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TIZIANA CARROZZA

The eye Over the Hill

Aerial Photography up to the First World War

Great use he thought, there might be made
Of these machines in his own trade;
Now o'er a fortress he might soar,
And its condition thence explore;
Or when by mountains, wood, or bog,
An enemy might lay incog,
Our friend would o'er their station hover
Their strength, their route, and views discover;
Then change his course, and straight impart
Glad tidings to his chieftain's heart;
Such lights convey, such knowledge gain,
As might decide the whole campaign.

(From *The Air Balloon or Major Money's Ascent*,
by George, Marquis of Townshend, 1785)

The observation of landscape features has always been of great importance even before the amazing technical improvement that came with the photographic camera and with the aeroplane. Observation has served people settling in new countries and having to explore them before deciding whether the location was suited to the needs of the community, but above all it has always and everywhere been of capital importance for the army.

On foot, or horseback, if possible from a hill where the gaze can sweep the horizon, men have always tried to define where they were and in what relation they stood with the surrounding landscape and with other human beings.

The strong link that relates observation to war makes it difficult to find studies which treat it from any other point of view. At least until the end of the Second World War, other applications for observation and reconnaissance were neglected. The oldest publications which conceive other uses for observation were above all archeological ones; but as regards sciences such as geography or topography, observation seems to have been used only for tactical purposes. After the technical improvements connected with the invention of photography, of balloons, of kites and finally of the aeroplane, when observation became aerial, another difficulty arose. Most writers put the accent on technical innovations connected with the aeroplane and forgot that in the meantime the photographic camera was becoming more and more sophisticated and capable of fulfilling the new requirements of observation, and that it should therefore have merited a

different and more complete analysis. Their books were much more histories of flight than studies of aerial photography, which was closely bound up with the aeroplane, but just as much with the photographic camera. Even works on map making are rare and very narrow in their focus: since photograph reading (defined as »the operation of recognizing normal features on a photograph«),[1] and interpretation (defined as »the operation of identifying military features such as machine-gun positions, trenches, dugouts, etc. It requires more skill and training than photograph reading«),[2] were strictly connected with the army, their treatment was exclusively tailored for soldiers and officers. It was assumed that nobody else could find the topic of any interest, and even less of any use.

Fairly soon after the invention of photography, some extravagant people started experiments with a camera taking photographs hanging from a flying pigeon. The attempts with cameras attached to birds went on at least until 1907. A patent applied for in the United Kingdom on 19 June 1908 by the chemist Julius Neubronner of Kronberg in the Taunus says:

> My invention relates to a method of and means for taking photographs of landscapes and it consists essentially in attaching to a bird (say a carrier pigeon) a photographic camera provided with time controlled means for actuating the shutter and causing the bird to direct its flights over the landscapes to be photographed[3].

Unfortunately, pigeons are not very keen on scientific experiments. A big problem with them was getting them to fly smoothly. Things went better with captive balloons and kites. At least, they didn't change their course voluntarily.

Like every new invention, the first captive balloons flying in the sky caused many doubts and perplexities. In a letter of 2 December 1783, Sir Horace Walpole wrote:

> Well! I hope these new mechanic meteors will prove only playthings for the learned and the idle, and not be converted into new engines of destruction to the human race, as is so often the case of refinements or discoveries in science. The wicked wit of man always studies to apply the result of talents to enslaving, destroying or cheating his fellow creatures. Could we reach the moon we should think of reducing it to a province of some European Kingdom.[4]

Sir Horace's fears were not in the least unjustified; in a letter of 25 August 1895, Graf von Zeppelin wrote to the War Ministry:

> Through their quick and long flight [...] the lighter-than-air craft become a means of strategic information as they have never been before. At a greater distance, the

assembly and the movement of an enemy army can be discovered and observed, while carrier pigeons can inform the Headquarters.[5]

Some ten years before, Aimé Laussedat, an officer in the Engineer Corps of the French Army pioneered the application of the invention of photography to simple observation from the air. He put into practice the suggestion made by the geodeist Dominique François Jean Arage in 1839 of using the daguerrotype for topographical maps. A real handicap to early aerial photographers was the poor quality of the sensitive material for the plates used in the cameras. An exposure of four hundred seconds was too long, and the photographs were rarely sharp enough to be of any use. By then, the exposure time of a plate had been reduced to eighty seconds by the use of bromine in the emulsion. Later on, in the 1850s, the exposure time was further reduced to one-tenth of that of the bromine daguerrotype. This improvement showed that the application of photography for aerial reconnaissance was only a matter of time. In 1856 Félix Nadar, a French civilian, photographed Paris from a captive balloon using the daguerrotype process. The first aerial photographs were just experiments in using the camera in every possible situation; once more appreciable results were obtained, they were considered as pictorial works to be shown in exhibitions for the amazement of a paying public. At the Paris exhibition in 1867 the public could, in fact, admire a map of Paris based on photographic surveys.

The Balloon Corps of the United States was the first to apply aerial photographs to military operations. Since 1861 some civilian balloonists had been working unofficially with the US Army. Their activity was considered of little significance by most of the officers. This attitude persisted even after 1910, when the Wright brothers invented the aeroplane. The historian Reeves Dache recounts »an illuminating incident concerning a certain commanding officer of the »old school«. Shortly before the Armistice he returned a quantity of aerial photographs to the Air Service still in their original envelopes with the remark »Very pretty pictures, but there is war on, and I have no time for playthings«.[6] A balloonist's life was no easier in Europe, except in France where there had been a balloon division since the 1840s. In Germany, people like Graf von Zeppelin had to push very hard to make the higher ranks realize the importance of observation and reconnaissance from the air. A real understanding of the tactical improvement offered by aerial observation developed very late in Germany, particularly as regards the use of photographic cameras. The Berlin *Reichsfilmblatt* of 5 February 1927 and the *Münchener Neuesten Nachrichten* of 10 April 1927 reported in commemorative articles that in 1898 Oskar Messter flew in a balloon called »Condor« with the Flying Officer Bartsch von Siegfeld and took some successful photographs, which did not seem of great interest or use. Until July 1914 the crew roster for a lighter-than-air craft did not include a photographer, but only an observing officer.[7] At the very least, the authorities' position regarding aerial photography was contradictory. While on the one

hand, they seemed to be unaware of the tactical implications of the new technology, on the other they were alarmed by the danger of espionage connected with aerial photography. In 1909 an article of the *Tägliche Sonderbeilage des Berliner* reports under the title »Unwelcome pictures of two German air flyers in Russia«: »The gentlemen Oskar Messter and Dr. Brinkmann from Berlin, who in the balloon ›Tschudi‹ undertook a research flight, landed a few hundred metres inside the Russian border. They were arrested, and were released only after they contacted the German Ambassy in St. Petersburg.«[8] The Russian border police destroyed the camera and the film taken by Messter and Brinkmann so that we do not have a photographic record of this adventure.

The aerial camera was of great help for the Italians in the Italo-Turkish war of 1911-1912. Taking advantage of French experience in the matter, and using single-seater biplanes, the Italians were easily able to overwhelm the Turks, who used a classic war strategy. Another rehearsal for aerial photography, before the Great War, was the conflict between the Turks and the Bulgarians in 1912.[9] Though both conflicts showed the great importance of aerial reconnaissance, its widespread application dates from the early days of the First World War. The delay is difficult to explain, particularly if one takes into account a British patent for »A New or Improved Apparatus for Obtaining Bird's-eye Photographic Views«, applied for as early as 1891, which says: »The present invention is applicable more especially to military operations, by taking photographic bird's-eye views of fortifications or other positions occupied by an enemy, from a distant position where they are not visible.«[10] In fact, while most European countries used aeroplanes regularly before 1914 for surveying, no air unit had been trained or equipped to take pictures.

> By 1912 there were nineteen trained pilots in Britain, while France had 263 flyers and over two hundred aircraft. In five years the French had built up the most powerful air force in the world. A close second was Germany, which had another threatthirty dirigibles. The French and the Germans trained their flyers to co-operate with the cavalry on reconnaissance, to direct artillery fire, and to take aerial photos.[11]

Aerial photography was a genuinely new departure, far more so than the tank or the steel helmet. It was the logical reaction to a completely changed way of making war, the off-spring of the first technological war in history. That is probably why it was not until the beginning of 1915 that the importance of photography was apparent, resulting from improvements in the type and general stability of aeroplanes. After the deadlock arising from the inauguration of trench warfare and new and more sophisticated camouflage, it was obvious that the old methods of obtaining intelligence information were out of date. The aeroplane replaced the cavalry and the ground scout of former days, and greater and greater demands were made on photography.

Unstable aeroplanes and inadequate photographic equipment made the first experiments very unsatisfactory for the requirements of reconnaissance. A very large proportion of the photographic work had to be done in unfavourable weather conditions, and this posed problems, in particular, atmospheric haze and thick cloud. While nothing could be done about cloudy weather except to hope for gaps in the clouds, the refraction of light rays caused by the minute particles composing haze could be overcome by using orange-coloured filters. In fact, it was found that these filters greatly improved the quality of photographs taken in hazy weather, even if they stopped a large amount of light and reduced the »photographic day« to the period from 9 a.m. to 4 p.m.[12]

Since the first experiments with film negatives were not successful, the Allies, whose co-operation in photographic matters was very close, preferred to use glass plates; a report dated September 1917 signed by Gilbert S. Dey, Superintendent of the Optical Department of the Eastman Kodak Co. of Rochester, notes:

> ... There have been many efforts to introduce the use of films especially for automatic and semi-automatic cameras. The French Government has even ordered film cameras of the »Brock« type from the U.S. Several inventors are at work presently trying to build new models utilizing films even in 13 x 18 and 18 x 24 sizes. It must not be forgotten that so far the inconvenience of film use [is that the] difficulty of having it as perfectly plane during the exposure and imperfection[s] in the grain have not been overcome. Before departing from the use of glass plates it must be proven that the quality of the proofs obtained with films is perfect in every respect. The decision should be taken only by a recognized expert in aerial photography.

Further on in the same file, under the title of »Notes on Aerial Photographic Work«, one can read:

> An aerial photograph has to be extremely clear and extremely well defined. This amounts to saying that the use of aerial cameras with films is under no circumstance advisable. The English and the French have tried film cameras again and again, and always with bad results. For aerial work we must take photographs of large dimensions and we can not get films flat enough, so that the centre of aerial photographs taken on films is never in focus, and we can not read them satisfactorily.[13]

The Germans used both plates and film. In a note sent by the O.I.C. Photographic Section to the Photographic Division, Army Air Service, Washington D.C. on 22 June 1918 one can read:

> The German plate is apparently the best plate being used on the front to-day. It is difficult to co-ordinate the various requirements in one plate. In the matter of supply this would be a great convenience. It is desirable to have an extremely rapid plate, and one that can be occasionally examined during development. This seems to eliminate a panchromatic plate, and is probably the reason the Germans are using an orthochromatic plate that is not red sensitive. The logical solution would be to have one plate that could be developed by a red safe light.[14]

Like the Allies, the Germans tried very hard to use film. According to Oskar Messter, writing in his autobiography, they succeeded, and in fact Agfa, which was the largest manufacturer of film for Germany, only survived the difficult war period because it supplied large quantities of film to the army.[15] Even if the film was highly inflammable and presented more difficulties in the development, its use instead of plates represented a great improvement, because of its light weight (a film magazine weighted only 2,5 kg and substituted 8 plates) and small size, which reduced problems of storage in the aeroplane and because it was easier to load. The danger caused by the high inflammability of the film was solved by the magazine which contained it and was made of aluminium. In 1916, new magazines containing 120 m of film instead of the previous 50 m went into use permitting photographic runs of about 150 km in length instead of the previous 80 km.The fact that the Germans used plates and film at least until 1917 leads us to wonder whether they had really improved film to the extent that it could serve as a respectable substitute for plates. In any case, in the *Final Report* of the Inter-Allied Commission of Control, created after the end of the war to check and destroy all German weapons and war material still on German soil, a conspicuous amount of film for aerial photography was listed.[16] Messter wrote:

> For the construction of the new camera [the first Reihenbildner of April 1915, D.R.P. 298 086], the use of film instead of plates used hitherto by aerial cameras was for me an implicit assumption. Since I thought that the frame size of 2x2,5 cm, which I had used in previous aerial photographic sorties was inadequate for intelligence purposes, I had to use a larger size of film. I couldn't go too far, particularly because of the problems the troops would have had in developing and printing them. I decided to use a 12 cm focal length and a frame size of 10x10 cm. [...] My camera could take 250 photographs on a 25 meter roll of film.[17]

This camera, according to Messter's autobiography and to a number of newspaper and scientific articles contained in his legacy,[18] was the first used by the German Army, and was called at the front »Strandhaubitze«. The first unit to make practical use of the new camera was the 40th Flying Section, in the second half of May 1915 in Handzaeme on the Flanders Front. A few days later, other photographs were taken over the Yser. The device was semi-automatic; the lens

used was a Zeiss-Tessar of 30 cm focal length. It was a success, allowing one to see the advantages brought by the use of film instead of plates.[19] Oskar Messter was able to continue his tests under the protective wing of the German air force, even if in a letter as late as 27.7.1916,[20] one can read that some officers of the army, i.e. Flying Officer Schmidt, tried to oppose the use of the new device, giving as evidence of its unreliability a bend appearing in the aerial photograph of a street which, according to a Russian map, was straight. Eventually the map was found to be inaccurate. With his superior, Flying Officer Fink,[21] stationed in the Western Headquarters, Messter dealt with all the problems connected with the Reihenbildner and worked out improvements for the device. Ever since 1910 Flying Officer Carl Fink, called by his comrades »Luftbild-Fink« (aerial-photograph-finch), had been trying to introduce the first primitive aerial cameras into the Königlich-Deutschen Fliegertruppen in Döberitz.[22] His collaboration with Oskar Messter meant an important step in what characterizes the First World War more than any other human conflict, i. e., the unification of industrial, technical and military interests. The army asked for an automatic camera which was ready, according to some sources, on 26 May 1915 [D.R.P. 332 233].[23] It had a frame size of 3.5x24 cm, which worked with unperforated film periodically moved ahead by a transport mechanism and which used a Zeiss-Tessar lens of 25 cm focal length.

Both armies strove to find a way of taking aerial photographs that provided the most visual information about the terrain being surveyed. The best interpretation of aerial photographs was obtained from viewing stereoscopically two shots of the same area, taken a distance apart. It was not possible to achieve this by taking a number of photographs in a single run, because the distance between the vantage point of each successive photograph was not sufficient to give a true stereoscopic effect. To take these photographs, the pilot had to fly at a constant speed in parallel runs at a set distance apart over the terrain. The aeroplane therefore offered an easy target to anti-aircraft artillery while it was performing this task. The prints were then mounted in such a way that the overlapping strips of photographed ground could be viewed through a stereoscopic viewer, increasing the dimension of depth in the image, and bringing into relief features of the landscape. On 20 October 1915 the German Army officially commissioned from Messter a »Doppelreihenbildner« (double Reihenbildner) which was delivered on 4 May 1916 to the »Deutschen Fliegertruppen für die Marine« (German flying troops for the navy).[24] This new camera was developed in order to reproduce human stereoscopic sight. And in fact the new device made the heights and depths of the terrain visible. Nevertheless the »single« Reihenbildner also worked well stereoscopically if the negatives obtained were overlapped in the right succession, then spliced together on a celluloid base and finally developed. The scale of the photographed terrain depended on the focal length and on the height of the aircraft above the ground. The film moved obliquely to the direction of flight. In a letter of 3 February 1916 Messter told Fink to read the

photographs he was sending him stereoscopically in order to see how the movement of people could be detected. Since the flight direction was always known it was then easy to find out the direction of the movement of people. »I hope that this discovery will make it possible to determine the direction of marching troops from photos shot with the Reihenbildner.« [25] Messter's assertion in the letter indicates that it was only from the beginning of 1916 onwards that aerial photography was conceived as a means of spying on the enemy's manoeuvres. Probably up to that date, photograph interpretation had not been sufficiently developed for its possibilities to be fully realized.

According to the *Inter-Allied Final Report* after the War:

> The cameras used by the German air force are [...] :
> 1° Photographic cameras, (designation Fk), with a focal length of from 25 cm to 120 cm Accessories: double cassettes (Doppelkassetten), magazines of six plates (Wechselkassetten), or magazines with film (Rollfilmkassetten).
> 2° Automatic film cameras of different types (designation Rb Reihenbildner) again featuring a narrow field of view (6 cm).
> 3° Automatic or semi-automatic cameras containing about fifty plates 13x18 called Prb (Plattenreihenbildner). [26]

Oskar Messter is quoted in the case of his Reihenbildner II with a note saying that the device has to be vertically suspended. According to Albert Narath, Messter's Reihenbildner II was the last improved model of his device.[27] In fact, there were other models like the Reihenbildner V, which had a focal length of 50 cm and a frame size of 6x48 cm. It worked with an unperforated film and had a frame size of 6x24 cm. Once Oskar Messter had invented the Reihenbildner, they were built by Messter himself and by others, among them Ernemann Werke AG Dresden and Projektionsmaschinen GmbH, which improved the device with new models. Messter himself worked hard at solving technical problems. His exchange of letters with Flying Officer Carl Fink is an important source for an understanding of what the technical steps towards the »perfect« device were. Reihenbildner I presented, for example, a poorly light-proofed camera, and the film transport mechanism did not work very well. This was the reason why Messter decided to perforate the film on both sides. No detail was passed over. On 13 October 1915 Messter applied for a patent for a device which calculated the speed of the aircraft, in order to establish the space between two subsequent exposures of the film. In a letter dated 15 September 1915, Messter discusses the positioning of the Reihenbildner on Albatros C aeroplanes. Even if the observer could more easily handle a camera set in front of him, Messter decided to mount the Reihenbildner behind the observer in order to keep the balance of the aircraft.

Up to the end of the war about 933,000 metres of film were shot with the Reihenbildner. From 1917 the western front from the North Sea to Switzerland

was photographed every week and the photos taken in the morning were on the table at General Headquarters in the evening of the same day. [28] After the »Strandhaubitze«, all the Reihenbildner (even the ones made by other factories) worked with a 6 cm wide film, taking an image whose length varied from 24 to 40 cm, depending on the different models. Those built by Messter remind one of the movement of a ciné camera, with a rocking lever that intermittently interrupted the movement of the film by pressing it against its backing plate (*Schläger*); the various Reihenbildner IV cameras (built by Projektionsmaschinenbau GmbH) did away with the sprocket wheel; they still remind one of the traction of a ciné camera because of their rubber disc, with a bulge in it, forming a cam (*Nockenapparat*); the Reihenbildner III camera, built by Ernemann, featured a transport mechanism which, even though it used a Maltese Cross, was very different from the ciné camera. Messter's cameras were powered by a propeller turned by the wind speed, via a belt; the final Reihenbildner V was powered by a motor via a belt running around different pulleys, according to the speed desired. It was the last he made for the war, but in fact Messter continued his improvements until 1926, working for the company Zeiss-Aerotopograph with his son Eduard and the engineer Hugershoff.

In the British Army the first experiments in aerial photography were started in late 1914. It was soon found that the balloons were often blown off course by the high winds encountered. Thus one of the first obvious improvements was to make cameras of the box type with the focus set at infinity. These cameras, called the »A« type, were fitted with focal plane shutters and the Mackenzie-Wishart system of changing plates. Some good work was done with them, but they were altogether too primitive. A new camera, called the »C« type, was built to be rigidly fixed to the side of the aeroplane, so that photographs could be taken from a more accurately vertical position than those shot with a hand-held camera. Furthermore, plate changing was improved. Sergeant Laws of the Royal Flying Corps invented a camera with a six-inch focal length that would take a 5x4 inch picture. This camera, called »L« after its designer, could take a good, useful photograph at 6,000 feet. At higher altitudes, this camera could take pictures which covered a much greater area, but failed to capture sufficient detail. The »L« type camera was improved in 1917. In some training notes on aerial photography, the »L« camera is described as thus:

> The camera body and bottom half of the changer are one casting in aluminium alloy. Into the body is fitted the plate changing and shutter mechanism, and a single flap light trap; the shutter is a simple variable focal plane type. The lens is fitted in an aluminium focussing jacket which works in a brass cylinder. The cylinder screws into the camera body and is locked there by a spring pin, in addition to the hand operating arrangement which is worked by means of the long rocking lever. This camera may be mechanically operated by a small propeller which revolves at a high speed due to the air pressure arising from the speed of the aeroplane. This operates

the plate changing and shutter setting mechanism and only the exposing has to be done with the hand. This means that the observer or the pilot has only one thing to do, i.e., expose.[29]

Many other improvements were subsequently added, but the tendency was always towards automatic and fool-proof cameras, in order that a pilot should have as little as possible to do and to think about while flying his aircraft. In all regular equipment in use with the French Army the cameras were of metal, except for the Italian cameras which were of wood. The magazines were of wood or metal. Wooden cameras were tried and abandoned in favour of metal ones. The standard cameras in use could vary between 26, 50 and 120 cm focal length, and their plate size could be 13x18 or 18x24 cm. The 26 cm camera was principally used for wide range reconnaissance, when large areas had to be covered to get general outlines far behind the lines. The 50 cm camera was used when either small areas needed to be photographed or when limited, well-defined areas had to be surveyed. The 120 cm camera was used when a picture of a particular spot was wanted. They could all be used at the same altitudes, preferably a low one. When it was necessary to fly higher than 6,000 metres, owing to gunfire, only the 120 cm camera gave adequate results.

The photographs could be vertical or oblique (normally at an angle of 45 degrees), depending on the requirements of the Intelligence Staff. Oblique shots were usually easier to read but gave less detail than vertical ones. They were made when it was impossible to get above the place to be photographed, or when it was difficult to detect objects depicted in vertical photographs, such as the entrances to dug-outs, the area beneath trees and on hillsides, or when they had to be used by the infantry, whose men were not very well trained in photograph reading.

Both armies strove to find a way of taking aerial photographs that provided the most visual information about the terrain being surveyed. The best interpretation of aerial photographs was obtained from viewing stereoscopically two shots of the same area, taken a distance apart. It was not possible to achieve this by taking a number of photographs in a single run because the distance between the vantage point of each successive photograph was not sufficient to give a true stereoscopic effect. To take these photographs, the pilot had to flight at a constant speed in parallel runs at a set distance apart over the terrain. The aeroplane therefore offered an easy target to anti-aircraft artillery while it was performing this task. The prints were then mounted in such a way that the overlapping strips of photographed ground could be viewed through a stereoscopic viewer, increasing the dimension of depth in the image, and bringing into relief features of the landscape.

Although the first experiments with the new hanging camera were the stuff of fairgrounds, and the photographs so obtained were shown in exhibitions for a public who paid for the new sensation of watching the world from above, the

First World War added other crucial meanings to the original harmless and educational ones. No previous war had involved aerial photography in such a complete way. Aerial photography had been used before, but the greater mobility that aircraft were able to give to the camera led to its rapid development during the First World War, until it became easily the largest source of observation. The form that the battlefield took in the Great War, the daily thickening network of trenches, the rapid discovery of the enemy gun emplacements required a precision in reconnaissance that only photography could give. The response to aerial photography was to develop highly sophisticated and effective forms of camouflage. Every attention was paid to keeping weapon positions secret, even to the extent of having troops wear biscuit tin lids on the soles of their shoes, which left prints that were less striking than foot-prints and, even if seen, did not show the direction in which they were marching. This in its turn forced the aerial photographers to elaborate methods of constructing stereoscopic views of the ground in order to enable the interpreters of the photographs to detect even the most carefully disguised units.

Notes

1 M. Reeves Dache, *Aerial photographs. Characteristics and Military Application*, New York, The Ronald Press Company, 1927, p. 21.
2 *Op. cit.*, p.22.
3 Patent Number 13.128 A.D. 1908
4 Quoted from C.F. Snowden Gamble, *The Air Weapon. Being some account of the Growth of British Military Aeronautics from the Beginnings in the Year 1873 until the End of the Year 1929*, Oxford, Oxford University Press/London, Humphrey Milford, 1931, p.26)
5 Quoted and translated from: *Die Militärluftfahrt bis zum Beginn des Weltkrieges 1914*, bearbeitet vom Reichsluftfahrtministerium, Kriegswissenschaftliche Abteilung der Luftwaffe, Berlin, Ernst Siegfried Mittler und Sohn Verlag, 1941.
6 M. Reeves Dache, *cit.*, p.10.
7 Compare this with: *Die Militärluftfahrt bis zum Beginn des Weltkrieges 1914*, *cit.*
8 BA NL 275/4.
9 Grover Heiman, *Aerial Photography. The Story of Aerial Mapping and Reconnaissance*, New York/London, Macmillan, 1972, p.36.
10 Patent Number 12.669 A.D. 1981, p.34. Snowden Gamble, *cit.*, p. 138.
11 Heiman, *cit.*, p.36.
12 M. Reeves Dache, *cit.*, p. 4.
13 Captain V.F. Bryce (R.A.F.), Document 83/26.2, Document Department, Imperial War Museum, London.
14 Bryce, *Op. cit.*
15 Oskar Messter, *Mein Weg mit dem Film*, Berlin, Max Hesses Verlag, 1936, p.128.
16 Inter Allied Commission of Control, *Final Report*, Chapter XVI, 1921.
17 Messter, *cit.*, p.81.
18 See particularly BA NL 275/271d.
19 Franz Manek, »Die Luftaufnahmegeräte von Oskar Messter«, in *Luftwissen*, vol. 8, no. 11, 1941, p. 348.
20 BA NL 275/271a.
21 See the correspondence contained in the Oskar Messter Legacy, particularly BA NL 275/92.
22 BA NL 275/259a
23 Manek, *loc. cit.*; Albert Narath, *Oskar Messter. Der Begründer der deutschen Kino- und Filmindustrie*, Berlin, Deutsche Kinemathek e.V. Filmwissenschaftliche Schriften, 1966, p.29; Messter, *cit.*, p. 84. A document dated 1941 contained in Messter's legacy (BA NL 275/253a) says that on 26 May 1915 the first version of the Reihenbildner was still being

used, as does a list of the devices (BA NL 275/260) constructed by Messter for the army. According to this list, a newer model was not delivered until 14 July 1916. A file contained in Messter's legacy (BA NL 275/69b) gives the patent numbers of the devices and of their improvements in the period between 1915 and 1916: D.R.P. 298 086; D.R.P. 309 227; D.R.P. 332 233; D.R.P. 295 432; D.R.P. 300 688; D.R.P. 333 614; D.R.P. 301 383; D.R.P. 301 382; D.R.P. 307 628; D.R.G.M. 650 283; D.R.G.M. 669 237; D.R.P. 304 316. For quotations from patents see also Narath, *cit.* p. 29; and BA NL 275.

24 BA NL 275/260.

25 BA NL 275/92.

26 Inter-Allied Commission of Control, *Final Report*, Chapter XVI, 1921, p.26.

27 Narath, *cit.*, p.29.

28 Narath, *loc. cit.*; Messter, *cit.*, p. 86 and BA NL 275/262c.

29 *Miscellaneous 1969*, Box 126, Document Department, Imperial War Museum, London.