Chapter 7

CAMERA ROCKETS AND SPACE PHOTOGRAPHY CONCEPTS BEFORE WORLD WAR II*

Frank H. Winter†

From the rocket we can see the huge sphere of the planet in one or another phase of the Moon. We can see how the sphere rotates, and how within a few hours it shows all its sides successively . . . and we shall observe various points on the surface of the Earth for several minutes and from different sides very closely. This picture is so majestic, attractive and infinitely varied that I wish with all my soul that you and I could see it.

--K. E. Tsiolkovsky, 1911‡

The spectacular photographs of the Earth from space made in the last few years are products of a highly sophisticated technology of the Space Age. However, the history of rocket and space photography can actually be traced back to the turn of the century. While the founder of modern science fiction and the common source of inspiration of several rocketry pioneers, Jules Verne, scarcely hinted at the possibility of space photography in his classics *From the Earth to the Moon* (1865) and its sequel *A Trip Around the Moon* (1870), the standard references on the history of photography are unanimous in crediting the French pyrotechnists Amédée Denisse as being the first to propose the camera rocket. Denisse was led to invent his "Photo-Fusée" in 1888 as a logical extension and improvement of conventional aerial photography by balloon. He had military aerial reconnaissance in mind, and at once saw definite advantages over the balloon. The journal *La Nature* (Paris) of September 22, 1888, which first reported his project, expressed the inventor's beliefs succinctly:

For military reconnaissance, a single man can launch the rocket. All the services which balloons can render to the military will not prevent them, we believe, from using the photo-rocket which operates in several seconds [as opposed to many minutes and perhaps hours for the balloon] and does not endanger the life of anyone, and had nothing to fear

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† National Air and Space Museum, Smithsonian Institution, Washington, D.C., U.S.A.

‡ From Tsiolkovsky's The Investigation of Universal Space by Means of Reactive Devices, translated in, K.E. Tsiolkovsky, Works on Rocket Technology (Washington, D.C.: National Aeronautics and Space Administration, NASA TT F-243, n.d.), pp. 76-77.

from enemy fire. Its spontaneous ascension, in full daylight, may not be noticed; only the parachute shows and it is difficult to hit.[1]

Amongst other advantages, military or otherwise, were a considerable decrease in expense in the rocket over the balloon, greater ease in transportation, and rapidity of retrieval. Even though a balloonist photographer had the option of personally selecting his precise choice of view and range for photographing, and of taking several pictures as opposed to one only for the photo rocket, Denisse's apparatus was equipped with a simple but ingenious system of taking an all-encompassing panoramic 360° photo.[2]

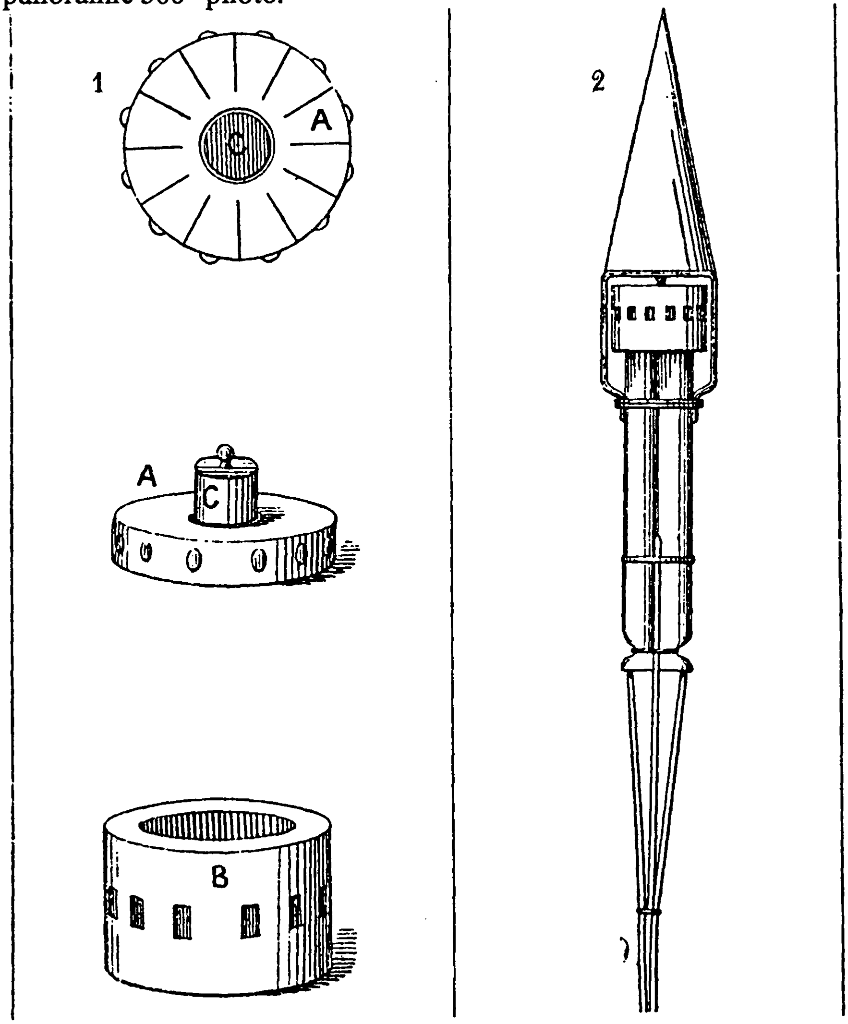

Figure 1 "La Photo Fusée," or "The Photo Rocket" of the French pyrotechnist Amédée Denisse, 1888. Believed to be the first or one of the first designs for a camera-carrying rocket. It consisted of a small cylindrical camera with twelve lenses (left), each lens being separated by a partition. In the center (C) is the senstized plate, over which was placed a circular shutter (B) which worked by its own weight and which was to fall or slide off the cylindrical camera (A) and open the apertures when the rocket commenced to fall after reaching its peak altitude. The apertures were closed again the moment the parachute was opened, the parachute being connected to the rocket by a cord. The right side of the figure reperesents the rocket ready for use. From: La Nature (Paris), Vol. XVI, September 22, 1888, No. 799, p. 263.

The complete system was launched by a pyrotechnical skyrocket, essentially the same as those Denisse fired in his festive fireworks displays and whose manufacture he richly detailed in his book *Traité Pratique Complet des Feux d'-Artifice* (Paris, 1882). The camera apparatus consisted of a small cylindrical chamber of twelve lenses in twelve separate compartments, each lens facing the exterior of the circumference of the cylinder (Fig. 1, a). The camera simply operated by an overhead, circular shutter (b), with twelve corresponding apertures, and which dropped into the chamber by its own weight. It was timed and activated by a burning strand of quickmatch, and was ignited at the burnout of the rocket. The fall of the shutter thus quickly opened and closed the twelve lenses simultaneously. The match also freed the locking-spring of the parachute. Retrieval was also insured by a long string tied to the rocket and held by the operator as the rocket descended.[3]

The negatives of the Denisse rocket had to be enlarged but were said to have given "some results" and to have been "sharp and clear." Denisse's photo rocket was thus actually constructed and flown, though no known photos, nor the rocket, are known to exist. *La Nature*, in fact, included several of Denisse's instructional details on how to use the apparatus. "The photo-rocket, which has already brought results," it concluded, "is at present only a study. As soon as the new instrument functions regularly, we shall speak of it at more length." Basically the same *La Nature* account was published widely elsewhere, but nothing further was heard. A search was made for patents that may have been taken out in France by Denisse on cameras -- or anything pyrotechnical -- between the years 1870 to 1915, but without result.[4]

No mention of the rocket appears in Denisse's book on pyrotechnics because it was written four years before he introduced the apparatus. But interestingly enough, there is an indication of how he may have been led to the thought of mating the rocket with the camera -- through formulas of a "light for night photography," or flash powders. From the same work, in his description of purely pyrotechnical rockets, it is significant to point out their sizes and general technology to gain an idea of possible and potential dimensions of his "Photo-Fusée." Denisse's skyrockets ranged from those with an interior diameter of 9 mm, the so-called "Petite Royale," to those of 34 mm, shown as "La Republicaine." He favored hand manufacture over the machine (i.e. hydraulic presses), he said, because it was "surer," and he launched his rockets from conventional wooden stands. He also spoke of parachutes with diameters of up to 55 cm, and also, of wings and step rockets.[5]

A photo rocket comparable in several respects to Denisse's appeared in Saxony, Germany, in 1891 when Ludwig Rohrmann of Krauschwitz bei Muskau (Oberlausitz) was granted Kaiserliches Patentamt Patent No. 64209 of July 14, 1891, for "the photographing of pictures of land from a bird's eye view by means of a gun or rocket projectiles." The same patent was also taken out in England (British Patent No. 12,669 of July 25, 1891), "A New or Improved Apparatus for Obtaining Bird's-Eye Photographic Views." A like patent was granted jointly to Rohrmann and R. Rauthe, of Rastatt, Austria, in Austro-Hungary on 23 March 1892. Rohrmann, like Denisse, also had in mind military applications. The rockets could be used to photograph "fortifications, or other positions occupied by an enemy," but could also be applied to non-military photography, "such as taking bird's-eye views of buildings, estates, or land." The apparatus was considerably more complex than that of Denisse, though it worked on the same principles. The type of rocket is not mentioned, but appears to have been a large central stick mounted firework or war (Congreve) type (Fig. 2). Like the Denisse rocket, a cord was attached to the cap and connected to the operator on the ground, but could either be worked by pulling in the rocket by hand or by a small steam engine (f and e). Insulated electrical wires were also suggested as a connecting cable, in case the camera was worked by electricity, through remote control. For increased range, the projectile could be fired from a gun rather than a rocket (Fig.2-3 and -4). In either case, the camera was "the kind used for taking instantaneous pictures." It worked by a spring clock-work which was prewound and could take six to eight exposures through a spring-operated movable plate system. By means of the resulting series of exposures, "a complete circle of views round the firing point may be obtained." (Fig. 2-5)[6]

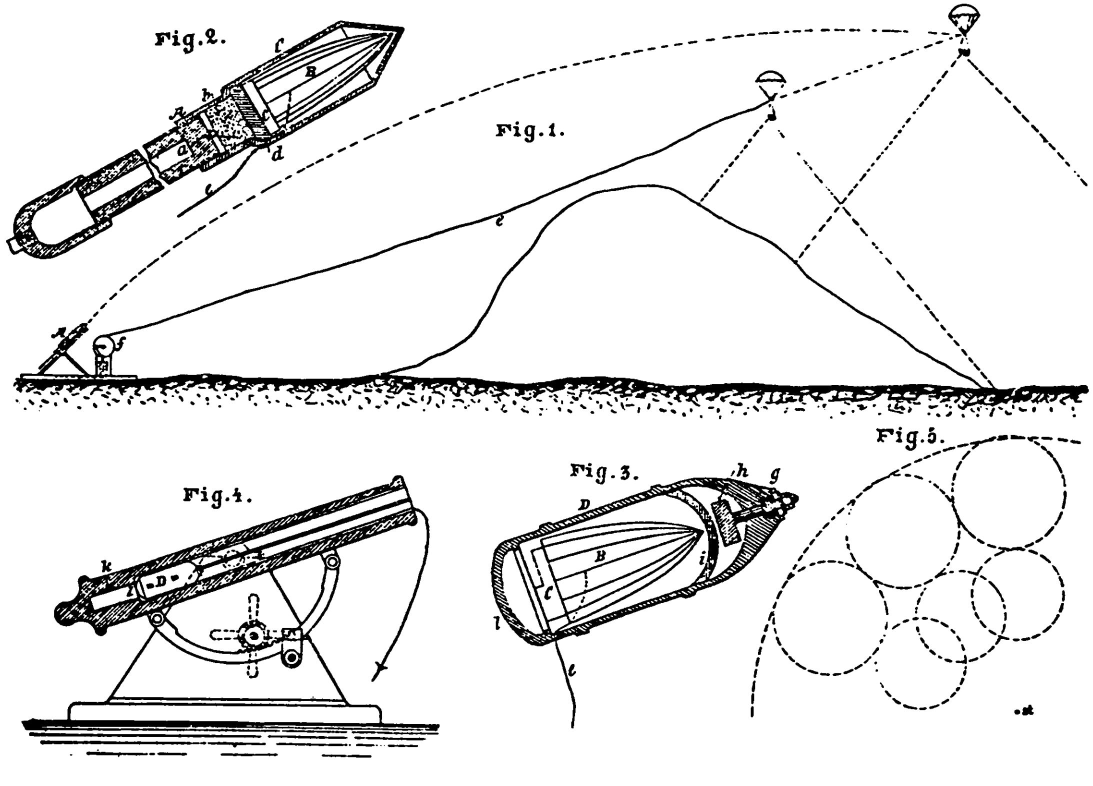

Figure 2 Camera rocket in flight and method of taking pictures and retrieval; as well gun launcher and projectile, and diagram of series of several exposures. Camera rocket of Ludwig Rohrmann, 1891. From British Patent No. 12,669 of 25 July 1891, "A New or Improved Apparatus for Obtaining Bird's-eye Photographic Views," to Edmund Edwards (patent agent) from a communication from Ludwig Rohrmann, Krauschwitz, Germany.

Though interesting in concept, especially the suggestion of electrical remote control, there is no evidence that Rohrmann ever constructed his camera. There were no follow-up patents, apart from his Austro-Hungarian and British specifications. It was left to Rohrmann's neighbor and possibly his associate, an engineer, Alfred Maul, of the nearby town of Dresden, to actually construct workable camera rockets. In fact, Maul became the most vigorous experimenter of this device for almost two decades. Maul, however, did not undertake his famous experiments until 1901. Meanwhile, in Sweden the idea of the camera-rocket combination also materialized.[7]

Alfred Nobel, world-famous inventor of dynamite and founder of the Nobel Peace Prize, independently devised a camera rocket just prior to his death in 1896. Nobel was "introduced" to rockets about 1890 by Swedish Artillery Captain Wilhelm Teodore Unge. Unge's own accomplishments were numerous and have been well documented elsewhere. But briefly, they consisted of a rotating "aerial rocket torpedo" which was fired electrically and which burned perhaps the first double-base propellant (ballistite) for rockets. He also made many other improvements in propellant technology, as well as in life-saving rockets. In these works he was greatly assisted, financially and technically, by Nobel. Nobel took out his first patent for rockets in 1890, which led to no less than six others. It is Nobel's British patent of May 12, 1896 (No. 10,118) that we are most concerned with. It is entitled "Improved mode of obtaining photographic maps and Earth or ground measurement." The patent was also taken out in France and a translation made into German, but never filed. None were taken out in his native Sweden, though hand-written and detailed drawings and specifications in Swedish exist. They are dated *after* Nobel's death (Nobel died Dec. 10, 1896) and present somewhat of a mystery.[8]

Nobel's rocket camera was "to provide means for taking photographic images at a great height above the ground, and making such images serve as maps, useful for telemetric measurements." Mention is also made of military reconnaissance and land surveying. Like Rohrmann, he also had alternative means of taking such photos, namely from a balloon and also from a mortar. Nobel's rocket was basically a large signal type. A pair of "cross wings" was suggested in lieu of the conventional guide-stick (Fig. 3, p). The camera itself was very simple and its shutter was opened and closed by a time fuse. The inventor felt the camera, rockets and optics were already "well-known" and went into no further details, though only one picture could be taken. The film processing was by the usual way but included enlargement "by micro-photography". The film was also projected by suitable lenses on a wall or other suitable surface which had grid lines drawn on it according to the patent, "to represent equal distances or surfaces of real ground on the enlarged map. These measures will, however, need correction to compensate for the difference of level of the photographed ground." Another interesting feature was the inventor's use of guncotton (g) to drive out the nosecone section containing the camera and parachute. A thread of guncotton also served as a time fuse for activating a spring shutter on the camera.[9]

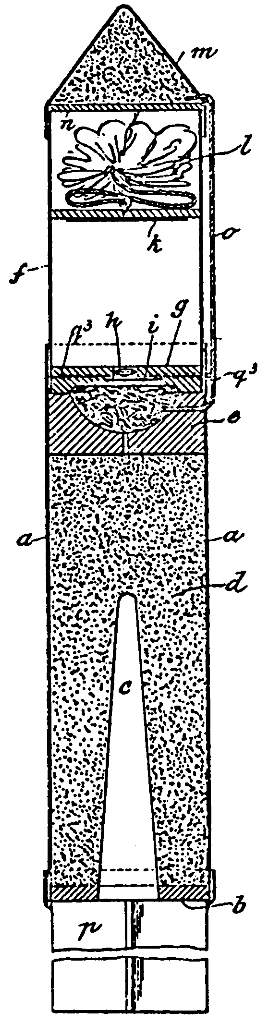

Figure 3 Photo or camera-carrying rocket of the Swedish chemist and engineer, Alfred Berhard Nobel, from his patent communicated to Alfred Vincent Newton, British patent agent, British Patent No. 10,118 of 12 May 1897. The specification drawing shows the rocket shell, with f, the section for containing the camera.

To resume the mystery of the hand-written specifications in Swedish, there are two actual documents in the Nobel Foundation in Stockholm. The first is dated 28 December, 1896 and is entitled (English translation) "Mechanism for rocket camera." The second, dated 9 March 1897, is the "Shutter for rocket camera." Both were executed in Nobel's laboratory in Sweden, the old works of Bofors at Björkborn. They are obviously not in Nobel's hand. But whose? Further, the drawings, particularly the "Mechanism for rocket camera," is actually a specification blueprint for the construction of such a mechanism, complete with dimensions. Two actual specimens of completed rocket cameras exist in Tekniska Museet, Stockholm, and are credited to Nobel, but by whom were they built, and were they ever flown? To heighten the mystery, the Nobel Archives has several aerial photos with circular plates, one of which *may* have been taken with a rocket camera (Fig. 4). It is signed "Karlskoga" (a town near Björkborn) and dated 26 April 1897. However, it was most likely taken with Nobel's "teleobjective" which was a balloon camera. Further, the cameras in Tekniska Museet have their shutters facing the rear of the rocket and took pictures of the Earth from a vertical and not horizontal position as in the Karlskoga photo. The author or authors of the drawings and the constructor of the rockets are still unknown, though undoubtedly they were one or more of Nobel's several assistants at the Björkborn laboratory.

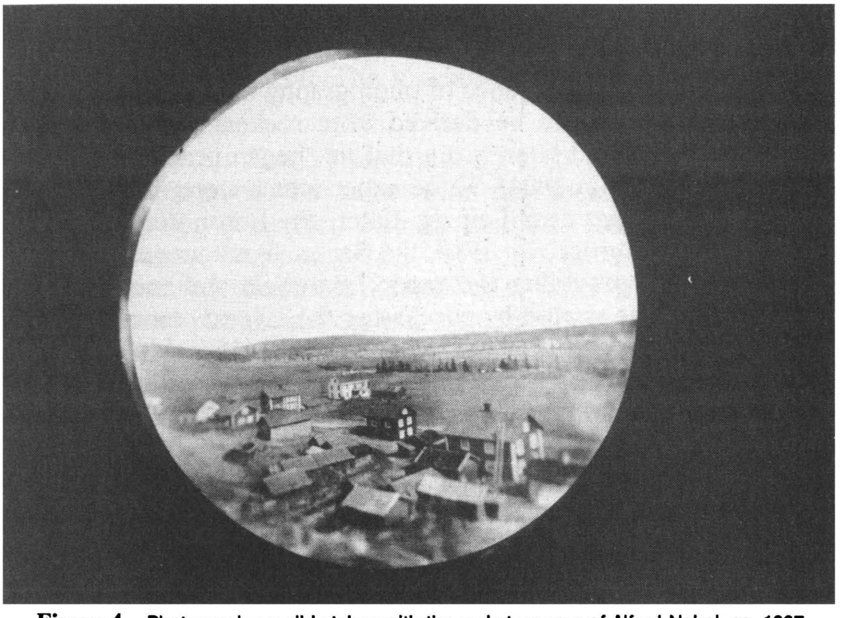

Figure 4 Photograph possibly taken with the rocket camera of Alfred Nobel, ca. 1897, showing the village of Karlskoga, Sweden, west of Stockholm. Photo from The Nobel Foundation, Stockholm (Smithsonian Negative No. 72-10662).

Ragnar Sohlman, Nobel's chief engineer and afterwards the executor of his will, has cleared up part of the mystery. Of the period in question, 1897, Sohlman later wrote:

> At the Björkborn Laboratory . . . the supervision of the work was done by me personally, when I was there, and otherwise by correspondence. The main work subjects were: . . . 'The Rocket Camera' or the photographic telemeter, an attempt in photographic mapping of areas from a camera, which was sent up by a parachute rocket or captive balloon, the exposure of which was released through either a fuse or by electrical means. The latter two experiments were soon abandoned as they proved to give no satisfactory practical results. I mention these experiments here only to show the amount of Alfred Nobel's ideas and their some times too ambitious nature. (Some of his ideas have later been realized in a modified form, for example: mapping by photographic means from the air as airplanes were developed and improved, was used extensively.)

It is still not known, however, how far the rocket camera project succeeded, who built it, and if it took any pictures at all. Whatever the story, Nobel must be given credit for independently originating the idea of the photo rocket but did not live long enough to see his subordinates carry out his plans.[10]

The first known constructed and workable camera rockets for certainty were made not long after Nobel's death, in 1901. Their designer and constructor was Alfred Maul, a civil engineer of Dresden-Trachau, Germany, and at that time a mechanic with the Dresden Installation for Electricity Telegraph Works. Maul from the start had one purpose in mind for his rockets: military reconnaissance. Curiously, apart from Alfred Boyarsky of Russia, he was to be the last of the camera-rocket pioneers advocating such rockets for military applications. Those who were to follow may generally be categorized in a new class. They stressed rocket or space photographs for purely scientific research. Maul, in any event, made impressive contributions and achieved worldwide fame.

After reflecting on the importance of photography in warfare for observational purposes, and the advantages to be derived from rockets carrying cameras compared to other methods, Maul later wrote that he "began practical experiments on this promising project early in 1901." These experiments were made in the suburbs of Dresden and at Niederau, near Leipzig. Later, the Saxon Army made available the firing range at Königsbrück. By 1910, the Saxon Army was actively supporting his work financially and providing the range, materials and men. As with many others before and since, he started by purchasing the largest commercial rockets he could find. These were of "questionable strength." They scarcely weighed 80 grams. He needed large rockets, but "above all, rockets of great efficiency." Even with small ones, however, he could attain high efficiency and lifting power when combined to form "double rockets mounted side by side." His initial experiments were with these types. The first apparatus could take a picture of 4x4 cm., and could raise 200 grams to 300 meters. However, he recalled:

> The first experiments employing this apparatus were not very encouraging, next to numerous rocket explosions and uncontrolled crashes, there were an impressive number of expensive apparatuses destroyed. Success was only rare, the parachute at the right moment came out but upset the body with the apparatus . . . the rockets would also oscillate in flight.

Maul quickly realized his major problems involved stability and weakness of construction. Ruggedness was attained by gradually increasing the size of the rocket and by more rigid construction. Stability was far more difficult to overcome. He enlarged and otherwise modified the wooden wings of his rockets, tried a pendulum and "through numerous experiments, with other means, the rotary motion was stopped ... and today [1915] a faultless apparatus is available." The stability problem was finally solved (though patented in 1906) with an internally mounted gyroscope. This was at least two years prior to Goddard's suggestion of gyroscopes specifically adapted to photo rockets.[11]

Ley distinguishes between four distinct models of rockets constructed by Maul up to his largest and most advanced system, covering the period ca. 1904-1912. The period 1901-1903 can thus be considered Maul's rudimentary and preparatory stage of rocket development. The first of the bigger models (1904) carried a camera with plates measuring 40 x 40 mm. It's altitude ranged from approximately 270 m to 300 m. The guidestick was 4 m long. The second model carried 120 x 120 mm plates, and reached altitudes of 450-600 m. This apparatus was powered by one or more lifesaving rockets (each burning approximately 4 kg of meal powder) procured from the Royal Fireworks Laboratory at Spandau, near Berlin (all of Maul's later apparatuses appear to have been propelled by such rockets, being modified and scaled up accordingly). The required altitude depended upon the number of rockets used. The guidestick was 3.9 m long and at its lower end four square fins protruded in cruciform pattern. The third model carried a camera with a plate size of 180 x 180 mm, and reached 500 m altitudes in 8 secs. The guidestick was 4.6 m, the total weight at launch was 25 kg, the diameter (of the nosecone), 350 mm, and the propulsion consisted of two 80 mm lifesaving rockets. The fourth, and final model, with a camera plate size of 200 x 250 mm and an altitude of 780 m in 8 secs. also had a 4.6 m guidestick and total launch weight of 42 kg. The length of the entire rocket was approximately 6 m. The maximum diameter (at the nosecone) was 25 cm.[12]

Maul took out his first patent June 5, 1903 (Deutsche Reichs Patent No. 162433) and was granted the same with the specification in England and in America. It is in the American Patent, entitled "Rocket Apparatus for Taking Photographs," that we learn that Maul was at least aware of Rohrmann's work. Maul cites Rohrmann's patent and stated that while this rocket was designed to take photographs of the ground from a camera aimed vertically, from beneath the rocket, his apparatus differed principally in taking photos laterally or from the side of the rocket. In this sense he may not have been aware of the ideas of Denisse, whose twelve lensed camera took 360 deg. photos. Maul's camera, however, was set obliquely (in practice, 50 deg.) in the nosecone (Fig. 5,n). The rocket itself remained at 90 deg. while its single photo was being shot. Two propelling rockets, (d) side by side, carried the apparatus 510 m. Besides the guidestick, the remaining space in the case was reserved for two neatly packed parachutes, of unequal sizes (e) in order to provide the correct equilibrium of the rocket upon its gliding descent. Protruding from the nosecone was the "projecting ring" (o), a kind of safety railing, "placed around the cap to protect the object lens from injury as the apparatus strikes the ground at the end of its downward flight." Also included in this specification was the launcher of the apparatus, a ladder-like frame-carriage which could be raised or lowered by a winch (Fig. 6).[13]

Maul took out many subsequent improvements on this patent in Germany, Austria, England, and the U.S., most of these concerned the arrangement of the camera, improvements in rocket recovery, and means of obtaining greater stability.[14]

Anticipating sounding rockets of a later era, Maul also suggested in one of these specifications that in place of a camera, his rocket might also carry other scientific instruments, such as those for measuring wind-pressures, humidity, etc. The primary feature of this patent, however, was an improved recovery method. The heavy rocket body and its stick were suspended from a single parachute on a long cord and the ejected camera and nosecone on a shorter cord. Therefore, the heavy rocket and its stick touched the ground first, leaving the parachute "free" to carry the comparatively light instrument payload. Undoubtedly the most significant feature of the British version of this patent (No. 10, 757 of May 8, 1906) was the use of a gyroscope within the nosecone.[15]

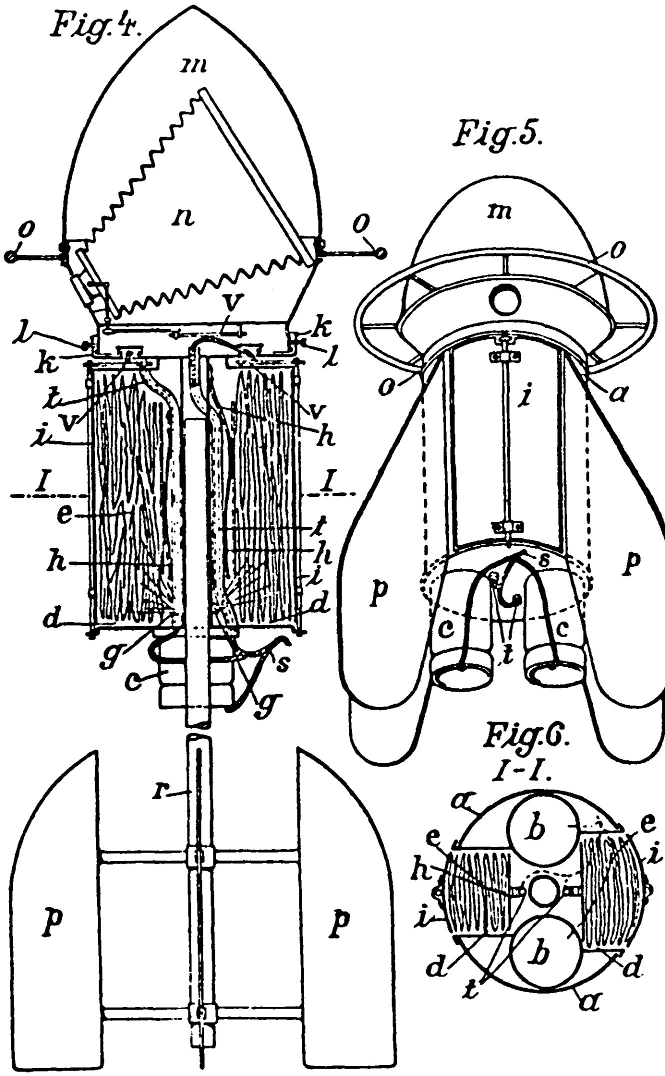

Figure 5 Sectional view of camera rocket apparatus, British Patent No. 12,772 of 2 June 1904 to Alfred Maul of Saxony, Germany. (A) Apparatus with tail-like prolonged rod to which fins are attached; (B) Modified design in which the fins are directly attached to the outside of the rocket case; (C) Sectional view of (A) and shows the position of the parachutes and two propelling rockets.

These latter two major improvements, the method of recovery by means of two separate cords to the nosecone and the rocket, and Maul's suggestion of a stabilizing gyroscope within the head, were both incorporated in his most advanced rocket, the model of ca. 1912-1915. (The Deutches Museum in Munich possesses an example of a gyroscope within its camera and nosecone, but dates these artifacts to 1906 due to the date of the patent.) (Fig. 7). In fact, these specimens appear to date to ca. 1912. The launcher for this larger model, considerably larger than the one depicted in Maul's first patents, was especially modified not only to hold and aim the rocket, but also to initiate the gyroscope and the internal electric-pneumatic contact system. Attached to it was a means of "target" tracking. In these respects, it was an "integrated rocket system."

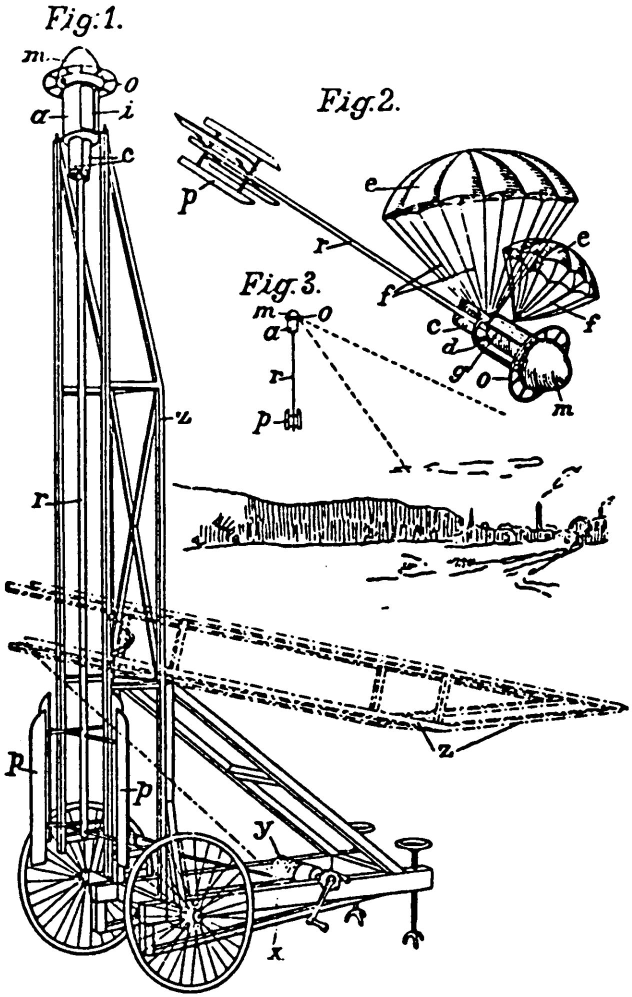

Figure 6 Launcher-transporter for photographic rocket. Specification drawing for British Patent No. 12,772 of 2 June 1904 granted to Alfred Maul of Saxony, Germany. The rocket was said to be capable of ascending 1600 to 1700 feet in a few seconds, taking a photo, and then descending by parachute.

The launching platform itself weighed 400 kg and was transported on a hand-pulled two-wheeled cart. Two or three men were required to operate the entire system (Fig. 8). Once the pre-assembled wooden platform was lifted off the cart and placed in its vertical position (it was 7.5 m tall), "sightings" were taken in the target tracking sight and scale to determine the direction of the terrain or the exact point to be photographed. A hoisting or drop weight suspended from the side of the platform was next attached to a cord wound around the gyro axis. The rocket apparatus was then carefully fitted vertically into the platform, the operators taking careful note of a free swinging pendulum and split level to further ensure the correct elevation of the launcher. Fine adjustments were made through screws. The apparatus was thus ready for launch. At a distance of approximately 200 m was stationed the man who "fired" the rocket. A dynamo-electric ignition inductor led to the apparatus by a light, umbilical type cable. A current from the inductor initiated the unwinding or dropping of the hoisting weight which, like a child's top, caused the gyro wheel to spin. A second current activated an automatic switch which actually ignited the rocket, lifting it to an altitude of 800 m in about 8 seconds (Fig. 9).

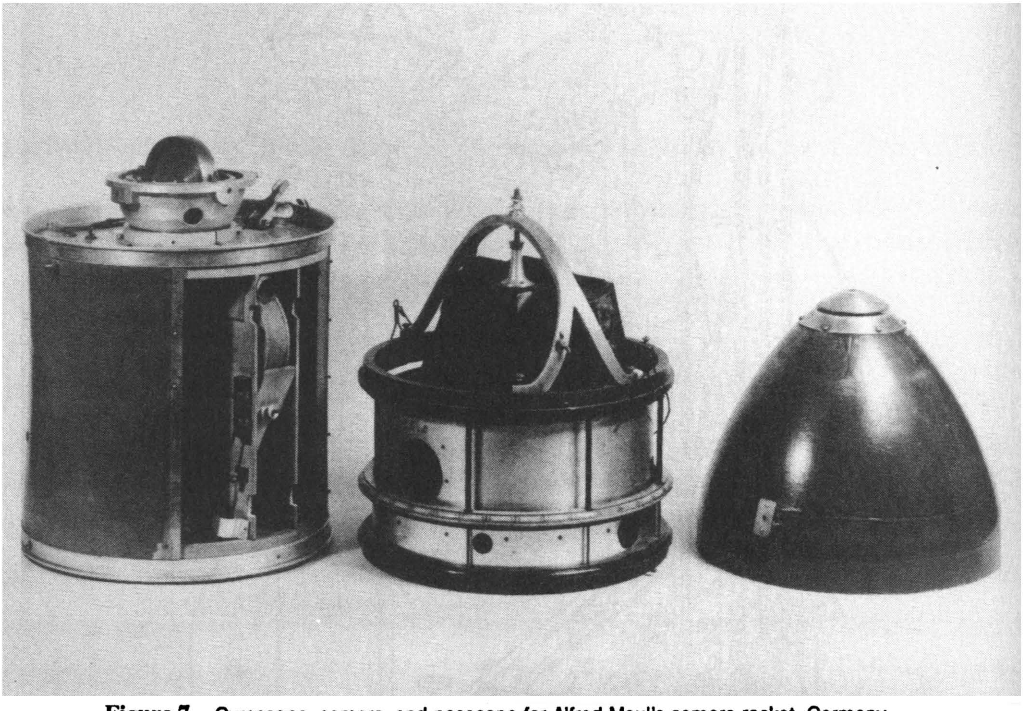

Figure 7 Gyroscope, camera, and nosecone for Alfred Maul's camera rocket, Germany, ca. 1900-1912. Photo from Deutches Museum, Munich.

Shortly before the apex of the flight path was reached, the internal pneumatic-electrical contact released the camera shutter and parachute mechanism. After the latter was opened -- conforming to Maul's patent of 1907 -- the apparatus separated into its two parts, the nosecone section and the rocket body with its tail, which remained connected by a cord approximately 10 m long. The rocket, striking the ground first, was shortly thereafter followed by the more slowly descending nosecone (Fig. 10). Thus, according to one contemporary description:

> The exposure, the opening of the parachute and the detachment of the camera follow in rapid succession, and in about a minute the apparatus comes safely to earth not far from the starting point . . . The whole apparatus is carried on a small hand-cart, which can be easily taken to the front, and the rocket is in little danger of being shot down in its brief flight.

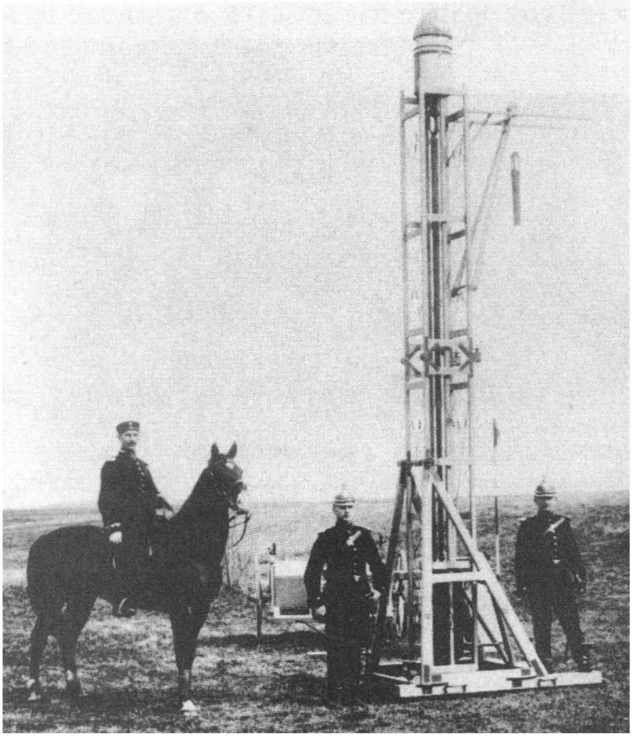

Figure 8 Alfred Maul's rocket and camera apparatus, ca. 1904, Saxony, Germany.

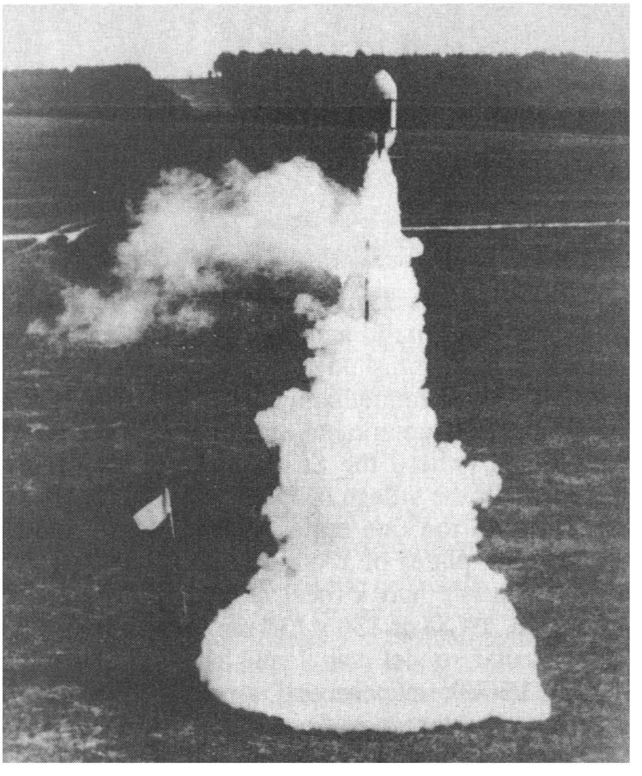

Figure 9 Launch of a photo rocket of Alfred Maul, near Dresden, Germany, early 1900s.

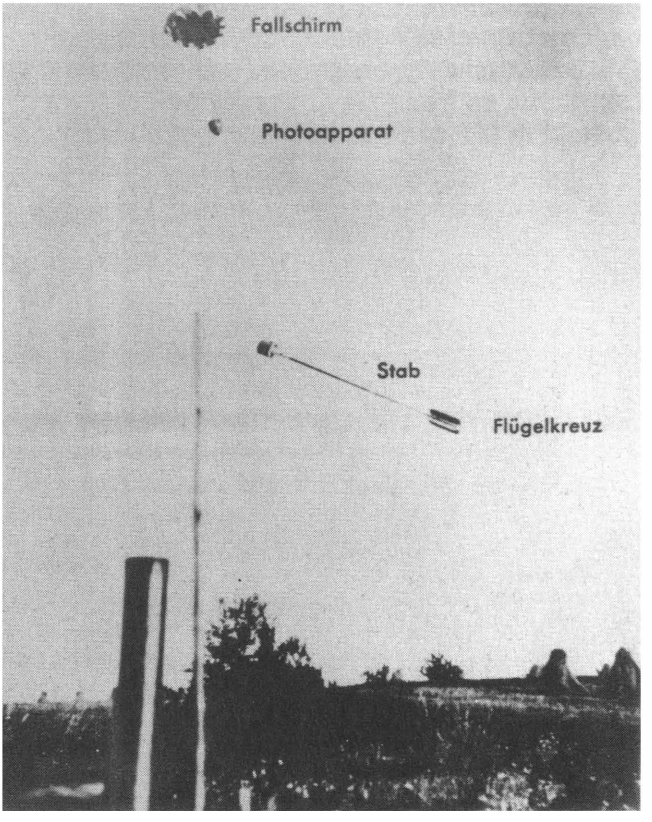

Figure 10

In actual operation, the apparatus drifted approximately 100 m away from the launching stand and in strong winds, about 300m.[16]

It took about 15 minutes from the moment the parachute was free until it dropped to the ground and the apparatus was recovered. A few minutes more were required for the finished picture (assuming photographic processing was close at hand and begun immediately). The resulting pictures were characterized as being "sharp." Several remarkable examples of these photos exist, primarily of the town of Königsbrück (where the Saxon Army firing range placed at the disposal of Maul was situated), the village of Laussnitz, and the village of Stenz and vicinity (Fig. 11). They attest to the fine optics of the system. The focal length of the medium-sized rockets (with plates of 180 x 180 mm) was 210 mm; and that of the largest (200 x 250 mm plates), had a focal length of 280 mm. The focal length for the smaller rockets (ca. 1908) of 130 x 130 mm plates was 210 mm. The aperture of the lens of this particular model was a split shutter, f/7.7, and the exposure times were from 1/100 to 1/300ths of a second. Apertures and exposure times appear to have been similar for the larger rockets. The theoretical range of sight of the rockets at altitudes of 500 m was 80 km. The rocket's "great military value, therefore," commented the *Scientific American* of February 6, 1915, "is self-evident, and [it] will probably receive many practical demonstrations in the present war."[17]

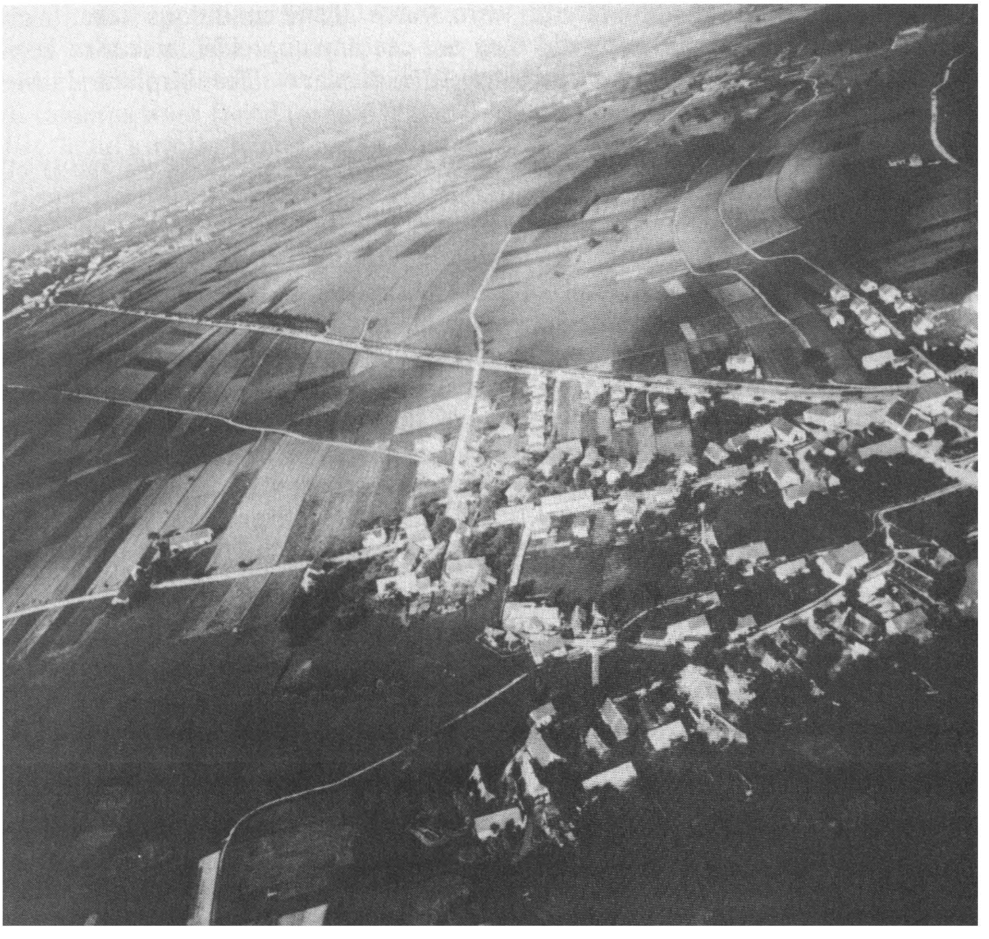

Figure 11 Alfred Maul rocket photo of village in Saxony, Germany (1904).

Were Maul's rockets employed at all in World War I? The answer is unknown, though as we have seen, the Germans were certainly experimenting with them. It is known for certain that Maul's photo rockets did actually serve on the battlefield, during the Balkan, or Turkish-Bulgarian War of 1912-1913. As the Bulgarians were friends of the Germans, Maul persuaded the Bulgarian army to try out his invention and may have gone himself to the front. During the so-called "pseudo-peace discussion" in London, according to Hirschberg, (apparently early in January, 1913):

> Mr. Maul sent his invention to the allied armies encamped this side of Taehalja. By means of it, the Bulgarians and their friends were able to take perfect photographs of the Turkish plans, equipment, fortifications, and numerical strength . . . The most perfect pictures ever taken are developed from Mr. Maul's skyrocket camera, and it is said that as long as the Turks lack this equipment they will be powerless before the advance of the conquering Bulgars.

Taehalja, or Tchataldja, was an ideal location to field-test the rockets. The terrain is mountainous, but the rockets also served well because the Bulgarian observation balloons on the Tchataldja lines were vulnerable to Turkish shells and because Bulgarian observation aircraft were scarce. If the conditions were ideal and the rockets were successful, why did they not see any appreciable service in other campaigns? The answer, in a word, was the airplane. The airplane inevitably sounded the death knell of Maul's rocket.[18]

Over 15 years Maul's photo rockets had received considerable laudatory attention in the world's scientific press and in military circles. They were introduced and well received at the annual (78th) meeting of the Gesellschaft deutscher Naturforscher und Aerzte (Society of German Scientists and Physicians) in Stuttgart in 1906. Dr. Alfons Bujard, Director of the Committee of the Municipal Chemical Laboratory in Stuttgart, presented them in his paper, "Rockets in the Service of Photography," and afterwards favorably mentioned them in his books on pyrotechnics. Maul's ideas enjoyed a similar reception at another scientific conference, in Dresden in 1907. At the 1909 International Photographic Exhibition in that city, according to Newhall, "Maul's rocket photographs were the center of attraction." While another source says that there were drawings as well as the complete apparatus to be seen.[19]

When Maul's rocket was first introduced, it had decided superiority over other means of aerial photography. The principal advantages of the photographic rockets versus balloon photography, for example, were as follows: (1) Very little manpower was needed to operate the apparatus; (2) the rocket was more rapidly assembled, launched, and returned to Earth; (3) because of the short flight time it was virtually impossible to hit the apparatus successfully during ascent or descent; (4) it could be moved comparatively closer to the enemy line than any balloon because it was almost "invisible", and consequently the photos were taken from a much closer range, another main advantage; (5) the photos did not in any way lack the sharpness of those taken from the balloon, and often exceeded them in clarity since the apparatus did not swing or turn; and (6) the cost of the rocket system was minor compared to the expenses of balloon photography. To these advantages Maul, in 1915, added others, though by that date his invention was already doomed. Captive balloons, dirigibles, and guided airships, he said, could all be shot down. The rocket could not. Balloons, he also pointed out, were dependent upon wind and were difficult to manage. The cost of running an airship was particularly high. Yet besides these, there were other contemporary but far simpler and cheaper means of aerial photography. These too had their drawbacks, however. Eventually the airplane alone became predominant. Again quoting Newhall:

> The advantage of the airplane as a camera platform over balloons, kites, rockets and pigeons is that it can be flown with great accuracy at specific heights over any area of the world; its flight is relatively steady and its speed constant and swift.

Thus, almost as soon as the Great War broke out, when aircraft were first strategically deployed for reconnaissance, all the major participating air forces began aerial photographic services. Progress was immediate and rapid, so that aerial cameras grew in ever-increasing efficiency and complexity. While the *Jahrbuch für Photographie und Reproductionstechnik* for 1910 reported that, "The

Englishmen have also approached the question [of Maul's rockets] and were planning to use rocket photography to take topographic pictures of terrains," both the English (possibly representatives of the British Army) and the Germans would abandon the apparatus in lieu of the aircraft. The rocket, with its single-frame photos taken at 800 m, could in no way compare with the astounding aerial photographic achievements at the height of the war. By 1917 observation planes with cameras were flying up to 6,000 m and taking a thousand or more photographs a day. Maul's work, which he had pursued so diligently over 15 years, ceased. He wrote one or two more engineering articles during and after the war, including a very general piece on rockets in 1918, "The Rocket as a Driving Force," and otherwise continued his profession as a civil engineer. He seems to have died about 1958 in Dresden and was then a Work Safety Inspector for the city.[20]

There is a possibility that Maul was responsible for Deutsches Reich Patent No. 301,270 of July 13, 1916 (granted November 8, 1919) for a "Rocket Apparatus with Parachute," assigned to the Saxony Work, Light and Power Joint Stock Company in Niedersedlitz bei Dresden. The patentee of this invention was probably aware of Maul's work. The invention itself consisted of "a rocket apparatus with parachute to cause light, smoke, and similar signals, photographic pictures and similar objects sent into the air." However, the text dealt only with the arrangement of an automatically blinking electric light payload. No other mention was made of either the carrying or the taking of photos.[21]

The next genuine camera rocket project to follow Maul was that of the Russian nobleman Adolf Erazmovich Boyarsky. Boyarsky's efforts, though they did not succeed, appear to have been quite independent of those of the German. Boyarsky had been the photographer of a former Russian scientific-trade expedition to China. Working with cameras, it occurred to him that their reach could be considerably extended with the aid of a rocket and that there were unmistakable military advantages in this combination. Consequently, about 1905, he wrote out his suggestions and submitted them to the army, and also constructed a model--probably the first camera rocket made in Russia. Boyarsky's plans--and his model--were thereafter forwarded to the Aeronautics Department of the Engineering Division, to Lt. Col. V.A. Semkovsky, Deputy Chief of that department. The camera, located in the nose of the rocket, was, according to Semkovsky's report:

> . . . cocked by air pressure, when the apparatus reaches its peak and then begins to descend by special wing-like parachutes which unfold and then an exposure in two copies will be taken. The first copy will be a plan, the other a circumference in the form of a tape (circumference 360). By reflecting the pictures on a screen with a special projector, one can get photos of 3 arshin [210 m] and even more, showing the location of enemy positions at a distance of 12 to 20 versts [12,600 to 21,000 m]. The whole device weighs 5 pounds [2.25 kg], shutter speed is 1/1000 . . . The total cost of construction including the tests will be about 2000 rubles. Mr. Boyarsky asks for his project: 1) to allocate the mentioned sum, 2) to order the Nikolaev rocket plant to make rockets according to the construction of the apparatus and to test it under the supervision of the inventor.

To the report Semkovsky later added a postscript: "This was reported to his Imperial Highness, General-Inspector of the Engineers. He ordered to forget it as useless. Lieutenant-Colonel Semkovsky, Deputy Chief of the Aeronautics Department." Thus, while the chapter on the history of the military camera rocket came to a close at the turn of the century, at the same time a new one was just beginning, for in 1908 the American physicist and the "Father of American Rocketry," Dr. Robert H. Goddard, made what appears to have been the first speculations on the purely scientific research applications of camera rockets, and the first speculations of photography from outer space.[22]

Goddard's earliest known writings on the subject, albeit somewhat primitive and fragmentary at this stage, were nonetheless perhaps the first germ of the idea of space photography itself (i.e. from a rocket). They are found in several volumes of Goddard's unpublished "green cloth-covered notebooks" in which Goddard in his own words, "first started to make a systematic record of suggestions, setting down the date of each as it occurred." The notebooks were continued through Goddard's graduate and undergraduate work in physics at Worcester Polytechnic Institute, Princeton, and Clark Universities from 1906 to 1915, and describe his preliminary thinking on his chosen goal: the scientific exploration of space.[23]

Seemingly echoing the German, Maul, Goddard's entry for May 23, 1908 speaks of the "Use of a gyroscope to keep the camera still." (The context of Goddard's note here indicates that he had already mentioned cameras earlier, but Mrs. Robert H. Goddard, his widow, has not located any earlier references.) However, the very important difference was that Goddard was thinking of a rocket-borne camera in space, and not of a strictly Earth-based military reconnaissance projectile. In this same entry, Goddard also foresaw that the camera would not only have to be stable at the moment it took pictures, but that it would have to be especially reinforced during the high initial escape velocity upon leaving Earth. "The camera in descending," he also wrote, "should be protected with a metal parachute, the edges of this forming springs which project below the level of the bottom of the camera, striking [the Earth] before it [the camera] does." This is somewhat of an extension of Maul's patented (1903) "projecting ring," designed to immediately soak up the initial shock of impact. Though it must be stressed here that there is no indication that Goddard was aware of Maul's rockets, or indeed, of any previous camera rocket system. On the problem of locating the projectile with its camera upon reentry, particularly at night, Goddard suggested that:

> . . . A very strong beam might be swept around the sky [i.e. a searchlight], the source attached to a large telescope--the light exciting a strong luminescence in a material coated on the camera [i.e. reflective material] the light sent out being about the only [one] that can pass through the telescope, by curtain ray screening. The photographic plate should, of course, be adequately protected.

This entry closed with a question Goddard put to himself and would have to think about later: "How will a very light camera stand the shock, if it is of sufficient size?"[24]

In the entry for June 19, 1908, Goddard first talked of photography of the planets in outer space. "There might be difficulty," Goddard speculated, "in having a camera shot around, say, Mars, strike the Earth on the return. Probably several cameras would have to be used. These would have to be made of some alloy of say Pt. [platinum] and Sn [stannum], so that the color would be peculiar and very striking, thus equaling the devices to be picked up on the return." Goddard then digressed at length at the enormous difficulties of landing on a planet, remarking that it "offers difficulties so great as to require a couple of lifetimes to work them out." He realized, for example, that:

> It would be next to impossible to shoot a camera . . . [as] it would just graze a planet several millions of miles distant, although it might work with the Moon, but the projectile might, perhaps, be directed so that it would move with the proper lateral velocity--to pass finally around the planet at the proper distance from it [and take photos]. The same might hold on return . . . Probably, however, the projectiles with the camera could be directed in time by energy carried by them--if not solar energy.

Here Goddard was anticipating the Mariner type craft to Mars, their power supplied by solar cells. Goddard likewise described a camera sent around Mars--also similar to the Mariner probes--guided by the intensity of gravity at predetermined points of the path (entry of June 24, 1908). For protection against meteors while in space, Goddard believed (his entry for August 25, 1908) that "the photographic plate of film should be properly protected," but he thought that the actual possibility of meteoritic impact would be minimal. It is also in his entry for August 25, 1908 that he first mentions lunar farside as well as again considering the possibility of Mars photography:

> Telescopes bring the Moon to within 100 miles. Can the camera do better than this unless it passes very near the Moon? Such a close approach would mean a delicate adjustment between gravity attraction and centrifugal repulsion apparatus--and the nearness of high mountains might throw this off. Also, on Mars, the atmosphere would prevent very close approach. Of course the binocular prism principle might be used, successive reflections,but this would be unsatisfactory probably, and would require an extremely short exposure. If this is true, the camera would only be employed to find the characteristics of the other side of the Moon--not a fundamentally important, but yet important, problem in astronomy.

Here Goddard was anticipating the first lunar farside photographic mission successfully accomplished by the Soviet space probe Lunar-3 on October 7, 1959, fully 51 years after the American physicist made his remarkable suggestion. Goddard continued:

> It is impossible, then, to get better results with ordinary telescopic photography, the camera might perhaps be let fall to the surface (?) [sic] and then made to jump to various nearby places collecting solar energy for its transit (storing it?) finally being shot back to Earth . . . If passage to Mars is impossible or extremely difficult, a big telescope might be made on the Moon. . . .

Goddard's entry for October 15, 1908 speaks of steering or guidance to the Moon and planets by photosensitive cells. "Side jets," or directional rockets for making course adjustments are also mentioned. The remarkable entry for February 27, 1910, had "the camera on return, float in the atmosphere on a balloon, being brought down, as desired, by a radio-wave device." To these and a multitude of other challenges of spaceflight, Goddard was to return again and again.[25]

By 1914 some more defined ideas had evolved. In what is evidently the first draft (dated August 21, 1914) of what was later published as his classic Smithsonian Institution monograph, *A Method of Reaching Extreme Altitudes*, Goddard suggested that "an apparatus of small mass capable of taking photographs automatically," (i.e. a sounding rocket), might be sent up far beyond the range of meteorological balloons of the day, above 20 miles, in which "the presence of an operator would not be essential." (Goddard's discussion of cameras was deleted from the finalized version of *A Method of Reaching Extreme Altitudes.*) He continued:

> The value of such a device in connection with the study of planetary evolution is at once evident from a few simple calculations. Granted that a camera could be made to leave the Earth, encircle the Moon, and return; if it had an objective of 1 ft. [300 mm] aperture, and passed within 500 miles [800 km] of the surface of that body, it would give the same resolution, 1/600,000 as an objective of 443.2 ft. [134.73 m] aperture on the Earth, when the Moon is at its nearest approach . . . and an object 3.9 ft. [1.18 m] wide would be resolvable. Again if the same apparatus were to encircle the planet Mars, and should pass with 1000 miles [1600 km] of its surface, the objective would be equivalent to one of 6.6 *miles* [10.56 *km*] aperture on the Earth, when the distance between the Earth and Mars is at least; viz. 35,050,000 miles [56,080,000 km]. An object 8.8 ft. [2.68 m] wide on the surface of the planet could be resolved. It is scarcely reasonable to suppose that any telescope on the surface of the Earth could compete with such an apparatus in the study of selenography and of planetary markings. Besides affording a means of photographing the far side of the Moon--a region amounting to 41 percent of the entire surface--which could be accomplished in no other way, such a photographic apparatus might be capable of giving information concerning the nature of the zodiacal light, the corona, and the constitution of the comets.[26]

As far sighted as they were, however, these thoughts were at that time purely theoretical and at best highly speculative. Such grandiose projects would indeed be accomplished, but would require the time Goddard's postulate: "a couple of lifetimes to work them out." In his first patent Goddard more directly transferred his thoughts on rocket photography into what was perhaps the first feasible camera-carrying sounding rocket. Certainly it was the first camera patented in the United States and was, interestingly enough, contemporary with Maul's purely military photo reconnaissance rockets. This specification, U.S. Patent No. 1,102,653 of July 7, 1914, for a "Rocket Apparatus," was "adapted to transport photographic or other recording instruments to extreme heights" (Fig. 12). Its three most significant features were: (1) the concept of the multistage or step rocket; (2) the utilization of the modern de Laval nozzle; and (3) the incorporation of gyroscopic effect for maintaining stability of the camera. The multiple-stage concept had been tried in rockets hundreds of years earlier, but this is the first known usage of it in a sounding rocket. As for the de Laval Nozzle, Goddard found by painstaking experimentation that they increased the efficiency of ordinary powder rockets from two to over 64 percent, with correspondingly far higher exhaust velocities. While the Swedish pioneer Unge, cited above, used de Laval nozzles at an earlier date, there is no indication that Goddard was aware of his efforts. In the third major feature of his patent, attaining the stability of the rocket and the camera, Goddard designed his entire apparatus to rotate. It was therefore spin-stabilized, like the Hale rockets of the 19th century. In addition, a gyroscope was also mounted in the nosecone.[27]

The electric gyro itself rotated independently, and caused the head to rotate around the camera. "The speed of rotation of the head is so great," says the patent, "that the passage of the supports . . . in front of the camera does not interfere with the taking of photographs thereby." Goddard's specification also mentions the possibility of yet a third stage being added to the rocket. While this invention was not constructed, it did at least establish several fundamental priorities for Goddard's coming work with rockets and helped establish him as the world's foremost rocket pioneer.[28]

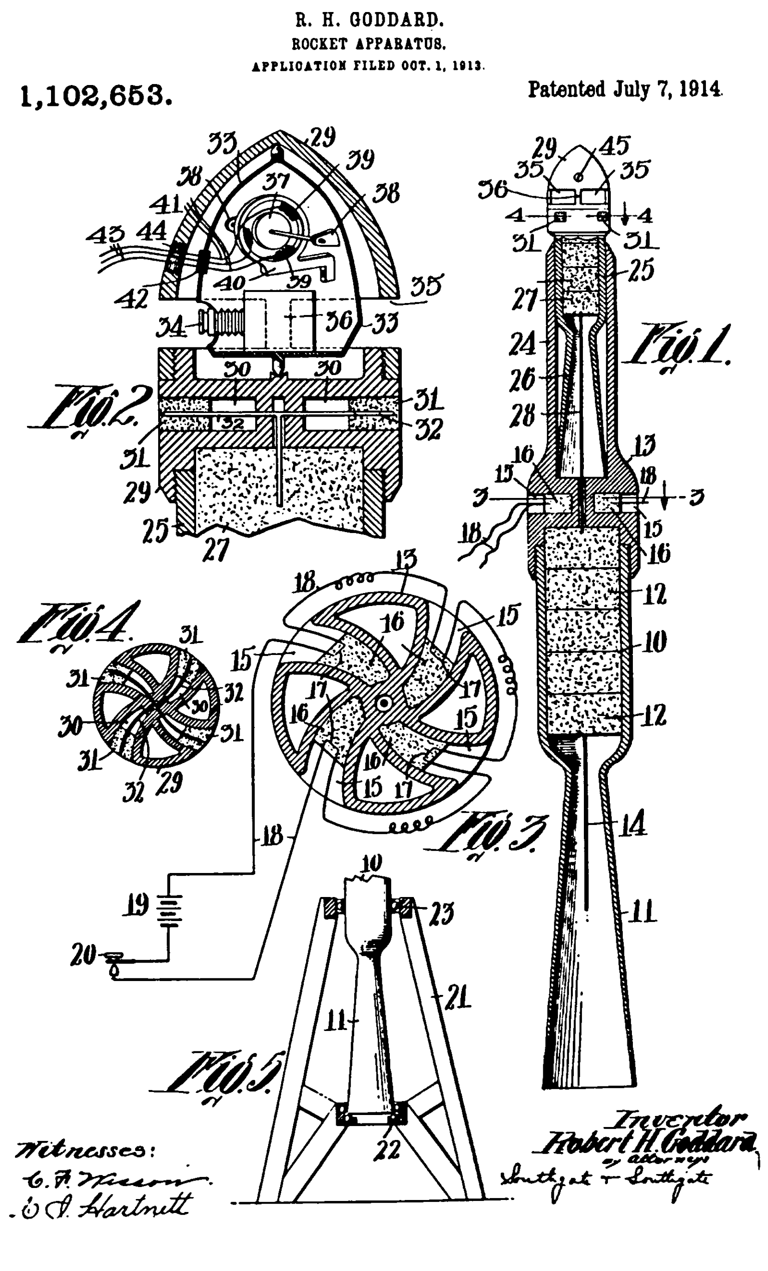

Figure 12 Robert H. Goddard, U.S. Patent No. 1,102,653 of 7 July 1914 for "Rocket Apparatus." The rocket is made to rotate in its flight and also to take photos, the camera (34) being fixed in the head on pivots and made steady by a gyroscope (37). The rotation is assisted by the rocket resting in a vertical launcher and supported upon a ball bearing ring (22 & 23) and by the device in the center of the rocket, a disc with rapidly burning powder, electrically ignited and which revolves the upper rocket.

Despite the enormous and seemingly insurmountable technicalities that lay ahead, the dream of true space photography never quitted Goddard. On August 8, 1915, according to his diary, he literally "Dreamed at 6:15 a.m. of going to the Moon . . . Saw and took photos of Earth with small Kodak while there--two fore stereoscopes--and glimpsed Earth once during return--South America?" Goddard also began lecturing and publishing his thoughts from this period, including the possibility of sending cameras up to great heights, "and thereby study the composition of the upper atmosphere, the light of the stars and sun, and further the study of celestial mechanics."[29]

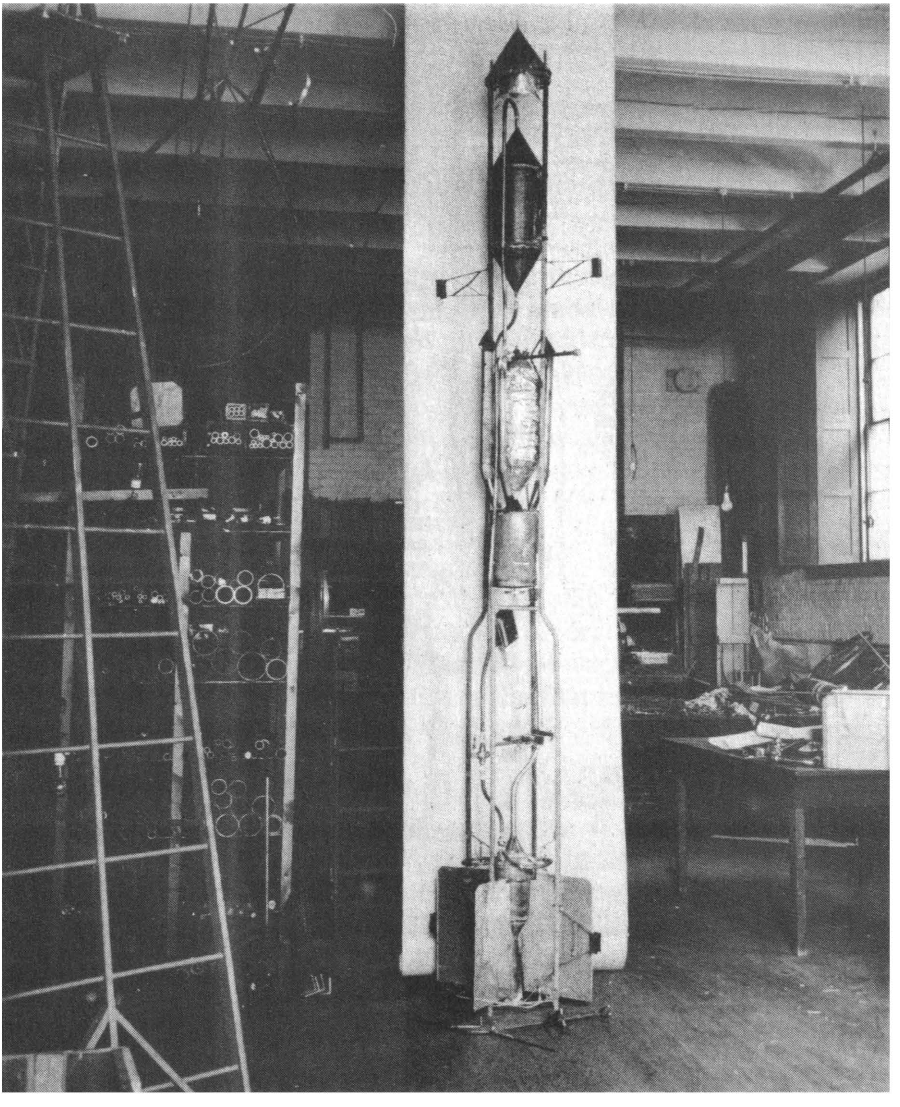

Figure 13 Rocket for test, July 17, 1929, in shop at Clark University showing camera installed.

It was inevitable that he would one day attempt to fulfill such dreams of a rocket-borne camera. This attempt, though quite modest, was made July 17, 1929, and was undoubtedly the world's first liquid-fuel camera-carrying rocket. It was also Goddard's fourth flight with a liquid-fuel rocket.[30] There were two actual tests with the camera, the first on July 8, 1929, being a static run. This rocket weighed 34 lb (15.3 kg). The flight version weighed 32 lb (14.4 kg) empty, and 57 lb (25.65 kg) when loaded with its 14 lb (6.3 kg) of gasoline fuel and 11 lb (4.96 kg) of liquid oxygen as the oxidizer. It stood about 11 ft 6 in. (3.5 m) high and its maximum diameter was 26 inches (65 cm), although the body had no external cover. The tanks, combustion chamber--and instruments, including the camera--were left exposed (Fig. 13). At the rear of the rocket were affixed four vanes of sheet aluminum, and besides the pointed nosecone, these features represented the only streamlining of the rocket as it was a relatively low-velocity (subsonic) vehicle. Its main purpose was to test certain internal systems, including the new instrumentation. According to Goddard's detailed report on the July 8th test:

> On the present rocket an attempt was made for the first time to install recording instruments. A small aneroid barometer was used, just above the combustion chamber, the needle being painted white, and a black paper with white divisions was placed under the glass and over the scale. An alcohol thermometer, showing a wide red line, was wired to a cross-brace over the combustion chamber, and an 'Expo' camera was fastened below the alcohol stove, so that the two instruments were in the center of the field, there being a 3.5 convex eyeglass lens 4" [10 cm] in front of the camera. Thus the instruments were in focus in the center of the field, and a view of the ground could be seen around this central part. A curved arm, 2" [5 cm] long, was fastened to the camera level and a small ring on this lever was arranged to e pulled, thus exposing the camera, when the parachute emerged from the rocket, a wire extending down from the parachute cord to the ring. It was planned to take one picture before the rocket started in order to show the temperature and pressure at ground level and one at the rocket's peak altitude.

Again we turn to Goddard's own words for an account of the test itself, which took place on his aunt's farm in Auburn, Massachusetts. In a letter written the following day to the Secretary of the Smithsonian, Dr. Charles G. Abbot, he reported that:

> A test was made of a 32-pound rocket [14.4 kg], 12 ft [3.6 m] long, sent out of the 60-foot [18 m] launch tower yesterday, at 2 p.m. The new combustion chamber I told you about was used, being extremely light, much lighter than any I had used previously for an actual flight. In addition, a thermometer and a barometer were installed, and a camera arranged to take a picture of these, as well as of the ground, when the parachute was disengaged, i.e. just as the rocket began to fall. This is perhaps the first time that recording instruments have been sent up on a rocket, certainly on a liquid-propellant rocket. It was planned to guide the rocket straight by using light vanes at the rear, depending for stability upon the initial speed acquired in the 60 foot [18 m] tower. The ascent was about 100 feet [300 m] . . . Everything about the test except the guiding during the flight functioned beautifully, releasing, starting, and operation during the flight. Of course, as the rocket did not come down to a stop vertically, the parachute did not operate, and the camera was not exposed [except for a photograph made prior to the test of the two instruments by Lawrence Mansur, one of Goddard's assistants]. The camera is intact, however, and also the barometer, which still reads accurately (minus the glass) on my desk. All the parts of the rocket, except those damaged by the precipitate landing, are as good as new, contrary to the first newspaper reports. The noise was, of course, loud, and led people to think it was the sound of an explosion; hence the police ambulance, which arrived before we could leave the field, and the airplane which searched for victims of a supposed

airplane crash. [Altogether the vertical flight lasted 17 seconds, hitting the ground at 18 seconds, and landing 171 ft [513 m] from the tower.] (Figs. 14-15)

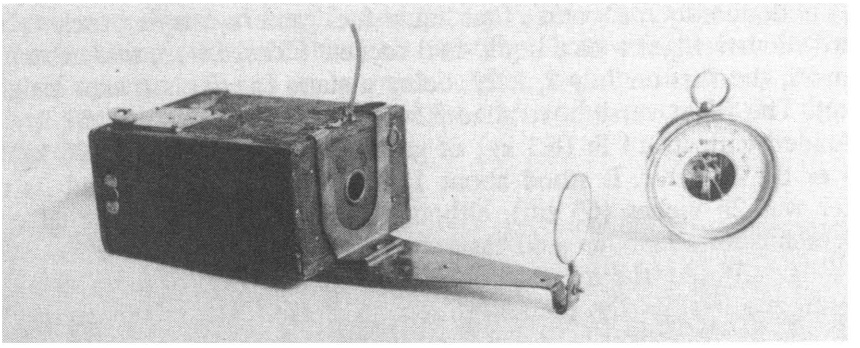

Figure 14 Camera and barograph used on Goddard rocket, July 17, 1929.

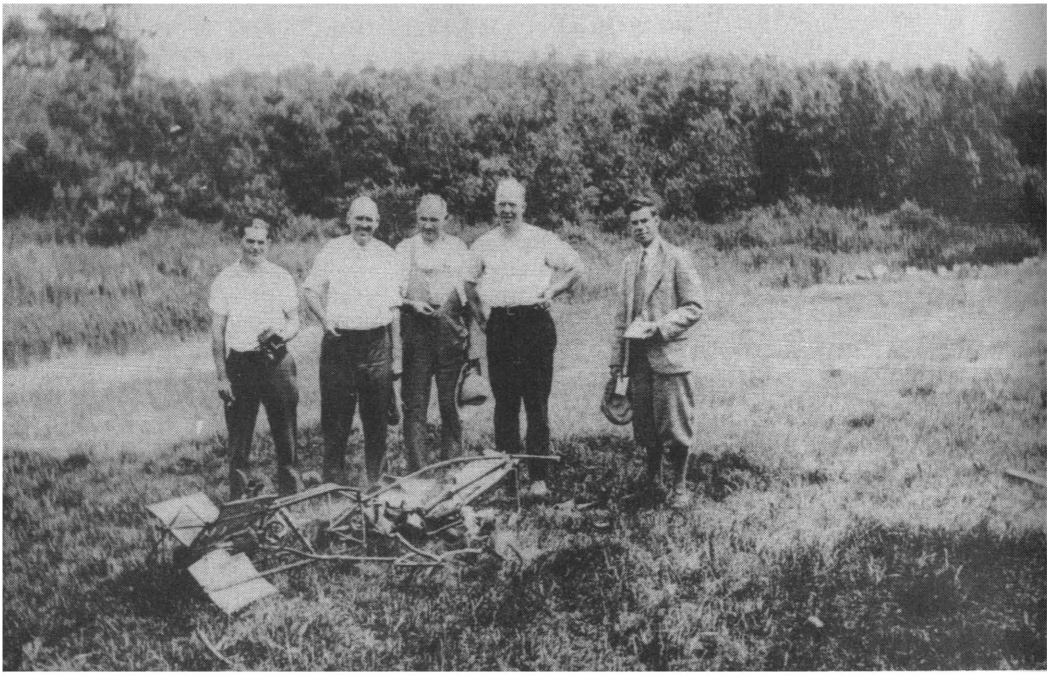

Figure 15 Goddard rocket after landing, flight of 17 July 1929, and group which witnessed the flight, Auburn, Massachusetts. Left to right are Lawrence Mansur, Prof. Robert H. Goddard, Henry Sachs, Albert Kisk and Percy Roope. The photo was taken by Esther Goddard. The rocket was Goddard's first to carry sounding instruments, including a camera, barometer and thermometer. The flight, however, failed to achieve sufficient altitude. From: R.H. Goddard, Development of Liquid Propellant Rocket - 1921-1929, Part II, NASM Collection.

In his official report on the test, Goddard said that "the camera was scorched, but still operated. The spectacle lens was intact and the barometer continued to read accurately, although the glass covering the dial was broken. The thermometer was broken, however, evidently owing to heating higher than it could register." Elsewhere he said the spectacle lens meant "to alter the focus at the center of the field . . . was not even scratched." The small Expo still camera had thus made its first and only flight. The camera along with the aneroid barometer are now on display at the Robert H. Goddard Museum at Roswell, New Mexico. No other camera, still or movie, appears to have been flown in Goddard's rockets, though certainly both types continued to be used in static tests as well as for obtaining ground based coverage of flights.[32]

Despite the failure of the camera to operate in a flight test, Goddard remained optimistic about the eventual practicability of both rocket and space photography. From time to time he conveyed his convictions to others. Soon after the camera flight, in fact, Dr. Abbot on behalf of the Smithsonian, issued a memorandum to the Associated Press (dated July 20, 1929) in which he expressed the belief that once Goddard developed automatic stabilizers and perfected the liquid propulsion system, it would be possible to launch an "automatic apparatus to record meteorological measurements, to photograph the Sun's spectrum, and to take samples of air." Some years later, Dr. Abbot again publicly spoke of this potential application. He said:

> As an astronomer, I am interested in flights up to a point where an automatic camera can photograph the spectrum of the Sun, getting the ultraviolet lines screened out by the atmosphere. An altitude of 100 miles or more is needed for this. It is the hope of astronomers that Dr. Goddard will achieve this.

Abbot was particularly intrigued with the promise of closer studies of the Sun, for he specialized in solar physics. In a conference on Goddard's rocket work, held in Washington, D.C., in December 1929, astronomical photos taken by rocket were again brought up. Attending the conference were Goddard, Dr. Abbot, Dr. John Merriam, President of the Carnegie Institution; Dr. Harold D. Babcock, an astronomer of the Mount Wilson Observatory, California; the Chief of the Weather Bureau; and the famous pilot and now supporter of Goddard, Charles Lindbergh. Dr. Babcock spoke of his interest in obtaining solar corona photographs from a rocket "without having to wait for a solar eclipse," while Dr. Merriam said he was attracted by "the idea of a photograph of the Earth taken at the Moon's distance." Here is one of the earliest known suggestions of photographic views of the Earth taken near or at the surface of another heavenly body, a feat to be accomplished 37 years later as Lunar Orbiter I circled our satellite in 1966. Though all but forgotten, the Washington conference may be said to represent a significant milestone in the history of rocket and space photography, for some of the nation's leading men of science were now beginning to seriously consider these possibilities. Nevertheless, it would be more than a generation before such dreams were fulfilled.[33]

Evidence that Goddard continued to contemplate a future for rocket and space photography is found in a statement of another famous aviator and supporter of his work, Major (afterwards, Lieut. General) James H. Doolittle. Doolittle, upon visiting Goddard in mid-October, 1938, at Roswell, New Mexico, where he had moved to continue his rocket work, wrote in his notes that Goddard's:

> . . . immediate objective is to send instruments higher than they have ever been sent before, well up into the stratosphere or possibly even beyond the Earth's atmosphere, and, through the use of a parachute, have these recording instruments returned to Earth. Lag, accelerational effects, and other possible errors in recording instruments may be checked

by a small camera taking periodic photographs of indicating instruments and a larger camera, synchronized with the smaller, taking photographs of a base line on the ground. This, however, is another future development.

Goddard would not see the fruition of his lofty ambitions. He died August 10, 1945. A year later, a captured German V-2 (A-4) rocket with a standard De Vry 35 mm motion picture camera was launched from White Sands, New Mexico, reached a peak altitude of 65 miles [104 km], and successfully made a continuous record of its ascent through the Earth's atmosphere to the threshold of outer space.[34]

The great aeronautical and astronautical pioneer, Robert Esnault-Pelterie is the first known advocate of space photography after Goddard. Unaware of Goddard's earlier writing on the subject and of his 1914 camera-carrying or sounding rocket patent, Esnault-Pelterie wrote to Goddard on June 16, 1920, regarding their mutual preoccupations of rocketry and space travel:

> The most interesting thing, as I consider the question, would be to send a projectile *around* the Moon with such initial direction and speed that it would come back to the Earth. It would be possible to fit it with a camera and to try by this means to get a photo of the other side of the Moon. I shall try to calculate some trajectories of this kind and believe such a performance to be (if successful) of greater interest than to shoot directly to the Moon.

Goddard answered Esnault-Pelterie July 8:

> Regarding the photographic experiment that you mention, I have already considered the possibility of correcting the flight and of reducing the impact on return. A calculation of trajectories, neglecting these two features, would however, be very interesting.

Esnault-Pelterie did follow up with calculations--keeping the camera in mind--but did so many years later, in his *L'Astronautique*, published in 1930, and later works. It was, however, largely the theoretical mathematics of trajectories that he was concerned with. The Rumanian-born astronautical pioneer Hermann Oberth (he later became a German citizen) was more categorical and explicit in his ideas of space photography.[35]

In the work that first brought him to prominence in the realm of astronautics, *Die Rakete zu den Planetraumen (Rockets in Interplanetary Space)*, published in Munich and Berlin in 1923, Oberth was one of the first to explore the vast possibilities of artificial Earth satellites, or as he called them, "miniature moons" and "observations stations." He wrote:

> With their sharp instruments they could recognize every detail on Earth, and could give light signals to Earth by use of appropriate mirrors. They would enable telegraphic connections with places which neither cables nor electrical waves can reach . . . They could be of use in geography and ethnology in that they could observe and photograph unexplored lands and unknown people (Tibet). Their value to military operations would be obvious. . . . The station could observe every iceberg and could warn shipping. . . . The *Titanic* disaster of 1912, for example, could have been prevented in this way. The stations could also contribute much to saving shipwrecked persons, for news service, etc.

While Oberth, according to his daughter, Dr. Erna Roth-Oberth, was accurately enumerating a multitude of present communication, weather, military reconnaissance, and Earth survey satellites, he was primarily interested in completing his doctorate on the possibilities of space flight, of the mathematical relationships of air drag, weight limitations, fuel expenditures, optimal flight velocities, and space flight itself. Elsewhere, Oberth conceived of the possibility of sending a rocket around the Moon with a movie camera. And in his second great work, *Wege zur Raumschiffahrt (Ways to spaceflight)* of 1929, he elaborated on his earlier ideas. He thought of:

> A rocket ascending 30-40 km [that] could be equipped with a motion-picture camera to make it photograph the landscape before it. In case of war, such a rocket could replace especially the captive balloons with the advantages over them that the enemy could not shoot them down.

Oberth's "geographical rocket," on the other hand, was for decidedly more peaceful purposes:

> it . . . could be equipped with a photographic camera and made to fly over unknown, hardly accessible areas and photograph and survey them photogrammetrically. For example, much would be gained for the exploration of inland Africa, the Tibetan plateau, the polar regions, Greenland, etc., if one had a complete bird's-eye-view photograph of the respective region, it could serve as a map and preliminary guide for the research expedition.

Although Dr. Erna Roth-Oberth concedes that "the name and projects of Maul were familiar to him," her father "had no further interest in them. He only mentioned photo rockets as potential uses in conjunction with his findings." Yet, in October, 1929, when Oberth did attempt to construct a workable rocket, a small one burning liquid oxygen and solid carbon sticks to be fired in conjunction with the premier of the motion picture *Frau im Mond (The Girl in the Moon)*, it was reported in the press that:

> If the experiment is successful, Professor Oberth contemplates the construction of a long-distance rocket carrying cameras, which would be dispatched on a photographic mission over unexplored territory.

This statement, of course was taken out of context from his *Wege zur Raumschiffahrt*. Neither Oberth's rocket for *Frau im Mond* nor any camera-carrying ones were ever completed. Oberth reiterated his thoughts on camera-carrying rockets in a lecture before the Vienna Meteorological Institute in 1931, but his real genius and reputation were already established and were to continue to grow as one of the pioneers of the principles of space flight.[36]

With the advent of the first great classical works of astronautics and rocketry--of Goddard, Oberth, Esnault-Pelterie, and earlier, Tsiolkovsky--the foundations of interplanetary flight had indeed been laid. Ever increasing examples of space and rocket photography after the mid-1920's emerged. While the great Soviet pioneer Konstantin Eduardovitch Tsiolkovsky made no mention of photography in his purely nonfictional works, as he appeared less interested in instrumentation than with the dynamics of interplanetary flight, theoretical propulsion, and in the maintenance of life on space missions, he did at least fictionalize some thoughts on the subject in his *Outside the Earth*, which was completed in 1920. Tsiolkovsky's heroes flashed "photo-telegrams" to Earth as their rocket circled the planet. This was a hint of television from space. And on the big asteroids, Ceres and Pallas, the inhabitants conversed with the aid of "natural" or telepathic pictures emanating from their chests. Tsiolkovsky likened these images to "the camera obscura (or photographic apparatus)." Another Russian, the author V. Levashev, in his fantasy novel *K-V-1*, published in 1927, visualized a small monoplane spaceship equipped with a:

> clever combination of magnifying glasses, cinecamera . . . [which would] bring any given planet closer to such a distance that the cinecamera operating in parallel with the engine would be able to photograph the surface of a planet . . . The entire round trip should last 24 hours.[37]

We thus conclude with a dream, a fantasy. Yet, as we now know, space and rocket photography were inevitable developments and only awaited the perfection of high-altitude rockets and spacecraft to become realities. This paper has dealt with the earliest rocket and space photography pioneers. There were many later pioneers prior to World War II, and these will be covered in a later publication. They will include the first known concepts of television transmissions from outer space as conceived by the American Mark P. Madden and the Russians F.A. Tsander and Maxium Pudovkin; the satellite and space station observation photography described by Franz von Hoefft and Hermann Noordung; the camera rocket designs of V.V. Razumov, L.C. Lee, Jr., Adolph Fierst and Rolf Engel; and the extensive camera rocket experiments of Friedrich Schmiedl, Karl Poggensee and A.I. Polyarny. In the overall study, as well as in the present paper, it is thus evident that by successive stages--through dreams, theories, inventions, and experimentation--mankind has indeed sought and fulfilled the desire to expand his knowledge of the furthest reaches of the universe.

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