LUFTWAFFE CAMOUFLAGE AND MARKINGS 1933-1945

Includes three RLM colour cards

Volume One

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The Nationalsozialistische Deutsche Arbeiterpartei (NSDAP), (National Socialist German Workers' Party) had inherited a strong, well-regulated aircraft industry and in April 1933, barely two months after the change of government, the Deutsche Luftfahrtzeugausschuß (DLA), the German Aircraft Committee, issued a document entitled 'Bauvorschriften für Flugzeuge (vom Unterausschuß für Flugzeuge Angenommener Fassung)' – ('Construction Regulations for Aircraft (from the Sub-Committee responsible for Aircraft')). Amongst other aspects it contained an extensive section on aircraft paint finishes. Titled Oberflächenschutz (Surface Protection), it laid out a full set of instructions for provision of protective finishes, compatible for land and sea-based aircraft, using both preservatives and paints on all types of materials used in aircraft structures.

While external coloration was not mentioned, and preservatives and paints were referred to in general terms, the document underscores the extent to which the aircraft industry was already regulated, and the degree of standardisation in terms of products. That degree of control would continue under the new government until 1945, though with some reduction in effect as wartime conditions imposed difficulties. Variations from the rule occurred as a result of difficulties associated with shortages of raw materials within the manufacturing industry and transportation problems. It should not be inferred however, that the RLM lost complete authority over its system of standards control.

The matter of colour standards was also inherited; the Reichsausschuss für Lieferbedingungen – (Committee of the German Reich for Terms of Delivery), had been formed in 1925 to try to bring together the resources of an economically suffering post-war Germany. Two years later a decision was taken to recommend to the Government that the number of colours for general use should be restricted as a means to simplify the process of purchasing and storage across industry. Emphasis was also placed on colours that could be produced from local pigments, thus saving valuable hard currency in importing raw materials. Initially 40 colours were selected, 13 of which were the base colours from which the remaining 27 could be mixed. This was the system in place when the National Socialists took power, and in the ensuing years they expanded it as they rebuilt the German infrastructure, establishing civilian and military services. By the end of the 1930s the number of colours had risen to more than 100 and precipitated a revision of the RAL system.

Paint colour (or more precisely the shade of colour) was identified by a numerical code expressed as a four-figure group, preceded by the letters RAL. This was divided up as follows:

1000 - yellows
2000 - oranges
3000 - reds
4000 - violets
5000 - blues
6000 - greens
7000 - greys
8000 - browns
9000 - whites, blacks, metallic colours etc.,

The range covered all the major colours of the spectrum, moving via mixtures between primary colours; then colours that neutralize each other to produce greys; then tertiary mixes which produce browns, and finally the extreme boundaries of the spectrum, plus special colour effects. As with traditional colour charts, each section began with a pure colour and moved through subtle mixtures towards the next pure colour in the range. It was a highly flexible system that allowed very precise colour identification and was applied widely within the Reichsbahn, Reichspost, Polizei, Feuerlöschpolizei, Heer, Kriegsmarine, and, at least initially, the Luftwaffe, providing a unifying system for all arms of Government and the armed forces.

This cross-correlation allowed different paint manufacturers to precisely *colour* match their products, where required, with those of other firms at time of manufacture (but each paint or lacquer base stock retained its own unique, commercially protected, company formulation). Supplementary items used in the paint process - which had no colour related aspect - were simply identified by generic name, e.g., beeswax, sandpaper, steel wool etc. General materials specifications, approved by the procurement branch of the RLM, listed paints/lacquers by their company formula codes, which was unconnected with the RAL colour code system. Aircraft manufacturers purchased these from paint manufacturers in normal commercial transactions. The RLM did not buy stocks of lacquers, store and then issue them to the aircraft manufacturing companies, a misconception that still lingers in some contemporary discussions. In later years the RLM did exercise some control over 'approval for purchase' of certain chemicals that had become in short supply, (throughout, documents relating to this subject consistently refer to aircraft paint by the description Flieglack – literally flight lacquer. However 'lacquer' is more consistent with the chemical composition of the products, and the general term aircraft lacquer will be used from here on).

By March 1935, when the Luftwaffe was revealed to the world, there was already in place within the RLM a similar system to that of the RAL. The German High Command planners had appreciated the value of the precise, but elegantly simple identification codes system of the RAL, and adopted the basis of the system, applying it to their entire military procurement system. By using four-number blocks starting at 0000 and running through to 9999, the system was large enough to handle, with precision, every item required for the military forces. Precisely when this system was introduced is not known, but the first issue of the section specifically referring to aviation materials, occurred in 1935. The document, with the rather imposing title of 'Fliegerwerkstoffe, Handbuch für die Auswahl der im deutschen Flugzeug-, Flugmotoren- und Luftfahrtgerätebau zu verwendenden Werkstoffe. I Teil, Metallische Werkstoffe. Herausgegeben vom Reichsluftfahrtministerium Werkstoffabteilung, 1935' (Aircraft Materials, Handbook for the selection of German aircraft, aircraft motors and aeronautical equipment manufacturers of relevant materials. Book I, Metal materials, Issued by the RLM Materials Division, 1935), dealt with code number groups 0000 to 9999.

The 0000 to 3999 allocation covered the entire range of metals used in the war industry; carbon steel, single layer alloy steel, multiple layer alloy steel, cast steel, cast iron, pure metal, gun metal, brass, bronze, special bronze, nickel alloy, tin alloy, zinc alloy, lead alloy, hard alloy, precious metal, treated heavy metal, pure metal (different grade), aluminium copper magnesium alloy, aluminium zinc alloy, aluminium silicon alloy, aluminium magnesium alloy, treated aluminium alloy, magnesium alloy, treated light metal. Many of these metals were the

mainstay of the aircraft industry, and stamp markings to identify them were a regular feature of internal markings in Luftwaffe aircraft. Some groups had single figure suffixes, divided from the main code by a period (.); these ran from .0 to .9 and identified specific types of treatment applied to various metals. (See Appendix G, Volume Two)

The 5000 to 6000 section was used to identify various grades of rubber, specific chemicals, leather, textiles, paper, felt, horsehair and kapok. Section 7500 to 9999 identified lime, asbestos, ceramic materials and glass. The sequence 7100 to 7199 was allocated to aircraft paints, 7200 to 7299 to paint thinners, and 7300 to 7499 to the colouring of corrosion proofing of materials. Again some groups had single figure suffixes, divided from the main code by a period (.); these ran from .0 to .9 and identified grades of various specific materials.

This form of subdivision was not applied to the 7100 to 7299 group, but most of the lacquers later identified from code groups within this spectrum did use a form of suffix to identify their ability for use either with or without additional specific colouring. This was signified by the addition of a suffix of a period and hyphen (.-), e.g. 7102.-. In view of a significant change that would occur in 1943 (see Chapter 6), it is important to understand what this marking actually implied.

All lacquers used by the aircraft industry had a natural colouring, produced by the colours of the various chemicals and materials that went into each individual formulation. This natural colouring could vary from production batch to production batch of each *specific lacquer* and there was no requirement imposed on the paint industry for any standard of colour for each specific lacquer. For example 7102.- had an inherent green colouring, the shade of which could vary to some degree between batches. The colour however was always a green. A zinc chromate primer based on phenolic resin, linseed and wood oils, it had good resistance to moisture, seawater in particular, which is why it remained the initial coating for external metal surfaces on aircraft. While translucent in its basic form, it was always thinned out for spraying, usually to a very significant degree, which made it almost transparent when applied to a metal surface, producing just a slight green tinge to the metal.

Lacquers used internally where they would not be seen, or where there were to be additional lacquers added over the top of them, retained their natural colouring and were listed on painting schedules with the '.-' suffix, (by 1945 only about 50 of the lacquer codes from 7100 to 7199 had been utilized. Of those, despite their capacity to have additional specific colouring added to them, less than half were ever used with added colouring). Where colouring was required, it was signified with a two-digit suffix, for example, 7102.02, the '02' identifying RLM graugrün.

The addition of this numerical suffix was the second half of the RLM lacquer identification system. In order to retain precise identification of colours used on aircraft, (usually for the final external finish, but also involving some internal colours and colour marking codes for services externally and internally), the RLM colouring added to the base lacquer was identified by a numerical system running from 00 to 99 (in actual fact the final number allocated was 100, but this was never used). With the exceptions of 00 and 99, each of the remaining two-digit codes that were issued identified a specific colour. In time, some colours would be declared obsolete and their two-digit code deleted from the stores procurement lists, in some cases some of those colours were later reintroduced into the system, but were given new two-digit codes. While the reader may think that procurement requirement codes and stores are far from the subject, it is worth recalling that no armed forces can maintain their operational ability, let alone efficiency, without the backing of an efficient supply system. This brief discussion on identification codes etc., is at the very heart of that supply system.

The two exceptions noted above, 00 and 99, have a special significance in the study of Luftwaffe colours. The first was a clear finish that allowed any underlying colour of a surface to show through; broadly similar to laying a sheet of glass over a coloured surface. As such 00 technically qualified as 'colour'. The second, 99, had a more significant role to play in due course and is discussed in detail in Chapter 6. All that is important to realize here, is that when this system of specific RLM two-digit colour codes was introduced, no one had any idea that 99 one day would be used for a purpose other than identification of a specific colour. In fact, quite the reverse occurred, with 99 being used to signify that no specific colour was required. In short, it never identified a colour of any sort.

To summarise the system then, the RLM had a specific four-numeral code for every aircraft lacquer and ancillary product, plus the capacity to specify an additional colour from within the RLM two-digit code sequence. The latter was unique to the Luftwaffe, all other branches of the armed forces retaining the existing RAL four-digit codes for precise identification of specific colours. Why the RLM chose to diverge from the broader system is not known for certain, but it may have had something to do with the nature of aircraft production with its multitude of materials and parts, making a dual four-digit system unwieldy and open to error.

Even so, initially the new RLM colour suffix system maintained a direct correlation with the RAL colour system, allowing paint manufacturers to continue using RAL codes for colour identification of their products while cross relating them with RLM colour code requirements. A Warnecke und Böhm company document dated 3 February 1935 [1] proves that the RLM system was, at that time, already using two-digit number colour identification codes that ranged from 00 to 46 to identify the colour component of specific lacquers, (details of the structure of this colour identification system will be discussed later in the text, but at this point it is necessary only to establish its existence). This raises the possibility that the RLM system probably had been established well before its public revelation, possibly soon after the National Socialists had taken power in January 1933, or had been inherited by them from the Reichswehr-Ministerium. This initial group of 47 numerical codes encompassed external and internal colouring, markings colours and special colours, each group having taken up only a few of the available numbers in its sequence, leaving room for further allocation as new colours were added. No references existed yet listing colours specifically for camouflage, because no such need existed.

A significant publication of the period was a document relating to general RLM standards - *B. Richtlinien für die Entwicklungen geeigneter Flugzeuglacke* - (B. Principles for the development of suitable aircraft lacquering). The material covered in this important work was addressed to the paint manufacturing industry as a whole and it could only have been issued by the RLM. No other authority at that time had an interest in the scope of the subject material. The only copy so far located carries a hand-written note concluding 'Ausgabe 2/1938' (Issue 2/1938). The letter 'B' in the title is thought to signify that two parts existed, A and B, and the original issue dates back to late 1936, something confirmed in a letter from the RLM, dated '27.12.1937'. [2]

The leading statement was that all constituents of lacquers were to originate from German raw materials, emphasising the problems facing Germany with regard to hard currency purchases from foreign sources, and the growing concern that, if isolated by war, Germany would have to rely on its own resources. However, while no doubt this restriction was desirable, it must have been recognised that this might constrain development where lacquers did require foreign source raw materials; in that case, for lacquers of special qualities exceptions could be made, but testing for approval depended on express permission being given by the RLM. A manufacturer therefore had to weigh up the odds on producing a paint that was technically superior, and thus gave a commercial advantage, against one not as good but reliant on German raw materials supply.

The rider to approval of a lacquer for production was the formula and production methods, which had to be revealed in full to the RLM on request, causing some concern to manufacturers because of the intense commercial competition. That disclosure had to include a list of

all sub-contractors supplying ingredients; the constituents of the paints as supplied by the sub-contractors; the intermediate compounds and their numerical composition of the ingredients and additives expressed as percentage points; the complete formula details in percentage points; a clear description of the product production sequence so that assessment of sub-contracting of parts of the formula could be made, and a precise specification of the type and weight, per kilogram of the paint, in percentage points of any materials not originating from German raw materials sources.

It also stated that, upon request by the RLM, the originating manufacturer had to grant other paint manufacturers the right to produce the product under a licence defined by the RLM. In addition, the originating company had to support the licensee with expert advice during start-up of production. This went against all normal commercial practices and with the RLM setting the conditions, but without submitting to the testing and approval system no lacquer could be approved for use, manufacture and sale. It was indicative of the degree of control that the new regime was imposing on industry – and it worried many.

This was not unique to the paint manufacturing industry. The aircraft industry also found itself faced with the same form of RLM directive, making revealing its commercial secrets essential if licensee building of their aircraft and sub-manufacturing of components was to become a reality. This move was absolutely critical, both to maintaining the strict production standards required and to the expansion drive. Failure to agree to this requirement automatically precluded an aircraft firm from any chance of gaining a government contract for its product. When one considers construction of even a small, one ton, aircraft involved around 32,000 parts and required about 10,000 DIN technical drawings (DIN stood for Deutsche Industrie Normen – 'German Industrial Standards'), the requirement for strict RLM control was obvious. While the aircraft manufacturers, like their counter parts in the paint industry, were unhappy, they had to conform if they were to profit from their products.

The parameters for new lacquers were stringent, both for the testing procedure as well as the commercial use of the approved lacquer by industry. The lacquer was to be supplied in two components – concentrated ('thick') lacquer and diluting solvent – to prevent sedimentation. The problem of sedimentation was covered by insistence that the lacquer be supplied with a set of test figures for checking with a viscosity meter. No unopened container of lacquer was to form a surface skin, and at no stage of its use was a lacquer to form a hard residue in the bottom of its container. The mixing ratio was to be stipulated and the lacquer had to be ready for use after 30 minutes of mechanical stirring. The spray gun settings and pressures were rigidly defined as was the climatic conditions under which the lacquers had to be stored and prepared.

There was no requirement specified for the colour, or shade of colour, of primary and intermediate coats of lacquer (which is probably why each paint manufacturer chose to use their own distinguishing eclectic written colour references on their lacquering schedules), but they had to be readily distinguishable from each another. That allowed physical checking to ensure that the complete sequence of lacquers had been applied to a structure. Aluminium bronze was only to be used in a final external coat, or for any intermediate coats applied over one already containing that additive. The aluminium bronze had to be as matt as possible.

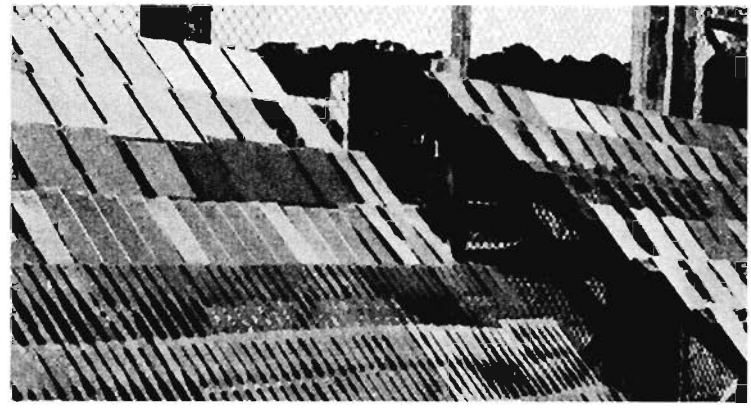
A lacquers relative ease of use was paramount. Preparation of structural materials for painting had to require nothing more than cleaning with tetrachloroethylene or a product called P3 almeco, or aircraft cleaner Z (another commercial product), or an organic cleaner produced by the paint supplier. Drying in natural air conditions, or using hot airflow had to be sufficient for completing the job. Wood and fabric surfaces had to require simple dusting to ensure that they were clean. Enclosure conditions for applying the lacquer were set, as were the drying times, humidity level and heat conditions. Exposure to various grades of aviation fuel and other corrosive agents were carefully and concisely stipulated.

The RLM was also considering the infrastructure needed for aircraft painting and expressed a clear preference for air-drying lacquers, which avoided the use of special equipment, e.g., hot-sprayed lacquers were in use that required pre-heating of the aluminium sheet, or stoving enamels that required an oven baking process. However, if an air-drying lacquer could have its curing time accelerated by use of a drying chamber, without impairing its properties, then it was considered an advantage, (that type of facility was far less complex than the requirements involved in the two example processes quoted).

Lacquers that reached the basic approval stage were then tested for tensile strength and fade qualities after six months exposure to weather and sunlight. The product had to meet a minimum requirement of a two-year life span in open-air conditions or 1,500 flying hours. A longer lifespan was a desirable target, with five years being set as a realistic maximum. During that period only minor repairs were to be expected and were not to exceed 15 per cent of the total lacquer surface area. This standard was for the general airframe, not for areas exposed to higher loadings or special conditions. Paint care products, which were in use, were permitted, but a single application had to last for 100 take-offs or two months of bad weather operations.

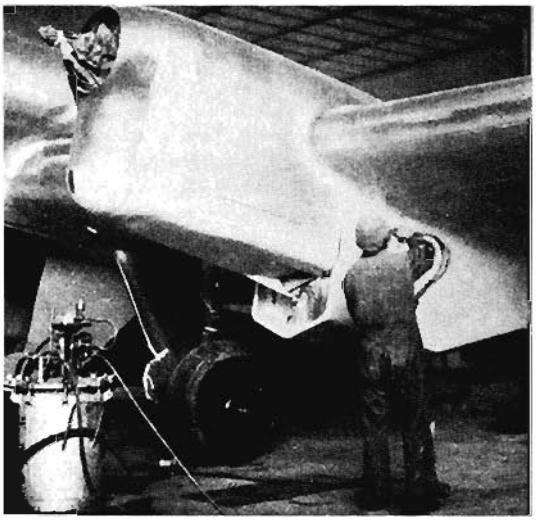
It was a rigid regime, but it produced extremely high quality finishes. Testing was carried out at the DVL institute at Berlin-Adlershof, which provided applicants with more detailed information on test conditions than were set down in the main document. Once a lacquer had been tested and approved by the DVL, it could be sent to the Technisches Amt of the RLM for flight-testing. Precise instructions for application of the lacquer had to accompany the product along with the DVL test report and a price schedule. The latter was obviously just as critical a factor as the lacquer. The best lacquer in the world was no good if it cost too much to use, something covered in the document that stated successful testing did not guarantee approval for production. The RLM eventually paid for both aircraft and paint finish under its procurement costing, so it had a very clear vested interest in the price of lacquers that would be used in vast quantities. Trials were then carried out at the discretion of the Technisches Amt on one or more aircraft, and conducted over a period of at least one year. Only then was the manufacturer informed of the lacquer's acceptance. The DVL had two establishments, one at Berlin-Adlershof, the other at Travemünde. Originally work was split between the two establishments, sea aircraft trials being held at Travemünde on the Baltic coast, and those relating to land aircraft at the Berlin site. Paint testing and specification was eventually concentrated at Travemünde under the Technisches Amt E-Stelle (Erprobungsstelle).

A colour card, the earliest one so far located, was included with this document and its significance is discussed later in this chapter.

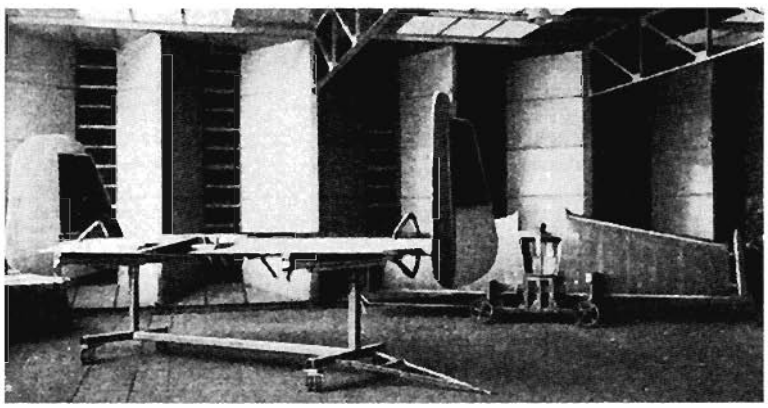


While of poor quality, this photograph shows the important test stage where lacquer samples were exposed on open-air racks to determine the effects of weather on various finishes and colours over a set, extended period of time.

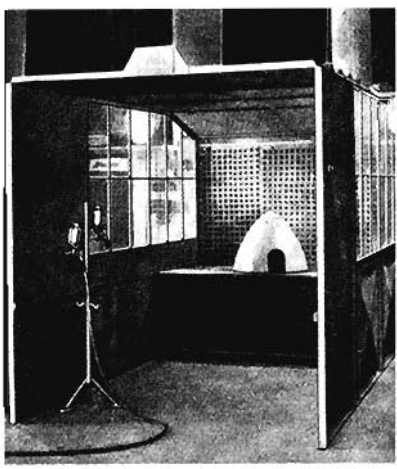
RIGHT: Factory workers using conventional equipment to spray black lacquer on the large inboard area around the engine of a Ju 52. The area to be sprayed has been marked out with a white chalk line. Note the man on the right touching up the lacquer of the 'B' of the civil registration (D-AB??) with a hand brush.



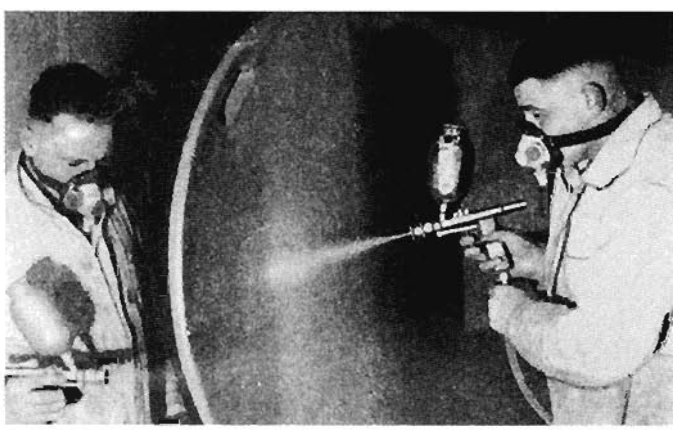
ABOVE: A factory worker sprays the base coat of translucent zinc chromate finish onto a Ju 86. In the foreground is the tank holding the 7102.- lacquer that had a greenish tinge and prepared the metal surface for the following lacquers. This base coat was always heavily thinned out, up to a ratio of 10:1, which made it almost transparent. The holding tank incorporated a mechanical mixing device to keep paint from settling, and also ensuring consistent colour quality when used with 02, or any of the camouflage colours; it was pressurised by means of a compressed air line.



ABOVE: The large spray room at the Henschel works where Do 17s were being produced under licence. The stand in the foreground holds a tail unit, sprayed with camouflage on the horizontal tail surfaces, and with the RLM 23 red section of the red banner marking sprayed across the fins. Behind a second tail unit, on its mobile frame, can be seen awaiting its turn to be sprayed. Vertical banks of extractor fans form the rear wall of the room.



ABOVE: Individual spray booths were used for small parts such as spinners. This photograph was taken at a sub-manufacturer's plant.



ABOVE: Spraying was done simultaneously on both sides of the wing.

RIGHT: Blanking templates were used where areas were to be given different colouring. This man is using a 'Prea' brand spray gun. This firm supplied much of the range of spray equipment used by the aircraft industry but some imported equipment, such as the 'Superior' compressor, was also employed.

The enigmatic paramilitary grey finish

As mentioned, the new government inherited a range of aircraft types, mostly trainers, but also paramilitary types already serving with disguised air units. The range of colour schemes was broad amongst the oldest training machines, with silver predominating. However, most of those new generation military machines that had been slipped into service wore a consistent pale grey finish. Precise definition of that pale grey colouring has proved elusive.

Amongst the paramilitary machines, a more consistent finish of pale grey had begun to appear from around 1930 that was a different shade of grey from the very pale grey employed by the civil operator Deutsche Luft Hansa (DLH), which had come into being on 6 January 1926. In black and white photographs from that early period, the DLH colour appears to have a paler, brighter appearance than the military colour. Aircraft serving with DLH (which did provide some clandestine training for military personnel) had a standard scheme of pale grey relieved only by black paint applied around engine-bays, wing walkways, landing gear spats, and for civil markings. However, unlike the clandestine military units, DLH had free choice of its own range of lacquers and colours, and for a long period retained its own colours and specific shades.

For a long time controversy has existed as to what that shade of paramilitary grey was - and for good reason. In studying a cross section of painting schedules for various types of military aircraft, ranging from 1932 to 1936, the reason for the confusion becomes apparent. In the following brief extracts, only the final *external* finish used for both fabric and metal on each single type is shown, (aluminium has been chosen as a standard from amongst the range of metals specified). Note that the fabric finish usually employed a three-part mix, or a specific product that employed the characteristics of a standard lacquer combined with a waterproof gloss coat. In some instances, precise dating appears on each particular painting schedule while in others only the year, or period of the year, is known; but the sequencing is clear enough to be established. The important factor is that the end result, in each group, was a consistent shade of grey *on each subject aircraft*.

He 45	**1932/1933**
Linen	Celesta-Flugzeugüberzugslack Nr. 2000/68
	Celesta-Flugzeugüberzugslack farblos Nr. 1606
	Celesta-Ausgleichsflüßigkeit Nr. 1611
Metal	Avionorm-Ölgrund hellgrau Nr. 5759
	Avionorm-Nitrodecklack silber Nr. 1708
	Avionorm-Nitrodecklack bronzemittelgrau Nr. 1562/7726
Do 23 F	**Spring 1935**
Linen	Avionorm-Nitrodecklack grau matt 7375
	Avionorm-Klarlack 4526
	Avionorm-Verdünnung 1333
Metal	Avionorm-Nitrodecklack grau matt 7375
	Avionorm-Klarlack 4526
	Avionorm-Verdünnung 1333
Ar 68 E	**11 November 1935**
Linen	Avionorm-Nitrodecklack RLM grau, SA 400
Metal	Avionorm-Ölgrund grau Nr. 5759
	Avionorm-Nitrodecklack RLM grau SA 400
Do 23 G	**2 December 1935**
Linen	DKH-Nitroemaillelack L40/52 grau
	DKH-Nitrolackverdünnung L40/50
Metal	DKH-Nitroemaillelack L40/52 grau
	DKH-Nitrolackverdünnung L40/50
Ar 68 F	**10 February 1936**
Linen	Zöllner Decklack RLM grau Rh 9069
	Zöllner Verteiler M 9304
	Zöllner Lasurlack RLM grau Rh 9070
Metal	Titanol Grundfarbe Rh 9212
	Zöllner Decklack RLM grau Rh 9069
	Zöllner Lasurlack RLM grau Rh 9070
He 51 C/D	**Late 1936**
Linen	Celesta-Flugzeugüberzugslack Nr. 2000 grüngrau 63
	Celesta- Flugzeugüberzugslack farblos Nr. 1606
	Celesta-Ausgleichsflüßigkeit Nr. 1611
Metal	Avionorm-Ölgrund hellgrau Nr. 5759
	Avionorm-Nitrodecklack silber Nr. 1708
	Avionorm-Nitrodecklack grau Nr. 7007

Several significant points are immediately apparent. Note that in the Ar 68 E schedule of November 1935, for the first time the colour is designated as 'RLM grau SA 400' (a combination of an RLM designation and company lacquer designation). This RLM grau is unambiguously the 'RLM grau' that appeared on the colour card of 1936, under the green-grey-coloured paint chip designated '02 RLM-grau'. Between that colour card, with its colour chips, and the dated painting schedule, it is safe to say that 02 was the overall external finish on that aircraft type for that period. With the Ar 68 F, and its schedule of February 1936, almost exactly three months later, although the types of lacquers and supplier had changed from Lüdicke & Co. to Zöllner-Werk, the same colour designation appears again - RLM grau, i.e., 02.

However, in looking at the Do 23 F and Do 23 G painting schedules, which span from spring to December 1935, things are not so clear cut, the colour designation being given only as grau matt (matt grey). If one looks at photographs of such bombers, the colour is quite light - so was it 02, or 63, which was one shade lighter?

The He 51 C/D schedule, which dates from 1936 seemingly complicates the process, listing the designation 'grüngrau 63' for the Ago product used on the fabric surfaces; and just 'grau' for the Lüdicke product used externally on the metal of the engine panels. Clearly the two products had the same colour as there is no visible discontinuity in the overall paint colour in any photograph. So, while it can be confirmed that Celesta-Flugzeugüberzugslack Nr. 2000 grüngrau 63 and Avionorm-Nitrodecklack grau Nr. 7007 were both consistent with colour 63, the apparent mystery remains as to why 63 was being used as an overall finish when RLM-grau 02 appears to have been adopted by 1935.

The answer to this 1935/RLM 02 and 1936/RLM 63 question lies in the document discussed earlier - 'B. Richtlinien für die Entwicklungen geeigneter Flugzeuglacke'. In the opening section, under the heading 'Colour Shades', the external finish for any aircraft was stipulated clearly:

"1) External surfaces of aircraft:
Unless agreed otherwise, the shade for the topcoat - Grau matt 02.

Colours of the primary and intermediate coats are not specified, but they must be clearly distinguishable within the lacquer system so that each completed stage of the work can be verified.

Addition of aluminium bronze is only permissible for the final coat of lacquer, or for any coats directly covered by the other coats containing bronze. The aluminium bronze powder used must be as matt as possible.

2) Internal components of aircraft:
Shade of topcoat: Grau 02."

This document was comprised of typed sheets with amendments by hand added in ink for the second (1938) edition, including notational changes to the accompanying colour card. It is possible then to determine that the text of the first edition remained virtually unaltered, including the references to 'grau 02'. Thus it appears that the first external overall colour put in place by the RLM (or possibly the Reichswehr-Ministerium) for all aircraft was 02, and the Ar 68 E and F painting schedules, which date from November 1935 to February 1936, show clearly that 02 was the grey colouring in use. The He 51 schedule of late 1936 shows the RLM's subsequent change to 63 and that accords with the contemporaneous introduction of the first multi-coloured camouflage scheme that occurred early in 1936, which included the new colour 63.

It would seem from this RLM 02 and 63 information that the pale grey finish cited in the 1932/33 He 45 schedule was either a pale grey from the RAL 7000 series, or more probably the colour designated 02 (RLM-grau).

As noted, introduction of 02 may not necessarily have been an RLM initiative, but rather an existing decision inherited from its predecessor, which had been working hard at building the infrastructure for a revitalised Air Force since 1920. Unfortunately no documentation has come to light to clarify all the clandestinely developed systems handed over to the RLM in 1933. However, given other well-developed systems already in place it is quite possible that use of a single, standard colour was already in place, if for no other reason than factors of cost and materials storage. If so, the identification that was allocated to that colour is not known, but as suggested, it could have been a company trade name equivalent designation.

In addition to the slight difference between 02 and 63, there was an additional factor that may have influenced the perception of a very pale grey and what appears to have been a slightly darker grey. The low pigmentation qualities of the lacquers used for the intermediate coat influenced the shade of the final external finish. The primary function of the middle coat, in the three-coat lacquering sequence used at that time, was to suppress the multiple colouring of the primer coat (different colours were used on different parts). The relatively limited covering power of the middle coat, in terms of pigmentation, meant that the final coat of lacquer was slightly affected, making some combinations appear a little lighter and others darker, (Appendix E, Volume 2). The difference was small, as was the difference of one shade between 02 and 63 (see colour charts), but it was enough under some lighting conditions to produce a perceptible visual effect.

Prior to the 1936 document and colour card, the existing range of RLM colours had ended at 46, with only two used for external overall colouring - 01 silber and 02 RLM-grau. Looking at photographs of the very early 1930s paramilitary aircraft it is not surprising then that the two colours in evidence were silver and a pale grey (actually a green-grey).

The colour card

The earlier mentioned Warnecke und Böhm company's letter of 3 February 1935[3] listed among the written colour descriptions 07 saturnrot (saturn red - a bright orange), 32 hellgelb (bright yellow) and 42 blau silber grau (bluish silver grey) which appeared on the 'Richtlinien' colour card as grau. This illustrates that an extensive range of colours had already been reduced by the time that the first colour card was issued in 1936. Given that numbers were always issued sequentially within the various groupings means that 03, 05, 06, 07, 08, 09 and 10 had already been discarded for military purposes, (RLM 05 remained in use for paramilitary gliders of the NSKF). Significantly, the 1936 colour card included only two internal colours – 41 and 42, the greys used for instrument panels and battery storage areas, plus the non-camouflage, standard engine systems marking colours. Other known colours were excluded, possibly because of their secondary purpose, e.g. RLM 32 gelb, used as an undercoat colour on wooden propellers.

While slightly larger than its successors, that were issued in 1938, 1939 and 1941, layout of this colour card set the standard. Each printed outline on the card face had an actual paint sample within it, with the RLM identifying number and (usually) a written colour description appearing below each one. Simply titled 'Farbtontafel', with 'Muster-Schmidt. Berlin S 42' marked in the lower right-hand corner, it contained 24 colour chips arranged as shown (See enclosed colour chart).

00 wasserhell	01 silber	02 RLM-grau	11 grau	04 gelb	*Blank*
21 weiß	22 schwarz	23 rot	24 blau	25 hellgrün	26 braun
27 gelb	28 weinrot	*Blank*	41 grau	42 grau	*Blank*
61 dunkelbraun	62 grün	63 hellgrau	64 dunkelgrün	65 hellblau	66 schwarzgrau
67 weiß	68 schwarzgrün	69 dunkelgrün			

The list and colour descriptions are significant in that they include 11, 41, 42, 64, 67, 68 and 69, numbers never again repeated on any subsequent colour card, though two of them (41 and 42) remained in use. Significance of these colours will be discussed in more detail later on; here it is sufficient to acknowledge their inclusion on a colour card.

On the chart, 63 was marked 'hellgrau' (pale grey), reflecting the loose colour definitions of the RLM system, but it was barely distinguishable from colouring previously used under the designation 02 and simply marked 'grau'. A far more accurate written colour description appeared in the late 1936 painting schedule for the He 51 C/D 'grüngrau 63'. The revised colour description must have arisen soon after the new colour entered manufacture, indicating the loose relationship between company and official RLM terminology, probably initiated in this case by the paint manufacturer since 'grüngrau' never appeared on any RLM colour card. It is unfortunate that some writers have seized upon these unreliable written colour descriptions to raise arguments about colours. The RLM hellgrau (pale grey) description versus the manufacturers' grüngrau (green-grey) description for the same colour pigmentation is one instance of the misunderstandings that are possible when examining a broad range of original documentation.

From 1936 onwards, 63 replaced 02 as the external finish. That favoured the rationalisation policy of colours and raw materials since 63 also formed the base colouring for the new three-colour upper surface camouflage introduced very early in 1936 for the new Ju 86 all metal bomber. To the base coat 63 were added segments of 61 and 62 to form a disruptive pattern, with 65 used for the lower surfaces. The painting schedule for the Do 17 bomber, which had also entered production that year, listed 63 simply as 'Nr. 63 grau'.

Returning to the enigma of the pale versus darker finish of pre-war aircraft, the actual difference, visually, between the colours designated 02 and 63 was marginal, as a check of the colour chips included with this work will show. Viewed from a distance, under normal lighting, it would be extremely difficult to detect that difference. However, in looking at the various aircraft of the period, a variation in tone seems more apparent in some photographs. The answer may lie, in part, in the fact that the finish for aircraft up to 1936, (when multi-colour military camouflage first appeared), included a clear lacquer as a sealant - not just on the fabric but also on the metal panels - and that produced a pronounced sheen. The brighter the light source, the lighter the tonal value with glossy surfaces due to the reflected light. However, there was another significant factor that may equally have contributed to the paler appearance, and in this

regard the reader is urged to read the technical factors set out in Appendix E in Volume Two. The limited colouring power (pigmentation) in some early paint formulations was significant and the information put forward in Appendix E could be the definitive explanation for the gradual change to a more consistent and slightly darker colour.

The Do 23 schedule of 1935 does include the term 'matt grau' in reference to the overall final external finish, 'matt' appearing in the other painting schedules only in relationship to painting of instrument panels as an anti-glare measure. Whether this indicates an attempt to tone down the extent of the 'gloss' finish, which would darken the tonal value of the external colouring, is not verifiable from existing documentation. Possibly the impending introduction of a full matt camouflage system early the following year may have precluded broader application of this apparent 'initiative', if indeed it was such, because the Do 17 G schedule, which appeared in December 1935, did not include the term 'matt' for anything but the instrument panel.

The DLH grey colouring

DLH, like other private civil aircraft operators, was independent of the RLM painting requirements, and its company overall grey colouring appears on a DLH painting schedule for the 10 ton Wal seaplane under the designation of Celesta Überzugslack DLH-grau 2000/67. For fabric surfaces finish on the He 111s in service with the company, Cellesta Überzugslack DLH-duralgrau 2000/91 was listed. In both instances, the same lacquer as was used on the He 45, but with a different suffix number and no written colour description. The metal parts of the He 111s were finished with yet another company's products, DKH-Nitroemaillelack, duralgrau L 40/52. This 'duralgrau' colour matched the 'duralgrau' of the Cellesta product used on the fabric surfaces - a nitrocellulose (organic) enamel lacquer. The company's He 70s used DKH Nitroemaillelack, grau L 40/51. Again a different suffix number, related to a specific lacquer stock, but producing what, from photographs, appears to be the same shade of pale grey. The Ju 52 fleet used a different type of lacquer, DKH Ölüberzugslack DLH-grau W 30/23 - but again achieved the same pale grey finish.

This seemingly erratic path through the 27 October 1936 DLH painting schedule (approved for implementation as from 1 November 1936) illustrates the confusion that attends any attempt to simplify the myriad company *lacquer* formulae designation numbers and to try to derive colour designations from them. In the absence of an accompanying colour description (no matter how loose), lacquer designations alone did not indicate colour, e.g., DKH designation L 40/51 for the finish on the He 70 had the added colour designation 'grau', but the same lacquer designation L 40/51 appears in two places in the 27 September 1938 painting schedule for the Blohm und Voss Ha 139, first as Nitro-Decklack DKH silbergrau L 40/51 for the internal lacquering of the fuselage, and then as DKH Nitrodecklack Lufthansa-gelb L 40/51 for the external lacquering of the wings. Thus L 40/51 *lacquer stock* appeared with grey, silver-grey or yellow pigmentation in those three instances.

Perhaps the determining factor in establishing that the DLH pale grey finish was different from the paramilitary grey are three notations in the DLH painting schedule of 1 November 1936 - Ikarol Einschichtlackfarben DLH-grau 132/1 (an experimental lacquer used on the Junkers Ju 160 exterior, and possibly the Ju 52 later), Ikarol-Zwischenlack I grau 103/1 (special lacquer for three-coat systems, government aircraft) and Ikarol-Decklack RLM-grau 103/2 (special paint for government aircraft). In each case grey is the colour description, but note the distinctive titles of 'DLH grau' and 'RLM grau' with the first and last of these. Had they been the same grey they would not have required that written colour distinction, especially within the same document.

Another piece of clear evidence comes from the DLH stock numbering system used for each of its paints and other parts. DKH-Nitroemaillelack, duralgrau, (L 40/52) had the stock number 015V054, while DKH-Nitroemaillelack RLM-grau, bronzemittelgrau (L 40/52) is recorded as 015V056. If they were the same lacquer stock *with the same colour pigmentation*, why then two distinct stock numbers? Compare this with the records for DKH-Ölüberzugslack DLH-grau (W30/23) with stock number 015V062 and listed for the external finish on DLH's Ju 52s. DKH-Ölüberzugslack Rb-grau (W30/23), also listed for external use on Ju 52 Rb aircraft, was distinguished by the stock number 015V066. The only thing that otherwise differentiated the two was the colour description - and both were greys. Both lacquers respectively were marked for replacement with Emaillelack Ton 54, 015V030 and Emaillelack Ton 53 015V031. The addition of 'Ton (colour tone) 54' and 'Ton 53' further clearly distinguished the two colours from each other, as well as their different stock numbers.

The meaning of 'Rb' is not known, but appears to refer to Ju 52s used by an operator other than Lufthansa. Possibly it identified Ju 52s used by the Deutsche Reichsbahn (German State Railway), which had begun operating an air-freight service, initially with Do 11s in November 1933, as a cover for night flying training of pilots of multi-engined aircraft. The reference to Government aircraft in the same document also points to Lufthansa's Staaken facility carrying out maintenance work for more than just its own aircraft fleet.

From this analysis it becomes clear that DLH grey and RLM grey were not the same colours.

The paint industry and painting schedules

Paint manufacturers simultaneously produced a wide range of paints for a great variety of applications, not just for the aircraft industry. Apart from the armed forces, the industry supplied paint for the trains, trams and buses of the state transport system, the Nationalsozialistisches Fliegerkorps (NSKF) gliding association, private aircraft and boat users, the vehicle industry and equipment manufacturers (for example farm implements and machinery). Within the military establishment it further provided a range of paint products used for buildings and equipment. Thus a single company could supply the RLM with paint for the camouflage of buildings, a different type for the camouflaging of ground surfaces such as runways, and even grass, and different ones again for painting aircraft ground-handling equipment. Each type had a different formulation and was not interchangeable, so that paint used for buildings could not be used on aircraft; similarly paint used on ground-handling equipment could not be used to spray runways or grass etc.

Nor did this apply only to paints. A range of allied products, for example, vinyls, stoving enamels, baked enamels, bakelite products, anti-fouling coating, artificial plasticisers and fillers, etc., were manufactured. To meet this eclectic demand the industry relied on large supplies of specific raw materials from a vast chain of suppliers which stretched worldwide; for example vegetable oils, linseed oil, mineral oils, natural resins, synthetic resins, waxes, paraffins, benzol derivatives, plasticisers, alcohols, solvents, acetates, copals, dryers, chloride, solvents, xylol, toluol, pigments such as lithopone, zinc oxide, silicate white, zinc white etc. In time, this reliance would become the industry's Achilles heel.

Manufacture of special ingredients used by the paint industry, for example, synthetic drying-oils, resins and plasticisers, were sub-contracted out to chemical manufacturers, and supplied to other paint manufacturers via the parent firm who added the final ingredient. In this manner each sub-manufacturer supplied its component in isolation of the final product, enabling the firm that had developed the original finished paint formulae to protect its copyright. This system was used by the major contractors of aircraft paints to the RLM and its extent may be judged from the fact that Warnecke & Böhm alone, based in Berlin, had ten paint-making firms in Hamburg working as sub-contractors.

The RLM did not purchase, store or ship stocks of paints to end-users, such as aircraft companies. The purchase and supply aspects were strictly a normal commercial transaction between the end-user and the relevant paint manufacturer, although the RLM did control the contractual aspects of some specific paint supplies. For example, A. G.

Johannes Jesserich was a private Hamburg-based company that produced anti-corrosive finishes for ships, and worked exclusively on that product throughout the war. All production stock was strictly for *Kriegsmarine* use and strictly controlled by the Reichstelle für Mineralöl (State Department for Minerals). This reflected the difficulties associated with supplies of certain raw minerals and the State controls imposed to closely regulate their use. Another Hamburg company, Beckacite-Kunzharz G.m.b.H., was one of the chief producers of synthetic resins (principally Phenol Formaldehyde and Alkyd resins which were of vital importance to paint manufacture) in Germany, its plant miraculously escaping major bomb damage. From 1941 to 1945 its products were exclusively under the control of the war ministries.

The DVL laboratories developed the methods of testing as well as preparing complete doping schemes for each new type of aircraft, but individual aircraft manufacturers had the option of establishing their preference for a specific paint manufacturer's products, possibly based on previous commercial transactions between them. The final painting schedule was then issued as an Oberflächenschutzliste - OS-Liste (surface protection list) to the aircraft manufacturer and any licensed sub-contractor producing airframe components. This schedule of painting of the airframe had to be followed precisely by the relevant aircraft manufacturer.

To exercise firm control standards the RLM approved a specification titled 'Farbanstrich für Flugzeugmuster' - (Painting colour for aircraft type), which covered every aspect of an aircraft's structure. Each sub-component was listed, further broken down into basic parts and the material described in detail (for example, steel, aluminium, wood etc.). The method of painting the component (for example, sprayed, dipped, hand painted with a brush, etc.) air or oven drying time, paint identification, supplier's name and finally special instructions, where such applied, was appended.

When a company produced a new aircraft type, a type-specific Farbanstrich was developed and issued; a practice continued until 1945 while undergoing a series of changes and title, Oberflächenschutzliste eventually being adopted. Initially these were quite extensive in format; the 1934 Farbanstrich für Flugzeugmuster He 45 had ten pages while the Farbanstrich for the Do 23 F and Do 23 G, issued in early 1935 and late 1935, ran to eight pages for the former and six for the latter. These very early examples sometimes included the Werknummern of the aircraft to which the schedule was to be applied. The one for the Do 23 F was titled:

Farbanstrich Do 23 F
Werk-Nr. 351 bis 386

while that for the Do 23 G was:

Farbanstrich Do 23 G
Werk-Nr. 387 bis 530, 573 bis 614, 627 bis 638.
Hergestellt in den Werken Friedrichshafen und Wismar.

The Ar 68 E painting schedule of 11 November 1935, which ran to eight pages, was:

Farbanstrich für Flugzeugmuster Ar 68
Werk-Nr. 937 - 945,
1301 - 1308,
1571 - 1640

This type of valuable information - production blocks and place of manufacture - would soon disappear in the interest of State Security, as evidenced by the painting schedule for the He 51 C and D which appeared in 1936. The title however remained the same:

Farbanstrich für Flugzeugmuster He 51 C, D

and still ran to six pages of fine detail. As aircraft structures became simplified, relative to the lesser variety of materials used, schedules would decrease in size and complexity, for example the OS-Liste for the Fw 200 filled just two pages and was titled:

RLM-Lackierungsformblatt
(OS-Liste) mit Mustereintragungen*

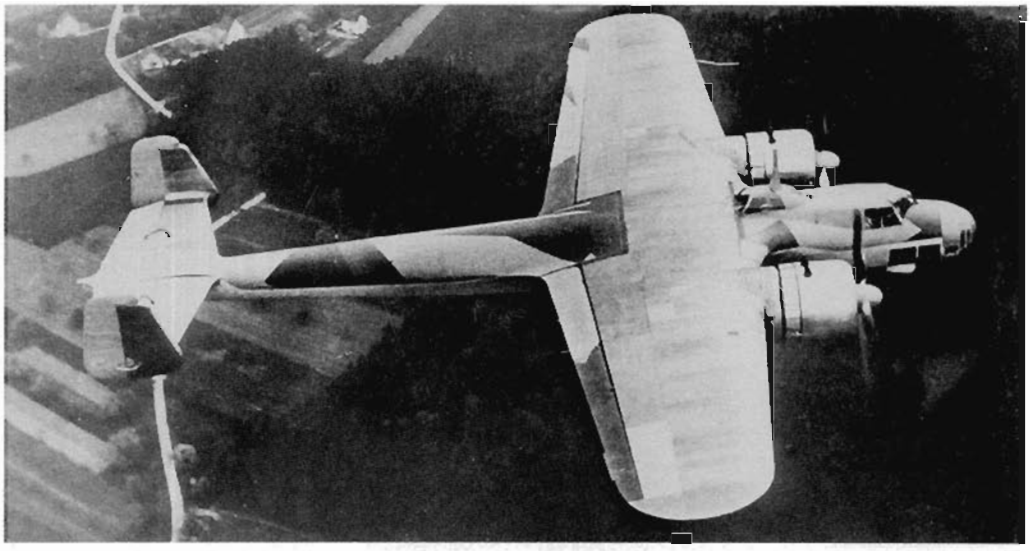
The RLM alone, via E-Stelle, established and controlled the standard range of colours used for military aircraft. These were issued to the industry as a whole in the form of official colour cards between 1936 and 1941. From 1941 to 1945 subsequent additions and replacement colour changes were issued only in loose form as colour 'chips' (initially as small squares of paint on card, the same size as the ones on the colour cards, but eventually issued as large, single sheets - see Chapter 6). Where the final colour of the lacquer was specified, the paint industry was required to manufacture stocks to match precisely those RLM standard colour card samples. The aircraft manufacturing industry, in turn, was required to prepare paint stock supplied to them to match the same RLM standard. The E-Stelle at Travemünde eventually became solely responsible for the testing of colours and for the provision of official written colour descriptions, though those were non-critical as a prime identifier as noted earlier, the RLM two-digit code being paramount for identification purposes. Every product used for surface protection in the war industry had its own specific numerical code as described later.

Copies of the same colour cards and, later, loose chips were also issued to aircraft depots where major overhauls or repair work were carried out. Operational units also had copies so that the routine *minor* paint maintenance of airframes would be to the same standard. The relatively small stocks of paint held by aircraft depots, and the much smaller stocks of front line units had to be stored and prepared to the same concise standards. Difficulties complying with the latter explains further why front line units held only small stocks and did not repaint entire aircraft, except under very exceptional circumstances, and even then only with substantial permanent support facilities. Repainting required dedicated facilities and equipment not available at front line units as will be explained later.

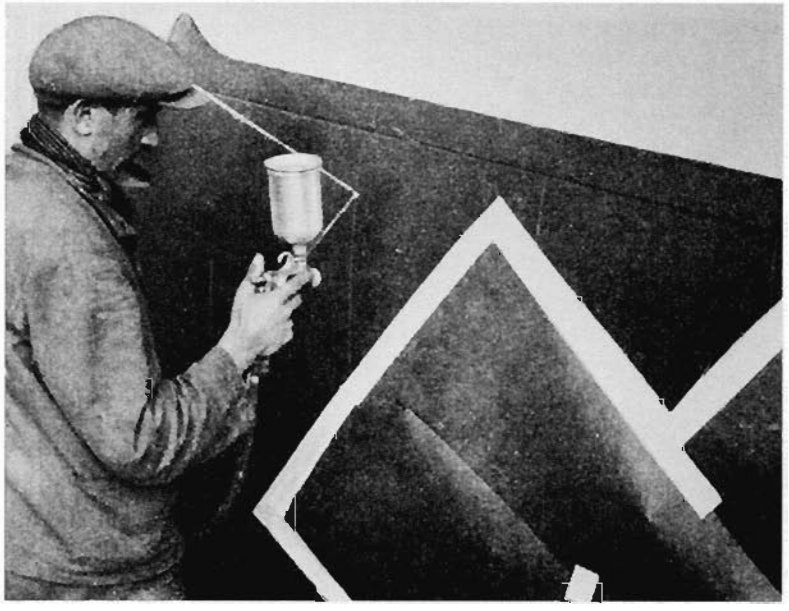
There remains a lingering perception that front line units repainted entire aircraft for specific battle conditions. This was not the case, though some units did modify *sections* of an aircraft's camouflage, as was done in France during August and September 1940. However, even those changes were made with the advantage of captured, pre-war, permanent airfield facilities that included maintenance hangars etc. Only special paint products issued specifically for front line use, usually temporary finishes, were applied to large areas of an airframe without access to any special facility. If an aircraft did require complete repainting- something that became increasingly rare in wartime because of attrition - it was done at a repair facility, or in some instances, even the original manufacturer's plant, usually as part of a routine major overhaul of the airframe. Front line maintenance was confined to daily maintenance, small battle damage repairs and component and engine changes.

Repainting an aircraft, even a significant part of it, under field conditions was not just impractical but also imprudent. Each lacquer layer had a set drying time that had to be adhered to. Dust had to be excluded because even a small amount deposited over the freshly painted surface produced a drag-increasing finish and poor bonding with the original lacquer surface. (The British had experienced a similar effect when they introduced RDM 2 matt black finish, early in the war. In that case the matt finish was relatively rough. Subsequent testing at Boscombe Down revealed a significant loss of cruising speed and the finish was withdrawn.) Freshly lacquered aircraft were also subject to extensive specific restraints.

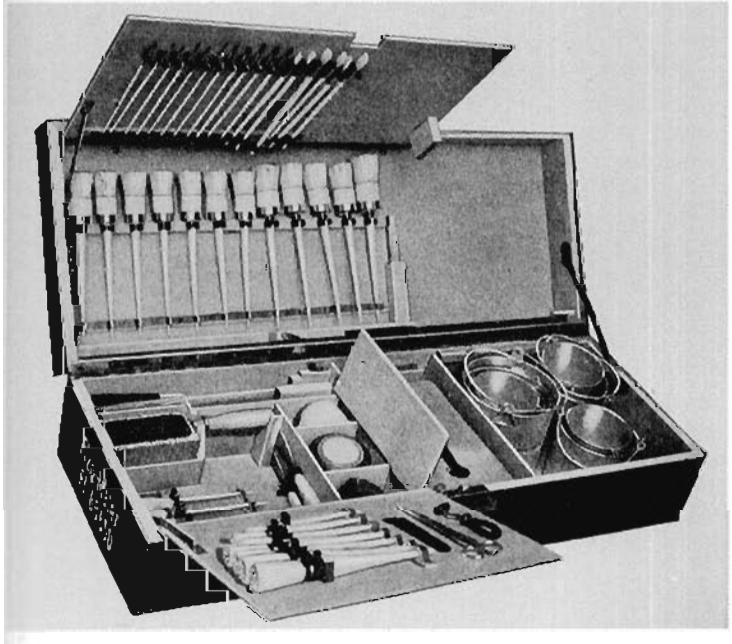
RIGHT: A Do 17, photographed during a factory test flight, fitted with a wing and engine cowlings still in translucent zinc chromate finish, to an airframe otherwise camouflaged in 61/62/63/65. Lack of national markings confirms its factory production cycle status. Both elevators are also still in 02-primer. The wing – a single component that was married to the fuselage during the final assembly stages – appears to have been a replacement made during initial factory testing. As on all German military designs, engines, and usually their cowlings, were produced as power pods. The fact that the rest of the airframe had already been camouflaged to the prescribed pattern illustrates how this form of very geometric camouflage-style allowed painting of major and minor portions of the airframe before final assembly.

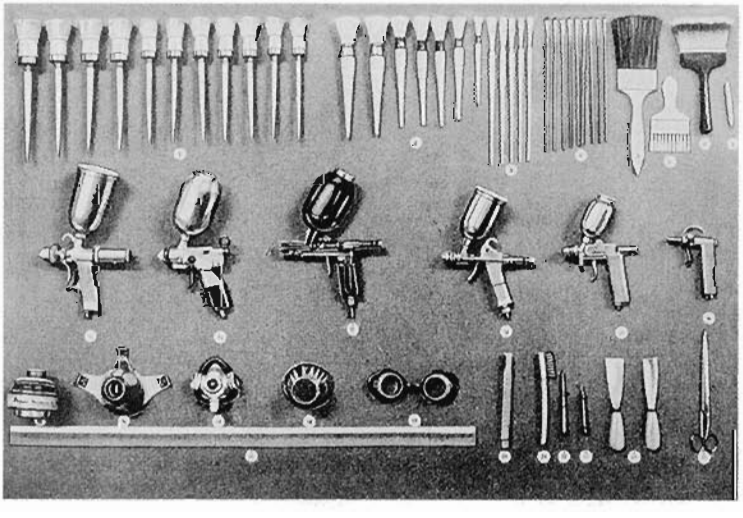


RIGHT: Applying the complex 61/62/63 upper surface camouflage pattern was preceded by marking out the areas with a chalk line. Each area of colour sprayed was then masked out with paper and tape and the next section sprayed in, and so on. (Henschel)

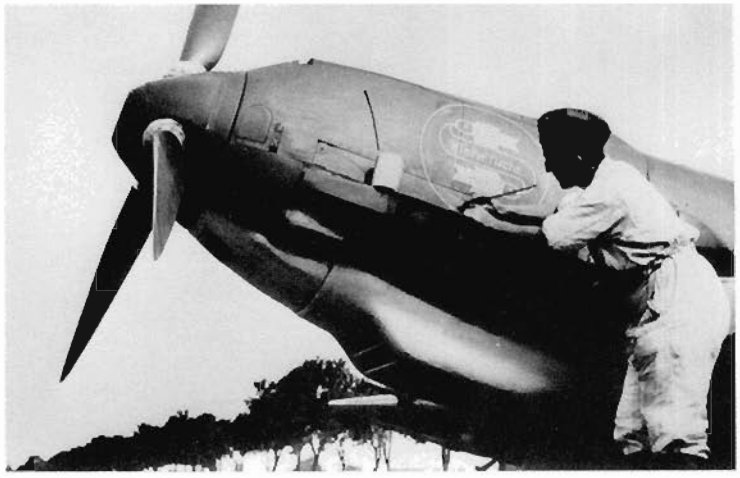


BELOW: Aircraft painters were supplied with an extensive kit in a customised wooden box (Werkzeugkasten Fl 68650) that contained the following 37 items. Three 1.25 ltr, 3 x 1.75 ltr, 2 x 2.5 ltr and one 4 ltr. paint tins, buffing brushes, one in each size Nr 18, 16, 14 and 12: 3 x Nr 10 flat brushes, 5 x Nr 8 and 5 x Nr 6 brushes; 2 x Nr 16 round collar buffing brushes; 2 x Nr 12, 2 x Nr 8 and 2 x Nr 4 brushes; one Nr 12 ring collar brush, 5 x Nr 10, 7 x Nr 8, 2 x Nr 6, 1 x Nr 4 and 1 x Nr 2 brushes; one tracing tool, one beater, one marker line, one scraper, one 17 x 7 cm ceiling brush; 1 x 30 mm filler tool; 1 x 40 mm filler tool, one face mask, one 150 mm cap; one folding rule, wooden 1 metre long; one rubber peg, one hand-sanding block; one straight edge of wood, 50 cm; one straight edge of wood 100 cm; one pair of paper sheers, 250 mm long; one tracing roller. The description 'buffing brush' seems to relate to cleaning up surfaces during painting.



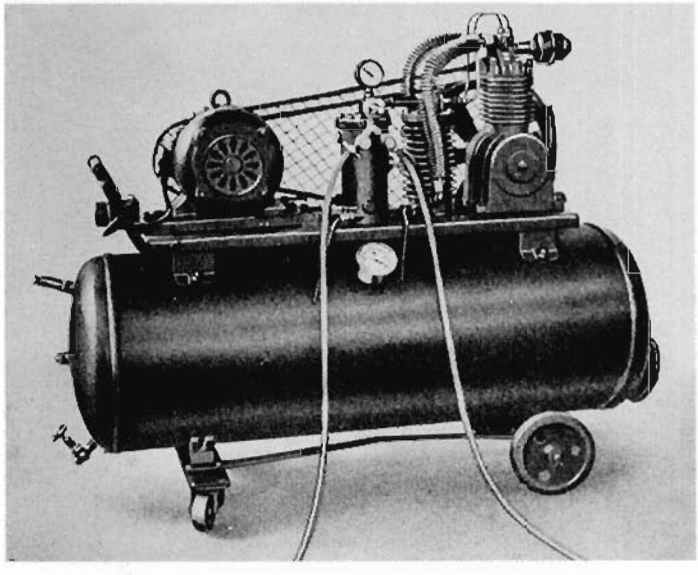


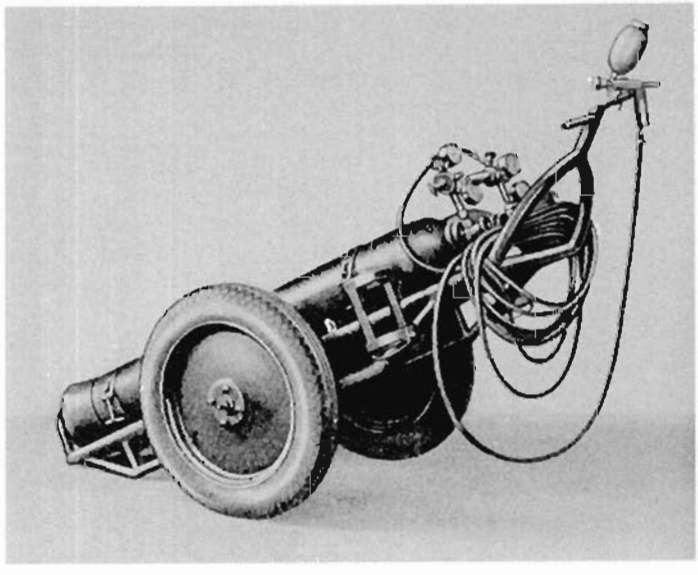
ABOVE: A display board showing a wider range of equipment for the factory-based aircraft painter. This included the full range of round and flat brushes, several spray guns, scrapers and wire brushes and also a range of safety equipment.



ABOVE: A range of painting equipment was issued to units for general minor maintenance and marking of such items as aircraft identification numbers and Staffel markings, etc. as seen here – a personal emblem of one of the JG 53's pilots being painted using a 1.25 litre tin, balanced on the exhaust stub shield, and one of the smaller of the round brushes. (Eric Mombeek)

ABOVE: Conditions for painting in the field as opposed to those in a factory environment are illustrated by this desert setting of a ground staff member applying the final touches to a JG 27 emblem on a Bf 109 F cowling. Four of the standard issue paint tins are visible, plus a food tin used to wash the brushes out using benzine from the very battered fuel tin.





ABOVE AND ABOVE RIGHT: Compressed air supply was available in three forms. The large vertical static tank, seen in the photograph of the Ju 86 (see page 24) being sprayed, was one. The second was this mobile horizontal tank and compressor. The third type (ABOVE RIGHT) was much simpler and more mobile – a pair of compressed air cylinders on a wheeled frame; a type that was also used at unit-level for minor spray painting tasks on aircraft.

RIGHT: Willi Messerschmitt and Fritz Wendel conferring after the Me 209 had taken the world speed record on 26 April 1939 (755 kmh). As a non-military aircraft it wore a high gloss finish in the Messerschmitt A.G. house colour of a dark grey-blue (RAL 5008 graublau). This was from the RAL range, not from the RLM camouflage list of colours. The civil registration was marked with RAL 9010 Reinweiß.

The L.Dv.521 document series

The RLM had thus ensured that a rapidly expanding Luftwaffe was supported by an integrated supply and control system. Paint manufacturers were assimilated into this system to guarantee conformity of paint quality, type, description and method of application. These standards were set out in a detailed booklet, 'Entwurf; eine Behandlungs-und-Anwendungsvorschrift für Flugzeuglacke' - (Outline, treatment and application instructions for aircraft lacquer). The earliest edition so far located, dated 1938 (printed by Gallus A.G. Berlin Charlottenburg 2) and issued to all paint manufacturers is marked 'Ausgabe: 2' (Issue: 2). With the exception of two introductory pages, it was an exact copy of the military document of the same title and layout issued as 'L Dv.521/1 eine Behandlungs- und Anwendungsvorschrift für Flugzeuglacke Teil 1' - (Treatment and application instructions for aircraft lacquer Part 1), on 22 March 1938. The introductory pages to the military edition reviewed recent advances that had stemmed from the wider development of aircraft lacquers and protective finishes. By tracing the sequence of such document issues, it is possible to gain a clearer idea of the level and extent of control standards that the RLM imposed on the aircraft industry as a whole.

L.Dv. was the abbreviation for Luftwaffen-Dienstvorschriften - (Luftwaffe Service Regulations) and the series was continuously updated and covered a vast array of subjects, including, weapons, aircraft handbooks, specialised equipment etc. Updated listings were issued periodically in L.Dv.1/1 entitled Verzeichnis der Dienstvorschriften und Druckschriften der Luftwaffe, Teil 1 - (Catalogue of Service Instructions and Printed Lists of the Luftwaffe, Part 1). The first military edition must have been issued before 1938 because L.Dv.521/3, containing alterations to the L.Dv.521/1, was issued in August 1937. The Luftwaffen-Dienstvorschriften series of handbooks had been issued first in 1935 and the original edition of L.Dv.521/1 may date from that year or, more probably, 1936.

While some paint manufacturers specialised in one line of paints, larger firms produced paints for widely differing uses as noted earlier. Lüdicke & Co, for example, produced paints that had been developed specifically for three distinct areas of use. Under the trade name 'Avionorm' it made paints for aviation and light metal applications associated with that industry. Its 'Luconorm' paints were for motorised transport while its 'Lucalin' range was specifically for marine applications. With rare exception paints from one group could not be substituted for use in another. Theoretically, aviation lacquers could be used on ground vehicles, but not the other way round because of the chemical and physical requirements of aircraft structures.

Occasionally an individual chemical *component* was common to different formulations for different lacquers, something that would have a profound effect on late war Luftwaffe lacquers as will be explained later. A more benign example was Beer u. Sohn of Köln who developed a formula that used scrap film (benzyl cellulose) from the Film Works Wiesbaden. The result was a colourless nitro cellulose lacquer that formed part of several lacquer formulae for aircraft paints. The distinct chemical and physical requirements of each class of paints normally precluded cross-use, but specific elements were common to most of them within certain classes of lacquers.

For close control of the airframe manufacturing process as noted it was necessary to provide the civilian-manufacturing sector with the same information supplied to the Luftwaffe maintenance sections. This was done, through a commercial printing firm, as a reproduction of the original L.Dv.521/1 series, which was identical other than for deletion of the issuing authority's name ('Der Reichsminister der Luftfahrt u. Oberbefehlshaber der Luftwaffe') and the designator 'Part 1'. An amendment inserted in the front page of the industry issue document 'Entwurf einer Behandlung und Anwendungsvorschrift für Flugzeuglacke' of 1938 stated:

> *"The present instruction for treatment and usage of aircraft paints is only to be used in its own business section. The colour shades 70 and 71 which are specified on the colour shade card are not allowed in any case to be produced or exported in foreign countries under this designation."*

This ensured that no foreign agency would gain access to the industry code standards. Interestingly, it was still possible to allow manufacture of, or to directly export, supplies of lacquers using colours 70 and 71, but they were not to be identified as such, for example, for maintenance of exported versions of German military aircraft sold to foreign powers. Increasing political tensions, created by Germany's expansionist movements and its planning for war, were probably the principal factors in that restriction.

The paint control system was thus split into three distinct areas, all of which overlapped or duplicated in full the requirements for the manufacture, testing and application of paints across both civilian and military establishments.

A few surviving pages (commencing page 103) from Part IX of what was a much larger document titled 'Allgemeine Wartungsarbeiten' - (General Maintenance Instructions), dealt with classes of paint finishes, splitting them into three main groups: (a) Protective finishes, (b) Camouflage, and (c) Internal finishes. While the document's form and content were more limited than the 1938 L.Dv.521/1 issue, it was clearly aimed at training service ground staff.

Reference to camouflage dates the document to at least 1936, but the additional statement that *"... trade names by which lacquers were originally called are now replaced by numbers,"* indicates that it could not have been released later than 1938 as it mirrors the final transitional phase between the old company system and the new RLM identification system for products. It provided a brief explanation of what was a Flieglackkette (group of specific lacquers and products) and how to identify the colour where added. It then gave an example of a Flieglackkette, but mixed new and old designations for lacquers together; something not done in the 1938 L.Dv.521/1 document where clear distinction between the two systems was made, (See Appendix D). This seems to place the date of the document closer to 1937.

> *"Flieglackkette 20 contains the following lacquers:*
> *Herbolit combination base lacquer grey-green BC 6965, present identification is 7113*
> *Herbolit combination intermediate lacquer silver BC 6966, present identification is 7114.01*
> *Herbolit top coat silver-matt grey BC 6954.*
> *For this lacquer dilute with Herbolit special thinner BC 6970. This is presently identified as Thinner 7213.00."*

The Herbig-Haarhaus A.G. trade name was misspelled throughout - it should have been 'Herboloid', not 'Herbolit' - and the table still identified the first two lacquers and thinning agent with both manufacturer's and RLM code numbers mixed together. It then omitted the RLM code number for the silver-matt grey top coat BC 6954, which in contemporary documents was identified as 7115.02. Note also 02 was referred to as 'silver-matt grey', perhaps further indication that the 02 finish was having its gloss finish toned down.

Also interesting is that while the example quoted was purportedly taken from Flieglackkette 20, its contents were those actually assigned to Flieglackkette 05 in the 1938 L.Dv.521/1 issue (and presumably the first 1938 issue), a non-flammable group of paints. Given the sequential issue of Flieglackketten numbers, the strong probability is that this was another error. Lacquer groups would be deleted and added, but there is no evidence of any assuming a number previously allocated to another lacquer group - to have done so might have been dangerous, let alone confusing. Security considerations for what was a public document

might be one answer for the erroneous information, or simply a printing error as both Flieglackketten followed each other in the L.Dv publication. In the 1938 issue Flieglackkette 20 correctly listed lacquers manufactured by Ago A. G. under their Cellesta product name, matching RLM designations 7130.-, 7135.02 and 7136.00. This was a dedicated group of lacquers used only for fabric.

Despite some shortcomings, these few pages of Part IX covered a considerable range of factors relating to aircraft lacquers and their care. It cautioned that lacquers for individual components were recorded in the aircraft logbook and care had to be taken, when refreshing the lacquer surface, that only those appropriate to the specific area and specified type of application were used. Commentary on the effects of weathering through ultra-violet deterioration and exposure to moisture was dealt with carefully. Simple wear and tear damage to lacquer surfaces, such as on-wing walkways, had to be repaired promptly. Fabric faults, such as damaged wing-rib tapes or small tears were required to be repaired immediately. Regular cleaning of the exterior surface of the aircraft was also essential - but using only the approved cleaner. Using substitutes, such as benzol, was forbidden as this could damage the surface of the lacquer.

The 1938 edition of L.Dv.521/1 also carried some information on a general finish for lacquer surfaces:

"A finish specially identified by the RLM will be applied to ready painted aircraft before delivery to the operator or within one month after the top coat has been applied. However, the finish should be applied only after thorough, lengthy drying of the coating, if possible not less than two weeks after the coating has been applied. The finish must be applied not too thickly and rubbed down with a dry cloth in order to achieve the necessary dull surface required as effectively as possible and to avoid dust accumulating. The coating must be entirely dry in all circumstances when applying the finish."

A more definitive instruction appeared in the Do 17 E maintenance handbook where it described how to use this DKH weather protection Nr 5005 after acceptance of the aircraft (i.e., at the end of the production routine flight-testing). The aircraft had to be dusted down and then the protective finish was to be either wiped on with a rag or applied with a hand spray, one or two applications being sufficient. This process did produce a very low sheen when first applied, but that dulled with time (another source of problems when assessing black and white photographs to try to establish colours). On 1 February 1940, an instruction was issued, placing a ban on further use of such finishing agents as it produced a slight sheen to the natural dull finish of the lacquer. The 1941 edition of L.Dv.521/1 carried a reminder that the prohibition remained in force until further notice.

Something else that drew adverse attention was the general cleaning of aircraft paintwork. War had brought additional pressures and ground staff had taken a more relaxed view on cleaning down aircraft, using any form of cleaning agent handy to remove dirt and oil stains. That was addressed with promulgation of an order, (Reinigungs-und-Pflegemittel für sichtgeschütze Flugzeuge. Az. 82 b L.C. 2 (VI) Nr. 5961/40.), on 10 April 1940 to unit commanding officers to have their engineering staff take immediate measures to make sure that the practices stopped immediately. The use of non-approved cleaners to remove oil and grease could, and did damage the lacquer finish, and that affected the aircraft's performance and camouflage.

The original issue of L.Dv.521/1 was subsequently amended by L.Dv.521/3 'Entwurf eine Vorschrift zum Ausbessern von Flugzeuglackierungen (Ausgabe 1937)' - (Outline; an instruction for the repair of aircraft lacquering (Issue 1937)), issued on 18 August 1937, under the authority of the Reichsminister of the Air Ministry and the Commander-in-Chief of the Luftwaffe. By this time most mixed wooden and fabric-built aircraft had been superseded by metal-skinned aircraft. L.Dv.521/3 identified all lacquers and associated product references only by a 7000-series of standard reference numbers.

This publication was focused on repair work, not repainting of entire aircraft, a distinction it made clear as part of its opening comments:

"The painting of entire aircraft components... wings, fuselage, control surfaces, etc., is called re-painting. The following Instruction refers only to improvements. Repainting is covered in L.Dv.521/1."

"Improvements" were defined as, *"...removing damage occurring over a limited area to aircraft paint work..."* - the introductory remarks going on to state that any damage to the surface protection (paintwork) had to be eliminated as soon as it occurred. Leaving such damage long-term simply produced further damage, and unserviceability of the aircraft. The lacquer designated for this repair work on external surfaces was 7112.-, not one of the existing lacquers used for the final external finish. The reason for this choice was the nature of 7112.- . Firstly it had improved pigmentation capacity, 20 per cent instead of 10 per cent (thus giving a more opaque and consistent colour finish); secondly, it could be sprayed as a fine mist and still adhere to the lacquer surface to which it was being applied, something the contemporary range of lacquers would not do. This ability would become significant in 1940 when mottling and fine sprays to damp down colouring became very important, (see Appendix E, Volume Two for a detailed explanation.)

However, 7122.- had an even more significant quality - it would adhere to light metals without the use of a primer - and by then the Luftwaffe's front line force was almost exclusively comprised of metal aircraft. It exhibited excellent durability and was manufactured from non-strategic materials. Further, it had very good air-drying qualities, not requiring the heat drying processes used for lacquers already in use. The latter retained superior durability but the trade-off in processes and resources favoured the exclusive use of 7122.-. By introducing this new lacquer the OKL had eliminated some reliance on imported materials, reduced painting processes, materials, labour and time, while finally having a lacquer with much improved pigmentation and adherence qualities. It had a drying time of just three hours compared to at least six hours for 7102.-, (the translucent preparatory zinc-chromate metal etching coat used before applying the Luftwaffe's other standard external finish of 7109.-, the latter requiring a further six hours drying time). It was a major advancement by the German paint industry. By the time the next issue of L.Dv.521/1 appeared, in November 1941, 7122.-, with various colour shades added, was the lacquer exclusively used both externally and internally.

While 16 further amendments to L.Dv. 521/1 would be issued as loose-leaf items in September 1939, a completely new edition would not appear until 1941. As far as can be determined, the latter was the last fully amended issue to carry the L.Dv.521/1 title, but an amended manufacturers' edition would appear in 1944. This parallel series of military and civil issue of control documentation eventually fell victim to increasing austerity measures that finally flowed on to even industry documentation. Apart from the civil issues of the military documentation, other industry related journals had kept the paint industry abreast not only of approved practices but also of new initiatives and patents. For example 'Rezeptbuch für die Farben - und Lackindustrie, Band 1, von Hans Hadert' - (Formula book for the Colour and Lacquer Industry, Volume 1, by Hans Hadert), published in 1943, recorded much information on technical data and patents (including American and British) of assistance to the industry as a whole. The 20 September 1944 issue of 'Industrie-Lackier-Betrieb' - (Industry-Paint-Management), another widely distributed document, carried an announcement on its front page stating *"...as from September 30, 1944, for the period of the war this magazine will not be published."*

Lacquer identification systems

As previously outlined, the revised 1930s RLM system divided aircraft paints into two main groups called 'Flieglackkette' (aircraft lacquer group) identified by two digits, - 01 to 19 allocated for application to metal surfaces and 20 to 39 for wooden surfaces, each governed by special requirements. This description was always identified by the full title and two-figure numerical group, for example Flieglackkette Nr. 03, thus avoiding confusion with the two-digit colour description referred to below, which used a similar range of numbers.

The Flieglackkette system is known also to have been instituted by 1935 from a reference to identification of a paint scheme in the 1938 edition of 'Entwurf; einer Behandlungs-und Anwendungsvorschrift für Flugzeuglacke' - (Outline, Treatment and Application Regulations for Aircraft Paint), which mentions Flieglackketten Nr. 01, 02, 20 and 30 and the date 1 July 1935. While this system of RLM identification codes had been introduced within the military regime, it was not imposed on the civil manufacturers until 1936. Even so, there was a considerable grace period during which time documents appeared listing both descriptions contiguously. Not all numbers in each range were used, deletions and additions occurring until 1945 as will be seen later in the text.

Each Flieglackkette was composed usually of the products of a single company, illustrating how the industry came to be dominated by a few main paint manufacturers, with the products of some smaller companies falling into a single Flieglackkette. As each grouping was for a specialised purpose it further illustrates how companies pursued definitive sections of each market - as a result of that, many of the smaller companies eventually became licence manufacturers for the few larger companies. Eventually that would prove beneficial by default, multiplying the number of sources for a particular lacquer and ensuring some continuing degree of supply when the coming war would eventually bring major disruption to German production centres.

As explained earlier in this chapter, a four-figure code group specified the Flieglack (aircraft lacquer) type, followed by a two-figure code to identify the Farbton (colour) where one was included. Initially the two digit identification code range ran from 00 to 46 in February 1935, but continued to expand reaching 73 by 1937, and had climbed to 78 by 20 August 1940 on which date the system was expanded to incorporate numbers from 79 to 100.[4] This was to be the total range of numerical indicators and most were taken up in due course. These two-figure codes covered all colours used both externally and internally, including undercoat colours beneath the final finish. However, by 1936 direct correlation between RLM and RAL paint identification codes had ceased as the RLM range of camouflage colours increased. The last four colours in use common to both systems were the first three upper surface camouflage colours 61, 62, 63, plus the internal colour 66.

Clear compounds were indicated by the addition of .00 after the four figures, e.g., 7200.00 (a clear solvent in this instance). The actual description appended to the code .00 was 'wasserhell' (clear water) indicative of the transparent quality of the finish. A colouring agent was added in some instances but this did not alter the *transparent* quality. Some confusion over interpretation has existed in the past, 00 sometimes being taken as always meaning colourless (which in most cases it was) rather than clear or transparent.

A tinge of colour was sometimes added to some transparent lacquers, indicated by a colour description, such as grün (green) or gelb (yellow), and the term 'lasierend' (transparent). That term was not usually affixed to clear lacquers unless colour was being added, (the designation 00 was from the group of numerical identifiers used for *colour descriptions* added to lacquer types. The term 'lasierend' was added to lacquer types that had a natural clear finish). The resulting finish retained its transparency. This could occur as either an addition to the .00 suffix, for example, 7111.00 gelb lasierend, or by adding the indicators '.-' to a lacquer code, for example 7140.- (grün lasierend). The surface finish could still be discerned, but there was an identifiable colour cast to it.

Each Flieglackkette had an associated group of specific Flieglacke, lacquers developed for use on individual materials and for express purposes, e.g., internal, external, metal, wood, fabric, plastic, fireproof, coloured, land or sea-based aircraft. As time progressed the composition of the Flieglackketten changed as Flieglacke were withdrawn or replaced (see Appendix D). Lacquers were continuously under development and improved types supplemented existing ones or replaced them. This process would be driven by both the search for improved materials as well as by necessity caused by a failing supply system of special ingredients.

Lacquering and camouflaging of metal propeller blades and spinners was also addressed; lacquer 7142 was used as the base coat with 7146.71 as the middle coat, and 7146.70 as the final coat. This brought these two items into line with introduction in 1937 of the camouflage scheme of 70/71/65 for some classes of Luftwaffe aircraft. The blade root and hub mechanism were made from high tensile steel, which had a good resistance to corrosion, and they were left in bare metal, lacquering ending 30 mm from the blade/hub connection point.

By the time that the 1938 editions of L.Dv.521/1 and the civilian 'Entwurf; einer Behandlungs-und Anwendungsvorschrift für Flugzeuglacke' were released, revision of the lacquer code identification system had taken place. A full listing of the original manufacturers' lacquer types, colour codes, and their previous descriptions, however was still included. The L.Dv.521/1 edition lists Flieglackkette Nr. 01, 02, 03, 04, 05, 20, 21, 22, 30, 31, 32, and 33. This section of the work is titled Lackketten für den Flugzeughalter und bei Überholungswerkstätten - (Lacquer sequences for unit holders of aircraft and repair workshops), (see Appendix D). It illustrates the variety and application of each group plus listing the supplier and the original manufacturer's description. Noteworthy is the unique example given under the listings for Flieglackkette Nr. 04 where it is possible to detect a further phase in the shift between manufacturer's original code descriptions and the new RLM numbers; the newly introduced 7109 with colour 02 added is shown under the manufacturer's listing as Ikarol 133.02, a combination of both systems.

Applying the system

From this it is possible to obtain a clear appreciation of the original extent of this system and the revisions that were already evolving. The shift from organic aircraft structures to inorganic with the expansion of all-metal aircraft structures produced a complementary shift in lacquer compositions. The original two- and three-coat internal and three-coat external finishes became redundant. The new single-coat lacquer, 7109.-, developed by Warnecke & Böhm, introduced a consequent saving in materials, production time and weight. Prior to 1938, all-metal airframe designs had their painting schedule revised accordingly, as noted below.

Supply, storage and handling of lacquers was set down in concise detail. Lacquer was to be supplied in containers that allowed easy stirring, pouring and efficient stock storage and the inscription on the containers had to be waterproof and non-dissolvable by the lacquer itself. Lacquer was supplied in undiluted form (marked as 'thick lacquer'), plus thinners that were specific to lacquer types and were to be used accordingly. The rate of thinning was to be clearly marked on the exterior of each can of lacquer.

The description on each container included the name and address of the manufacturer, the specific official description of the lacquer (e.g., Flieglack 7107.02) and its related thinner, the area to which the lacquer was to be applied and the sequence in which it was to be used within the Flieglackette, for example, 'Thick lacquer for metal application of Flieglackkette 04.'

The method by which the lacquer was to be applied was also marked on the container, for example 'Only applicable by spraying at ...

parts per volume', or 'Only applicable by dipping', or 'Only applicable by brushing'. Use of thinners was specified, e.g.,'Thinner Nr... mix in the ration of ... parts by volume with thick lacquer as per official instructions'. The date of delivery was also marked and across the label and overprinted in red lettering at an angle was the paint stock description, e.g., 'THICK LACQUER'. Once thinners had been mixed with a particular container of paint the description had to be amended. Any paint found to be contaminated was rejected. This applied especially to stocks of paint that had been standing for a long time.

Storage of paint stocks was rigidly controlled. Room temperature was not allowed to vary by more than plus or minus five degrees Celsius. After mixing of two ingredients, for example, thick lacquer and thinners or thick lacquer and pigment colouring, such containers were to be stored separately from unmixed stock. Paint was to be prepared for use by stirring for 30 minutes with a tool made specifically for this purpose by Brea G.m.b.H. of Jena, and allowed to reach the temperature of the room in which the paint was to be applied.

Viscosity (resistance of a liquid to flow) was then to be checked using a viscosity meter with a 3 mm opening (manufactured by Franz Hering Jenaer Apparatebauanstalt, Jena who appear to have had sole rights to this ubiquitous item) at a temperature of between 18 and 21 degrees Celsius. The 3 mm aperture could be exchanged for a 4 mm aperture, DIN 53 211, for certain paint types. (The DIN reference was the Deutsche Industrie Normen - 'German Industrial Standards' code number). Rates of flow times for both sizes were set out. Examples of the general spread of viscosity ranges are shown below.

Lacquer	Application	Flow rate (seconds)	
		3 mm opening	*4 mm opening*
7102.00	metal primer	45-50	19-25
7109.65	metal finish	70-80	27-52
7130.00	aperture finish	540	136
7135.22	fabric and wood	300	72
7131.00	wood primer	160	35
7132.00	primer	295	63
7122.00	metal	50	21

While this may seem of small interest, the chart makes clear the differences in lacquer quantities that occurred by just a change of viscosity (i.e., by under- or over-thinning of a lacquer). In a private enterprise industry that would eventually consume tons of lacquers per month, attention to such detail would become paramount, especially when supplies of lacquers became threatened by a rapidly declining war situation. It had more immediate consequences though, as shown - the same spraying time period produced differences that were, in some cases, quite startling. This meant that the amount of material used could vary quite dramatically, and affected both the weight of the aircraft (and its performance) and the thickness (and durability) of the finish. The cost factor to the purchasing company was also a significant economic factor to the airframe manufacturing industry.

This highlights the fact that it was not sufficient only to ensure that pigmentation was fully mixed to match the specific RLM standard chip for a given colour, but also that the resulting flow rate of a lacquer, whether applied by spray or brush, was correct. If viscosity varied, then the correct air pressure, nozzle setting and distance from the spray surface would still produce an incorrect final thickness. That type of variability in flow rate eventually would become more visually significant nearer to the close of the war when camouflage lacquers, already officially reduced to extreme thinness, were further affected by the chaos besetting the aircraft industry at that time.

The surface to be painted had to be carefully prepared. Metals had to be cleaned and the document detailed both technical and chemical methods for achieving that. Wooden surfaces were to be visibly free of any extraneous material and glass paper grade 000 (extremely fine) had to be used to ensure removal of any such material. Pre-lacquered surfaces were not to be cleaned by other than methods specifically laid down. A lacquer stripper, identified by the code P3, was specified for use where such was needed.

Lacquer had to be applied under specific conditions; no open fires or radiators were to be present. Where spray applications were specified, spray guns with apertures of 1.8 to 2.5 mm were to be used at a pressure of 3 to 4 atmospheres. Lacquer was applied first in one direction only, then after allowing a short drying time, an application at right angles was to be made. Room and lacquer temperature was to be between 18 and 25 degrees Celsius, and relative humidity between 50 and 75 per cent; conditions were to be tested using a temperature and humidigraph. Excess sealing material used on rivet lines was to be immediately removed; wet grinding or harsh grinding of joints was only to be undertaken with the permission of RLM-GL/C-E2 VII.

Specified numbers of coats of paint and appropriate drying times were to be strictly adhered to, (standard thickness and dry weights were set for each lacquer layer, i.e., single coat - 5/100 mm thick and 60 gm/square metre; two coats - 8/100 mm and 100 gm/square metre; three coats - 1/10 mm and 150 gm/square metre). Inaccessible areas were to be completely lacquered prior to assembly. On areas where, after assembly, adjoining areas were to be lacquered in full, the layers on top of each other were to be staggered to allow later joining of the lacquer sequences. Synthetic wood filler was used for evening out blemishes in wooden surfaces before the lacquering process commenced. The first application of lacquer could only be made after the wood filler had completely dried out. Use of such wood filler however required the permission of the head of the workshop area, which, in turn required specific permission from RLM GL/C-E2 VII. Accidentally dirtied metal or wood surfaces could only be cleaned with 00 grade steel wool, care being taken not to blemish the metal or wood surface. Any lacquer removed by such action had to be replaced immediately. After ensuring that all traces of steel wool had been cleaned away any blemishes in lacquered surfaces were to be reported to the workshop chief. The finished lacquer application had to be as *matt* as possible, *high gloss* and *gloss* finishes on aircraft were allowed only with the consent of RLM GL/C-E2 VII.

The room itself had to be completely dust free, and paint applications using a soft spray (fogging-style application) were not permitted in the same room. Air extractors were to be used at all times, the down draught type for main tasks, top ventilated extractors being permitted only for touch-up work. For touch-up of paintwork related to small repairs, room temperature and humidity conditions were not so strict, but an enclosed area was still required. Higher temperatures to speed up drying times could only be used after consultation with the RLM.

Individual Flieglackketten were set out in detail, listing each lacquer type included, and giving the full directions for application, e.g., whether the lacquer was to be sprayed, brushed on or the part dipped into it, the drying time to be allowed for each coat and the time in seconds, within a prescribed temperature range, for a properly mixed sample of the lacquer to be run through the prescribed viscosity metre size. Average weight of paint per hundred square metres of surface was also detailed. In some instances the method of spray application was specified, usually 'Kreuzgang spritzen', the cross-hatch, cross-spray method mentioned above.

The following example provides a better understanding of the extent of the control set down, and the conditions needed for a normal painting sequence. This also helps illustrate why front line units did not repaint entire aircraft under field conditions. Note that the two-digit designator at the top of the page was a Flieglackette (lacquer group) designation - not an RLM paint colour description.

Process instruction
Paint Group Nr. 02

Lacquer	Use per 100 m² (referred to on spraying material)	Continuous flow velocity in viscosity meter (regulator bowl) Spraying material 3 mm at 18-21°C per second
1.) Aircraft lacquer Nr. 7102.-	15	
2.) Aircraft lacquer Nr. 7106.-	10	
3.) Aircraft lacquer Nr. 7108.02.-	6	
4.) Aircraft lacquer Nr. 7107.02.-	10	
I. Process for interior lacquering of floats and interior and exterior lacquering of boat hull		
1) Degrease with the medium as described under D 3		
2) Aircraft lacquer 7102.- sprayed, 10:1 thinned with aircraft lacquer thinner 7200.00		45-50
Drying time min. 6 hours		
3) Aircraft lacquer 7106.- sprayed, 2:1 thinned with aircraft lacquer thinner 7200.00		45 - 55
Drying time 3 hours		
4) a. Aircraft lacquer 7108.04 underwater section sprayed 2:1 thinned with aircraft lacquer 7200.00		75 - 85
Drying time 4 hours		
b. Aircraft lacquer 7107.04 underwater section sprayed 2:1 thinned with aircraft lacquer 7200.00		75 - 85
Drying time 4 hours		
II. Process for exterior lacquering of floats		
1) As above		
2) As above		
3) Aircraft lacquer 7106.27 (and as above)		
4) Aircraft lacquer 7108.04 of over - and underwater surface		
Drying time as for I		

(The reference to the degreasing medium and 'D3' referred to section D3 of the document, 'Cleaning the material' in which specific mediums were described in full).

As noted earlier, the reader may care to reflect on this example of the intensive and extensive process when contemplating claims that aircraft were completely re-painted at unit level under front line conditions.

Similar detailed instructions were also included for special applications of certain paints, 7140, 7170, 7160 (which was used for the marking lacquers pigmented with RLM 21 to 23 and 28), 7161 (used for marking lacquers 23 to 27), 7136.00, 7142.- 7146.70, and 7102.02 single coat lacquer (also used with 01, 22, 61, 62, 63, 65, 66, 70 and 71), 7111.00 yellow transparent, and 7118.00 blue transparent.

A pro-forma document was included titled 'Muster einer Lackierungsübersicht für Flugzeuge, Flugzeugmuster Zi 99 W.Nr. 118' (Sample of lacquering summary for aircraft, aircraft summary Zf 99 W Nr. 118), which had by then become the standard layout sheets for all types of aircraft. Materials had been grouped into four categories, the identifying letter being listed against the various aircraft materials in the schedule.

Group A Corrosion-proof material (e.g., stainless steel).

Group B Corrosion-inhibiting metal skin of the material (applied by plating, galvanising or metal spray process) and additional protective paints.

Group C Non-metallic protective coatings (chemically produced, for example anodising, atrementation [phosphate coating] and phospherizing processes) and additional protective paints.

Group D Lacquers (air-drying, stove-drying) applied to otherwise unprotected materials.

This much-abbreviated form had replaced the earlier, more extensive version. The precise title varied however and the 1939 edition of 'Der Flugzeug Maler' used the following example 'Beispiel eines RLM Lackierungsformblattes für Flugzeuge. Flugzeugmuster Zi 99 SNr. 118'- (Example of an RLM-lacquering form sheets for aircraft, aircraft summary Zi SNr. 118). That in turn was replaced by a revised form titled RLM Lackierungsformblatt (OS-Liste) mit Mustereintragungen-(RLM-lacquering form sheet (OS-Liste) with summary entries). The precise date of change to this slightly more detailed form is not certain, but was most likely to have occurred in 1939.

The final section of the work gave a two-page summary of all 32 lacquers, and 19 thinner, spreader, filler paste and tape numbers in use, their application, the supplier and, where appropriate, any special notation.

While it remains contentious as to whether a colour card was issued with the first edition of 'Entwurf; einer Behandlungs-und Anwendungsvorschrift für Fliegerlacke', (if so, it would have been a repeat of the 1936 B. Richtlinien colours), the revised 1938 edition did incorporate one, titled 'Farbtontafel zur Behandlungs-und Anwendungsvorschrift für Flugzeuglacke (Ausgabe 1938)' - (Colour card with the treatment and application regulations for aircraft lacquer (Issue 1938)), and marked in the right-hand lower corner with Muster-Schmidt Berlin SW 68.

00 wasserhell	01 silber	02 RLM-grau	04 gelb	21 weiß	22 schwarz
23 rot	24 blau	25 hellgrün	26 braun	27 gelb	28 weinrot
61 dunkelbraun	62 grün	63 hellgrau	65 hellblau	66 schwarzgrau	70 schwarzgrün
71 dunkelgrün	72 grün	73 grün	*Blank*	*Blank*	*Blank*

Colour range had been extended to 73, but no longer included some that had been listed on the earlier colour card issued with 'Richtlinien für die Entwicklungen geeigneter Flugzeuglacke'. The 1938 Issue 2 of that earlier document and some of its changes were reflected in hand written comments added to the earlier colour chart; 11 grau, 68 schwarzgrün and 69 dunkelgrün were marked 'fällt weg' (deleted), 61 dunkelbraun, 62 grün, 63 hellgrau, 64 dunkelgrün and 65 hellblau were marked 'geheim' (secret), while 67 weiß, actually an off-white, was still included, but not marked with either comment. However, it too did not appear in the 1938 revised colour chart.

As 61, 62, 63 and 65 had been in use as standard camouflage from early 1936, those colours and their purpose are accounted for. What purpose 64 and 67 had filled in the intervening period is not so easily understood; nor is it known at what date they had been deleted, but obviously they must have been before issue of the 1938 chart. Similarly the purpose of 11, 68 and 69 is equally enigmatic. The designations for 68 and 69 mirrored those applied to the two new dark greens 70 schwarzgrün and 71 dunkelgrün on the new colour card, colours that had been introduced in February 1937. It might be argued that 68 and 69 had been intended for use on the new generation of fighter aircraft, but had been superseded by the darker, two-colour upper surface combination of 70 and 71. Rationalisation of paint varieties and

raw materials could account for that swift deletion, given the lengthy testing period that must have preceded their approval. That would date the amendments to this document as early 1937, which also would account for the marking of the new camouflage colours of 61, 62, 63, 65 as 'secret'. The speed with which changes were flowing is reflected in the decision taken in 1938 to replace the three-colour camouflage of the bomber force with the same two new greens, 70 and 71, simplifying the number of camouflage colours right across all classes of aircraft and easing pressure on raw materials as war loomed.

It is worth reminding the reader, that unlike the 1936 card, colour cards issued with the L.Dv.521/1 series of documents included only colours used for external finish, including any interior area visible through cockpit glazing or opening that visually formed part of the upper surface camouflage. Such areas, understandably, were subjected to equally strict colour controls. Markings colours, for pipe runs and electrical wiring, were also included because they were used both externally and internally.

RAL colour codes had been directly correlated to the RLM system up until 1936 when the 61/62/63/65 scheme came into force. The document 'Taschenbuch für Lackierbetriebe, Ausgabe 1944' - (Pocketbook for paint shops, Issued 1944), printed by Curt R. Vincentz of Bad Harzburg, included various listings that break down usage into individual organisations. The RAL Reg. 840 R numerical listing gave the following correlations:

Number of RAL-Register 840 R	Series	Colour Tone	Corresponds to the number	the card
1003	gelb	postgelb	27 gelb	RLM*
1004	gelb	chromgelb	04 gelb	RLM
3001	rot	feuerrot	23 rot	RLM
3008	rot	weinrot	28	RLM
5000	blau	dunkelblau	24 dunkelblau	RLM
6000	grün	hellgrün	25 hellgrau	RLM
6003	grün	aschgrün	62 grün	RLM
7003	grau	RLM grau	02 RLM-grau	RLM
7004	grau	hellgrau (steingrau)	63 hellgrau	RLM
7019	grau	schwarzgrau	66 schwarz-grau	RLM
8004	braun	braun (fleisch braun)	26 braun	RLM
8019	braun	dunkelbraun (nachtschatten)	61 dunkel-braun	RLM
9000	sonstige Farbtöne	wasserhell	00 wasserhell	RLM
9001	ditto	weiß	21 weiß	RLM
9004	ditto	schwarz	22 schwarz	RLM
9006	ditto	aluminium (silber)	1 h 01 silber	RAL 840 B 2

*The actual abbreviation for the RLM colour card source was listed as 'RLM z. Behdlg. u. Anwdg. Vorschr. f. Flugzeuglacke (Ausgabe 1938)', which, in full, was the 'Behandlungs und Anwendungsvorschrift für Flugzeuglacke (Ausgabe 1938)' - (Treatment and application regulations for aircraft lacquer (Issued 1938)). The reference 'sonstige Farbtöne' (former colour tone), which was appended to 00, 01, 21 and 22, relates to the fact that clear, silver, white and black are colours for which there was only one standard tone *in this context*. However, the reader is reminded that the RAL colour system included multiple shades of *all* colours, including black and white, for example 9001 weiß (white), 9002 reinweiß (pure white), 9004 schwarz (black), 9005 Tiefschwarz (jet black). The cross reference of 9006 to the RAL 840 B 2 listing simply records that 01 silver had an existing description prior to the establishment of the RLM listing. It should also be noted that RAL 7021, by 1941, had replaced RAL 7019, both colours being described sequentially as RLM 66, (see Chapter 6)

The RAL colour descriptions for 61, 62 and 63 are interesting, 61 having an identical description in both systems. The term 'ash green' for 62 was little more descriptive than the bland 'green' term of the RLM. The alternative of 'ash grey' for 63 also was a little more precise than that of 'light grey'.

It will be noted that this 1944 listing contained colours dating back to the obsolete 1936 upper surface camouflage RLM colour references of 61, 62, 63 plus 66, but does not include 65 or any of the subsequent camouflage colours introduced between 1937 and 1944. It effectively shows the point at which the RAL system and the RLM system ceased to have direct equivalents. Note also that the cross reference for the RLM colours is given as the 1938 colour card issued with L.Dv.521/1 of that date. The first colour card, included in the 1936 document 'B. Richtlinien für die Entwicklungen geeigneter Flugzeuglacke', is not mentioned in the RAL listings, nor the two subsequent colour cards of 1939 and 1941. This underscores the contention that the 1938 L.Dv.521/1 issue was probably the first to be released with that form of document.

Introduction of 65 in 1936 had been the first break with the universal RAL system. As a single colour it had not warranted issue of a colour card as all other camouflage colours matched the available RAL colour system. However, with 70 and 71 being introduced in 1937, followed by 72 and 73, it had obviously been considered that the need for a comprehensive revision of L.Dv.521/1 existed, along with a single colour card to accommodate the five new colours that fell outside the RAL colour matching system.

This raises the question of how colour matching at aircraft production centres had been managed between 1936 and 1938. As those colours had been introduced incrementally, it is possible that some form of loose colour chips had been issued - no other practical procedure of colour matching seeming probable. If so, what then occurred in 1941, regarding colour matching for new colours, may have had its precedent in the pre-war period.

The two new colours, 70 and 71, were identified respectively as schwarzgrün (black green) and dunkelgrün (dark green), but colours 72 and 73 were simply both described as grün (green). No attempt had been made to distinguish between their colour shades despite the fact that they did have written colour descriptions at this time of seegrün and dunkelseegrün in other source documents. This highlights the fact that colour identification by their RLM two-digit code was seen as sufficient, written colour descriptions being of secondary importance, a fact reinforced by changes that would occur to specific colour descriptions in later years.

This colour card contained only colours for use externally (or visible externally), almost exclusively for identification or camouflage purposes, wasserhell 00 being the exception at that point. However, as stated earlier the colour code allocation was much more extensive, commencing 00 and ending with 100. Allocation was in blocks as follows: [5]

00 to 19	Grundfarben (Innen-Aussen-anstrich) (Base colour [Internal - external base finish])
20 to 39	Kennzeichnungsfarben (Marking colours)
40 to 59	Sonderfarben (Special colours)
60 to 79	Tarnanstrichfarben (Camouflage colours)
80 to 100	(no documentation identifying this final mixed group has been located, but it contains only camouflage colours, plus 99. This final group is also the numerical exception with its block of 21, not 20 numerical codes.)

('Internal' refers to colours used both as final surface colouring inside aircraft, and also to colour identification of primer and intermediate coats of lacquer covered with a final coat of another colour, either inside or outside the aircraft structure).

Sufficient latitude had been built in to allow expansion of the system both as a whole as well as within each specific group, and not all numbers had been allocated by 1945. The nature of 99 produced an exception to a system that otherwise always allocated numbers

sequentially within each specific purpose group. It should be noted also that while numbers were allocated sequentially *in the development system*, it did not always follow automatically that all were introduced *into service* in the same order, for example, see later references to 83 preceding 81 and 82 into service. It should also be noted that the term 'Marking colours' had a slightly broader meaning, 32 for example was a yellow used on wood, its purpose being to identify the sequence of lacquering of the material.

Numbers up to 46 had been allocated by 3 February 1935. Numerical codes for colours had been allocated systematically within each group of twenty and 63 had entered use by late 1935, indicating that 60, 61 and 62 already had been approved though not all had entered general manufacture (60 was one which did not achieve general production status). Introduction of those colours, plus 65, on the first Ju 86s early in 1936, supports this timetable. Colours 70 and 71 appeared on the new Bf 109 B fighters in February 1937 and documentation dated 1 September 1937 confirms that colours 72 and 73 were also in use.

While 41 and 42 were from the group Sonderfarben (Special colours) and used internally, they had been specifically included on the 1936 B. Richtlinien colour card. Also included was colour 11, from the group Grundfarben (Innen-Aussen-anstrich) (Internal-external base colouring). That colour card, like subsequent RLM cards, included only colours that could be seen either from outside the aircraft structure through cockpit glazing or an opening, which possibly accounts for inclusion of 41 and 42. Colour 41 was used for instrument panels only up to 1937 after which it was replaced by 66; 42 however remained permanently in use until 1945, for acid proofing around battery storage areas, probably being retained to identify the very specific purpose of that acid resistant lacquer.

Colour 11, by the nature of the group in which it had been placed, was by definition a 'base' (primer) colour, but for exactly what specific purpose is undetermined. RLM 02, which also came from this group, had been employed as a final external finish from the very early 1930s until 1936. That poses a conundrum - if 02 could be used for such a purpose, in spite of the more definitive nature of this group's categorisation, then for what purpose could a fairly similar, but darker colour be employed? It may have been used as the external finish on undercarriage oleos, as a visual indication of the protective finish applied to those parts. At the time of its introduction aircraft had fixed undercarriage components, shielded by metal fairings finished in the prevailing external colour. RLM 02 was used for colouring of the protective finish applied to oleos once retracting undercarriages became the norm (1937), so this may simply have been yet another instance of reducing the range of colours in use. By that stage, 02 colouring was the principal identifying colour for all other primer finishes.

What is also strange is that colour 11 should be placed out of numerical sequence, still within its specific group, but grouped directly with the two main colours used for exterior finish, 01 and 02, the only such anomaly to occur on any colour card issued. It was darker and greyer than 02, but still a distinguishable green-grey and recorded as 7009 (jägergrau - hunter grey) in the RAL 840 R listing. That odd grouping may reinforce the contention of its use on oleos. Whatever its purpose, it was obsolete by the time that the next issue of a colour card occurred.

Note that the only other colours shown on the card in this group were 01 (silver) and 04 (yellow). Silver was also used as an overall finish, and RLM 04 (RAL 1004) was still used for the large areas of wing painting employed as a safety feature on maritime aircraft; in both instances, as a final external colour. It is true though that 01 and 02 were also employed, in keeping with this group's basic definition of purpose, for interior painting, as was 04, though in a far more restrictive manner.

It is possible that the initial range of colour group codes had been far more restrictive between 1933 (or earlier?) and 1936. Looking at the early paramilitary aircraft the range of colours was restrictive, and no category of specific 'camouflage' colouring had existed prior to 1936; indeed, no colour chart is known to have been issued prior to that date, company identification systems, based on the common RAL system, had been sufficient for the very limited range of colours employed by the fledgling paramilitary force.

Referring back to the breakdown of categories listed earlier for the RLM blocks of numbers, it is interesting to note that between 00 and 19 only five numbers were ever listed on an official colour card, yet 05 had been in use on gliders for the NSFK and remained in use until 1945. This may reflect the technically 'non-military' status of gliders. L.Dv.521/2, which dealt with gliders in use by the Luftwaffe (see further on), did not contain a colour card, because with the exception of 05, it used only colours needed for national markings and the black registration codes, all of which were to be found on the standard L.Dv.521/1 colour card. The 3 February 1935 document had included reference to 07 saturnrot (Saturn red), a bright orange. Its purpose is unknown, but it appears also to have remained in use since a sample matching this colour description was found by the writer on the lower internal metal structure of the fuselage of the Me 163 B held by the Australian War Memorial. Of the 20 in the 20-39 block, only eight appeared on the colour card; colour 32, a bright yellow used for wood, was also excluded yet appeared in several painting references.

The 20 included in the block 40-59 are the most enigmatic though, as noted above, only the first six are known to have been allocated. The only full allocation taken up was the block 60-79, of which all 20 were used (while 60 did not go into production, it must have been approved for potential use as it had received its RLM number within the sequential allocation system). The last block, 80-100, has only five known allocations if the enigmatic green-blue colour is not included, though it would have had a reference number within this last group; four camouflage colours plus 99, which was not a specific colour indicator at all, as described in detail later and which accounts for its allocation out of sequence in early 1943, when camouflage colour numbers were still in the low 80s.

From the point of view of lacquer manufacture, this system worked extremely well during the following years, but despite a very extensive set of painting instructions issued to Luftwaffe personnel working in repair facilities, in the form of a document titled 'Der Flugzeug-Maler' - (The Aircraft Painter), sub-titled 'Lehrblätter für die Technische Ausbildung in der Luftwaffe' - (Training document for Technical Education in the Air Force), physical application of a lacquer could and did lead to *slight* colour variations. The earliest edition so far located is by Dr. Ing. Adolf Erlenbach, published by Dr. M. Matthiesen & Co., Berlin SW 68, in 1939. It incorporated the technical information included in the 1938 edition of 'Entwurf; einer Behandlungs-und Anwendungsvorschrift für Flugzeuglacke. Ausgabe:2', with further amendments. It also included the statement, in bold print, that regulations relating to carrying out of painting of aircraft set out in the L.Dv. documents took precedence over this civil version of the book.

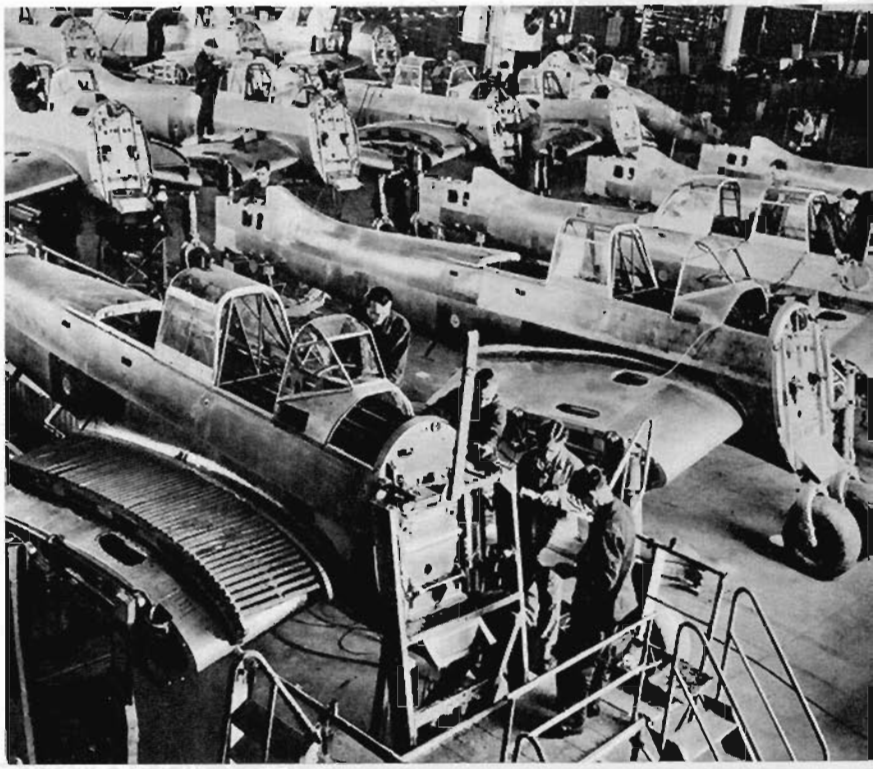
Despite the date of issue and amendments, it contained what appear to be some anachronisms. While lacquers 7142 and 7146 were listed for propeller blades the sequence went on to stipulate use of a base coat of 7142, followed by a coat of 7136.32 (a yellow undercoat used for wood), and 7146.22 for the final coat. Black however had been superseded by then, even for wooden propeller blades, and subsequent documents referred only to the sequence mentioned earlier, i.e., 71 as undercoat followed by 70. The descriptive narrative of this document also omitted any reference to metal propeller blades then in widespread use. There are several other such references in this document, 7107.41 for instrument panels was another anachronism as 7107.66, had already been rigorously promulgated for that purpose in the 1937 document. Instrument panels were mostly composed of wood veneer and continued to be so, the rare exception being pressed metal sub-panels, so the anomaly is not explained in terms of the material to be lacquered.

Rationalisation had occurred both to the range of Flieglackketten and to the Flieglacke. Four of the former, Nr. 04, Nr. 05, Nr. 22 and Nr. 33 had been withdrawn from use along with five of the Flieglack, one of the thinners, one spreader and three of the sealer pastes. Absence of Flieglackette Nr. 04 is enigmatic as it was, at the time, in the process of replacing Nr. 01, but the latter still appeared in the new listing. More easily explained was deletion of Flieglackette Nr. 05 and Nr. 22, both of which dealt with finishes for ship-borne aircraft; and Nr. 33 that dealt with external wooden airframe structures.

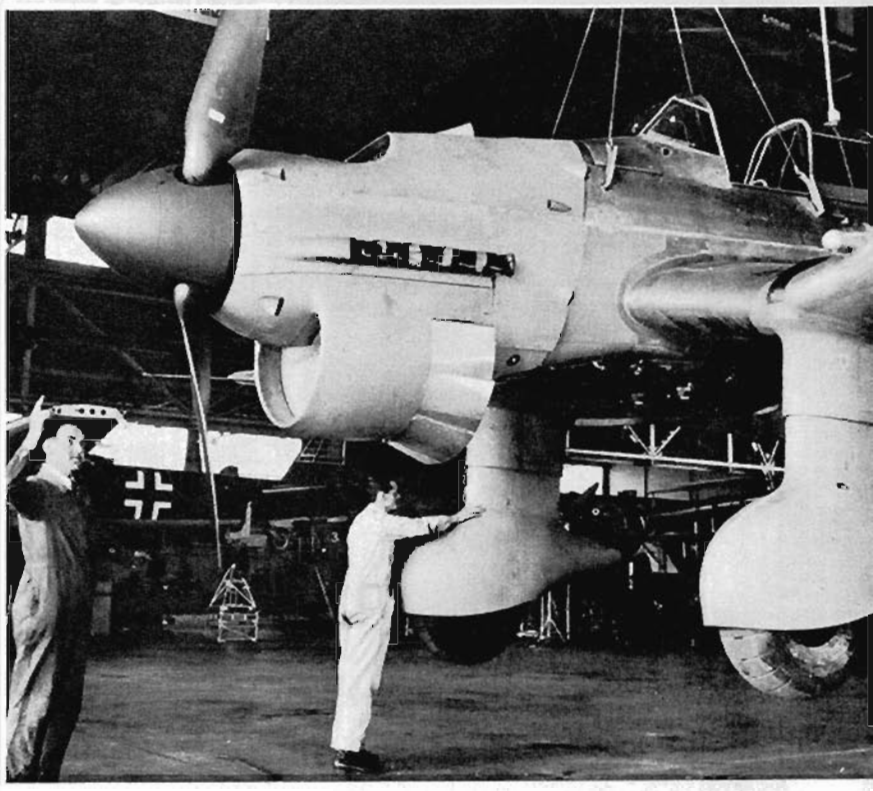
The new edition of the 'Der Flugzeug-Maler' (The Aircraft Painter) was much expanded, including photographs of the work materials and methods as well as examples of paint and sealer application faults, plus detailed analysis of all equipment to be used. A section was devoted to the application of civil markings and military codes plus the Reichs-und Nationalflagge (the red bar marking with its white disc and swastika emblem), and the plain military Hakenkreuz (swastika) and its proportions based on the Hoheitszeichen (National marking) that had been withdrawn in late 1938 following the Munich crisis. No diagrams had been included for the military Balkenkreuz markings or their precise positioning, nor was a colour card for lacquer colours included as had been done with the 1938 document.

However, a colour diagram laying out the colour combinations to be used to identify pipe runs internally was included, and a reference to this stipulated that colour matching did not have to be precise. Until the introduction of the designation 99 (explained later) this is the only such reference in any official documentation that otherwise continually stress absolute adherence to colour matching. This particular colour code system had been introduced in 1927 for all classes of aviation and incorporated into the German Standards under DIN 5 of April 1927. Colours, indicated by a circular patch of each one, were red (fire extinguisher systems), green (water), blue (air), yellow (fuel), brown (oil) and black (exhaust gas). All matched RAL standard colours. A second issue, dated March 1935, set out a revised system in full, this time with colour combinations and dimensions, again using written colour descriptions and circular patches of each colour, (see Appendix G, Volume Two). Precise colour matching however was not required as these were engineering makings, not camouflage or surface finish colours.

Even with this degree of control in place, some minor variations in use of specified colours, not the colours themselves, have been noted. Messerschmitt production facilities sometimes utilised a dark green paint to cover the area where the wing attached to the main airframe on Bf 109s and Bf 110s. That took the form of a shape contiguous with the root rib of the wing as well as the tail plane on Bf 110s. Why that was done in place of the more usual 02 is unknown, but all examples, - and there are several - date from very late in the war. The same green (which matched some internal radio equipment in Bf 109s) was also used as the cockpit colouring on some Bf 109 and Me 163 aircraft. No RLM identification number has been determined for this colour but most probably falls in the sequence 00 to 19.

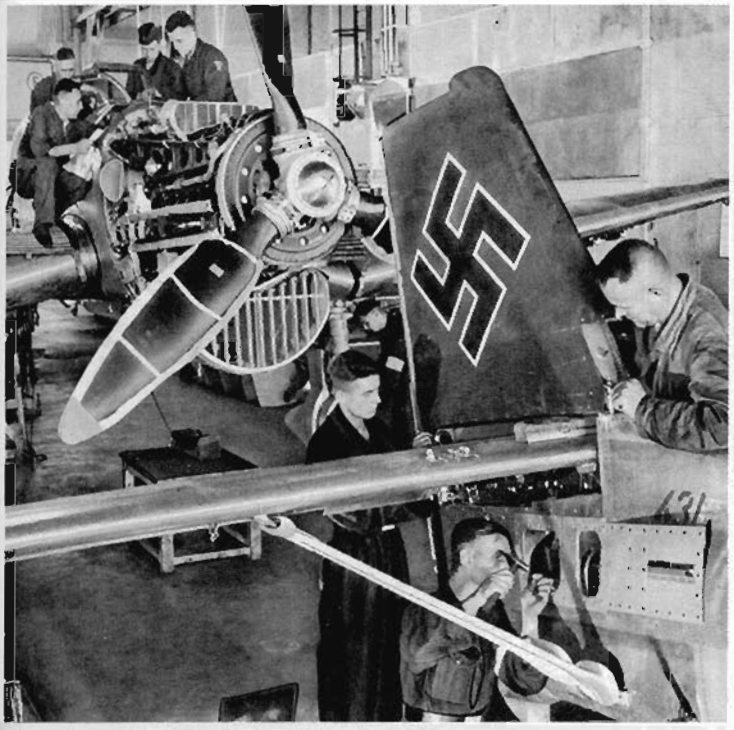


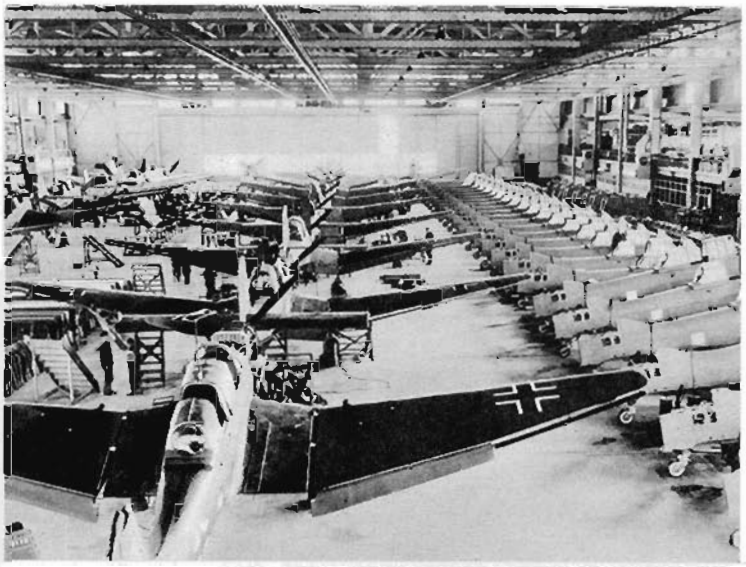
ABOVE: This sequence of production photographs, taken during the assembly and painting sequence of Ju 87 Bs, illustrates the variance in method between different manufacturers. The fuselage and sub-wing assemblies were left in their zinc chromate metal etch primer of translucent, green-tinged 7102.- lacquer, which allowed the various metal skin textures to still show, giving the appearance of plain bare metal.



ABOVE: The engine was then dropped into place and its cowlings fitted. The latter were a su contracted item, delivered to the main plant already primed in 02. The undercarriage spats were also delivered in the same finish.

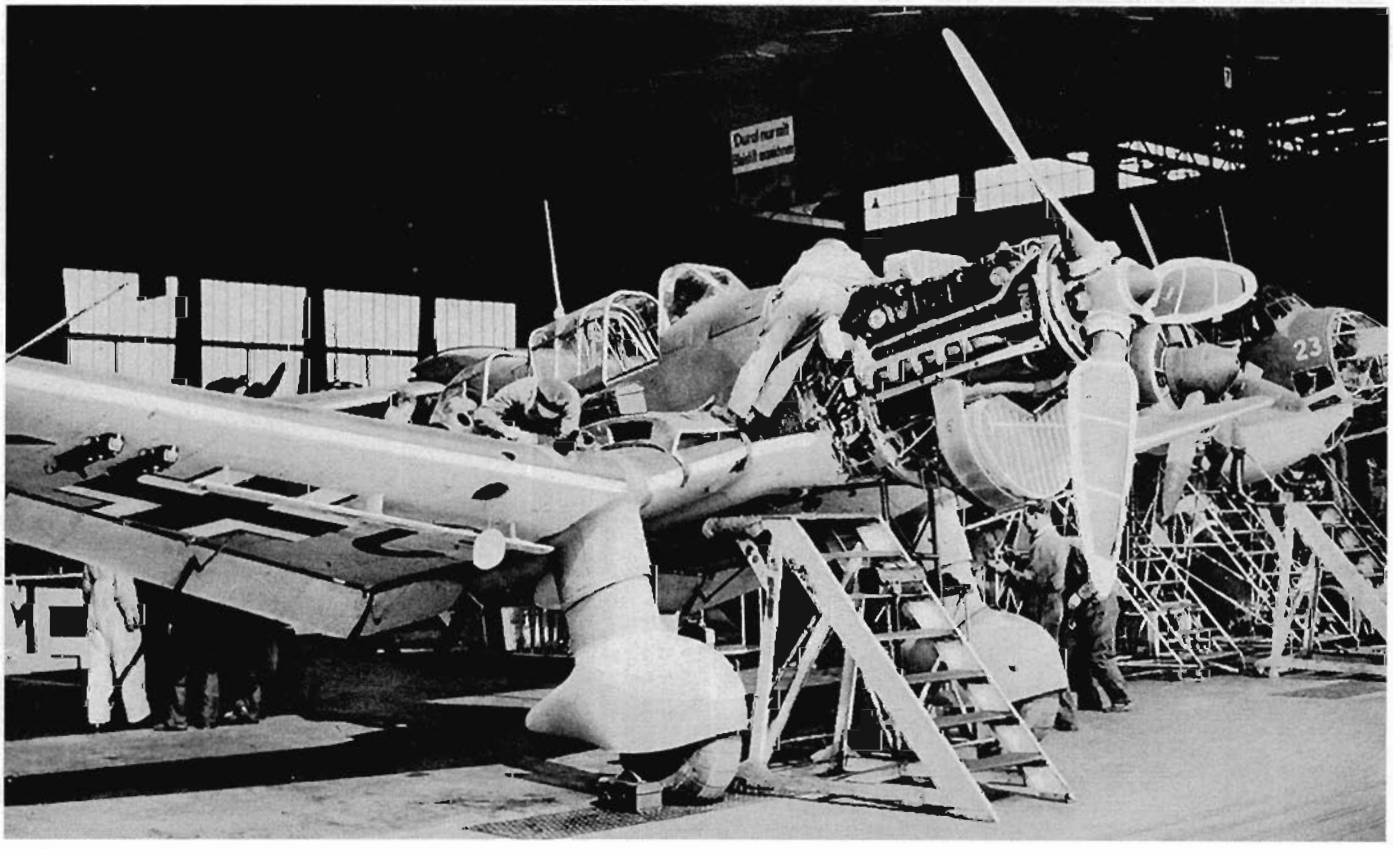
BELOW: Not all sub-contractor-built items were delivered just in 02 primer. The fin, horizontal tail plane and struts were the next items to be fitted and it will be seen that the fin had already been pre-painted in its full 70/71 camouflage pattern, while the tail plane and its struts were still in 7102. Note the '431' painted on fin fillet, either the Werknummer of the main airframe, or the sub-contractor's production number of the sub-component itself. The propeller on the aircraft behind is fitted with protective padding on the lower two blades. This was another item supplied fully finished, painted in 70.

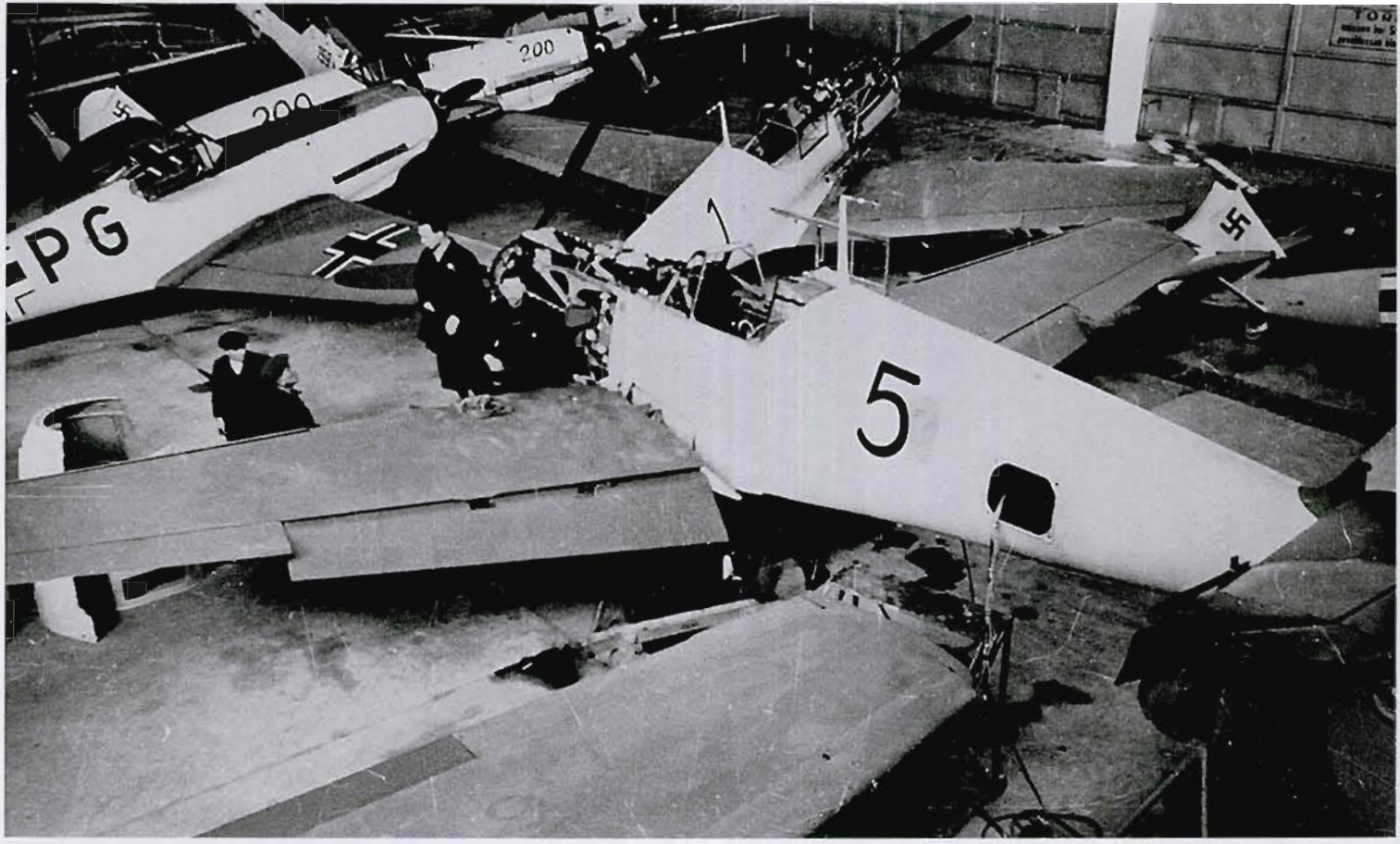




ABOVE: This view along the assembly line shows the outer wing panels (another sub-contracted item) in place on the aircraft in the centre line, while on the right fuselages finished in 65-overall await final assembly and painting.

BELOW: The finished aircraft was rolled out for a final check of engine and ancillary services. The protective padding on the lower two propeller blades remained in place until the aircraft was ready for transfer for its factory acceptance test flight. The first two letters of the Stammkennzeichen on the machine were XO, and the size and positioning of the underwing Balkenkreuz marking indicate that this was probably part of the 1939/40 production cycle.





ABOVE: Bf 109 E-4s undergoing final painting. The two in the foreground still have wings painted in 02 with the fuselage in overall 65. The sub-contracted tail units however have 71/02 camouflage. Behind is CA+PG, in full camouflage. The aircraft behind have '159', '200' and '300' roughly marked on each engine cowling, possibly the last three digits of their Werknummer. The black '1' and '5' markings on the aircraft in the foreground may have been flight test numbers.

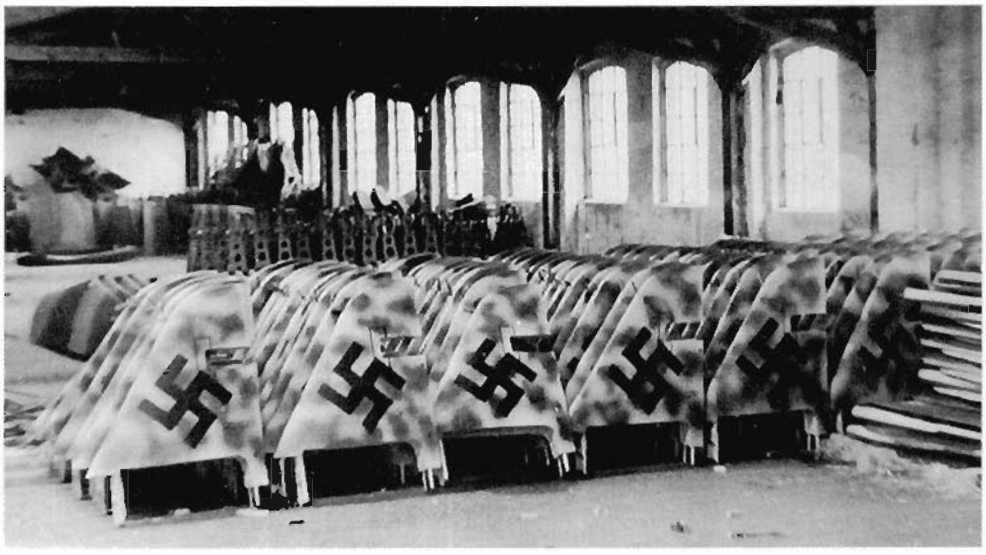
LEFT: Bf 109 airframes under construction, still in their 7102 zinc chromate metal primer finish. The 'E' and 'F' series of prefixed numbers marked on the airframes were production batch identification numbers that would eventually disappear beneath the final camouflage.

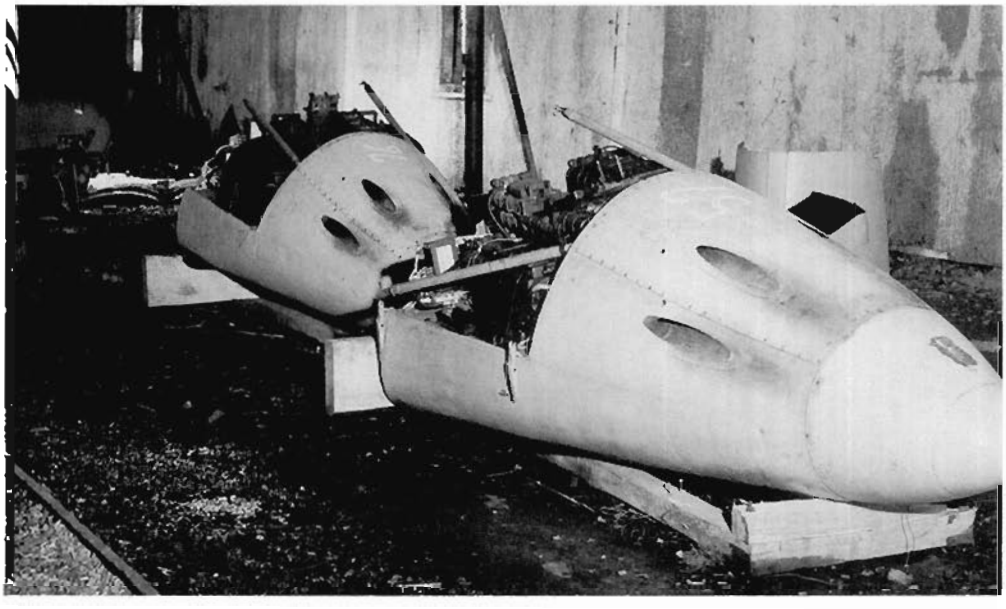
RIGHT: The remains of Bf 109 G-6 Trop, W.Nr. 18030, 'Black 6' found on 13 July 1943 by British troops at Comiso, Italy, wrecked after a take-off accident on 26 May 1943. Note that each main component of this aircraft had been marked in white with its Werknummer '18030' (rudder, horizontal tail plane and wings) during construction. No attempt had been made to paint over those when it had been issued to its front line unit. It wore standard 74/75/76 European camouflage with North Africa tactical colouring of white rudder, wing tips (and probably nose section), plus fuselage band. These additions had been made at the factory as the presence of the Werknummer marking on the rudder shows.

LEFT: Bf 109 G-6 production at Messerschmitt's Erla plant at Leipzig in the Autumn of 1943 shows fuselage structures painted in 76-overall with Balkenkreuz markings applied. Note the application by stencil of each airframe's Werknummer, in two places; the one across the Balkenkreuz required repainting of the black area of the marking later, but the other number would disappear beneath the upper surface camouflage greys of 74 and 75. The aft section, bolted to Frame 9, was a sub-contract component delivered in 02.

RIGHT: The chaotic conditions in the Me 262 parts storage facility at the Obertraubling plant were indicative of this industry as a whole. With the exception of the fuel tanks, the remaining items were all pre-painted in 76. Engine cowling parts, all undercoated in 02, are stacked on the left while to the right are leading edge slat units undercoated in 02. In the latter case this was required by the RLM as they were steel units and had to be given some anti-corrosion covering during storage and distribution though even that protection was eliminated in some instances. All were sub-contracted parts.

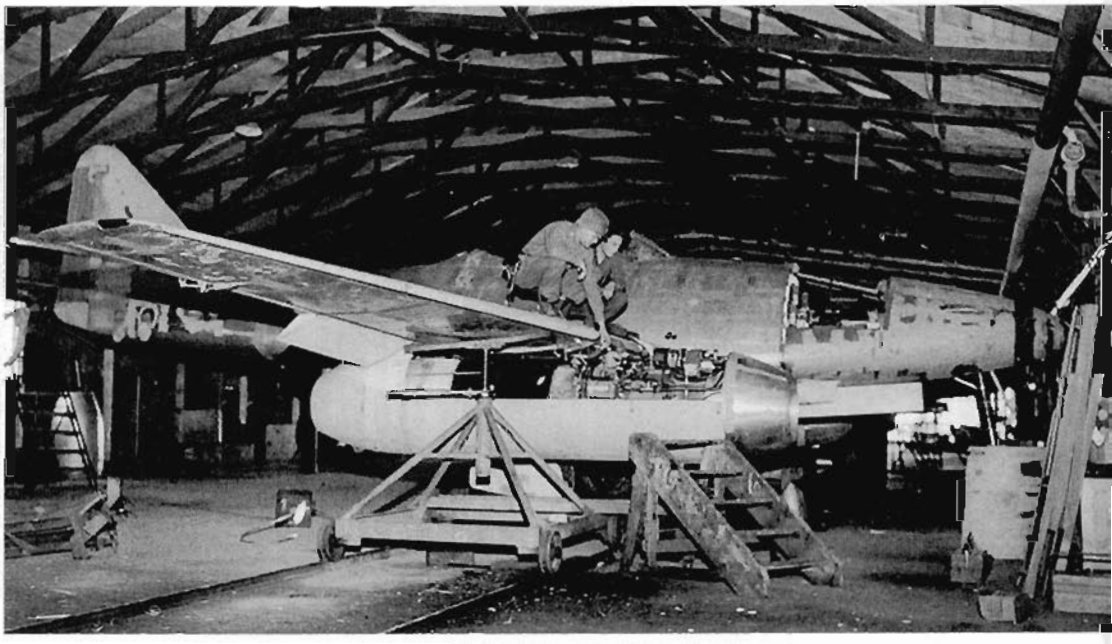
RIGHT: The use of several painters, preparing similar components and with no set pattern parameters, resulted in wide variation making each component's camouflage finish unique. These tail fins for late production Bf 109 G or K-4s, built by a sub-contractor, were found at a facility in February 1945 during the advance on the Second Belorussian Front. There are about 100, no two of which are identical. Behind is a stack of horizontal tail planes, the camouflage of which appears to be 81/82. At the rear, on the right are stacks of wings for a different type, while behind them is what appears to be an He 111 wing. (R. Michulec)





LEFT: Major sub-assemblies, such as these Me 262 nose sections at Messerschmitt's Obertraubling plant, were delivered finished in 02, prior to final assembly necessary in this instance for rust protection as they were clad in sheet steel, not duraluminium (powder stains show that the guns had been test fired). Sub-contractor construction numbers were painted in white on the top surface, the nearer nose section is marked '57', the rear one '76'. A plethora of such markings appeared during construction, most normally lost forever beneath the final camouflage. However, the extremely thin coats of lacquer being used in the last year of the war meant that some showed through under certain lighting conditions because no primer coat was used for most of the airframe.

RIGHT: In the final stages of assembly, this Me 262 airframe illustrates well the minimal undercoating lacquer finish by then common across the entire aircraft industry. The nose section of the fuselage, the undercarriage doors (wooden), the upper section of the fin, the control surfaces, and all but the forward part of the engine cowlings are in 02, the only parts to receive any primer coat. The extensive use of Spachtel (filler) paste to smooth out the joints is clearly visible. This filler was originally silver in colour, but shortages of aluminium bronze (aluminium powder for colouring) had reduced the paste to a pale grey by this stage of the war. The rest of the airframe was left bare metal for the application of the thin coat of each colour of the camouflage paint.



Repair and recycling

The extensive network of civilian repair facilities established pre-war had been expanded over the war period, which served the Luftwaffe well. Salvage and recycling of parts had also reached a high degree of efficiency during that time and a set of special markings had been introduced that identified the multitude of parts put back into service. Rebuilding of aircraft to a revised standard was also part of this system, and engines were also partly or completely overhauled.

A coloured equilateral triangle, 15 mm on each side, was used to identify recycled components large and small. It was marked on each component, along with a three-letter code in red that identified the repair facility, (this coded security system had been introduced by the Heerswaffenamt - [Army Ordnance Department], in 1940). A red triangle identified airframe components, large and small, cleared for re-use. A yellow triangle was applied externally to the completed airframe along with date of completion of the rebuild.

Engines were similarly marked. A yellow equilateral triangle, 15 mm on each side, marked on the port side of the crankcase of in-line engines and on the reduction gear housing or front crankcase cover of radial engines, indicated a part overhaul. The engine Werknummer was marked in 40 mm high numerals immediately above the triangle. Each successive overhaul was marked with another yellow triangle. After a complete rebuild, the yellow triangles were painted out and a single red triangle of the same dimensions replaced them. Succeeding overhauls were marked by the addition of yellow triangles until such time as another complete rebuilding occurred and the process repeated with a second red triangle added.

This system had been modified following a number of complaints from the Luftwaffe that overhauls had not been carried out satisfactorily, and there was no way of tracing which factory or facility had carried out the overhaul. An instruction originating in Berlin, dated 28 May 1942, stated that from then on, engines were to be marked with a 15 mm equilateral yellow triangle for a complete overhaul and a red triangle for detailed (part) overhauls. The triangles were to be displayed one below the other, not next to each other as before. Next to each triangle was to appear a code symbol identifying the overhaul facility, plus the date of the overhaul; such markings were to be applied in 3 mm high white lettering, (a British Intelligence assessment comment on a copy of this report suggested that the white markings were possibly similar to the factory security codes found on the manufacturing plates of German aircraft; however, the latter were composed of two or three letters, but the only reference to the engine markings noted that they were composed of four letters, so their manner of identification remains unresolved).

This change in marking colour meanings had been adopted across the recycle/rebuilding system. The Bf 109 G, W.Nr. 163824 held by the Australian War Memorial had been marked on the fuselage with a yellow triangle and date on completion of its re-build; individual components used in the process had red triangles, with earlier dates, marked on them. This parallels the changes to the engine overhaul marking system.

As the war situation worsened recycling and rebuilding produced some hybrid schemes as parts were matched for technical necessity rather than empathy of camouflage. The Australian War Memorial (AWM) Bf 109 G referred to above is still in its original finish and provides a unique record of this system of rebuilding and the mismatching of camouflage colouring in some instances, (see Chapter 6).

ABOVE: One of the problems facing the aircraft manufacturing industry, and especially the sub-contractors and repair facilities, were slipping standards with both the preparation and application of lacquer. This close-up of the under side of part of the wing structure of Bf 109 G, W.Nr. 163824, shows the crazed effect produce by using too much thinning agent for spray painting, (the silver colour is modern paint that had been sprayed over a plasticised film to disguise the original finish when an attempt had been made to ship the aircraft out of the country.) Note the sample of quite dark, late war 02 on the circular panel. Compare this with the green-blue colour of the affected paint section.

LEFT: The inside face of the starboard fin off Major Wolfgang Schnaufer's Bf 110 G of NJG 4 exhibits its colouring of 76 with thinned out 02 sprayed as a fine streaked mottle in places. The dark green underpainting where the fin and horizontal tail plane meet can be clearly seen. This unidentified non-camouflage colour was sometimes also used for wing root areas by Messerschmitt. It also has been found on some Bf 109s and matches the colouring on some internal equipment. (AWM)

1. Bokelman research and correspondence.
2. Ullmann research.
3. Bokelman research.
4. Bokelman research.
5. Bokelman research.

Official Camouflage Patterns

3

Introduction of a ground defensive camouflage system can be traced back to 1936 when a multiple-colour system for the new range of Luftwaffe front line aircraft had been introduced, though development had commenced the previous year. The Ju 86 A-0 appeared in spring of that year wearing camouflage composed of a straight-edged, segmented pattern incorporating three upper surface colours, with a fourth colour for the lower surfaces. Upper surface colours were dark brown 61, green 62 and the existing green-grey 63; lower surfaces were light blue 65.

ABOVE: The Ju 86 was the first of the Luftwaffe's aircraft to wear the new three-colour camouflage. This machine, 33G+24 of 4./KG 253, was painted in the Sichtschutzschema A1 pattern with a slight modification to the pattern on the port wing tip. The 61-colouring had been taken straight forward to the leading edge of the wing, instead of angling back towards the fuselage; possibly because the area was so small, its application had been simplified. A check with the Do 17 grid patterns in this chapter will show how the more aft placement of the Ju 86 wing brought an entirely different section of the standard pattern layout into play.

Why camouflage had been introduced at that point relates to the political moves within the German Government and the military High Command. Until that time, the neutral green-grey 63-colouring for all classes of aircraft had sufficed because the situation in Germany had not generated concern from its powerful neighbours; the country was being reorganised industrially but initial attempts to form a loose consortium of aircraft and engine manufacturers with the Government had failed. However, things had become a little more uncertain with public proclamation of the Luftwaffe in March 1935, which effectively tore up the Versailles Treaty and its constraints. From that point on Germany knew that its expansionist moves would draw increasingly unwelcome attention from its European neighbours. Eleven months later, camouflage had appeared on Luftwaffe land based bombers. Given the rigid testing regime for both lacquers and pigment, the process of development of the pattern must have started in 1935. Equally, while the lacquer stock used had not required any alteration, choice and testing (for colour effectiveness) of pigments and their formulation would have required some considerable time. It could be speculated then that the concept of a defensive camouflage had begun its development cycle somewhere in the first half of 1935, probably coincidental with the shift in political dynamics after public revelation of the Luftwaffe in March of that year. The aim of the new government was towards re-arming Germany at any consequence, and a reaction from the Allied Powers was a distinct reality. The existing lacquers had their colouring component altered to produce the three new colours, but development of the camouflage pattern had had to be done from scratch.

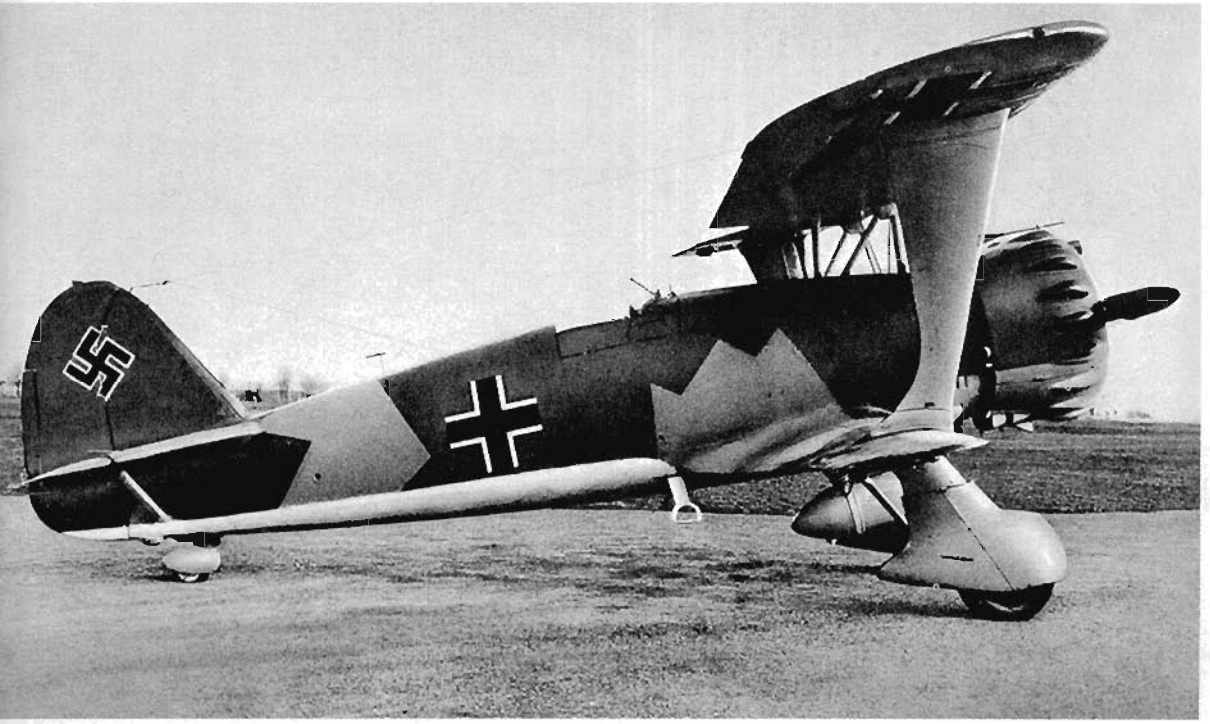
German reoccupation of the Rhineland followed in March 1936 and Germany had waited to see if the anticipated reaction from the Western powers would bring conflict. The surprising lack of reaction had simply accelerated the rate of re-armament, voices that had cautioned a steady, slower, less provocative growth rate being swept aside. International events had also aided the pro- acceleration faction; Italy had conquered Ethiopia, in Spain civil war had broken out and Japan had signalled its expansionist policy by invading Manchuria. War was now on the horizon and Germany moved as swiftly as its dependence on imported raw materials, foreign currency limitations and slowly reorganizing industrial capacity would allow.

Design of camouflage patterns and their associated colour schemes had been extensively investigated, as also had been design of a system to ensure those complex patterns were correctly applied. Using a constant grid of equal-size squares had been the basic starting point on paper for each aircraft type. Only one standard camouflage pattern was employed, but by using a mirror reversal option, plus a rotation of two of the three upper surface colours in a set order, the system had been made very flexible, producing options of four different camouflage schemes.

The aircraft plan view drawing was projected onto the grid, such that the rearmost edge of the horizontal surface (not the tip of the fuselage) touched the baseline of the grid. For the side areas of fuselage and engine cowlings the diagram was 'wrapped around' to cover them, the basic plan allowing sufficient lateral overlap to cover those areas. The aircraft's plan form was then painted in the three colours wherever it was overlapped by sections of the diagram. Demarcation between camouflage colours on the aircraft sides and the lower surface colour of 65 was determined by projecting an angle of 35 degrees above the horizontal starting from the longitudinal mid-point on the bottom line of the fuselage. Where that projected line intersected the curve of the fuselage determined the lowest extent of the upper surface camouflage. Depending on the cross-sectional profile of the fuselage, the maximum vertical extent of the lower surface colouring permitted was 10 cm from the lowest point seen in profile. Colour demarcation along the leading edge of wing and tail plane was on the datum line between upper and lower surfaces.

In addition to the four options mentioned, the different plan form of each aircraft type, particularly with reference to the shape of the wing plan form and its positioning relative to the fuselage length, produced seemingly different camouflage patterns at times. This three-colour splinter scheme was applied only to bomber, dive-bomber and reconnaissance aircraft. As an aside to this range of Luftwaffe colours, the camouflage colours used for some export aircraft have been subject of much speculation in previous writings, to the point where they had

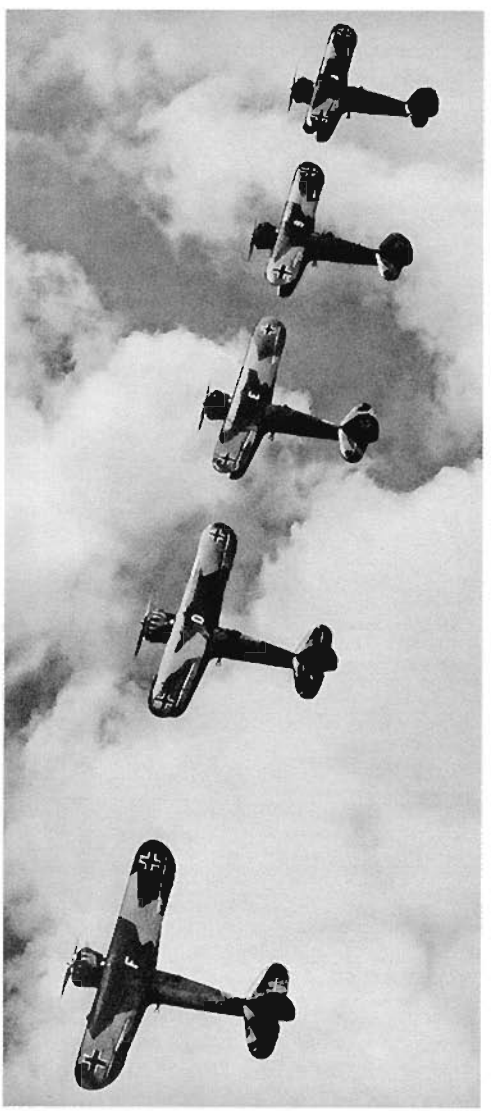
ABOVE, RIGHT AND BELOW: The twelfth production Ju 87 A, D-IEAU, and an early production B model, (ABOVE) D-IELX, demonstrate the apparent difference in camouflage pattern produced simply by transposition of colours. D-IELX had pattern A1, while D-IEAU had pattern B1; both patterns could also be mirror reversed, providing four alternatives in all.

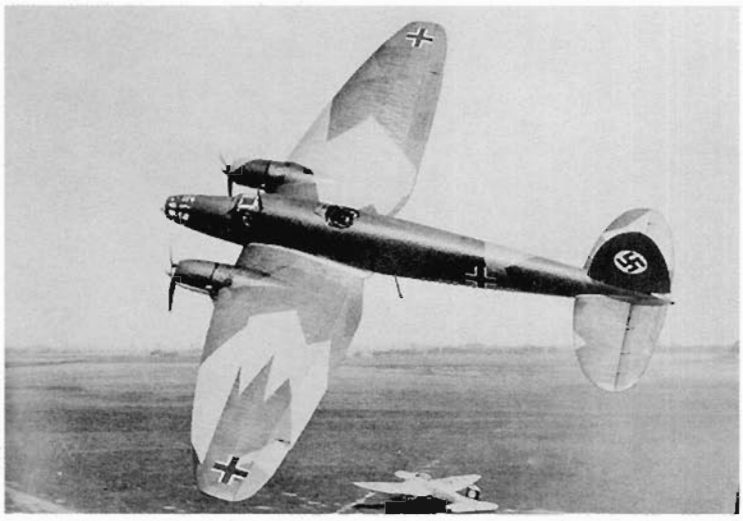


BELOW: The dramatic difference that could be created simply by changing colour sequence of the pattern is illustrated here with this formation of Hs 123s of 3./St.G. 165. The second aircraft from the bottom of the photograph had pattern B1 colouring, the remainder were all camouflaged in pattern A1.

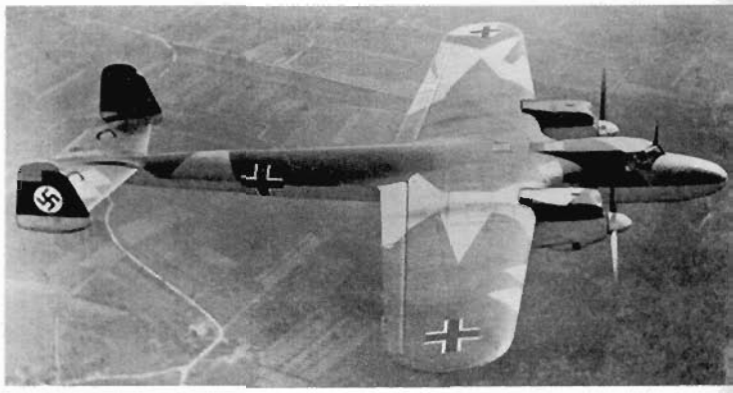
ABOVE: The Hs 123 was another of the new breed of aircraft to wear the three-colour splinter pattern. This brand new production example was finished in the A1 pattern. The absence of the red band and white disc behind the Hakenkreuz, (which however remains in its former central location) indicates that this aircraft was produced around December 1938, at which time the background markings were declared obsolete. If so, then the retention of the old 61/62/63 upper surface camouflage continued later than indicated by the shift to 70/71 on the larger production run aircraft of the period. This may simply have been a case of using up current stocks of the colours, the relatively small production run of Hs 123s not requiring the huge stock holdings of paints that were required at works like Junkers or Messerschmitt.

ABOVE: Another from the Henschel stable was the Hs 126 reconnaissance aircraft. D-ODBT was one of a batch of ten Hs 126 A-0 aircraft completed in 1937 before adoption of the 70/71/65 scheme for the main production run of this type. (D. Wadman)





LEFT AND BELOW: The illusion of a different camouflage scheme is illustrated by these two aircraft, a He 111 B and the Do 17 V10. Both wore the A pattern, illustrating the radical difference in appearance produced by wing position and shape relative to the fuselage length.



LEFT: This hangar scene of Do 17 Ps of 1. and 3.(F)/Aufkl.Gr. 123 provides good examples of the pattern changes possible with the 61/62/63/65 scheme, several variants being visible. The late date of retention of this form of camouflage is unusual, the four-letter code system having been introduced on 24 October 1939, while the 61/62/63/65 camouflage pattern had been superseded in 1938. None of the aircraft shows any sign of repainting where an original five-character military code would have been marked on them. Why this should have occurred is unexplained, but they may have been aircraft brought out of reserve stocks for use in the opening stage of the war. In which case, repainting of the camouflage would not have been carried out until their first major overhaul, some 1,500 flying hours or two years service hence.

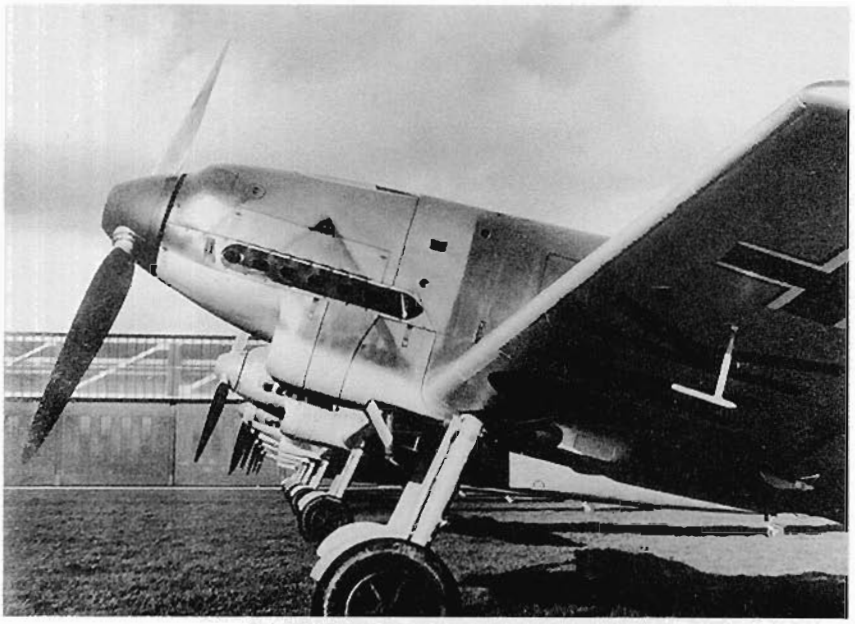
been identified, incorrectly, as 64, 67, 68 and 69. Those four numbered colours have been positively identified, and none were used as export colours,[1] only the style of camouflage pattern was varied from that used by the Luftwaffe.

In 1937, along with the introduction of the new generation of all-metal monoplane fighters, came a significant revision to camouflage. The existing three-tone upper surface colour system was supplemented with a two- tone colour scheme of 70 schwarzgrün and 71 dunkelgrün, which were a good tonal match for the dark pine forests and open grasslands of Germany and central Europe. Only the undersurface colour of 65 hellblau, for the lower surfaces, was retained from the existing camouflage scheme. Given that development of the existing three-colour upper surface camouflage scheme introduced eleven months earlier had taken much time and careful testing, and would continue in use until 1938 on bomber and reconnaissance aircraft, why then had a second one swiftly appeared that was so different?

The answer lies in the fact that German reoccupation of the Rhineland had been planned well in advance - and the possible reaction to the move had been calculated in military terms. For that reason a new form of camouflage had been introduced. The existing three-tone splinter pattern was a general-purpose disruptive pattern of light and dark that had some value as an airborne camouflage. The new two-tone splinter pattern of greens however were closely matched, producing a distinctly ground defensive pattern with little air-to-air value. 1937 was also the year in which German war planning shifted irrevocably from development of a strategic bomber force to one more suitable to support a Blitzkrieg philosophy; the need was for a fast-moving, highly mobile air force, one able to operate effectively far from the conventional home airfields of peacetime Germany and in direct support of the ground forces. The airfields of such future battles would be more likely found in the countryside where the two new dark greens would be of better use.

There was also an element of materials conservation and production time behind adoption of the new camouflage, the two-tone scheme taking less time to set out and apply; and while the quantities of paint remained the same, need for two pigmentation colours rather than three had provided savings in chemicals and labour. The growing nemesis of raw materials shortages was already becoming obvious to the planners, foreign currency shortfall pushing German industry towards development of synthetics, something it did extremely well in due course. Rationalisation of the entire aircraft industry had also been under way to attempt to turn it into a smooth running, highly efficient 'united body' under the guidance of the RLM. The general change to a two-colour camouflage was also extended to

ABOVE: The introduction of the all-metal Bf 109 B-1 fighter into Luftwaffe service also heralded a major change in camouflage colouring and style. This line-up of very early production aircraft illustrates the conformity of the new design pattern in 70/71/65. The same general pattern was soon to be extended to the other categories of Luftwaffe front line service types. The second and third machines have their Werknummern, hand-painted in 02, marked in the upper left angle formed by the fuselage Balkenkreuz; the first is '1046', the second '1029'. At least one other machine in the line also carries its identity in this form.



ABOVE: Reputed to be the last Bf 109 Bs manufactured by BFW in November 1937, before the company name changed to Messerschmitt A.G., this line-up of seven aircraft provides some interesting detail. The nearest aircraft, (reputedly W.Nr. 1719 marked with Überführungskennzeichen BF+AK), illustrates the higher contrast sometimes seen on aircraft freshly painted in 70 and 71 and then treated with the DKH weather protection wax-like finish. The triangular segment of 70 shows how, after marking out, the edge of each segment was first sprayed in with a relatively broad line of the relevant colour, and then back filled. In this instance, the latter had not been as heavily applied as the edging strokes. The gun troughs were left in what appears to be 02, the tone being slightly darker than the 65 that would sometimes be used for this purpose on future production aircraft. The 65-colouring of the under surfaces also had been used for the undercarriage oleos, but eventually that would be changed to 02 on later production aircraft. The second aircraft in line, also a B-2 model, was still in its base coat of 65-overall, awaiting the 70 and 71 finish, but the B-1 next in line already had been camouflaged. (S. Santos)

marine aircraft that until 1938 retained 63 overall colouring. The new maritime colours were a second set of two closely matched greens (slightly darker in tone than the 70 and 71) and allocated the RLM numbers 72 and 73. Each had been given no distinguishing written description on the official colour card other than grün (green); again 65 had been retained for the lower surfaces.

With the shift of all aircraft types to the new colours, the system of laying out the patterns to be used had also undergone revision. The grid of equal-sized squares had been replaced by rectangles that were unique to each aircraft type by virtue of the fact that the dimensions of the rectangles resulted from dividing the length and breadth of major components into set numbers of divisions. The new camouflage scheme was a pattern of angles that created a standard two-tone pattern. The plan and side view elevations of each aircraft type were divided into a grid of rectangles, the longest side in each instance running parallel to the lateral datum line on the wings and the longitudinal datum line on the fuselage. At first sight the patterns appear to be identical from type to type, but subtle variations resulted from the slightly different ratio of length to breadth of each set of rectangles established for each aircraft type.

LEFT: This close-up photograph of the nose section of a Bf 109 B-1 shows how the camouflage colours were sprayed with a soft edge where they met the 65-colouring. The 65-colouring of the wing was also taken up the curve of the wing leading edge, something that was soon abandoned but then re-introduced with the 1940 wing pattern revisions for day fighters. The pale grey colouring of the hub section of the Heine fixed-pitch wooden propeller, and its red-edged white manufacturer's marking, can be seen.

The basic system used to establish the dimensions of the rectangles involved a simple set of standard parameters. To establish the size of the longest edge of the rectangular pattern for the entire wing plan form, (which incorporated the fuselage area between the wings), the wing was divided into 20 equal segments from wingtip to wingtip. It was then divided into five equal sections from leading to trailing edge, using the maximum chord dimension. Allowance had to be made where wing plan form shape exceeded certain parameters, or was of unusual shape, for example the He 111 had root chord fairings longer than normal and to have used a division of five based on that odd shape would have significantly distorted the overall pattern; instead a division of six had been used, but spaced evenly about the mid-line. Horizontal tail surfaces were treated in the same manner except that the tip-to-tip division was only ten, with five sections from front to back. Additional squares that appear to have no function are sometimes shown on diagrams. These were used for setting pattern angles where the limits of the normal grid pattern were too limited to determine the angles. Examination of the He 111 diagram at the end of this chapter shows that the additional squares provide grid intersection projection points for some of the angled lines contained within the five-by-five grid pattern.

The plan view of the fuselage was divided longitudinally into ten segments from nose to the line where the leading point of the tail unit met the fuselage; from side to side it was split into five segments, the overlapping rectangles of the wing grid being disregarded. On the side elevation, the fuselage had been divided into five sections from top to bottom and used the existing ten longitudinal divisions. The vertical tail surfaces were treated as a single unit, which was divided into five equal segments vertically and five horizontally, unless the horizontal length of the surfaces was excessive. In that instance, to stop distortion of the basic pattern, the horizontal division was increased, as on the He 111 where six divisions were required because of its unusually broad outline. Division of the vertical tail surfaces was deleted from camouflage drawings for single and twin-engine fighters in 1941, following the change to camouflage for those types.

Variation in length-to-span ratio of the various aircraft types in turn varied the size of the rectangles, producing some slight compression or expansion of the basic common pattern used for both land and seaborne aircraft. Inevitably, there were exceptions, such as the He 111, the unusual shape of which required some special adjustments, in addition to those mentioned above. Its short nose section, almost in line with the tips of the spinners, required a dummy section to be added to the diagram to keep the proportion of length to breadth of the rectangles within reasonable parameters. The extended wing plan of the Ju 188 produced distortions of the original Ju 88 pattern and so on. The diagrams at the end of this chapter, illustrate some of the subtle variations.

The upper and lower side surface colour demarcation line remained as before, set by projecting a line at 35 degrees to the horizontal, commencing at the lowest central point of the fuselage cross-section. Colour demarcation between upper and lower surfaces of wing and tail plane at the leading edge also remained set on the datum line (though that would change for all classes of fighter aircraft in 1940). The pattern remained reversible - left and right mirror imaging - as established with the original grid system. The grid pattern was not always shown on factory preparation drawings, often only the camouflage pattern, with dimensional markings from specific, clearly defined structural points appearing. For some patterns, where a grid point was close to a clearly defined structural joint, the latter was used for ease of laying out the pattern for spray painting. There were also some minor variations between different factories producing the same aircraft type, most notably the Bf 109. Such variations were just that - only minor and inside the dimensional tolerances set by the RLM. As a result of the revisions, the painting schedules for each type were issued in far more abbreviated form (see Appendix C).

Camouflage diagrams were prepared for each type and approved by the Erprobungsstelle Travemünde. Specialist firms then produced the diagrams that were then issued to the relevant aircraft manufacturer under the Luftdienst (Air Service) series of documents, for example, L.Dv. 380, issued on 17 March 1937, was the camouflage pattern diagram for the He 111 B series. L.Dv 383, issued on 19 September 1938, was the camouflage diagram for the Hs 123. In both instances this was the three colour upper surface camouflage and the additional

BELOW: A Do 17 Z-1 wearing the regulation standard factory finish 70/71/65 scheme of 1938. The main stencil markings on the wings were in yellow. Application of the pattern conforms completely to the RLM standard.

ABOVE: This advertising poster for the Fw 191 A bomber, based on Focke-Wulf's advertising scale model of the aircraft, illustrates the standard camouflage pattern in 70/71/65 that had superseded the old three-colour upper surface scheme by 1938.

designation A or B simply identified standard or mirror pattern. The colour order of each pattern also had two forms, providing four variations overall, though the latter variation was rarely seen, probably for ease of manufacture once industry commenced a war footing. The numbering system used was part of the general RLM series issue and applied to a wide range of aeronautical subjects, for example, L.Dv. 366 was titled 'Flugrichtlinien für Sturzflüge' - (Flight criteria for diving flight). That broad system of subject identification was replaced in 1940 by a D.(Luft) T 2000 series that was specific to aircraft camouflage. The last three digits identified the aircraft by its RLM type designation, e.g., D.(Luft) T2018 was the camouflage diagram for the Do 18; D.(Luft) T2129, the diagram for the Hs 129, etc. By the time that that revised system had been put in place, aircraft were using two-tone upper surface camouflage, that with rare exception, by 1939 had replaced completely the three-colour system.

The onset of the Spanish Civil War in 1936 had provided opportunity for Germany to test its aircraft under war conditions. Existing types, and initial supplies of newer designs like the He 111, had been sent to Spain in their existing green-grey 63 overall colouring, but the majority of new bomber types had arrived wearing the three-colour upper surface splinter pattern. Supplies of the four colours, 61, 62, 63 and 65, had accompanied them for maintenance of their camouflage. In time, those supplies of colours had also been used for other purposes.

The new range of paints introduced for metal structured aircraft had produced a saving in materials requiring fewer coats of lacquer than the old fabric painting sequences, which included tightening lacquer applications to shrink the linen. The latter had required three coats of red-coloured primer, two coats of 63 containing a stabilising compound followed by a further coat of 63 and a final coat made from five parts lacquer 63, two parts of a colourless lacquer and three parts stabilising compound. By comparison the new all metal structure aircraft required washing to degrease the surface, followed by a sprayed base coat of 7102.- (diluted 10:1 with thinner 7200.00), sealer paste 7240.- applied to all external seams and joints, followed by a second coat of 7102.-, diluted as before. Inside surfaces were sprayed with undiluted 7105.02, while the exterior surfaces were sprayed with 7106.- (diluted 4:3 with thinner 7200.00). The exterior then received a sprayed coat of 7107.02 (thinned 2:1 with 7200.00).

As with the fabric finish process, the metal process took 16 hours of drying time and on first examination, there seems to be little advantage between the two forms of application. However, there had been both a labour time and weight saving with the new range of paints.

As stated earlier, all patterns were established not by individual aircraft manufacturing firms, but by the Erprobungsstelle Travemünde, part of the RLM control standards system. Documents issued to manufacturers when maritime colours 72 and 73 had been introduced, concomitant with 70 and 71, provide clear information as to how the new patterns were to be set up and applied. The following document relates to the Arado Ar 196.

*"**Camouflage Paint***

Ar 196 A and B receive a 2 colour camouflage in the shades 72 and 73 from above and 65 from below.

As covering, lacquer Flieglack 7115.- has to be used in the above mentioned colour shades on metal and also on fabric.

The application of the segment scheme has to follow the camouflage drawing for seaplanes that was published by the Erprobungsstelle Travemünde. The correspondence of the RLM of 24. 5. 39 LC 2 Nr. 2890/39 (VI) geh. Az 70 k has to be consulted.

The application of the segmented scheme on the aircraft can be done by sketching or by cover stencils or by measuring chord. The defined corner points are combined with a thin chalk line in a practical manner. Applying the colours should be undertaken in a practical manner field by field [area] *by spraying the appropriate colour along the chalk lines or other applied markings. After a sufficient drying time, the free fields* [open segments] *are filled and at the same time the outlines are produced according to the segment scheme as accurately as possible. Small divergences (up to 5 cm) are admissible. The camouflage colour shades need not contrast sharply with each other, but can blend into each other to a width of 5 cm. The lines of separation between the colour shades 72 and 73 (top side) and colour shade 65 (lower side) are to be positioned in a manner, that from above - vertical or oblique (less 35 degrees to the horizontal line) - no light blue area is visible. Bearing surfaces of the undercarriage and tail wheel are left unpainted. If the components are painted separately the junction between areas have to be assimilated with each other after assembly if necessary."*

While the style of this instruction is somewhat laboured, the information is very clear. The second page concerned a high visibility coat of paint in yellow 04, showing, that although camouflage had now been introduced, the prevailing use of an 04-coloured panel, for visual safety in case of a forced-landing at sea, was still incorporated, though that eventually disappeared from the painting requirement. The remaining element of the instruction referred to sealing of other parts, but is retained to give a general sense of how much these painting instructions covered.[2]

*"**High Visibility Coat of Paint***

The application of the high visibility coat of paint with the colour 04 will follow from a drawing provided by the proving authority Travemünde and correspondence from the RLM dated 24.5.39 LC 2 Nr. 2890/39 (VI) geh. Az 70 k.

Application to be as follows

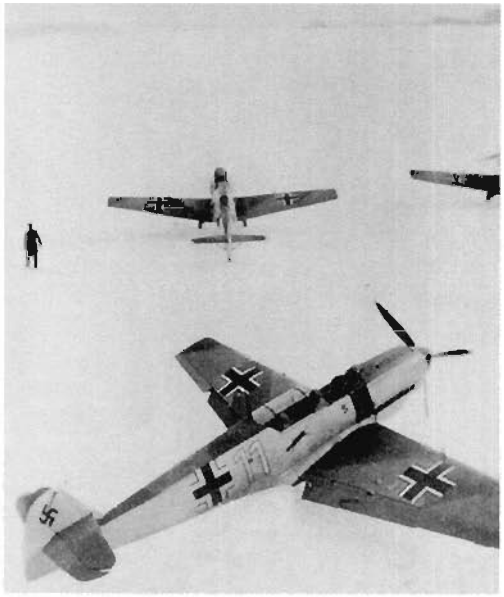
***Fabric (fuselage)**: aircraft lacquer 7115.04*

***Float**: aircraft lacquer 7108.04*

Clamp at the tube framework
The space which is left free between the fuselage tube and the clamp has to be closed with flight packing [paste] *Nr. 7250, consisting of 30 parts stearin, 20 parts beeswax and 50 parts paraffin which have to be melted together in a water bath.*

***The positions, where water can infiltrate** the fuselage, the stabilizer, the vertical fin and the wings have to be sealed with flight packing Nr. 7240.*

The tank space in the float has to be protected with Shell corrosion protection grease (experimental grease Nr. 40) which should be plasticized by warming-up to 50°C in a water bath. The ball-bearings of the control surfaces have to be greased according to the written instruction at installation and then covered with Shell-rocker-arm-grease which is made plastic in a ratio 3:1 with washing benzine. On all tail unit parts (vertical fin and rudder, stabilizer and elevator, ailerons and flaps) in the [sea] *spray range, the Hydronalium has to be treated like Duralplat concerning interior conservation."*



RIGHT: The standard Type 5 pattern is illustrated here by these two Bf 109 Es of 1./JG 26 photographed in the winter of 1939/40. The raised demarcation line of the upper surface camouflage dates the photograph to December 1939 or very early 1940. The Hakenkreuz marking remains in the pre-January 1939 position.

The accompanying diagrams were not located with the document, so the specific areas that were to be marked in 04 cannot be identified beyond the brief references given.

Flight packing paste 7250, one of a range of specific sealers, was a waterproofing compound developed to counter the corrosive effects encountered by seaborne aircraft. The ingredients were relatively basic; stearin was a chemical binder (stearic acid) produced by steaming suet and tallow, a fundamental part of the candle making process. The references to Hydronalium and Duralplat were identification of specific types of aluminium used in the aviation industry.

While camouflage patterns for bombers retained a high degree of consistency throughout the war years, those used for fighter aircraft would change not only the pattern used, but also the colours. The initial pattern (Type 1) of the first production Bf 109 B-1 aircraft was soon modified, the starboard wing having one segment increased in size by a change in angle. This changed pattern (Type 2) was employed from 1937 to 1939 without further alteration, being used by the succeeding C, D and early deliveries of the E-1 model. (For ease of identification for the reader, the various patterns will be identified as shown above, as 'Type 1' or 'Type 2' and so forth. Please note though that no such designations existed within the German system.)

The development of camouflage patterns involved some degree of field-testing, for the obvious reason of establishing effectiveness. That process resulted in some short term tests in 1939, using variations on the standard colours then in use, 70, 71, 65 and, perhaps significantly, 02. The latter had disappeared from the camouflage schedules of the Luftwaffe by then, but its value was obviously being reassessed. Some of the experiments revisited the use of multiple-coloured splinter patterns once more, something the Luftwaffe had favoured before moving to a more defensive form of camouflage. However, this phase of the testing evaluated a totally random series of patterns, possibly in an attempt to judge the most effective ratio of colour areas, no two aircraft involved having the same pattern, though the combination of colours remained constant.

There were also less complex variations that followed the existing form of camouflage more closely, but adding 02 in combination with one or both of the two standard greens, 70 and 71. The outbreak of hostilities and the rapid nature of the Polish campaign appear to have precipitated a final decision on these variations, possibly influenced to some degree by the overwhelming air superiority of the Luftwaffe during that opening gambit of the war. A totally defensive ground camouflage was no longer the primary necessity, a more balanced, ground/air camouflage being considered a better choice. This resulted in the adoption once more of 02 into the camouflage regime and the other changes detailed below. The use of 02 softened the outline of the aircraft and broke up its solid mass, re-establishing some of the values of the obsolete three-colour disruptive camouflage pattern.

While the E-1 was still in production a significant change took place, the timing no doubt influenced by looming war. With the Type 3 pattern both wings and horizontal tail plane surfaces had been changed, the wings most noticeably with their greatly simplified pattern. Within months, probably coinciding with the service introduction of the Bf 109 E-3 series, a Type 4 pattern had been introduced and was also applied to some E-1 aircraft, probably retrospectively during refurbishment. That further modified the pattern of the port wing as well as once more revising the horizontal tail plane pattern.

Upper surface colouring had been confined to the strict plan view, while the lower surface 65-colouring had been raised over the sides of the fuselage, including fin and rudder, to a point just above the top edge of the fuselage Balkenkreuz marking, producing a better sky camouflage while retaining a reasonable element of ground defensive camouflage. At the same time that these revisions were incorporated into the production cycle, colour 70 was replaced by 02, in particular breaking up the dark mass previously formed by the 70-coloured spinner and nose section; 70 however had been retained for both spinner and propeller blades. Horizontal tail surfaces also had their camouflage pattern revised. The new colour scheme appeared in either late November or early December 1939, and followed on immediately from the revisions to Balkenkreuz markings introduced in late October.

The Type 5 camouflage pattern was introduced onto production lines just prior to the raising of the 65-colouring line to the top section of the fuselage in December 1939. The existing port wing pattern was altered only slightly, the outboard segment being simplified. Changes to the starboard wing however were more extensive, while the horizontal tail plane pattern had been greatly simplified. The line where top and bottom camouflage met along the wing leading edge also changed on the E-3, the lower surface colour being taken up to the top surface edge, thus breaking up the dark line of the wings in the frontal view. This was also done retrospectively to some existing aircraft in service.

LEFT: The experimental camouflage schemes applied to JG 53's Bf 109s during 1939 were innovative, but ultimately proved too complex and time consuming to apply, offering no advantage over the revisions to the standard scheme introduced in November/December 1939. Photographed at Wiesbaden-Erbenheim in September 1939, colours 70, 71 and 02 were used on this machine in a mixture of straight, as well as flowing-edged segments, with 65 for the lower surfaces. The scheme varied widely though, no two aircraft showing any close similarity of pattern.

ABOVE: Part of the camouflage pattern adopted for this bogus 'production' fighter the He 100 D-1 can be seen clearly here. It was a one-off pattern that appears to have had no relationship to the standard patterns in use for the contemporary Bf 109, the only single-seat fighter in service at the time.

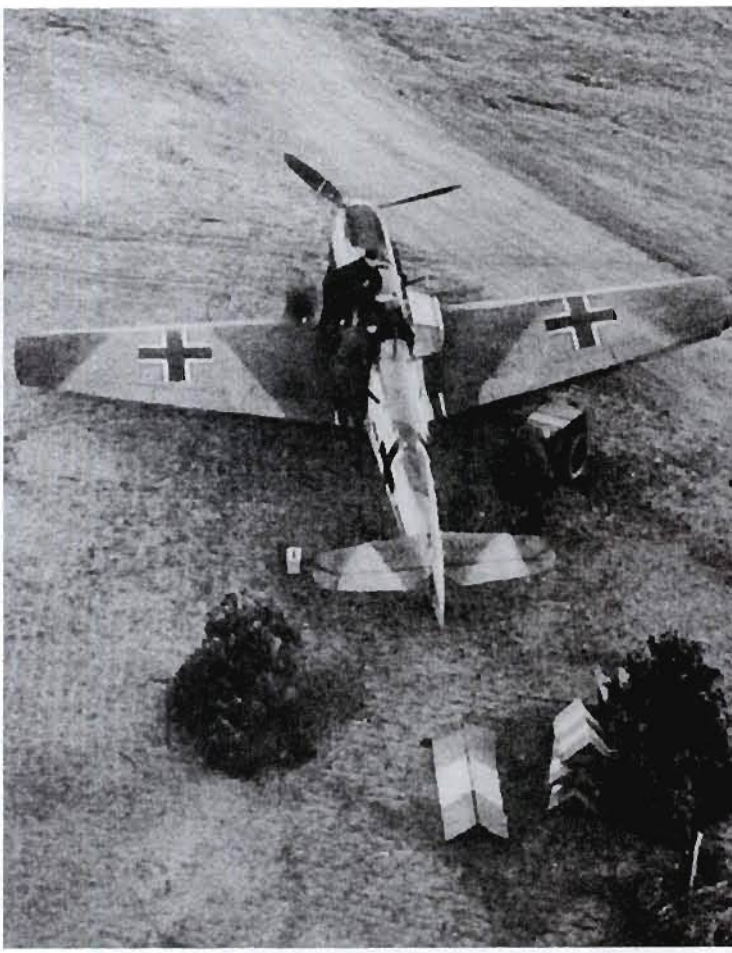
LEFT: This colour propaganda photograph of a line-up of so called 'He 113s' of an allegedly operational unit, shows them wearing standard 70/71/65 finish. These aircraft were painted in several spurious markings in order to confuse the Allies into thinking the Luftwaffe had many more of these aircraft in service.

BELOW: A good example of the revised style and colouring that had been introduced at the end of 1939. This Bf 109 E-3 has 71/02 applied in the Type 5 pattern. Balkenkreuz and Hakenkreuz markings are of correct form and size, indicating that this was a 1940 production aircraft. Note also incorporation of the revision to the demarcation line along the leading edges of the wings, making them less obvious head-on.

LEFT AND BELOW: The raised demarcation line between upper and lower surface camouflage, introduced in December 1939, was applied in two distinctive styles, one with the lower line taken down to the bottom edge of the cockpit (LEFT). In the photograph below, on the aircraft in the background, the 65 has been raised to a line that would still give an uninterrupted uppersurface splinter pattern plan view. Note the VDM company trademarks on each propeller blade of the aircraft in the foreground. (P. Hilt)

ABOVE: 'Red 9' of 2./JG 2 illustrates the revised camouflage scheme introduced at the end of 1939. This is the Type 5 pattern in 71/02. Note the small variation on the port wing, at the tip of the Balkenkreuz, with the diagonal line continuing to the leading edge; possibly adopted for ease of re-painting at some maintenance facilities. The positioning of the Hakenkreuz marking shows that this is early production aircraft, with its original camouflage modified to the revised camouflage standards at a maintenance facility.

RIGHT: This view of a Bf 109 E-1 makes interesting comparison with the previous photograph. Note the changes to the colour segments along the spine of the fuselage between cockpit and fin, making it appear as if there has been a complete reversal of the colour. The wing pattern is standard Type 3 form.



Both Type 4 and Type 5 patterns continued to appear on production Bf 109 Es, something that has not been satisfactorily explained from surviving evidence. The introduction of pattern changes normally would have signified automatic redundancy of the existing pattern, though the RLM did have a mandatory two-month period for allowing any changes to camouflage and markings. That may account for the overlap. (The Bf 109 F series also used the Type 5 pattern.)

No factory camouflage pattern so far located for the Bf 109 E series shows addition of mottling for the side surfaces, but photographic evidence points to this as having been introduced at production centres by about May 1940. As with Bf 110 production, mottling may have been part of a general revision that followed the introduction of the Type 5 pattern at production centres. The first known photograph positively identifying Bf 109 Es with the revised scheme, complete with factory-applied mottling of the side surfaces, is that of W.Nr. 2782, GA+HP. Fritz Wendel, Messerschmitt's chief test pilot, had flown W.Nr. 2777, KF+SR on 20 June 1940:[3] just five aircraft before the one in the photograph. This demonstrates that the revised scheme was being applied at point of manufacture no later than the third week in June. There is no suggestion that W.Nr. 2782 was among the first to wear the revised scheme, but it at least establishes a time marker beyond which the application is known to exist.

As detailed earlier, revisions to camouflage were pursued continuously by the E-Stelle Travemünde, something that continued until the very last stages of the war. During the mid-war period, field tests of camouflage changes, both to colours and patterns, would be centred on just a few select units, JG 54 being the principal recipient of such experimental changes. The only time that this strict control was eased occurred during the summer of 1940, during the air campaign against Britain. However, what occurred then were relatively simple additions to the existing camouflage schemes, not revisions of the entire camouflage system, though some changes did push the boundaries to greater lengths than others. For most, however, the changes were relatively simple, as described in Chapter 7.

Camouflage for the Bf 110 had also been revised, matching the changes introduced on the Bf 109 E series aircraft. Raising the division between upper and lower surface camouflage colours had been incorporated at the same time as the shift to 71/02 colouring for upper surfaces. In the past it has been assumed that this took place at manufacturing centres in late summer 1940. However, this in fact appears to have occurred on the production lines at an earlier date.

The first example of a Bf 110 wearing the full camouflage revisions was captured intact on 21 July 1940; W.Nr. 2177, 5F+CM of 4.(F)/14, had been built by a sub-contractor, Gothaer Waggonfabrik AG, and its finish included mottling in both 71 and 02 on the raised 65-colouring of the side surfaces. This is an important time marker in establishing introduction of mottling at point of manufacture. The aircraft carried on the port side – just forward of the tail plane – the increasingly rare paint maintenance specification table. While not completely discernible from surviving photographs, enough can be determined to establish one very important fact. The marking read:

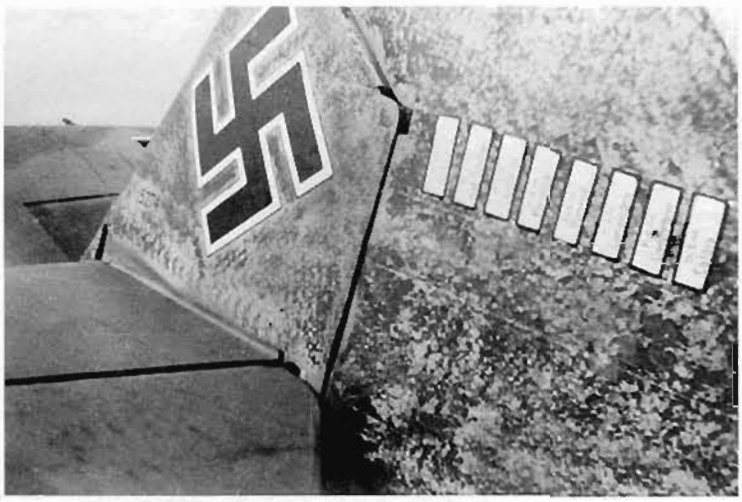
LACKIERUNG	
Metall; Innen ———- ———-	(Metal, Internal———-)
Metall; Aussen ———- ———-	(Metal, external ———)
Stoff; Flieglackkette Nr. 20	(Fabric, Flieglackkette Nr. 20)
hellierlack gespritzt.	

The last line is significant. Marked in lower case lettering, it translates as 'light (coloured) lacquer has been sprayed' That definitive notation indicates that the addition of the mottling had been applied at a production centre, not at a maintenance centre where post-production changes were usually carried out. Also, it had been unusual enough to warrant specific notation being made on the aircraft.

(text continued on page 65)

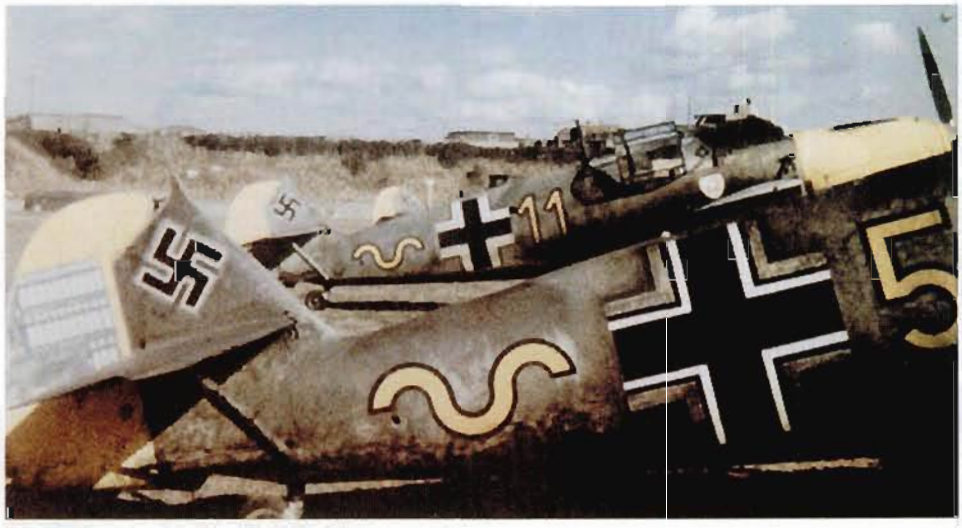
BELOW: A line-up of Bf 110 Cs, the first two from V.(Z)/LG 1, showing the revised form of camouflage introduced for Bf 110s in May 1940. The sides of the nearest machine, L1+XB, W.Nr. 3560, (brought down over England on 27 September 1940), have a pale mottle of 02. The aircraft behind, L1+YB, and 3M+AA, W.Nr. 2116 from the Stab of ZG 2, both wear the same style of camouflage though the latter appears to have had a soft sprayed application added to the upper surface 71/02 pattern – something that became more common as the air fighting over Britain developed.

LEFT: A detail photograph of Bf 110 C-5, W.Nr. 2177, 5F+CM, of 4.(F)/14, which was forced down over England on 21 July 1940. It wears the factory finish of 71/02 on its upper surfaces with mottling in both colours on the 65-coloured side surfaces. The paint legend carrying the information on this new finish appears just forward of the tail plane. Under the letter 'C' the three lines (the top one very faint) of stencilling are maintenance markings which read: 'Hier anheben. Vor dem Aufbocken 300kg belasten' ('Lift here. Before jacking, ballast with 300 kg'). (R. Lutz)



ABOVE: Close detail of the application method used by JG 2 for some of its aircraft. The stipple effect on W.Nr. 5274 was produced by using a 'stabbing' motion with one of the larger size brushes from the standard painter's kit issued as maintenance equipment. This style of finish has often been erroneously identified with use of sponges, an item that was not part of the standard kit. The series of repetitive near half circle shapes at the base of the fin show that the edge of a circular brush had been used. (E. Mombeek)

BELOW: This view of a Bf 109 E-3 of Oberstleutnant Harry von Bülow-Bothkamp, Geschwaderkommodore of JG 2, provides a more detailed example of the stippling style of application that illustrates that brushes were used, not sponges. Note the overlapping of the edges of the Balkenkreuz with the 71-colour, which was confined to the 65-coloured areas of the fuselage side surfaces. (E. Mombeek)



LEFT: The very intensive form of mottling used by JG 2 was sometimes enhanced by combining stippling with a soft-sprayed application. In this view of 'Yellow 5' of III./JG 2, the sprayed application of 71 had been done with thinned down colour on the upper part of the fuselage sides, and then enhanced with stippling in full strength 71 in other areas. Note that the Balkenkreuz marking had been reduced to the non-official, narrow-edged, style adopted by some other aircraft of JG 2 in a further attempt to increase the camouflage effect. The regulation style of marking can be seen on 'Yellow 11'. (M. Payne)

RIGHT: Compare the previous photograph with this one of Lt. Hermann Graf climbing out of a Bf 109 E of 9./JG 52 during the summer of 1940. Here mottling had been achieved using a spray gun. The soft mottles of 71 had been applied in two forms; very sparsely below the cockpit with a much denser application, with a connecting softer spray, aft of the wing, extending the darker segment of the top surface camouflage down the side area. (E. Mombeek)

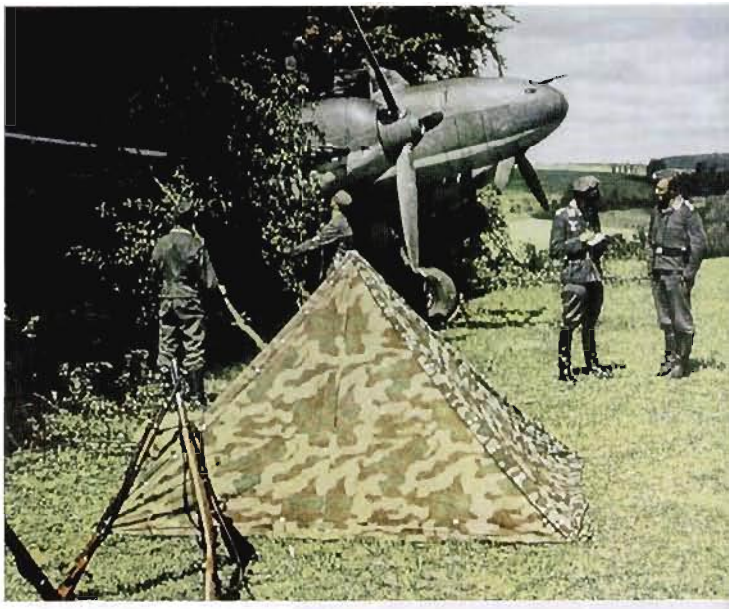
LEFT: While sometimes it is possible to identify a particular style of application of the additional camouflage with a specific Staffel, there still were distinct variations as shown here. All three Bf 109 Es belonged to 9./JG 52 and were photographed at Coquelles in early September 1940. The middle aircraft had a distinctly different style of application of 71 and 02-mottling from the other two. The very distinctive use of plain cross-hatching in lines of 71 on the other two aircraft point to them having been painted by the same person or persons, while the middle aircraft had been painted at a later stage, or at a different maintenance facility. The gun troughs on the middle machine had been painted with a paler colour, something noted on other Bf 109s; some published sources claim it to be yellow though it is closer to 02 in tone. (E. Mombeek)

LEFT AND ABOVE: Two views of Bf 109 E-4, 'Yellow 13' of 9./JG 54 illustrate yet another distinctive style of application, this time using just 71, to break up the 65-colouring of the side surfaces. (E. Mombeek)

RIGHT: Bf 109 Es of I./JG 3 seen in October 1940 illustrate another form of amended camouflage, this time using a soft spray of 02 on the flanks with soft mottling in 71. The engine cowling and rudder were both painted in 04 yellow.

RIGHT: Not all modifications to the camouflage of Bf 109 Es during this period were so subtle. This example, a Bf 109 E-4 of 4./JG 26 photographed at Marquise in October 1940, records a very crude form of application indicating that it had been done at unit level. The 65-colouring of its flanks had been all but obliterated with a heavy streaking of 71. On either side of the area directly below the cockpit, the streaks of 71 had been sprayed over with 02. This took the general camouflage colouring back to the late 1939-style.

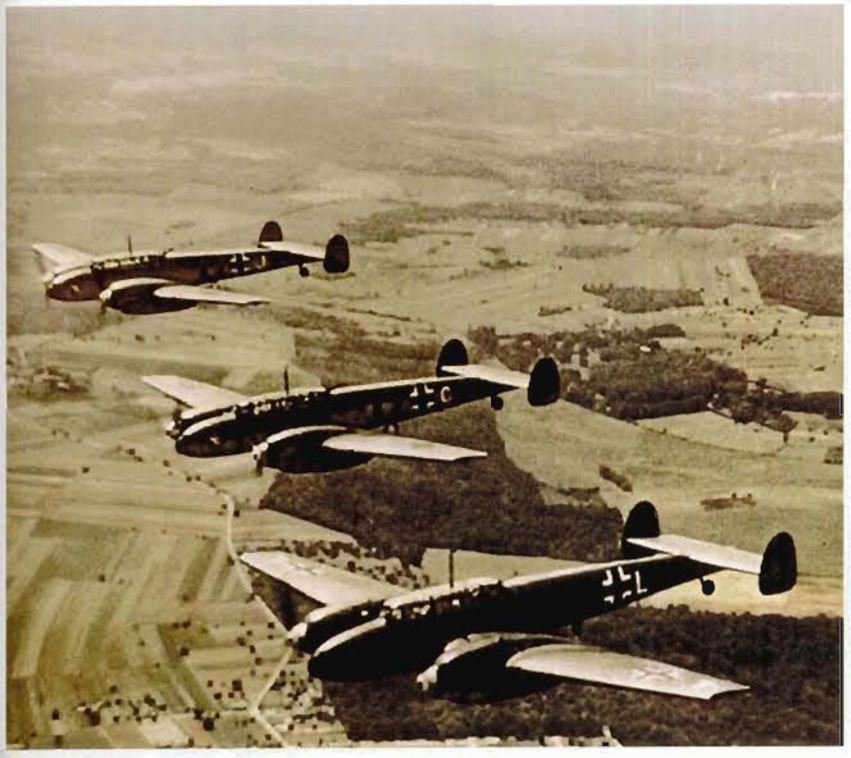
ABOVE: Bf 110 C M8+DK of I./ZG 76, was photographed during the Polish campaign. The 70/71 camouflage can be seen, but the effects of lighting conditions could make it difficult to discern. The individual letter was painted in the 2. Staffel colour of red and outlined in the Gruppe colour of white.



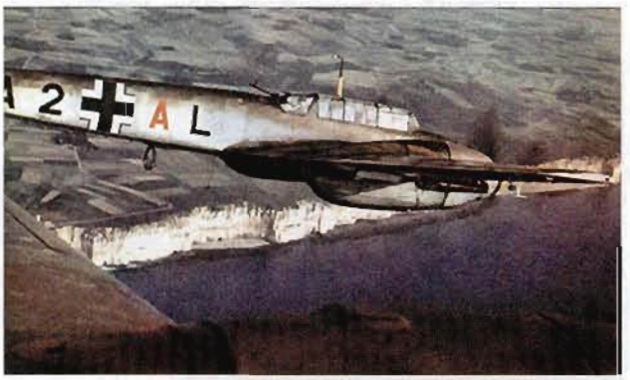
ABOVE: A Bf 110 from the Stab of an unidentified unit shows the original 71/72/65 pattern taken right down the fuselage sides to the lowest point (35 degrees tangential mark as shown on the He 111 P diagrams). This dates the photograph to the summer of 1940, during which period the camouflage for the Bf 110 type was changed to a soft-edged application of 71/02/65 as used by the contemporary single-engine fighter type. (P. Hilt)

ABOVE: Bf 110 C W.Nr. 2143 KD+TM in factory-finished splinter camouflage of standard 70/71/65. Some small patches of red oxide primer can be seen on the wing root walk area. This aircraft was test flown on 17 May 1940.

RIGHT: Part of the remains of Rudolf Hess's Bf 110 which crashed in Scotland a year later, June 1941. A brand new machine, its camouflage still incorporated the soft overspray of 02 on the upper and side surfaces. (Ken Bokelman)



LEFT: This unique photograph shows the full sequence of change introduced for Bf 110 camouflage during the summer of 1940. The aircraft nearest the camera, A2+LH of II./ZG 2 (formerly I./ZG 52), wears the original factory standard pattern of 70/71/65 with colours taken right down to the bottom edge of the fuselage. The middle aircraft, A2+CH, has the 71/02/65 scheme with the transition line taken down to the upper horizontal bar of the Balkenkreuz, while the third aircraft, A2+JH, has the 71/02/65 finish with an additional overspray of 02 over the upper surface camouflage colours. This illustrates that the transition between these three schemes took place over a period of time.



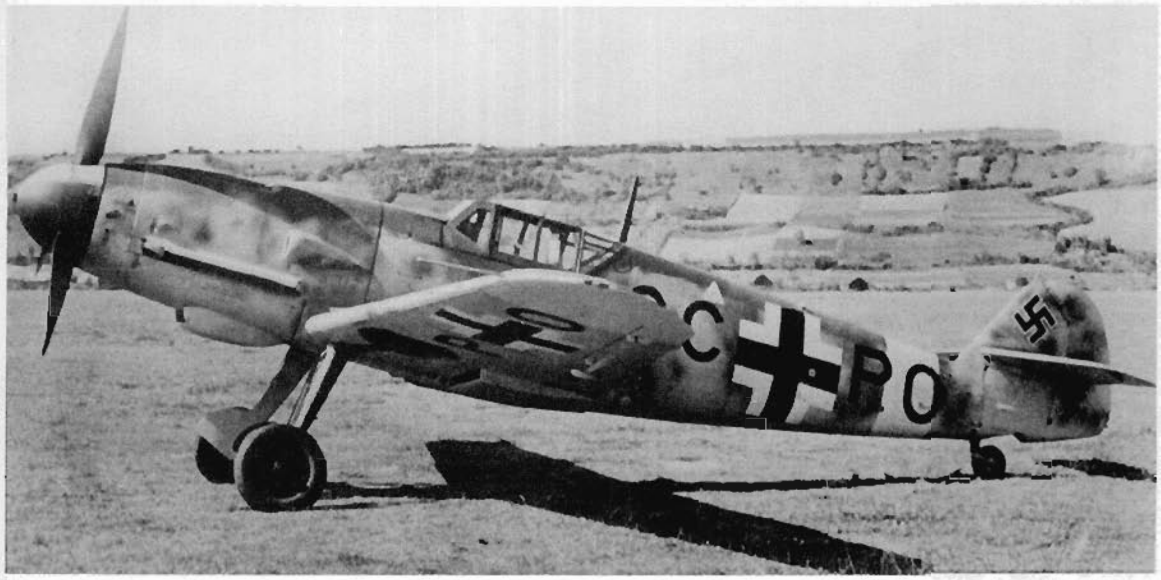
ABOVE: This in-flight view of a Bf 110 C of II./ZG 2, A2+AL, shows the application of a fine spray of 02 over part of the upper surface camouflage, markedly toning down the effect of the segmented 71/02 pattern along the spine of the fuselage.

LEFT: This close-up of the nose section of a Bf 110 C being prepared at a production centre shows the soft application of 71/02 to the upper surfaces. The main segment areas of the standard pattern have been retained, but the use of soft-sprayed areas of each colour, rather than a solid application, have subtly altered the colour effect, the underlying 65 being allowed to influence the upper colours. (P. Hilt)

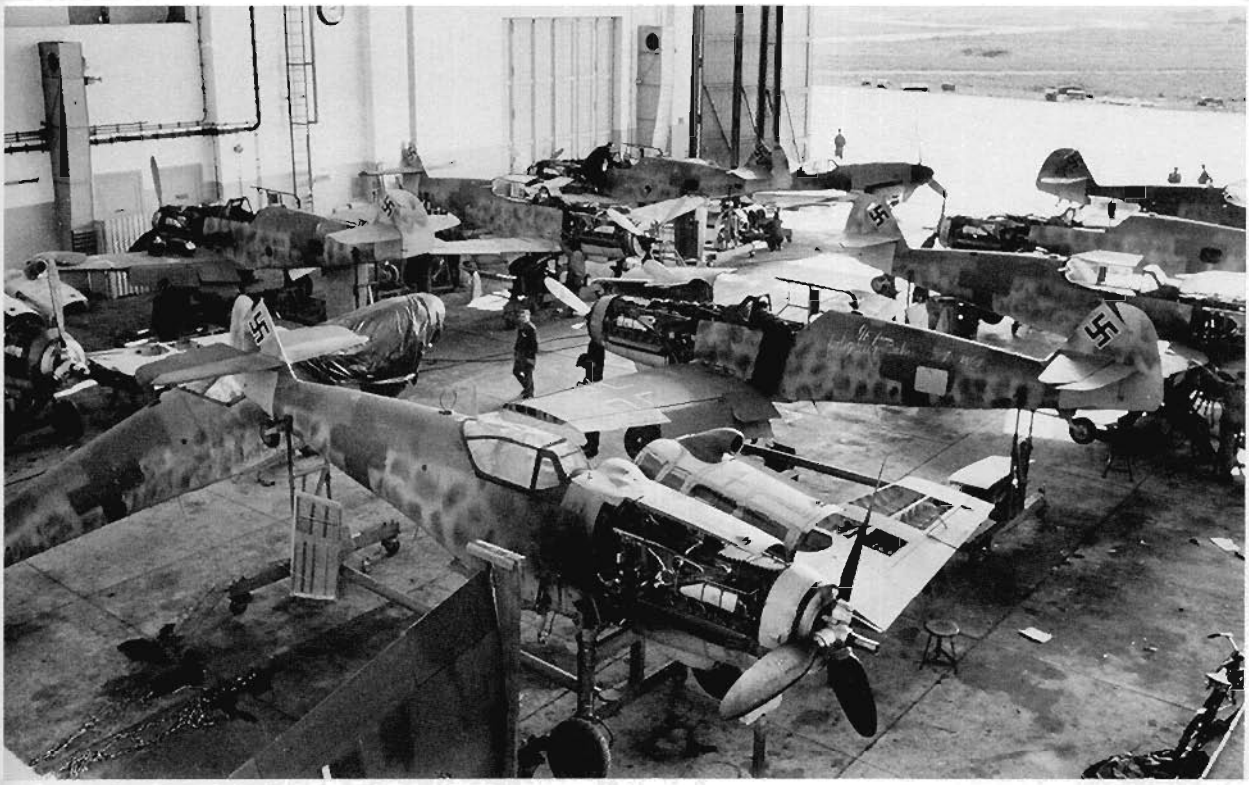
RIGHT: Though a feature of Bf 110s, the use of an overspray of 02 to tone down camouflage was occasionally seen on single-engine fighter aircraft. This photograph of a Bf 109 E-3, flown by Hptm. Werner Mölders while serving with JG 53 in the late spring of 1940, shows the same use of 02.

LEFT: Experimentation with lacquers, as well as colours and camouflage schemes, was an ongoing process. This badly shot up Do 17 Z-2, 5K+CT of 9./KG 3, carries a marking showing field trials of a new lacquer. The legend, marked in yellow on a ragged black patch on the rear fuselage, reads 'DKH Versuchsanstrich 1.3.?. System 11' Unfortunately, a bullet has removed the last date, but it would probably have been 1940 as field-testing was conducted for one year, and this photograph was taken during the air battle over Britain. (This is possibly W.Nr. 3270, which crashed at Le Culot on 2 October 1940). The letters 'DKH' identified the paint company Dr Kurt Herberts, a major supplier of Luftwaffe lacquers from the inception to the demise of the Luftwaffe. Note the reflective surface of the lower area of the paintwork below the DKH legend and compare it with the matt finish of the 02-undercoat around the bullet hole. This is not 65, as that matt colour can be seen immediately forward and on the side of the tail wheel fairing below. Remnants of temporary night black on the front face of that fairing show that the aircraft had been used recently for night bombing duties. The ragged black background to the DKH data marking may indicate that this was the lacquer being tested, 7124.22, which in 1941 eventually replaced the temporary finish used during 1940.

RIGHT: Bf 109 G, PC+PO, had streaked side 'mottle' applied in 74, and concentrated from the cockpit aft to the tail unit, with the same colour used for mottling on fin and rudder. The engine cowling area had just very soft mottles of 74 and 75. Yellow tactical markings had been applied to fuselage and the undersurface of each wing tip during production, normal practice during construction where aircraft had been pre-allocated to a specific theatre of war.



LEFT: Compare this photograph of CC+PU with the previous one of PC+PO. The style of camouflage application is identical, but both 74 and 75 had been used for the streaked 'mottling'. Consistency of style can sometimes – but not always – provide distinct clues as to where an aircraft had been produced as well as to specific production batches. (H.Obert)

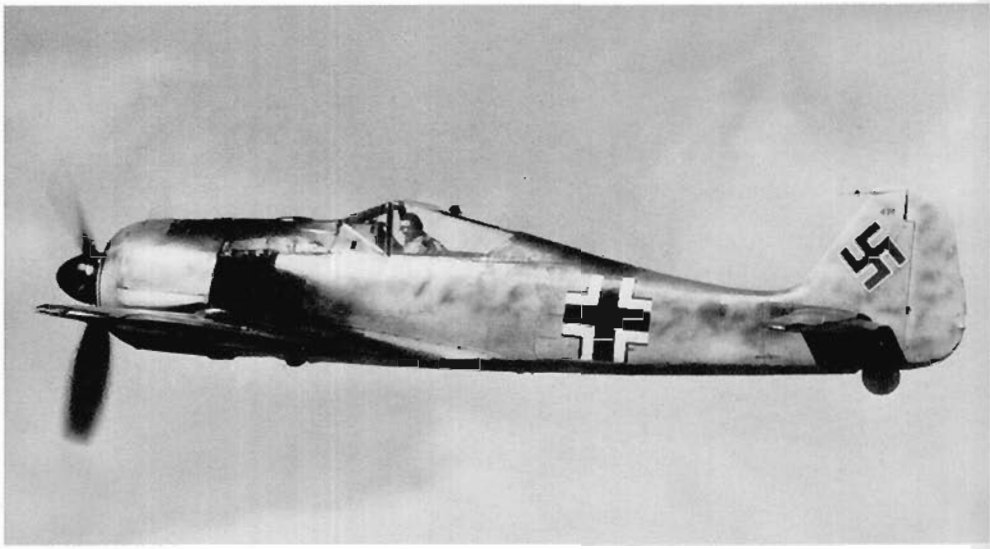


BELOW: A production batch, Bf 109 G-6/R6 aircraft, using the same standard camouflage pattern, as shown on the previous page, but with the downward streaking effect applied right along the fuselage in both 74 and 75. Note the development of a scalloped-edge effect to the division of the upper and side surface colour areas. The style and density of mottling to the vertical tail surfaces had remained consistent through the F and G series to this point.

ABOVE: Bf 109 G-6s nearing the final stage of construction illustrate how pre-painted components were married to partly or unpainted components. The main fuselage units had already received their camouflage (74/75/76 in this instance) with the Balkenkreuz marked in 74 and requiring only the addition of the white edging. Complete tail units were supplied by a sub-manufacturer and delivered fully camouflaged complete with the Hakenkreuz marking. The section immediately below the fixed horizontal tail surfaces was usually left in plain 76, but after attachment, some factories added a blending mottle to the dividing line. Note the engine cowlings on the aircraft in the foreground were still in zinc chromate primer with the silvery-grey filler paste clearly visible. Wing sections were also pre-painted prior to assembly. While a fair degree of consistency of camouflage style is visible, the aircraft on the left, with canvas covering to its engine area, had a distinctly looser application of the side mottling, though in the same colour sequencing – proving that one cannot always rely on style of application as a positive form of identification of production facility or production batch. The aircraft centre right had been inscribed with some production information, typical of such temporary markings. They read '1/F f.... 51 W1' along the top line with 'Fertig zur Bahne' on the second line ('finished for transportation') plus identification numbers relating to the production, or flight test, batch.

LEFT: Interpretation of side surface mottling, specified only loosely on the relevant RLM-approved camouflage drawings, lead to a series of distinct styles. Deliveries of the Fw 190 A-1 began to reach units in June/July 1941. This machine, W.Nr. 067, TI+DQ, was produced around July 1941 and shows the factory applied scheme of 74/75 upper surfaces, with 76 side and lower surfaces, as applied at the Marienburg plant. The high division line between the two major colour areas had been softened with a very lightly sprayed mottle of 75, with small touches of 74 that had been extended to the vertical tail surfaces. This showed little variation, other than for colours used, from the May 1940 style. (C. Cole)

RIGHT: The Fw 190 A-2 began to leave the production lines in August (Warnemünde plant) and October (Oschersleben plant) 1941. Seen here on a test flight, W.Nr. 471, had been produced in early 1942. The darker 74-camouflage segment, forward of the cockpit, had been extended onto the engine cowlings, illustrating a small but noticeable difference from the earlier production machine shown in the photograph of TI+DQ on page 61. The 74/75 mottling was more widely spaced and used a predominance of 74. The differences noted reflect the looser interpretation of the mottling application by various plants. The absence of Stammkennzeichen markings is unexplained; they were usually applied while the aircraft was under production, however, some production centres appear to have refrained from doing so until after an aircraft had successfully completed its acceptance test flight.

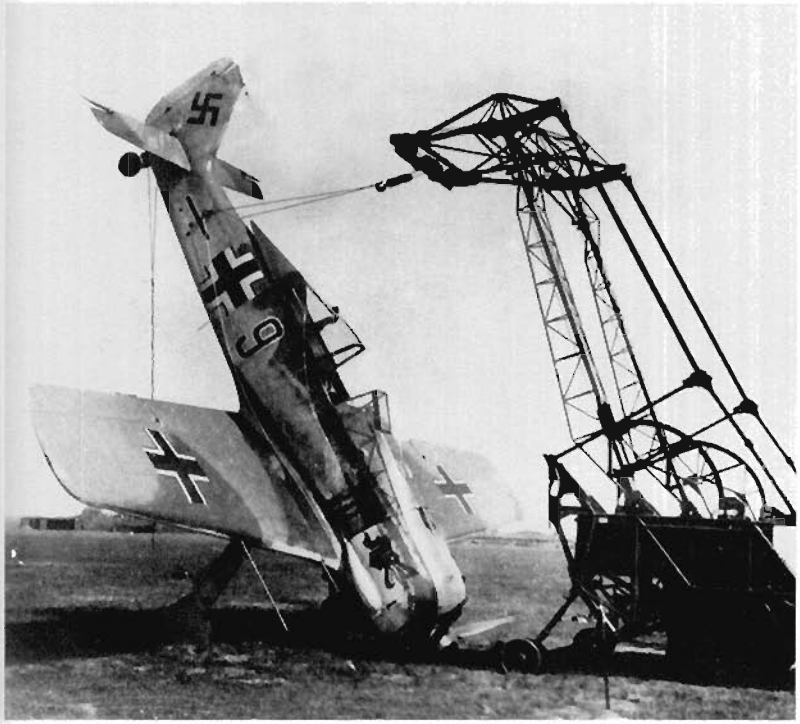


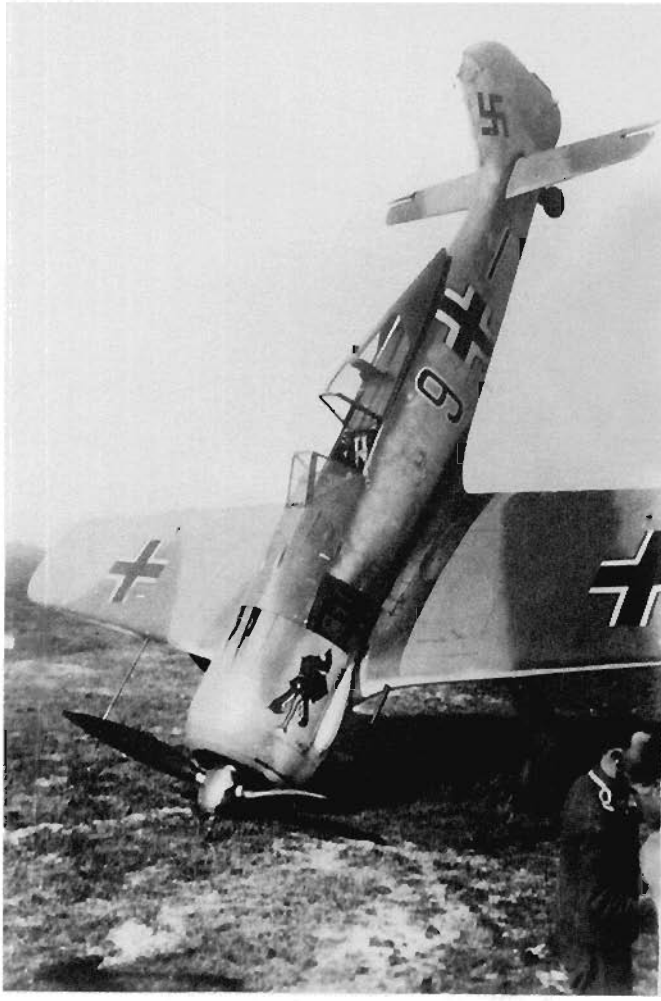
LEFT: Compare the camouflage on this Fw 190 A-2, W.Nr. 0485, just 14 aircraft later in the same production block, with the previous photograph. The 74-segment on the nose section has been taken a little further onto the engine cowlings this time, while the upper surface camouflage colours have been extended further down the sides to the horizontal line of the cross arm of the Balkenkreuz. There is evidence that the painting out of the Stammkennzeichen with 76 had removed some of the side surface mottling from the inside point of the Gruppenadjutant's Stab marking afterwards. Note that forward of the marking the upper surface colours were blended into the 76 with an almost solid, but much thinner application of 74 and 75. The style and density of mottling on the fin and rudder is about the same in both photographs. (E. Mombeek)

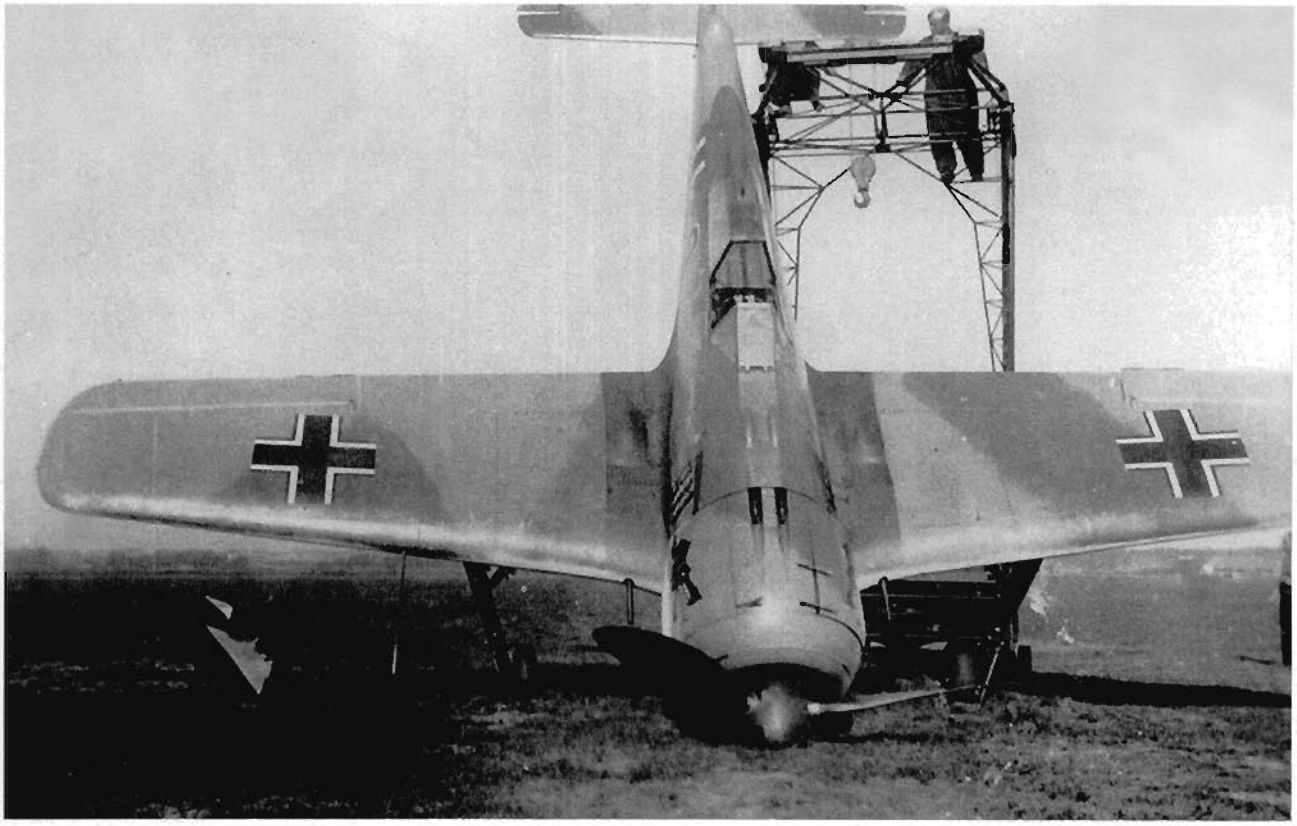
ABOVE LEFT AND RIGHT: These two close-up photographs of the fuselage of Uffz. Rudolf Rauhaus's Fw 190 A, 'Red 3' of JG 1 show the style of blending between the upper surface camouflage pattern and the 76-coloured side surfaces. The main colours have a scalloped bottom edge that had received only a narrow, thinly sprayed application of 74 and 75. This was a very conservative interpretation of the mottling requirement laid down by the RLM.

The two emblems represent Rauhaus's personal one, (the coat of arms of his home town Neuss) on the starboard side, with the 6. Staffel emblem on the port side. This close similarity of style of transition colouring points to this aircraft having been produced at the same production centre as the one shown in the photograph above. (E. Mombeek)

THIS PAGE: Three views of Fw 190 A-2, 'Black 9' of 5./JG 1 taken in 1942, they show clearly the standard RLM approved type 5 camouflage pattern of 74/75/76 approved for single-engine fighter aircraft, but incorporating the soft, curved-edged pattern characteristic of Focke-Wulf aircraft. However, mottling of the side surfaces has been done lightly to the point of being almost non-existent. The leading edge of each wing has been left in the lower surface colouring of 76, reducing head-on visibility. Note also the dark wing walkway strip carried through the camouflage on the inboard section of both wings. The unit badge is marked in the 2. Staffel colour of red. (E. Mombeek)

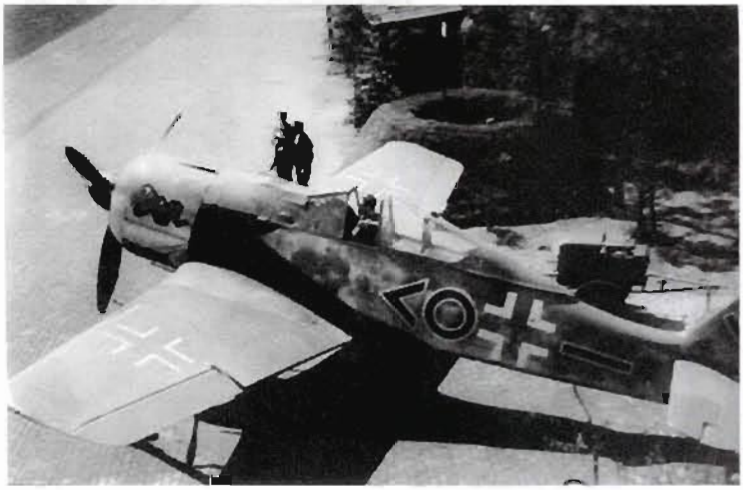






LEFT: A Fw 190 A-3, W.Nr. 1033 'White 14', finished in 74/75/76 camouflage with full 04 tactical markings. Again the side mottling had been reduced to a transition between upper and side surface colouring by means of a ragged, wavy application to the edge of the top surface colours. Location appears to be France.

RIGHT: This rear view of Fw 190 A-4, W.Nr. 6735, 'Black 12' of 8./JG 2 provides an interesting comparison with the three views of 'Black 9' on the previous page. The application of the pattern is almost identical, but there are subtle variations. The starboard tailplane has the darker colour extended further inboard.



LEFT AND BELOW: Two views of an Fw 190 A-5, the mount of Lt. Rüdiger von Kirchmayr, Technical Officer of II./JG 1. The upper surface camouflage had again been modified on the section forward of the cockpit, the 74-coloured segment being significantly reduced. Note also the very heavy style of mottling on the side surfaces. (E. Mombeek)

A photograph of Bf 110 C-4, W.Nr. 2116, 3M+AA, of the Gruppenstab of I./ZG 2, shows a less complex camouflage. While the 71/02 had been reduced to just the upper surfaces the 65-coloured side surfaces had only a very faint trace of 02 mottling. Upper surface camouflage colours, adjacent to the top edge of the fuselage Balkenkreuz marking, had been carried down slightly to provide a strong background for the white angles of the marking. That, along with the uneven division between upper and side surface colouring (i.e., a well-defined line in some places and ragged in others), indicates that this aircraft had its camouflage revised 'in the field', i.e., at a maintenance facility. Another Bf 110 C from ZG 2, W.Nr. 2133, 3M+HL, had been lost next day, 4 September 1940, and a photograph of its burnt remains shows a full 70, 71, 65 camouflage.

While details of Werknummern for Bf 110 C-4 production batches are limited the following have been positively confirmed; - 2104, 2116, 2130, 2133, 2137, 2143, 2145, 2146, 2159, 2162, 2167, 2168, 2177, 2190, 2191. These bridged the gap between W.Nr. 2116 and W.Nr. 2177 and beyond, sufficiently to show that the production run was probably continuous between the two. W.Nr. 2133 was still in the old camouflage scheme of dark greens, but between production of that aircraft and W.Nr. 2177, i.e., 42 aircraft, the new scheme had been introduced at production centres.

Fritz Wendel had test flown W.Nr. 2143, KD+TM on 17 May 1940,[4] a little over two months before the loss of W.Nr. 2177, and a colour photograph of W.Nr. 2143 shows it wearing standard 70/71/65 camouflage. Given the production rate for that batch of aircraft, and a gap of only 34 aircraft between W.Nr. 2143 and W.Nr. 2177, it could be reasonably extrapolated that the latter aircraft had been produced somewhere around the end of May. It would be presumptuous to assume that it was the first to wear the revised colours and mottle but it must have been fairly close given, as noted, the special legend marked on its fuselage. Thus a date of late May would be a reasonable estimate for the introduction of the new scheme at production centres.

While changes to both colour and pattern distribution had been altered, the original 1939 camouflage pattern for upper surfaces had been retained at manufacturing centres and continued in use for the type's proposed successors the Me 210 and Me 410.

Fighter camouflage had been further revised when colours 74/75/76 were introduced at point of manufacture around April/May 1941. Initially, the camouflage pattern had remained unaltered, early production Bf 109 F-1 and F-2s wearing the Type 5 pattern still in use on Bf 109 Es. A revised camouflage pattern (Type 6) for the Bf 109 F was then introduced on 15 August 1941. It retained the geometric style of pattern, but the directive stated that the colours were to have a slightly irregular edge where they met. Overlap between the two upper surface colours was to be softly merged (like meshing teeth, not sprayed over the top of each other as sometimes has been stated in other publications) over an area 100 mm wide, allowing the two colours to blend optically into each other in a soft line, this being the reason for the soft-edged patterns. This eliminated the need for precise grid layouts, though pattern area positions and dimensions were still well regulated. The starboard wing had been the main area of change, using a pattern similar to the original Type 1 variety, but reversed front to back. The fixed horizontal tail surfaces had also been revised.

Interestingly, both Type 5 and Type 6 camouflage patterns were used at manufacturing centres for Bf 109 G series aircraft, at least to G-4 production. The reason for that latitude is unexplained and the suggestion put forward for the Type 4 and 5 patterns appearing simultaneously could not be valid in this instance because of the extended time factor. In addition, most of the Fw 190 series was allowed to retain the Type 5 pattern, as mentioned below. This appears to indicate a degree of latitude by E-Stelle Travemünde, but for what practical purpose is hard to comprehend. A further change to the starboard wing pattern and horizontal tail surfaces occurred in 1943 during G-6 production. This Type 7 pattern reintroduced the inverted outboard section wedge-shape of the Type 5 pattern, but reversed colour sequencing while retaining the existing colour sequencing of the port wing. This left the starboard wing tip in the palest colour.

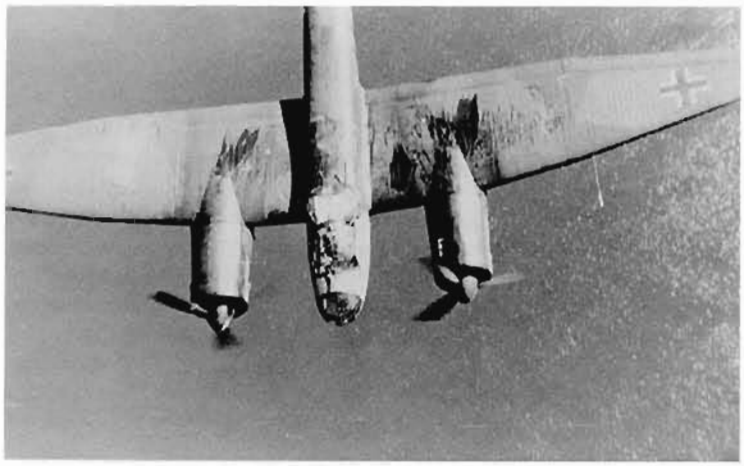
A further modification produced the Type 8 pattern, introduced for the Bf 109 G-10 and K series.[5] Again the starboard wing was the focus of most change, the pattern being greatly simplified, and reversed colour sequencing retained. The horizontal tail plane pattern had been simplified in form. One further modification to that pattern occurred in the last months of the war, Type 9 producing the final pattern for the Bf 109 series. The starboard wing pattern and colour sequencing had been retained, but the port-wing had been modified to produce a large area of the darkest colour occupying the mid-wing area with the tip area pattern reduced. The modified horizontal tail plane surfaces were the same for both of those last patterns.[6]

When Fw 190s entered service in 1941 they did so using the basic Type 5 pattern, but incorporating very minor modification in the form of a curved, soft-edged pattern on wing and tail plane that slightly distorted the area of the original near straight-edged pattern. The port wing pattern also had the small extension of darkest colour along the trailing edge eliminated. This pattern was retained for Fw 190 production throughout, only a small addition being made by extending the outermost colour blocks to accommodate the longer wing form of the Ta 152 series when they had been introduced. Unlike the Bf 109 series, the Fw 190 and Ta 152 series did not use a mirror image of the camouflage pattern. Those distinguishing features between Messerschmitt and Focke-Wulf piston engine designs continued to war's end. Why Messerschmitt production had been the subject of so many variations is not clear. It does appear to indicate that manufacturers at least had some input in the E-Stelle's design changes to camouflage, and were able to negotiate some degree of choice from the final approved forms. The administrative processes relating to camouflage at the design and approval levels are something often disregarded; it is to be hoped that some documentation eventually emerges that throws more light onto this important aspect.

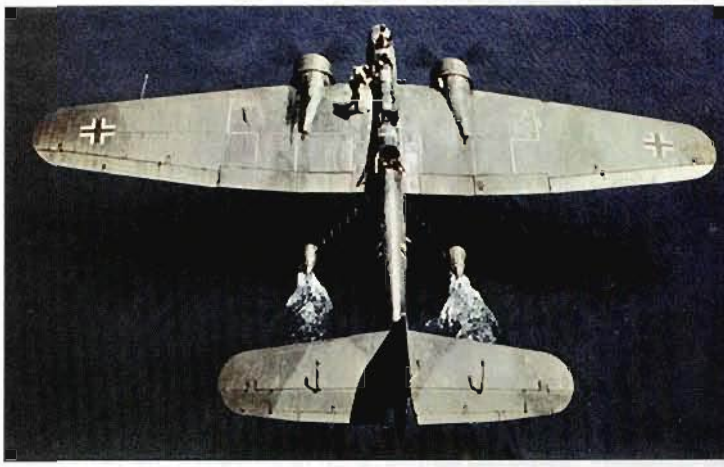
With the advent of both jet and rocket-powered fighter aircraft, camouflage patterns were again revised. The 1939 pattern change introduced with the Bf 110 C series, and adopted for the Me 210 and 410 series, initially was also used for the Me 262 A series of prototypes and early production aircraft. That remained in force until redesign of the Me 262 camouflage pattern introduced with effect from 26 September 1944.

The diminutive Me 163, because of its unique shape and dimensions, had required a pattern of exclusive design, but the one introduced in January 1945 for the equally small He 162 marked a radical departure from the long standing practices; the grid system was finally abandoned in favour of individually painted components, each in a single colour. That departure from a system that had been in force since 1936, in one form or another, reflected the final phase of an austerity drive not only under pressure for materials but also to cut production time to an absolute minimum. With components pre-painted in a single colour, marking out of camouflage was eliminated. It also overcame the problems of mismatched camouflage on components from sub-manufacturers. How far the process would have been extended to more conventional fighter types remains speculative, but the Me 163 may eventually have become part of that change. It also remains speculative as to how far the more radical approach to camouflage, described in Chapter 6, might have progressed had the experiments had time for completion and appraisal.

1. Ken Bokelman and Michael Ullmann research.
2. Robert Michulec research.
3. E.J. Creek research.
4. E.J. Creek research.
5. T. Poruba research.
6. T. Poruba research.



ABOVE: The splinter pattern on this Ju 88 of LG 1 conformed to the official RLM standard pattern for the type, but oil and grime had obliterated sections of it. (H. Stubert via Lloyd Line)



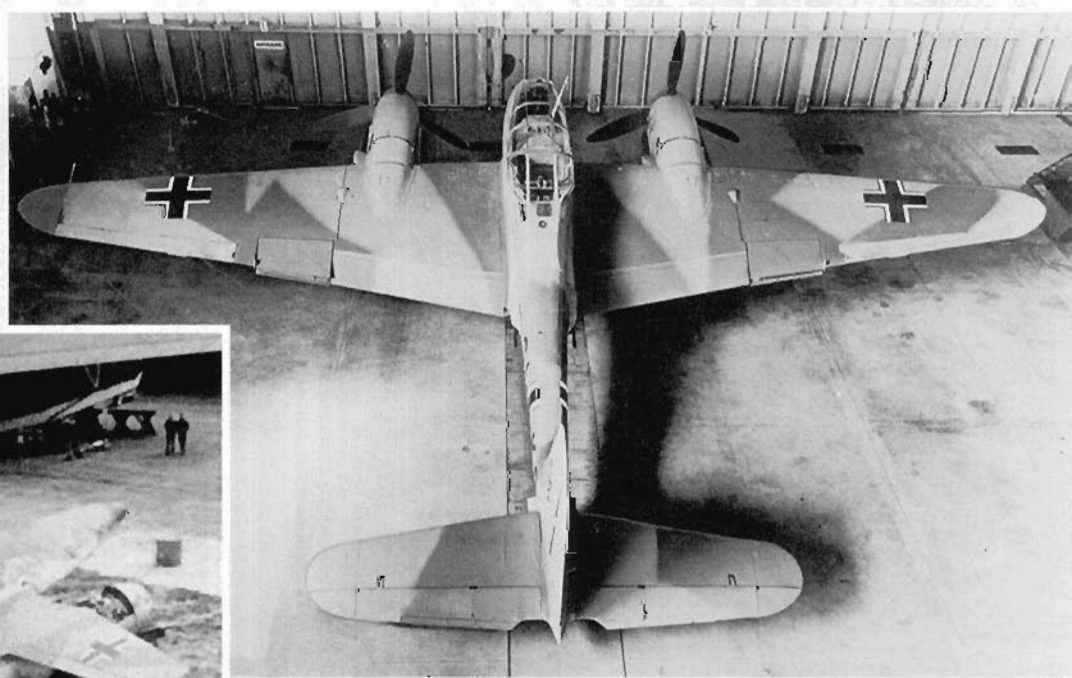
ABOVE: This colour photograph illustrates the standard splinter pattern, applied in this instance to a He 115. This is pattern A. Compare it with the diagram for the He 111 P Muster A.

LEFT: As the war progressed to its final stages, standards were eroded, but manufacturers of sub-components seemed best able to retain some standard of conformity of style longe than the main assembly plants, though in the end they too failed to some degree. This Bf 109 K had a finish of 82/83 o its vertical and horizontal tail surfaces with upper surface colouring taken right down the sides of the fuselage, a narrow wavy band of 76 dividing it horizontally. This distinctive style o camouflage application is similar to that seen on the W.Nr. 330200 batch built by Messerschmitt at its Regensburg plant. However, continuation of the 76-wavy line forward of the Balkenkreuz is different. The area below the fixed horizontal tail surfaces is bare metal, as is the access panel just forward of it – the result of the last stages of the austerity directives. These were part of the tail assembly parts supplie by a sub-contractor. The under surfaces of the fixed section of the horizontal tail plane were probably also left in bare metal.

RIGHT: Not the same aircraft as in the previous photograph as close examination of the positioning of the spots of 83-colouring show (see the lower rearmost spot of 83). These aircraft were all found near Wertheim. The near consistency of their shapes and the bottom colour division line makes it clear that a stencil had been used. The unpainted area below the fixed horizontal tail surfaces and bare metal rear access panel can also be seen. However, note the dark 81-coloured rear section of the fuselage with that colour taken up over the fin fairing. The remainder of the fuselage was 82/83. Compare these two photographs with that on page 42 of the stockpile of Bf 109 fins that had free-hand applied camouflage.

ABOVE: Recycling was undertaken throughout the war by both Allied and Axis forces. In Germany it became a significant contributor to the production cycle, especially with regard to the very large number of single-engine fighter aircraft produced as the war entered its final phase. This view of the assembly line beneath Tempelhof Airport shows Fw 190s being rebuilt using recycled airframe parts. Careful examination reveals a variety of camouflage finishes. White numbers marked on the fin of each aircraft identified its production number within the plant and allowed recycled components to be allocated sequentially. The parts have corresponding white numbers, but problems caused the reallocation of such items at times, with consequent changes to the identifying number that matched that of the main airframe. The mismatch on the first aircraft, W.Nr. 170997 marked in white with '221', with a recycled rudder allocated for aircraft '242', and then crossed out, demonstrates the difficulties being experienced at this late stage of the war. The second, W.Nr. 174256, had '292' marked in white on the tip of the fin, across the centre of the Hakenkreuz and just forward of the cockpit, with '25?' marked on the rudder and '262' on the leading edge of the port wing. All the airframes were covered with a thick layer of dust, giving the camouflage the appearance that it had been sprayed with another colour.

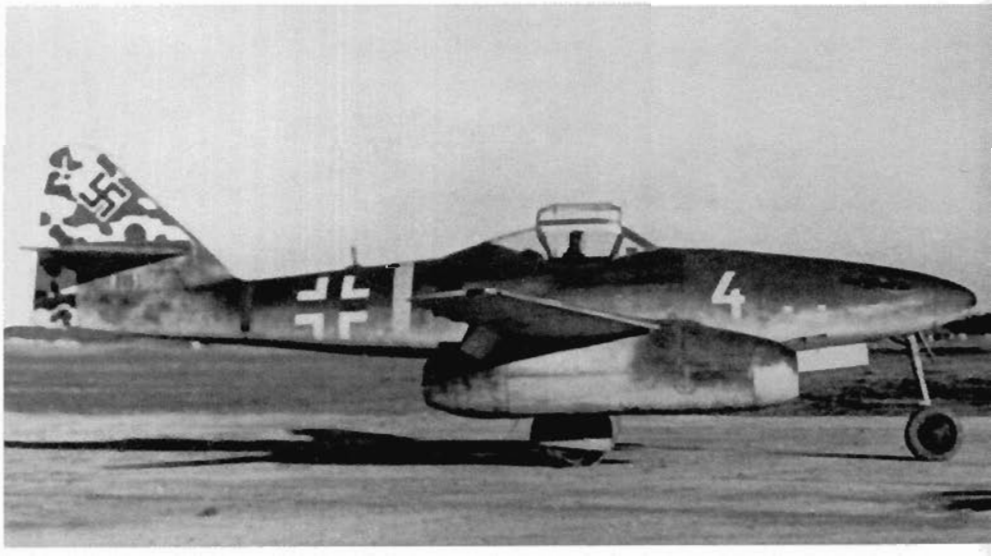
BELOW AND RIGHT: Me 262 V3, PC+UC, shows the early camouflage pattern applied to the first test aircraft, the same pattern introduced with the Bf 110 C series and used also for the Me 210 and Me 410 types. Colours were the contemporary 74/75/76. Compare this with the accompanying photograph of the Me 210.



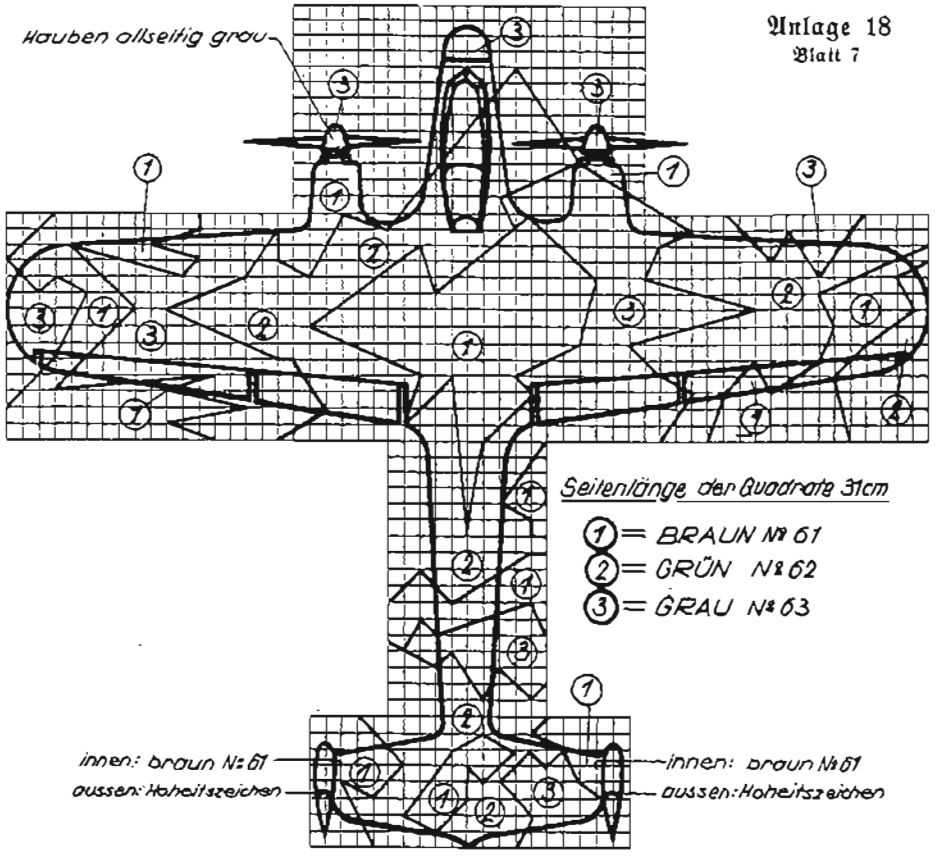
LEFT: Me 262s of Kommando Nowotny, showing the distinctive stencilled mottle used by the sub-manufacturer who supplied fin and rudder assemblies to the particular production centre. The 81 (or possibly 83) patches contrast strongly with the very pale 76 colouring. The very dark camouflage colouring of the two aircraft in the foreground contrasts with other machines used by this unit, marking the transition between the earlier 74/75/76 scheme to the late war colours of 81/82/76. 'White 1' had the 81 and 82 pattern taken right down the fuselage side surfaces, but 'White 19' appears to have retained its original high demarcation 81/82 pattern, with the side surfaces sprayed over in just 82. Both aircraft have bare metal nacelles at the front of the engines, a consequence of the short life of engines at that time, resulting in constant engine changes. The forward cowling on the Jumo 004 engine was integral with the engine, containing the fuel tank for the Riedel starter motor, and was not painted prior to factory fitting. At unit level, it was obviously not considered worthwhile doing so. All the aircraft wear the distinctive narrow 04-coloured fuselage band, and 'White 1' in the foreground also has a white 'S' marked below the tail plane, identifying it as a training (Schulflugzeug) machine for the unit.

ABOVE: This view of 'White 7', W.Nr. 110376 belonging to III./EJG 2 taken at Neubiberg in May 1945, shows the sharp-edged pattern of 81 on the fin and rudder surfaces. The exact repeat of this pattern on each aircraft was accomplished by using a stencil.

RIGHT: The other side of the fin and rudder pattern is seen here on 'White 4' of Kommando Nowotny. The contrast between the pale 76-shade on the fin and that of the lightly oversprayed 76 seen on the lower parts of the aircraft can be seen. The rear vertical joint between the tail unit and the fuselage was covered with a doped fabric strip, and it appears that this one had been replaced and hand-painted with the darkest of the camouflage colours. The narrow yellow band was in 04.

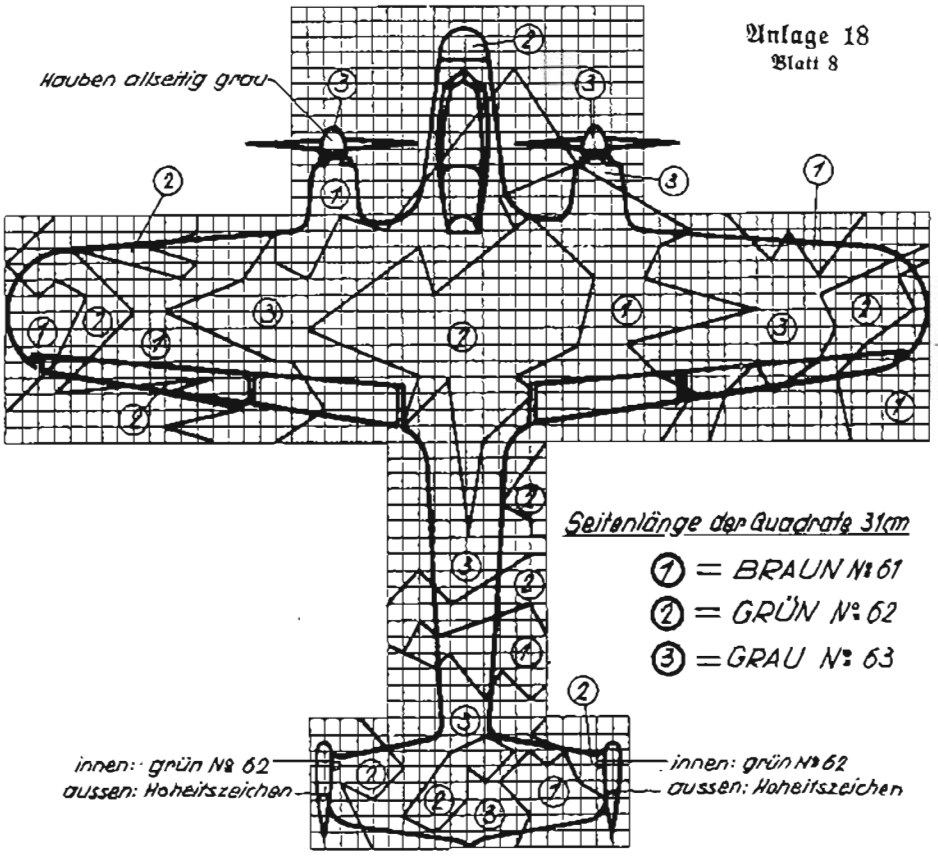


ABOVE AND BELOW: Three photographs of Me 262 A-2, 9K+YH, of 1./KG 51, showing the difference in style of the two production line painters who had camouflaged the aircraft. The port side had soft mottles while the starboard side had a more linear form of application. The nose cone was white, the Staffel colour, the same colour being added to the tip area of the fin and rudder. The style of the aircraft letter 'Y' was most unusual, having a cursive form with a curved lower stroke. Overall camouflage was 81/82/76.



Sichtschutzschaubild 2a

Farbenanordnung A



Sichtschutzschaubild 2a

Farbenanordnung B

Diagram 1a and 1b – RLM splinter pattern applied to the Do 17 airframe

These two diagrams show the standard camouflage schemes introduced in 1936. Both are the same pattern, but in Farbenanordnung B with colours 61, 62 and 63 transposed (61 being replaced by 62, 62 by 63 and 63 by 61 in scheme B). Mirror images of both patterns and both colour combinations were also used. Colours are listed by their RLM designation number and also a written colour description. Note, this form of standard square grid required no size measurements as on later types of grids that used rectangles (see He 111 P diagrams).

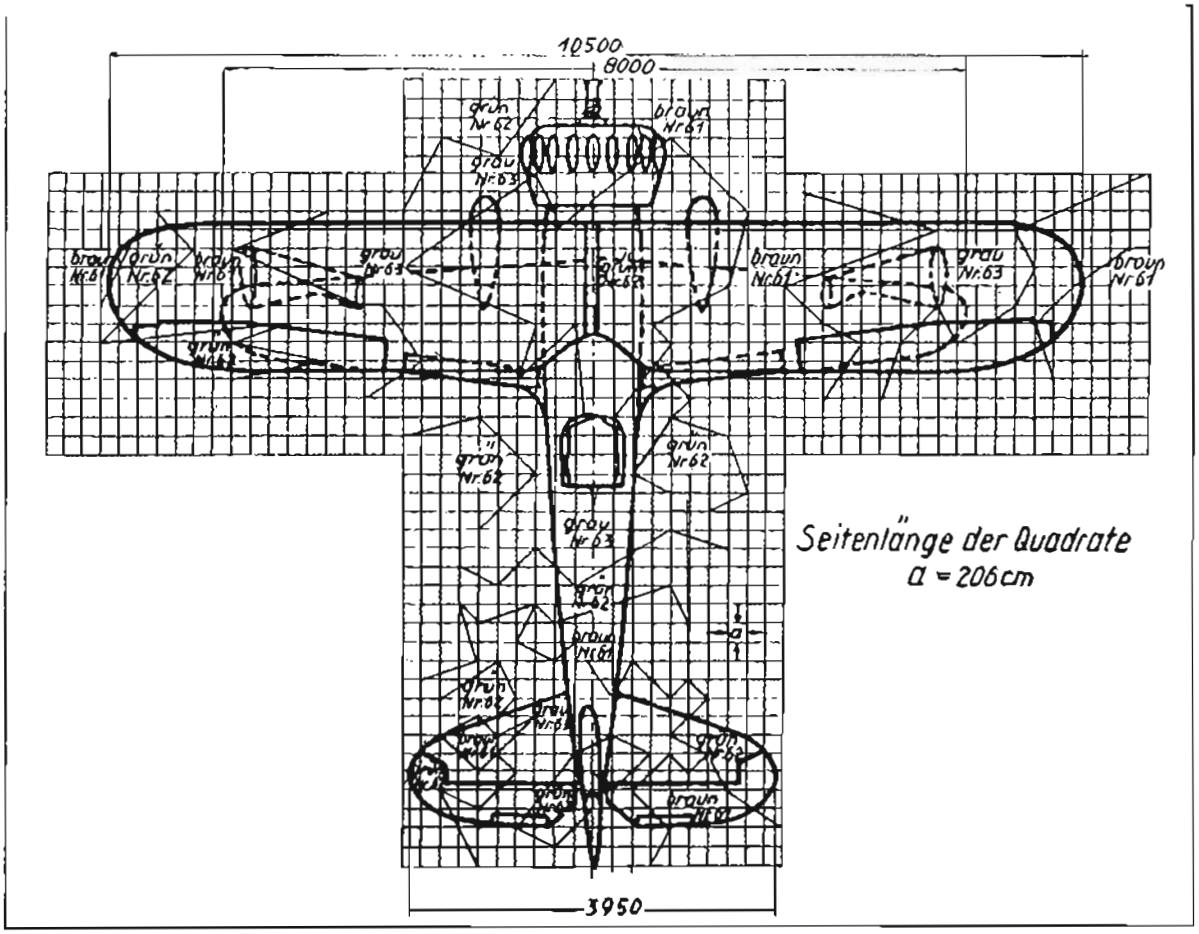


Diagram 2 – Hs 123
Compare this camouflage pattern with that of the Do 17 diagrams. The relative proportions of both aircraft produce a distinct variation in perceived pattern, even when using the same colour distribution in each case.

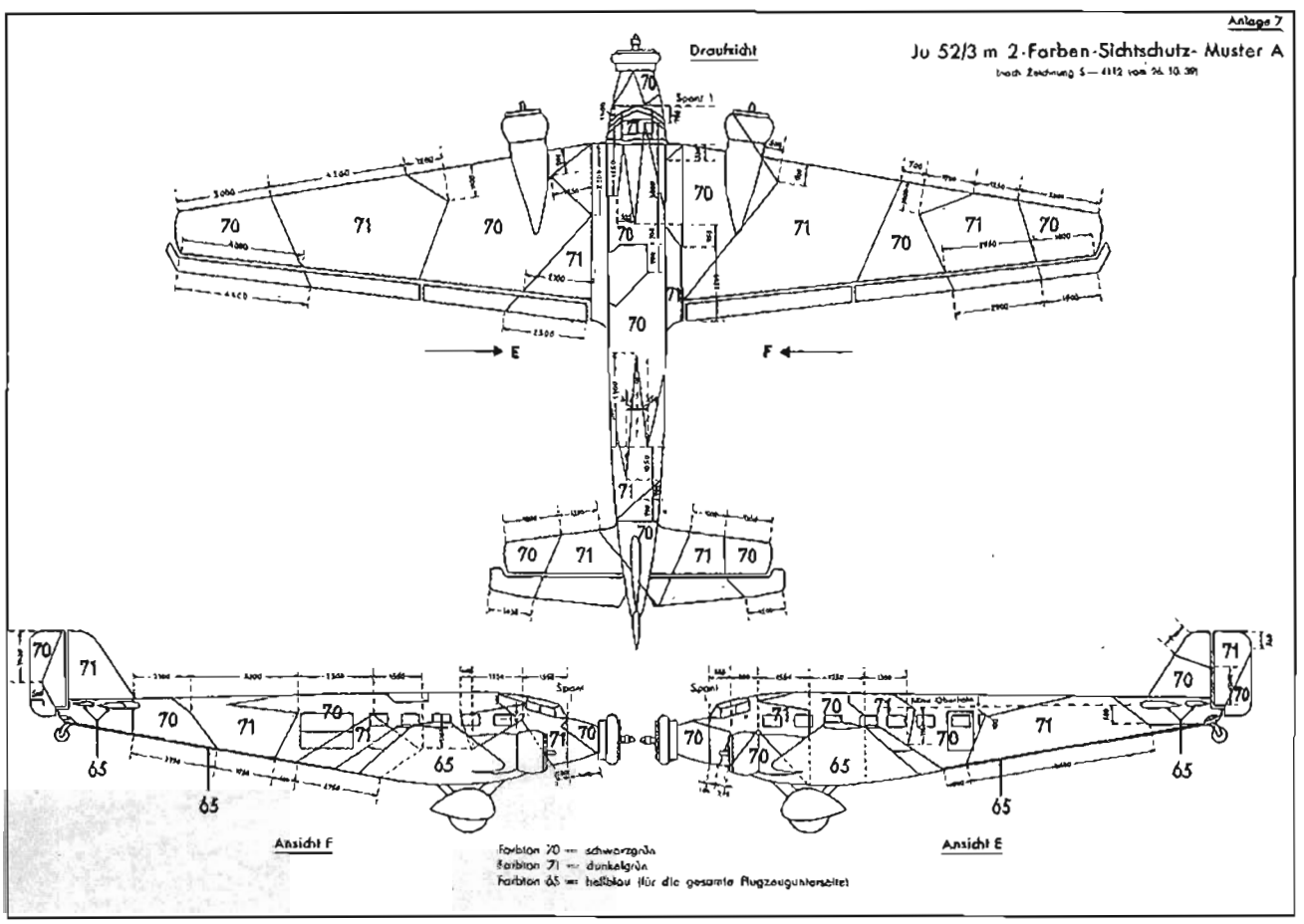


Diagram 3
Ju 52

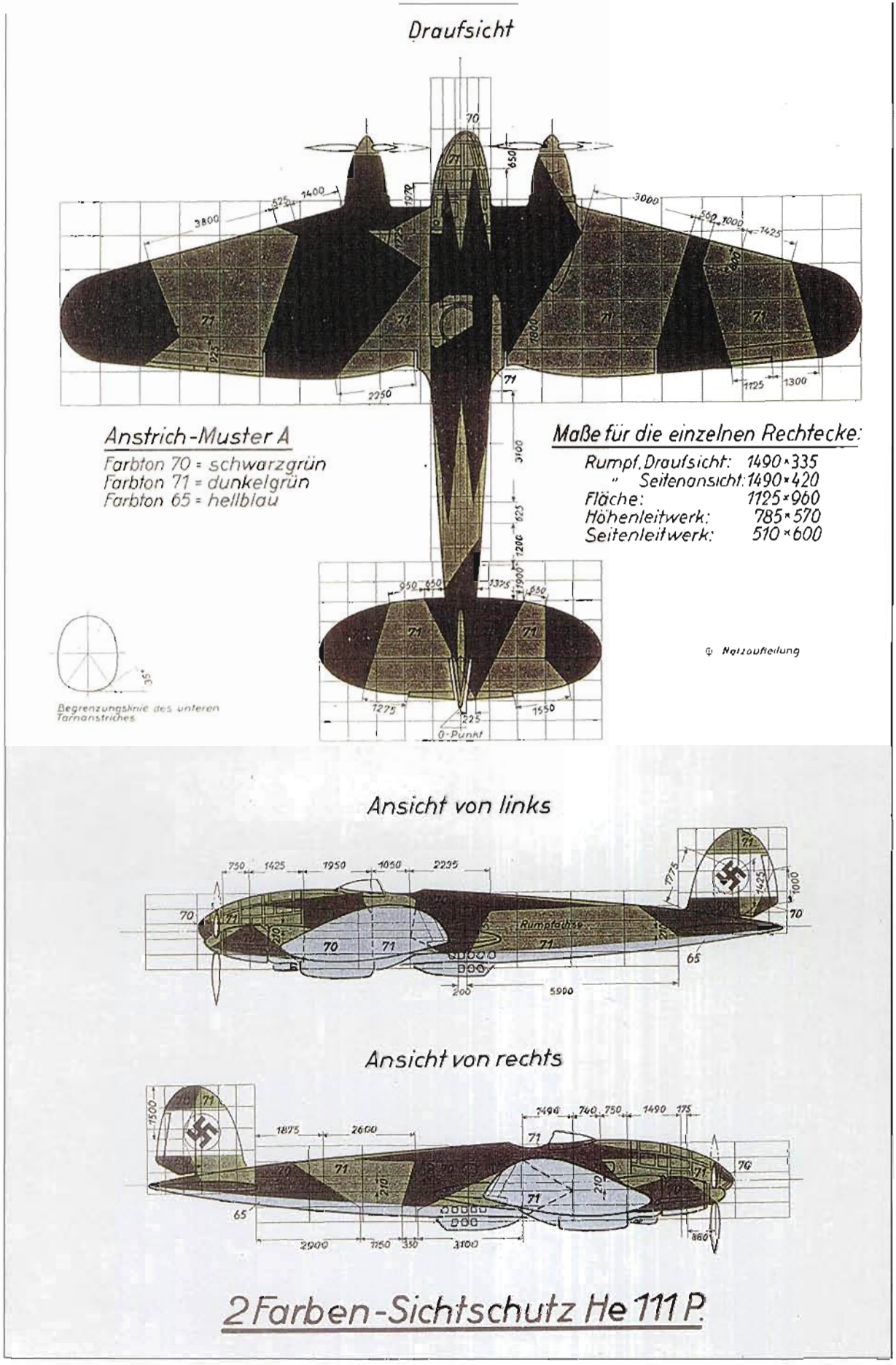
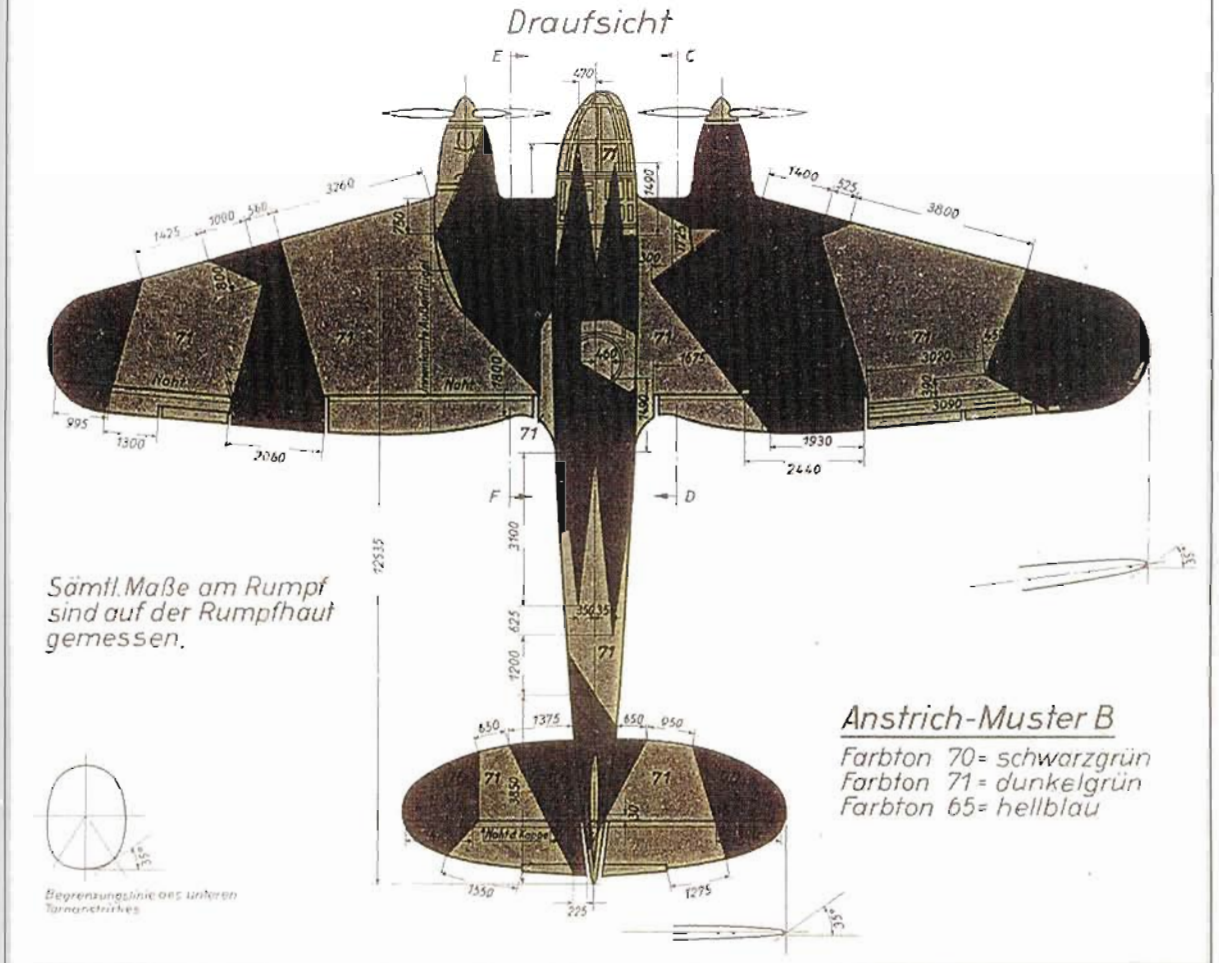
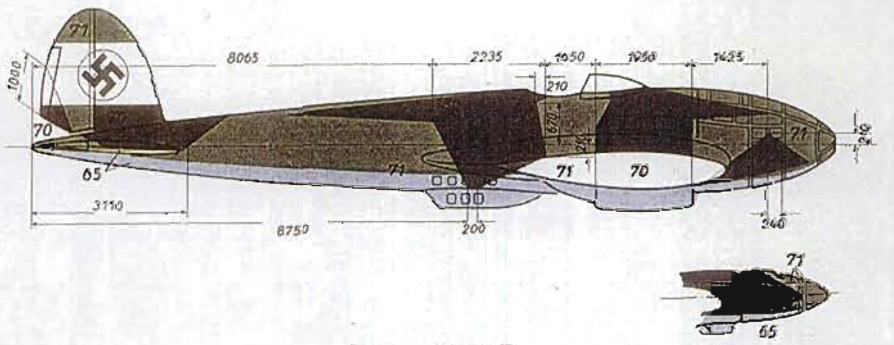
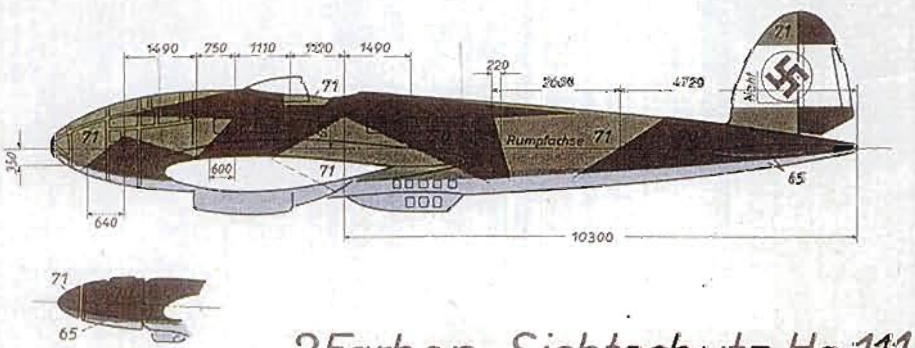


Diagram 4a
He 111 P

THIS PAGE AND OPPOSITE: The changeover to the new camouflage colours of 70/71/65 precipitated a new set of camouflage diagrams for then current Luftwaffe types. The two patterns shown here for the He 111 P illustrate the standard and mirror image applications that could be utilised. Note that these more elaborate plans retained the 35 degree angular displacement for the lowest extent of the upper surface camouflage colouring. The dimensions of each rectangle of the grid are quoted, something that became necessary with the changeover from the earlier system used for the three-colour splinter pattern. Note that camouflage colours are quoted here both by RLM number as well as a written colour description. The distinctive outline of the He 111 required additional grid extensions as mentioned in the text.







2Farben-Sichtschutz He 111 P.

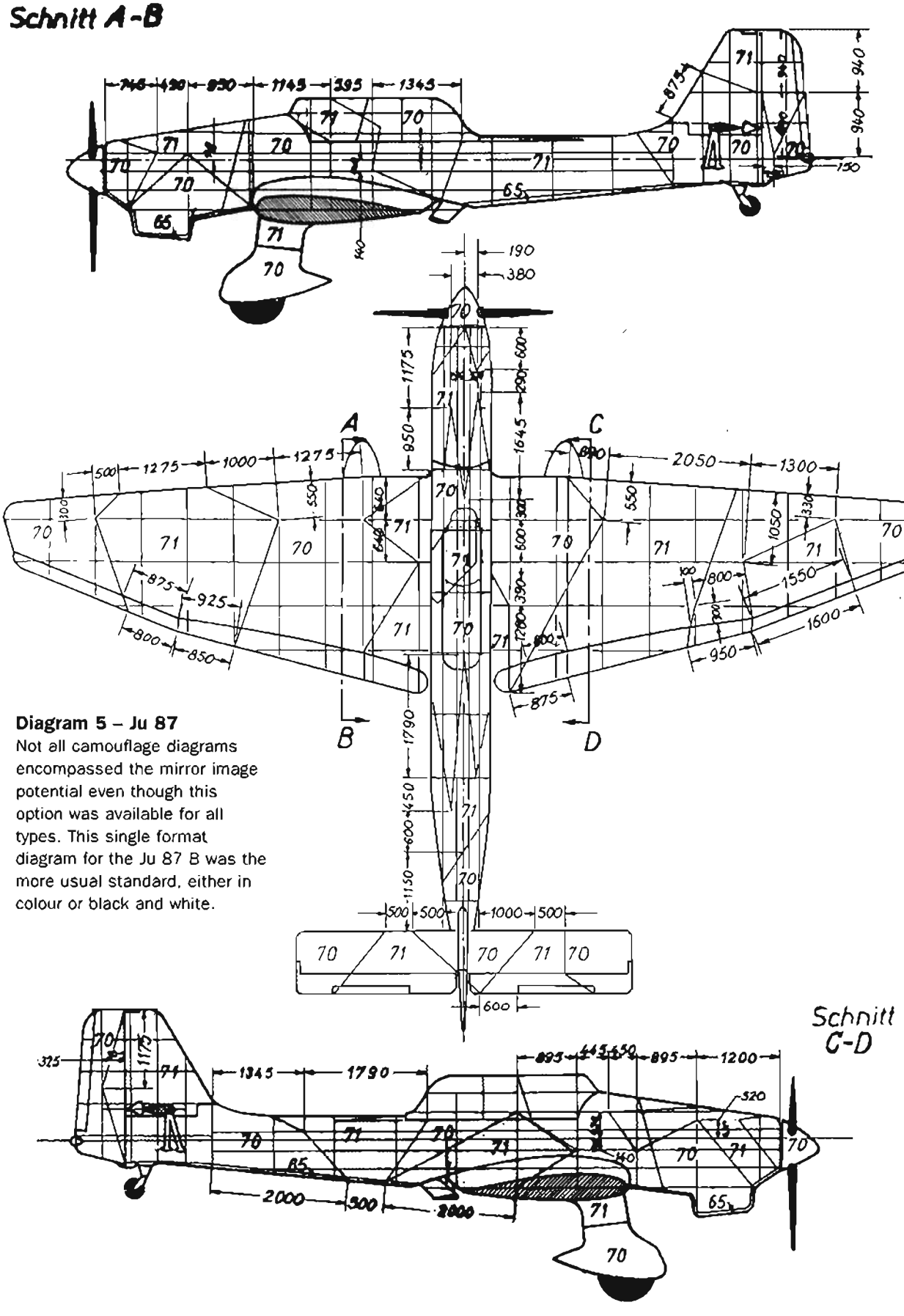


Diagram 5 – Ju 87
Not all camouflage diagrams encompassed the mirror image potential even though this option was available for all types. This single format diagram for the Ju 87 B was the more usual standard, either in colour or black and white.

Diagram 6a – Hs 126

Positioning of the wing relative to the fuselage length produced a slight variation in the splinter pattern. Comparison of these two standard and mirror image patterns with those for the He 111 and Ju 87 B will illustrate the differences. Note that in this instance the grid and its dimensional references have been omitted. Colour designations are quoted both by RLM reference number as well as a written colour description. Note however the simplification of the latter, both greens being given no distinction, simply specified as grün, while 65 is expressed as blau.

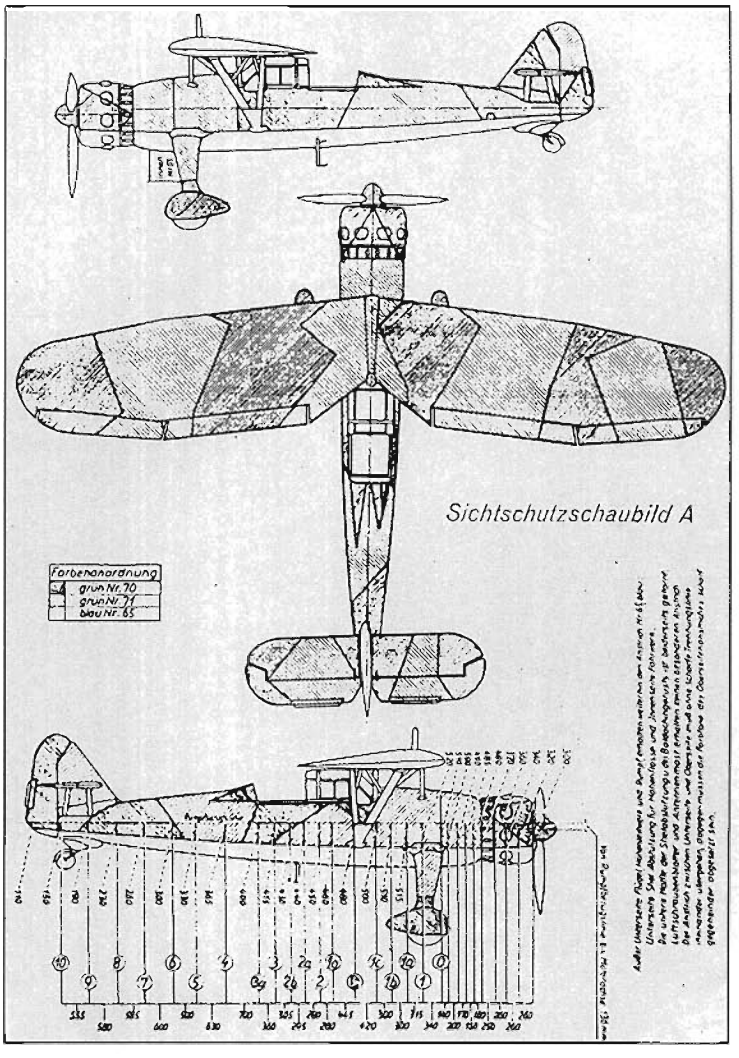
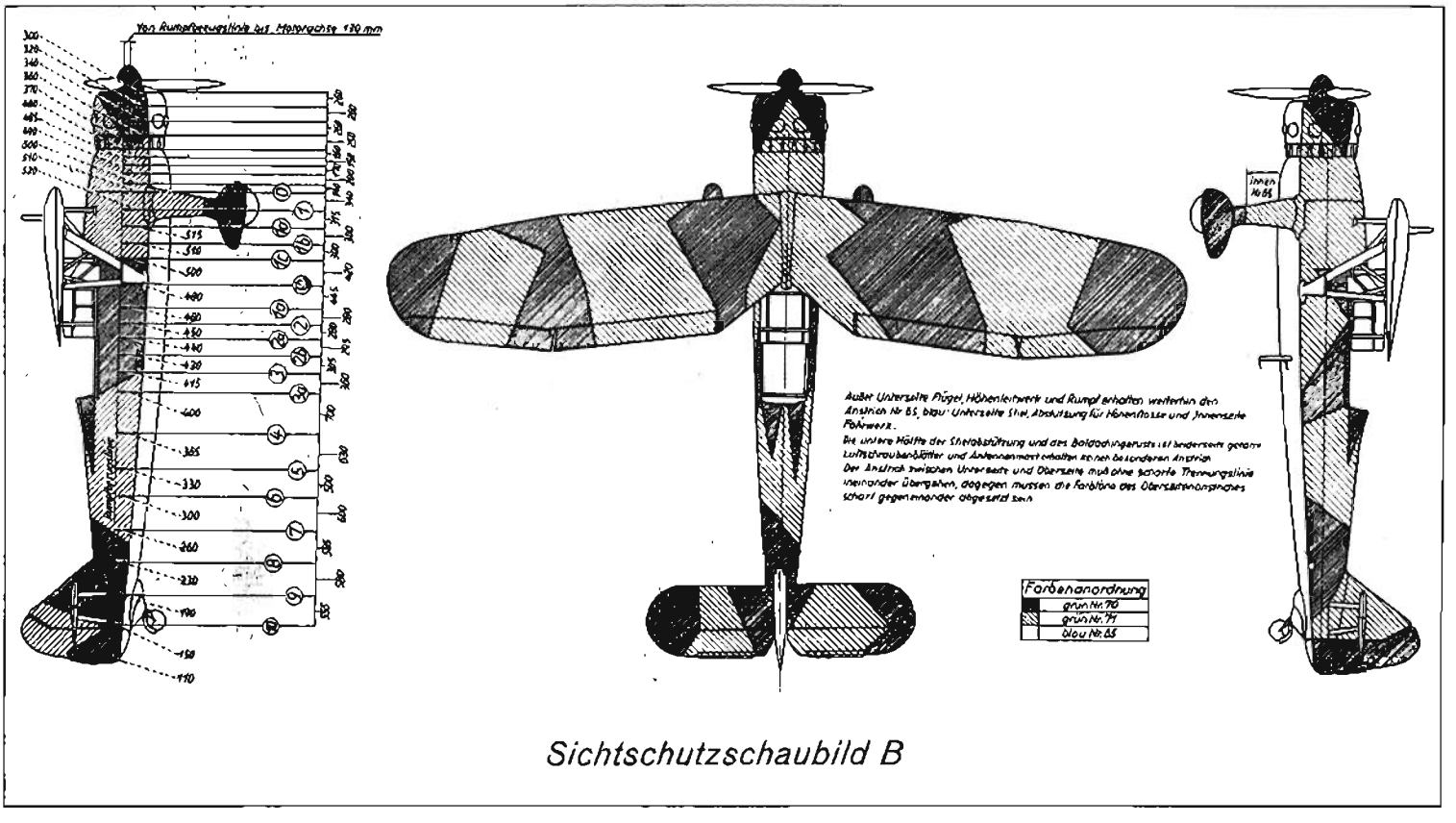


Diagram 6B – Hs 126

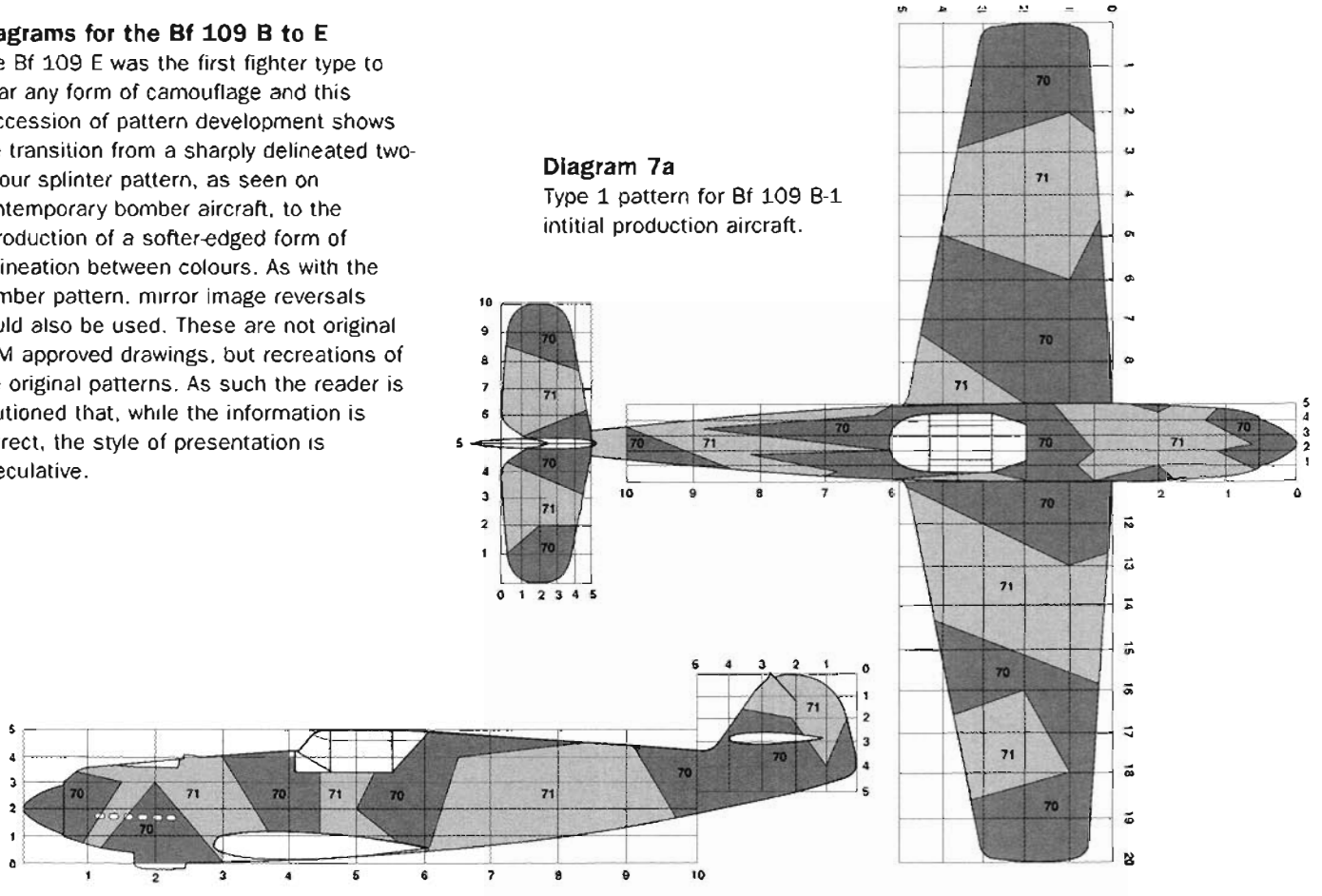


Sichtschutzschaubild B

Diagrams for the Bf 109 B to E

The Bf 109 E was the first fighter type to wear any form of camouflage and this succession of pattern development shows the transition from a sharply delineated two-colour splinter pattern, as seen on contemporary bomber aircraft, to the introduction of a softer-edged form of delineation between colours. As with the bomber pattern, mirror image reversals could also be used. These are not original RLM approved drawings, but recreations of the original patterns. As such the reader is cautioned that, while the information is correct, the style of presentation is speculative.

Diagram 7a
Type 1 pattern for Bf 109 B-1 intitial production aircraft.



Port and starboard splinter patterns of Bf 109s to go with plan-view Diagrams 7a and 7b.

Diagram 7b
Type 2 pattern for late production Bf 109 B-1, B-2, C, D and E-1.

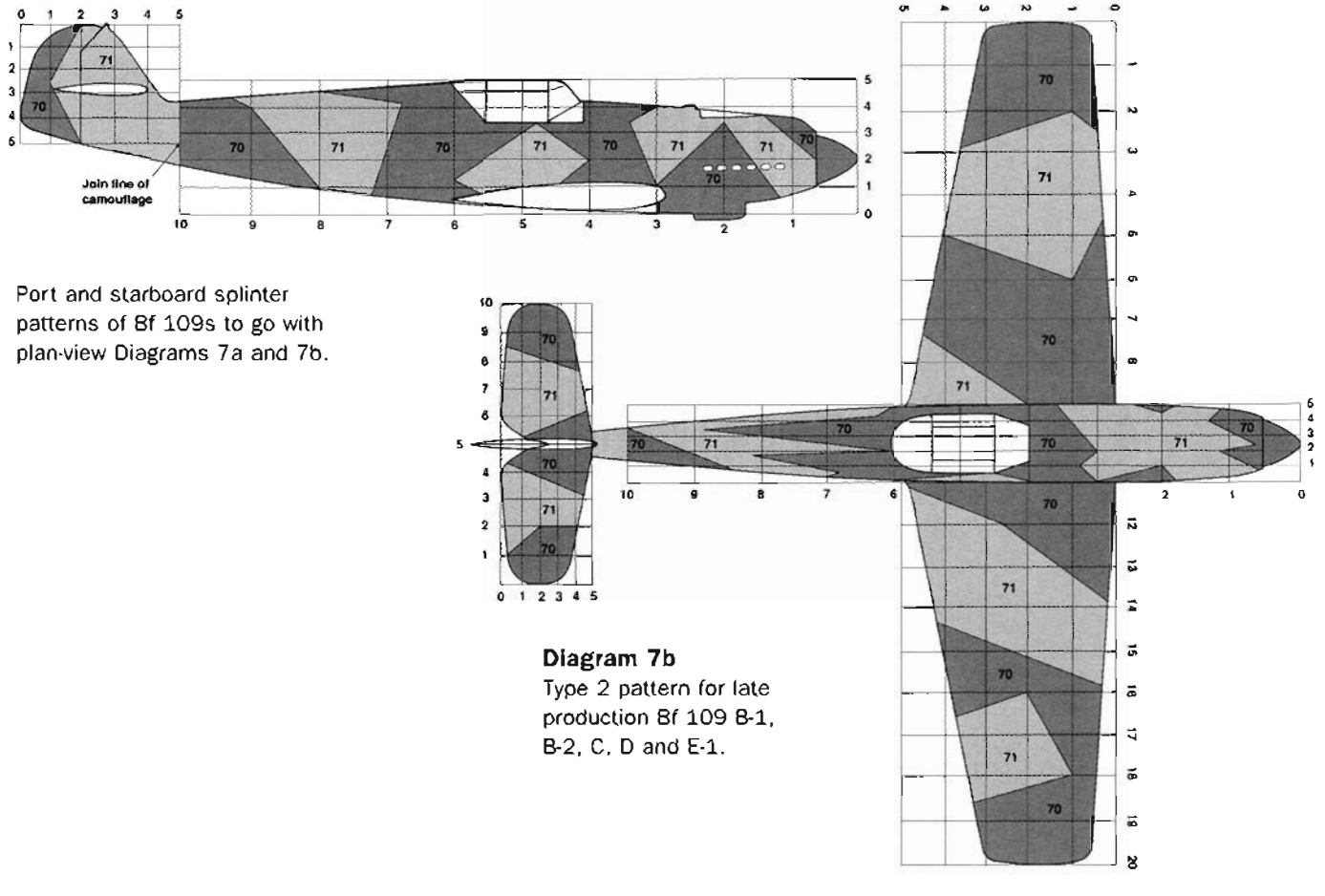
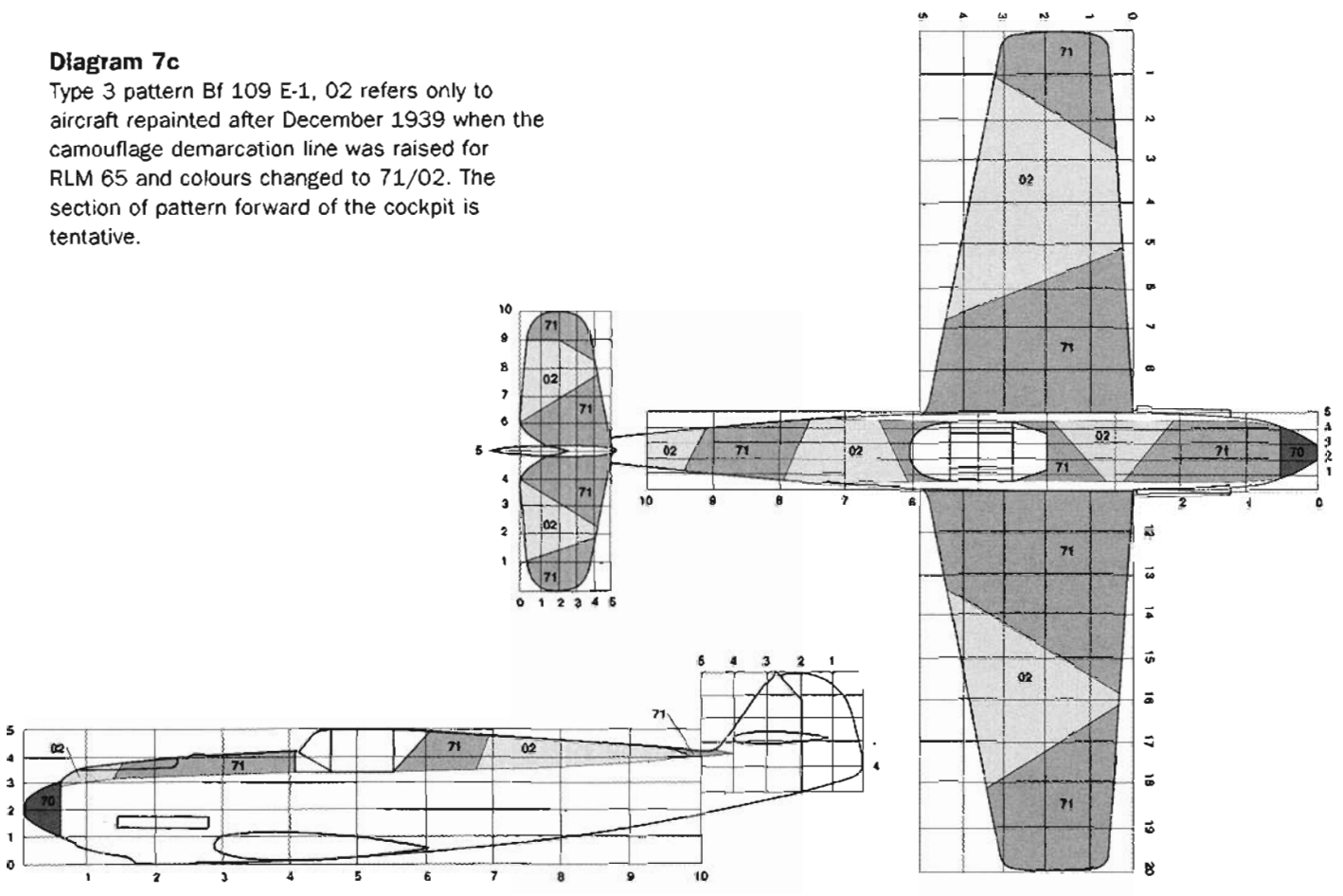
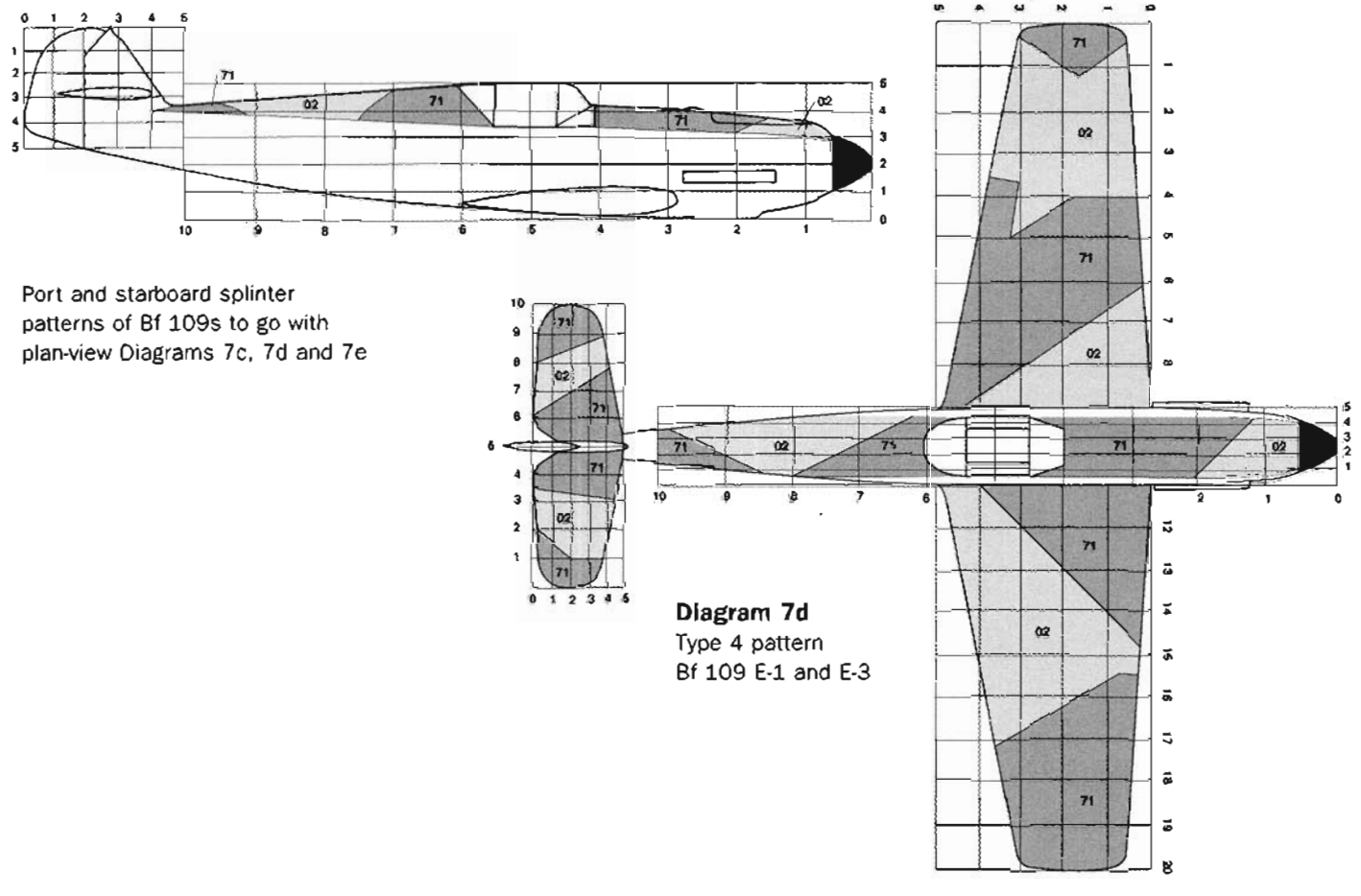


Diagram 7c
Type 3 pattern Bf 109 E-1, 02 refers only to aircraft repainted after December 1939 when the camouflage demarcation line was raised for RLM 65 and colours changed to 71/02. The section of pattern forward of the cockpit is tentative.





Port and starboard splinter patterns of Bf 109s to go with plan-view Diagrams 7c, 7d and 7e

Diagram 7d
Type 4 pattern
Bf 109 E-1 and E-3

Diagram 7e
Type 5 pattern for
Bf 109 E-1, E-3 and E-7

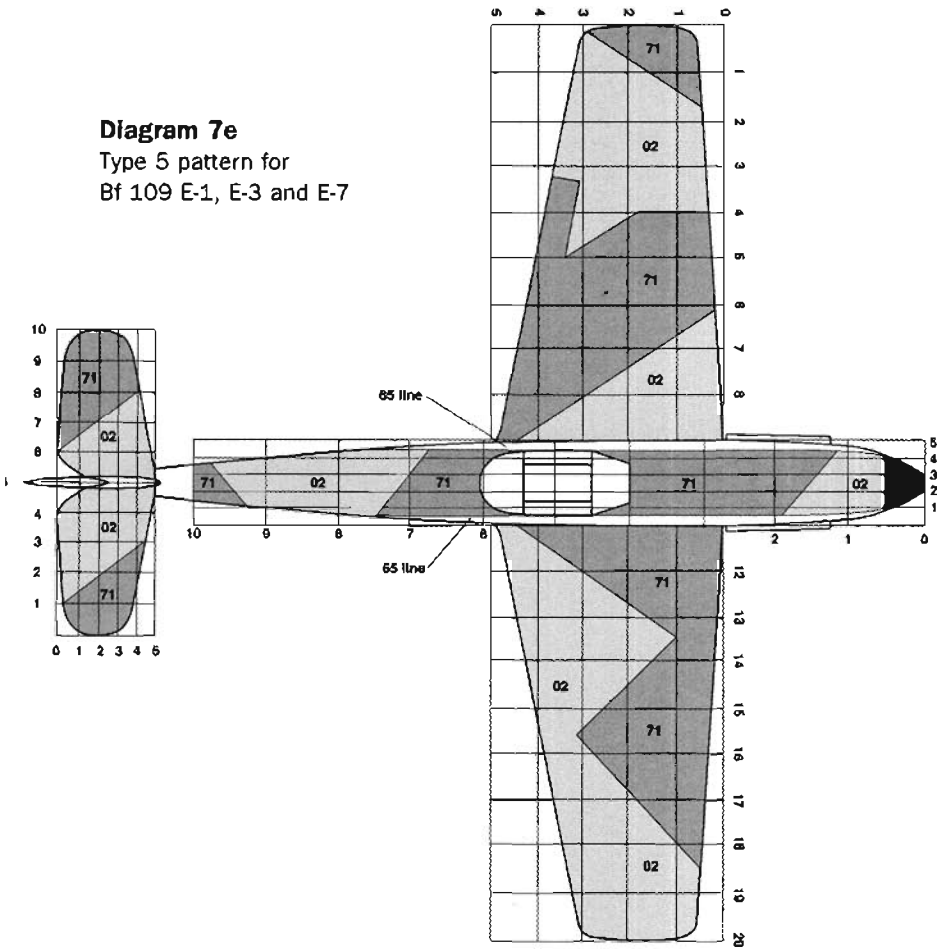


Diagram 7g for the Bf 109 G
(Opposite top)
The Type 7 pattern was used for the Bf 109 G-6 in 1943. It reintroduced some elements of the Type 5 pattern to the starboard wing.

Diagram 8 – Me 262
(Opposite bottom)
The 26 September 1944 revised camouflage pattern diagram for the Me 262 was issued just prior to the RLM decision to abolish camouflage for lower surfaces on day fighter aircraft, something corrected on the 23 February 1945 diagram for the Me 262. This September issue diagram incorporated revisions to the main pattern. Compare it with the photographs on page 67. Refer also to the text on page 184, Chapter 7.

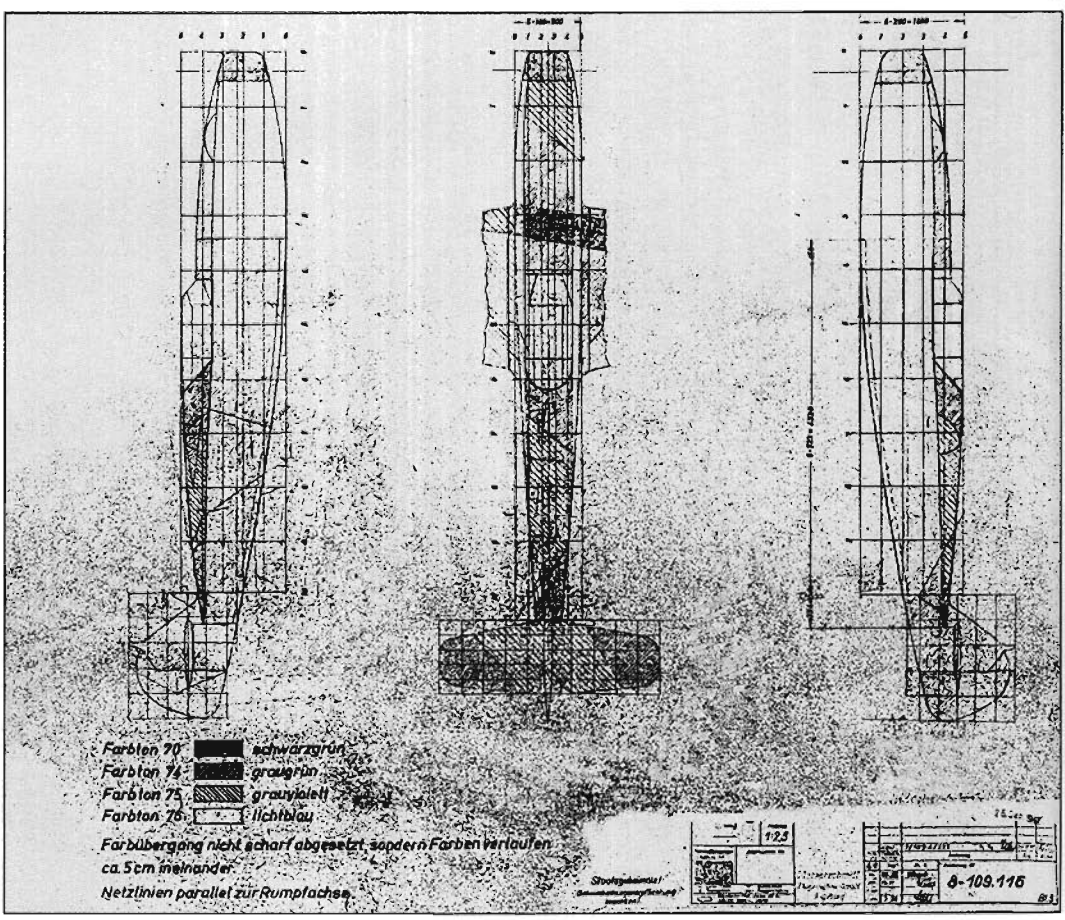
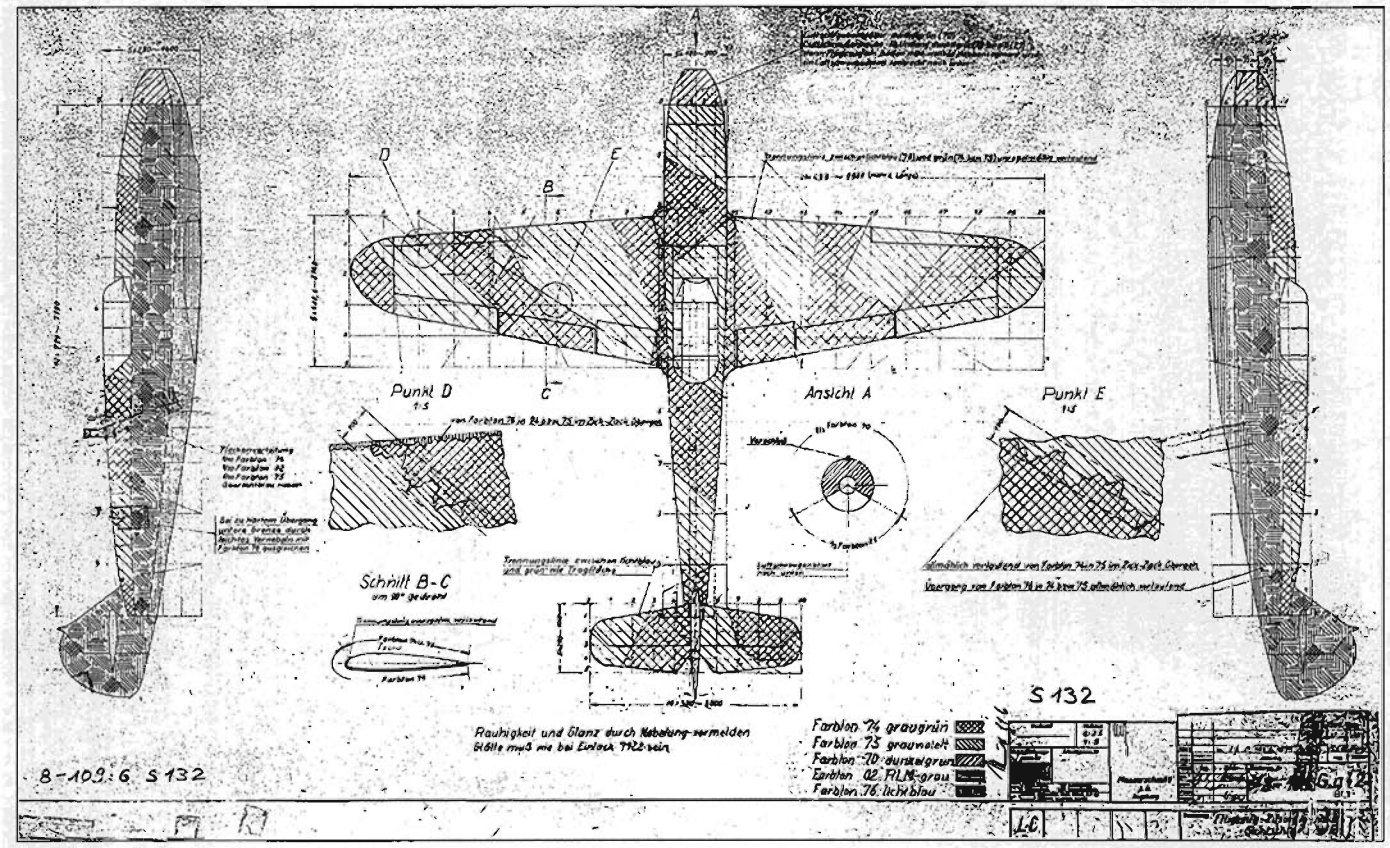


Diagram 7f for the Bf 109 F
Part of the Type 6 pattern introduced on 15 August 1941. Early production Bf 109 Fs had used the existing Type 5 pattern then still in use on the Bf 109 E. It was also retained for the initial Bf 109 G series aircraft.


Punkt D
1:5
Ansicht A
Punkt E
1:5
Schnitt B-C
um 18° gedreht
Farbton 74 graugrün
Farbton 73 graumatt
Farbton 70 dunkelgrün
Farbton 02 FLM-grau
Farbton 76 lichtblau
S 132
8-109.6 S 132

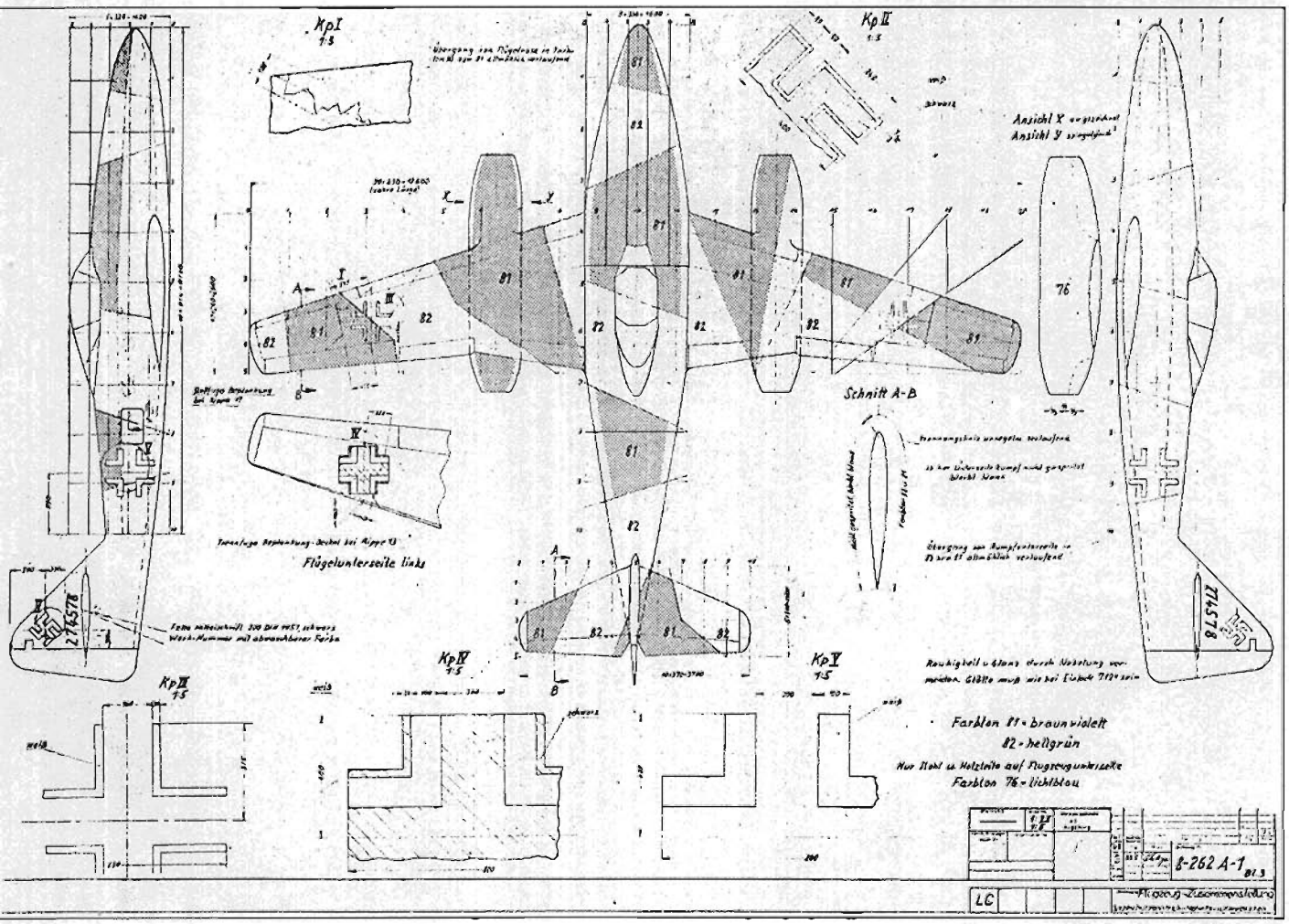
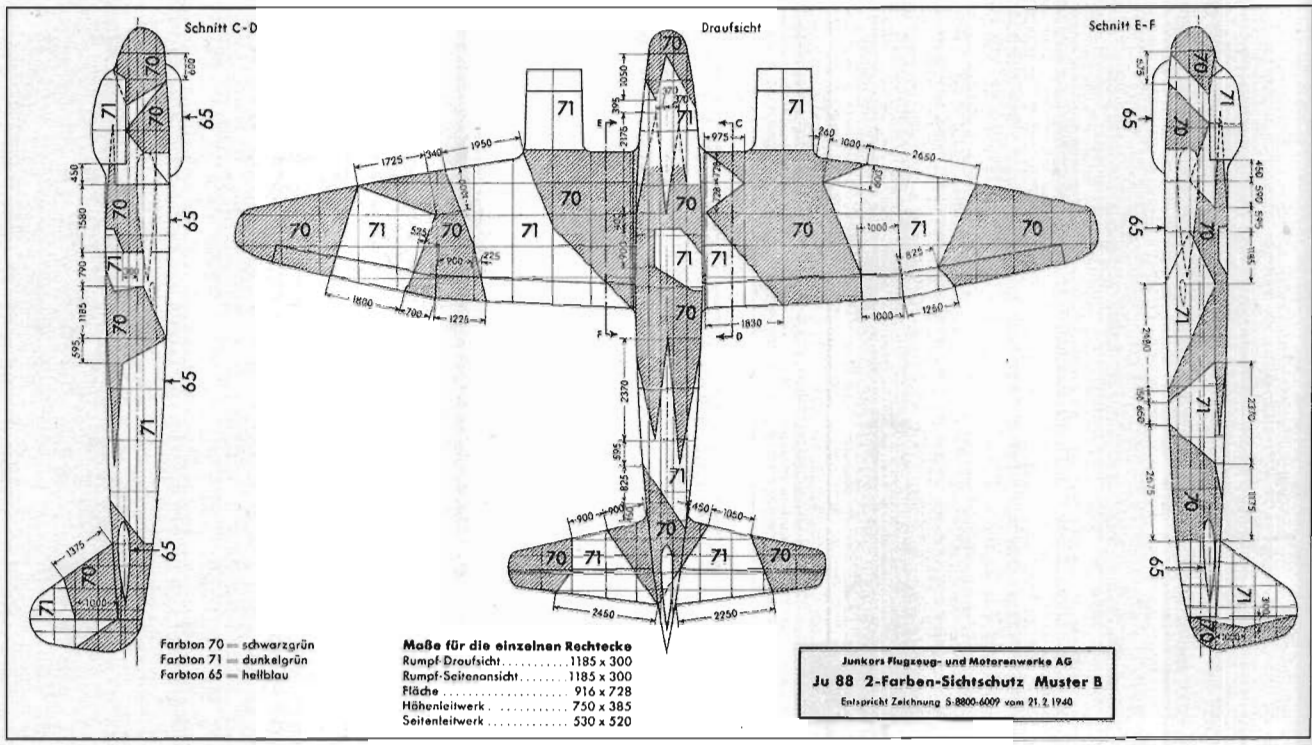
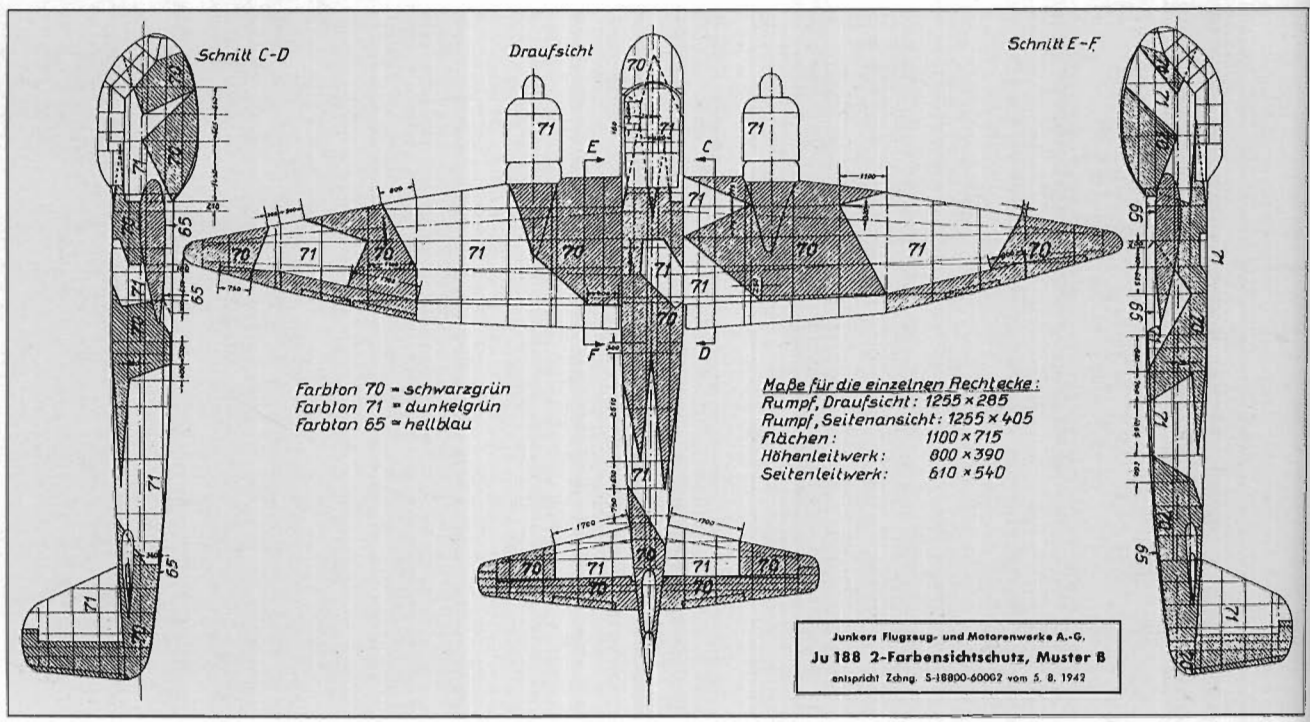

KpI
1:5
KpII
1:5
Ansicht X
Ansicht Y
Schnitt A-B
Flügelunterseite links
KpIII
1:5
KpIV
1:5
KpV
1:5
Farbton 81 = braunviolett
82 = hellgrün
Nur Kiel u. Holzleiste auf Flugzeugunterseite
Farbton 76 = lichtblau
8-262 A-1

Diagram 9
Ju 88 A-4 and D-1
(issued 21 February 1940)



The introduction of a new model, in this case the Ju 188 E-1 and F-1, sometimes required a significant adjustment to the existing pattern allocation. The drawing below, dated 5 August 1942, illustrates the changes made to the existing Ju 88 standard pattern, as comparison of the two diagrams will show. Division of the wingspan into the standard number of segments has spread the pattern, which, combined with the changed relative position of the wing now utilising a slightly different section of the pattern, produced a strong visual difference. The ailerons were given a solid application of one colour, while the flaps were given a solid application of the opposite colour, making a further a distinction to the pattern. The pattern of the horizontal tail surfaces had also been changed, but the pattern on the fuselage remained unaltered.

Diagram 10
Ju 188 E-1 and F-1
(issued 5 August 1942)



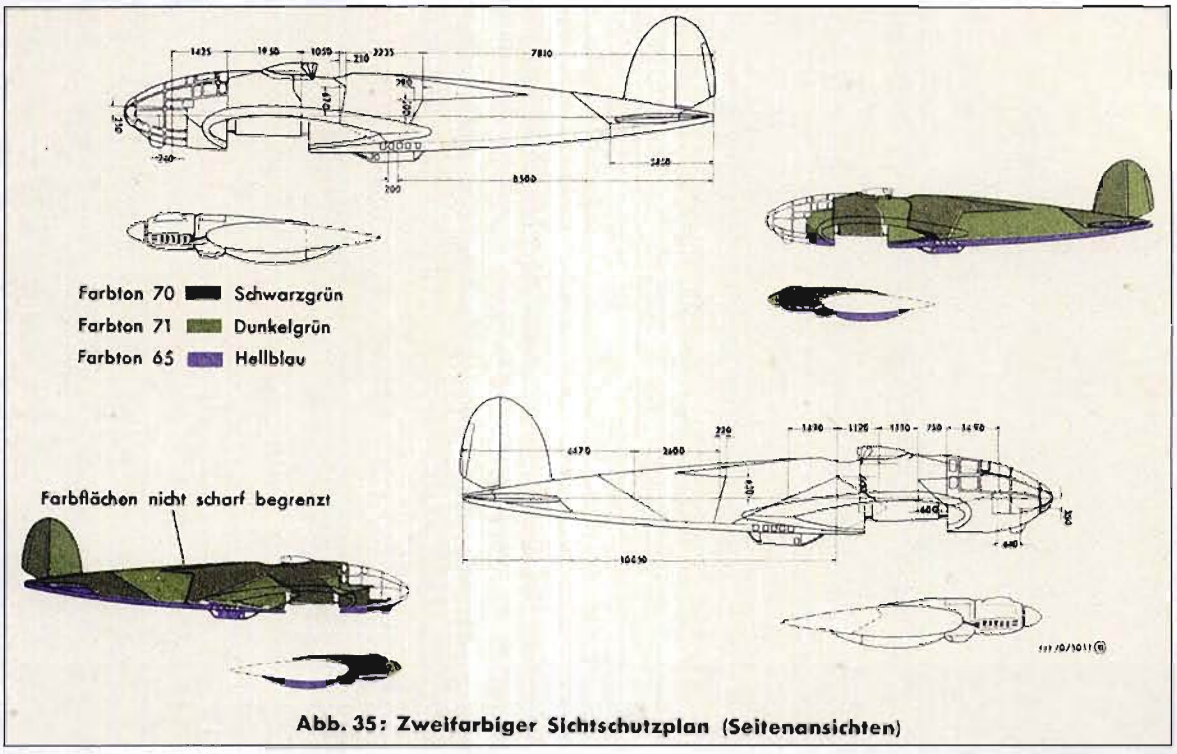


Abb. 35: Zweifarbiger Sichtschutzplan (Seitenansichten)

Diagram 11 – He 111 H-16 from D.(Luft)T.2111 H-16 Teil 0, November 1943, serves also for He 111 H-11 and H-14

Comparison of the A camouflage pattern for the Ju 52, dated 26 October 1939 and the B (mirror image) pattern for the Ju 88, dated 21 February 1940, illustrates the two alternative methods for laying out such diagrams. Both used dimensions set to specific points on the airframe, but the Ju 88 diagram also retained an underlying grid pattern with dimension specified. Note that again colour information was quoted both by RLM number and a written colour description, though in these instances the correct RLM written designations were used. Note the two distinct styles of setting out of the camouflage pattern, that of the Ju 52 being a far simpler representation. The presentation of the camouflage drawing for a single type could also vary, depending in which official publication it appeared. Why such variation in information occurred is unknown, the dates on various diagrams eliminating any suggestion that it was a result of refinement (reduction) of detail. Diagrams were sometimes updated as this one for the He 111 H 16 shows, where the starboard wing pattern has been changed.

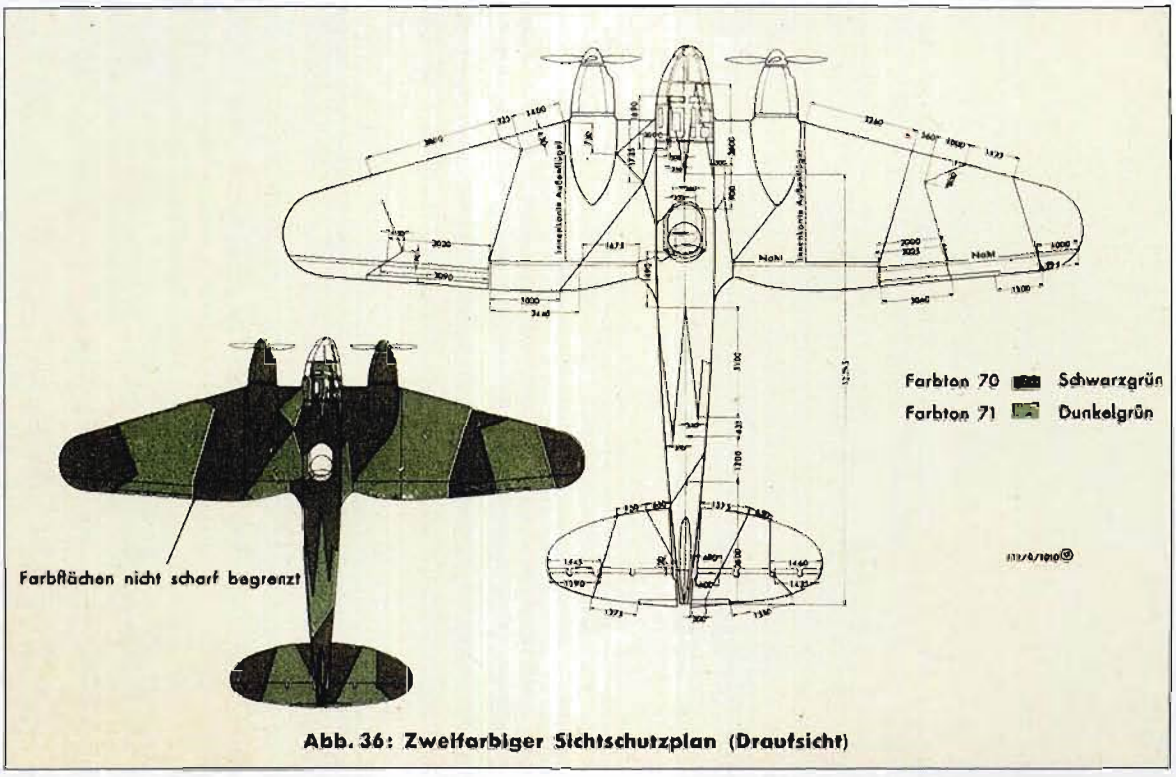


Abb. 36: Zweifarbiger Sichtschutzplan (Draufsicht)

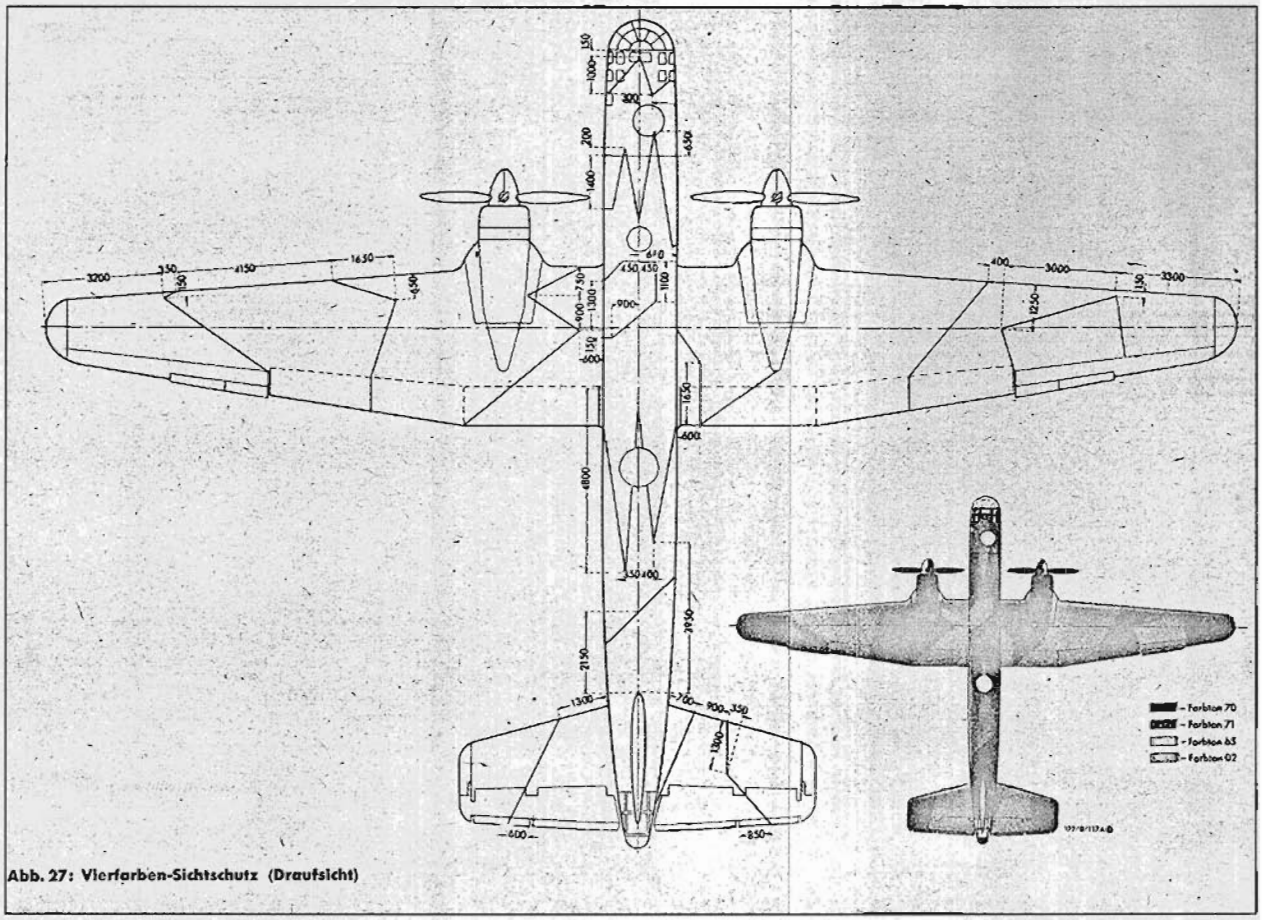


Abb. 27: Vierfarben-Sichtschutz (Draufsicht)

Diagram 12
He 177 A-5
from
Werkschrift
2177 A-5
Teil 0, May 1944

Camouflage diagrams underwent steady development. This one for the He 177 incorporated dimensions set to specific points of the pattern, plus a two-tone diagram, but specified each colour only by its RLM reference number.

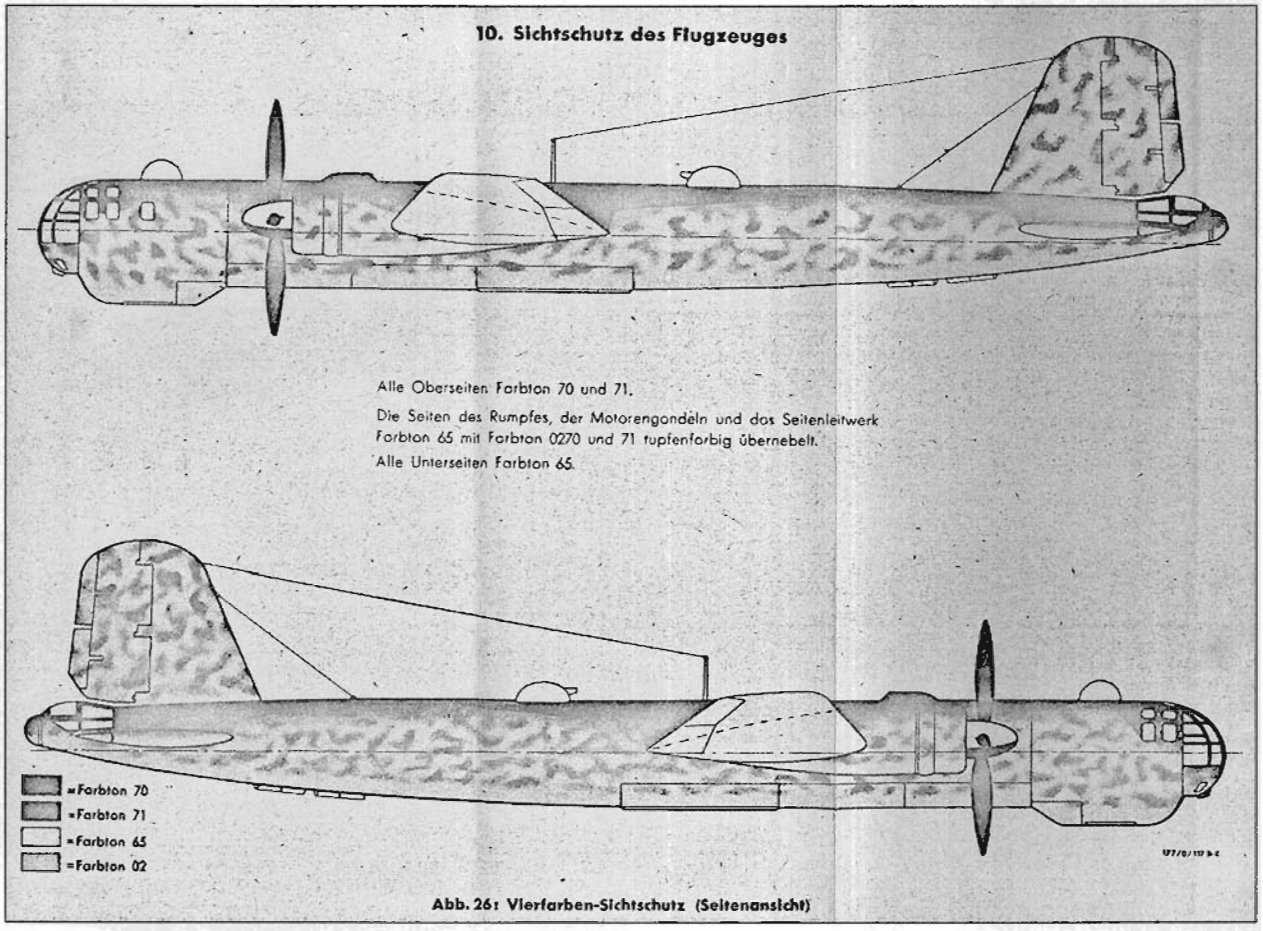


Abb. 26: Vierfarben-Sichtschutz (Seitenansicht)

Paint Composition 4

Between October and November 1945, the German paint manufacturing industry was carefully surveyed by the British Ministry of Aircraft Production which was seeking to catalogue both the extent and nature of German paint development over a wide range of uses. Ten firms were visited, as well as the DVL at Travemünde, and interviews were conducted with the senior staff of each establishment. The result was the British Intelligence Objectives Sub-Committee Report No. E.1462, which provides a wealth of detail on the subject. A synopsis of the findings explains in more depth the nature and application of the lacquers and ancillary products detailed so far in this work, as well as confirming the problems later caused by war shortages.

The chemical composition of the paints and fillers that had been developed by German industry in the 1930s and 1940s was extremely innovative and broad in its scope. Nitro-cellulose varnishes (lacquers) were in widespread use before the war and used on aircraft of both wooden and metal construction. On wood the application was preceded by a special waterproof primer, a penetrating varnish of phenol formaldehyde to which phosphoric acid hardener was added before use. Nitro-cellulose was mixed with a compatible alkyd resin, coloured with red iron oxide pigment, to produce a filler which was then applied. Over this was added a final coat of nitro-cellulose mixed with the required camouflage pigment. This produced a very smooth surface with good aerodynamic properties. The process was flexible and the number of coats of each lacquer could be increased dependent upon the type of wooden structure and its vulnerability to weather.

Phenol formaldehyde had been gradually introduced as the war proceeded but shortages of drying oils, imported from Sweden and South America, (such as tung or linseed), had produced the need for a substitute. Without these drying agents the curing time of the lacquer was considerably extended, a situation not congruous with wartime production schedules. Shortages also caused modification to some long-accepted construction practices, such as the covering of wooden structures with fabric, which had to be abandoned.

Lacquers for metal aircraft were mixtures of resins (oil-modified phenol-alkyds) and oils with sulphur as the metal bonding agent. The primary requirement was for a lacquer film that gave a very smooth surface whilst remaining elastic at low temperatures experienced at high altitude (aircraft metals expand and contract significantly with each flight, which is why aircraft paints of the period had such critical tolerances). For filling rivet holes, a quick-drying putty based on polyvinyl chloride was supplied by the firm of Herberts; a similar product, based on chloropolyvinyl chloride, came from Herbig-Haarhaus. Adhesion of these fillers to metal and the subsequent coats of lacquer to the filler were extremely good. Under questioning, the staff at Herberts volunteered the fact that the prevention of corrosion on light metal alloys produced a significant saving in speed loss, an unprotected aircraft capable of 700 km/h losing up to 50 km/h because of corrosion-produced drag. The alternative process of anodising metal had been put forward, but wartime shortages of electricity prevented its adoption on a broad scale, most applications being restricted to internal surfaces on seaborne or tropical aircraft. The major exception was Junkers, which had become a state-owned firm pre-war; probably because of its economic basis as a State owned facility, it was able to secure more access to electricity. As such, it was the only producer of airframes and engines to make extensive use of electro-chemical anti-corrosive processes. While this form of specialized treatment was used for hydraulic cylinders and pressure tubes in general manufacture, Junkers used it also for structural parts, primarily internally on Ju 87 and Ju 88 airframes. If a surface treated with this form of protection was damaged it was possible to restore the damaged area with a thin lacquer that served a similar function (see colour Chart Nr. 3 for examples of two of these types of electro-chemical finish). It has been suggested that this yellow-coloured 'touch-up' lacquer may have been identified as RLM 32 under the allocation of colour identifying numbers issued for internal finishes, but that remains highly speculative.[1]

Viewing the paint chip samples in these two volumes shows how little colour contrast sometimes existed between certain colours, e.g., 70 and 71, 72 and 73, 80 and 83. The chips are completely accurate in terms of colour, tonal value and surface texture - the latter being a particularly significant factor. Spectral response of the original paint finishes, under certain light conditions, could produce seemingly wide variations in colour (tonal) contrast. Where curvature of parts of an aircraft structure changed their angle to the point of illumination, so also did the light value falling on the painted surface, producing the optical illusion of an apparent change in colour contrast within the same colour. The reverse effect can sometimes also be seen on aircraft photographed in very dull light conditions, producing a monotone camouflage effect.

Paint samples, in addition to stringent testing for resistance to corrosion and fading in a variety of tanks and closed, controlled atmospheric conditioning units, had also been weather-tested under open-air static conditions over long periods to assess durability of colour. While fading was minimal under normal weather conditions experienced by aircraft, the abrasive environment produced by intensive flying did add an extra element to surface change.

Camouflage of buildings, factories and airfields etc., had included a research programme designed to produce paints that would be less susceptible to infra-red than normal types, the assumption being that enemy reconnaissance aircraft might eventually use such equipment to detect sites through their camouflage colouring. Work on this had commenced in 1931 and the RLM had given the programme a high security status, all resulting data being exclusively for military purposes. After ten years of development and much testing, a detailed report was compiled and submitted to the RLM under the title 'Deutsche Luftfahrtforschung, Forschungsbericht Nr. 1502, Infrarotechte Tarnfarben, Neubert Hartmann Gund, Verfaßt bei I. G. Farbenindustrie Aktiengesellschaft '- (German Aircraft Research Report No. 1502, Pure Infra-red Camouflage Colouring by Neubert, Hartmann, Gund, compiled for I. G. Farben Industry Joint Company). The report was signed by the three scientists and dated 23 October 1941.

Among the paints tested were two RLM colours 'Flieglack 70 olivgrün' (the reader may care to note yet another new written description for this standard colour) and 'Flieglack 71 dunkelgrün', which were tested in their original chemical composition and as infra-red resistant paints. That part of the research points to development of what might have been intended as purely ground defensive means when aircraft were at dispersal, or as a counter to air-to-air detection by enemy search equipment based on

infra-red technology. Testing of such apparatus for German night fighters was already in progress though it was eventually abandoned in favour of electronic detection. There is no record of further development, possibly as a result of the lack of deployment for either purpose, of British equipment based on this technology.

Other specialised paints however had been developed and put into manufacture. Petrol resistant, flexible stoving lacquers were required for use on aircraft external surfaces of fuel tanks that were made of mild steel. Tanks were coated both inside and out with a lacquer made from resin constituted from oil modified phenolic compounds. Varnishes (lacquers) were made by melting the resins, running in the solvents, adding the colour pigments and then grinding on a one-roll mill. Red iron oxide was one of the pigments used, producing a reddish-brown colour. The undercoat was oven dried for half an hour and the top-coat for one hour. Without addition of drying oils these times would have been extended and again wartime shortages ultimately forced substitutes to be found.

Butile-based anti-corrosive finishes were also used on some metal surfaces. All metals had to be identified so that the correct treatment was used - and the aircraft industry had many different metal finishes in its inventory. Using the incorrect finish on a metal surface could produce problems that affected the materials applied to it - and from this, other more serious problems could arise. For this reason, RLM regulations required the surface of all metals be stamped with the appropriate identifying code, which had to be marked on the interior surface. This requirement was relaxed in 1944, but problems then arose with stamping codes that were not stable and caused 'staining to appear through the very thin camouflage layers of that period. A code number, usually applied in black (but also in red on occasions), ensured correct identification for treatment, for example, on Aluminium (3000), Dural plate (3116), Dural (3125), Hydronalium 5 (3305), Hydronalium 7 (3310), Hydronalium 9 (3315) and Pantal (3355), all of which could then be painted with lacquer 7122, plus any of the regulation camouflage colours. Fuel tanks employed 3000, 3116 and 3355 and were given a single coat both internally and externally; 3000 and 3355 were also used for the pipes in the coolant radiator systems. Magnesium alloys were identified by a range of numbers, 3501, 3506, 3507.9, 3510 and 3515 Elektron, which produced fine detail castings for parts. The latter process resulted in a thin coating of black oxide that acted as protective finish for the part, eliminating painting completely. Where machining was required, the resulting exposed surface was touched up in black. Wheel castings were a common external example of this finish, often appearing as if painted with black or one of the dark camouflage greens, but in many instances it was simply the black oxide coating. (A fuller explanation of these metal codes is given in Appendix G, Volume Two).

Lacquer composition was subjected to continuous development and new types had been introduced progressively, mostly in response to the declining raw materials situation. Where earlier lacquers and finishes became obsolete, orders for their return had been distributed as part of the control mechanism to ensure conformity of production standards. This should not be confused with the changes to the pigmentation (colour) that had resulted from changes to camouflage requirements. In those circumstances, generally lacquers pigmented with the obsolete colour had to be used up before introducing the new pigmented stock, the only exception occurring in August 1944 when, after allowing time to use up some specifically pigmented lacquers, the remainder had been withdrawn quite abruptly (see Chapter 6) These changes sometimes had been reflected in revised issues of documents for the industry, but actual dates of withdrawal were not always precisely stated.

1 J Kiroff research.

Examples of German paint manufacturers' advertisements as they appeared in newspapers and industrial and aeronautical publications during the 1930s-40s.

Revised Standards and New Colours 1941-1943

5

Throughout the 1930s and up to the end of the Second World War, a progression of changes to standards were made periodically, producing sometimes subtle, sometimes major effects, and these can be traced back through surviving documentation. The 1938 edition of 'L.Dv.521/1 Behandlungs- und Anwendungsvorschrift für Flugzeuglacke Teil 1:Motorflugzeuge' - (Treatment and Application Instructions for Aircraft Lacquers. Part 1: Motorised Aircraft), had been followed by a revised edition on 8 November 1941 issued by the Reichsminister der Luftfahrt und Oberbefehlshaber der Luftwaffe, Technisches Amt. The department responsible had changed its original designation of LC 7 VI to GL/C-E2 VIIC following creation of the office of the Generalluftzeugmeister (General of Air Production) in 1938. GL/C was one of three directorates created at that time and by the following year it controlled development, supply and procurement.

A second volume, L.Dv.521/2, applied to sailplanes and glider aircraft, while a third, L.Dv.521/3, dealt with minor amendments to the first two documents. The first and only issue of L.Dv.521/3 is dated 18 August 1937, reinforcing the probability that the L.Dv.521 series of instructions had first been issued in 1936.

A revised edition of the colour atlas appeared in the 1938 issue of L.Dv.521/1, some of the colours shown on the original Farbtontafel issue of 1936 (part of the Richtlinien B. publication) having been eliminated, but still retaining the contemporary camouflage colours 61, 62 and 63. A further revision to the colour atlas was issued in 1939, this time on its own but retaining the 1938 title, to coincide with deletion of colour 61, 62 and 63 from the camouflage schedules. In September 1939, 'Deckblätter Nr. 1 - 16 zur L.Dv.521/1' (Supplementary Sheets Nos. 1 - 16 relating to L.Dv. 521/1) were issued, quite conclusive evidence of when the revised colour atlas also appeared

The final colour atlas appeared with the updated and last issue of L.Dv.521/1, published in November 1941. The title of the colour atlas had not changed, 'Ausgabe 1938' (Issue 1938) still appearing without modification. Three additional colours had been added, 74, 75 and 76, all greys, none of which was identified by a written colour description. The atlas was marked in the lower right-hand corner as for the previous issue and was the last ever issued.

Surviving copies of this atlas are rare and have lead to misinterpretation in some reference sources, resulting in the presumption that two shades of RLM 65 existed, an original bright blue was replaced in 1941 by a slightly more greenish-blue shade. This shift from the bright blue of the original 1938 charts is the result of slow, but inevitable chemical change to the original colour chip because of instability in some of the minerals used in the formulae. This is the problem, even when relying on original colour material - optimal storage quality has proved critical, but even so, the lack of acid free mounting card upon which the original colour chips were attached is the main cause of the problem, (the RAL Institute storage methods have been the most successful, yet even their examples show some slight, technically discernable evidence of deterioration. Even so, their examples of RLM 65 remain the truest to the original bright blue colour). Appendix E in Volume Two provides a detailed technical explanation of these critical factors.

Tropical colours

The German High Command had not envisaged any form of extended operations in the Mediterranean by land based aircraft and, as such, had made no provision for tropicalised versions of the Luftwaffe's land-based aircraft. However, seaplanes, by the nature of their specialised conservation painting and preparation during construction, which included anodized components, were already able to operate in such climatic conditions.

Italy had declared war against France and Britain on 10 July 1940 and a week later started its thrust into Egypt from its colony in Cyrenaica. This began a series of events that by October had the German High Command looking at an unexpected need to reinforce its ally with air operations from Sicily against targets in North Africa. The fact that the need for tropicalised aircraft was unanticipated is clearly reflected in the following two RLM documents issued in mid-October 1940. The opening paragraph of the first one highlights the urgency. [1]

LC 2/VII *17 October 1940*

To
LC 2/IV

Regarding: Measures for the urgent usage of the production aircraft for tropical usage.

A. Coats of paint

Exterior paint

As urgent measure, the airframes are to be sprayed with aluminium bronze varnish.

1. Aircraft already painted to be cleaned thoroughly with aircraft lacquer detergent 7238 and after complete drying they have to be recaulked at the sheet-metal joints with Ikarol joint paste 50/10 D. Afterwards, the existing camouflage paints to be oversprayed opaque by aircraft lacquer 7108.01. The paint on the underside in the colour shade 65 has to be retained.

2. New, not yet painted airframes receive the following 3 layers of paint:
1 x aircraft lacquer 7102.-
1 x aircraft lacquer 7106.-
1 x aircraft lacquer 7108.01 for the aircraft top side respectively
1 x aircraft lacquer 7108.65 for the aircraft underside

Interior paint

3. Already complete, painted aircraft will subsquently get an additional coat with aircraft lacquer 7122.02 as an interior coat of paint, as far this is possible without disturbing the installed equipment (a spraying with Selenol or similar is not possible, because these materials have a relatively low degree of softness and therefore act as a dust- and sand-catcher)

4. Interior conservation for production aircraft for tropical usage.
a) On these airframes fundamentally, as far as installations are on hand, the light metal parts excluding Elektron have

to have Eloxieren finish [anodised]. *The anodised parts furthermore receive the following conservation:*
1 x flight paint 7118 (dipping paint)
1 x flight paint 7122.02

Elektron- and steel-parts have to be conserved as shown under 4.b).

b) *If eloxal-installations are not on hand, then the interior conservation has to be carried out as for seaplanes.*
1 x aircraft lacquer 7102.-
1 x aircraft lacquer 7109.02

Steel- and Elektron-parts receive
1 x aircraft lacquer 7102.-
1 x aircraft lacquer 7106.-
1 x aircraft lacquer 7109.02

General

Cockpits are to be kept in colour shade 66; this means they receive shade 66 of the appropriate aircraft lacquer. The sole provider for aircraft lacquer 7108.01 is the firm Warnecke & Böhm, Berlin-Weißensee.

B. *Cover fabrics*

1. *For the covering of cockpits and canoples a fabric with a soft underside and a weather-proof, sand exclusive, oil- and solvent resistant Plexolcoat has been developed. The final colour shade is silver grey. The designation of the fabric is 'Komet a'. The producer of this fabric is the firm Mechanische Weberei, Mönchengladbach/Rheinland.*

2. *For the covering of engines and undercarriages a similar lighter fabric without soft interior coating has been developed. This fabric is absolutely light-tight. It is intended to mix into the coat an aluminium pigment to increase the ageing durability. Designation of the fabric '4085'. Producer: Mechanische Weberei Schürenberg, Mönchengladbach/Rheinland.*

3. *For cockpit curtains a double artificial silk fabric has been developed with an inside green and outside silver grey colour shade. Because of the fine weaving, the light-transparency is very low. Production firm Waltenberg, Seidenstoffweberei, Gütersloh/Westfalen.*

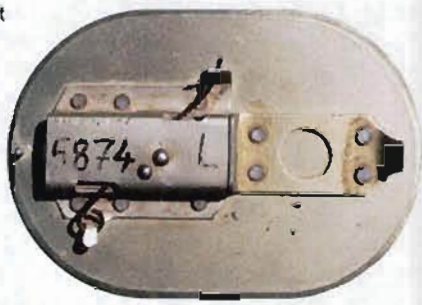
These companies have been instructed to produce a sufficient stock of the above mentioned fabrics, so that shortages in supply may hardly occur. Delivery date is 15.11.40.

As replacement for natural leather the artificial leather '7430 A' of the Deutsche Kunstlederwerke, Wolfgang bei Hanau is provided. In particular, it has still to be confirmed if artificial leather is suitable for upholsteries in tropical aircraft or if a simple upholstery fabric is preferred.

(signature unreadable)

This document refers to two forms of aircraft – those already built and secondly, to aircraft in the process of being completed. The order of precedence is significant, underlining the urgency; existing aircraft had to be modified as there was obviously insufficient time to wait for the required numbers of new production aircraft. Note also the instruction to ensure that delays in deliveries of the 'curtain' (sun blind) material did not occur. The project was very urgent.

The lacquers specified were the same as those used specifically for marine-based aircraft, and which appeared in Fliegjackkette 02; use of 7108 – for upper surfaces on land-based aircraft. In this instance, instead of being used for the water-immersed sections of seaplanes as specified, it was used for the upper surfaces, due to reversal of the main source of corrosion, namely the salt laden atmosphere. For the same reason the 65-coloured surfaces were left untouched and recaulking and sealing with 01 coloured lacquer was only applied to the sides and upper surfaces. Aircraft that were to operate from land over the tropical waters of the Mediterranean would receive their most corrosive influence when parked in the open and subject to the formation of salt impregnated dew at night. The additional coat of 7122.02 for the cockpit areas was also an indication of the environment into which the aircraft were being sent, the sun-bleaching effects being very high compared with Europe. Ju 87s had a small existing advantage as they had all internal surfaces, other than the cockpit, finished in a translucent yellow anti-corrosive, anodised finish, something noted by British Intelligence when they examined a Ju 87 that had been manufactured in February 1940 by Weser Flugzeugbau. The same finish was employed for Ju 88 production and was extremely resistant to corrosion, being described in German documentation as '93Eloxieren'.



RIGHT: The RLM standards, as set out in L.Dv.52/1 specified that tropical aircraft, or those used for maritime duties, had to have an Eloxieren (anodised) anti-corrosive finish on internal parts. The Junkers firm had used the same finish widely on its aircraft, regardless of where they were to be used. One of the Intelligence reports on a Ju 87 B brought down over England in 1940 remarked on the use of that finish throughout its structure. The process produced an extremely durable, shiny metallic finish as shown here. This panel was taken from the underside of the wing of Ju 87 R-2 J9+CH, W.Nr. 5874 from Stab III./St.G. 1, one of three shot down over Tobruk on 14 April 1941 by fighters from 73 Squadron, RAF. The external surface was 65, but inside had been anodised. The aircraft W.Nr. 5874, had been marked in black paint by hand, the suffix 'L' simply denoting 'links' (left).

ABOVE: The same anodised finish was used for the Ju 88 and testimony to its durability is this photograph of a Ju 88, recovered from the sea in only recent years. It is now on display in the Flymuseet in Norway. The resistance to corrosion of this finish is evident. (Flymuseet)

A week later a second document was issued,[2] which, as its distribution list shows, was an internal communique within department LC 2/IV. In the interim the first document would have been issued - with a new heading and RLM code - to aircraft production plants and Luftwaffe servicing depots. The latter handled major overhauls, refitting and some repair work. These were part of the pre-war system and were extended and added to once the Germans had occupied Poland, France and elsewhere. The aim was to have major depots available, within reasonable proximity to the local battle-front, that could handle overhaul or modification of aircraft without having them removed from the front for too long. The perception that front line units carried out major repair or modification work, or major overhauls, is incorrect. Front line staff could replace specific units, such as engines, wings, control surfaces, or ancillary components, but day-to-day running maintenance was their normal limit. Repainting of airframes was not done at unit level either as the necessary infrastructure was not available unless a unit was occupying a large permanent air base, with extended facilities; something that rarely occurred.

LC 2/IV
LC 2 Nr.7499/40 (IVA) g *Berlin, 24 October 1940*
Gef. Fl. 25.10.1940.

Document Notice! ***Secret***

Regard.: Axis situation of the material preparations.
From LC 2/VII the following has been advised:
1.) Coat of paint:
Aircraft already painted must be cleaned thoroughly with aircraft lacquer detergent 7238 and after complete drying have to be recaulked at the sheet-metal joints with Ikarol joint paste 50/10 D. Afterwards, the present camouflage paints have to be oversprayed opaque by aircraft lacquer 7108.01.
The paint on the underside in the colour shade 65 has to be retained.

a) Aircraft lacquer 7108.01:
It will be completed [organized] *by LC 2/VII at firm Warnecke & Böhm, Berlin-Weißensee:*

until 1.11.	*7000 kg paint,*
from 6.-8.11	*further 7000 kg,*
from 10.12.11. remainder together	*20 000 kg.*

b) Ikarol joint paste 50/10 d will be delivered by the firm Warnecke & Böhm in an equal quantity to aircraft lacquer 7108.01.

c) Aircraft lacquer cleaner 7238 will be provided by LC in a quantity according to the number of airframes that have to be resprayed. A corresponding clarification between LC 2/III and LC (Toben) has been made.

2.) Cover fabrics:

a) Curtain fabrics for cockpits:
Double artificial silk fabric - inside green, outside silver grey.
Producer Waltenberg, Seidenstoffweberei, Gütersloh Westfalen.
There is available:

immediately	*1000 sqm,*
by 10.11. a further	*1500 sqm (partial delivery probably earlier, depending on the timing of development of the drying process, which is still not finalised)*
by 15.11. a further	*1500 sqm*

The existing orders from firms and DLH were delayed.
A delivery of 300 sqm to firm Weserflug, Bremen, which was delivered 8 days ago, will be, if at all possible, taken back at the insistence of LC 2/VII).

b) Cover for canopies, engines and undercarriage:

Fabric designation 'Komet a', producer firm Mech. Weberei Schürenberg, Mönchen-Gladbach. There is at disposal:

from 5.11.	*2000 sqm*
from 10.11. further	*4000 sqm*
from 15.11. further	*9000 sqm*

until end of November further 15000 sqm.
Orders exist at firm Schürenberg.
Availability off site is however
Kunstlederwerk Wolfgang at Hanau, where the fabric is being rubberized

Distribution:
1 x LC 2 head
1 x LC 2/II
1 x LC 2/III
1 x LC 2/V
1 x LC 2/VII
1 x LC v. Kapherr
1 x LC 2/IV Vfg.

Again the urgency is implicit in the comment that Deutsche Lufthansa stocks were to be delayed, and stocks already delivered for an existing order recalled.

One interesting, if peripheral, point is the ambiguity in both documents, neither of which, though specifying retention of the 65-coloured areas and repainting of the existing camouflage with 01 as part of the process, mentions restoration of the original 70/71 camouflage - though, from photographic evidence, clearly this was carried out, as no tropical camouflage colours were in existence in October 1940. This sort of ambiguity is easy to spot where there is continuity in documentation, but many researchers have been misled by isolated documents - this writer included.

The first Luftwaffe aircraft to operate in what would be termed 'tropical conditions' were Ju 52s sent to operate briefly from Foggia in Italy, ferrying Italian troops to Albania to help put an end to the Greek resistance that had followed the unexpected Italian invasion of Greece. For such a short operation, tropicalisation measures, as listed above, would not have been necessary. However, by late November the first operational elements of the Luftwaffe were moving in strength into the Mediterranean.

German strategy required that British shipping between the western and eastern ends of the Mediterranean be cut, and Luftwaffe units were to support the Italians in achieving that objective. X. Fliegerkorps was transferred from Norway to Sicily in January 1941 where it assumed responsibility for southern Italy, Sicily, part of Sardinia and part of North Africa. The amount of work tropicalising the aircraft involved would have slowed the build up of numbers ready for operations to some extent.

In North Africa, the Italian forces had suffered severe reversals, and in order to boost their flagging allies, the Germans had begun moving in both land and flying units. The first elements of the Luftwaffe - Bf 110s of 2./ZG 26 and III./ZG 26, plus the Ju 87s of St.G. 3 - arrived at the end of January. In February, the Ju 88s of II. and III./ LG 1 arrived along with more Ju 87s, this time from I./St.G. 1 and II./St.G.2. March saw the Hs 126s, Bf 110s and Bf 109s of 2.(H)/14 begin operations. More units would follow in April and May.

The initial deployment of German forces in North Africa had been intended as only a limited commitment, the impending war against Russia, remaining the main focus. However, it rapidly had become clear that a much longer time commitment would be required if North Africa was to stay in Axis hands. At what point realisation that a specific set of tropical colours was then needed is not clear. Certainly, prior to January 1941, no such need was present, so perhaps somewhere between January and February might be likely.

On 18 April, the following instruction was issued to the Luftwaffe depot at Erding, in Southern Germany.[3]

Carbon copy for LC 2/IV

The Reich Minister of Aviation and High Command of the Luftwaffe — *Berlin 18.April 1941*

LC 2
Nr. 12639/41 (VII) Az.: 70-k-10.18.

To the
Material Office Erding,
Erding

Regarding: Conversion of tropical aircraft

For the conversion of tropical aircraft new tropical camouflage shades have been developed. These have the following numbers:

1.) RLM-colour shade 78 (blue)
2.) RLM colour shade 79 (sand yellow)
3.) RLM colour shade 80 (olive green)

For this change of camouflage, which has to be undertaken by the conversion site Erding the material office will receive initially

9000 kg of aircraft lacquer 7109.78,
4000 kg of aircraft lacquer 7109.79,
7500 kg of aircraft lacquer thinner 7200.-

After arrival of these paint quantities, the airframes for conversion are to be painted over *as follows:*

1.) Cleaning of the present camouflage-paint according to LDV 521/3 with aircraft lacquer detergent 7238.
2.) After an adequate drying time, a solitary opague over-spraying in cross style the present camouflage paint shades for the aircraft top surface.
3.) Spraying of the lower surface of the aircraft with aircraft lacquer 7109.78.
4.) To the extent to which stocks have been provided according to the existing paint list, over-spraying of the paint shade 78 with insulation paint LS. 238.

By order of
(Signed) Reidenbach

The opening lines make clear that these were new colours. The Erding Luftwaffe depot was situated near Munich, close to the Austrian Tyrol that narrowly divides Germany from Northern Italy, an ideal location to prepare aircraft for onward transfer to the new front. No document is known that proves that the Erding depot was the principle or only conversion site for aircraft proceeding to the Mediterranean and North Africa, but it seems most likely that it was responsible for the majority of the initial tropical conversion work carried out in 1940 and 1941.

Two interesting points arise from the document. Firstly, RLM 80, though identified, did not form part of this shipment. Secondly, the inverted ratio of quantities of 78 and 79, the very opposite of what might have been expected since upper and side surfaces would require the most lacquer. Flieglack 7109.-, produced and supplied by Warnecke & Böhm, had been in production for many years. It was originally part of the company's 'Ikarol' trade name paint series, appearing in mid-1930s schedules as Ikarol Decklack 133, and later used with 02-pigmentation. And it was only a change of *pigmentation* that was needed to produce the new lacquer stocks, not an entirely new type of lacquer.

Even so, development of a suitable pigment was a careful and slow process, involving the science of camouflage techniques and much testing. However, this was a unique and unanticipated situation where the geographic locality required immediate availability of an entirely different and unique form of colouring, and in a very short space of time. This drove the time scale, forcing the use of new colours after just a few weeks, pushed on by the urgent war situation. This was in marked contrast to the stringent RLM one-year testing process that had been conducted with the new fighter colours of 74, 75 and 76, which coincidentally would appear around the same time (no documentation is known for the general introduction of 74, 75 and 76, but cumulative circumstantial evidence points clearly to an April/May 1941 date). In addition, instead of a few select aircraft being discretely tested with the new colours, this time an entire front line force of varying types would have to be involved.

Another significant feature of the two new colours was the actual hue of each. The European landscape was a blend of many shades of green and 70 and 71 represented an 'average' of the darkest and lightest of those greens. In North Africa there was but one major colour that resulted from the almost consistent 'sea' of sand, broken only by sparse coastal scrub that showed little variation in its shade of green.

It has been commented on for many years that the swiftness of the German entry into North Africa had caught the RLM unawares in terms of tropical paint colours with many writers, including this one, advocating that initially Italian paints must have been utilised. One reason which supported that incorrect theory was the difference in the strength of tone of the colours seen during the very earliest period of Luftwaffe intervention in North Africa; particularly noticeable were differences between the two shades of 79 recognised from photographs, one being paler than the other. Thanks to the research of Czech author, Tomás Chory, genuine RLM colour samples of the original 78 and 79 colour issue have been located. They not only prove very interesting, but also revealed why the tropical colours had never appeared in any colour atlas, instead being issued as loose paint chips on card backing that were then stuck into the L.Dv. 521/1 manual, on the blank page 40 marked 'Anlage 1' (where the loose colour atlas was normally housed), as the accompanying photograph shows.

ABOVE: This photograph shows the original shades of colours 78 and 79 as well as their method of distribution to the industry. They were stuck into the 1941 edition of L.Dv.521/1, on the blank page opposite the section that contained the standard colour chart. (T. Chory).

This marked a significant departure from the previous practice. As such 74, 75 and 76 were the last colours to appear in any colour atlas; thereafter only colour chips had been issued to the end of the war. The fact that 74, 75 and 76 had been issued at about the same time as the new tropical colours was coincidental, the urgency of development and issue of the latter no doubt precluding opportunity for them to be added to the revised colour atlas, even though it did contain spaces for extra colour samples. That omission underscores the unusual nature of the introduction of the tropical colours as well as the time period for the acceptance of the final colour shades. The 1941 issue of L.Dv. 521/1, which contained the last colour atlas, is dated November 1941. Had a final decision on exact shades of 78 and 79 been reached in time, those colours undoubtedly would have been included in the atlas. This absence of the colours provides a provisional time marker for the final selection of the precise shades. The best refinement of a date points to the close of 1941 or early 1942 – and that also could account for the continued availability of stocks of these early colour shades at some airframe manufacturing plants (once paint stocks were made available for the main manufacturing cycle) as detailed further on in this chapter.

Only chips for 78 and 79 appeared in L.Dv. 521/1 and its civil equivalent, not 80, which adds a little more proof to the contention that 80 was never issued to the main aircraft manufacturing plants, being

sent to conversion, overhaul and repair depots, as well as being issued in very small quantities to front line units for touch up work. As such, a loose chip for the colour had probably been issued directly to post-production facilities and front line units, the main manufacturing plants not requiring sample cards. All aircraft known to have received tropical camouflage at the point of manufacture exhibited just a 78 and 79 finish. The diversity of style of application of 80, where it occurred, also is visual testimony to more disparate sources of application.

The fact that the Erding site did not receive stocks of 80 with the first shipment of tropical colours probably hinged upon the extreme urgency for this site to handle the increasing flow of aircraft to North Africa. The initial requirement appears to have been to bring aircraft to a standard state, namely 79 upper and side surfaces with 78 below. The addition of 80 was to be addressed as and when required by actual geographic locations. It must be remembered that the Luftwaffe was already in North Africa by the time of the first deliveries, and Erding was by then processing additional aircraft that had already left the main production plants in standard European camouflage. As mainstream production centres took into account specific allocations of aircraft to the North African theatre of operations, those aircraft were completed in standard 78/79 camouflage, leaving 80 to be added by maintenance depots, such as the one at Erding, or one of the similar facilities in Sicily. Erding's role, on the route from Europe into North Africa, was more involved with the processing of aircraft passing through, rather than with new aircraft being sent to North Africa, tropicalising engines and changing camouflage.

The two colour chips revealed why the discrepancy in colour shade had been commented on for so many years. The initial 79-colour was paler than the one that replaced it, while the 78 blue was a darker, more saturated colour shade than the brighter blue colouring that replaced it. The 79-shade was an exact match for the desert sand of North Africa, something the author has been able to confirm from an access panel taken from a Ju 87 shot down over Tobruk in 1941. The panel retains its 70/71/65 camouflage and has sand embedded in the internal lock system, some of it crushed to a fine powder that has stained the surface- and its sand colour matches the pale 79 sample exactly. Presumably, the pressing need for new colours for tropical use had resulted in E-Stelle resorting to matching the actual, all pervading, monotone desert sand colour, approving 80 as an added colour only if needed, to match the green of the coastal scrub encountered in some areas.

Unfortunately, an exact match is not as successful as a slightly darker shade, because the intensity of sunlight makes objects, even those painted with matt paints, reflect some light, giving the colour a paler appearance, (an official German document on camouflage principles made reference to this factor, stating that it was better to keep camouflage one or two shades darker). In the air the paler shade of 78 worked, but on the ground it was less effective. In addition, the extent of the rapid fade factor had not been allowed for, probably because at the time of establishing the new pigment shade there had been no intention of deploying Luftwaffe forces to North Africa long term. Its replacement colour, a distinctly darker shade, allowed for both factors.

The blue presented the reverse situation in that the colour toned down with illumination, blending into the sky. Keeping it several shades darker negated the value of the optical effect though, and the paler and brighter chroma of the colour that eventually replaced it was a much better match for the desert skies. This apparent 'mistake' is discussed a bit further on. The inverted quantities of paint stocks delivered to Erding also seem odd. Why 9,000 kg of 78 blue, but only 4,000 kg of 79 sand yellow? - an inversion of quantities that one would normally expect, given that aircraft generally used approximately two thirds upper and side/surfaces colouring to one third lower surface colouring. The document announcing the first supplies of the two colours clearly specified the sand colour 79 for upper surfaces, and the blue colour 78 for the lower ones, there being no cause for confusion of purpose from that directive. But why such a deep blue colour? A clue may lie in an event that happened 18 months later. However, the reader is cautioned that what follows is pure speculation, based firstly on the curious disparity in the paint stocks delivered at a time when Luftwaffe aircraft were not just commencing operations in North Africa, but had been - and would continue - to conduct shipping and coastal attacks and attacks on Malta; and secondly, the deep blue of the 78, deeper than any sky colour camouflage ever previously used by the Luftwaffe.

Late in the evening of 21 October 1943, a Ju 88 A-4/trop landed at Dübendorf airfield in Switzerland. En route from Germany to its 1./KG 54 base at Bergamo, in Northern Italy, the crew had become lost and with failing fuel reserves they landed. The main feature of B3+MH, W.Nr. 550396, was its unique camouflage, described by the Swiss Intelligence report of 23 October as '*Farbe: Oberseite Wasser - und Wüstentarnung, Unterseite Schwarz*', (Colour: upper surface water - and desert camouflage, underside black). The choice of colour descriptions was unique, water and desert (sand). The report failed to mention the black snaking lines also present over the entire upper and side surfaces, beneath the snaking lines of sand colouring. The term 'water' was meant to describe a shade of blue, but in studying the photographs of the machine, and comparing the colour with the 79-coloured lines, this was a much darker shade of blue than regulation 65 or 78 that subsequently came into use, either of which might otherwise have been applicable.

Other Ju 88 A-4s of the unit, at Bergamo in 1943, show a similar dark finish with pale, snaking lines. In black and white photographs, both B3+MH and the other unit aircraft give the appearance of the usual dark green upper surface camouflage colours with snaking lines of 65 over them. Had it not been for the Swiss report, and very high quality photographs of the aircraft, supplied by the Swiss Air Force Museum, the strange camouflage would not have been distinguishable. The paleness of the sand-coloured lines also accords with the first shade of 79 issued, looking more like 65 in black and white images. The aircraft data plate showed that the parent firm had completed it on 13 November 1941 and the Swiss report noted that the aircraft was in excellent condition, reinforcing the supposition that it had just been refurbished. The dates also correspond to the normal Luftwaffe maintenance schedule of two years between refurbishment of the external lacquer finish.

As noted above, the overall dark blue colour had snaking lines of permanent black over which pale sand coloured lines had been added. Undersurfaces were finished in permanent black, though the engine cowlings had only part of their lower surfaces sprayed solid black, snaking lines of the same colour being used in some areas.

1./KG 54 had moved to Sicily in December 1941 where it came under the command of X. Fliegerkorps. It had then moved to Crete in June 1942, but was back at Catania, in Sicily, at the beginning of 1943. Its operational deployment had been over water for most of that period, which might explain further the reason for adopting the unique 'sea' camouflage. The few other photographs of aircraft from this unit show the same snaking lines over a darkish camouflage, with dark snaking lines on the pale under surfaces, something found on B3+MH, but obscured in parts by the more solid application of night camouflage.

Given the disparity in paint stock quantities, plus this odd colouring, it is possible, in theory at least, to propose that the RLM had intended the darker shade of 78 to be used not just for lower surface colouring, but perhaps also as an upper surface colouring for an over-water scheme, the snaking lines of black and the sand colouring making it particularly effective in the Mediterranean area. The speed with which the new tropical colours had appeared may have influenced a decision to compromise with the blue between use for over-water camouflage and sky camouflage. That would have simplified not only the colour development process, but also the production and shipping factors.

Another report on a Ju 88, from the same unit, found at Foggia after the German retreat, adds a little more to this seemingly strange choice

LEFT: The Ju 88 A-4 of 1./KG 54, W.Nr. 550396 coded B3+MH, which landed at Dübendorf airfield on 21 October 1943. It wore a most unusual colour scheme as explained in the main text. The reduced form of Balkenkreuz, half size, was marked only by the white angles, dulled to an off-white colour. The original, full size marking could just be detected where it had been painted over. The Balkenkreuz markings on the wing upper surfaces were full size but shown only as narrow, off-white, outlines. Note also the yellow wing tip markings, something omitted from the Intelligence Officer's report. What appears to be two shades of base colouring is actually a single overall blue colour with lines of permanent black sprayed in snaking lines (Arabesken). The snaking lines of pale sand colouring were marked over the entire upper and side surface finish. The aircraft letter was in yellow, outlined in white, an oddity, as both Staffel and Gruppe colouring were white. Flame dampers had been fitted for night operations. (Flieger Flap Museum)

ABOVE: Taken after Swiss markings had been applied over the original German markings, the combination a snaking black and pale sand-coloured lines can be seen more clearly on the rear section of the fuselage and the fin assembly. (Flieger Flap Museum)

RIGHT: The front view reveals that the permanent black spray on the undersurfaces was not applied to all sections; the gondola,has black only on the inboard half, and the engine cowlings have the black confined to their lowest sections. Where the bomb shackles have been removed, the original 02-primed wing surfaces are visible. The Balkenkreuz markings on the wing under surface had been reduced to half size and marked only with the white angle sections. (Flieger Flap Museum)

LEFT: The marking on the bomb aimer's window is the letter 'M', applied in what seems to have been tape, with one section having peeled away. It was repeated in white on the opening section of the crew entry hatch, but the sweeping line of sand colouring obscured part of it. Note that the overall blue finish extended to the lower surfaces, as shown by the open section of the crew entry hatch. The black lines can be clearly seen on the gondola and the undercarriage door. The flame damper extension to the port engine has 'UK' marked in white, with a fainter 'G' aft of it, and what appears to be part of a W.Nr. 1741 on the top curve – a part recycled or borrowed from another of the unit's Ju 88s. The unit emblem appears in a form not usually seen; instead of being stencilled directly onto the camouflage it is presented on a shield, the colour of which appears to be yellow with black edging. There is also a ribbon marking across the top right hand corner. Close examination shows the emblem had, as usual, been applied using stencils. The spinner tips were white, marked off with a thin black line. (Flieger Flap Museum)

of colour scheme. Ju 88 A-4, B3+ER W.Nr. 0880140541, was noted in the Intelligence report as having been built in January 1943. Its camouflage was described as, *all upper surfaces, light blue with black underneath*. (The description of 'light blue' is enigmatic but possibly more descriptive of the subsequent brighter shade of 78 adopted, or even 65). Less than a year old, it appears to have had a similar type of scheme, though perhaps with a different shade of blue.

Joachim Siebers, who served with KG 76 in Italy, wrote an account in 1976 describing the all-blue finish on some of the Ju 88s at Foggia airfield. In it he stated: [4]

> *"Unfortunately, I cannot give you exact details of the blue colour.Was it Blue 24? As before, I would describe it as a dark 'Royal Blue'. In the plain of Foggia, the remnants of five Kampfgeschwader were stationed during the summer of 1943. These were all supplied with replacement machines from Munich, which arrived at the front already painted in this ominous camouflage.*
>
> *"...it is certain that the field workshops (Frontwerften) would spray a wave-mirror pattern over the existing finishes, whenever aircraft were principally engaged over water."*

This, combined with the details of the machine that had landed in Switzerland, make it clear that a darkish shade of blue was employed as an overall finish for some of the Ju 88s stationed in Italy at that time, and that that practice had continued into 1943. The variation in colour description for the blue in the various reports may indicate also that the original stocks of the darker shade of 78 (if it was that blue) had been used up and replaced by an existing blue, 65 or the revised shade of 78. The RLM practice of using up existing stocks of lacquer may be behind the continued use at some production centres as there would have been relatively limited production demand for tropical colours as a whole. Siebers' comment that the aircraft about which he was speaking were replacements, flown in from Munich, would seem to lend strength to that thought. Others may have come from production centres where stocks of the darker blue no longer existed.

Whether the blue Siebers described was the darkish blue originally introduced as 78, or an exceptional use of RLM 24 as a camouflage colour is not verifiable through any RLM documentation. The latter colour was usually only supplied in small quantities, but it was technically suitable for such use. His description of "*...dark 'Royal Blue'*" provides a small clue. The *Methuen Book of Colour* cites chip 19C7 under that universal description. Even allowing for the additional qualification of 'dark', the colour is still not dark enough in tone to match RLM 24 blue. But verbal descriptions are notoriously inaccurate when defining a particular shade of a specific colour; as such the reader is cautioned that the above recollection is not sufficiently definitive to categorically resolve the matter.

How long before those initial shades of 78 and 79 were replaced for the main land-based forces is not known, but the photographic evidence does appear to favour a moderate rather than long period of use, even allowing for the usual instruction to use up existing stocks before adopting the replacement colours. Given that this had been, by default, field-testing of colours by E-Stelle in a time-scale forced by circumstance, perhaps it is not so surprising that the colours subsequently should have been modified. That was not the same as withdrawing a colour completely, then reinstating it in later years, unchanged, but under a different numerical identifier as happened with 61, 62 and 64 as will be explained later.

RIGHT: A Ju 88 of III./KG 30, also seen in Italy, employing a very similar form of camouflage, but the presence of 65-colouring to the undersides, with a clear distinction with the upper surface colouring, points to a more conventional base camouflage of 70/71/65. However, the camouflage had been modified in a similar fashion, with snaking lines of black and 79 added to the side and possibly uppersurfaces, with black lines only on the 65-coloured undersurfaces. The latter had no areas of solid black, as on the Dübendorf machine.

BELOW: This Ju 88, ('A' of an unidentified Kampfgeschwader photographed in Italy in 1944) also wears the same style of camouflage modification and colouring as shown in the previous photograph, again employing lines of black and 79 over the base colouring. The clear similarity in the style of the added camouflage, across three different examples, highlights that the origin of the additions was specific to the operational theatre and had been added, post production, through the Luftwaffe repair and maintenance system of depots.

RIGHT BELOW: While this Ju 88, also photographed in Italy, exhibits a similar type of modified base camouflage, the style and sharpness of the continuous network of 79-coloured snaking lines is distinctly different, indicating that it had had its camouflage modified at a different depot from that of the previous three examples. There also appear to be no black lines. The difficulty in assessing the base camouflage colouring of these Ju 88s operating in Italy will be apparent from these examples. Superficially, they all appear to be just modified standard camouflage finishes of 70/71/65, but the details given in the text, and the examples shown here, highlight the traps when assessing photographs.

LEFT: The depth of the colours, 78 and 79 in particular, may be judged from this wartime colour photograph. While such resources are not suitable for establishing exact shades of colours, the tonal differences shown here give some idea of the relative shades of the original 78 and 79.

ABOVE: Seen amidst terrain for which its 71/02/65 camouflage had never been intended, a Bf 109 E undergoes an engine change in the open at a Libyan airfield. The unexpected drawing of the Luftwaffe into the Middle East conflict, launched by Italy, produced such anomalies until a range of suitable tropical camouflage colours could be hastily brought into production. The extensive mottling on the sides of the fuselage date the photograph to 1941. (D. Vincent)

LEFT: Taken in Sicily during the period when the Luftwaffe was making some rapid re-deployments for the opening phase of the Balkan campaign, this photograph caught two of I./JG 27's Bf 109 Es in the background in their new 78/79/80 finish. The disruptive pattern of the 80-coloured spots could be seen even at reasonable distance. The aircraft in the foreground, Bf 109 E-4, W.Nr. 785, from Stab III./JG 27 was still in its 71/02 finish with a heavy mottling of the darker colours on its flanks, and yellow tactical colouring on the engine cowl and rudder, to which had been added the Mediterranean tactical marking of a white band around the rear of the fuselage. (R. Michulec)

RIGHT: The repainting in tropical colours scheduled for JG 27's Bf 109 Es was tempered by the current battle conditions. The work was carried out in Sicily and this machine, 'White 12', had just been completed when photographed. The distinctive style of the dark green 80-coloured 'spots' was limited to the first batch of aircraft, subsequent Bf 109 Es exhibiting a different style of mottling application. This particular Bf 109 E was one of several reputed to have served with 10./NJG 1, in Holland in 1941. The Perspex bulge below the fuselage held direction-finding equipment used in a series of night-fighting experiments during early morning and late evening patrols. When those had been completed the aircraft were dispersed to other units.

A final small window into the combination of tropical and European colours makes an interesting addendum. In a portion of an RLM report (unfortunately not identified from these fragments taken from it) concerning problems associated with the Mediterranean area, Item 13 included a photograph (shown here) showing part of a Ju 52 with Stammkennzeichen 'NN+00'. The caption contained in the original report stated: [5]

> *"The standard camouflage for flying over water in the European theatre is satisfactory, but for aircraft flying to Africa on delivery flights it was found that the use of sprayed 'yellow lines' (Arabesken), but not bright yellow was most effective."*

The yellow referred to was 79, RLM 27 or 04 clearly being excluded by the reference to "...not bright yellow". The report went on to state:

> *"The Mediterranean has a blue colour and aircraft painted yellow make them very easy to spot. The standard dark green is less discernible but to paint all the aircraft in a blue camouflage is not practical."*

This is very informative. The 'yellow' referred to was the 79-finish applied to all aircraft operating in that area. The remark that the sea was blue, but painting *all* aircraft that colour was impractical, lends some support to the details given earlier in this chapter regarding Ju 88s. Those aircraft appear to have received priority in terms of a more suitable over-water scheme because of the nature of their operations.

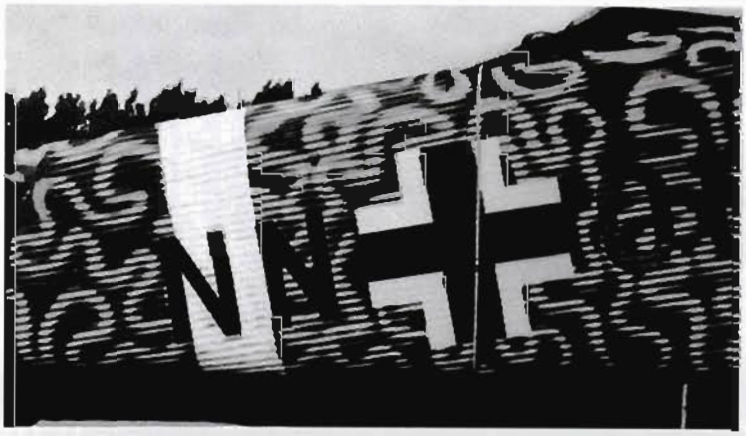
The report used the term *Arabeske* to describe the pattern of 79-colouring, (in English arabesques), meaning scrollwork or fanciful intertwining of a linear form, a very good description of the weaving lines of 79. This form of addition to the basic camouflage would become more widespread in the ensuing years, and sometimes referred to in some writings as *Wellenmuster* (wave pattern).

ABOVE: These two Bf 110s of ZG 26 flying over the Mediterranean clearly show how RLM 79 Sandgelb alone stood out against the blue water.

Item 14 of the report mentioned internal colouring and is equally noteworthy:

> *"Cockpit interiors - it is recommended that all dark painted parts that are to be touched by the pilot should be replaced with those of an 'ivory colour'. Metal parts having a dark colour can reach a temperature of 80 degrees Centigrade making them impossible to touch. By using white paint the temperature falls to around 30 degrees Centigrade."*

The term ivory, qualified by reference to white makes it a little difficult to determine just which colour was used in place of the standard RLM 66. Clearly this was not a reference to 02, which by nature of its grey-green colouring would have been another heat sink. The ivory colour was possibly 05, (the term fits precisely, as well as the colour description). The only other white available was RLM 21 used for markings. This re-painting, because of the need to carefully mask off and even remove some of the cockpit equipment, was probably handled at one of the Luftwaffe's Sicilian repair facilities, though replacement or refurbished aircraft transiting from Germany may have had it done somewhere en route, such as the Erding Depot.



ABOVE: The photograph of Ju 52, NN+00 was attached to the report on camouflage changes for aircraft for delivery flights to the Mediterranean. The base camouflage remains standard European 70/76/65, 'Arabesken' lines of 79 added. The density of the latter shows that breaking up the dark background colour into small areas was necessary to be effective.

ABOVE: The break-up using 79-colouring to the dark greens of the European camouflage for flying over water is shown here to good effect; the ragged edges adding to the effectiveness of the camouflage. The background colour appears to be a single shade of brownish-green, but closer examination, particularly of the elevator, shows it to be standard 70/71 finish. The narrow 'white' band around the fuselage was the tactical marking for Luftwaffe forces based in the Mediterranean area and the narrowness may have been the strict interpretation of the 50 cm dimension set for the Bf 109 units. Ju 52 4U+NH was a unit hack operated by 1.(F)/123 in support of its Ju 88 force.

The 1941 L.Dv.521/1 documents

To return to the discussion of the 1941 re-issued colour atlas, it should be noted that 77 had also not been included, even though that colour was in use prior to publication of the new issue of L.Dv.521/1, both on night bomber Balkenkreuz markings and for unit codes on the early black-camouflaged night fighters.

Of the original Flieglackkette, eight had remained in use (Nr. 02, Nr. 03, Nr. 04, Nr. 05, Nr. 20, Nr. 22, Nr. 30 and Nr. 33). In some instances sequences had been reinstated and some original applications had been extended. Deletion of others was for reason of obsolescence - Flieglackkette Nr. 03 being a good example of this. Each paint sequence had a subsidiary notation with it, stating whether it was coloured, (i.e., capable of having colour added to some of the lacquers within its sequence) or non-flammable, or both. Flieglackkette Nr. 03 however had stipulated just silver, i.e., no other colour option could be used. Its purpose as a lacquer group for metal aircraft, both internally and externally, had been superseded by RLM-grey 02 colouring.

Flieglackkette Nr. 02 had been extended, its definition now stating that it was to be used on floats, flying boats and on aircraft used in the tropics. In addition, sea-going aircraft would be given Eloxieren (anodising) treatment as per the special instruction set down in the special amendment issued by the RLM for this finish. It was also noted that not all aircraft manufacturers had this facility (it was not widely used within the aircraft industry because of the requirement for large amounts of electrical power). The range and type of lacquers also had been revised; aircraft using the Eloxieren process were to be finished with aircraft lacquers 7118.-, 7102.- and 7109.02 (the latter colouring could be replaced by any of the appropriate camouflage colours). Non-Eloxieren aircraft and tropical aircraft were to use 7102.-, 7106.- and, again, 7109.02 or any of the camouflage colours applicable.

Flieglackkette Nr. 04 had been reinstated, its application being for exterior lacquering of aircraft that previously had not employed a single-coat finish, i.e., there were still older aircraft in service that had the old three-coat finish. The fact that the older lacquer formulas could now be used with the more recently introduced new single-coat lacquer 7122, to form a two-coat lacquer system, accounts for this reinstatement of Flieglackkette 04. The constant development of lacquers was driven by a search to improve their qualities as well as the need to find substitutes that used fewer raw materials, and more importantly, freed them from dependency on imported chemicals and minerals. This compromise was aimed at enabling older aircraft to continue in service without the labour intensive, time consuming process of having to strip and repaint their entire airframe. Maintenance depots refurbishing aircraft were required to check the aircraft log to ensure lacquers were compatible before carrying out re-spraying because of the mix of old and new production paint finishes. Eventually attrition eliminated the problem.

Flieglackketten Nr. 05, Nr. 22 and Nr. 33 had had their application extended to include transport gliders, for example DFS 230 and Go 242. The lacquer 7130.- in Flieglackkette Nr. 20 could now also be used as an adhesive, while Flieglackkette Nr. 30 remained unaltered.

The list of specialist lacquers had also been revised, changes reflecting the new paint technologies. Single coat lacquer 7140.- was introduced for all wooden sections not exposed to external airflow. To aid identification, it was to have a greenish tinge. Another new single coat lacquer was 7122; mainly used with colour 02 on interiors, it could also be used externally with any of the camouflage colours where a single-coat application was required. (It rapidly became the premium lacquer because of its higher pigmentation holding capacity and its ability for use as a misting spray). 7117.-, used to protect areas subjected to contact with acids, was replaced by 7119.-. Lacquer 7136.00 could now be used as an insulator coat between metals and fabrics where both were already painted, such as in wings and tail planes. 7102.- was still used for hollow welded steel sections and was pumped into the lowest section until it flowed out at the top. The section was then tipped up to drain the excess. It was to be used on seaplanes. In each instance the changes reflected simplification of use.

Camouflage colours were also restated, the original German listing being as follows:

a) Schulflugzeuge (Sichtschutz)
b) Jagdflugzeuge (Farbton 74, 75, 76, 65)
c) Zerstörer (wie b)
d) Bombenflugzeuge u. Transporter (Farbton 70, 71, 65)
e) Seeflugzeuge (Farbton 72, 73, 65)
f) Tropenflugzeuge (Farbton 78, 79, 80)

From this listing it can be seen that training aircraft had no specific colouring set down as many of the aircraft in the school system, particularly the advanced flying schools, were obsolete front line types that were received in a variety of camouflage finishes. The air situation over Germany at this point of the war officially did not warrant the repainting of such aircraft in contemporary camouflage colours. However, some school aircraft did acquire contemporary camouflage when they were sent for major overhaul, the consistent higher than usual flying hours bringing them to the regulation 1,500 flying hours before the usual two-year time limitation.

The camouflage for fighter and heavy fighter aircraft included choice of two under surface colours, 76 and 65. This has proved confusing as it does not appear to relate to contemporary instruction for use of extra colours for mottling on day fighters. However, it can only be assumed that both colours could be used in combination as the instruction did not specify '(... 76 *or* 65)'. The 15 August 1941 camouflage instructions for the Bf 109 F-4 series, which was contemporary with the L.Dv.521/1 document, specified mottling using equal amounts of 02, 70 and 74. The inclusion of both 02 and 70 in the specification was not reflected in the listing shown above - *but 65 was*. It would appear then that the listing included only the main camouflage colours, mottling being peripheral to the general instruction, by which standard reference to 65 indicates that it had also been retained as a main camouflage colour.

The only logical deduction that can be made from this confusion is that 65 was possibly used for the transition between the lower surfaces and the 76 of the side surfaces where it met the 74 and 75-camouflage of the upper surfaces. If that was the case, it has proven impractical to detect in any contemporary photographs and the August painting schedule for the Bf 109 F-4, which had preceded the particular L.Dv/.521/1 issue, did not reflect such latitude.

That leaves only the possibility that the mixture of main colours may have referred specifically to night fighter aircraft, which it will be noted, did not otherwise appear in the listing as a specific category. A precise date for the instruction to change from overall black to 74/75/76 for night fighters is not known, the best estimate so far being around the beginning of 1942. The overlap between the existing and old schemes, which inevitably was not swift because of the prevailing policy of not re-camouflaging aircraft until they reached major overhaul status, further adds to the confusion. However, when the change had been set down in camouflage documents, 02 and 76 had both been prescribed as under surface colouring. That dual application of main camouflage colours was still being reflected in the 23 February 1943 camouflage pattern for the Do 217 N-1 night fighter. That was some 15 months later and the practice was still in place, which seems to support the contention that the dual colouring applied to night fighter rather than day fighter aircraft. The 8 May 1942 document '*HM - Anweisung Nr. 7/42*', which promulgated simplification treatment of specific materials and camouflage for land-based aircraft, specifically cited only 74/75/76 for the Fw 190. Day fighter camouflage definitely had only one lower surface colour specified by that date, while nightfighter camouflage would seem to have retained a broader mix of colours until at least 1943, as noted above.

The lacquer sequence table for aircraft completed on an assembly line, painted on the port side of the rear section of the fuselage, had also been revised. Date of completion of lacquering and lacquer details were given as shown below. (Lacquer sequence tables for experimental finishes remained as before).

Lackierung vom 1.7.40	*Painting on 1.7.40*
Metall: Fl 7122.65/70/71	*Metal: Lacquer 7122.65/70/71*
Holz: Fl-kette 30	*Wood: Lacquer sequence 30*
Stoff: Fl-kette: 20	*Fabric: Lacquer sequence 20*

However, continuance of this practice of marking the information on the airframe appears to have declined by 1942 for front line aircraft (and was absent on day fighter aircraft by then), and had disappeared altogether by 1943, such details being recorded only in the maintenance record which accompanied each aircraft throughout its service life. The reason simply may have been a security measure.

Looking back briefly, the mid-third of 1940 had been a period of great changes, in particular for the Luftwaffe's fighter camouflage schemes. The relatively basic 'field' attempts to develop a more suitable defensive camouflage for operations over the English Channel, and for the intense air-to-air fighting over Britain, had produced a range of colour combinations at unit level. However, the RLM had already been developing three new grey colours that worked to best advantage in the air-to-air situation.

The earliest confirmed example of a 74/75/76 camouflage scheme dates from June 1940. Dr William Berge, an experienced Norwegian researcher, was part of the team that recovered a Bf 109 C-1 of IV.(N)/JG 2 from 27 metres of water off Lindesnes. The Staffel had moved to Vaernes in early May and stayed until 2 June when it commenced a transfer flight back to Germany to re-equip with Bf 110s. W.Nr. 2450, the only C-1 amongst the D-1s, experienced engine failure and ditched. Dr Berge has carefully examined the aircraft and confirmed that it was finished in 74/75/76 scheme and showed signs of having only recently been repainted prior to its crash. The paint history on the fin was most interesting; the original pre-January 1939 red band marking had been painted over with 70, then 65 (reflecting the revised demarcation between upper and lower colours introduced in December 1939), then 76, then 75, then 76 again. Significance of a lone Bf 109 C-1 amongst the otherwise Bf 109 D-1-equipped Staffel may just be coincidental; this was after all a special unit hastily formed using obsolescent aircraft. This colour information accorded with the E-Stelle practice of field-testing a colour (or colours), or any lacquer, for one year prior to giving approval for general use and mass manufacture. Only a handful of aircraft was involved for practical reasons.

ABOVE: The amount of repair work able to be carried out at front line-level was relatively limited. Here, a ground staff member of III./JG 26 was photographed while applying a metal patch to the inside surface of the fuselage of a Bf 109 E, having already carefully removed a rectangular section of damaged metal. The pressure clamps further out from the hole define the real size of the metal patch.

It may be speculated that the greys were under development for night fighting application. However, subsequent adoption of black overall finish for aircraft in that role would seem to put this in doubt, (even though the greys eventually would supersede the black finish for that self same purpose). The development being aimed at finding a suitable over-water camouflage was also a possibility, but eventual wider scale use of the scheme undermines such specificity. It seems then that this was simply a field trial of the new colours in an area where the aircraft was less likely to be lost in action, or fall into enemy hands and thus compromise the new scheme. The camouflage pattern found on W.Nr. 2450 was the revised form introduced in April/May 1940, so the application of the 74/75/76 scheme is confined to a fairly narrow time band and matches the statutory one year trial period required by E-Stelle Travemünde.

Absence of this revised colour scheme on production aircraft dating from this period would appear to support the contention that the paints were still in the field trial stages when the aircraft was lost. Had these paint colours been in production they would have been made available to fighter units when the air battle over Britain erupted, eliminating the endless series of innovative schemes that are in ample evidence in contemporary photographs, and widespread hybrid colours mentioned in intelligence reports. While the units involved had access to captured pre-war permanent facilities on the main French airfields for this work, it is more likely, at least amongst most units, that mobile Luftwaffe repair and maintenance teams carried out the work using the captured facilities. There is no specific record, written or photographic, of aircraft being painted in the non-standard colours by the ground staff of the actual units involved. The most that appears to have been done by them was the application of tactical markings (for which photographs do exist) as the battle progressed. Daily maintenance was at a peak and additional tasks, extensive tasks in some cases, would have impinged heavily on the existing workload. This may explain the distinct variation in style of application seen amongst some units, where several aircraft of a Staffel had a very similar finish while a few others wore a completely different style of additional colouring.

Returning to the early appearance of the grey colours, there was also some anecdotal evidence concerning a Bf 109 E-3, 'Red 14' of 5./JG 77, which made a forced landing at Mandal on 11 April 1940. An eyewitness account by someone present at the crash site described the camouflage of the fighter as greys, but without actual paint samples from the aircraft, or

BELOW: Among the other forms of common front line repair work was replacement of control surfaces, such as this rudder, which appears to have been removed to provide access to the internal area of the fin as there is no evidence of major damage to the rudder itself. The Bf 109 belonged to II./JG 54, whose style of camouflaging of the 65-coloured areas was done using a loose pattern of short strokes in both 71 and 02. The eight kills on the rudder of 'White 1' recorded the score of Oblt. Hans Philipp. Replacing, or even swapping cannibalised parts did sometimes lead to mis-matched colour schemes or patterns.

ABOVE: This Erla-built Bf 109 G-6, 'White 10', W.Nr. 19881, flown by Lt. Willmans of 1./JG 52, shows the mix of mottle colouring to the fuselage side surface in colours 74, 75 and 02. (M. Jessen)

a more specific description, it is impossible to verify the details of account or to state definitively the nature of those greys. This was a unit that originally had been based in Norway for defence before a part of it was transferred later to France during the battle over Britain.

An intelligence report on another JG 77 aircraft, a 1. Staffel machine in this case, occurred on 7 September, during the Battle of Britain. The report referred to the airframe being *"... Grey speckled on top"*, again far too speculative a reference upon which to place any firm assumption. Had this been a 74/75 finish then it might have been a more extensive reference to greys being applied to the airframe, not just a 'speckled' finish. Other reports on greys during September and October also occur, but these were isolated cases and the term grey is a broad one. Given the over-water environment of the Channel, and the multitude of greys that could easily be mixed from the available lacquer stocks, it is not surprising that some intelligence assessments refer to a generic grey colour. If any of them did record the greys 74/75/76 then they were still at the field trial stage and had not entered the mainstream aircraft production cycle. Also, if greys were being applied at production centres, one would expect a standard form of camouflage rather than the disparate forms of application described in the intelligence reports. Intelligence officers were alert to all changes to enemy aircraft 'systems' and such a significant change would not have gone unrecorded.

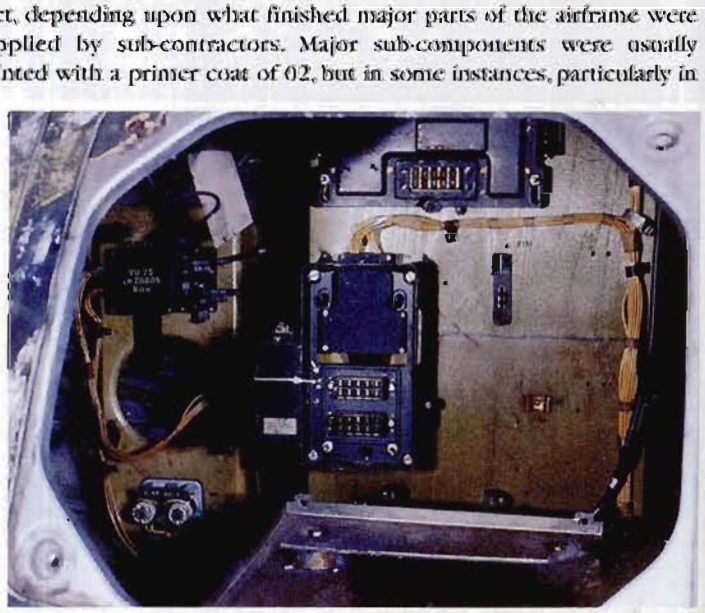
Factory camouflage applications

Revised factory painting schedules and camouflage patterns were issued to the industry throughout the war years. While it was expected that these would be adhered to as closely as possible, it was impractical not to have minor variations, particularly so with the introduction of mottling on side surfaces. The latter was an area beyond strict definition from the outset, other than for the proportion of colours used, and the general area to be painted. This was sometimes expressed in the camouflage instruction as approximately equal parts of each colour. Production line spraying usually involved two spray painters, working one each side of the aircraft, or a single man working alternately on each side of an aircraft, making it impossible to duplicate the pattern of mottling on both sides of a single aircraft. Equally, it was impossible to precisely duplicate areas of mottling on successive aircraft.

However, with widespread introduction of mottling to side surfaces, some production centres developed an individual style of application that was, sometimes, recognisable - a form of fingerprint as it were. Some applied very soft, misty-style mottling, some formed more definite colour spots, while others used a soft edged streaked application. All were a direct result of individual interpretation of the non-specific section of the factory painting specification, which stated only that fuselage side areas were to be mottled, and prescribed the colours, and approximate ratio of each, that were to be used.

From 1936 to about very early 1943, production had involved an application of 02 over the overall zinc chromate metal etch coating. Over that, the various camouflage colours were applied in their respective areas; 65 overall with the darker upper surface colouring then added and brought down to meet it at the lowest point. From December 1939, the procedure for fighter aircraft had changed with the reduction of camouflage to the upper plan view. The two upper surface camouflage colours had been blended into each other optically by means of a prescribed 100 mm overlap where they met each other. As noted in an earlier chapter, the 'overlap' description meant colours met in a soft, serrated edge, the maximum width of which was 100 mm - it did not mean that the colours were sprayed over the top of each other for a width of 100 mm. Wings and horizontal tail surfaces were treated as for other classes of aircraft as noted above.

Normal production procedure for painting airframes varied between manufacturers, precise sequencing being left to individual firms, and in part, depending upon what finished major parts of the airframe were supplied by sub-contractors. Major sub-components were usually painted with a primer coat of 02, but in some instances, particularly in



LEFT AND RIGHT: Lacquers 7140.99 (grün lasierend) and 7141.99 (gelb lasierend) were both transparent lacquers, each of which had a touch of colour added to aid in their specific use. They were used on both the Bf 109 and Me 262 for the wooden panel holding the wireless equipment. On the left is the panel inside Bf 109 G, W.Nr. 163824 and on the right is the one from inside Me 262 W.Nr. 500200. The two aircraft were produced some 18 months apart, but the finish was consistent (the restricted lighting inside the Me 262 makes the colouring look darker here). The transparent nature of the finish can be seen on the Bf 109 panel, where pencilled notes made on the wooden surface during construction can still be read through the lacquering. The yellow-marked pipes above the panel were part of the fuel system while the dark blue of one of the oxygen bottles can just be seen to the right of the panel.

the case of single-engine fighter aircraft, also had the finished camouflage colours. That arrangement was probably one agreed to between the main manufacturing plant and the individual sub-contractor, as the entire process was a private commercial arrangement outside government controls.

At some facilities the airframe was lacquered while divided into its major components - fuselage, wings and horizontal tail surfaces - while other factories did no final painting until the entire airframe had been assembled. In the latter case, this appears to have been part of the process of air testing for acceptance, leaving final painting until the aircraft was accepted for service use. During this process many quite small notations were often added to components, either on the treated bare metal, or over the 02-undercoat. These were connected with production matters, not the service role of the aircraft, but were often applied in permanent lacquers in varying colours, though red predominated, and even pencil. They disappeared beneath the final camouflage colouring.

Some factories applied Balkenkreuz and Hakenkreuz markings to the treated bare metal surfaces in some instances, and then masked them out for the final application of the camouflage. There are numerous illustrations of Bf 110s utilising this system, including air-testing the aircraft prior to final painting. The reason appears to be that aircraft were often tested before final painting, thus avoiding loss of materials and labour time if an accident occurred; and there was also a security necessity to have aircraft marked with national markings as a precaution against friendly fighter attacks.

Late in the war, when camouflage schemes had to be revised even further in the interests of austerity measures, the system again changed Sub-components continued to be undercoated with 02, but the main airframes were left in translucent zinc chromate-treated bare metal. The lighter of the two upper surface colours was applied as a single coat (thus acting as a substitute undercoat with savings in materials, time and weight) with the darker colour then applied over it. This sometimes produced a distinct colour shift where the two coats were applied over each other, as both were extremely thin, (5/100ths of a millimetre, a result of the advanced chemistry of the paint structure). However, unless applied in strict accordance with the preparation instructions the colour could, and sometimes did, vary slightly. Reversing the order of application, with the darker coat applied first, produced a more subdued contrast between the colours, and this was sometimes done. Upper surface camouflage colours also were often taken right down the sides of the fuselage, returning to a style not seen since the close of the Polish campaign in 1939. Lower surfaces of wings, and sometimes horizontal tail planes for fighters, were often left in bare metal.

RIGHT: This collection of aircraft provides a rich source of comparative schemes. In the foreground is Fw 190. W.Nr. 170088 'White 40', (note the faded '1') camouflaged 75/82, the marked contrast level being seen on the port wing, which is in full sunlight. Compare the lighter colour with the small area of 76 on the cowling, and the darker colour with the black of Balkenkreuz marking. Behind is a Bf 109 G two-seat trainer; the small amount visible shows a 75/82 finish on the rear section of the fuselage and the horizontal tail surfaces with some heavy mottling of 81 aft of the Balkenkreuz. The 7. Staffel Fw 190, 'White 5' W.Nr. 750125, has patches of 81 applied along the spine of the fuselage and onto the fin area, as large, crisp-edged areas over the 75/82 colour, creating a three colour mix. This can be seen on the horizontal and vertical tail surfaces. In contrast, forward of the Balkenkreuz marking, the fuselage has a soft application of 82/83 with a haze of both over the very pale 76-side surfaces. The starboard wing has what appears be a rough repainting in 76 with an area of 82/83 showing along the aileron and adjoining wing section. Compare it with the wing of the next aircraft, which was in the same direct lighting conditions. This appears to be an older aircraft that had been repaired. The Fw 190 next to it had a dark camouflage that matches the general colouration of 'White 40'. Directly to the right, on the edge of the photograph is another Fw 190 finished in 75/82. In the centre is a Fw 190 D-9 marked with a IV. Gruppe emblem over what appears to be a band of colour, darker than the 76, stretching from the Balkenkreuz marking to the tail unit, and obscuring the white edges to the rear half of the marking. To the right is a Fw 190, 'White 10', in a very dark, low contrast finish of what appears to be 81/83.

1. Michulec research.
2. Ibid Michulec.
3. Ibid Michulec.
4. R. J. Smith research.
5. E. J. Creek research.

The Critical Years
1943-1945

6

The beginning of 1943 marked the turning point of the war for Germany with a shift from offensive to defensive policy, something that had not been part of the planning by the High Command when war was launched in 1939. Everything then had been based on a series of Blitzkrieg actions. The war in Russia had ground to a halt, and the best that could be hoped for was to form a new defensive border to hold the territory already taken. Worse still, the strategic reserves had been used up. RAF Bomber Command's bombing campaign, augmented by the USAAF daylight raids, had witnessed introduction of a round-the-clock bombing policy in February. German policy had never allowed for a defensive strategy. Reserves of aircraft had been at their lowest at the beginning of 1943, the attrition rate in the previous year having been exacerbated by the savage fighting on the Russian Front. It then became an elaborate game of chess, shifting forces around to meet developing crises. For those reasons the anticipated change to a defensive camouflage for the Luftwaffe as a whole had become only a matter of time.

Evidence that such a change was to take place occurred in a notice promulgated on 21 August (GL/C-E 10 Nr. 10585/43 (IVE), Ref. 82 b 10, 21.8.43) concerning future introduction of camouflage shades 81 and 82 to replace 70 and 71. This mirrored a similar development introduced for the Army at the beginning of that year in the face of the changing war situation.

Why those colours were not put in to production and issued to the aircraft industry in late 1943 is unclear given that losses to bombing and daylight strafing attacks were rising by that time. The document however did use the term 'future', indicating that a final decision had not been made on a date of introduction. Possibly losses on the ground, where the new colours would be most effective, were judged as not yet having reached a critical phase, a fact that nevertheless became inescapable by mid-1944. There was also the air-to-air camouflage requirement with German fighters now the predominant force for the defence of the homeland.

One aspect largely overlooked in post-war writings was the infighting between different departments and factions within both the German High Command, and also within the RLM itself. Anticipation that the war in the West would be quickly concluded had vanished by late 1940 causing a revitalisation of production of critical munitions and equipment that had been allowed to slow in anticipation of a victory. That put pressure on strategic reserves of materials. The fact that the Russians did not crumble under the German assault was the second shock. Both events had created a vacuum that not only stalled or delayed decisions on aircraft development, but also ancillary needs that rapidly arose from the changed fortunes of the German forces.

The RLM was essentially a civilian staffed organisation, a very large-scale bureaucracy controlling everything from engineering, maintenance, to logistics for a large force intended for Blitzkrieg-style warfare but which, increasingly, found itself engaged in a protracted war on two fronts. With the revised situation it had found itself torn between conflicting demands as senior officers argued priorities while sometimes, perhaps more significantly, ignoring the realities of the war situation. Several prominent personalities committed suicide, or were removed, slowly paralysing the Ministry's ability to respond quickly. The internal struggle within the armed forces as a whole for share of declining raw materials no doubt also played a significant part, for it is known that strategic materials were siphoned off to specialist areas at the expense of other manufacturing practices. Palliatives that seem so logical, and relatively simple from the distance of more than half a century were not so clear or easy to implement at the time. Defeatism was a word that no one wanted to be associated with, and negative comment, even such as a realistic assessment, was enough to be associated with that word, something to be avoided by many who still held the power to make decisions.

Bureaucracy, in any country, is not immune from indecision and power play. To have it occur in the wartime RLM, when the forces opposing Germany were starting to squeeze the life from its armed forces and civil population, was a disaster; death by slow strangulation as consequent political and administrative pressures affected the operational effectiveness of the combatants and the responses of industry. The role and significance of this bureaucratic force has never been fully analysed for its effect on many aspects of the war, but enough snap shots of critical events and decisions have been recorded that illustrate the potential it held, adding to, if not creating, critical moments. [1]

Constant revisions to painting systems and usage for aircraft, begun pre-war, gathered pace as the war developed. The earliest significant one found had appeared in HM - Anweisung Nr. 7/42, (HM - Instruction No. 7/42), issued on 18 May 1942 by the Technisches Amt. Titled 'Vereinfachung des Oberflächenschutzes für Landflugzeuge' - (Simplified surface protection for land aircraft) it had addressed a range of matters, including simplified painting for the Fw 190, He 177 and Ar 96 types in relation to specific types of materials used internally.

Metal types were identified by a coded system consisting of a four-number group followed by a period, then by a single number (e.g., 0000.0). These were marked on each piece of metal, usually in black but sometimes in white or red. Metals were divided into three major groups, each of which was defined by the first digit in the four-digit group, i.e., '1' for Stahl (steel), '2' for Schwermetall (heavy metal), '3' for Leichtmetall (light metal). Each major group was further sub-divided into sub-groups that identified specific types of metal within the parent group. Group 1 had eight sub-divisions, Group 2 had six and Group 3 had five, numbering commencing from 0 (not 1). Each sub-group was further divided into numbered categories depending on specific characteristics. The full system is explained in Appendix G, Volume Two.

HM - Anweisung Nr. 7/42 also made reference to 'HM-Anweisung Nr. 056', which had previously dealt with simplification of surface protection for land aircraft in the quoted types of structures. These were no longer in force, being replaced by the following revisions, which read in part:

Metal parts composed of Flw 3305 (Hy 5), 3310 (Hy 7), 3315 (Hy 9) and 3116 (Duralplat), not exposed to the free flowing air [i.e., slipstream] *shall remain without surface protection.*

1. *No further paint to be used for internal parts in materials 3305 (Hy 5), 3310 (Hy 7), 3315 (Hy 9) and 3116 (Dural sheet)...*
2. *Fuels tanks in 3000 (Aluminium), 3116 (Dural plate), 3355 (Pantal or Legal) are to receive neither inner nor outer painting.*
3. *Coolant pipes in 3000 and 3355 are to be left unpainted.*
4. *Material 3126 in condition 4 and 5 remains unprotected but at stage 9 is treated as previously.* [Numbers 4, 5 and 9 referred to the metal treatment. See Appendix G, Volume Two].

5. *Parts in galvanised steel remain unprotected, all others treated as before.*
6. *Material 3115 receives one coat of paint as before.*
7. *Elektron is painted twice, as before.*
8. *Crew compartments are to receive only one coat of 66 instead of two.*
9. *Camouflage, as before shall be applied with a single coat of paint.*

The previous painting schedule for the Ar 240 and Ar 232 remain unchanged. Nor will there be any simplification for seaplanes as the results of corrosion cannot be answered for. The simplified painting schedule for the Fw 190, He 177 and Ar 96 is henceforth specified as follows..."

A three-page schedule then covered all types of metal used, dividing them into four categories - corrosion prone metals, galvanised metals, plated metals and untreated metals - setting out the lacquer to be used, and where applicable, the number of coats, colour and how it was to be applied, i.e., sprayed or hand-brushed on.

On 24 March 1943 a revised edition of L.Dv.521/2 'Behandlungs und Anwendungsvorschrift für Flugzeuglacke, Teil 2: Segelflugzeuge' - (Treatment and Application Instructions for Aircraft Lacquers, Part 2; Gliders), had been issued. This was one area where little could be achieved in terms of savings in strategic materials. Even so, the revised listings did include the changes to colour matching requirements.

Interior painting was still required because of the porous nature of wood, which included load-bearing spars and ribs. Remaining stocks of 7171.27 were to be used up before changing over to 7171.99. The cockpit area received pre-treatment with 7171.99, two coats, well rubbed down in between, and finished with a single coat of 7174.02. It is interesting to note that while the '99' designation was being phased in, the cockpit area still required colour-matched 02. Because of the overall neutral 05-coloured finish of gliders, use of 66 for cockpits was unacceptable because of the stark contrast when seen from above. The fuselage was primed with a fine coat of 7171.00, special wood putty 7251.99 being used to ensure a smooth surface. This was a pale yellow colour. The surfaces were then given a single coat of 7172.99 followed, after drying and curing, by the final exterior coat of 7174.05, applied with a fine misting spray in the first instance to ensure complete even coverage.

The document contained all necessary instructions for sanding and lacquers, curing times, as well as instructions for repairs to wood and fabric. The next and final changes to glider lacquering would appear in 1944, forced by the declining war situation.

The year 1944 had started well for the Luftwaffe in so far as the number of fighter aircraft available had almost reached the same peak as in June 1943, and the oil plants producing synthetic fuel had reached peak output, providing reserves of fuel higher than had been achieved since July 1941. But the sudden return appearance of USAAF daylight bombers, accompanied by long-range fighter escort, and the shift to bombing of aircraft production centres by day and night, reversed all those advantages. The resulting high damage forced even wider dispersal of the aircraft manufacturing industry, exacerbating time, fuel and transportation problems.

The Junkers company provides a good example of the extent of the dispersal, which did prove effective in some instances, but which also produced severe problems for final production. By mid-1944, Junkers had the following plant profile; Dessau (main company works - 12 dispersed plants); Oschersleben (Ju 88 and Ju 188 production - four dispersed plants); Halberstadt (production of wings - six dispersed plants); Leopoldshall (production of tail units - one dispersed plant); Bernburg and Langensalza (assembly and test flying - five dispersed plants); Leipzig (repairs - five dispersed plants); Breslau (repairs - one dispersed plant). Licensee companies were A.E.G., Wildau (who were sub-contractors to Henschel), A.T.G. at Leipzig, Henschel at Schönfeld, Kries Teltow (construction of fuselages and assembled Ju 88s), Siebel at Halle, Volkswagen at Mockau (repairs), Weser (which produced Ju 87s) at Bremen and Berlin, and Heinkel in Berlin, which produced Ju 88s.

Because of the extent of dispersal Junkers had always relied heavily on rail transportation, which had carried 95 per cent of all production, but bombing during 1944 and 1945 severely disrupted that, causing a reduction in delivery of raw materials to dispersed plants and delays of finished parts from the dispersed plants to the assembly plants. The company had turned to road transport as a replacement, but fuel shortages had a crippling effect. The fuel shortage had also prevented completed aircraft from being test flown, sometimes trapping new aircraft at the test fields for up to three weeks, and often resulting in aircraft being delivered without being tested at all.[2] The susceptibility of such aircraft to air attack was yet another pressing reason for the change to a better ground defensive camouflage.

The L.Dv.521/2 issue of March 1943 had dealt exclusively with lacquering of sailplanes and gliders (see Chapter 19, Volume Two) specifying a range of finishes for use as an undercoat on both metal and wood. However, where the suffix 99 had replaced colour identity for some lacquers in that document, it now appeared in every Lackkette sequence specified, Nr.02, 04, 05, 20, 22, 30 and 33, appended to each lacquer other than those used for the final coat (which continued to specify RLM 02 plus camouflage). The other minor exception occurs in Flieglackkette Nr 20 and Nr 30, both of which specified 7136.00 - as a clear protective coat over tightened fabric surfaces and over the camouflage finish on wooden floats. The reason dates back to the same time as the March 1943 issue of L.Dv.521/2.

The suffix 99 predominates in this revised document, and the nature of this two-digit code, which was not an indicator of a specific colour, is explained a little further on. In the section on wood lacquering, the part dealing with internal protection lists two lacquers to be used, Flieglack 7141.99 (gelb lasierend) and Flieglack 7140.99 (grün lasierend). The term 'lasierend' means transparent, in these instances indicating a transparent finish with a yellow tinge and one with a green tinge, two different colour descriptions for the similar types of lacquer finish. In Flieglackkette Nr 20 it was used on sealing tapes between joints, and in Flieglackkette Nr 30 as part of the sequence of external painting of wooden floats.

Use of colour tinge descriptions are not without precedent; the 1941 edition of L.Dv.521/1 mentions, under Flieglackkette Nr 33, application of what is termed a single cell lacquer, 7140.- (grün lasierend), e.g., a green tinge to an otherwise transparent finish that was used for colouring all wooden parts not exposed to external airflow. Lacquer 7111.00 (gelb lasierend) had appeared in the 1938 edition of Entwurf einer Behandlungs-und Anwendungsvorschrift für Flugzeuge.

The purpose of this new, ubiquitous description of 99 was simply to replace the 'period dash' designation of the original RLM system. Changes to the method by which, amongst other things, supplies of now vast stocks of lacquers were being controlled, right across the military system, witnessed the introduction of an early form of computer system, a Hollerith machine. The machine however had specific limitations, and required a six digit sequence in order to operate. The existing period dash (.-) suffix to many aircraft lacquers could not be used as the computer system failed to recognise it as a valid entry. A relatively large range of lacquers and supplementary products existed which used the '.-' suffix to signify that the natural colouring of the formulation was sufficient, no additional specific RLM colour being required, as such colour matching was irrelevant and no colour standard (colour chip) existed. The only indicator sometimes added was a relatively vague written general colour description, such as 7102.- green, 7106.- grey, 7113.- grey-green, 7130.- red, 7132,- grey wood filler, 7137.- red, 7140.- greenish tinge, 7142.-red, 7260.- silver gum paste yellow or green. Those were never meant to be other than broad indicators to help identify where a particular lacquer or paste had been applied to parts of an airframe. The official RLM announcement of the introduction of the designation 99 was slightly ambiguous, due to some of the terms used. The main area of

confusion for many has been the RLM retaining its bureaucratic, ubiquitous description of 'colour shade' when referring to 99. While 99, along with all other two-digit suffix numbers in the sequence set up in 1935, had originally been intended as a potential designator of a specific colour shade, its function had been usurped and employed for a secondary, diametrically opposite function - namely a general lack of any specific colour shade. The reader may judge the wording of the document in that light.

On 3 April 1943 an order was issued to all distributors of lacquers. It read:

Aero Lv.RP.13.430

Copy/JK

Der Reichsminister der Luftfahrt Berlin, den 3.4.1943.
Und Oberbefehlshaber der Luftwaffe App.: 81/2742
Technisches Amt

GL/C-E 10 Nr.4966/43 (IV E) Az.170-k-10.31.

To
Distributor.

Reference: Alteration of the RLM-colour shade designation '.-' to the aircraft paints in RLM-colour shade '.99'

The aircraft raw material, and also aircraft lacquers are marked by digits, so that statistical, commercial and other inputs into Hollerith computers are possible. To fit the aircraft paints completely to this system it is necessary to replace the symbol '.-', which stood in place of a 2-digit colour shade designation and meant that precision of the colour shade is without significance (compare L.Dv.521/1, page 7, remark), by the number '.99'. The set day for the alteration is 1.5.1943.

Explanation of the colour shade 99.
The designation 'RLM colour shade 99' means:
1. The colour shade in itself is optional, it results at any given time from the RLM approved formula of the aircraft lacquer concerned. The colour shade of the lacquer concerned must not be altered without permission of the RLM because this means a simultaneous alteration of the formula.
2. In opposition to all other RLM colour shades the exact retention of the colour shade is without importance.
Example: The basic aircraft lacquer 7102.99 has a green shade. It is of no consequence if the green results in something lighter or darker. A difference in the shades of two deliveries is therefore no reason for an objection.

Execution regulations:

a) Present stocks of aircraft lacquers, which are stored in containers with the old designation, are to be used up first.

b) The lacquer manufacturers are to use, beginning from 1.5.43 the new colour shade designation on labels of the lacquer containers. Labels with the old designation can be used up, if the colour shade designation '.-' is overprinted or overstamped by '.99'. Confirmation of the implementation measures are to be sent to GL/C-E 10.IV until 15.5.43.

c) In the L.Dv.521/1, part 1 and the L.Dv.521/3 the designation '.-' has to be replaced in the manuscript by '.99' until 1.5.43.

As the colour shade 99 is not able to be presented in the colour shade card, the note on page 7 of the L.Dv.521 part 1: Powered aircraft (edition of November 1941) is replaced in the text with the following new form:

+) The number 99 after the point of the four digit lacquer number means: the accuracy of the colour shade is of no concern.

d) In the OS-lists the designation '.-' has to be replaced by '.99' until 1.5.43. The licence producers have to be instructed about this alteration. The OS-lists need not be handed in to the RLM for authorization of the alteration. On the other hand the GL/C-E 10.IV has to be informed until 1.5.43 about the implemented measures together with the declaration of the altered OS-lists.

By order
signed Leyensetter
For Control.

The number 99 was the highest available number in the existing system of two-digit colour designations, chosen because it provided the additional two digits required by the new six-digit system while not disrupting the potential of the remaining available range. In 1943 the extent of future colour changes was still unknown and the designation system had already reached the 80-mark. The Hollerith machine referred to in the letter was an early form of computer using a punched card system, reputed to have been developed by a German subsidiary of IBM. It was unique, and obviously had more potential than simply the speedy issuing of stores to the armed forces. Note the reference to "*...statistical, commercial and other inputs ...*" This system, and costs allowed tracking of the entire supply system, an extremely valuable asset when conservation of materials had become so important to the German war effort.

There has been much speculation that the designation 99 referred either to a relaxation of colour matching requirements amongst lacquers that previously had a two-digit designation, or represented a colour, or range of colours. As noted above, the *primary* function of the 99-suffix was to produce a six-figure number for the computerized supply system. In achieving that goal it made it impossible to continue using the old 'period dash' designation. As a result, colour matching requirements had not been relaxed, lacquers already marked by '.-' as not requiring exact colour matching were simply marked with '.99'. In effect; nothing had changed fundamentally since the system had been originally introduced; '.99' was simply the new '.-' symbol.

Luftwaffe units were advised of the changed designation in Luftwaffen-Verordnungsblatt 5 April 1943 , which stated in part:

From 1.5.1943 the RLM colour description .- for aircraft lacquer is to be replaced by .99.
For example the previous aircraft lacquer 7102.- is now 7102.99

Nothing changes as to the qualities or use of the lacquers.

In the above noted L.Dv. documents all lacquer descriptions containing a four digit number marked with .-, are to be replaced with 99.

The footnote on page 7 of L.Dv.521/1 Part 1 is to be amended by hand to the following instruction
**) The number 99 after the point following the four digit lacquer identification means: exact colour does not matter.*
[which is what the period dash suffix had always meant].

Future OS Lists from the aircraft industry are not to continue with the existing scheme of aircraft lacquers in place of this change.

Der R. d. L u. Ob. d. L., 25.3.1943,
Az 70-k-10. 31. Nr. 4978/43 (GL/C-E 10/IV E)

The statement "Nothing changes as to the *qualities* or *use* of the lacquers." is particularly significant.

As before, non-specific shades of colours continued to be mentioned, but now with 99 in place of the old 'period dash' designation. This was a carry over from the pre-RLM civil RAL-based system where, in addition to specific colours being identified by company numerical codes, other

colours were simply noted by a general description, e.g., grey, red, etc. Examples of this practice appear in documents, sometimes specifying a transparent colour, e.g., 99 gelb lasierend (yellow transparent), or grün lasierend in the manufacture of wooden aircraft components such as those used in gliders. An application of each of these resulted in the greenish-yellow translucent colouring seen on such structures at that time, however it was more usual to use just the grün lasierend. A brownish tinge was sometimes specified for some applications of light metal primer. In some instances specifications called for full strength colours, not rigidly specified by an RLM standard, using such general descriptions as 'red oxide' or 'oxide brown', possibly variations of the same colour. Examples of designations of other full strength colours known to have been excluded from precise colour matching, and added after the suffix 99, were blue, silver, brown and green.

A small area where the two systems did co-exist at times within the same painting schedule occurred later in the war. Eventually shortages of raw materials did have an effect on some colours that had previously required exact colour matching. These were all internal colours and it must be emphasised that this option was *never* implemented for *external* camouflage colours. RLM 01, by then forbidden for external use, RLM 02, where it was used only for internal application, and RLM 66 would all be affected in some way. The usual designation was set down, but with an option, e.g. 7101.02 or 99; 7101.66 or 99. This revised form of marking allowed the aircraft manufacturer to use up existing matched stocks of 7101.02 or 7101.66, or, by means of the 99 designation, more recent supplies where the natural colouring of the formulation was not relevant to any RLM standard. The location of the materials for which these paints were used did not compromise the aircraft's external camouflage system in any way, e.g., 7101 was used to paint steel or magnesium tubing used internally for airframes. In the past it had been coloured with 02, but that was no longer a requirement, making a saving in colour pigments.

The designation 99 also affected ancillary agents such as pastes, fillers and other such items where some form of basic, non-specific colouring agent was present. The following extract from Luftwaffen-Verordnungsblatt for 28 June 1943, provides an example. In this case the instruction advised not only of the change from the '.-' suffix to 99 but also a complete change of product code.

Introduction of the new aircraft paint stripper.

Instead of using the usual aircraft stripper 7210.99 (old description 7210.-) Flw 7209.99 is introduced.

Orders for new stock can only be made using the new Flw Nr.

Description. Old stocks must be used up first under old description Nr. 7210.99. A new publication will be issued of TA. Gen. TT.

Der R. d. L. u. Ob. d. L., 22.6.1943,
Az. 70 k 16.12 Nr. 10337/43 (GL/C-E 10 IV E).

Note also the generous time allowance for introduction of the new system, with industry documents mentioned earlier already containing the description 99 by March, and the official changeover date of 1 May 1943 being promulgated on 5 April, the usual two month grace period. Introduction of this measure is significant as it was part of an austerity process that would continue to gather pace as the war continued.

The decision to implement this new designation however was already in train, as reflected by the fact that the March 1943 edition of L.Dv.521/2 Behandlungs- und Anwendungsvorschrift für Flugzeuglacke, Teil 2: Segelflugzeuge - (Treatment and application instructions for aircraft lacquers, Part 2: Gliders), listed three lacquers utilising the designation 99; 7251.99, 7172.99 and 7102.99, some applications on wood, others on metal.

Returning to the lacquers, 7140.99 (grün lasierend) and 7141.99 (gelb lasierend), mentioned earlier, both were transparent lacquers, each of which had had a touch of colour added to aid in their specific use. Lacquer 7140 was one of the original ones listed in the 1937 edition of L.Dv.521/3 issued for repairs to aircraft. Originally identified as Herboloid lacquer BC 6929, it was used for internal and external painting of wooden aircraft decking. Lacquer 7141 however was a new product, used in conjunction with 7140, both using the same original thinning agent 7233.00. First 7141.99 was applied, having been thinned with 7233.00 in a ratio of 3:2 and then allowed to dry for three hours. 7140.99, thinned to a ratio of 1:1, was then sprayed in a cross hatching manner and allowed to dry for three hours. In this way the two differing tinges of colour make sense, clearly identifying one lacquer from the other, the greenish tinge of the 7140.99 turning the underlying yellow to a greenish-yellow finish.

A revised issue of 'Der Flugzeugmaler' - 'The Aircraft Painter', subtitled 'Lehrbücher Der Luftwaffe, Technische Grundlehrbücher Band 1' - (Training Manual of the Luftwaffe, Basic Technical Training Manual Volume 1) by K. Flieg was issued in 1944, this time printed by Walter de Gruyter & Co., Berlin. A compilation of several previously issued documents on the subject, the precise date of issue is not stated but must have been by March as it did not incorporate references to directives mentioning colours and lacquer-type changes promulgated after that date.

The Flieglackketten listed in the November 1941 edition of L.Dv.521/1 had been retained. Lacquering of repaired metal propellers had been amended; 7147.99 was to be applied to the cleaned and repaired propeller, followed by a final coat of 7146.70. The number of intermediate coats however had been reduced from two to one.

A further directive, 'Az. 70 K 10.11 GL/C-E 10 Nr. 4135/44 (IVE)', was issued on 10 March 1944 by the Technisches Amt regarding reduction of painting. It dealt with internal painting of land planes with steel or Elektron finished parts and at first reading, it gives a seemingly contradictory picture of the tightening supply situation. It read:

"Due to the improved raw materials situation, lacquer 7101 (colours 99, 66 and 02) previously used only as a primer, replaces lacquer 7121. This results in a substantial economy of 7121 (smooth finish), more than half of which was previously used for interior finish. This measure ensures the availability of 7121 for camouflage paint and results in a useful saving of time. Henceforth it is forbidden to use 7121 and 7122, colours 66 and 02, once existing stocks have been exhausted. Exception: In the few cases where colour 02 is used for camouflage, 7121.02 may still be requested from the paint industry."

The specific reference to 02 where used as a camouflage finish makes it clear that adherence to camouflage colours was still strictly controlled. Demand for external camouflage lacquer 7121 coloured with 02 was in decline by this time, which helped to ease the supply problem of 7121. The other changes underscore the efforts to conserve time as well as materials.

"On technical grounds, it is impossible to guarantee colour uniformity between paint batches of colour 02. As this is of no importance in interior painting, deviations from the official colour standard are not grounds for concern."

This should be read in the light of the earlier quote that stipulated that the instruction applied to 02, 66 and 99 used "*...only as a primer*". Valuable production time was no longer to be expended on colour controls for those colours used internally on aircraft.

Interior painting was summarised as follows:

"Internal painting of land-planes of all metal construction in future has consequently to be as follows:
A) Two coat procedure (for Steel and Elektron)
1) single coat 7101.99
single coat 7109.02 or 66 or -
2) single coat 7101.99
single coat 7101.02 or 66 or -
3) two coats 7101.02 or 66
B) Single coat lacquering
single coat 7101.02 or 66"

Note that where 7101 was used as the base coat, the suffix '99' had been added, removing the necessity for colour matching in 1) and 2), but it remained essential for the final coat in each case. The phrase *'improved raw materials situation'* is misleading. It referred only to availability of one area of supply making a welcome saving in another area.

Judging by the OS-Liste for the He 219, rationalisation of interior painting had taken a significant step late the previous year. The painting schedule, prepared in September 1943 and issued in January 1944, gave instructions for deletion of paint for internal surfaces, (other than the cockpit, which retained its 66 colouring), including the inner surfaces of the fuel tanks and the undercarriage components. Where steel and Elektron until then had escaped total removal of paint protection, because of their corrosion potential being far higher than that for dural or plain aluminium, that also had finally changed. Marine aircraft appear to have been excepted only because of their corrosive environment, e.g., the OS-Liste for the BV 138, prepared in December 1943 and issued in March 1944, carried no such restriction. Metal interior surfaces were coated first with an Eloxieren finish (anodised) then 7118 or 7102, and finished with 7109.01 silver. The vast bulk of airframe production was however treated as for land-based aircraft, and the savings in materials and man-hours were substantial.

Problems of raw materials in short supply, as well as delivery of the finished product, was becoming more difficult due to transport shortages and petrol rationing as a 1945 British Intelligence report [3] on the paint industry recorded:

"At nearly all targets [firms] *reference was made to substitute drying oils, linseed oil and particularly China Wood oil being in poor or indifferent supply."*

In addition, bombing was a constant threat to stored stocks of paint. Reducing the range of paints and their scope of application was one measure to counter these problems to some extent. Attempts to achieve savings were about to make a major jump, and not just materials but also production hours were targeted.

On 30 June 1944 the management of Focke-Wulf's Bad-Eilsen plant had been contracted by the RLM to produce a test batch of 50 Fw 190s with no under surface colouring. This had the approval of the Fighter Staff and GL/C-B2 who had agreed that only primer (actually referring to the filler as noted below) should be used. The RLM was to be advised of consequent savings in labour and materials. The initial parameters were not totally rigid and details were to be decided on site, in consultation with representatives of the E-Stelle, Travemünde.

While not all the ensuing exchanges have been located, sufficient have survived to give a clear picture of what was being done and why. An advisory notice (Mitteilung,) issued on 15 July 1944 under the signature of Herr Klemm at the Detmold facility, was distributed to personnel at the Sorau plant and the control line. It summed up the proposed production trial in the somewhat stilted bureaucratic terms of the period.

Subject: Fw 190 - Abolition of camouflage paint on the aircraft underside.

Organisation: FS RLM GL/C-E 2/III Nr. 10 333 of 30.6.44 and Fr. 3173 of 14.7.44
In the above quoted communication the RLM informs us, that in accordance with the fighter staff and GL/C-B 2 the colour paint to the lower surface of the aircraft is to be left off. As a large-scale test first of all to 50 airframes at the Sorau plant only the primer filler has to be applied on the bare sheet metal. In the individual records of each airframe, the deletion of camouflage paint has to be particularly noted. (Information [to be advised] *to quality control).*

We ask AB Sorau to inform us at once about the following:

1) When the first aircraft will be delivered in the specified finish.
2) How much working time and material was saved with each airframe.
3) The construction numbers of the airframes.

Should there be any objections due to this measure or in the test flying operations then we ask for immediate information.

Please hand the written answers to the above itemised subjects, to our courier.

Kubb, Focke-Wulf, Bad Eilsen.

Technic. External.
(Klemm)

On 24 July two more communications were issued. The first was addressed to:

Erprobungsstelle der Luftwaffe,
Abt. e 21
s.Hd. Herrn Fischer

Travemünde

4.7.44 WP/Gr/Schg/4 2712 24.7.44
Subject: Fw 190 - Abolition of camouflage paint on the aircraft underside.

We confirm the arrival of your communication of 4.7.44 and your telex of 2.7.44 and confirm to you that the large-scale test will be carried out immediately according to your directions. As you informed us today by telephone, the Ruth company was commissioned by you to send us 100 kg of putty. The filler has not yet arrived at Sorau today. Immediately upon its arrival we will transport it by courier to our plant at Posen where the large-scale test will be carried out. For the priming of bare sheet metal we have considered the putty 119 D from the Warnecke & Böhm company, which we ordered on 16.7.44 by telex, in addition to the putty from the Ruth company.

As we have organized today by telephone, we will additionally camouflage in the shade 76 the tail plane parts that are conserved by red dope and the varnished wooden parts on the undersides of the fuselages and wings. We will inform you by telex about the start of the test at Posen and as directed by you we will:
1. Report the construction numbers of the simplified conserved airframes before delivery to GL/C-b 2 and GL/C-e 2.
2. Point especially to the omission of the camouflage paint in the individual [aircraft] *records and add the remark that objections have to be reported immediately to Gen. TT GL/C-b 2.*

3. Also report to GL/C-b 2 and GL/C-e 2 any complaints [problems] *which occur during production or during test flying.*
4. send you an exact report after completing the test, regarding our experiences, especially about the working time and materials saved by this simplification.

Heil Hitler!
Focke-Wulf Flugzeugbau G.m.b.H.

The second document was another company 'Notice' with a distribution list to personnel at the Posen, Sorau, Sommerfeld and Detmold plants:

Instruction

Subject: Limitation of the camouflage paint.

In addition to the instruction from the material-testing division of 11.7.44, today it was agreed with the E-Stelle Travemünde, that tail-plane parts, which are conserved by dope and the wooden parts which are conserved by varnish on the undersides of the fuselages and wings are not to be protected by silver paint but by the hitherto usual camouflage paint in the shade 76. Therefore it is not necessary to obtain special paints for this large-scale test other than the already quoted putty 119 D from the Warnecke & Böhm company.

Again it has to be pointed out, that the introduction of this simplification is extremely urgent and that the divisions named in the distributor [distribution list] *have to be informed immediately about the start.*

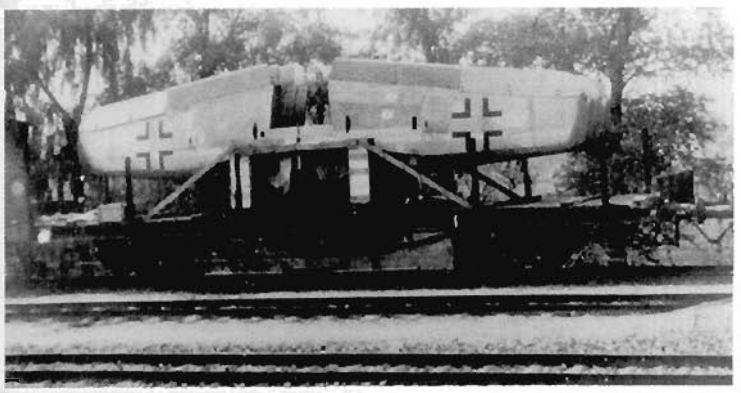
Sorau, 24 Juli 1944.
Gr/Schg/-
Material testing.
(Grahlmann)

The repeated emphasis on the urgency of these tests is telling as to the state of material supplies and manpower in the face of the accelerating austerity campaign and rising production targets with regard to defensive fighter aircraft.

The explanation regarding the conserving and painting of wooden parts as normal is interesting as it makes it clear that these aircraft had small parts of their under surfaces painted in 76. The documentation does not extend to identifying the production batch, or the date of the first deliveries, but an ULTRA intercept Ref: XL 6014 dated 13 August 1944, provides a clue as to the approximate date of delivery of the first modified aircraft. It read: *

JG TWO SIX ON NINTH REQUIRED REPORTS ON DIFFICULTIES) IN PILOTING ME £ ME ONE NOUGHT NINE AND FW £ FW ONE NINE NOUGHT WITH CAMOUFLAGE PAINT ONLY ON UPPER SURFACES. QUOTE A CONSIDERABLE NUMBER UNQUOTE TO BE DELIVERED IMMEDIATELY.

This signal indicates that the test batch was ready for delivery by the end of the second week in August and, further, that deliveries were not scattered across many units but concentrated, JG 26 possibly receiving



BELOW: Following operational experience with bare metal under surfaces, colouring was restored to the front section of the wing lower surfaces on Fw 190s, usual back as far as the main spar line and including the oleo fairings, in order to prevent glare at low sun angles when the aircraft were at dispersal. The colouring used was usually 76, or the green-blue where that occurred on the main airframe. This example, 'Yellow 12' of an unidentified III. Gruppe, used 76, the same colouring appearing on the ailerons, but the fabric of the elevators appears to be in red-oxide primer. The nose section has a 04-coloured tactical band marking around the front portion. (J. Crow)

ABOVE: This wagon-load of new Fw 190 wings shows the earliest form of bare metal lower surfaces, as devised during the trial. The wings have just the darkest of the two upper surface camouflage colours (81 or 83 in this instance) taken just round the leading edge and across the wing tip area. The ailerons and flaps, both sub-contract built items, were supplied finished in 76 colouring. (S. Sheflin)

* Decryption of this intercept revealed the following message:

'On 9 (August 1943), JG 26 required reports on difficulties in piloting the Me 109 and Fw 190 with camouflage paint only on the upper surfaces. A considerable amount to be delivered immediately.'

most, if not all. Logically the RLM would have wanted rapid field assessment of this somewhat radical departure from the usual camouflage practices – a process more easily achieved if the subject aircraft were concentrated in one unit.

The signal appears ambiguous, seeming to imply that Bf 109s also were being delivered in bare metal under surface. The message reads 'required reports' i.e., more than one report; one relating to handling of the Bf 109, the other on Fw 190s with only upper surfaces camouflaged. The documentary evidence, which points to the entire experiment with bare metal lower surfaces being focused on the Fw 190, qualifies this interpretation. [4] Results were valid no matter what class or type of day fighter was used for the trial, and there was no reason to duplicate the process. The trials proved satisfactory and resulted in this measure being gradually instituted throughout sections of the aircraft industry already engaged in the production of day fighter aircraft. However, Bf 109 production was slow to adopt this measure, despite the contemporary company product, the Me 262, adopting bare metal under surfaces by late December 1944. That change was incorporated into the 23 February 1945 camouflage document for the Me 262 but no such documentation has so far been found for the Bf 109.

ABOVE: The Do 335 A-12, W.Nr. 240112, the second two-seat trainer prototype as found at Oberpfaffenhofen at the end of the war. Although allocated the Stammkennzeichen RP+UB, but in accord with the last change to the regulations on such markings promulgated in July 1944 this had not been marked on the airframe. Only the Werknummer was to be displayed across both vertical tail surfaces, but Dornier, like some other manufacturers, chose to use just the last three digits for most of its Do 335 aircraft. Camouflage was shown on the works drawings as 81/82/76, but the very low contrast scheme seen here was more likely to have been 70/82 – the same mix found on the Do 335 A-02, W.Nr. 240102, during its 1975 restoration. Dornier, as a manufacturer of bomber aircraft, had a surplus of 70 and 71 colours and was allowed, under the transitional provisions of the change in camouflage colours, to use that combination. The lower surfaces of wings were left in bare metal, only ailerons and flaps being coated with 02-primer, indicating that the airframe had been finished after September 1944. The engine cowlings were still in bare metal but would have received camouflage had the construction programme continued.

No indication is given as to which model of Fw 190 was being tested, but it is almost certain that it was the Fw 190 A-8. Losses of Fw 190 A-8s serving with JG 26 between mid-August to December 1944 show a mixture from the 170000 to 177000-series Werknummer blocks inclusive; too large, allowing even for gaps in sequences, from which to make any definite identification.[5]

The correspondence between Focke-Wulf's staff and the RLM makes it clear that only wooden and fabric areas of the tail plane under surface were to be given any 76-colouring. However, the photographic record shows that additional colouring was subsequently added to other parts of the lower surfaces, usually in 76, or the unidentified green-blue colour. This was added under the engine section, and to the front section of the wing back to approximately the spar line; the latter ensuring that the undercarriage oleo legs were painted. This was an anti-reflection measure needed because of the high ground angle of the Fw 190 type; the change presumably resulting from the subsequent field trials.

While the bare metal test were being conducted at the Focke-Wulf facilities, a new set of instructions was promulgated to aircraft production centres, sub-contractors and Luftwaffe repair and conversion depots on 1 July 1944. Titled 'Sammelmitteilung' (Collected Instructions), it contained a number of changes and new products. One item that was unusual, given the stringent testing regime for all paint products, was a withdrawal notice for 7151.99, which had proved faulty. It was to be replaced by 7152.99 and any stocks in excess of 10 kg could be returned to the sole manufacturer, Messr Herm. Fenkel (IC).

A stock count of non-aviation paints was notified as part of the rationalisation of strategic materials.

"By 15 August 1944 all aircraft factories are to submit a report to GL/C-E 10 IV on all non-aircraft lacquers used in aircraft construction laid out according to the following example:

Description	Supplier	Used for	Aircraft type	Monthly requirement
Exhaust lacquer Heat resistant Ikarol 173	Warnecke & Böhm of Berlin–Weisensee	Exhaust pipes & other heated pipes constructed	He 111	275 kg

The intention is generally to introduce a product that is most advantageous in terms of raw materials. Only in this way will the necessary control and safeguarding of supplies by GL Ro IV and the Reich Office for Chemicals be possible."

Following extensive testing at E-Stelle Travemünde, Flieglack 7280.99 had been developed by Atlas Ago for painting over Klebelack Nr. 4637, an adhesive lacquer for use on fabric, wood and metal surfaces. This was a flammable lacquer and could not be used with Flieglackketten Nr. 05, 22 and 33. For those lacquer sequences, non-flammable 7285.99 had been developed by Herbig-Haarhaus A.G. for overpainting of fabric and metal parts covered with Klebelack W1. 7826 oxide red finish. A third lacquer, 7191.99, was introduced as a base coat for welded parts as an anti-corrosive finish.

The document also contained a number of orders relating to camouflage and markings. Camouflage for gliders was dealt with in paragraph 6 (see Chapter 19, Volume Two), using colours 81 and 82, the same referred to in the August 1943 document. It concluded with the statement:

"The delivery of colour sample cards for the RLM shades 81 and 82 is for the moment not possible, thus testing of the paint for correct colour shade is omitted."

A more extensive description of the new colours appeared in paragraph 8, which signalled their official introduction for front line aircraft. It stated:

"8.) Use of colours 81 and 82.
The impending introduction of camouflage colours 81 and 82 in place of 70 and 71 was announced in instruction GL/C-E10 Nr. 10585/43 (IVE) Az. 82 b 10 of 21. 8. 1943.
The introduction of these colours is henceforth prescribed

as follows:

1) *All new aircraft types whose mission would have called for the use of colours 70 and 71, are from now on to be painted in colours 81 and 82.*

2) *For types already in production, colours 70 and 71 are to be superseded by colours 81 and 82 as soon as possible.*

   Available stocks of 70 and 71 are naturally to be used up. As it may be assumed that these colours will not be exhausted simultaneously, and in order to avoid re-orders of small quantities of 70 and 71, the use of residual stocks in the following combinations is authorised:

   Colour 70 (remaining quantity) + colour 82
   Colour 71 (remaining quantity) + colour 81

   However, should stocks of one colour be so large as to unduly delay the implementation of the regulation camouflage, efforts must be made to trade away these stocks to sub-contractors, company plants or to other aircraft manufacturers.

3) *The method of application (mottle scheme) of these colours is unchanged.*

4) *Aircraft plants will report implementation of the colour change, together with the modified OS-lists to GL/C-E 10 IV."*

No mention was made of lower surface colouring changes and for the moment 65 appears to have been retained, though a withdrawal order appeared six weeks later.

In addition, no mention was made of the qualification, included at the end of paragraph 6, regarding supplies of colour cards for checking. Given the pedantic nature of German documentation this is significant. It has always been assumed that the paragraph 6 reference had been a blanket coverage for any other references to the new colours contained in the Sammelmitteilung. However, it should be kept in mind that the entire document was a collection of orders, many having no direct relevance to others. As such, the qualification may have been directed only to the multitude of units operating basic training gliders and sailplanes (transport gliders were specifically excluded). It is possible, indeed probable, that the main *aircraft* manufacturing centres, (the major assembly plants and sub-manufacturers), may have been given priority on supply of colour match cards. If so, assumed problems of colour matching were possibly even less relevant than previously thought. Other factors that would have an impact on colours are detailed later in the text, but they would result from a general deterioration in infrastructure, rather than a lack of colour cards.

When the RLM had selected and introduced its first range of defensive colouration for aircraft in 1936, it had done so after vigorous testing and selection. A range of camouflage colours had resulted for production status under designations 61, 62, 63, 64, 65, 66, 67, 68 and 69. As is already known, 66 was used not as camouflage per se, but for interior areas visible through clear glazing, though still forming a small part of the overall camouflage. From the remaining colours, 64, 67, 68 and 69 were not put into use. Such largesse of choice did not occur again, but not all was wasted.

Colours for upper surface camouflage were a warm toned dark brown (61), a mid-green (62), and a warm toned pale green-grey (63) that contrasted with the other two colours, breaking up the general mass of the shape. These were confined to all classes of front line, land-based bomber and transport aircraft, fighter and marine aircraft retaining their existing pale green-grey 63 finish.

A simplified scheme in two shades of dark green, 70 and 71, had appeared with the service introduction of the Bf 109 B monoplane fighter early in 1937, and 63 consequently disappeared from front line fighters. By 1938, the dark green colours had become universal for all land-based aircraft following rationalization to reduce the number of colours in production - sensible in terms of production and supply logistics. Maritime aircraft were the exception, requiring their own colours, and 72 and 73 replaced the 63 overall finish.

The rapidity of these changes reflected the constant attention being given to camouflage, which was a well-considered, scientific subject within the German armed forces and which was never left static. A review of camouflage in general, L.Dv.984, 'Tarnfarben' (circa 1940) - (Camouflage), recorded in part of its preface:

"2.Camouflage against aerial observation is the most important and most difficult part of camouflage. No type of reconnaissance offers such all-embracing and extensive possibilities of recognising and noting the camouflage of troops and installations, as aerial reconnaissance by visual observation and aerial photography.

3.Troops must always reckon with the possibility of being recognised by means of aerial reconnaissance, even when they do not see or hear an enemy aircraft. Even from heights at which he is no longer perceptible, the aerial observer can take photographs which show troops, positions and installations with sufficient clarity to render them liable to enemy attack."

Later this document dealt with specific details relating to camouflage against aerial observation.

"25.Camouflage paint should render arms, equipment, vehicles and if possible constructional works inconspicuous to the aerial observer. In this connection it should be noted that on smooth surfaces even dark paints reflect a lot of light, so that the article can easily seem lighter as a whole than the natural surroundings.
For camouflage against aerial reconnaissance therefore, it is more a question of the camouflage paint being dark and matt, rather than agreeing with the surrounding shades of colour.

26.Black-grey and black-brown in irregular alternation have proven suitable as colours for camouflage paint. Only a few large areas of the two colours should be formed. These should not have regular borders nor be set harshly against each other. They should merge imperceptibly into each other."

While aircraft were not specifically cited, the principles were equally pertinent to aircraft on the ground, something reflected in the range of dark colours employed initially for all classes of land-based aircraft and retained for bombers and transports until the July 1944 'Sammelmitteilung'. Fighter colouration had broken free from the ground defensive colouration requirement in 1940 because of air-to-air camouflage requirements associated with fighter operations. However, by 1944 that distinction had changed dramatically under the intense Allied bombing and ground strafing. As noted, initially the camouflage order was restricted, by definition, to all classes of land-based aircraft other than fighters - but this changed within a few weeks.

It is worth revisiting some earlier camouflage directives before moving on. Two years into the war a second, more specific document relating to types and uses of paints developed for ground camouflage, had been flagged in a single-page notice from the office of Gernerallluftzeugmeister Ernst Udet, (LC 2 Nr. 12 157/41 (VII) Az.: 82a), on 31 March 1941. Titled, 'Vorläufige Anwendungs - und Verarbeitungsvorschrift für RLM - Tarnfarben' - (Provisional Direction

for the Use and Processing of German Air Ministry Camouflage Paints), it addressed a significant rationalisation of colours and their uses and commenced with the following statements:

"It has been found that paints unsuitable for the purpose by their composition, or having valuable and scarce lacquer components which ought, in view of the current shortages, to be preserved for other uses, are being widely employed for the camouflage of buildings and sites.
The 2.Abteilung of the Technical Office (LC. 2) has been entrusted with the task of standardisng camouflage paints and directing their distribution with the view to developing technically adequate camouflage paints in collaboration with industry for using as far as possible only readily available materials."

The document concluded with the following statement:

"It is requested that these 'Provisional Directions' be forwarded to all responsible authorities and firms and that their application is made compulsory in subordinate departments."

A second, much expanded form of the same document and subject had been issued in April 1941, printed by Verlagsgesellschaft Rudolf Müller of Eberswalde, and distributed through the office of 2. Abteilung/Gruppe VII. It contained a detailed analysis of RLM rationale and practices relating to defensive ground camouflage and also a colour atlas comprising the following - schwarz (black), dunkelbraun (dark brown), dunkelgrün (dark green) olivgrün (olive green), ziegelrot (brick red), erdgelb (earth yellow) and grau (grey).

As in the previous document, L.Dv. 984, it was pointed out that for camouflage *'...dull and subdued colours are used for this purpose'* The first page opened with a significant admission:

"Necessity for Control of Raw Materials
The shortage of raw materials for paint and binding agents, sizes [surface preparation products] *etc., has rendered it necessary to switch to the use of raw materials for camouflage purposes, which are easy or fairly easy to obtain."*

The concluding paragraph was the familiar one made every time changes occurred in the paint industry.

"Stocks in Hand.
Small stocks of existing paints still in hand may be used up. Paint ordered but not yet delivered by firms not approved by the Reich Air Ministry may however only be accepted upon special authorization."

In the next section, titled 'The New German Air Ministry Camouflage - Paints', all types of paint were carefully listed and grouped into specific classes dependent upon their chemical composition and use. Specific reference to colours to be used was as follows:

Use of the various colours:
"The colours black, dark brown, dark green and olive green are used for 'blending camouflage', i.e., they are used to make it difficult or impossible to distinguish buildings, taxiing areas etc., from their surroundings. In most cases it will be necessary to make do with black, dark brown and dark green, a fact that should be taken into account when ordering and storing..."

"The general principle to be remembered when choosing colours is that hitherto those selected have been too light and dazzling. It is much less dangerous to keep camouflage one or two shades too dark than to lighten it too much by only one shade."

A smaller edition of the same core information was printed (by the same firm) in 1944, as 'Verarbeitungsvorschriften für LS-Tarnfarben (Gebäude-und Bodentarnung), der Reichsanstalt der Luftwaffe für Luftschutz' - (Processing of LS-Paints (Buildings and Sites), the Reich Institute of the German Air Force for Air Protection).The 'LS' in the title stood for 'Luftschutz' (Air Defence). It acknowledged relationship to the 1941 document on the title page (the reader may reflect upon the fact that the three colours, black, dark brown and green may be seen today on a wide variety of the ground vehicles of various European military forces because the same topography and needs continue to apply).

While the above information was addressed to ground objects in general, the same factors applied to aircraft at dispersal during daylight hours, which was the case with land-based bombers and transports; a premise that extended to the mobile vehicles using the same area if they were exposed to extended periods of potential observation from the air.

This colouring change was reflected in the 1943 series of Heeres-Verordnungsblatt, (Army Regulation Amendment) that announced changes to equipment camouflage colouring. Two amendments appeared in quick succession; 'Nr 181 Anstrich des Heersgeräts, O.K.H.(Ch. H. Rüst u. BdE) 18/2/43 - 72/88/16 - In 2 (V)' (No. 181 Colouring of Army Equipment,Army Supreme Command (Ch. H. Rüst u. BdE) 18/2/43), and 'Nr. 322 Anstrich des Heeresgeräts O.K.H.(Ch. H. Rüst u. BdE) 3/4/43 - 72/88/16 - In 2 (V).' Section 2 of the first document read:

"2. Camouflage Paint. The camouflaging of a piece of equipment by applying applicable colours according to prevailing field conditions is a matter for the troops. For this purpose, the troops are to carry camouflage paste (3) [colours] *in the following colours; olive green in paint boxes of the RLM for camouflage colours (building and ground camouflage), red-brown RAL 8017, dark yellow to pattern set out in number* 1" [Section 1 of this Army instruction].

The second document, Nr. 322, sub-titled 'H.M. 1943 S 113 Nr 181 - Heeres Mitteilung 1943' (Army Instructions 1943), identified the three colours concisely which remained in force for the Army until the end of hostilities in its first section:

"1. The colours, dark yellow as for the sample and olive green after the RLM for camouflage colours (building and ground camouflage), are in the RAL Colour Register 840 R under the flowing designation:
dunkelgelb RAL 7028 (dark yellow)
olivgrün RAL 6003.

H.M. 1943 S. 113 Nr 181 digit 1. Excerpt 2 is herewith complete."

The identification of the green colour as RAL 6003 is interesting as this was the RAL equivalent for the pre-war camouflage colour RLM 62. While withdrawn from use for aircraft in 1938, it had remained in use for camouflage of buildings and airfields.The last part of section 3 is also significant. It read:

"In view of the existing situation as regards raw materials, production and transportation, it must be made the duty of the troops to use paint and camouflage paste cautiously and to limit the consumption to what is urgently necessary."

This was further concise evidence of the problems already affecting the German armament production and supply situation by early 1943. Note particularly the emphasis that stocks be used only for '...what is

RIGHT: Recovered sections from an Fw 190 A-5 of 4./JG 54 that crash-landed in July 1943 still clearly show the colours of its non-standard camouflage, confirming that JG 54 had been used to test the re-introduction of the pre-war camouflage colours. On the left can be seen the rear section of the fuselage, finished in 62-green; the yellowish areas are where the green colour had been sprayed over the original 04 yellow tactical band marking. Positioning of the yellow tactical marking varied, but in mid-1942 it was standardized behind the Balkenkreuz. The full yellow rudder marking had been reduced at the same time, making both markings less compromising to the camouflage, a direct result of the increased intensity of the fighting. The fin and rudder assembly on the right has clear evidence of its base colouring of 61 that had been sprayed over most of the port side. To that had been added a segment of 79-sand brown that extended up the rear section of the fin and around the trailing edge portion of the Hakenkreuz marking; the latter has a square of 02 behind it. At the time, JG 54 was involved in ground-attack work and this form of camouflage would have worked well. The month after this aircraft crashed, an RLM instruction was issued stating that colours 81 and 82 were ready for reintroduction into the main manufacturing cycle. JG 54 had received its first Fw 190s, complete with the non-regulation camouflage, in late December 1942, undoubtedly as part of the field-testing of the revised camouflage colours. (M. Sheppard)

LEFT: This overall view of the aircraft, as it was discovered, shows its remarkable state of preservation. The area of 02-colouring behind the Hakenkreuz, seen in close-up in the previous photograph, can be seen to be original. The red areas of fabric primer can be seen in the torn areas on the tail section. This exotic form of camouflage began to disappear from aircraft of JG 54 around the late summer of 1943 and had gone entirely by mid- to late 1944, when the last surviving examples had been lost in action. By then the RLM had reintroduced the pre-war colours of 61 (RLM 81), 62 (RLM 82) and 64 (RLM 83). (M. Sheppard)

RIGHT: The random nature with which the mixture of colours was applied to Fw 190s of JG 54 also may be judged from this photograph. 'Black 5' has large areas of 81 (61) and 82 (62), 79 and 02 in a very random patchwork of colours that blend into each other, leaving just traces of the original 76 side surface colouring in one or two places. Even the spinner had been given a mixture of colours. The aircraft immediately behind has a less eclectic pattern of colours, though the 81 (61) and 82 (62) colours can still clearly be seen, but mixed with large segments of 02; the same colours being used, in similar style on 'Black 6' to the rear. Note the difference in shade of yellow used for the tactical marking on rudder and around the fuselage compared with beneath the engine cowling. The deeper colour beneath the engine cowling may have arisen from heat factors, though that is not consistent with the colour stability in the same place on many other Fw 190s. The under surface colouring was 76 in each instance. (M. Sheppard)

urgently necessary.'

The statement in the July 1944 'Sammelmitteilung' that new colours had been ready for introduction since August 1943 is interesting in view of the ongoing shift to a reduced, more appropriate range of colours for ground-based objects and equipment as a whole.

The colours settled upon as being critical were given as schwarz (black), dunkelbraun (dark brown), dunkelgrün (dark green) and olivgrün (olive green). Such a range had been in use since 1936 for the Luftwaffe designated 61 (dunkelbraun), 62 (grün) and 64 (dunkelgrün) and 66 (schwarzgrau), a de facto form of black. The Army colour RAL 8017 was very similar to 61 (which was RAL 8019), slightly more red being observable in the former.

The July 1944 announcement of issue of new colours 81 and 82 with reference to their having been available since August 1943 appears confusing at first. If these colours had been ready in 1943, when had they been developed, and for what purpose? They were, in fact, simply a reissue of the original colours 61 and 62, withdrawn from service use in 1938, which is why they were available.

Combining 66 black-grey with a dark brown and a green matched the main colouring range changes that had been occurring generally since April 1941. Missing to complete the range of issued ground based objects and equipment colours was a dark olive green, and this was introduced under the designation of 83. The latter matched the pre-war RLM 64 dunkelgrün. This re-issue of older colours also explains why 83 (64) was able to be introduced into service ahead of 81(61) and 82(62), seeming to be an exception to the standard rule of introducing colours in numerical sequence. This would point to 83 having been considered for fighter aircraft ahead of 81 and 82 being adopted for bomber aircraft.

The reason for the change of RLM identifying code number was simply one of standard stores issue procedure; once an item was officially withdrawn from use its identifying code was deleted, not to be used again. If it was later reinstated it received a new identifying number as noted. The same procedure is still in force to this day within the German military procurement system. The stores supply system requirements had already produced a major change with issue of the '99' suffix code in 1943.

The entire manufacturing industry, and the armed forces as a whole relied on an efficient stores procurement and issuing system, something pertinent to all military forces. When the German infrastructure finally crumbled it caused havoc, something reflected in the eclectic paint schemes that emerged in the last months of the war.

Colours identified as RLM 61, 62 and 63 for the Luftwaffe had remained colour standards available via their RAL equivalents, which never changed their designations and are still available today under the same access numbers. While the RLM contracts board supervised the tender process for supply of *aircraft* lacquers, paint producing companies were always able to manufacture stocks of RLM superseded colours, e.g., for aircraft companies that had contracts to supply military aircraft to friendly foreign powers who wanted the older colours, or for repainting of aircraft transferred from the Luftwaffe, for example, Bf 109 Fs transferred to the Royal Hungarian Air Force. Paint companies, as already mentioned, did not manufacture paints exclusively for any one end user, such as the Luftwaffe, but met Army, Navy, Air Force and civil use requirements simultaneously. While formulae and ingredients required for each application were different, careful balancing of all ingredients produced a standard colour.

A second document, 'Sammelmitteilung Nr. 2' appeared on 15 August 1944. Once again a collection of orders, some of which had been promulgated through other sources but issued by a different authority from within the RLM. It contained several camouflage directives, beginning with a change in lacquer stock for night camouflage purposes. The existing 7142.22 permanent black finish, first detailed in the 1941 issue of L.Dv.521/1, was replaced by 7126.22, which was applied directly over the existing 7121.65 coloured surfaces as per the old instructional diagram showing areas to be painted black. As always, existing stocks of the old night finish were to be used up first. A second section of this document announced that re-camouflaging lacquer 7126.76, the other field-applied colour change used in conjunction with 7126.22 to convert aircraft back to day camouflage, would replace 7126.65. Unlike the night black finish, which was sprayed on, the 76 finish was applied by brush. Both lacquers were for front line use. This change also signalled the shift from 65 to 76 for the Luftwaffe front line units per se.

The section introducing the single, universal filler 7270.99, referred back to the extreme simplification order of 30 May 1944. While it stated that this filler replaced all existing fillers, it then stated that it was exclusively for use on fighter and Zerstörer aircraft '*...and other aircraft to be specified*'. Whether this was a reference to maritime and tropical aircraft is unclear.

Replacement of 7101.02 with 7101.66 formalized changes that had been taking place with simplification of interior painting.

> *"Flw. 7102.02 was specified for lacquering aircraft interiors. But as the interior lacquering of metal aircraft is largely no longer applied, due to substantial simplification of aircraft interiors, and as the principal requirement in lacquer is for anti-glare reasons in the cockpit, namely in colour 66, the following has been stipulated for reasons of simplification in stock-keeping and rationalisation in the paint industry:*
>
> *Aircraft lacquer 7101.02 is uniformly replaced by*
>
> *aircraft lacquer 7101.66*
>
> *Future orders for Flw. 7101 should be placed only for colours 66 or 99 (as undercoat for two layer systems). The paint industry has been instructed to produce Flw. 7101 only in colours 66 and 99. Existing stocks are to be used up."*

Paragraph 7 reinforced the conservation drive under the heading '*Elimination, maximum conservation of solvents used for cleaning*'. In the provisional instructions, under the section 'Cleaning of Metal Parts, Assemblies and Complete Aircraft, B.Nr. 238/44' of 12.7.44, sheet metal, riveted and welded assemblies were to be washed with an alkaline-based cleaner, raising some complaints about corrosion effects. The response is indicative of the harsh measures being forced on the aircraft industry by this time.

> *"Testing has proven groundless, fears of corrosion induced by residues of the cleaning material, especially when the present relatively short life of aircraft is considered. The use of organic-based cleaning material such as aero-cleaner Z, Per, Tri, petrol or other organic compounds offered by the chemical or paint industries, is hereby forbidden. To prevent error, it is stressed that permission is granted for the continued use of Siltron WL for the purpose described in L.Dv.521, pp. 39-40."*

The document went on to state that introduction of the alkaline cleaning agents, which replaced organic solvents, eased considerable pressure on the solvent sector, benefiting lacquer production. Despite the general move to reduce man-hours, the order stated that additional man-hours might be caused by the change and this had to be accepted. Trials in aircraft factories had shown that re-arranging working practices absorbed most of the increase. Raw materials obviously were more important than manpower, especially as slave labour or foreign workers were by then being used in many parts of the industry. And the comment about attrition rates was tacit admission of Allied air superiority.

The manpower aspect, and its strict control, was also touched upon in another paragraph:

"The Savings Representatives [responsible] *for lacquer etc.*

The reports sent in reply to the The Savings Commissioner of the Luftwaffe GL/C-E 10 Nr. 506/43 (IV E) ref. 70 k of 30.9.43, in which names of savings representatives nominated by the factories were given, have been destroyed. We request that this report be repeated and addressed to the Travemünde E-Stelle E 21: deadline 15.9.44.

It is requested that all collective communications be forwarded to the savings representative."

Paragraph 10 dealt with aircraft material marking, commencing with a warning that various incidents had made it necessary to point out the dangers of removing aircraft material markings - the principal means of identification.

"Some bleed markings, particularly in connection with the light camouflage 76, is no cause for complaint! For this avoids attention having to be given during the cutting of panels to the correct position of the marking, i.e., on the inside of the aircraft. It is requested that the Travemünde E-Stelle E21 be informed of the names of sub-manufacturers whose products have exhibited such bleeding so that the former can initiate a change in the markings lacquer."

Previously, such markings were placed on the inside face of the metal, avoiding any chance for them to be seen through the lacquer finish. The change to ultra-thin lacquers no longer requiring a primer coat, allowed the markings to show through the final camouflage coating, and the paleness of the 76-colouring exacerbated the problem. This notice also referred in part to the use, by some metal manufacturers, of paints that were not stable under the standard camouflage lacquer finish, producing a blurred stain.

Paragraph 12 gave clear indication of just how bad things were in terms of aluminium shortages:

"12.) Aircraft Lacquer 7114 (Intermediate lacquer for non-flammable Flieglackkette 05).

Aircraft lacquer 7114.01 has had to be changed because of the limited allocation of aluminium-bronze to 7114.99. The colour, because of the low aluminium content, is only light grey."

This had an effect on the filler used for the bare metal wing sections that were about to become more commonplace on fighter aircraft. With its normal 'silver' content reduced to a pale grey the filler was more easily seen against the surrounding bare metal, but this was accepted.

Camouflage in general received a special reference in paragraph 5.

"5.) Camouflage colours and their distribution over the aircraft have been uniformly redefined. The companies responsible for providing camouflage drawings will receive a camouflage guide with the required information from the E-Stelle Travemünde. With the issue of this camouflage atlas the industry is expressly forbidden to use any camouflage types or colours, e.g., in response to special requests from front line units, other than those specified in the camouflage atlas, unless specifically authorised by the E-Stelle Travemünde.

'In future as a result of this new regulation the following RLM colours are to be discontinued: 65, 70, 71 and 74. Colour 70 continues to be specified solely for propellers.'

Propellers, manufactured by specialist firms, were delivered pre-painted, supplies of 70 continuing to be made available to them, via this special approval.

This instruction was directed at the firms producing camouflage diagrams for the aircraft industry as a whole. The camouflage atlas referred to was an instructional atlas, which set down the camouflage requirements, not a camouflage colour atlas.

The instruction to withdraw colour 74 was already retrospective in some respects. This colour already had been excluded officially from the He 219 night fighter painting schedule issued in January 1944, both the written descriptions and the accompanying camouflage colour illustration listing only 75/76 externally. This reduction in colouring initially may have been stimulated by the concept that just the two colours were sufficient for night operations. However, on some older Fw 190 A aircraft, 76 had also replaced the usual 74 on upper surfaces, being combined with 75 to form the standard camouflage pattern.

There is some physical evidence, taken from an Fw 190 found in Norway [6], that a two-colour scheme of this nature was already being tried on some day fighter aircraft. Austerity measures had eliminated the original practice of using 02 as an external undercoat. Spraying 76 over the 02 and over the entire airframe had been normal painting practice until the mid-war period; from then on 76 doubled as both undercoat and the base layer of camouflage applied over the entire airframe (this was why the paragraph on materials markings had become so relevant). As a sky camouflage this colour was adequate, but it had no value as a ground defensive scheme (even less so after the RLM officially changed the shade of 76 in late 1944 from its old blue-grey colouring to a paler version that rapidly faded to whitish-grey).

The other significant camouflage comment in the August Sammelmitteilung document appeared in paragraph 9.

"9. National Insignia.

It has been noticed, despite various orders concerning simplification, saving measures etc., the Balkenkreuze and Hakenkreuze are still being applied in the original style. With Balkenkreuze only the angles and in the case of the Hakenkreuze either the black area or the white surround only are to be painted, namely on:

Light shades Colours 76 and 21 only the black angles of the Balkenkreuze and the black Hakenkreuze,

On dark shades Colours 72, 73, 75, 81, 82, 83 only the white angles of the Balkenkreuze and the white surround of the Hakenkreuze.

This directive applies also if transfers or decals are used; existing stocks are obviously to be used up. However, future orders should be placed in line with the above; colour 21 for the angles of the surrounds is replaced by colour 77 grey, in the case of night camouflage lacquering in colour 22 (as on page 18 of L.Dv.521/1)

The Savings Representatives are to be made aware of this reminder."

Reference to a third colour for land-based aircraft was made without preamble, the abruptness making it clear that some previous notification of colour 83 had to have been made, and obviously well before the promulgation date of 15 August. The first 'Sammelmitteilung' is frequently incorrectly referred to in some publications as 'Nr. 1', when, in fact, it had no such identifying number. It was a collection of instructions, most of which had not been promulgated through the

usual military channels or the 'Dienstvorschrift' publications. The 15 August document however did carry a series number, being titled 'Sammelmitteilung Nr. 2', but again it was largely a collection of notices published through other, disparate sources.

The reason for this difference appears to stem from the fact that the first document had been issued from Der Reichsminister der Luftfahrt und Oberbefehlshaber der Luftwaffe Technisches Amt. Its lack of a series number would appear to indicate that it had been intended as a one-off issue, not a continuing series of amendments. Gathering the various documents into one publication was a much quicker and efficient method of correcting a shortfall in distribution to what had been an eclectic collection of end users.

The second document had originated from Oberkommando der Luftwaffe Chef der Technischen Luftrüstung. The first organization was an administration concerned with precise standards; the second was more directly concerned with operational matters. This shift of issuing body, and the introduction of a series number, indicate changes that had occurred more by circumstances than forward planning and adoption of a blanket distribution system. Previously, only specified organisations addressed by the contents of a single order or amendment had received them - a selective system that had now succumbed to the limitations of the prevailing distribution system.

All these notices, in both documents, were directed at the end users of such paint industry products and practices, not at the paint manufacturing industry itself, something that should be clearly borne in mind. Notification of changes, or intended changes, to items produced by the civil manufacturing industry was sent directly to the relevant commercial sector organizations (there being no need to promulgate such information to the military forces). For that reason RLM correspondence with paint manufacturers, who would subsequently produce and supply RLM 83, must have taken place prior to the notification in the 'Sammelmitteilung' documents, which were issued to the aircraft production centres and Luftwaffe repair facilities.

The RLM inspectorate system was eventually able to identify enough collected examples from the entire range of colours listed in the document, including 83, to be noted in its subsequent report. To do that, inspectors must have been checking either at factory production centres, or at aircraft parks where new machines were gathered prior to dispatch to front line units.

Both document issuing offices occupied the same building at Leipziger Strasse 7 in Berlin, and both documents bore a contiguous RLM general series code that included Nr. 237/44 (document 237 for 1944) on the earlier issue and Nr. 239/44 on the latter. Clearly a document numbered 238/44 had been issued between those two, and it has been suggested that it was the missing document announcing to the end users the introduction of colour 83. However, all that can be stated with confidence about document 238/44 is that it could not have been a 'Sammelmitteilung' and its precise nature, and subject matter, remains unknown. Equally all that can be stated with confidence about the actual introduction of 83 is that it must have been in the form of a specific announcement, and that it was a 1944 addition to the 1943-announced 81 and 82 colours.

Lack of any mention of 83 in the July document raises two conflicting possibilities; either it had not yet been announced, or it had already been announced and promulgated to the end users, requiring no further comment at that time. The latter seems the most realistic; 83 was a re-issue of the pre-war 64 colour, which accounts for its rapid appearance, no lengthy testing being required, just a change of stores identification code. The ability of the paint industry to manufacture large volumes of lacquer with that colouring within a seemingly very tight time frame was equally uncomplicated, the standard base lacquer stock needing only a change of pigmentation - and colour pigmentation formulae were kept on file.

Sufficient supplies had to have entered the aircraft manufacturing cycle for the RLM inspectorate system to have identified, prepared and included the comment in the August document. In addition, the paint manufacturing industry would have had to have had advance warning of the change over from 74 to 83 to avoid a build-up of unnecessary stocks of the former and also have stocks of the latter ready for immediate distribution. The context of the reference to 83 in the August 1944 document also makes it clear that it had to have been introduced prior to announcement in the same document of the complete withdrawal of 74.

The timing makes it seemingly incontestable that 83 originally was intended to replace 74 in the 74/75 scheme to produce a grey-green combination more suitable for a ground defensive camouflage without too strongly compromising the airborne qualities of the scheme (a very similar combination, of 71/02, had served the Luftwaffe well at an earlier time with a grey/green combination, colours also continuing to serve the RAF simultaneously). Such was the intent, but the rapid deterioration in the war situation soon made that change redundant, with subsequent adoption of a fully ground defensive scheme as will be noted later in the text.

Unlike the nightfighter camouflage change, there had never been an intention to reduce day fighter camouflage to just a single upper surface colour. The OS-Liste for the He 219 night fighter, prepared in September 1943 and issued in January 1944, included a colour camouflage diagram, and instructions, which showed the entire airframe in 76 with random mottles of 75 restricted to just the plan view. The fact that this reduction in colouring took place eight months prior to announcement of *final* and immediate withdrawal of 74 for day fighters is of interest. In the case of the night fighter airframes, it produced an immediate saving in materials and labour without compromising effectiveness of the camouflage. However, withdrawing 74 from the day fighter scheme while replacing it with another colour, 83, negated any savings in materials and labour, reinforcing

RIGHT: Destroyed at the Luther factory at Braunschweig-Waggum by the retreating Germans, these Bf 110 G-4/R-3s wore the simplified night fighter scheme of 75 over 76 introduced in 1944. However, unlike other night fighter types of the time, the 75 had been applied as a solid coat on the strict plan form view, a style of application favoured at some production centres. All four Bf 110s found, (from Werknummer block 160786 to 160790) wore a yellow tactical band marking around the rear of the fuselage as well as yellow under the wing tips, indicating that they had been intended for issue to a unit, or units operating on the shrinking 'eastern' perimeter of the Axis-held territories.

speculation that the intention behind the change was one of camouflage requirements. That may have been forced onto the RLM because there is some evidence that there had been a push to simplify all day and night fighter camouflage - with consequent savings.

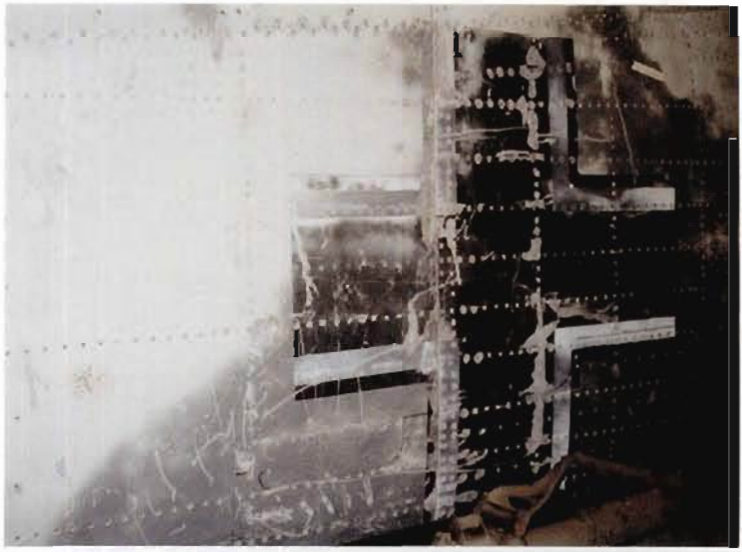
As noted earlier, samples of this have been found on large sections of the Fw 190 wreckage recovered from Norway, which provides an interesting clue. It had been lost in 1943, yet its remains clearly show that 76 had been applied directly to the bare metal surfaces, with 75 over that. Internal painting was mostly eliminated, leaving bare metal with just random patches of a very pale grey primer predominating, only the flap and aileron attachment points being coated in 02. The latter were sub-contracted parts, which would account for the 02 primer. While the colours have faded, close examination of the structure makes it quite certain that only those two colours were present externally. Possibly the deteriorating war situation militated against this move being made permanent as the very stark nature of the 75/76 finish appears to have proved unfavourable in the longer term. The experiment, if it was that, must have been reasonably extensive as examples of fighter aircraft wearing just a 75/76 finish were to be seen well into 1944, possibly older aircraft that had survived. These changes mirrored those in the 1943 revisions appearing in the OS-Liste for the He 219, which also excluded 02 priming.

It is obvious that 83 had been rapidly phased into the day fighter camouflage process prior to the August 1944 reference, and the wording of the latter makes it clear that some forewarning of impending withdrawal of 74, and introduction of 83 as a replacement colour, had to have been known within the aircraft manufacturing industry. Given fragmentary but physical evidence of the elimination of 74 noted on some airframes many months prior to the August announcement, it is possible that a gradual phasing out had to have been under way for some time. Just what overlap occurred between 74 and 83 is undetermined, but there may be a direct link with the reduction of night fighter colouring and the growing need for a better ground defensive camouflage for day fighters. The two events do appear to coincide.

Looking at the factors noted earlier, gathering evidence for compilation of the RLM inspectorate report would have required a fairly large sample, and even by conservative standards could have taken two weeks given the number of production centres and/or aircraft parks. Preparation and circulation of the 15 August document could have added another week. If one assumes that document 238/44 was the missing announcement of 83 and withdrawal of 74, even if it had been issued soon after the 1 July document, the time factor is unrealistic, implying a swiftness and efficiency of the supply system that did not accord with prevailing conditions.

If the missing document was not the one between the two 'Sammelmitteilungen', then it is probable that the original announcement of introduction of 83, and withdrawal of 74, had occurred prior to the July document. That would account for the large numbers of airframes with 83 seen by the inspectorate personnel and would also better fit with instances already noted of day fighter airframes using a 75/76 upper surface finish, something that had begun in late 1943 and lingered on until the appearance of 83 to replace the deleted second upper surface colour. The number of day fighters using a 75/76 scheme, while not large, was still significant in terms of basic numbers. It was possible that the original attempt to reduce the range of lacquer colours had stalled, at least for day fighters, in the face of rapidly changing circumstances with the sudden rise in losses from Allied strafing attacks. That had precipitated reactivation of the need for a ground defensive camouflage.

This would also accord more closely with withdrawal of 74 from night fighter camouflage in late 1943/early 1944. If these factors are put together with the usual two month RLM grace period for changes to be completed, then it is probable that 83 had entered the production system by June 1944. That would explain many things, including how large stocks of that colour apparently had been distributed so swiftly to



ABOVE: This section from the wreck of an Fw 190 A-3 of JG 5 found in Norway provides vital evidence of the change to camouflage colours, at least on a limited basis, for some day fighter aircraft. This aircraft was lost in 1943 and while the colours have faded, their identification is indisputable – 75 and 76. (B. Ryle)

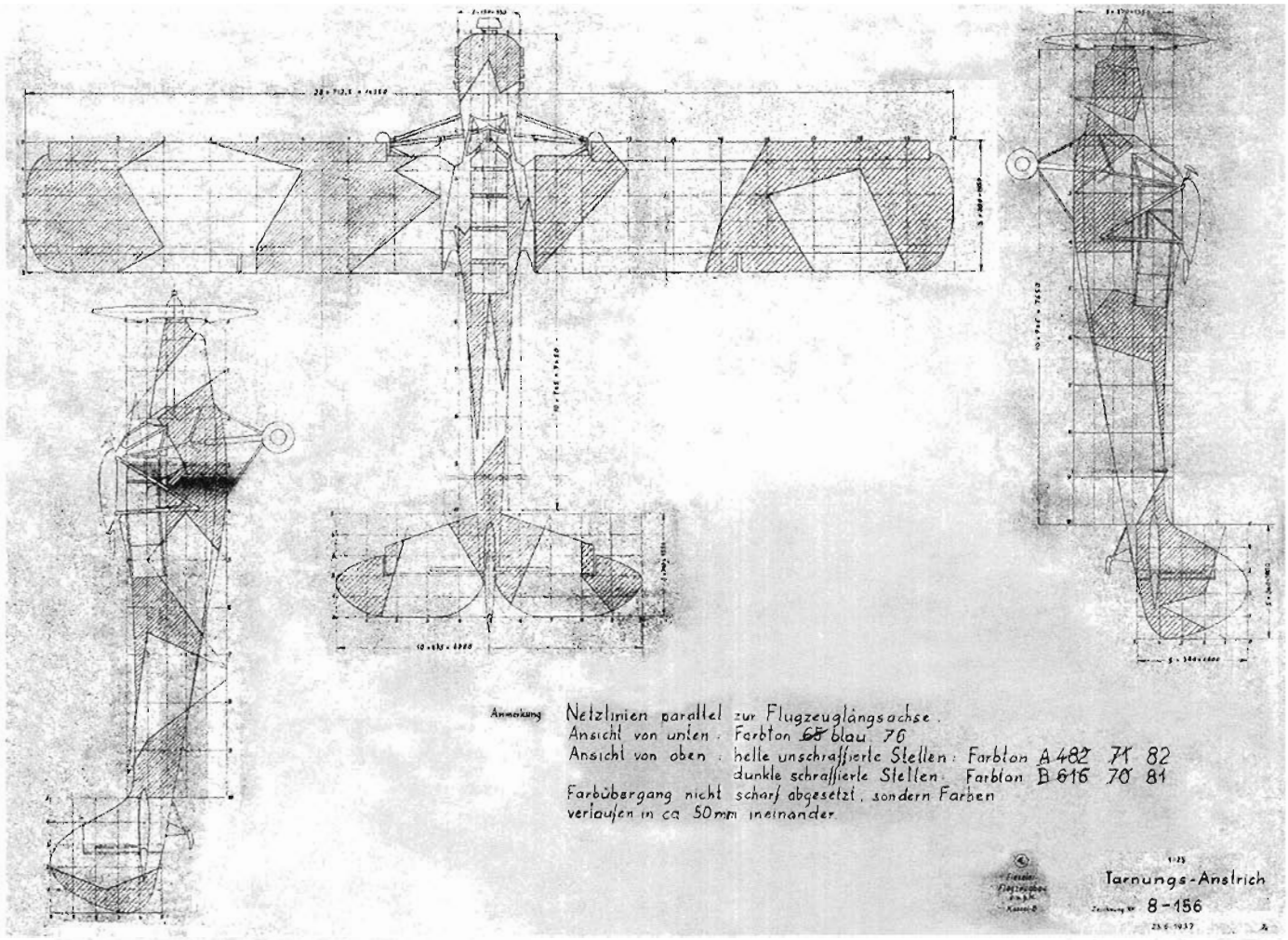
the airframe factories, and why 83 lasted for so long in the production cycle, and how stocks of 74 had had time to be run down at the same aircraft factories before final withdrawal of the colour announced in the August document. Compare this with the announcement of the introduction of 81 and 82, and the elaborate instructions concerning the withdrawal of 70 and 71, including the usual requirement about using up existing stock. The August announcement made no such remarks for 74, nor mentioned its replacement - it simply included 74 in the definitive statement that the listed colours were not to be used in future.

The paint industry must have had prior notice, not only to have stocks of 83 ready, as mentioned above, but also to stop manufacture of 74 to prevent surplus stocks building up, even briefly. Supplies of essential chemicals and other ingredients were under pressure and a huge volume of aircraft lacquer was being produced in any one month. Dr Kurt Herberts & Co. alone were manufacturing 200 tons a month of the Ikarol aircraft lacquers under licence to Warnecke und Böhm (and that was just part of the 1,000 tons of all paint types the firm was producing per month, the Kriegsmarine being the other principal customer). If one takes into account all the other firms producing aircraft lacquers, the sheer volume becomes apparent.

Looking at the change in colour, 83 had the advantage of being a dark green, thus more suitable for ground camouflage, while of very similar tonal quality to the withdrawn 74, establishing a two-tone upper surface scheme more compatible with current camouflage requirements. RLM 74 had the RLM E-Stelle written designation of 'dunkelgrau, grünlich' (dark grey, greenish). The greenish aspect was very hard to discern at anything other than very close range, while 83 was a distinct green with a brownish tinge.

It is clear that 83 was intended to be used as a solid, major colour, likely to be seen with national markings across it in some applications, as well as for mottling. Its use seems also to have been fairly extensive across all the current day fighter types, again indicating that supplies reached the major aircraft manufacturing centres.

Some additional evidence was furnished by a contemporary Intelligence report, that on 19 June 1944, Fw 190 A-8/R-6, W.Nr. 130957, had been shot down by fighters and its camouflage was described as *'...surfaces mottled green and grey, lower surfaces light blue.'* Contemporary camouflage for the type was 74/75/76, so the mention of green and grey would appear to indicate a combination of 75/83, as no



Fl 156 Camouflage pattern

This drawing originally issued on 23 June 1937 remained the only drawing for the type until the end of World War Two. The drawing key incorporates all three changes to the type's colouring during that period. Note that it lists light colours (shown by unshaded areas) as Farbton A 482, 71 and then 82; and dark colours (shaded areas) as B 615, 70 and 81, with under surfaces first as 65 blau then just 76. In each case the preceding colour notation had simply been crossed out and replaced with the next one. The colour references A 482 and B 615 remain enigmatic, as the type entered service in the winter of 1937/1938 in full 70/71/65 camouflage as shown by the camouflage drawing pattern.

other standard green was available for day fighter aircraft at this time. If correct, that provides a modest time marker for the introduction of 83 in place of 74, which fits with the forgoing remarks.

The relatively brief status of 83 as an approved camouflage colour may also account for why no camouflage diagrams have yet been located which officially specify a 75/83 camouflage scheme for fighters. As it was a matter of substitution of one colour for an existing one on day fighter camouflage drawings, (rather than the actual camouflage pattern being changed in shape or dimension) a simple amendment to the colour key would have been all that was needed, 83 replacing 74 in the colour key notation. That was normal practice as with the Fi 156 camouflage; it had three changes to colours between the time of its original pre-war issue and the final change to 81/82/76. All were done simply by hand amendments of the numbers alongside the camouflage key - no new drawing had been issued throughout the entire eight-year production cycle of the type.

Once the decision had been made to adopt 81/82/76 universally for all classes of land aircraft, 83 was eliminated from the *paint* production cycle, something that must have occurred very early in September as the 13 September BV 155 document proves (see below). However, large stocks of 75 and 83 had to have been distributed to day fighter production centres and were required to be used up before shifting to the new colours, which accounts for some aircraft of that period being seen in combinations of 75/83, 82/83, 75/82, or occasionally even 75/81.

An 82/83 scheme, tonally, would have been similar to an 81/82 scheme. In air-to-air fighting, camouflage is only of advantage at considerable distance, to blend the aircraft *tonally* into the background. Colour perception falls off rapidly with distance and tonal value is of more importance; conversely when fighting at close range, colour ceases to be of consequence. With the final shift to 81/82/76, colour 83 had been taken out of the production cycle; but 75 continued in limited production for the night fighter force. An instruction, announcing those changes, must have been issued in early September, but no trace of it has been found so far.

The fact that 75 was still being used at some production centres for day fighters as late as the end of 1944 may indicate that stocks intended for night fighter production were diverted in some cases to day fighter production centres: or simply that stocks of 75 were very large and slower to be used up, something reflected by the inclusion of 83 in some 81/82 schemes as mottling, examples of such being seen well into October.

Adoption of bare metal for under surfaces.

The success of the Focke-Wulf bare metal under surface tests are clear from what followed in a letter to Blohm und Voss barely one month to the day of the intelligence intercept referred to earlier, regarding the operational introduction of the 50 test Fw 190 aircraft. An internal company instruction for the BV 155, advanced prototype high-altitude fighter, sent by the 'Flugzeug-Werkstoffprüfung' (Aircraft Material Testing Section) of Blohm und Voss on 13 September 1944, stated:

"Re: Camouflage for BV 155.

The E-Stelle Travemünde authority have advised the following: The BV 155 shall have an upper surface finish of colours 81 olivbraun and 82 hellgrün. Mottling spacing and placement should be similar to the BV 109 [sic Bf 109] camouflage scheme. The fuselage side surfaces, sides of the vertical tail plane and leading edge of the wings and horizontal stabiliser should be painted in colour 76, thereafter except for the wing and horizontal stabiliser leading edges, the remainder of the aircraft should be sprayed with colours 81 and 82.
Also, looking ahead, paint schemes will be simplified and we should be advised of this shortly and will publish same. After that the above mentioned aircraft, which will be used for day service, will have the camouflage on the under surfaces deleted. Positioning of the mottle scheme should be applied on the aircraft from the line of the bare metal up to the camouflage. The pattern is to be soft flowing lines.
Where filler paste is needed (filler paste 7270.99), it should be applied on bare metal beyond the borderlines of the paint scheme and the bare metal should be sanded smooth in the usual manner with no camouflage on the filler paste. The painting of the under surfaces is being deleted to economise."

This document serves to pinpoint the rapidity with which changes were being set in place. Despite this, some test work was still being undertaken with actual lacquers. I. G. Farben at Leverkusen had been experimenting with polyurethanes and synthetic resins. Polyurethane had some drawbacks for surface coating due to the immediate interaction of the two components required. Eventually the use of a modified spray gun with two nozzles - one for each chemical component - solved the problem. In a post-war interrogation [7], Dr. Otto Bayer, who had been involved in the fundamental chemical research with these products recounted that thin films applied in such a manner were dry in two to three hours, a moist atmosphere accelerating the drying time. This would have provided a further saving in production time. The films were very elastic and had good alkali-resistance properties and produced a very smooth finish. Bayer went on to state that tests made on a Messerschmitt fighter (type not identified) had shown an increase of 13 km/h in top speed.

Written colour descriptions

Written colour descriptions had always been notoriously loose, even pre-war. The Do 17 E painting schedule, in addition to the official pre-war camouflage diagrams on pages 7 and 8 which listed colours as 'braun Nr: 61, grün Nr. 62, grau Nr. 63', contained a detailed painting instruction for each component. On page 4 however, in the section detailing external painting of the fuselage upper surfaces, under 'Grüne und braune Flächen' (green and brown surfaces) it listed colours as 'grün Nr. 62' and 'grau Nr. 61'. It is indisputable that RLM 61 was a dark brown, or that RLM 63 was the grey-green; yet even in this pre-war document the written colour descriptions are clearly misidentified. Compare the familiar colour descriptions with those in the 1936 official colour chart of '61 dunkelbraun, 62 grün, 63 hellgrau'. While in the He 51 C/D schedule, 63 was identified as 'Nr. 63 graugrün'.

Other pre-war anomalies occurred in a letter from Dr. Kurt Herberts paint company, dated 1 September 1937; in a list that runs from RLM 60 to 73 it contained descriptions, some of them bizarre, for some colours already named on the 'Richtlinien für die Entwicklung geeigneter Flugzeuglacke' colour atlas. Colour 64 'dunkelgrün' is recorded as 'braune Erde' (brown earth), 67 weiss as 'Zinnobergrün' (cinnabar green), 72 as 'seegrün', with 73 named 'dunkelseegrün'. [8]

The common and consistent combination of 65, 70 and 71 was described in a 1942 document, concerning non-flammable paints from Herbig-Haarhaus A.G., as '65 blau, 70 und 71 hell - und dunkelgrün'. The use of blue instead of light blue is followed by a further inaccurate description for 70 and 71; indisputably 70 was always the darker of the two colours. It would also be difficult to accommodate the colour description of hellgrün (light green) for 71. Description of those same two colours in the I. G. Farben Industrie report on infra-red testing described them as 70 olivgrün and 71 dunkelgrün - olive green and dark green respectively.

The August 1941 Dornier company camouflage documents for the Do 217 E-1 and E-3 used the usual RLM stipulated colour key, but include both the written and numerical colour identifications 'hellblau Nr. 65, mittelgrün Nr. 72, dunkelgrün 73' (light blue Nr. 65, middle green Nr. 72 and dark green Nr. 73). In this instance the originator of the document had again reversed the colour descriptions - poor comparative descriptions for 72 and 73, especially as 72 was the darker of the two colours. The same written colour descriptions appeared on the March 1942 camouflage schedule for the Do 217 E-2 and E-4. However, by the time that the camouflage schedule for the Do 217 M-1 was issued in August 1943, only the numerical descriptions were retained. Colours 72 and 73 had been in use for several years, and included on the colour charts issued with L.Dv.521/1, but there they were only ever given the enigmatic common identification of grün.

Another colour for which no previous notification has been located prior to its sudden mention in the 1941 document, relating to night camouflage changes for bombers, was 77. No written colour description accompanied it and the only example so far located occurred in the August 1942, Do 217 J night fighter camouflage schedule, where it was described as 2401/77 (dunkelgrau). This was a somewhat misleading term as it was a medium not a dark grey. This was another colour chip excluded from the 1941 colour atlas, along with 78, 79 and 80, despite all those colours having been issued and put into operational use by the time the L.Dv.521/1 document containing the new colour atlas had been issued. This appears to mark the point at which the RLM decided to revise its practice of re-issuing complete colour atlases, individual colour chips being more expedient and less wasteful, with obsolete issues ordered destroyed. The 1941 colour atlas also excluded any written colour descriptions for 74, 75 and 76. Written colour descriptions for 78 and 79 were also rare, and one of the few times they appear is in the 'Anstrichvorschrift Ju 188 trop' under the 'Farbenliste' as sandgelb (79) and himmelblau (78) (sand yellow and sky blue)

OS-Liste for fighters in the mid-war years refer to colours simply by their RLM code identification of 74, 75 and 76. Paint tins delivered to aircraft production centres and used by the factory spray painters, carried no written colour description, only the relevant RLM numerical code description, e.g., Flieglack 7102.02. Written colour descriptions were obviously of no consequence at the point where the lacquer was actually used.

The reader may care to keep these examples in mind when loose written colour descriptions are cited as proof that specific colours were changed in some manner. The colour samples issued in various RLM colour charts, or later as loose chips, were only used to check the prepared lacquer prior to spraying, or to check batches of lacquer for quality control purposes from time to time at the paint manufacturing centres.

Testing to eliminate camouflage lacquers completely

The Fw 190 bare metal trials recorded earlier were pursued further in a far more radical approach to the entire process of camouflage for

aircraft. This may have been instigated by the success of the process, long used, for producing magnesium castings with a thin coating of black oxide to provide a protective finish. This was simply touched up if it became deeply scratched or scuffed through use. The fact that the Focke-Wulf company had been chosen to test a new radical camouflage process appears to imply an ongoing research directive from the RLM, via this company, with regard to the entire question of saving camouflage materials and labour. The relatively close timing between this experiment and the previous one points strongly to this.

A test order had been issued on 3 October 1944 to the Raw Materials Research Section of the company. On 17 November an interim test report reference, 'Fw/WVA-13.3789(ITLB)' on this new project was issued under the signatures of the Division Director Dr. Müller, the Group Director, Herr A. Müller, and an Official Expert, Herr A. Strass The report stated:

"Etching Methods for Colouring of Light Metal.

For increasing the performance of the Fw 190 the airframe will not be covered with paint, but the camouflage colour will be achieved by etching the light metal.
As the test order shows, the weight question is not significant. On the other hand, the solidity and durability against corrosion of the light metals may not be affected. In general aluminium and plated alloy surfaces are prepared by etching. Generally, the cleaner each type of metal gets, the slower corrosion reacts to this process.

Good greased sheet metals made from materials Flw. 3000.5, 3115.5, 3125.5, 3126.5 and 3355.5 were used for the tests. Most of the tested solvents produced only a cover of insufficient adhesive strength if colouring corresponded to the intended purpose.
With the following mixed solvents the tests were successful:

Picric acid, copper chloride of ammonium and KmnO4 [potassium permanganate]*:*

2. This solution consists of two components;
2a, CuCl2 [copper chloride]; *hydro-sulphite, NaF* [sodium fluoride], *sawdust.*
2b. Consists of NH4Cl [ammonium chloride] *solution.*

2a. is being boiled longer after mixing for a good soaking of the sawdust, which should effect a better adhesive strength at the surface during the reaction time.
2b. is dissolved warm, both components are mixed after cooling down. The degreased sheet metal has to be worked twice with the etching liquid, especially pure aluminium.

At the second stage of etching it apparently forms a copper-sulphur compound which settles itself at the surface which is roughened by the NaF [sodium fluoride]. *The dark grey to black deposit is easily washable at first, but after drying the colouring becomes adhesive. In the experiment the samples were dipped twice briefly in the etching solution.*

A reagent, which creates compounds with the metal which have the desired colouring, has not yet been found. The etched samples were tested for weight increase or decrease. Mixture 1 produced a weight increase of 0.006 to 0.11 per cent (at 1 mm sheet thickness), at mixture 2, 0.009 to 0.08 could be determined.

Durability of the colouring by weathering has still to be tested, also the influence of the durability of the material against corrosion."

The 'desired colouring' was probably a dark grey-black and a brown, or a green, as these colours had long been identified as ideal, and the process was already capable of producing the dark grey-black colouring.

This was a decidedly radical departure from the entire process of camouflage for airframes. Nothing further is known of the tests and obviously, if successful, the process proved too late an innovation to be implemented. However, the process underlines the ingenuity of the industry and the drastic supply shortages of raw materials. Had it been successful, the entire process of camouflage would have changed completely, freeing up enormous resources in materials and production time. The chemicals used in the process were relatively unsophisticated and more readily available than those used in the normal lacquer formulae of the time, making it an attractive alternative. It also would have allowed complete diversion of key minerals also needed in the steel industry.

It also predicated a shift to the type of camouflage system specified for the He 162, where individual components were painted in one colour. The only way that the etching method could have been employed would have been by etching individual panels already cut for assembly. Depending upon the individual type of airframe structure, it might have been possible to employ colour alternation on some parts of major sections. However, with the severe problems facing the industry, it is more probable that it would have been confined simply to major components, such as entire fuselage sections, wings, etc.

In the interim period, under surface colouring continued to be specified in most instances; but once the official deletion of colour for lower surfaces instruction was instituted, most day fighter aircraft conformed to the new instruction. The Fw 190 D-9 series began to reach Luftwaffe units in August 1944 and photographs show many to have had only part painted/bare metal lower wing surfaces. Just when the results of the Fw 190 experiment were implemented into the D-9 production cycle is unknown, but it must have been very soon after the completion and delivery of the test batch of Fw 190s to JG 26. The BV 155 painting instruction of 13 September shows just how rapidly the revision had been adopted by the RLM, the original document having originated at least several days earlier.

The November 1944 painting specification for the Ta 152 H and C series stipulated an upper surface finish of 81 and 82 with 76 restricted to the vertical side surfaces, and 81 and 83 as a mottle on the vertical tail surfaces. All under surfaces were to be left in bare metal, but the leading section of each wing, as well as the engine cowling lower surface on some aircraft, was to be given a coat of 76. No written colour descriptions were appended, the RLM two-digit code being used to identify each colour.

As already mentioned, Me 262s were also produced with unpainted lower surfaces, however the sub-manufactured components of nose section and engine cowlings continued to arrive at the main assembly plants with primer paint on them. The primer was probably 7270.99 as it was not intended to form the final camouflage finish and thus not an exact match for 02. This mixture of colours was not a deliberate aspect of the camouflage-painting schedule, but rather a result of the complexities of the sub-component manufacturing cycle that seems never to have caught up completely with the rapid changes and deletion of camouflage on certain parts of the airframe. All wooden components supplied by the sub-manufacturing system continued to require painting, adding its own dimension to the resulting mixture of colours.

Introduction of colours 81 and 82 into the production system

The July Sammelmitteilung introducing the new colours had made it clear that small stocks of old colours could be used in combination with the new colours, thus approximating the tonal value of the new camouflage of 81 and 82. How extensive that practice became is difficult to judge from black and white photographs of the period. However, the point about re-ordering small quantities of either 70 or 71

shows that the RLM did not expect the practice to encompass a large number of airframes from any one source. However, in one instance the process never even reached the stage of mixing old and new lacquer stocks as the following document illustrates:

"Supplement for graduation stage 10/44 for Ju 188.

The camouflage paint of the Ju 188 D-2 aircraft which is mentioned at subject 8 of the graduation stage 10/44 for the Ju 188, cannot be changed over to the new finish, because there still remain large stocks of paint in the old shades (70 and 71). According to a decision of the E-Stelle Travemünde this stock has to be used up first.

With reference to the discussion by telephone with OKL Commander TLR Fl.B2/H.Fl. Stabsing Rietz on 9.10.44, regarding the subject mentioned in the foregoing [telephone discussion] *herewith it is cancelled from the graduation stage 10/44. We request to carry out the graduation as per your list.*

As Ju 188 D-2 [construction] *is terminating in January 1945, conversion of the camouflage paint generally will not be undertaken because of the* [existing] *available stock of paint.*

Director of the Special Commission

FLÄ"[9]

The letter is stilted and ambiguous, but it is referring to the RLM's comprehensive plan for the gradual introduction of the new colours 81 and 82 across the entire airframe manufacturing industry, whilst ensuring that the old stocks of 70 and 71 were used up. The reference to '8' in the letter, was to Point, or Part, 8 of the overall changeover plan. The discussion between the Special Commision's representative and Stabsing Rietz was to argue for an exemption from the 71/81 and 70/82 phasing change requirement specified in the Sammelmitteilung of 1 July, because of the obviously large stocks of both 70 and 71 still held by the company; at least enough to complete production of the Ju 188 D. (The D-1 and D-2 were reconnaissance variants, produced only in small numbers).

The writer of the letter is quoting the E-Stelle instruction, about using up old stocks, to strengthen the argument. According to the prevailing master plan, the company would have been required to purchase additional stocks of either 81 and 82, or both, in quantities equal to those already held of the 70 and 71. With production of bomber aircraft rapidly grinding to a halt, and no new contracts likely to be issued by the RLM, it was unlikely that there would be time also to use up the existing very large stocks of 70 and 71; the size of which also precluded any meaningful trade-off options with other companies. The letter indicates that agreement had been reached to exempt the company's Ju 188 D-2 programme from the process. This was probably a unique situation.

The letter also reveals that a special commission had been set up to handle this industry-wide changeover from old to new colours, something not simply left to individual aircraft factory management decision. Despite the crumbling supply system, central control was still being exercised. The fact that there was a programme of controlled, graduated change in place is hardly surprising though, given the level of regulation imposed by the RLM, at any time, to ensure conservation of materials. It also highlights the fact that some sectors of the aircraft manufacturing industry were slow to change over camouflage colours as evidenced by the dates in this communication. The fact that the Special Commission was still active in October illustrates that the transition was still continuing, something that runs contrary to some writings that have claimed a short and swift transition period.

Reference to using 81 and 82 (as at July) only for aircraft then currently using 70 and 71 camouflage is interesting because the new colours, in one form or another, also soon appeared on all types of day fighters. No general RLM instruction has been found specifically ordering change to 81/82/76 for day fighters as a whole, but an official decision must have been made and promulgated as clearly confirmed by the subsequent RLM approved painting schedules for the BV 155, Me 163, Me 262 and He 162. The reasons are not difficult to find; the rising rate of destruction of aircraft whilst on the ground and the pressing need to simplify lacquer production and delivery of stocks.

In June 1944 Allied air attacks on Luftwaffe fighter airfields in the West had commenced in force and losses increased dramatically, either on the ground or in transit between airfields where fighters were hidden between sorties; such losses exceeding those of the air-to-air fighting. By September, Luftwaffe forces defending the Reich by day were incapable of inflicting average losses of more than one per cent on the attacking force. In addition, the number of days per month in which the Luftwaffe successfully intercepted the American bombers had fallen from 11 in March 1944 to five in September; in October and November it fell to four, then to three in December. By the end of 1944, the Allies were mounting 4,000 sorties daily against which the Luftwaffe could put up only 300. Bad weather, fuel shortages and a lack of trained pilots were significant factors. In such conditions the Luftwaffe was losing an average of six to seven aircraft for each Allied aircraft they downed, three out of four being destroyed on the ground by Allied strafing attacks.

By night, the German night fighter strength had been increased from 685 in July to 830 in October, but the success rate had declined rapidly from 2.9 per cent in June to 0.7 per cent by December. Loss of early warning radar sites as the Allies advanced accounted for part of the decline, as well as the same factors that affected the day fighter force. There was also another, quite pressing point related directly to the austerity campaign in force as will be detailed further on in the text.

There was a peak production of about 400 bomber aircraft in November 1944, but that was the virtual last gasp of manufacturing industry for this type. Massive bombing damage during 1944, and dramatic changes to manufacturing quotas, left production concentrated principally on fighter-types as defensive needs greatly outweighed the already limited offensive policies. Of the newer generations of heavy transports, numbers were very small and amongst liaison aircraft, the ubiquitous Fi 156 was almost alone in continuing in production. Relatively few types qualified for use of the new camouflage colours and among those that did even fewer appear to have had time to adopt them.

The German paint industry was still producing a reasonable range of lacquers and paints for a wide variety of purposes, but the range of colour pigments for land-based equipment had finally been reduced. The diminished range of colour pigments were then common to many applications, though chemical composition of, for example, paints used for buildings and glass, and those applied to vehicles, were obviously different from those used for aircraft structures. The latter required sophisticated physical characteristics such as greater elasticity, ability to remain bonded while exposed to rapidly and widely varying temperatures, and much more resistant to the abrasive effects of high-speed airflow.

Within the aircraft lacquer range, consistency of pigmentation matching to a common standard (i.e., identical pigment colour, but different lacquer composition) was achieved by varying the ratio of ingredients that made up the pigmentation portion of a formula. Each private company had its own formulation for a given product, each of which had its own specific pigmentation ingredients. Sometimes different products manufactured within a single company required identical colouring. The Gustav Ruth company had manufactured only a limited range of aircraft lacquers, mostly under licence; the formulae

for two distinct types, 7109.65 and 7121.65 (both Warnecke und Böhm products) but with the same colouring requirement, illustrate this point.

7109.65	7121.65
8.90 parts titandioxyde	15.0 parts zinc white
0.87 parts zinc white	3.8 parts blue of ultramarine
0.21 parts zinc chromate of W&B) 75 per cent mixture strength	22.0 parts artificial resin 100M
	19.0 parts talc
	33.0 parts xylol
0.81 parts ultramarine blue	3.2 parts butyglycol
0.05 parts aniline blue	4.0 parts butylacetate
58.5 parts varnish 7109	100.0
11.7 parts talc	
14.35 parts thinner 7200	
4.61 parts butylglycol	
100.0	

('W&B' denoted Warnecke und Böhm)

In both formulae the principal pigment agents were zinc white and ultramarine blue. However, the 7109.65 lacquer also contained extra colouring agents of zinc chromate and aniline blue to balance the natural colouring effects of other constituents - but the result was the same colour, RLM 65. Simply using standard constituents for the pigment part of the formula to produce the requisite colour was not practical.

The same process occurred between different products from different firms. Herberts (D.K.H.) made a metal lacquer identified as 10100.76 (an unusual identifying number) while Warnecke und Böhm made aircraft lacquer 7121.76 tinted to the same colour. Examination of the two formulae shows that the principal colouring ingredients varied slightly to account for the colouring effect caused by other ingredients.

D.K.H. Metallack 10100.76	Ikarol - Fliegiack 7121.76
24.1 Mischlack	29 Ikarol Kunstharz 100 M
53.6 Zinkweiss	22 Zinkweiss
5.3 Talkum	10 Amylacetat
0.9 Kobalt blau	24 Talkum 0000
0.02 Eisenoxydrot	12 Xylol
0.09 Nitro blau	3 Kobalt blau
15.99 Verdünnung (Xylol/Essigester 2/1)	100 parts
100 parts	

In both instances the principal colouring agents were zinc white and cobalt blue, though in different proportions, but the D.K.H. formula used additional colouring in the form of iron oxide red and nitro blue - yet the end result was RLM 76 in both cases.

The lacquer type was the same in both instances but the variation in ingredients, other than those used directly for pigmentation (zinc white, cobalt blue and ultramarine), provides a vivid illustration of how much one set of ingredients affected the other. Kunstharz - the artificial resin - was the principle ingredient but had to be varied in quantity and balanced by changes to other additives. For readers interested in another comparison of the variation, the formula for 7121.66 is given later in the text. It is interesting to compare also the two Warnecke und Böhm formulae for 7121.65.

Colour variations

Referring back to paragraph 6 of the 'Sammelmitteilung' of July, as noted, the announcement that colour cards were not yet available for colour matching of stocks of 81 and 82 for the repainting of basic gliders may not have reflected a similar problem across the main aircraft manufacturing industry. The 'Sammelmitteilung', of course, had been directed to the *aircraft* manufacturing industry, not the paint manufacturing industry, which always had precise colour checking systems in place and continuous access to both RAL and RLM colour standards. So problems, if any, of colour matching referred only to the pre-spraying mixing process prior to applying the lacquers at aircraft manufacturing centres.

Some confusion continues over reports of variation from the RLM standard set for each specific colour. The basic reason is that post-war observations persist in comparing paint found on parts of aircraft (with rare exception, faded or altered by the conditions to which they have been exposed over the last 50 or more years) with paint produced and supplied to the aircraft industry. Paints found on recovered parts are usually a good enough guide (approximation) to allow clear identification of the specific colour, but they should not be used as evidence that any changes present resulted from poor paint manufacturing standards. The reader may care to consider a simple analogy - if you were to check the paint on the outside of your house after ten years, and compare it with the colour chip that matched the original paint you used, would you be surprised to see a visible difference? Apply that process to aircraft parts that are up to 60 years old and the reader may view colour variation discussions more objectively.

Paints were produced by paint manufacturers to a very consistent standard - then delivered to the aircraft manufacturing fraternity. Basic paint stock, mixed correctly prior to application to an airframe, was still within the boundaries of the RLM standard prescribed for any particular colour. What happened when the paint came out of the spray gun and covered parts of an airframe was the critical point where colour could, and sometimes did vary *slightly* because the mixture no longer relied only on the colour of the lacquer being used. Thus, how it was applied to an airframe was the principle agent of variation from the standard.

During the late 1930s through to the early period of the war, by the nature of the individual painting schedule requirements, lacquers had been applied as a series of layers that had ensured a solid application over a good quality base of other preparatory lacquers. The gradual approved reduction in surface preparation prior to adding a final coat of camouflage lacquer, plus the reduction in thickness of the actual

ABOVE: Mismatching between pre-painted parts supplied by sub-contractors to the main assembly plants began to appear more frequently in the closing months of the war as supply and demand were torn in different directions. This Bf 109 K-4, 'Red 12' of a Hungarian unit, had camouflage of what appears to be 75/82 for the main airframe, but the entire tail unit was in 81 with only small patches of 82 showing through, the same style seen on the prototype Bf 109 K-4. Note that the lower half of the fin assembly, beneath the fixed tail surfaces, was finished in a richer shade of 76 than that of the main airframe. The engine cowling can be seen beneath the engine section and appears to have been in plain 76, possibly coinciding with the main 76-camouflage segment forward on the engine section. (J. Crow)

camouflage coats (which had arisen with the newer lacquer formulae because of raw materials pressures) marked the point where circumstances for minor variation had begun to appear. The use of mottling and soft-sprayed applications to blend areas of colours added to subtle changes to any standard colour. The most common example was the use of soft-sprayed fogging applications of 02 over other colours to either tone down a colour or to blend colours.

If lacquer preparation procedures were followed at aircraft plants, colour matching with a colour card was somewhat redundant, the factors previously outlined above being more relevant in terms of minor variation. However, as the war progressed other aspects began to influence colour variation, but this should not be exaggerated. There were inspection requirements that remained in place until the very last months of the war, though these were not foolproof by any means, as may be judged from the following anecdotal account.

During a discussion with former Luftwaffe ground staff veterans, a comment by a former member of JG 11 referred to camouflage colours.[9] He stated that in the spring of 1945 (the time period is very significant) a new Fw 190 A-8 had been received and he was assigned to maintain it: *"It was purple and green. I could not believe it. I thought it was ugly. I wasn't very happy with it being my aircraft."*

The 'purple' colour (technically a red-violet) had probably resulted from poor mixing prior to spraying. A balance of red and blue pigments were present in 81 and insufficient mixing of the pigment had allowed the blue content to dominate the red of this tertiary colour. The second colour was 82, but that was not the subject of adverse comment. Colours 81 and 82 had been in use since July 1944, so finding a badly prepared mix of one of the colours in the dying weeks of the war was perhaps not so unreasonable given the bombing to which the aircraft production centres had been subjected by then. Was this a general condition of all camouflage of that late period? Judging by contemporary accounts and Intelligence reports on crashed enemy aircraft it seems to have been an exception.

The same veterans also recorded that they had kept a number of spare tail units on hand for major repair work. This highlights again the unintentional potential to produce either hybrid colour matches, or simply mismatched colour scheme patterns.

Some samples of colours taken from some aircraft during that turbulent period do show slight variations, though nothing as pronounced as the example given above, even allowing for the 60 year interval. Control standards were never relaxed but circumstances could and did put pressure on standards in the face of the pressing production needs. Volumes of lacquers in use were always large for the general production painting process and mixing was always done mechanically, inside large pressurised spraying tanks that relied on electrically driven stirring mechanisms. However, air raids and disruption to electricity supplies could temporarily produce poorly mixed stocks *at times* while the standard 30 minute mechanical mixing time specified was regained. Production was paramount and resumption of work immediately following a disruption to electrical supply - such a relatively simple factor - could influence what flowed from the spray gun, at least for the next few aircraft.

Equally, something as simple as an unreliable source of compressed air for spraying could vary the consistency and colour of the lacquer being applied, a factor specifically warned against in painting manuals that had been issued to the industry continuously since pre-war times. Not using the standard distance for spray applications could also thin or thicken a coat of lacquer and vary the colour density, (deliberate exploitation of such factors had been used to produce specific effects, such as the graded 'ribbon' scribble pattern seen on some reconnaissance Me 262s found at Lechfeld in 1945). Incorrect amounts of thinning agent, something that had been scrutinized more carefully in earlier times, may also have contributed to subtle colour variations. Quality of workmanship at aircraft production centres had been deteriorating steadily due both to conditions under which workers were forced to live and work, and also to falling levels of skills. For example, to counter the effects of bombing and dispersal, Junkers occasionally had to employ two shifts, and during the last eight months of the war employees were forced to work 69 to 70 hours a week under deteriorating conditions. [11]

The workforce situation had been further aggravated by replacement of experienced workers with less skilled, forced, or slave labour as the armed forces had stripped industry of able-bodied men, adding to the gradual deterioration. Just how seriously this had affected the aviation industry may be judged by what happened following the first major call-up of additional able-bodied men for the armed forces in October 1942. The Heinkel works had obtained 6,000 prisoners from the Oranienburg concentration camp to work on the He 177, while Messerschmitt had sought 3,000 prisoners from Dachau for its Augsburg plant - and the situation had become steadily worse. By war's end Junkers employed some 147,000 workers, of which 67,000 (46 per cent) were slave labourers, prisoners of war, or foreign workers.[12]

The extreme reduction in lacquering procedures could produce a pronounced visual effect even using correctly mixed lacquers. The Australian War Memorial Me 262, W.Nr. 500200, had no 02-undercoat (as noted) and nor was 76 used as a base overall coat. A single overall coat of very thinly applied 81 had been sprayed on the bare metal upper and side surfaces, probably because the grey filler used for the joints of the upper and side areas of the fuselage had been brush primed with the same colour, 81. Normally areas treated with the grey filler were simply sanded until smooth and left un-primed except where camouflage was to be applied. Because of the extreme thinness of the sprayed lacquer, priming was usually done with the lightest colour over the 76 - but, as noted, in this instance the process had been reversed. The 82 had been applied to complete the pattern, equally thinly, and the darker lines of primed filler could be seen at certain light angles. The advantage of this reversal of painting technique was to allow the darker base colour to more significantly influence the paler second colour that was laid over it. This toned down the contrast between the two colours, something that was more desirable by the late war period when concealment was even more critical for survival. This technique possibly accounts for some of the darker two-tone schemes seen on some Me 262 and Ar 234s.

Complicating the resulting colour perception on the Australian War Memorial aircraft, the wheel well doors, nose cone, upper and lower surfaces of all control surfaces, plus the engine cowlings, as sub-components were undercoated in 02. The control surfaces had been given a coat of 81, with 82 over it where the camouflage pattern required. The rudder was painted in 76, the only component to use that colour, (another sub-contracted unit delivered finished in that colour) with mottling in 81 and 82. The central upper panel of the nose section, directly over the upper cannon ports, had been painted with a much thicker coat of 81. Why is not known, but it did make the panel look darker, something clearly visible in black and white photographs of the aircraft, and illustrating the difference in appearance of the same colour, from the same source, when applied differently. The under surface of the nose cone, engine cowlings and wooden undercarriage bay doors had been painted with the unidentified green-blue colour. Soft mottling with 81 on the nose cone upper and side surfaces allowed the base colour to show through. The result was variations to the 81 and 82 between individual areas of the same airframe despite those colours being taken from lacquer stock of consistent colour.

To emphasize the manufacturing problems at the manufacturing plant concerned (Obertraubling), this aircraft had its tail cone fitted with a pronounced vertical misalignment. The joint had a thick layer of grey filler, sanded smooth, and sealed with the usual saw-toothed edge tape before priming and painting. Despite this, the aircraft went on to see normal operational service with KG 51. Post-war analysis revealed that filler had been used, at times, up to one centimetre deep to rectify such manufacturing problems, something that would have been rejected in

earlier times. This type of construction fault reflected the declining work practices as the skilled labour force had been bled away and foreign workers had been forced to replace them. All major components were built on jigs, and the individual jigs were periodically checked against a master jig – something that usually ensured consistency. But even those critical measures had failed in the last months of the war.

As noted earlier, with the high standards of control of earlier times being steadily eroded (but never entirely absent as some writers have suggested) by the relentless bombing of the airframe manufacturing infrastructure, minor variations in colour are not surprising. And most variations noted in other writings reflect only minor changes to colour, usually a paler shade being mentioned, possibly because of over thinning as factories stretched lacquer stocks as much as possible. However, to extrapolate from those factors that entire production batches, peculiar to a single manufacturer, used a different shade of a camouflage colour, or colours, is misleading. Given the number of aircraft built, even of one particular sub-type and by one manufacturer, it would require a far more empirical source of evaluation than from disparate parts of a number of similar aircraft types to establish a pronounced continuous colour shift. Equally, to suggest, as some writers have done, that there was no standard for a particular colour within the *paint* manufacturing industry is to misunderstand the entire process.

At the time of writing, arguments continue to abound about 81 supported by 'definitive' statements (but with not a shred of original industry-wide evidence to support them) that there was no standard 81 colour. Why 81 should be the subject of such continued controversy when no similar comments or arguments have surfaced for the companion colours of 82 and 83 only adds to the eccentric and unfounded nature of such statements. The only basis for such specific controversy that the writer can identify is the single, incorrect written identification of 81 as dunkelgrün on the now (in)famous Do 335 factory drawing. The reliability (sic) of such written colour descriptions has been dealt with elsewhere and should eliminate once and for all the value of such 'facts'. If there is any merit in the logic used to defend the argument that there was no standard for 81, the same criteria must also be applied to all other camouflage colours – in which case there was no colour standard for any of them given the eclectic written colour descriptions that exist for all of them.

Unidentified colours

Two additional greens (for which no RLM documentation has yet been located) – one, a much brighter shade used for upper surfaces, the other, the lower surface green-blue colouring – appear in Allied Intelligence records at this period of the war. The brighter shade of green upper surface colour would have worked effectively with 83 and the green-blue lower surface colouring but the likelihood is that that colour, identified only once in a single intelligence report, was a thinned out application of 82. The Australian War Memorial's Me 163 had streaks of a brighter green on its rudder in its original condition, but this appears to be just a thinned out application of 82.

Evidence for the warm shade of unidentified green-blue lower surface colour however is a different matter. It was empathetic with the warmer tones of the upper surface colours 81, 82 and 83 and, in contrast, 65 and 76 both appeared quite stark, producing a 'washed out' cold tonal effect, particularly the latter colour. A sample of metal, taken from remains of an aircraft based at Neuburg-Zell airfield, and housed in a barn since 1945, revealed three distinct layers of paint; still able to be clearly identified as being originally 78, then 76, and last, a warm green-blue colour.[11] Rubbing back the green-blue paint to remove oxidation layers did not produce any significant colour difference or a match for the 76 beneath it, oxidized or otherwise – the same results as found on the three aircraft held by the Australian War Memorial when carefully examined by the writer. Paints were still being produced in huge quantities, not just by the parent firm (Warnecke & Böhm in this instance), but also by their many subsidiaries. The chances that a single, mismatched batch of one colour should have reached the three geographically separate centres where the three aircraft in question had been produced would have required remarkable odds.

The Australian War Memorial's Bf 109 G W.Nr. 163824, Me 163 W.Nr. 191907 (ex-JG 400) and Me 262 (ex-KG 51) W.Nr. 500200, all have this distinctive, matching lower surface colour of green-blue in full or in part, and on both the Bf 109 G and Me 262 in conjunction with separate distinct sections that are in clearly identifiable 76-colouring. All had been produced between December 1944 and the early weeks of 1945 at different factories. (As noted below, in the discussion of substitution of Hansa blue in the 76 formulae at some centres, there was a second consideration relating to this green-blue colour, but the odds on these

LEFT: A clear example of the distinction between 76 and the unidentified green-blue colour. Upper surface camouflage was 81/82, and is identifiable from the sections of colour along the leading edge of the wings. The side surfaces were in 76 but the lower surfaces of the engine cowling and forward section of the wings, including the undercarriage fairings, had been painted in green-blue. The addition of a different colour than 76 to these areas points very strongly to this Fw 190 having been produced originally with bare metal lower surfaces, and then having had specific areas painted after leaving the factory facility. Following field-testing of the fifty aircraft around August/September 1944, the bare metal finish was modified on later production aircraft to incorporate some form of colouring beneath the engine and along the leading section of the wings, including the undercarriage fairings. In this instance, the additional colouring was done after production (as shown by the over-spray of the green-blue on the 76-colouring in places), indicating that this aircraft might have been one of the initial batch of fifty airframes. (J. Crow)

ABOVE: This view of the wing surfaces of Me 163 B W.Nr. 191907 shows that this late production machine, issued to JG 400, was camouflaged in exact accordance with the camouflage directive and pattern for the type. Colours are 81, 82 and green-blue with mottling on the vertical tail surfaces in 81 and 82. The markings are all correct for the last directive. A soft spray of 81 had been used as a background contrast to the white outline Hakenkreuz marking. The red primer spots are not original (RAAF applied red oxide over small corrosion spots on metal surfaces).

BELOW: Engines for Fw 190 Ds were delivered as a power pod, complete with cowlings, from the engine manufacturer. The panels were usually finished in a solid upper surface colour of 82 with the lower sections in green-blue. Most existing black and white photographs show a distinctly warm tonal shade for the lower colour, as seen here – the same colour as seen on the undercarriage fairings and leading edge of both wings where the lower surface colour curves round. The port undercarriage oleo and the inside face of the wheel fairing were both in 02, which by that stage of the war, no longer conformed to a precise colour for such non-camouflage applications. Its colour varied slightly, but was always a warm shade of greenish-greyish yellow, producing a tone similar to that of the green-blue in black and white photographs. (J. Crow)

three aircraft, of disparate manufacturing origins, displaying the same chemical colour change are extremely long).

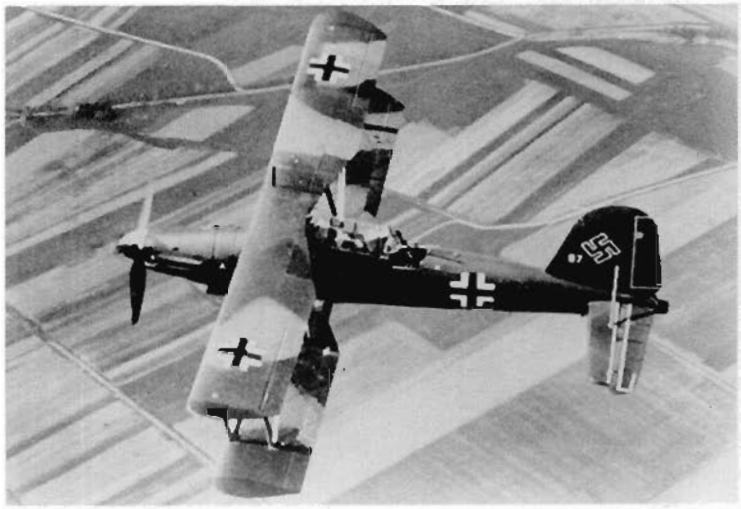
The Me 163 had had its metal structure stripped of its paint some years ago, but the wooden wings had simply been over-painted with replacement modern paints. Removal of the latter revealed the colour mentioned.The Me 262 has the same colour under the nose section and on the engine nacelles (all sub-manufactured items). Examination of areas permanently covered from light exposure, such as the overlapping edges of metal panels etc., confirm that the colour is definitely not oxidised 76 as often inferred in some publications.

The Bf 109 G fuselage and tail plane had been repainted in December 1944, following an extensive rebuild, using a mixture of 81 and a non-standard black-grey colour that approximated the tonal quality of 83 rather than 82.The side and lower surfaces were a mixture of 76 and the green-blue colouring; the latter was used on several parts of the airframe, particularly the empennage and lower section of the fuselage.

The use of the locally mixed black-grey colour reflects the difficulties being experienced at that time in maintaining supplies of lacquers to such secondary facilities. The same black-grey, non-standard, colour, coarsely sprayed, had also been used as mottling on the fuselage. The coarseness of the spray was caused by using too low an air pressure for the spray equipment, depositing the pigment in a granular pattern, something specifically warned against in standard industry painting documents.The result was an unstable paint surface that was more easily abraded than the other lacquers on the airframe.The same dark colour had also been sprayed over the existing monotone, mid-grey colouring of the starboard wing, to establish a two-tone scheme. In contrast to such coarse sprayed application of a non-standard colour, the Me 163 had a well-applied upper surface camouflage of 81 and 82 in standard pattern, it being a new aircraft built at a major production facility.

More recently still, recovered remains of some fighter aircraft have produced further examples of the green-blue colour. Parts from an early production Fw 190 D-9, 'Yellow 4' of III./JG 54, were in good enough condition to identify that it had originally been sprayed 75/83/76 and later repainted in 82/83/green-blue. The first colour combination indicates a production date of around mid-1944 while the repainting indicates that this aircraft had been damaged, salvaged, and married to replacement components.A new camouflage scheme to merge the disparate colours of the original components would be normal in such circumstances (though, as the Australian War Memorial owned Bf 109 G shows, that did not always happen).The use of 82/83 indicates a rebuild done after September 1944. Parts from another Fw 190 D-9, W.Nr. 211028, 'Black 8' of IV./JG 26, shot down on 18 March 1945, showed evidence that it also had been repainted, again indicating that it had been damaged and rebuilt - this time using 82/83/green-blue, which indicates a similar time frame. Luftwaffe loss records from 1944 are not available prior to November, so it can only be stated that the previous accident had occurred before that date.

The advantage of the green-blue colour, combined with 81/82 colouring, is significant when it is recalled that by the last months of the war most units were fighting from forward airstrips, often secreted in forested countryside. The 76-colouring, while acceptable for aircraft operating from main airfields as they had been until mid-1944, would have been a distinct disadvantage when aircraft were dispersed amongst trees.The examples of this unidentified green-blue colour all appear late in 1944 and onwards, probably the result of using up whatever stock had been distributed before the adoption of bare metal lower surfaces for day fighters from about September 1944. (The RAF had started the war in defensive mode, with aircraft camouflaged in a very similar combination of colours - green, brown and a greenish-blue - that worked effectively). The earliest documented reference to a colour of similar *verbal* description had occurred on 8 October 1943 when a Halifax of 58 Squadron RAF, on a daylight anti-shipping patrol, had intercepted a BV 222.A lengthy running fight had followed between the two aircraft, in broad daylight and good visibility, during which time the Halifax pilot



ABOVE: One of the two Fi 167 aircraft, the A-07, TJ+AP, which carried out sea camouflage trials using a three-colour scheme. The overall effect, in terms of tonal values, was very similar to the old 61/62/63 scheme. Identification of the lighter colour is enigmatic but it was light enough to be 02; equally it might have been the elusive green-blue colouring mentioned in several instances in the text. (P. Jarret)

closed repeatedly with the BV 222 so that each of his gunners could engage it. The BV 222 had taken no evasive action, returning the fire with its two dorsal turrets and each beam gun before it eventually broke off the action and pulled away from the Halifax.

During the subsequent debriefing, all members of the Halifax crew agreed that the BV 222 had been painted in what they collectively described as duck-egg blue overall.That term, in English parlance, is usually taken to describe a blue with a distinct greenish tinge to it. Checking of German records shows that the crew of a BV 222, either the V2 or V4, had reported an engagement with a Lancaster and claimed to have shot it down. Lancasters were not used for maritime duties and this can only have been the engagement with the Halifax, this being the only such recorded encounter between a BV 222 and a four-engined RAF bomber.

Existing photographs of the BV 222 V2 and V4 show both in 72/73/65 scheme, so the green-blue overall finish may have been a field test of a new colour - what ever the true nature of that colour was. If so, it would tie in with the more frequent appearances of this colour in late 1944, one year of field-testing being the E-Stelle and RLM standard.The extreme size of these aircraft made them visible from long distance when airborne, and an overall sky colour would have reduced that factor significantly - this may be the origin of that colour's design purpose.What is interesting though is the verbal description given for the colour, one that matches closely the unidentified late-war colour occasionally used with 81/82 and 81/83 schemes. Intriguing though the connection is, it remains speculative, as no German documentation for special repainting of a BV 222 has been located. It should also be noted that 65, the colouring normally used for lower surfaces on a BV 222 at that time, did tend to a chemical deterioration with age, producing a duller, green-blue colour. However, the use of an overall 65 finish for a BV 222 would have been a rare, short lived, one off instance - a different situation from an aircraft that had had its 65-camouflage colouring exposed to long service. The shade of green-blue best fitting the description of 'duck-egg blue' also is far closer to the late war green-blue colour than the dull green-blue colour of age-deteriorated 65.

Furthermore the green-blue would have been a better camouflage than 65 or 76, the latter particularly being too bright and stark when seen against the dark backdrop of the ocean. In the northern latitudes, the summer is extremely short, and the duller light of the remainder of the year would have favoured the green-blue colour over 76, especially in the winter

months. (The Royal Navy adopted a similar shade of colour, post war, for its carrier-borne fighter aircraft.) It will be recalled that fighter units based on the French coast had had dark mottles and lines added to the forward area of their aircraft for just that reason – to break up the starkness of the 76 lower surfaces.

The colour description also matches the under surface colour identified from paint samples provided by Dr. Berge who very carefully analysed numerous paint samples gathered from wrecks in Norway. Among them, he identified examples of green-blue colouring on the undercarriage fairings of an Fw 190 (Fw 190s of JG 5 were based in Norway for coastal patrol operations). The paint layers on the part were first 02, then a neutral grey, then 76, and then the green-blue colouring [14]. The distinct layers of 76 and green-blue colourings should dispel any inference of the latter being simply a chemical deterioration of the former. Dr. Berge's method of research is meticulous, extending to removal of rivets to follow colour changes into areas totally preserved from light sources and the atmosphere. Identification of this green-blue colour in association with aircraft engaged on maritime operations may further point to its original intended use. Camouflage experiments had been carried out over the sea from Holland, in 1942, employing a three-colour camouflage. The trials were carried out by two Fi 167 A-0 aircraft whose 72/73 camouflage had been modified by the addition of a third, very pale colour. Identification of this third colour has proved enigmatic, but it is tonally similar to 02, and also to the unidentified green-blue colouring. There may be a connection between these experiments and development of the green-blue colouring.

As explained by Jürgen Kiroff in Appendix E, Volume Two, very late in the war shortages of cobalt blue had lead to some instances of substitution with Hansa blue at some paint manufacturing centres. That chemical colouring agent was not stable, and 'with age' could deteriorate from unstable phatlocyanine blue to a stable phatlocyanine green. While this may account for some green-blue colouring found on post-war samples of wrecks, its introduction very late in the war can not account for the earlier examples or the broader, though never numerous, range of examples seen in some colour photographs where 76 is clearly identifiable in conjunction with distinct areas of camouflage in green-blue. Colour photography is a tenuous source of colour identification as is also explained, but for comparative checks between two colours *within a single photograph*, it does have some reasonable attributes. The masses of Luftwaffe aircraft, of many types, recorded with washed out blue-grey 76 colouring belies the idea that change to the unstable Hansa blue colouring agent had been widespread enough to account for all examples of the green-blue colouring.

While Warnecke und Böhm were the originators of the lacquer and RLM approved 76-formulae, paint stocks were produced on a vast scale utilising sub-contracted firms. The rate at which Hansa blue was substituted for cobalt blue is not known, nor at which factories it took place, either in part, or all together. What is clear is that from photographic evidence, instances of what appears to be the warmer shade of green-blue are relatively rare. Had Hansa blue been substituted en masse for cobalt blue, then one would expect a much broader spectrum of examples. The starkness of the cobalt blue formula 76 is quite apparent in many late war photos, an advantage in making a relative assessment of that colour. Also, the RLM had issued large paint card samples, very late in the war, for 81, 82, 83 and 76 – and as discussed below, the inclusion of 76 was to account for its new paler shade. The author has original sections of the last issue of colour cards, and the 76-colouring is still simply a very pale whitish-blue shade of 76 – even after some 60 years. So the final card issue of 76 involved cobalt blue, not Hansa blue. Had a decision been made to move to broad scale substitution of Hansa blue to release more cobalt aluminate to the other priority industries, it should be expected that sample cards would have deteriorated to a green-blue colour. Also one would expect to see in photographs many more examples across a much broader and more numerous range of aircraft, as well as written descriptions of the green-blue colour in intelligence reports on Luftwaffe wreckage.

The principle factor in the deterioration rate of Hansa blue was, as stated, the time scale (age factor). Given the Luftwaffe's appalling rate of attrition from mid-1944 onwards (a factor used as an argument by the

BELOW: As the sign states, the '27th Air Disarmament Wing of the 192nd Air Service Group' were in control of this massive dump of aircraft and parts, consisting mainly of Ju 88 night fighters. There were a few other types present as well, such as an He 111 on the left and an Me 410 on the far right. But the overwhelming impression was one of stark pale grey colouring – a sea of 76 in effect, relieved only by tiny fragments of colour, such as the occasional red gust lock or yellowish-green painted wooden part, or the 70/71 greens of the He 111, or the solid 75 colouring of a large wing section. This gives a good visual impression of the washed-out shade of the final RLM standard for colour 76. (J. Crow)

ABOVE: The distinct contrast between the dark, low contrast 81/82 camouflage of this Bf 109 G's upper and side surfaces and the cold tonal quality of the 76 on the lower section of the engine cowling, is quite clear in this photograph. (The nose section of the Ju 88 nightfighter looming above provides a good 76-colour match). The lower engine cowling appears to have been a replacement that had been painted, rather roughly by hand, leaving a sharp edge between the two colour areas. Note the much warmer tone of the colouring along the leading edge of the latter – possibly green-blue, the same colour that can be seen where the wing meets the fuselage lower surface. This appears to be a Bf 109 G-14 fitted with FuG 16ZY antenna more usually associated with the Bf 109 G-14/AS. (S.Coates)

RLM in the August 1944 Sammelmitteilung for continued use of corrosive alkaline cleaners for new sheet metal, components and cleaning and degreasing of parts), it is very unlikely that many aircraft survived long enough for the chemical deterioration to take effect where the substitute Hansa blue colouring had been used There are also verifiable examples, noted above, where a green-blue colour is clearly identifiable, along with 76, on surviving museum stored aircraft.

Photographs of many very late war production airframes show 76-colouring tending to even paler shades than specified on the final colour card and in some instances, such as the Me 262 fin and rudder assemblies painted with the distinctive stencil pattern, it appears as off-white. The fact that this paler colour was more pronounced on pre-painted components, produced and supplied by sub-manufacturers, may also indicate excessive thinning of paint stocks resulting from the chronic supply situation to those secondary production centres.

It is not difficult to consider possibilities that documentation covering addition of a lower surface colour, to harmonize with 81 and 82, should have proved elusive. Colour 83, widely used for a period of at least six months, appears in known official documentation only once, and then as a secondary component to part of a general reference. It is also plausible that the green-blue colour was never put into large-scale use (or at least on a scale originally intended), time having run out before it could be distributed in large enough amounts. The relatively limited scale of use of this elusive colour and its origins may never be resolved; however, the reader should be conscious that undisputed matching examples of it have been found, and identified, from a variety of aircraft manufacturing sources.

Another enigmatic colour (which lacks *documented* proof of its official RLM colour number, despite its extensive operational use), was the high-altitude grey seen on Bf 109 G-6/AS and G-10 aircraft employed as fighter escort for the slower, heavily armoured Fw 190 A-8/R-8 anti-bomber aircraft. Such operations had begun in the autumn of 1944, the specialist escort role having been given to elements of selected Reich's defence fighter units. Among them were III./JG 1, I./JG 3 and JG 54, but other units are known to have been involved.

Research based on primary sources show that the issuing of new colours, and their consequent number allocation, had been done systematically and sequentially within each specific grouping. The only serious candidate to appear to contradict this system in the blocks reserved exclusively for *camouflage* purposes (i.e., the 60 to 100 block) was 77, which had first appeared in 1941 in conjunction with temporary night black camouflage. Photographs of this colour painted over the white outlines of Balkenkreuz markings display a tone identical with the sample of high-altitude grey obtained from the Bf 109 G at the Australian War Memorial, which had the upper surface of one wing (a recycled component) originally painted only in this colour.

Had 77 been destined to be used exclusively as a 'markings' colour, employed only with the temporary night black camouflage, it would have had a number from the 20 to 39 block, or even by stretching its description as a 'special colour', from the 40 to 59 block. By issuing a reference number from the camouflage block of numbers, the intended purpose was clearly identified for something more extensive than simply over-painting national markings on night bombers and night fighters. (the reader is cautioned that the author has not located an official document to substantiate this, but positive identification of the precise shade of 77 adds weight to this argument. In addition, absence of any other external camouflage colour within the promulgated RLM range appears to refute a previously unknown colour being used so extensively).

Camouflage colours 74, 75 and 76 were in general use from around March/April 1941 and stocks of 78, 79 were first issued in April 1941; thus issue and employment of 77 would have been possible from at least April 1941. The date of introduction of 77 to over-paint fuselage Balkenkreuz markings, in conjunction with temporary black, is still not positively known from any RLM document, and careful dating of some photographs indicates only that this occurred in about late summer 1941. This also coincided with the gradually extended employment throughout early 1941 of the Ju 86 P-1 and P-2 aircraft in their high-altitude bombing and reconnaissance roles. Photographs of some of those modified Ju 86 aircraft show an overall pale finish on upper and side surfaces that is slightly tonally darker than the underside colouring. Given the nature of the aircraft (i e., bomber rather than fighter) the latter colouring probably was 65 rather than 76, though 76 cannot be ruled out.

Official revisions to existing colours

Paint samples of 76 taken from a number of aircraft, at differing locations, indicates a lighter shade in use during the last 18 months of the war - a change also reflected in the final colour card issue for 76, and mirrored in a revision to 66 that had taken place in 1941, though for different reasons.

The most likely explanation for the official change to a lighter shade of 76 was the critical supply of raw materials. Cobalt blue, the main colouring pigment of 76, is described in technical parlance as a greenish-blue made from cobalt aluminate, usually made by heating together cobaltous sulphate, aluminium oxide and phosphoric acid. However,

German stocks of aluminium were under severe pressure as noted in the August Sammelmitteilung discussed earlier, silver colouring having been reduced to a bright grey. Cobalt also was not a very abundant mineral, and was further required for the production of high-grade steel, adding further to the pressures that produced shortages of this mineral. In its natural form it has a greyish-white appearance.

While the description of cobalt blue as a greenish-blue might momentarily appear to answer the puzzle about the unlisted green-blue colour discussed above, on some late-war fighters, the reader should note that the revised official standard for 76 was one of a much more washed out blue than before, exhibiting even less strength of colour, and with no trace of a greenish cast as shown by the colour chip in Volume Two. Also oxidation of 76 tended to white, not green, the colour pigmentation weakening, not increasing (something that further refutes the idea that the unidentified green-blue camouflage colouring was oxidised 76).

As noted above, the evidence that 76 was revised as a colour was highlighted when the colour chips were issued for 81, 82 and 83. There had also been one issued for 76. At a time when the RLM was having difficulty issuing sufficient quantities of colour chips for the new colours to anyone other than the main aircraft-manufacturing firms, it seems superfluous to have reissued one for 76, a colour that had been in use since 1941 and was still available on the RLM charts on issue to all establishments. It would seem then that the reason for the new issue of 76 was to accommodate the official change in its colour.

The original RLM 66 had a precise RAL equivalent, RAL 7019, which had a greenish-brownish-grey cast to its colour, even though it was labelled 'schwarzgrau'. (On the back of the colour card is printed 'In das Register übernommen von: Farbtontafel des RLM zur Behandlungs- und Anwendungsvorschrift für Flugzeuglacke (Ausgabe 1938) Bisherige Farbton-Nr. 66 schwarzgrau'. (In the Register over the name of; Colour card of the RLM for the treatment and application instructions for aircraft lacquer. (Issued 1938) Current colour shade Nr. 66 black-grey). However, a specific notation on page 33 of the 1941 edition of L.Dv.521/1, under the heading of 'Painting Generally, b) Appropriate shade', stated in part:

"...Only the interior walls of glazed cockpits and canopies may be protected in shade 66 (corresponds to RAL-shade 7021) against dazzle."

RAL 7021 has a greenish-blue cast to its dark colouring and in the RAL register is described as 'nachtgrau' (night grey); however, the original written colour description was retained in RLM documents. The reason for the change appears to have been the difficulty with the complexity of the original mixture. [15]

The fact that the RAL number had been changed is proof positive that this was not a case of deterioration of the colour samples on colour atlases. The British Intelligence team who compiled the B.I.O.S. 365 report had examined samples of 7109.66 and 7121.66, and listed this colour as 'sea green' (a dark green) in both instances. The formula for Warnecke & Böhm's Ikarol Flieglack 7121.66 demonstrates how the green tinge was present - but to most eyes it would be difficult to detect at even a moderate distance, unless seen in isolation.

13.0 parts Zinc white
3.0 parts Zinc chromate
0.3 parts iron oxide red
0.8 parts black of carbon
23.2 parts artificial resin No. 100 M of Warnecke & Böhm 75 %
17.0 parts talc finest
37.0 parts Xylol
3.4 parts Butylglykol
2.3 parts Butylacetate
100.00

As noted above, this formula was a difficult one to control unless the purity of the chemical components was first class. Herr Kiroff explains:

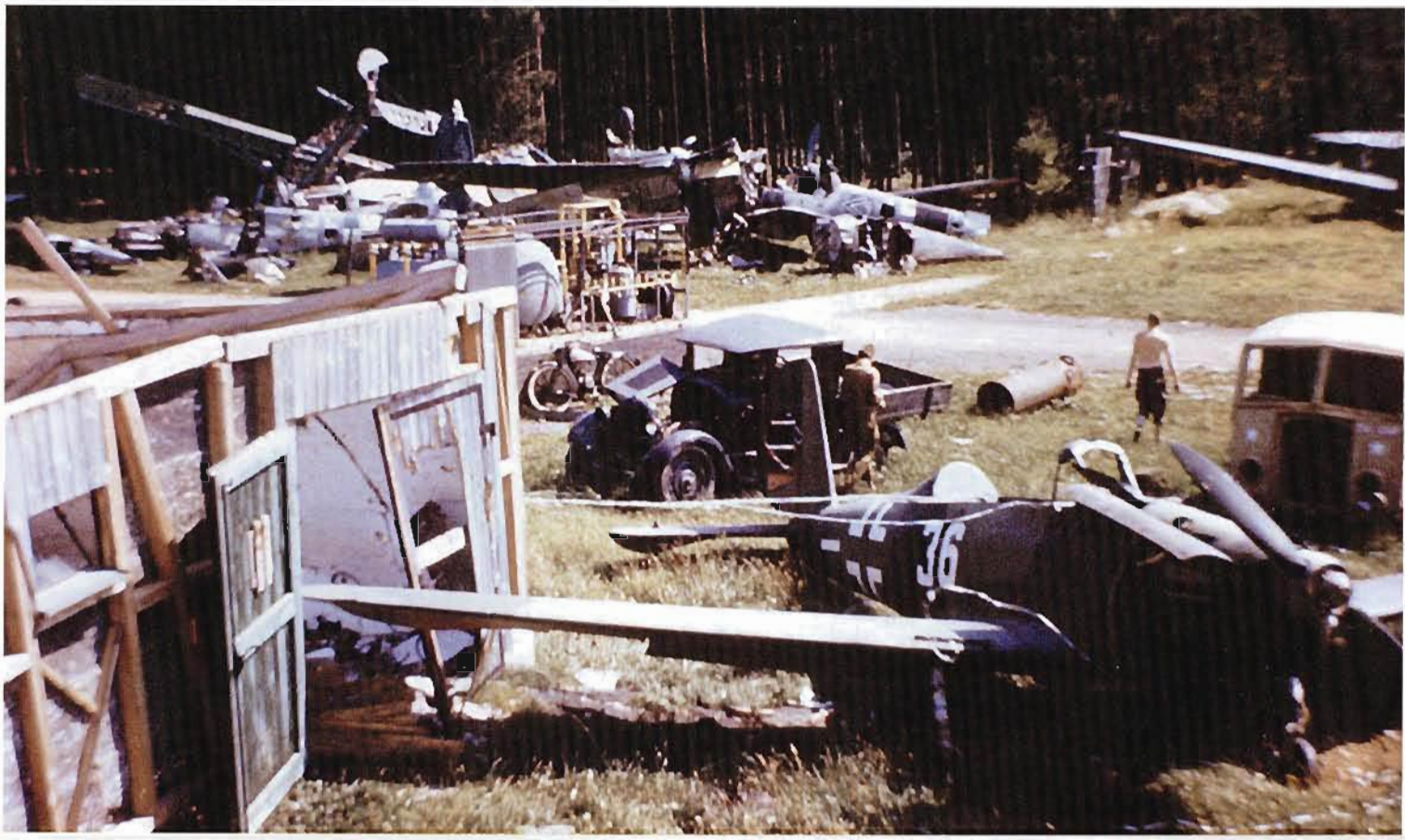
"...the W&B 7121.66 works perfectly if you have the right iron oxide red (a real violet one) and the real carbon black (which was in fact Sechsbrandruß, a bluish one). If you do not use these then it comes out like the following: 10 parts white, 2 parts black, 2 parts ochre, 2 parts iron oxide red, 1 part Hansa-Blue, 0.5 part Zitronengelb." [16]

The formula quoted is for the replacement 66 (RAL 7021). Brand new components, still wrapped in their packing, as well as many existing examples on airframe parts held in museums, all show a shift to a slightly blue cast, the greenish tinge having faded with time. (Late in the war the quality of zinc chromate began to suffer as its prime component, chromium oxide, became harder to obtain and increasingly in demand for treatment of specialist metals needed elsewhere in the armaments industry. This added yet another pressure on lacquer production quality control).

This example highlights the continued problem associated with written colour descriptions. E-Stelle Travemünde was the primary authority for testing and approving lacquers and lacquer colours. It was also the official naming authority for all written colour descriptions, yet even the E-Stelle changed its written descriptions. The revised description of 81 from olivbraun (olive brown) to braunviolett (brown violet) was one that laypersons could more easily identify with the actual colour, and perhaps that was the reason for the change, especially in the initial absence of a colour chip for checking 81, at least for secondary users such as repair and maintenance establishments and units. Existing faded samples do show a slight violet cast to the colour, but the wartime attrition rate would not have allowed sufficient time for such deterioration to become obvious. Introduction of 83, with its colour description of olivgrün (olive green), also might have been the influence to the change. Note also that the colour descriptions used, even in the correct context, are not consistent with the original written descriptions included in the pre war 'B. Richtlinien' chart for 61(81), 62(82) and 64(83). Two colours with a similar descriptive term of 'olive' (81 and 83) may have been seen as having potential for causing some confusion outside of the main aircraft manufacturing centres. The timing of the change of name appears to fall close to the shift to 81/82/76 for all classes of aircraft with 83 still in the system and needing to be used up. If so it was overcautious, as staff at aircraft production centres relied on the RLM two-digit colour code for positive identification, and no written colour description appeared on anything other than some, but not all, camouflage diagrams.

Many writers and researchers assume that the 'colour sample cards' referred to in 'Sammelmitteilung Nr. 2' were never issued in the final chaotic period that engulfed the aircraft industry. Tomás Poruba the Czech researcher and author has supplied proof that they were issued. Four large colour sample 'cards', used for checking that paint had been properly mixed before using it on an aircraft, were found at Prague-Ruzyne airfield at the end of the war. This was one of the numerous DLH repair facilities where airframe and engine repairs, mainly for Junkers aircraft, but also other types, were carried out throughout the war. As such it had good facilities for repainting aircraft. The sample cards of colours 76, 81, 82 and 83, measuring 150 mm x 150 mm, were issued as loose sheets and not accompanied by any manual. The fact that colour cards had been issued to what was a secondary facility further emphasises that the initial shortage of colour cards had been overcome. The inclusion of 83 is also significant, at least as anecdotal evidence. As such, these cards appear to have been issued after July 1944, and this points to the continuing use of 83 at the same time as 81 and 82, which combination was being listed officially, in some specifications, for fighter use by early September.

These originals have been made available and checked by this writer. They are in mint condition, and match exactly other verified RLM samples of 76, 82 and 83. The 81, 82 and 83 samples also matched with the colours shown in the colour chart appended to the document 'Anwendungs - und Verarbeitungsvorschrift für RLM Tarnfarben (Gebäude - und Bodentarnung)' - (Application and Finishing Instructions for RLM Camouflage Colours (Buildings and Ground)). (The latter also matched the colour chips for 61, 62 and 64 from the 1936 'B Richtlinien' colour atlas). The large paint sample cards (two of which have their identification marked on the back in black, as 76 and 82), are examples of the practice of issuing colour 'chips' (cards in this instance) rather than re-issuing entire colour atlases. The only difference was the very large size compared to the smaller chips previously issued and glued into L.Dv. 521/1. These large cards simply may have been examples of the usual 'master cards' produced for cutting into the normal, small colour chip size. If so, then possibly the large cards may have been issued with the intention that they would be divided up, once received by the major repair facility within a region, and then distributed within the local sub-manufacturing and repair facilities of the area. That is simply speculation, but if so it reflected the RLM's distribution system difficulties, which accords with the statement referring to gliders in the July Sammelmitteilung.



Above: The aircraft dump at Kaufbeuren was representative of numerous such sites across Germany at war's end, home to a disparate collection of types and parts, and a source of multiple variations of the colours that had adorned the Luftwaffe throughout its career. It was the last hurrah to a cycle of innovation, production and finally, desolation of an aviation industry. (J. Crow)

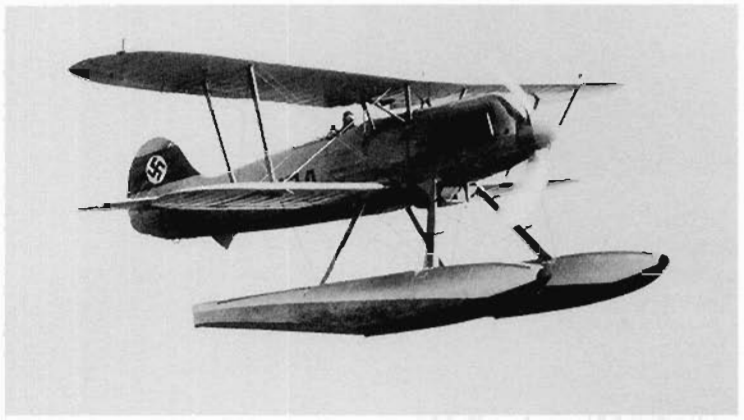
1. B. Rinder correspondence.
2. U.S. Strategic Bombing Survey Air Frame Plant report No. 1, Junkers Aircraft & Aero-Engine Works, Dessau, Germany.
3. British Intelligence Objectives Sub-Committee report No. E. 1462, German Aircraft Paints, 1945.
4. Dr. J.H. Kitchens correspondence
5. Ibid
6. E.B. Ryle correspondence and photographs.
7. B.I.O.S. Final report No. 1498 (Interrogation Report No. 543).
8. Bokelman research
9. The abbreviation 'Fl.Stabsing (Flieger Stabsing)' translates as Aircraft Staff Engineer. The abbreviation FLÄ at the end of the document is unidentified but given the subject matter may stand for Flieg Lack Änderung (Aircraft Paint Alteration)
10. M. Laing research and correspondence.
11. U.S. Strategic Bombing Survey Air Frame Plant report No. 1, Junkers Aircraft & Aero-Engine Works, Dessau, Germany.
12. Ibid
13. K. Bokelman correspondence.
14. Dr. W. Berge research.
15. Jürgen Kiroff correspondence.
16. Ibid

Day Fighters 7

Between 1933 and 1935 a variety of paramilitary aircraft were developed by the German aircraft industry as it geared up for the creation of a national air force. The Ar 65 aircraft already in service were not considered up to international standard and the RLM focused its hopes on the He 51 that was intended to become the principal fighter. Like the Ar 65, it was initially seen in civilian guise, working alongside the older type in the DVL 'Reklame-Staffel Mitteldeutschland' (Central German Publicity Squadron).

Painting sequences and choice of lacquers depended on the aircraft company's preference for a particular supplier. For the He 51's fabric surfaces (either Weber-Leinen 1403 FL II or Kisker II FO IV) aircraft were sealed with three hand-painted primer coats of 'Celesta-Nitro-Flugzeuggrundlack rot Nr.1603B' that produced a dark reddish colouring. A light sanding was applied between coats, followed by two sprayed coats of 'Celesta Flugzeugüberzugslack Nr.2000 grüngrau 63' mixed with equal parts of a liquid spreader Nr.1611. This was followed by a single full strength coat of the 63 and finished with a single sprayed coat of a mixture of five parts of the 63, two parts colourless Nr.1606 and one part stabilizing additive Nr. 1611. External surfaces of metal parts of the fuselage were finished in a sprayed application of Avionorm Nitro-Decklack grau Nr. 7007, which matched exactly RLM-63 colouring. The finish produced a sheen on the surfaces, especially when first painted and treated, the sheen being enhanced by damp conditions, which underscores that the scheme originally was not intended for camouflage purposes. Where floats were fitted, above water they were sprayed with a coat of Avionorm Nitro-Lasurlack silber Nr.V192, and below water with Avionorm Bitumen-Lack silber Nr. 120. But again there was no variation

ABOVE: The He 51 was the standard fighter of the new Luftwaffe. This collection of 2. Staffel (front) and 3. Staffel machines (rear) of I./JG 132 illustrates the 63 overall finish with its glossy sheen. The nearest aircraft, 'White 5', is W.Nr. 1094. In the background are several He 46 Es in the same 63-overall finish, two of which wear codes 60+V42 and 60+W42, identifying them as machines of 4. Staffel of II./ Kü.Fl.Gr. 406. Amidst aircraft at the rear is Fw 44 C, D-ELYV, wearing the same overall colour and marked 'Yellow 1', outlined in red, in a black circle. (R. Harrison)



ABOVE: The maritime version of the He 51 B-2 type used the same overall colouring as seen here on D-IXZA; however, the floats were finished in 01 silver down to the water line, below which silver anti-fouling finish was used. The solid rubber nose bumper on each float was usually painted red RLM 23. (D. Vincent).

in colouration of the silver. Use of silver was a common feature where waterborne aircraft were to be concerned, its aluminium powder content being an aid to waterproofing.

With public revelation that the Luftwaffe's existing fighter units had been transferred to the new Jagdgeschwader structure, JG 132 being the first and adopting the traditional name of 'Richthofen' for propaganda purposes. The existing pre-production batch of nine He 51 A-0 aircraft had been gradually supplemented by the first production He 51 A-1s. As more became available JG 134 'Horst Wessel' had joined the ranks, the first Staffel being presented to the Führer on his birthday on 20 April 1935. Initially aircraft of both units had been left in their plain RLM 02 overall finish, but with the bestowing of what were referred to as 'traditional colours' they had adopted red and brown respectively. Previous references have inferred that these colours were applied right from the inception of the units, but photographic evidence in the contemporary German publication 'Der Deutsche Sportflieger' show the aircraft wore only their plain overall finish. With the move to a full system of camouflage at the beginning of 1936, fighter aircraft had their overall colouring changed from 02 to 63.

The absence of traditional colours had continued until 1 September 1936 at which point traditional colours began to appear. The colour was confined to the engine cowling area forward of the wing leading edge on the He 51s of JG 132, which received red in keeping with its 'namesake'. By 1937 colours black (JG 131), brown (JG 134), blue (JG 135), green (JG 232) and orange (JG 234) had been allocated. Orange was probably rich chrome yellow as the 'traditional colours' had been drawn from the standard RLM range of special marking colours using 04 and the 22 to 26 group inclusive. Withdrawal of the five-character code system for fighters in 1936, shortly after the March re-occupation of the Rhineland, had witnessed introduction of a new system of fighter markings, a much revised style of application of traditional colours already being carried by some of the units, curving lines were used on the engine cowling and the colour was swept back

ABOVE: In Germany, prior to the appearance of the Bf 109 Bs, Ar 68 F-1 fighters had replaced He 51s, initially retaining the contemporary 63-overall colour scheme as seen here on this 3./JG 134 aircraft. Upper decking of the fuselage was in mid-range colour, possibly RLM 24. 'White 7' was the mount of Otto Hintze. (Hintze via J.Vasco)

along the upper surface of the fuselage to the fin leading edge. However, with the change-over from biplanes to monoplanes in 1937, and immediate adoption of the new camouflage colours 70/71/65, the use of traditional colours had rapidly lapsed.

First of the all-metal Luftwaffe monoplane fighters, the Bf 109 B-1 had begun to leave the assembly line at Augsburg-Haunstetten in February 1937. Pre-production aircraft were left in zinc chromate finish, and a few of the initial production B-1 aircraft temporarily were left in their primer-coat colouring of 02, but once production started in earnest aircraft were finished in the new ground defensive camouflage of RLM 70 and RLM 71 for upper surfaces with RLM 65 for under surfaces. This reflected the more aggressive stance being taken by the National Socialist Government, which had begun a rapid expansion of its military forces.

The war in Spain

The expansionist military policy involved Germany in its first war situation since 1918 when it transferred forces to Spain in 1936 to assist General Franco's Nationalist Government forces, which were in conflict with the Republicans. The first fighter aircraft sent, six He 51s despatched on 31 July, arrived at Cadiz on 7 August but it was not until the 11th that reassembly began. These aircraft retained their existing 63 colouring but bore no trace of their real ownership. The Nationalist forces had adopted a plain black disc marking in the usual six national markings positions, wing upper and lower surfaces and fuselage sides, plus a black cross on a white background for the rudder, and these were applied to the He 51s, giving them the appearance of being part of the Nationalist forces. Designated Jagdgruppe J/88, the He 51 element would gradually be expanded to 36 aircraft and split into three Staffeln.

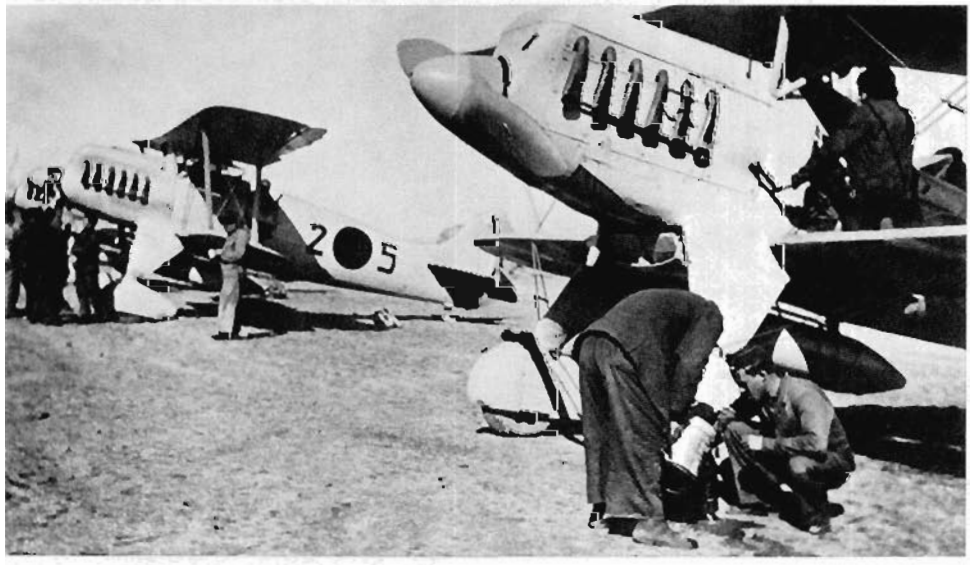
Codes were allocated to each Nationalist aircraft unit, each of which was generally based on a single type for ease of maintenance. As the German presence became more pronounced the Legion Condor, as it was then designated, added a simple white cross to the centre of the black disc marking on both surfaces of the wings, the fuselage marking being left blank for the time being.

It was decided to field test both the Bf 109 and He 112 fighters in Spain and four Versuchs machines, the Bf 109 V3, V4 (B-01), V5 (B-02) and V6 (B-03) were sent in late 1936/early 1937 in company with the He 112 V3 and V9 (B-02). The He 112 V3 was delivered in bare metal finish treated only with zinc chromate, a common finish for experimental aircraft within the German aircraft industry. This translucent pale greenish finish often highlighted slight differences in surface finish between various panels. The V3 was written off after a forced landing on 19 July 1937, but the V9 survived into 1938, eventually acquiring a finish of 02 on upper and side surfaces with 65 for the lower surfaces. The Bf 109s were also delivered in 7102.- finish, and, like the accompanying He 112s, had had their black civil registrations removed prior to delivery.

The 7102.- zinc chromate finish in which the V series, and later the initial Bf 109 B-1 series, machines arrived in Spain has caused some confusion amongst writers on this subject for many years. A former ground staff member, Friedrich Heydrich, who served with 2./J 88, recorded[1] that the aircraft had a 'silvery grey finish' which he also described as greenish-grey overall except for blue under surfaces, indicating that 65 was used for the lower surfaces on some aircraft. The description of greenish-grey with 65 may indicate that he was referring to later machines. Photographs of these very early Bf 109 B-1 aircraft do show what appears to be a bare metal finish, usually with the radiator core section painted in black.

When Feldwebel Otto Polenz was forced to land his Bf 109 B-1 (coded '6●15') behind Republican lines it was closely examined by the French Intelligence Mission and later by the Russians, the aircraft being transferred to the Soviet Union for detailed testing along with an He 111.

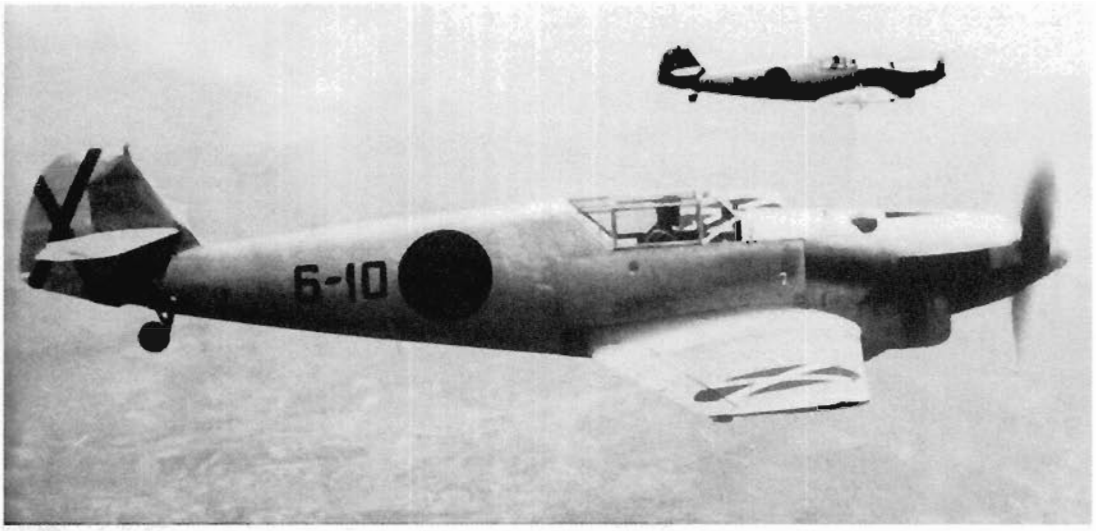
The subsequent Russian photographic record of it has now been published and reveals that what appears to be bare metal finish is actually a very thin coat of a colour that matches closely the 02 colouring of the interior parts. Heydrich's description of a "silvery grey finish/greenish-grey" matches well with the usual initial, very thin coat of zinc chromate metal preservative, applied before the usual undercoat and camouflage colouring. The 7102.-zinc chromate was manufactured by Warnecke & Böhm under the company designation of Ikarol light metal base coat green 201. This was a relatively transparent finish with



ABOVE: The He 51 was the first fighter type to be sent to Spain with the German 'volunteer' forces. Finished 63-overall, they were marked with a simple system of codes that integrated with the existing system of General Franco's Nationalist forces in general, and Gruppo 2 in particular which was already using the same type. The OKL wanted its forces to appear as part of that force. The numeral '2' identified 1./J 88, while the individual aircraft number was marked aft of the black disc. The style of the marking however would change within a short time. 1. Staffel was later redesignated 4./J 88 and eventually disbanded in March 1937.

LEFT: The original form of code marking for the Bf 109 force (deliveries of which had commenced in March 1937) is seen here at Escratôn airfield, the number '6' having been allocated to the type. A smaller, more angular form would soon replace the cursive style; placement would also alter.

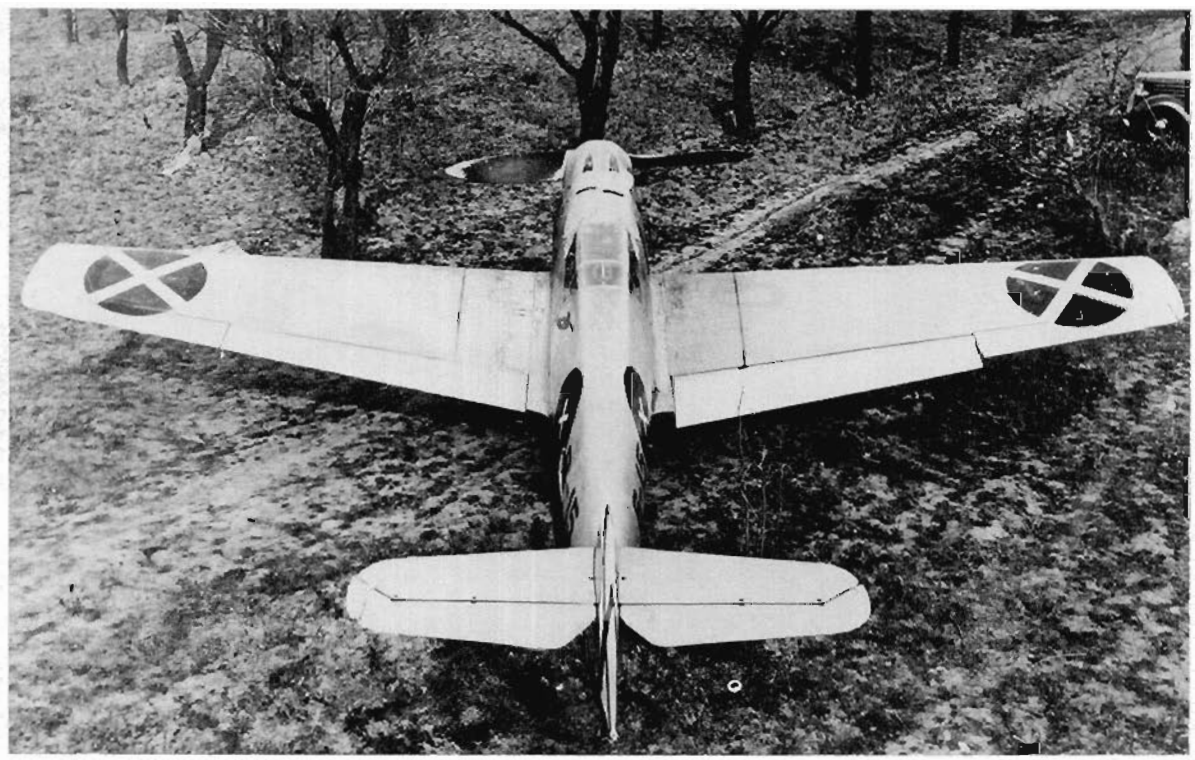
RIGHT: The same Bf 109 B-1 in the foreground of the previous photograph illustrates the revised style of code marking and the fact that existing markings had been retrospectively changed. The unit badge of a top hat, seen in the previous photograph, was marked only on the port side of the aircraft.



RIGHT: The distinction between the 62 and 65 colouring can be more clearly seen in this close-up of ground staff rearming a Bf 109 D-1. Note the canvas wheel cover, camouflaged with RAL 8019 (RLM 61 and RAL 6003 (RLM 62) colouring. (D. Vincent)

BELOW: The finish for Bf 109s changed with deliveries of the B-2 version, the first using a combination of 62 for upper and side surfaces, with 65 for lower surfaces, as shown here. Demarcation between the slightly darker upper surfaces and the paler 65 of the lower surfaces can be seen around the engine radiator area and just near the tail plane.

ABOVE, ABOVE RIGHT AND RIGHT: These photographs illustrate placement of the black disc markings and the white cross symbol, the latter having been adopted for extra identification. The original disc size did not overlap the ailerons and on the original print the additional ring of black added to enlarge the disc marking, is just visible. Note alignment of the 'X'-marking was not the same above and below the wing; below, the tip of the inboard white stroke being closest to the wing leading edge. Wing tips had been painted white to a point approximately 50 cm inboard. This was the aircraft captured and later transferred to Russia for detailed examination.



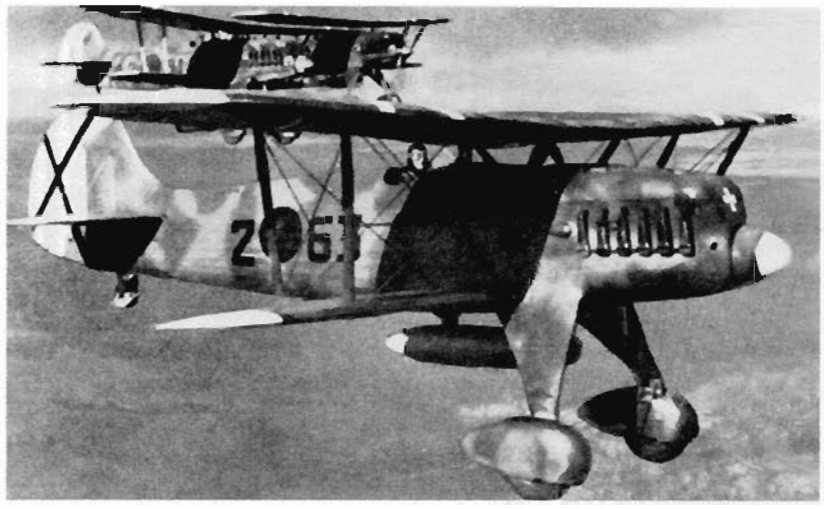
a natural greenish tinge that could vary slightly from batch to batch. The colour was influenced by the natural metal surfaces because it was applied very thinly, and usually followed by a thicker coating of 02. (The captured aircraft '6●15' subsequently saw service with a Russian reconnaissance unit, equipped with German aircraft, until recaptured in almost identical circumstances, by the Germans. It subsequently served with the Spanish 'Salvador' unit within JG 27).

By summer 1937, a camouflage of 70/71/65 had already been adopted for the Bf 109 B-1s in service in Germany, but initial deliveries to Spain did not use this camouflage scheme being given a base coat of 02 overall. Retention of 02 was a good compromise as a rudimentary form of air-to-air camouflage, and it was in the air that aircraft were most at risk in that campaign. This may have been a reflection on the general unsuitability of a European green camouflage for the much drier Spanish terrain (though a few Bf 109s would be delivered later in a 70/71/65 scheme).

As the Nationalist forces gained support, the extent and savagery of the fighting had intensified. By the summer of 1937, the He 51s in service with the Legion Condor were switched to ground-attack duties, their air fighting capabilities having proved disappointing. As a result they had their existing monotone 63-overall finish modified, using supplies from the three newly introduced upper surface camouflage colours of 61 dark brown, 62 green with 65 blue for the lower surfaces, (sent for maintenance of the finish used by the first shipment of bombers). This produced a rudimentary form of camouflage, better suited to the colours of the Spanish terrain, for their low-level operations. This was done using either paint brushes or spray equipment to achieve the patches or smaller mottles of colour which covered the upper and side surfaces down to the line joining the lowest point of the sternpost to the wing trailing edge. Photographs of some of the earliest examples show poor adhesion of the 62 to the existing 63 finish, indicative that the work had been carried out under sub-standard conditions, not allowing the lacquer to cure correctly, and probably applied on not completely clean surfaces. When conditions permitted, and facilities were available, a more controlled form of change was effected using spray equipment, sometimes using both 61 and 62 in combination over the base 63-colouring.

The addition of camouflage was not always needed though as some deliveries of Bf 109 B-2s and Ds arrived in 70/71/65 finish. The slightly erratic mix of fully camouflaged and aircraft in 63-finish probably resulted from a combination of the re-equipping programme taking place in Germany at that time and the urgency to deliver supplies of B-2 and D machines. For example, amongst the 39 Bf 109 B deliveries, photographs of 6●26, 6●27, 6●29, 6●34, 6●36 and 6●38 all show a 70/71/65 finish, while 6●32 retained the old 62/65 finish. That may reflect the order in which coding was applied rather than order of delivery. The ban on the export of aircraft wearing colours 70 and 71

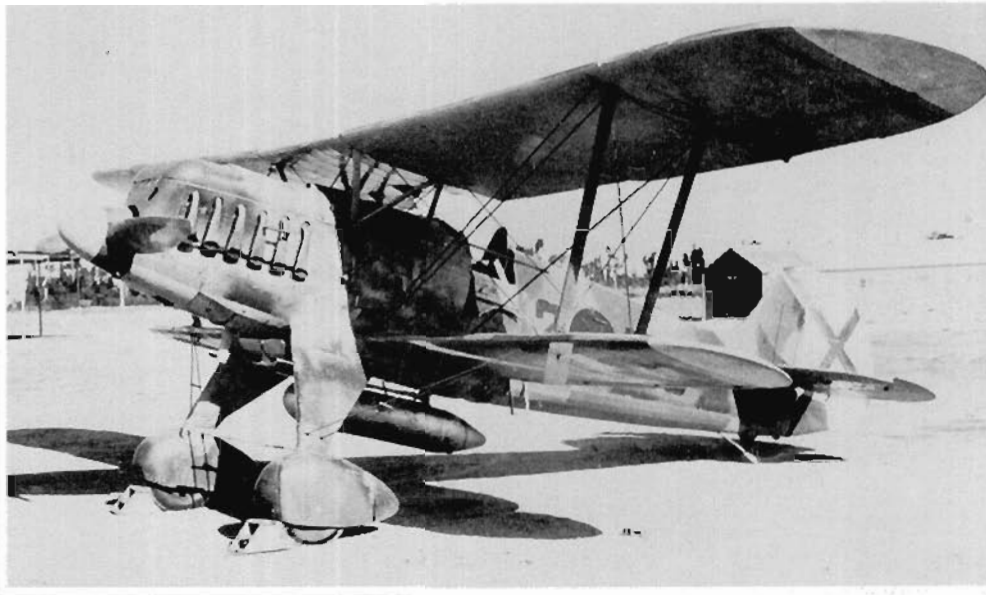
RIGHT: As the air fighting developed, camouflage was introduced for aircraft originally shipped out in overall 63-colouring. This had been done locally, using 61 and 62 from stocks of lacquer shipped for maintenance of bomber and reconnaissance aircraft. The process followed no specific pattern as can be seen on these two He 51s, 2●63 and 2●51. Again, only 62 had been added, but all three camouflage colours (61, 62 and 63) eventually had been used for the type, usually in conjunction with 65 for under surfaces. The front of the engine cowling on this type was a popular location for personal markings. The original plain black disc marking on each wing had proved inadequate and the number was doubled. When that failed to address the recognition problem a set of white wing markings was introduced.

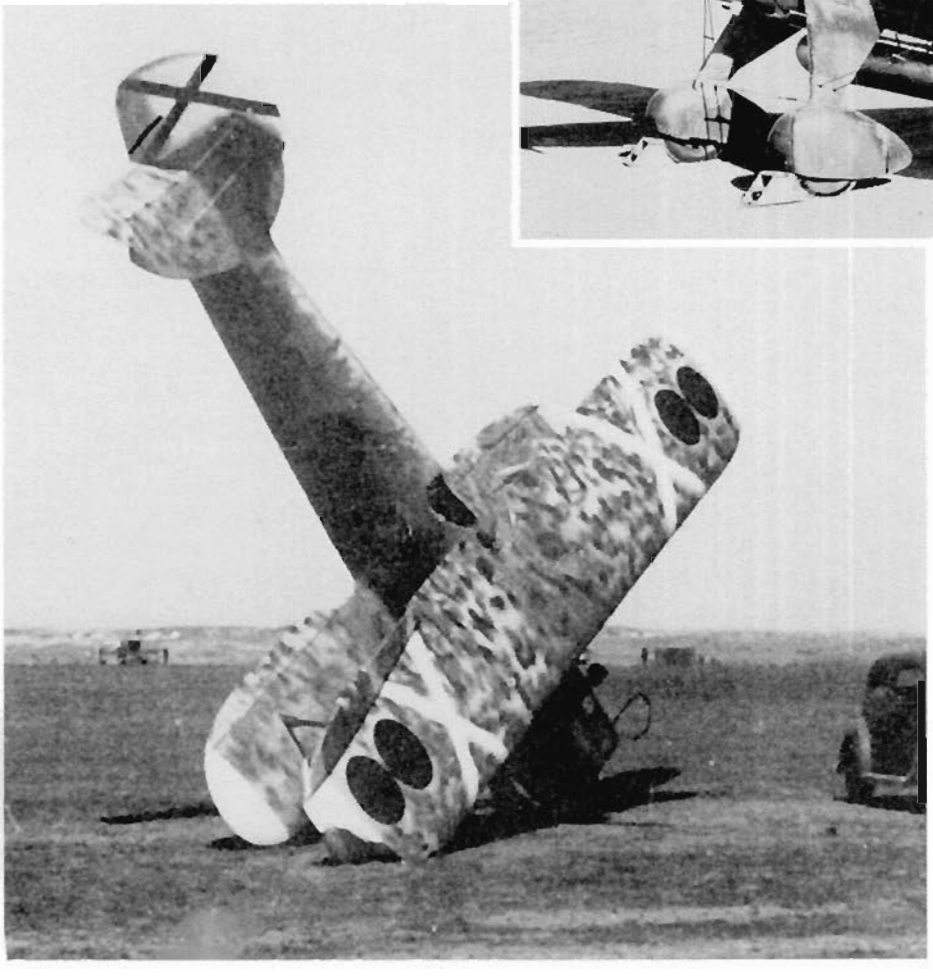


LEFT: This line-up of He 51s shows the random nature of the application of 61 and 62 to the base colouring of 63.

BELOW LEFT AND RIGHT: Two photographs of 2●85, taken on 5 December 1937, illustrate the extent of the additional white markings that had been added to the Legion's aircraft to help identify them. The eclectic mixture of aircraft types operated by both sides was found to be dangerously confusing during air fighting. Perhaps more significantly, the He 51s needed quick recognition for their ground-attack duties to save them from friendly fire. While not easy to see here, the upper surfaces of the top wing also had two black discs on each wing in addition to the large white cross marking and white wing tips. The underside of the bottom wing shows more clearly the double black disc marking, (the two pale strips on the centre section appear to have been replacement wing joint tapes.) The white centre to the fuselage black disc marking was a personal addition, that part of the identification markings proving popular for such additions. An heraldic-style shield had been painted on the front of the engine cowling, possibly the coat of arms of a German town. Camouflage was a mixture of 61 and 62 over the original 63-overall finish, with what appears to have been 65 for the undersides. The external fuel tank had been left in bare metal.

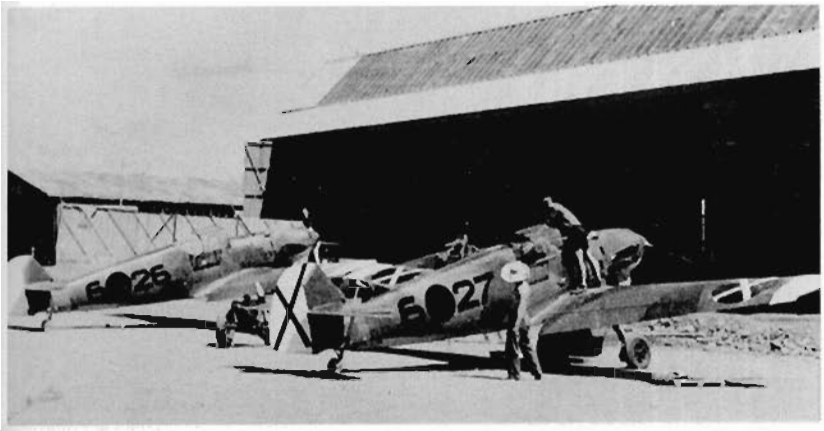
BELOW: Unlike the camouflage style shown in the previous two photos, in this instance a soft mottle of 61 and 62 had been sprayed over the original pale 63 finish on all upper and side surfaces. The double black disc marking and white wing tips can more easily be seen here, but note that the breadth of the white wing crosses was narrower. Because of their size, those markings were applied using a single strip stencil, which allowed for the angle of the intersecting lines to be varied.





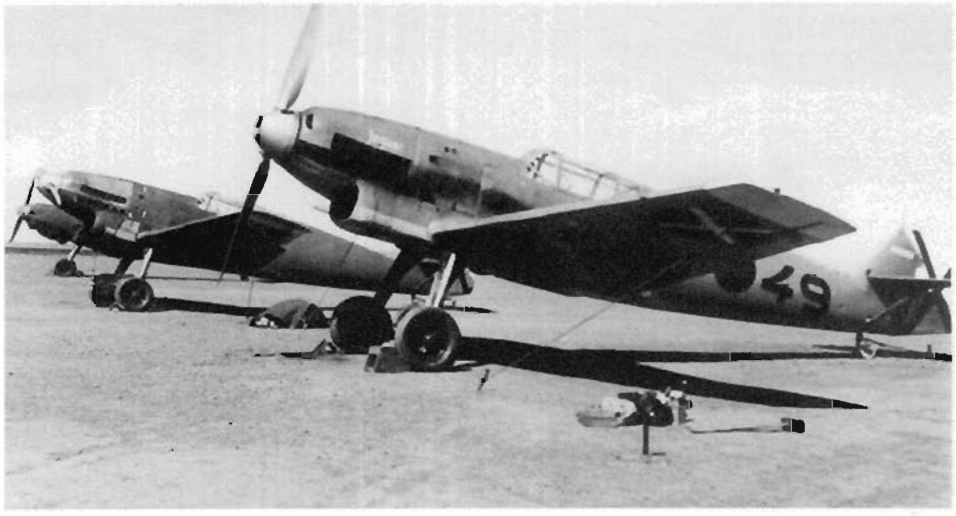
ABOVE: An He 51 B-1 of 1./J 88 at Leon in the summer of 1937, wearing a quite complex pattern of 62 used as a base colour over parts of the 63 finish and 61 applied as a sprayed soft mottle on the front of the aircraft, and as hard-edged segments on the rear half. Undersurfaces were 65, but the auxiliary fuel tank remained in bare metal. (H. Obert)

BELOW: This He 51 B-1, 2●106, of 4./J 88, illustrates the progressive shift to very dark camouflage for the type, which operated at low-level for much of the time in the ground-attack role. Upper and side surface colouring appears to have been 61 sprayed over a base colouring of 62, (this combination would be resurrected in 1944, but under revised RLM designations 81 and 82). In terms of visibility, the advantage of the tactical white markings is apparent.



ABOVE: This elevated view of 6●29, shows more clearly the standard Luftwaffe Type 2 camouflage pattern.

ABOVE: This pair of Bf 109 B-2s, 6●26 and 6●27, delivered in the autumn of 1937, retained full contemporary Luftwaffe camouflage of 70/71/65 in the Type 2 pattern. The complete complement of Nationalist markings had not been finished when this photograph was taken, 6●26 still lacking its black cross marking for the rudder. The size of the wing black disc marking had been increased by that time, overlapping the aileron.



LEFT: Although Luftwaffe domestic camouflage had already started to appear in Spain with the B-2s, the only five Bf 109 C-1 aircraft delivered to the Legion Condor had reverted to 62/65 finish, as seen here on 6●49, delivered early in 1938. This camouflage colouring had then become standard for subsequent deliveries.

applied only to aircraft sold to foreign governments and not to Luftwaffe units employed outside the greater Reich territories where integrity of the paint stocks and designations could be maintained.

Only five Bf 109 Cs were delivered to Spain and the scant photographic evidence, of just two of them, shows 62 on upper and side surfaces. While initial deliveries had been repainted in Spain it is possible that the later series aircraft arrived pre-painted, such work possibly being done at a Luftwaffe depot in Germany prior to delivery. The Bf 109s, unlike He 111s, lacked the range to fly from Italy and all were shipped to Spain, unloaded at Cadiz and subsequently assembled at Seville's Tablada airfield where any repainting probably was carried out for machines requiring a change of colouring.

One oddity was Bf 109 D-1, 6●51, photographed wearing a combination of 61 and 62 on the wings and horizontal tail surfaces. Careful examination of the two extant photographs of this particular aircraft show that originally it had standard Luftwaffe Bf 109 pattern camouflage of 70/71/65 - just like the Bf 109 Cs that had been delivered. The all-green finish appears to have been of less camouflage use than the colours already adopted for the He 51s and other types operated by the Legion Condor for land operations. As a result, 6●51 had been re-sprayed with a coat of 62 on all upper and side surfaces, leaving large segments of the original 70 and 71 finished surfaces to wing and horizontal tail surfaces in a rough approximation of the original standard pattern. The 62-colouring had been very thinly applied, and on the upper and side surfaces of the fuselage the original segmented pattern could still be detected. The lower surfaces retained the existing 65-colouring. (This aircraft survived the war, was handed over to the Nationalists, and was again re-sprayed, this time with the standard 62/65 finish adopted post-war). Some, or possibly all, of the other Bf 109 Ds delivered were also re-sprayed in 62, over the original 70 and 71 finish.

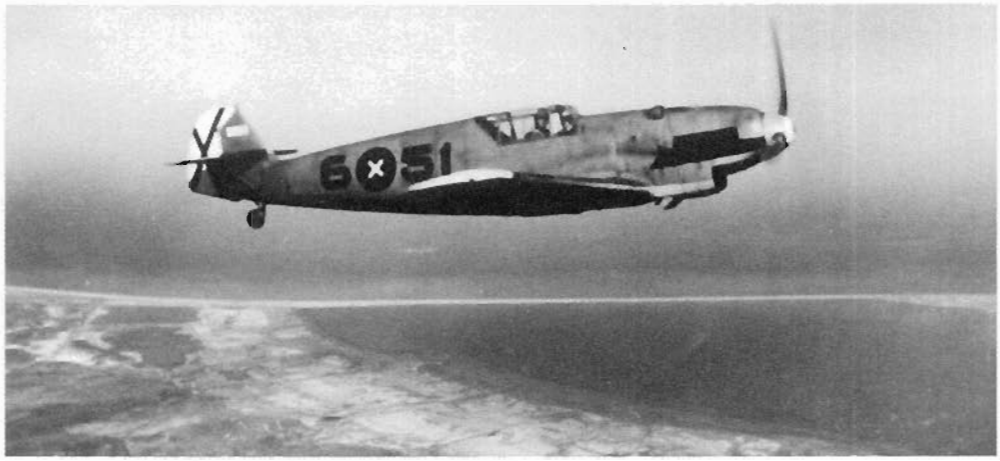
Whether 65 was used for undersurface finishes on all of these modified aircraft remains debatable; but photographs of individual Bf 109 Ds do show 65, and Heydrich's remarks mentioned earlier would seem to bear out that fact.

As the war progressed, the value of a more universal camouflage had been quickly appreciated and most of the existing Bf 109s, and later deliveries, were repainted on upper and side surfaces in green 62, with 65 for lower surfaces. The shift to a finish of a mid-green overall for upper and side surfaces appears to have been driven by the fact, that by 1938, the Nationalist forces had command of the air for all practical purposes, and ground camouflage was then of less importance. As a sky camouflage, 62 worked quite well while also providing some protection against detection when seen against the ground during airborne operations. The old 63 finish was too pale for the latter. The fact that the Nationalist forces adopted the 62-overall finish after the Spanish Civil War supports the value of this colouring as a general-purpose camouflage.

Post-production modifications to camouflage

It will be useful to pause at this point to briefly clarify some facts regarding changes made to aircraft camouflage. The term 'field applied changes' unfortunately has become a universal phrase for anything done to aircraft camouflage and markings after leaving the original manufacturing centres. Such changes, with rare exception, had nothing to do with actual 'field' locations other than for when Luftwaffe units eventually found themselves occupying major airfields with full facilities, as happened once war broke out in Europe.

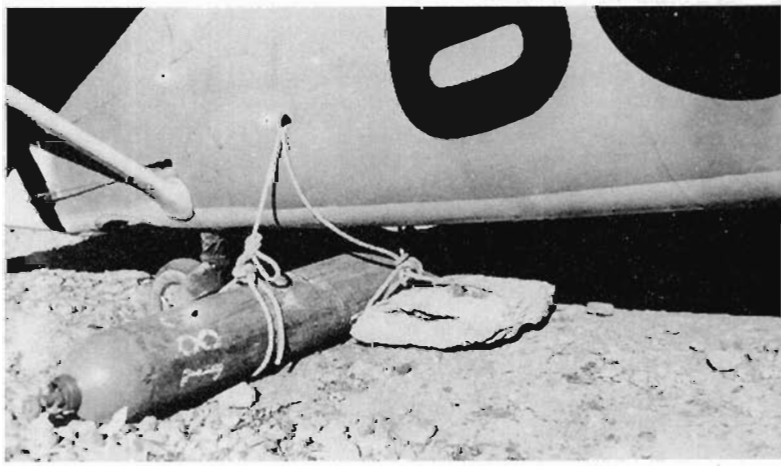
While Germany remained on a peacetime footing, field maintenance of aircraft paintwork, other than for touching up small areas, had been carried out under the Luftwaffe servicing procedure. Major mechanical maintenance work had not been undertaken by ground staff serving



ABOVE AND RIGHT: Two photographs of Bf 109 D-1, 6●51, finished in 62/65 colouring. However, close examination shows the original 70/71 camouflage beneath the thin 62 coating. The darker segments on the wings appear to be part of the original colours, retained as a rudimentary disruptive pattern, the section near the wing root being identical, though a larger segment appears to have been left inboard of the disc marking. The spinner was white, as were the six kill markings shown on the fin. The latter were those of its regular pilot, Hptm. Wolfgang Schellmann, who, with 12 kills, became the second highest scoring German pilot in the Spanish conflict.

RIGHT: This photograph of 6●53, taken in the summer of 1938, has appeared many times before and been subject of much speculation as to its colouring. In view of what is now known of Bf 109 D-1 deliveries, and 6●51 and its colouring, the contention can now be resolved. The third D model to be delivered, 6●53 also arrived in full 70/71/65 camouflage, which had then been oversprayed with 62. The thin nature of the 62 re-spray finish can be detected on the fin where the original darker colouring shows through in patches, and on the starboard wing root area where the 70-coloured segment can still be detected. This move to a 62/65 finish was in keeping with the dominance by that time of Nationalist air power.

RIGHT: Detail of the sharp delineation between the sprayed 62-green side surface and the 65-coloured lower surface on Walter Oesau's Bf 109 D-1 of the Legion Condor. Close examination shows that a straight-edged blanking piece was used forward of the tail plane bracing strut, tiny 'steps' in the line showing that it was of short length. Aft of the strut is a soft-edged spray, this section being a more difficult shape to blank off with a straight edge. Note also the J 88 unit identification marked on the compressed air cylinder. The tail wheel tyre had a white sidewall – an addition often erroneously associated only with later model Bf 109s modified to full tropical standards – the Spanish summer also was extremely hot. (D. Vincent)



ABOVE: Bf 109 E-1, 6●118, one of 45 delivered to Spain, photographed in 1938, illustrates the universal 62/65 camouflage that had been adopted for the Bf 109 force by late 1937. Use of stylised black trim for the exhaust area and wing root fillet was a feature introduced with deliveries of the 'E' variant.

ABOVE: This rear angle view of Bf 109 E, 6●119 shows the full extent of the black trim marking introduced to screen the dark stains from the engine exhausts on the 62-green of the upper surface camouflage. This was the mount of the last Staffelkapitän of 1./J 88, Hptm. Siebert Rents, and was amongst the batch of Bf 109 Es handed over to the Spanish Air Force at the end of hostilities in Spain.

LEFT: A Bf 109 E-3 bearing the Mickey Mouse emblem of 3./J 88 and camouflaged 62/65. Note the crisp division between upper and lower surface colours visible below the engine exhausts and on the wing leading edges. (D. Vincent)

with a front line unit, but done either by mobile teams of specialist Luftwaffe personnel of a Frontwerft-Abteilung (Frontal Maintenance Unit); or, occasionally, teams from the manufacturers where technical problems were being addressed. Alternatively aircraft were flown back to a Luftwaffe servicing centre for routine major overhauls and unless an aircraft had been subjected to exceptional wear and tear, refurbishment of the paintwork was usually done at the same time. Pre-war, such servicing centres were in Germany but once war erupted, centres had to be established both in the occupied territories and also those of Germany's allies. This kept transfer times down to a minimum and ensured that aircraft returned to their front line units as rapidly as practicable. During the war more than a 1,000 aircraft repair and maintenance units were established, some specialising in a particular aspect or aircraft type, for example. Werftzug für Me 262.

The reasons why unit maintenance staff did not carry out major repainting was due to the technical problems of storing sufficient supplies of relevant lacquer stocks (and transporting them in a mobile war), storing them at requisite temperatures, finding closed hangar space with exhaust extraction systems to remove dust during drying, plus the temperature control needed to accurately cure the various layers of lacquer, something that took several hours. (See Chapter 2).

Luftwaffe ground staff were equipped with the standard aircraft painter's basic kit of the type found in factories. That was provided in a wooden box (Werkzeugkasten Fl 68650) and contained a wide selection of round and flat brushes, sanding blocks, scraping and filling tools and nine cans for different small amounts of lacquer. Several types of spray gun were also on issue as well as mobile, two bottle, compressed air units (see photographs in Chapter 2). This allowed repainting of small areas of damaged or worn areas of paintwork, or where minor repairs had been made to an airframe. It had never been intended that ground staff would have to repaint entire airframes; a bad application of paintwork not only failed, but also cost an aircraft some of its performance. The application of tactical markings was a unit-level task left to ground staff most of the time because of changing battle requirements. However, even that small exception would be pre-empted by 1941 as the war settled into definite theatres of operation and aircraft manufacturers were instructed to add the relevant tactical markings at time of construction. The process would eventually revert to local unit control in 1944 when the reversals and rapid moves on the Eastern Front would precipitate a series of localised requirements. The only other circumstance involved a range of specially developed rapid change day and night camouflage lacquers and these are dealt with in Chapter 14, covering bombers in Volume Two.

For the most part, ground staff maintenance of camouflage was more mundane but essential, using cleaning aids designed specifically for field maintenance, for example aircraft exposed to high workloads had to be cleaned externally with cleaning fluid 7238.-, a water soluble agent, but no polishing of the surfaces was to occur during the process. Dirtied areas of paintwork had to be rubbed with a sponge or soft cloth. After 15 minutes the area cleaned had to be washed with clear water and the surfaces gently rubbed dry. Any patches that proved difficult or resinous could be treated with concentrated 7238 - (instead of the normal 4:1 ratio) then washed off as before.

The Spanish conflict had precipitated the first significant changes to camouflage applied away from the production cycle. A more extensive example, indeed the most extensive ever to be experienced by the Luftwaffe, would occur during August and September 1940, as detailed later in the text. But even this event would involve access to major facilities of the type and extent described.

There were two distinct factors that drove post-production changes; the first localised campaign conditions; the second, field tests of changes initiated by E-Stelle Travemünde, usually on the basis of operational feed back from units in the field; and evidence appears to point to specific fighter units having had a long term relationship with that official process.

War on the Western Front

While JG 52, JG 53 and JG 54 would be involved with extensively modified camouflage schemes at one time or another (and JG 51 to a lesser extent), perhaps the best photographically documented series of camouflage experiments involved the Bf 109s of I., II. and III./JG 53. Whether the subsequent extensive use of 02 as an addition to, or in some instances, replacement of one of the existing colours resulted from the experimental schemes remains undetermined, but clearly they were experimental and aimed at a better compromise camouflage between ground defence and air operations' needs. Any major change to camouflage required prior RLM approval and the extent of the changes made within JG 53, Gruppe by Gruppe, make it clear that this had to have been done in consultation with the RLM.

The first noted involved raising the demarcation line between upper and lower surface colours, from the wing root aft to the tail plane, to a point approximately in line with the lower edge of the horizontal arms of the Balkenkreuz. Introduction of 02 into the camouflage scheme was noted on 1. Staffel aircraft where it replaced the existing entire 70/71-coloured side surfaces, confining the remaining 70/71 colouring to the spine of the fuselage. In some instances that narrow area of colouring was replaced with a solid application of 70. Use of 02 was also extended to the wing upper surface camouflage, areas of that colour being sprayed over the 70/71 finish to produce a third dominant colour, something recorded in varying forms on 4. Staffel aircraft.

A more radical approach was adopted on the 3. Staffel aircraft, where a combination of 70/71/02 was used. The spine of the fuselage was given a single colouring of 70 while the 71 and 02 were used as camouflage segments on the sides. Aft of the wings the 65-colouring was raised to a point roughly in line with the centre of the Balkenkreuz. A more complex application comprised linear segments of 71 and 02 as well as incorporating a raised demarcation division, the 65-colouring being brought part way up the sides as had been done on 2. Staffel aircraft. Wing upper surface camouflage was modified in the same manner.

Widely differing schemes incorporating an 02/71 combination were also used by 7. Staffel. In some instances the entire upper and side surfaces were oversprayed with 02 leaving only small ragged-edged patches of the original 70/71 finish. Less radical was substitution of 02 for 71 on side surfaces that followed the projected line of the original upper two surface colours of 70 and 71.

These schemes would remain in evidence when the French campaign opened in May 1940, individual aircraft not having been withdrawn after the appearance of the officially revised form of raised 65-colouring for fuselage side surfaces and adoption of a 71/02 camouflage. Precise dating of these experimental changes is not certain, but all appear to have been made between the close of the Polish Campaign and November 1939. The simplified official scheme seems too closely related to the principle elements of the JG 53 trial schemes to have been mere coincidence.

What is interesting about the JG 53 experimentation with 02, and the dramatically revised camouflage patterns that emerged, is that it involved all three Gruppen, yet each adopted an individual approach, even between Staffeln within the same Gruppe. A few aircraft survived long enough to carry their unique finish well into September 1940, possibly even longer. Overall the surviving examples may have been retained either to test their efficacy under battle conditions, or more likely because it was not worth having the camouflage removed from so many aircraft and then having them repainted. To simply over-paint them (after one round of repainting already having taken place) would have increased the weight of the aircraft even further at a cost to performance.

Given the total number of Jagdgeschwader in the Luftwaffe inventory, most of which conformed to the prevailing camouflage standards, the consistency of change seen in the few others under discussion defies the reason being simply the whim of a series of commanding officers. To imply that all hybrid schemes resulted from such capriciousness is to misunderstand the depth of control and order that prevailed within the military system.

ABOVE: Controversy remains about the alleged evidence of a monochromatic finish for some Bf 109s in the period before the war. This photograph of 'Red 9' of 2./JG 1 appears to show just such a monochromatic green finish, in either 70 or 71. There are others that show a similar effect, but often the two-tone camouflage can be detected on parts of the aircraft.

ABOVE: This Bf 109 E-3 of I./JG 76 (later II./JG 54) also appears to have a monochromatic finish. However, careful examination of the wing leading edge reveals the presence of a two-tone pattern with segments that correspond to a Type 2 pattern. The style and positioning of national markings and the Hakenkreuz clearly date this photograph to post-January 1939.

While the 70/71 green upper surface colour scheme remained in evidence on older aircraft new *production* Bf 109s reaching units in late November early December 1939 were finished in a 71/02 upper surface scheme, with raised demarcation line between upper and lower surface colouring, and revised upper surface camouflage pattern. Decision to adopt this simpler form of revision probably was seen as the most practical, requiring little change to the existing painting techniques or schedules while producing an adequate solution.

Production aircraft introduced an optical reversal of the original colour areas with the darker segments now 71. The general camouflage pattern was also revised, the splinter pattern on the fuselage spine being replaced by simplified segments to eliminate the thin angular elements. The sharp-edged division to the segmented pattern of the wing upper surfaces was also revised; a soft 'toothed' integration of the two colours producing a distinct, but not absolutely sharp division between the colours. This revised pattern would be retained for the F-model introduced at the end of 1940. New aircraft delivered from May 1941 introduced soft mottling in 02 on the fuselage sides.

With commencement of the air battle over Britain, German aircraft began operating over the sea for the first time in the European Campaign. Initially, camouflage varied very little from the new standard factory scheme, or that seen on older aircraft repainted to incorporate the revised, raised demarcation line. However, as the fighting intensified in August, field staff began applying variations in an attempt to produce a more disruptive air-to-air camouflage similar to that seen on deliveries of newer aircraft that by then had soft mottling in 02 on their side surfaces. Closed hangar facilities were usually available where fighter units occupied former permanent French bases, but not all units had access to such facilities, something needed for the more extensive spray applications. That may account for some of the Jagdstaffeln not modifying their aircraft to any great extent, or not at all. Sprayed applications were used to modify upper surface camouflage areas, breaking down the usual straight-edged scheme to produce a soft-edged pattern; sometimes this was done with an application of large areas of 02 over the existing 70/71 schemes on older aircraft. Alternatively mottling in 02 was sometimes added, effectively breaking up the dark, almost solid green-looking upper surface segments into something that blended more readily with the sea background over which the aircraft were operating. (The sea is not a solid dark colour; wave motion produces continuously changing areas of reflected light).

ABOVE: Taken in November 1939 at Kirchberg, another of JG 53's unique camouflage schemes is shown here. While of questionable quality it shows the same combination of colours 70, 71 and 02 used in a different manner, with a mixture of hard-edge splinter pattern forward and wavy line demarcation on the rear part of the fuselage.

BELOW: Despite having the III. Gruppe marking aft of the Balkenkreuz, these Bf 109 E-3s, photographed in late September 1939, belonged to I./JG 20. Reputedly the Gruppe was not re-designated III./JG 51 until July 1940, making use of the III. Gruppe marking unexplained. The nearest two aircraft each had areas of their fuselage overpainted in 70 to eliminate the original aircraft number and what by its shape was a II. Gruppe horizontal bar which adds to the mystery. The camouflage of 70/71/65 and style reinforce the date of this photograph prior to the opening offensive against Poland on 1 September.

Stocks of paint held by all forward maintenance units encompassed the full range of external colours including 66, which served for both internal and external use. While colours 74, 75 and 76 are known to have been undergoing limited field trials (see Chapter 5), they were not available to manufacturing centres or to front line maintenance units. However, existing 'field' stocks of colours provided potential for a range of colour mixes, including greys and distinctive blue-greys. A simple mix of 65 and 66 in varying ratios produced a wide range of blue-greys suitable to break up the starkness of the pale 65-side surfaces while aiding concealment over waters of the Channel. Simple mottling with 02 over the existing dark green was sometimes enhanced with patches of a darker colour such as 66 to produce a startling but effective camouflage. Yellow-greens and olive greens were also noted in intelligence reports and these could be readily produced from mixtures of 70 or 71 with 02, or simply by varying the strength of application of 02 over the existing green. Mixes using 04 or 27 were less likely to have been employed, as stocks of those paints were always small because of their limited and specialised use. Field generated colours became much more pronounced from September, when the air battles were reaching their peak.

Aircraft brought down over Britain were examined for both technical and unit intelligence purposes and the following brief extracts have been taken from subsequent evaluation reports. While by no means exhaustive of variations seen on Bf 109 Es of the period, they do give some insight into the range of colours produced by these innovative modifications:

28/8 [Unit?] *13+1 (white) Light blue side and lower surfaces and navy grey mottled on top surfaces. Spinner dark green.*

30/8 [1./JG 27] *6+ (yellow). Light green mottled on upper surfaces, normal blue under surfaces.*

30/8 [7./JG 27] *12+ (yellow) Camouflage standard.*

30/8 [7./JG 26?] *Grey-green top surfaces, pale blue below.*

31/8 [7./JG 26?] *->.Grey and green upper, dark egg-blue under.*

31/8 [9./JG 26] *10+1. Green upper surfaces and blue underneath.*

2/9 [8./JG 54] *2 (black). Top of fuselage dark green, sides mottled light green, lower surfaces pale blue.*

5/9 [3./JG 3] *7+ (yellow). Mottled dark and light green and grey. Wings standard.*

5/9 [Stab JG 53]-+-*I, marking, two straight lines with a + in the middle, then III./Gruppe vertical bar. Light navy-grey (a second report describes this as mottled grey).*

6/9 [7./JG 53] *5+1 (white). Mottled light and dark green and grey.*

6/9 [6./LG 2] *C+ black triangle outlined white. Two shades of grey on upper surfaces. Standard duck egg blue lower surfaces.*

7/9 [1./JG 77] *11+ (yellow). Grey speckled on top.*

7/9 [4./JG 26] *12+-. Grey speckled on top.*

7/9 [1./JG 2] *8+ (white). Camouflage: standard.*

15/9 [3./LG 2] *2+ (brown with white edge). Cloudy grey on fuselage, wings battleship grey upper surfaces and light blue lower surfaces.*

30/9 [7./JG 53] *12+1 (white). Blue and green dappled yellow and green on upper surfaces, sky blue underneath.*

2/10 [8./JG 53] *9+ (yellow). Dappled dark blue and yellow green on upper surface, light blue lower surfaces.*

5/10 [7./JG 53] *10+ (white). Grey, dappled black, carefully done.*

15/10 [8./JG 3] *7+1 (black). Mottled dark grey and olive green.*

20/10 [6./JG 52] *Dark green on top of wings with pale blue cloud effect running diagonally.*

27/10 [7./JG 54] *13+ (white). Upper surface of wings darkish grey except for a triangle formed from wing root at trailing edge to a point halfway along leading edge. This triangle towards fuselage is a dirty light blue. Fuselage also a dirty light blue dappled with grey.*

1/11 [7./JG 2] *9+ (white). Whole of fuselage marked very dark mottled olive green.*

2/11 [8./JG 53] *6+1 (black). Yellow dappled green-grey all over.* [2]

It has often been suggested that the greys 74, 75 and 76 made their first broad scale appearance during this period, but in looking at individual applications it can be seen that the range of greys was sufficiently diverse to dissuade such a contention. The three new colours were in existence, and undergoing the usual stringent RLM tests before being approved for general use, but had 74, 75 and 76 been available one would also have expected these three greys to be used together, as they had been on the field test aircraft noted in Chapter 5, rather than as a single colour added to existing greens or mixes of yellow-greens. Also, had these colours been in use, why then did the remaining Bf 109 E production cycle continue with the then standard 71/02/65 scheme - a scheme that was also used for the initial batch of Bf 109 F aircraft?

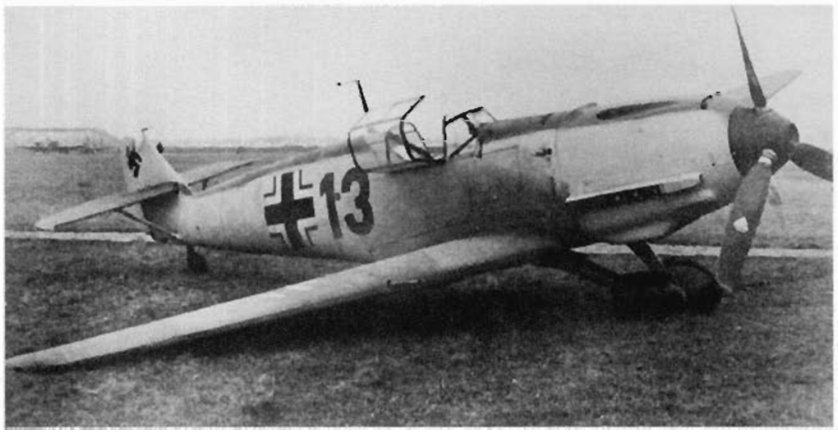
The only serious contender amongst those oft-quoted as wearing a 74/75/76 scheme was the 7./JG 54 Bf 109 E-1, W.Nr. 3576, 'White 13', brought down on 27 October 1940. The range of colours described in the intelligence report seem to support use of the three colours, lower surface colouring being covered in the description of a 'dirty light blue' applied to the side surfaces. However, this is the same colour description used for the 'triangle formed from wing root at trailing edge to a point half way along leading edge.' The triangle is the paler area of colour seen in the Type 4 camouflage pattern in which this aircraft was finished.

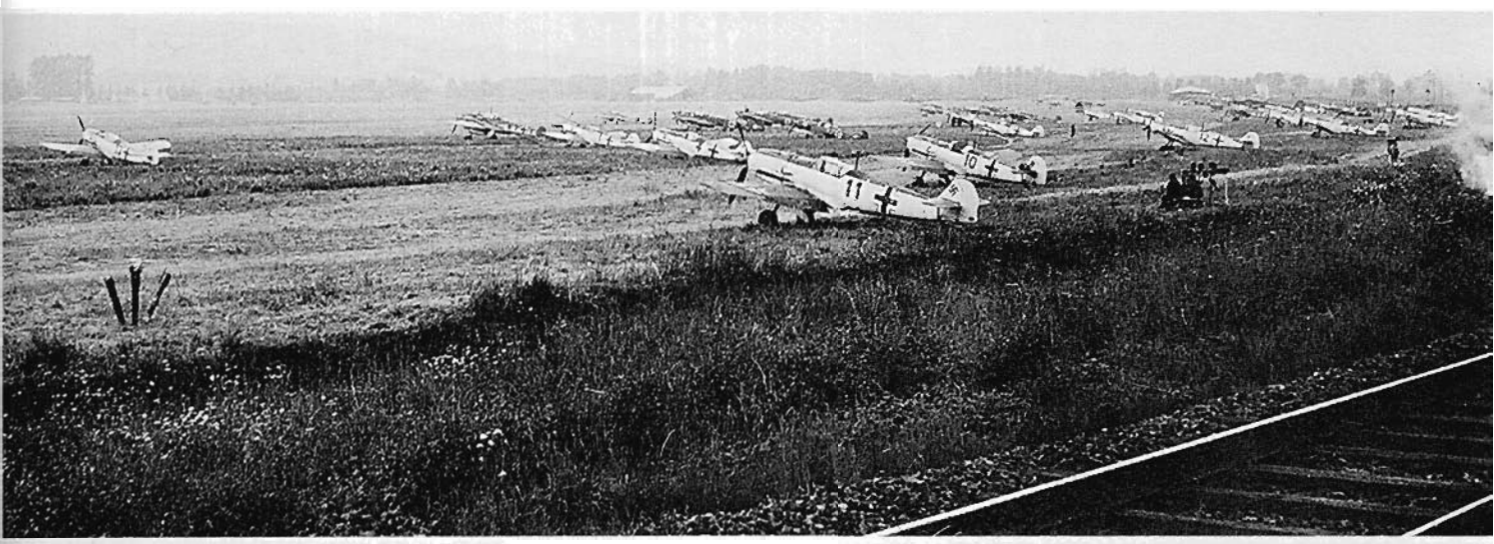
If the fuselage sides (which in the photographs are clearly much lighter than the wing camouflage colours) were 76 then it would appear that the Intelligence Officer mistakenly recorded the same colour in part for the wing upper surface. As this is not the same colour visible in the photographs, then the colour descriptions used become contentious. Further, the report makes a clear distinction between the 'dirty light blue' of the fuselage sides and the 'darkish grey' of the wings. Dappling on the fuselage side surfaces is in three distinct colours, two of which match those seen along the spine of the fuselage. The third mottle colour is very dark and only sparingly used - immediately aft of the cockpit glazing and just forward of the '13'. Its closest tonal match in the photograph is the 70 of the propeller blade in the foreground. The very limited use of this latter colour possibly accounts for it being overlooked in the general colour description of the intelligence report. All three are darker than the paler side surface colouring.

The Bf 109 E-7 of 3./LG 2 (either W.Nr. 2058 or 2061) also makes references to greys, but in conjunction with light blue lower surfaces. The subsequent introduction of 74, 75 and 76 on the Bf 109 F-2 model in 1941 also begs the question why these colours were not broadly employed earlier if available. Had they been available all those hybrid unit-modified colour schemes would not have been necessary.

A more detailed analysis of the aircraft listed in the previously mentioned intelligence reports show that they were, predictably, a mixture of E-1s, E-4s and E-7s. The occasions where greys are found in the camouflage descriptions are eclectic with the colour term grey scattered across all three sub-types. W.Nr. 3576, the example discussed in detail above, was an E-1,

RIGHT: Following the Polish campaign, camouflage for subsequent production single-seat fighter aircraft was revised, resulting in a raised demarcation line between upper and lower surfaces; a revision implemented by modifying some, but not all, aircraft already in service. This Bf 109 E-3, in addition to revised side surfaces, had had its Type 4 (B pattern reversed colours), upper surface camouflage changed to the simplified one being introduced for production aircraft. Positioning of the Hakenkreuz marking, still centred over fin and rudder, confirms this was a post-production modified scheme. Despite the incorrect positioning, the fuselage Balkenkreuz had been increased to approximately the revised proportions, but in doing so the demarcation line had been lifted slightly to clear the top of it. Upper surface colours were 71/02. These revisions and the background indicate a date of early spring of 1940. (B. Robertson)





ABOVE: Bf 109 Es of JG 52, sharing a mist-laden airfield with Bf 110s of II./ZG 2, provide an interesting study in camouflage transition. The bold 65-coloured side surfaces makes the Bf 109 Es stand out against the background. In contrast a Bf 109 E, 'Yellow 17', in 70/71 camouflage (immediately in line of sight over the canopy of the Bf 109 E marked 'Black 11') is difficult to detect. This illustrates well the shift from a ground defensive to an air defensive camouflage scheme for the Bf 109 E. The Bf 110s scattered across the entire photograph also exhibited old and new schemes. Immediately right of the lone Bf 109 E 'Black 13', on the left of the photograph, is a machine marked A2+IK(?); it has revised camouflage with 65-coloured side surfaces and 02-mottling, dating the photograph to around May/June 1940. A lone Ju 52 in 70/71/65 is difficult to detect, and there are more Bf 110s in the new style of camouflage, plus another Bf 109 E in old style, to the right of the photograph. This mixture of camouflage schemes well after the introduction date for the Bf 109 change, illustrates the slowness that sometimes occurred in getting older machines repainted. (D.Vincent)

LEFT: Photographed during the winter of 1939/40, this Bf 109 E-1, was a production aircraft delivered in the revised, Type 5 camouflage pattern introduced into manufacturing centres following changes resulting from the Polish campaign. The raised demarcation line of the 65-colouring and its slightly ragged edge is indicative of a post-production change to its camouflage, indicating that early deliveries of aircraft in production Type 5 pattern may have had full camouflage in 71/02 that was then revised in December, something supported by the fact that the Hakenkreuz and Balkenkreuz markings were in the revised dimensions and positions introduced in October 1939. (D. Vincent)

RIGHT: 'White 9', a Bf 109 E of 4./JG 51, seen here being refuelled in snowy conditions during the winter of early 1940, had oversized Balkenkreuz wing markings and undersized fuselage markings, both based on the October 1939-size revised fuselage Balkenkreuz proportions. Also significant is the revised camouflage, which had been modified further by addition of 02 as large 'spots' on the spine of the fuselage and as longitudinal ribbons of colour on the wings. The upper portion of the fin and rudder had been camouflaged in 71/02. This was an extreme, but not unique, interpretation of the revised camouflage style that had reduced upper surface colouring to a strict plan view. Some production, and refurbishment centres, where aircraft had their camouflage revised, had interpreted the order in strict minimalist fashion as shown here; painting wing fillets in 65 and taking the upper surface camouflage to the highest possible point. When viewed from above the slight bulge of the fuselage and the wing fillets were visible as a pale blue division in the pattern. However, this form of camouflage was discouraged, and viewed from above most aircraft had a continuous upper surface camouflage.

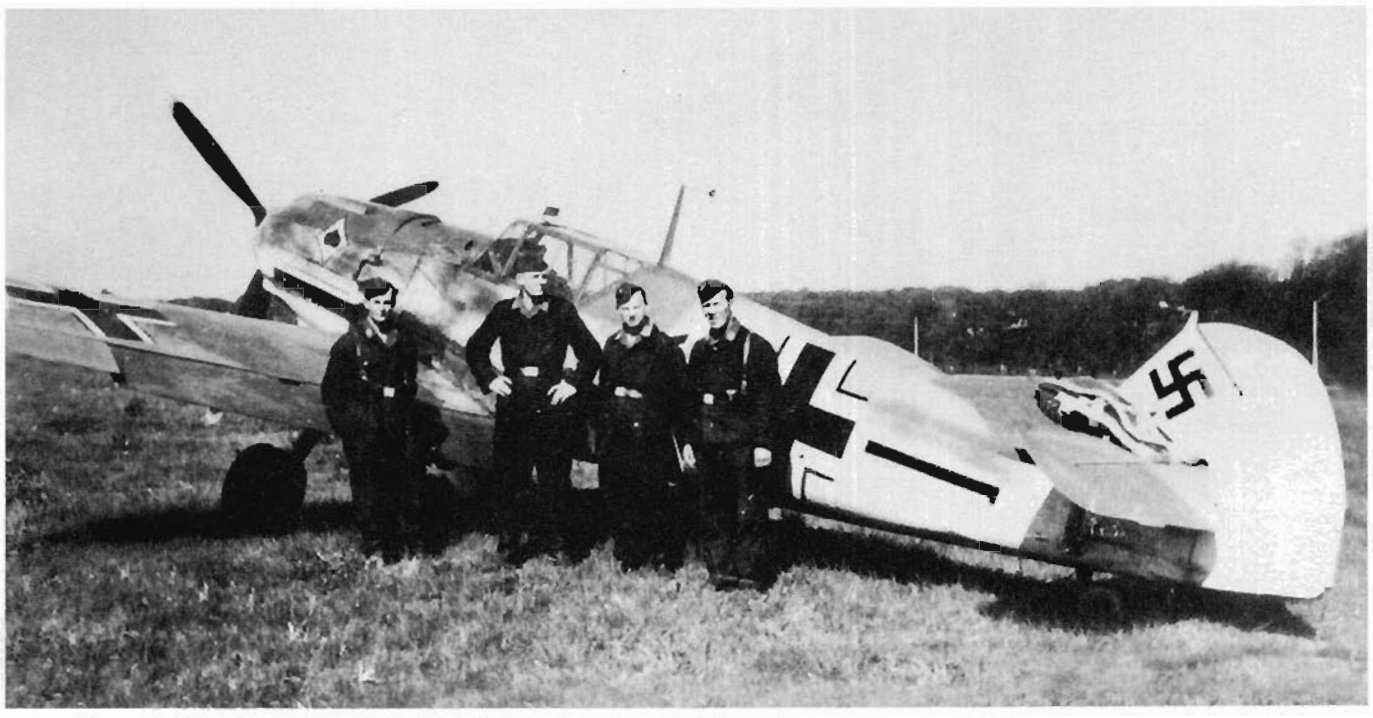
ABOVE: France, summer 1940. The 70/71/65 finish of this Bf 110 C of Stab ZG 76 had had its camouflage compromised by the unit's large shark's mouth marking, but confidence of total Luftwaffe superiority was still very high at that time. Spinners and propeller blades were in 70 with the hubs of the latter in treated natural metal. Spinner tips were blue 24. (P. Hilt)

ABOVE: The 70/71 upper surface finish for Bf 110s had been phased out in May 1940, production centres changing over to the 71/02/65. This Bf 110 D, 3M+DB of Stab/ZG 2, was photographed during the transition period and wore the revised factory-applied scheme with side surfaces mottled in 02. The older Bf 110 C-4s behind retained their 70/71/65 finish.

BELOW: Bright sunlight on this Erprobungsgruppe 210, Bf 110 emphasises the soft blending effect produced by the thin spray of 02 over the 71/02 camouflage. It has also been used here to tone down the 65-colouring, blending upper and side surface camouflage.

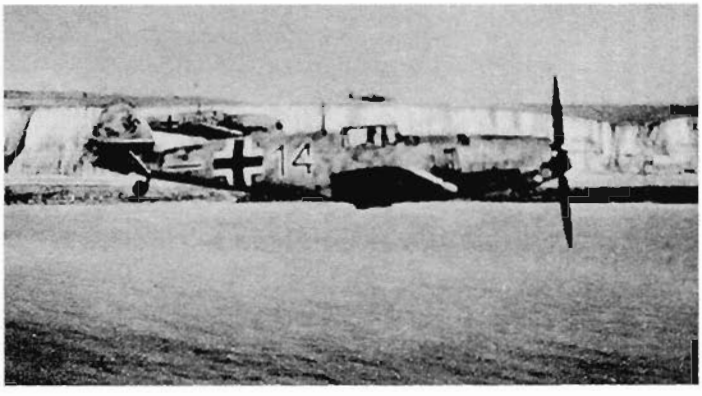
ABOVE AND RIGHT: Oblt. Werner Bartel's Bf 109 E-1, W.Nr. 6296F from the Stab of III./JG 26, brought down on 24 July 1940, displayed the first tentative changes to the camouflage revisions that had been introduced at the end of 1939. Upper surfaces were 71/02 but with transition to the 65-sides applied with a soft sprayed application along the engine cowling to produce a ragged effect. Very soft traces of mottling, in both colours, had been added to the engine cowling, down to below the exhaust stubs. The gun troughs were a pale colour, something still seen fairly often at that period of the war. Judging from other photographs, the colour was probably 65, not yellow or white as has sometimes been suggested. Note the tonal contrast between the 70 of the propeller blades and the darkest upper surface colouring. The spinner was black with a one-third white segment, another recently introduced change to fighter aircraft. The suffix 'F' (Flugklar) to the Werknummer indicated that it was a repaired aircraft (apparently also upgraded from original E-1 configuration, probably at the same time), which probably accounts for the additional camouflage revision. This form of suffix to the Werknummer did not continue much beyond this date as the Luftwaffe revised its system of repair codes and symbols. The illusion of a very pale rudder colour was produced by the angle of the rudder to the sun, something confirmed from the head-on view.

LEFT: Oblt. Daig's Bf 109 E-1, W.Nr. 3488, 'Red 13' of II./JG 27, which was shot down near London on 9 September 1940; the cowling and rudder were finished in temporary yellow. It wore the Type 5 camouflage pattern in 71/02 on upper surfaces, but that had been heavily oversprayed with a dense soft mottle of a medium toned colour, possibly 02. The spinner was described as being divided two-thirds dark and one-third 'pale'. (D. Carnck)



ABOVE: II./JG 53 appears to have been amongst the first units to operate aircraft with some form of mottling to subdue the otherwise over bright 65-side areas of the fuselage of their Bf 109s. The form of mottling is limited though, being concentrated more around the nose area of the aircraft. This photograph of the adjutant's aircraft is reputed to have been taken in May 1940 in France. It has Type 5 pattern camouflage.

RIGHT: From the same unit, and taken in the same month, this Bf 109 E of 5./JG 53 wears a similar form of disruptive mottling, taking the upper surface camouflage back down to the horizontal mid-line of the aircraft. This may have been initiated as a more defensive measure, the pale blue-grey colouring of the 65 sides not then outlining the fuselage in an oblique view. This may have resulted from some of the unit's aircraft having had their 65-side colouring aft of the cockpit raised to the high position when the change to the old scheme was initiated in December 1939. Two distinct variations had resulted, one with the upper surface colour line taken up to a point level with the top frame of the cockpit (as here); or to a point level with the bottom line of the cockpit (as in the previous photograph). This particular machine was taken on charge before the removal of the old red banner and white disc marking, which left the Hakenkreuz centrally located, spanning fin and rudder.



LEFT: Just as general conformity had been achieved by the July/August 1940 period, some aircraft began appearing in unit-initiated camouflage schemes, though some variations were merely extensions of the existing upper surface colours as shown here – standard 71/02 upper surfaces with heavy mottling in both colours over all side surfaces. Whilst this photograph is of indifferent quality, it does illustrate the effectiveness of such schemes.

RIGHT: By August 1940, mottling had become more extensive. These two Bf 109 Es of 5./JG 77 show the variation that occurred between individual aircraft; while 'Black 5' in the background had mottling concentrated more heavily on the forward section of the fuselage, its overall application was relatively lighter than that of 'Black 3'.

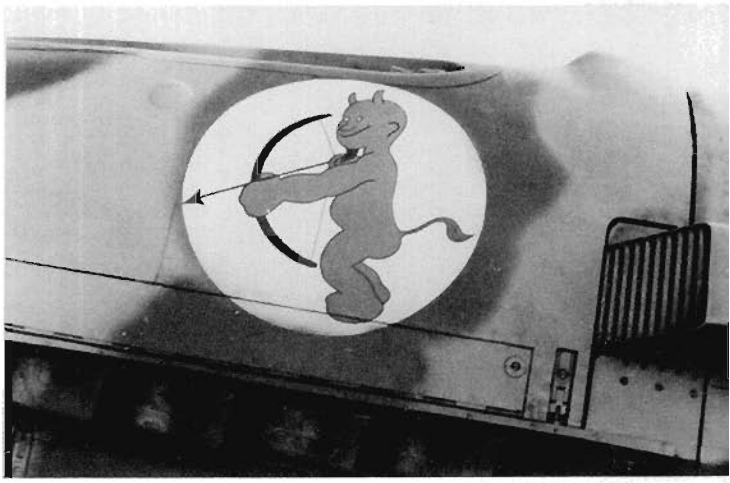
LEFT: A similar style of application had been applied to this Bf 109 E-4, 'Yellow 5', camouflaged in standard 71/02. In this case 71 appears to have been used as short dashes of colour over a very thinly sprayed finish of 02 on the fuselage side surfaces; some of the 02 had also been applied over the spine of the aircraft. Note the high contrast around the square of the Hakenkreuz marking, part of the original standard 65-background. Wing and horizontal tail surfaces however remained in plain 71/02 finish. The rudder was finished in white, indicating that the photograph was in September 1940. (F. Kovács.)

RIGHT: A Bf 109 E-3 of 2./JG 77 wearing the Type 5 camouflage pattern using 71/02 on wings and fuselage upper surfaces. Fuselage side surfaces had been densely sprayed with 71 and 02, the 71 having been extended to give a dark background to the white-edged, 'Black 7' marking. The high contrast camouflage finish is clearly visible on the wing. (F. Kovács.)

ABOVE: A more radical change is seen here. Displayed in Australia for fund raising and recruitment at Horsham Town Hall, in Victoria in 1943, Uffz. Grabow's Bf 109 E-4, W.Nr. 0750, 'Yellow 7' of 3./JG 3, had been shot down on 5 September 1940. The intelligence report stated that it was mottled with dark and light green, and grey. The darker colour was possibly 70 with thinner sprayed applications of 71, the 'lighter' green, and 02, probably the grey. Close examination reveals the Type 5 camouflage pattern, as the original finish. The 65- coloured side surfaces had been heavily sprayed with dark and light mottles, the former predominating. While the wings had been given similar treatment, almost obscuring the original splinter pattern, the horizontal tail plane had retained its original 71/02 pattern. This was a common feature of these modified camouflage schemes, presumably the small surface area involved not being considered significant, or more probably indicating a reluctance to add weight to the control surfaces. Lack of the original white tactical markings on the engine cowling and rudder was a result of the time span involved, the temporary finish having long since powdered away. The rudder was the original one as the pattern of mottling shows. The black disc and white cross marking appeared only on the starboard side, probably a connection with the Spanish conflict as this was also seen on some aircraft of other units. (N. Paterson)

BELOW: A Bf 109 E-4 of II./JG 77, possibly the Gruppen Adjutant's aircraft, finished in 71/02 with mottling of the side surfaces in both upper surface colours and extending to the oil cooler beneath the engine cowling. The rudder was in 04. (F. Smith)

ABOVE: This close-up of the fuselage area of W.Nr. 0750, taken during the fund raising tour in Australia, shows how the dark and light green had been applied, the darker over the lighter one, using short bursts of spray closely linked together in places, but more widely spread in others. The visual result of such a simple technique over the 71/02 base finish was quite effective. (A. Paterson via D. Vincent)



ABOVE: This example of the emblem of 2./JG 52 on a Bf 109 E is backed by a hybrid application of 02. Examination of the original photograph reveals that the broad areas of 02 had been applied over the existing 70/71 standard finish. (M. Payne)

BELOW AND RIGHT: The finish on Uffz. Arno Zimmermann's Bf 109 E-1, W.Nr. 3576, of 7./JG 54, brought down on 27 October 1940, is often raised in the conjecture about the introduction of 74 and 75 into Luftwaffe front line service. Upper surface colours were 71/02 on the fuselage spine, but the wings, according to the intelligence report on the aircraft, were darkish grey except for a large triangular area of dirty light blue colouring (Type 4 pattern). The fuselage side colouring was also described as a dirty light blue dappled with grey. Careful examination of the photographs shows that the dappling in grey follows the projected angles of the upper 71-coloured areas. Where dapples overlapped the 71, they appear darker which might indicate that the grey used was either 66 or a mix of 66 and 22. Engine cowling and rudder were in 04, the latter colouring on being confined to the rear two thirds.

production of which sub-type had ceased by the autumn of 1939. Its retention of the original E-1 style of canopy and lack of head armour indicates that it had not been upgraded, and its original 70/71 camouflage had been repainted, not at a factory but at a field maintenance unit. When the three greys 74, 75 and 76 were introduced, they were done so at the factory, not at maintenance unit-level.

The consistency of style and colours used in modification to camouflage of some units' aircraft indicates that some repainting had been done in batches; the quality and extent of such work also indicating that good facilities and ample staff were involved. While some units were stationed at French facilities with good infrastructure, it must be recalled that these innovative schemes resulted from the growing needs of battle and peaked around the time that the Luftwaffe was operating at its most intense pace, something reflected in the fact that some Bf 109 Es brought down relatively late in the battle were still in standard 71/02/65 camouflage, devoid of any additional colouring. To expect that under those operational conditions ground staff had time for such extra work, not just for a single aircraft but entire groups, is an unrealistic assessment, especially when the Luftwaffe had well staffed mobile maintenance units whose role was, in part, to handle such work. Normally they helped alleviate the pressure on ground staff by carrying out engineering maintenance tasks, at times including engine changes, something usually left to unit ground staff. There were instances where unit ground staff did make camouflage changes, but their handiwork is quite apparent, for example JG 2 adopted a stippled application that was within the capabilities of its own ground staff and equipment, just standard issue round brushes being used. The relative crudity of the application is apparent in close-up photographs. On the broader scale, the varying styles of camouflage, with some consistency within units, does indicate that the particular unit did have an input into how its camouflage schemes were modified - but in most instances that appears to have been the extent.

It should be stressed that for the most part camouflage modifications were more of 'touching up' style painting, not the full repainting of the airframe, but something that still required closed working spaces with heat control and free from dust. Front line units were issued with the smallest, mobile version of compressed air facility for painting, a small hand trolley with two cylinders as seen in the illustration of factory equipment in Chapter 1, used primarily for applying markings, such small changes not requiring extensive facilities.

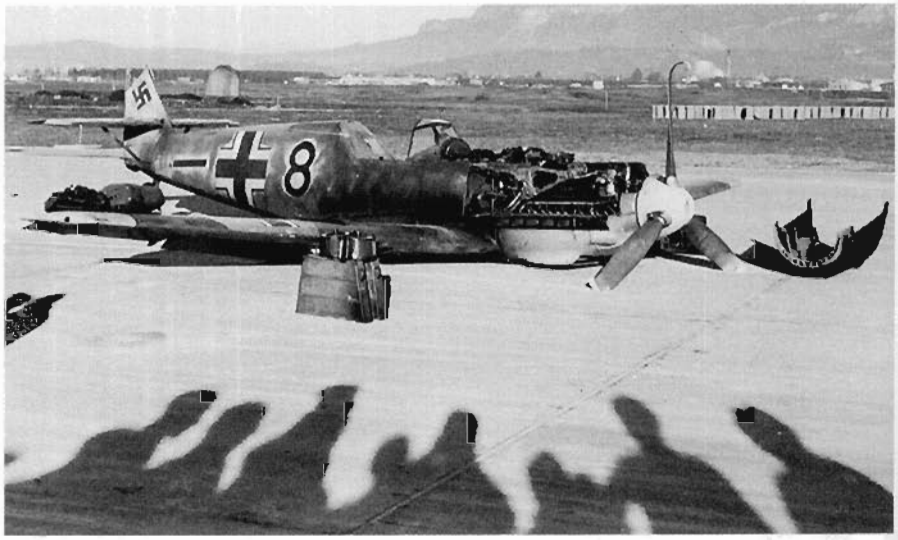
Application of almost all such modifications was usually done by spray gun, which resulted in some innovative styles, but paintbrushes were also used to apply a coarse stipple effect as noted above. The aircraft painter's kit, in addition to a range of tins and tools, included a wide selection of flat and round bristle brushes (see Chapter 2). Oft quoted references to stippling being done with sponges is unlikely as no such equipment formed part of the extensive standard kit, and close examination of aircraft of the main proponent of this form of camouflage, those of JG 2, show the distinctive effect of stippling with a brush.

That summer of 'unit' modification was to prove the only time that such a large number of aircraft had their camouflage modified by maintenance personnel. The modifications were done under great pressure and the methods ranged from fairly crude (dry brush stippling) to more sophisticated spray gun applications, and from small changes to quite extensive ones. Never again would the RLM sanction such a wide-ranging action, but never again would the Luftwaffe be so well housed at bases or so tightly grouped for one collective action, and free from attack.

While older aircraft survived with front line units those 'field-modified' schemes continued to be seen, but the rising attrition rate produced more examples of 71/02/65 factory schemes, with 02-mottling on the fuselage sides, as 1940 came to a close. Even so, many non-standard schemes were still in evidence well into 1941 until the aging Bf 109 Es were replaced.

The distinctive modifications to camouflage were particularly useful for free-range attacks by fighters and fighter-bombers which developed as the

LEFT: The highly individualistic camouflage schemes adopted by various Bf 109 Es during the air battle over Britain remained in use until aircraft were replaced. This Bf 109 E-3, the mount of Kdr. Herbert Ihlefeld, commander of I./LG 2, was based at Calais-Marc when this photograph was taken on 31 March 1941. The 71/02 type camouflage had been retained untouched on the horizontal tail plane, but the wings had been oversprayed with random patches and wedge shapes of a colour darker than the 71, possibly 70, and fuselage side surfaces had also been mottled with the same colour. The rudder was painted 04 other than for a patch of the dark colouring probably 70 on which 32 kill markings were displayed. Note the pale square of original 65-colouring surrounding the Hakenkreuz on the 70 painted fin. (F. Smith)



RIGHT: JG 77 had continued to employ very dense forms of mottling during its deployment in Norway. This photograph of 'Black 8', W.Nr. 5011 of I./JG 77 was taken after a forced landing at Stavanger-Sola on 10 May 1941. The very dark mottling, with extensive use of 71, was an advantage over the dark waters and dense pine forests of the Norwegian region, taking the general camouflage back more to its 1939 form.

Battle progressed, small groups of Bf 109s sweeping in at low level below the radar screen being made less detectable to early warning visual observation by their disruptive colouring.

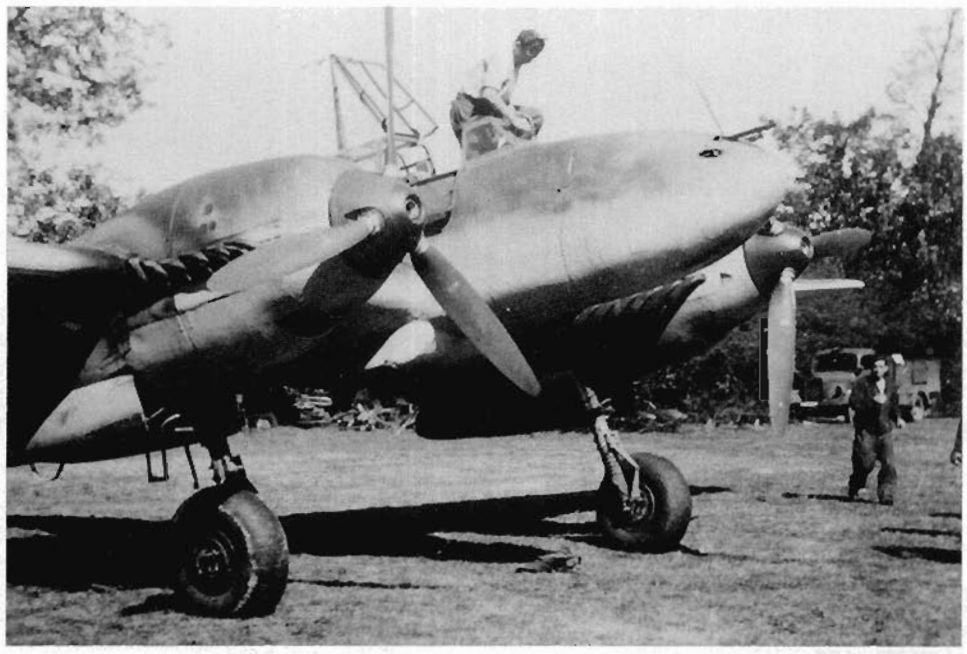
During the French campaign the Bf 109 E-1 had been considered as a possible fighter-bomber and eventually some aircraft were modified to Bf 109 E-1/B configuration. These were augmented by Bf 109s modified to E-4/B configuration and issued to 3./Erprobungsgruppe 210. In July 1940, after successful operational testing against shipping in the Channel, orders had been given that one Staffel from each Jagdgeschwader was to be equipped with the Jabo version. Whilst they achieved a relatively small degree of success, and could never hope to match the precision of the Ju 87, they filled a valuable niche. Camouflage for the fighter-bombers was whatever was prevalent amongst the rest of the particular unit at that time, no specialised camouflage being adopted for this role.

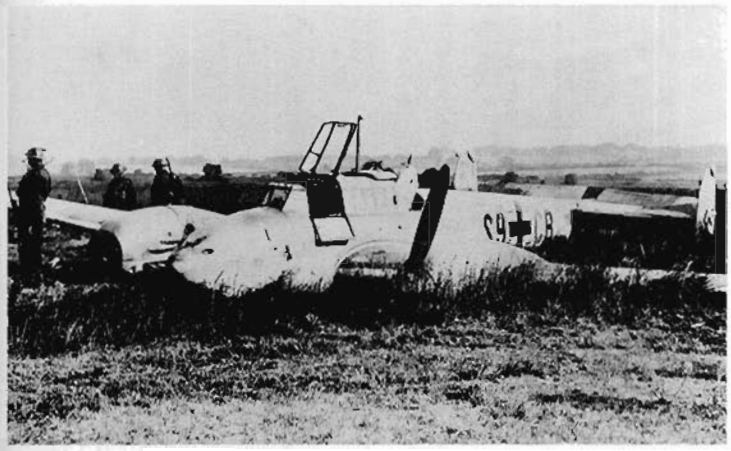
Bf 110 units found themselves with needs similar to the Bf 109s and, while the process was a little slower in the beginning, by May/June 1940 examples of the type were in 71/02/65 with 02-mottling of side surfaces. However, unlike the Bf 109s, demarcation between upper surface camouflage areas was soft-edged and on some examples, curving rather than the original straight-edged, splinter pattern. These variations all appear to have been factory originated.

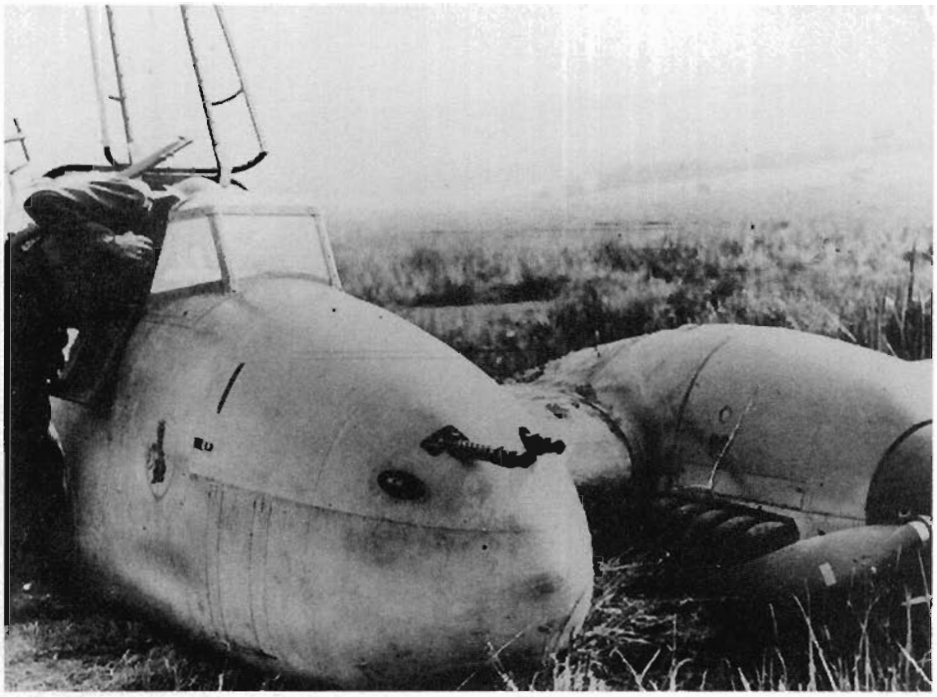
Examples of old and new schemes appeared in the same unit and there seems to have been little attempt to modify the 70/71 camouflage of older aircraft, possibly because of the extent of the painting involved and the tempo of the air fighting. However Erp.Gr. 210 appears to have 'unit-modified' some of its Bf 110s equipped with the revised camouflage, producing a paler upper surface finish. A thin coat of 02 was sprayed over the 71/02-coloured areas along the fuselage spine and on the tops of the engine nacelles. This resulted in the 71-coloured areas becoming just discernible as a slight colour shift to the 02 finish. Upper surfaces of the wings and

LEFT: Following the success of fighter-bomber tactics developed by the Bf 109 E-equipped 3./Erprobungsgruppe 210, the RLM had ordered that every Jagdgeschwader was to have a 'Jabo' Staffel. This Bf 109 E-4/B of III./JG 77 was fitted with an ETC 250 bomb rack for a 250 kg bomb and had had its wing-mounted MG FF cannon removed. Camouflage was 71/02 with mottling in 02. Note the finish of the upper surface wing camouflage along the wing leading edge. The undercarriage oleos were painted in 66, and the lacing of the canvas liner for the wheel well is just visible.

RIGHT: Erprobungsgruppe 210 was charged with developing fighter-bomber tactics. This Bf 110 D of 2. Staffel wears the revised 71/02/65 scheme with raised demarcation line that came into use during the battle over Britain in 1940. A twin ETC 500 rack to carry two 500 kg bombs had been fitted. (J.Vasco)



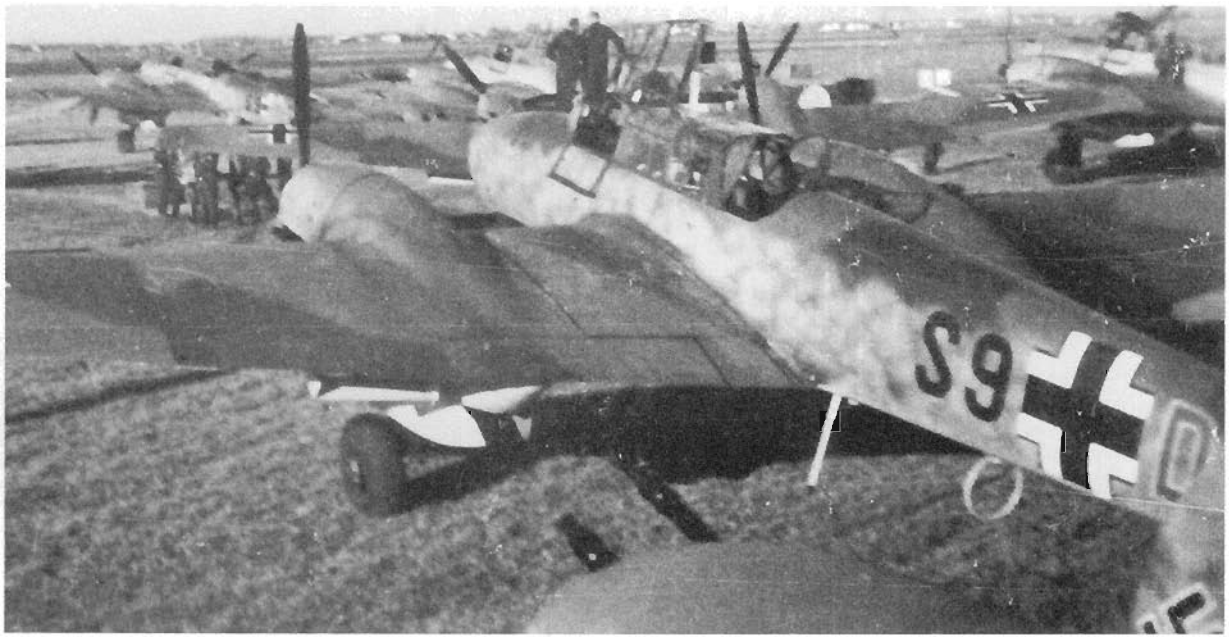




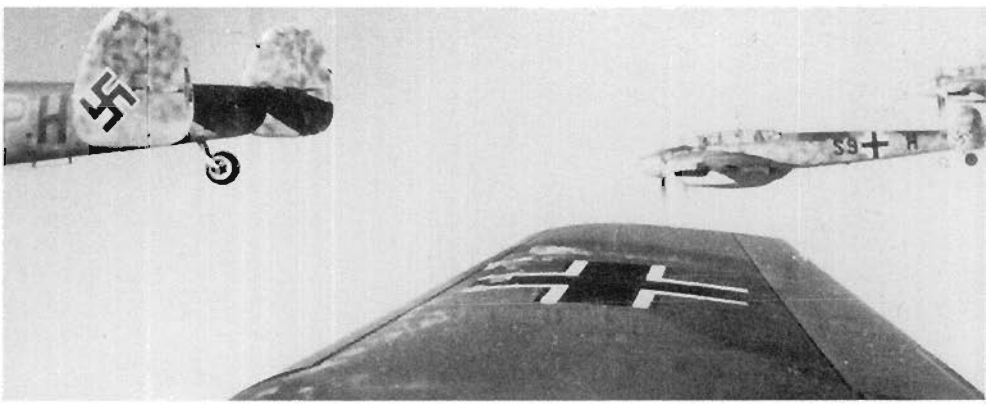
ABOVE LEFT AND ABOVE: Fighter-bombers were in the thick of the heavy fighting over Britain in July 1940 and Lt. Koch's Bf 110 D, W.Nr. 3339, S9+CB of Stab Erprobungsgruppe 210, had been shot down after the raid on Croydon on 15 August. The very pale finish had been produced by using a thin spray of 02 over the upper surface camouflage of 71/02 on the fuselage and engine cowlings; however, the wings retained their 71/02 finish without any 02 spray. The elevators were discoloured with engine exhaust stains. (P. Cornwall via J.Vasco)

LEFT: Close up, the nose section of Koch's aircraft shows how the extra spray of 02 had subdued the original two-tone camouflage. A high demarcation line between side and upper surface colouring was also being recorded on later model Bf 110s by this time. (P. Burgess via J.Vasco)

RIGHT: Compare the solid 70/71 finish on the remains of Lt. Beudel's Bf 110 C-6, S9+TH from 1./Erprobungsgruppe 210, shot down five minutes earlier than Koch's aircraft; the lighter colouring was the 02-painted internal parts. The Bf 110 Cs on strength with this fighter-bomber unit retained their original 70/71/65 scheme without modification, 71/02/65 camouflage only appearing on subsequent deliveries of Bf 110 Ds. (J.Vasco)



LEFT: Whether used as heavy fighters or fighter-bombers as seen here, Bf 110s were changing over to the same form of camouflage as used by the Bf 109 Es – 71/02 upper surface camouflage, 65-side and under surfaces with demarcation high on the fuselage. Photographed at Erprobungsgruppe 210's base at Denain during the August/September 1940 period, these 1. Staffel Bf 110 Ds had side surfaces mottled with the two upper surface colours, each extending the relevant segments of the upper surface camouflage. (J.Vasco)



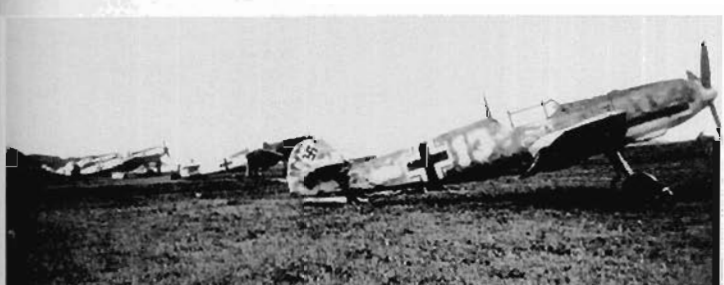
RIGHT: 1./ Erprobungsgruppe 210 Bf 110 Ds, photographed before 6 September 1940, illustrate the revised camouflage scheme. Note the intensity of the mottling in 71 and 02 on the fin and rudder of the nearest machine S9+PH. Similarly intense mottling can be seen on S9+GH. Use of almost identical style of mottling on side surfaces by Bf 110s of other units points strongly to this being part of a factory-applied scheme. The camouflage was thus following the contemporary changes to Bf 109 Es. (J.Vasco)

LEFT AND BELOW: Even as late as October 1940, some Bf 109 Es were still operating in the old full 70/71/65 scheme. This usually resulted from the need to bring reserve aircraft into action, and losses during the Battle of Britain placed heavy pressure on such resources. Fw. Boche's Bf 109 E-1, W.Nr. 3465, of 4./JG 52 had been brought down during a raid on London on 8 October, the aircraft breaking in two. Apart from the 04-coloured cowling and rudder, and white figure '2', the aircraft's dark 70/71 colouring was relieved only by the red cat emblem. The Intelligence Officer with the notebook wears his identifying 'IO' armband.

horizontal tail surfaces remained in 71/02-segmented pattern to produce a contrast with the light-coloured fuselage and engines.

An intelligence report for a Bf 110 of I./ZG 2 brought down on 3 September 1940 recorded it as having *"...dark green upper surfaces, light green fuselage sides, light blue-green lower surfaces."* This is probably a reference to a 70/71 scheme with an 02 overspray or mottling of the fuselage sides. Certainly by September Bf 110s were being produced with 71/02 upper finish with a soft mottling in 71 over the 65 of the fuselage side surfaces. The colour was washed out at the edges of the mottle, which may have prompted the description of light green. Again consistency of this latter finish on several aircraft is indicative of a factory-applied scheme.

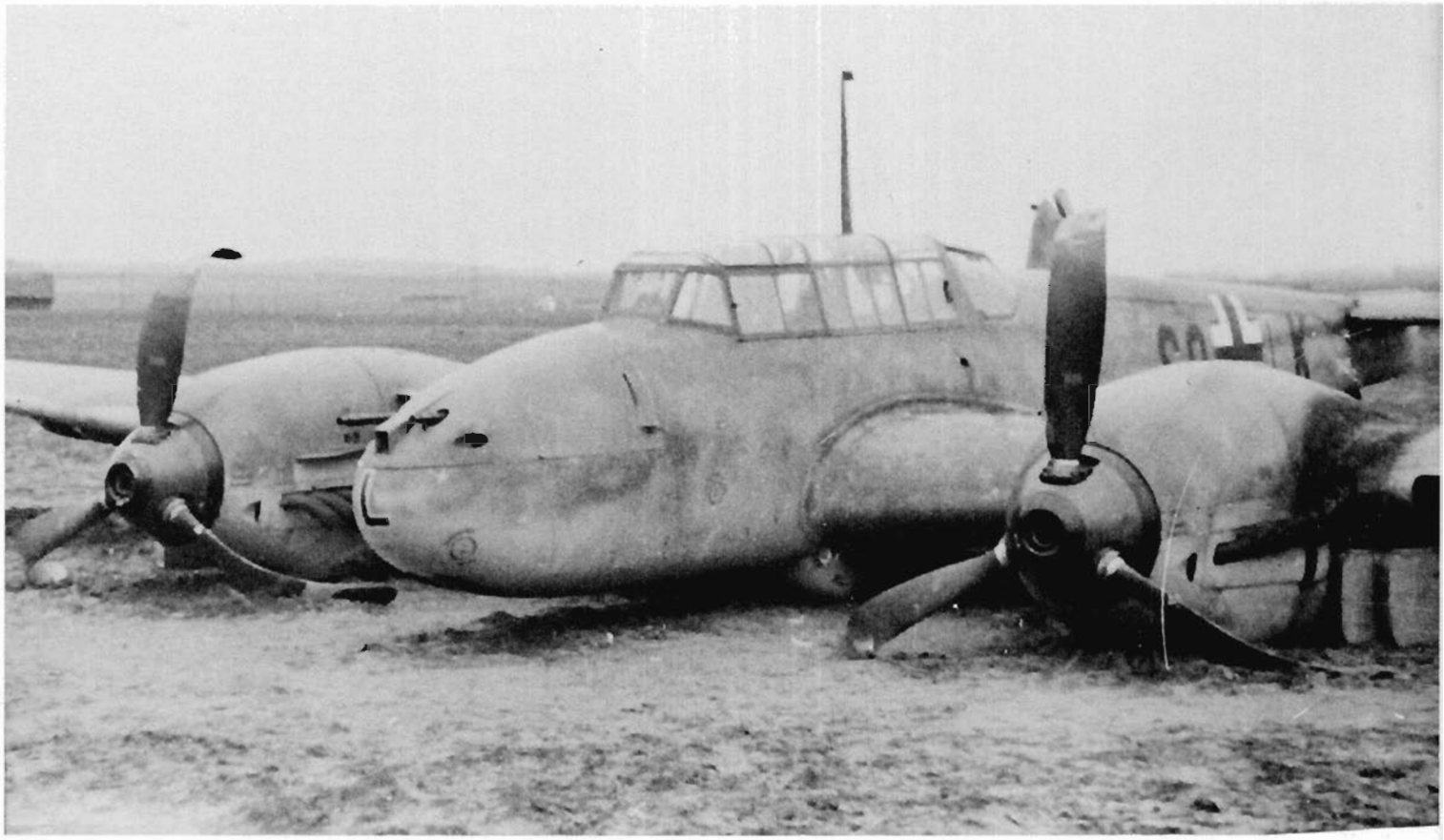
Units based in Norway as part of X Fliegerkorps under Luftflotte 5 were engaged in over-water operations for most of their operational flying time and a suitable camouflage for this very dark background was important. Initially the Bf 109 Es of JG 77, the only single-engine fighter unit based there, used the same soft mottling of side surfaces as seen on Bf 109s engaged in operations over the Channel. However, after the Stab and I. Gruppe moved south to France, late in August, to join the main battle, the paler form of mottling gradually gave way to a quite intense darker form. The 71 colouring was applied heavily to the side surfaces as an almost continuous haze of mottles, eliminating the pale-coloured finish. Later, when JG 5 moved into the Baltic region, its Bf 109 Es were given a solid application of what was either 70/71, or a true sea camouflage of 72/73, while the Bf 109 Gs with which it was eventually equipped finally adopted conventional 74/75/76 scheme. Examination of surviving fabric samples have revealed several camouflage greens below the grey final layer. [3]



ABOVE: JG 77, which had moved to Trondheim, Norway in 1940 to intercept RAF raids, adopted mottling in the two upper surface colours of 70 and 71 to reduce the stark colouring of the 65-coloured side surfaces on its Bf 109s. This photograph of 'White 13' of 4. Staffel, taken at Herdla, during the late summer, shows the denseness of mottling adopted by this Jagdstaffel. This was an older machine, as indicated by the central position of the Hakenkreuz. (Note that the two Bf 109s in the background had yet to have their camouflage modified).

I./JG 52 was transferred to the North Sea coast in Holland in the summer of 1941. An interesting colour photograph of one of its Bf 109 F-2s shows the entire upper and side surfaces of the aircraft finished in a three-colour scheme. The base coat colour was 65 (the colour is too rich for 76 and early F-1 and F-2 aircraft were delivered in 71/02/65 scheme) with wavy 'ribbons' of a green and a rich brown applied over it. These appear to have been 71 and a reddish-brown which matched well with colour RLM 26; the latter would have been available as an external finish for applying Staffel numerals, but there is no firm evidence for that, or any other source of the brown colour. The odd finish may have been the source of an intelligence summary of German fighter camouflage, compiled from RAF fighter pilot reports of encounters with Bf 109s on 31 August 1941. Among the descriptions was a reference to some enemy machines being seen wearing a *'dark brown and green'* camouflage.

The conclusion of the intense air fighting over Britain had left Bf 109 units stationed in France and Belgium. At the beginning of November 1940, JG 27 had departed, along with the Bf 110s of ZG 26, followed in December by JG 51, JG 52 and JG 53. That had left JG 2, JG 3 and JG 26, with elements of JG 52, JG 54, and the Stab of JG 1 in France. The Bf 109 F-1 model, which had begun to replace the older E-models in very small numbers from October 1940, had been delivered initially in the prevailing 71/02/65 scheme. However, substantial deliveries of the F model did not take place until early 1941. By then the new range of greys, 74, 75 and 76, had been approved for daylight fighters. The actual date of introduction of the new greys appears to be around March/April 1941, on the Bf 109 F-2 model from the Wiener Neustädter Flugzeugwerke factory.



ABOVE AND LEFT: Uffz. Artez' Bf 110 D, S9+LK, of 2./Erprobungsgruppe 210 photographed after a forced-landing on 21 March 1941, following a night bombing attack. Camouflage was still 71/02/65 with a thin spray of 02 over the camouflage of the fuselage and engines. The extended tail cone housed a dinghy. (J.Vasco)

RIGHT: In this view the darker camouflage of the wing upper surfaces can be seen, the 71/02 finish being left without an over-spray of 02. (J.Vasco)

ABOVE: Early deliveries of the improved Bf 109 F series in September 1940 carried standard 71/02 with mottling applied to the fuselage side surfaces. This aircraft had its side surfaces almost covered with a light spray of 02 taken right down to the lowest point. Based on the French coast, yellow tactical markings have been retained for engine cowling and rudder. The temporary yellow on the engine cowling tended to deteriorate more quickly than that applied to the rudder, heat from the engine no doubt hastening the process sometimes producing a deeper shade of colour.

Photographs of the pre-production Fw 190 A-0 machines tested operationally in March 1941 reinforce this assessment. While the Versuch series aircraft had worn greens or overall 02-colouring, the A-0 machines were in 74/75/76.

The Fw 190s of JG 2 and JG 26, stationed on the French coast, appear to have had their basic camouflage modified for their coastal patrol and cross-Channel operations. Early examples of the type show a camouflage that appears, tonally, more consistent with a 71/02 upper surface finish than the prevailing 74/75/76 finish. One of the few colour photographs of the period shows a heavy application of 71 up the leading edge of the fin on Kurt Ebersberger's Fw 190 A of 4./JG 26. This photograph was taken in May 1942, so use of that colour was still in place, at least on some machines, at that time.

The fact that deliveries of Bf 109 F-1s and early F-2s had used a 71/02/65 camouflage may have influenced the decision to keep the scheme, or most of it, for the coastal-based aircraft. The change in camouflage for coastal-based Fw 190 As however was probably post-production, carried out by a Luftwaffe maintenance depot. This opens speculation as to the side and lower surface colouring, which had probably been left in 76, there being no reason to use 65. While 65 had been withdrawn from use at production centres, and maintenance depots may well have held stocks for longer, it would have been superfluous to change the 76 colouring. The use of dark strokes of colour and heavy mottling mentioned later in the text, appear to have been the camouflage variations that eventually superseded the early 71/02 scheme for over-water operations.

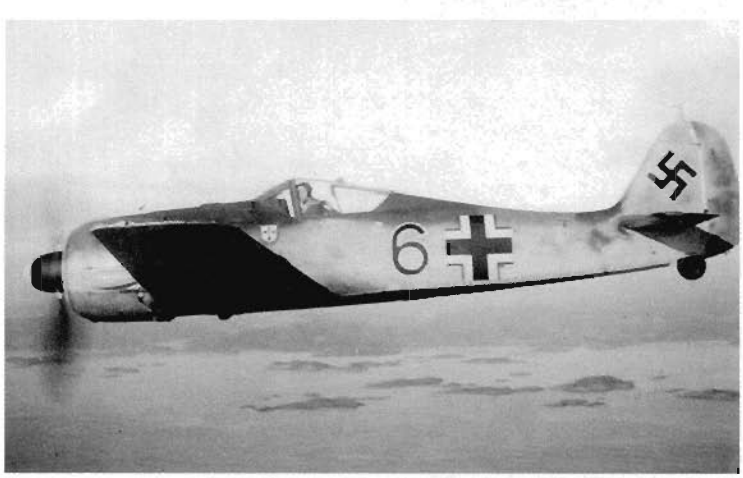
While use of this localised camouflage may seem to provide a possible answer to the enigmatic camouflage listing for fighter aircraft quoted in L.Dv.521/1 of 1941, which had specified 74/75, 76 *and* 65, the connection is purely speculative.

As noted, up to March, deliveries of factory fresh Bf 109 F-1s and F-2s had retained the 71/02 scheme, and those delivered to II./JG 54 had their camouflage scheme reworked into the same unique form developed for its Bf 109 E-4s. That was done by extending the 71 right down the sides to the bottom line of the fuselage in seams of continuous colour, the centre of the enclosed 65-colour being filled with a soft-sprayed patch of 02. That congruity of application within one Gruppe, and the number of aircraft involved, is consistent with a scheme approved by RLM GL/C-E2 VII.

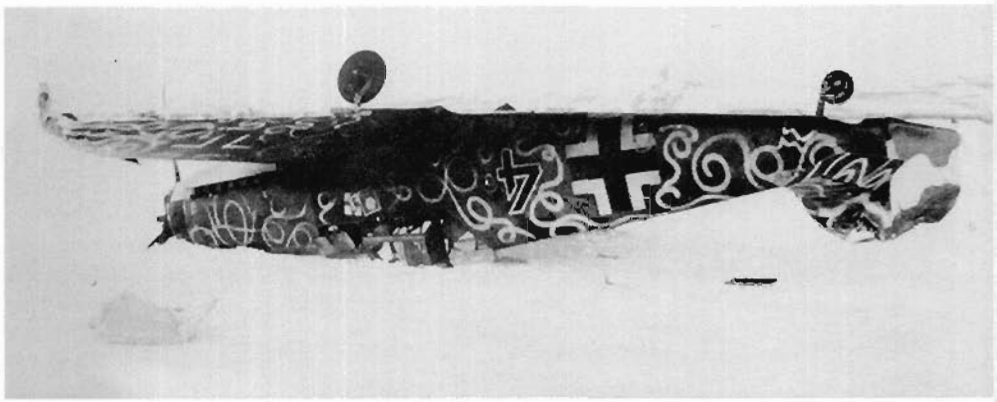
When the Fw 190 A-1 model began to enter service in the West (with the exception noted above) it did so in standard 74/75/76 camouflage. While Bf 109s displayed a range of camouflage colours and variations, front line service of the short nosed version of the Fw 190 would be marked, with few exceptions, by its consistency of a single, standard camouflage pattern throughout the war. Mirror image patterns were seen but even that variation appears to have been fairly limited.

Of the few variations recorded, one took the form of dense mottling on the fuselage sides, vertical tail surfaces, and in some instances, beneath the engine cowling to break up the strong yellow tactical marking (and on some aircraft, dark strokes were also used on the yellow of the rudder). The colour used was very dark, probably 74 as the shade matches the darkest of the upper surface colours when viewed isolated from the 76 background. The unit or units have not been positively identified, but could have been JG 1, JG 2 or JG 26. The photographs all seem to date from 1943 so the additional colouring had probably resulted from replacement of the original 71/02 scheme that had been more empathetic for over-water operations along the coast. The very pale 76-coloured side and lower surfaces would have reduced effectiveness of the camouflage against dark seawater and breaking up the pattern with dark areas countered that effect.

ABOVE: Fw. Friedrich Eberle's Fw 190 A-3, W.Nr. 518 'Yellow 1' of 10./JG 1, displayed the revised colours for European-based fighter aircraft 74/75/76. Initial production Fw 190s used very little side mottling despite the general order to use a mixture of both upper surface colours to blend the upper surface camouflage into the pale side surface areas. The rudder carried twelve kill markings. (E. Mombeek)



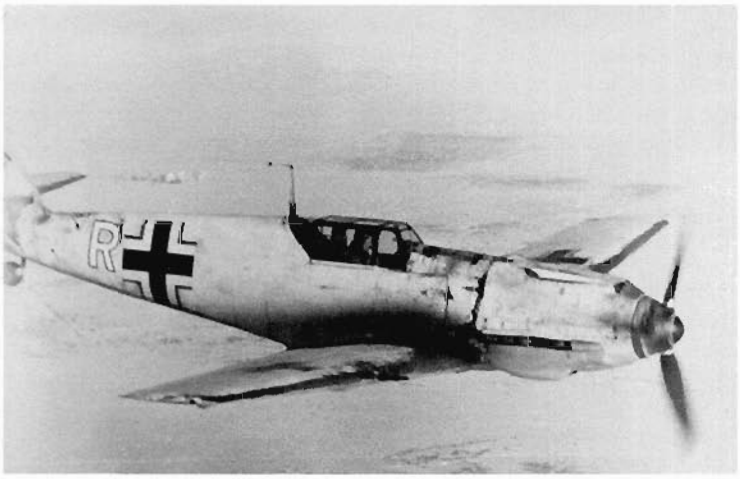
ABOVE: Uffz. Alois Job's Fw 190 A-4, 'Black 6' of 8./JG 1, illustrates the very restricted form of side surface mottling. Job shot down a Spitfire using this aircraft on 12 January 1943. (E. Mombeek)



RIGHT: A Bf 109 F-4, 'Black 4' of 8./JG 5 photographed in March 1943 when the unit was at Petsamo in Finland. The overall camouflage had been drastically changed, with a finish of 74 used as the base colouring for all upper and side surfaces. Over that, random, curling lines of 76 had been added. The rudder has what appears to be two areas of 75 added, above and below the remains of the yellow regional tactical marking, the same yellow colour being visible beneath the engine area. This sombre camouflage suited the dark backdrop of the heavily forested ground and the dark grey of the coastal waters.

Temporary white winter camouflage

The Luftwaffe had fought the first winter of the war without the use of any form of specialised winter camouflage (no doubt a result of the relatively static nature of the period, and the following winter had also passed without such specialised need as the war again bogged down to a more desultory state no major land battles being in progress. But by the following winter of 1941/9142, things had changed dramatically and the Luftwaffe was deep inside Russian territory and fighting fiercely. Temporary white camouflage then began to appear on Luftwaffe aircraft in the form of a white pigmentation added to the formulae that had been used for the extensive yellow, white and pink tactical markings introduced during the Battle of Britain. Temporary lacquer 7126, coloured with 21 white, was employed for the remainder of the war.



ABOVE: The first and second winters of the war had been fought without the benefit of winter camouflage; not a disadvantage due to the static nature of the fighting. By the winter of 1941/1942 things had changed dramatically and a temporary finish was put into widespread use. Applied at unit level, the style and extent of the finish varied widely. This Bf 109 E-4 had a solid application, but along the leading edges of wings and horizontal tail plane it had been eroded by the flying conditions.

RIGHT: This photograph of Bf 109 Fs being serviced in a permanent hangar somewhere on the Russian Front during the winter of 1941/1942, shows the variation in temporary white finish that was inevitable due to the method of application. 'Yellow 3' of 6. Staffel, in the foreground, had a thin finish that allowed the underlying darker colours to show through as a soft mottle. To the left, the wing of another shows a more pronounced form of this style of application. The 4. Staffel 'White 3' on the right had a more uniform application of temporary white, while 'Yellow 12' behind had an even more solid application, almost obscuring the yellow tactical band marking left untouched on the other machines. (H. Obert)

The 1944 edition of 'Der Flugzeug Maler' summarised its use as follows.

> *"Snow camouflage is only to be applied during the winter months with lacquer 7126.21. The lacquer is best applied with brushes. Only the upper surfaces will be camouflaged, including the fuselage sides down to the light blue paint of the under surfaces. The insignia on the upper surfaces and fuselage sides must remain visible."*

This was a change done at unit level, as the nature of temporary lacquers did not require sophisticated application techniques. As the snows began to retreat, parts of the overall temporary colour were gradually removed to expose the original camouflage, breaking up the stark shape of the aircraft against the changing landscape, the process continuing until the aircraft were again in normal camouflage.

War in the Mediterranean and North Africa

We must now return to 1941 in order to examine some significant changes to aircraft camouflage per se, and also to colours. As noted in Chapter 5, German war plans had never envisaged involvement of Luftwaffe aircraft in other than a peripheral role in the Mediterranean region, that area of operations being the domain of Germany's Italian ally. However, German forces had been drawn into the Balkans during 1940 to bolster the faltering Italian campaign in Greece, disrupting the planned German timetable. Italy's invasion of Greece had caught the German High Command by surprise; its plans were to have used the Italian held flank in Macedonia to thrust into Salonika and then on into Russia. Thus, unwittingly, the German forces were seduced into the Italian campaign.

ABOVE: A Bf 109 E-3 of III./JG 77 brought down during the Balkans campaign. Camouflage was 71/02 with fuselage side surfaces mottled with softly sprayed 71 and 02 that almost obscured the 65-colouring in many places. Note the stronger contrast between the 71 and 02 on the section of the wing outboard of the cloth draped over the Balkenkreuz marking. Tactical markings were 04 on rudder and engine cowling. The 9. Staffel badge below the cockpit had been discoloured by the engine exhaust, but the III. Gruppe marking on the cowling is clearly visible; note the latter large style. The aircraft retained the 1939-size Balkenkreuz marking and smaller code application, the numeral size being based on the proportions of the Balkenkreuz.

Elements of the Luftwaffe had been sent to the Eastern Mediterranean in 1940, the subsequent campaign against Malta, which commenced in January, and convoy protection interception duties kept them occupied operating from Italy and Sicily. By the middle of that month there were some 330 first line aircraft based in Italy and Sicil. All retained their European camouflage, including the green and grey upper and side surfaces of the fighters which, while suited for operations over water, was not satisfactory for land operations in the hot and dusty Sicilian landscape. By the time that the first quantities of new tropical colours 78, 79 and 80 were ready for issue in late April, some 200 aircraft were already in North Africa, approximately 60 per cent of the available Luftwaffe force in the Mediterranean. Among them were the first Bf 109 Es, comprising all three Staffeln of I./JG 27, which, along with the Stab and II. and III./JG 27, I.(Jagd)/LG 2 and II.(Schlacht)/LG 2 and the Stab and II. and III./JG 77, had been transferred to Romania and Bulgaria to support the coming assault on Greece and Jugoslavia which commenced on 6 April.

JG 27 is the interesting unit here as the I. Gruppe had a unique role in the introduction of tropical camouflage. The entire Jagdgeschwader had been withdrawn from France in November 1940 and sent to Detmold, in Germany, where its personnel were rested while their aircraft underwent a refit. That usually involved major overhauls of airframes as well as engine changes etc., and on 26 January 1941 they had been activated again, moving to Bukarest-Banesa (Bucharest) in Romania where they subsequently took part in 'Operation Marita'.

However, I./JG 27 was already in Sicily, having transferred to Comiso on 3 January , but staying only for seven days during which it took part in operations against Malta. It had then moved back to München-Riem staying there to refit until 4 April, before transferring approximately 300 km south-east to Graz-Thalerhof in Austria, close to the Hungarian border. On the 11th it flew south, a bare 160 km, to Agram airfield (Zagreb), but stayed just four days, long enough to carry out a few operations before again returning to München-Riem on the 14th. There the unit's aircraft had undergone yet another period of maintenance prior to moving to Ain-el Gazala.

The first conversions to standard tropical equipment (not camouflage) had been scheduled to take place at Böblingen in November 1940. Conversion of a Bf 109 E took approximately two man-hours, which involved fitting an extended air filter and its operating cable as well as adding survival equipment into the rear section of the fuselage. There is no clear indication though that the work was actually commenced at that time, though by that date aircraft were already being tropicalised for deployment to the Mediterranean area to support Italian operations from Sicily against Malta and Allied shipping. Unfortunately, existing photographic evidence is unable to support when that work to the Bf 109 Es was carried out, but photographs alone are a flawed basis for accurate dating of when and where that work was carried out.

Photographs of some I./JG 27 Bf 109 Es in North Africa do show a combination of European camouflage and tropical filter, substantiating the fact that sand filters were fitted, and the aircraft deployed for operations before tropical camouflage was added. One published source states that I./JG 27 picked up the first 40 tropicalised Bf 109 Es on 10 April, but at that time the unit was at Graz-Thalerhof. The conflicting data make it impossible to determine where and when the actual mechanical work was undertaken, but the re-camouflaging process is less controversial.

This whirlwind of transfers and brief operational sorties indicates a degree of uncertainty by the OKL as to what the role of this unit should be - possibly reflecting the sudden shift in plans that were in hand to move ground forces, with air support, into North Africa. The last period at München-Riem seems to have had little if anything to do with modification of the Bf 109 Es for tropical service. Unit personnel were obviously unaware of their destination, one oft quoted story telling how, on arrival, they were forced to buy tropical clothing from the local Arab market. I./JG 27 was tasked with providing support for the Ju 87s already in North Africa supporting the assault on Tobruk, the unexpected resistance possibly having a bearing on the rapid transfer of the Bf 109s. Camouflage remained unaltered initially and existing fighter support for the Ju 87s comprised approximately 18 Bf 110 Cs of III./ZG 26 which doubled as fighter escort and ground-attack aircraft. Like the Bf 109s of I./JG 27, they also had retained their existing camouflage of 71/02/65 with a soft overspray of 02.

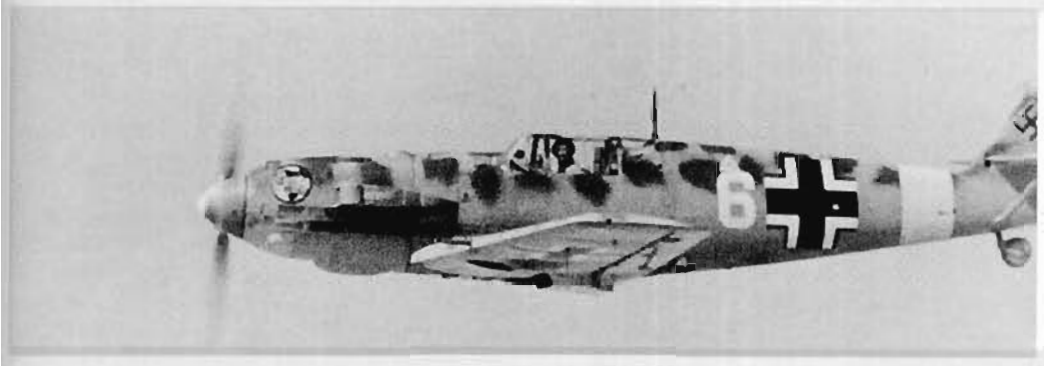
Many references to camouflage colours in North Africa have stated that the Bf 109 Es of I./JG 27, the first of which arrived on 18 April, displayed the new tropical colours that same month. That cannot have been possible, since the first supplies of 78 and 79 did not reach the Luftwaffe depot at Erding until after that date as previously noted in Chapter 5. Stocks of 80, a colour used extensively on the first Bf 109 Es, also was not included in the shipment to Erding. While Erding was subsequently responsible for carrying out re-camouflaging of aircraft en route to North Africa and Sicily, JG 27 had moved to Romania before paint stocks ever reached the Erding depot.

Given the distance and the time needed for rail and shipping transfer of paint stocks to Sicily, where the Luftwaffe had complete use of Catania and Trapani and partial use of the Comiso and Palermo facilities, it is unlikely that any paint stocks reached the facilities in Sicily until the end of April at the earliest. Rommel already begun the opening gambit of his counter-offensive in February, finally halting the British offensive and retaking lost territory. By 15 April, Tobruk was surrounded and under siege by the Afrika Korps while the skies over the desert were being intensely contested. JG 27 could muster between 30 and 40 Bf 109s, but serviceability was never 100 per cent and losses occurred from the first day of its air operations. It is unlikely then that,. on most days, more than 30 aircraft on average were available on any one day, for example on 23 April, when the largest air assault so far undertaken by the Germans was mounted against Tobruk, I./JG 27 committed almost all of its 34 serviceable Bf 109 Es for the operation; but such numbers of serviceable aircraft were the exception rather than the rule.

LEFT: In 1941, the Luftwaffe was drawn into the battle in North Africa. Initially, the Bf 109 Es of JG 27, which had begun arriving in April 1941, were forced to fight wearing their European camouflage as seen on this wrecked Bf 109 E-4, victim of the first Libyan offensive. It retained the extremely unsuitable 71/02 scheme on its upper surfaces with side surfaces sprayed with a very thin application of 02, over which an equally thin application of 71 had been applied as a vague mottle. It also retained its 04-coloured rudder from the previous theatre of operations despite the North African tactical white band marking having been added. The 'Yellow 8' marking replaced an earlier number that had been painted out.

RIGHT: A war artist sits painting one of JG 27s Bf 109 E-4 trop aircraft, 'Black 4', amidst the dust and sand. This aircraft retained its unsuitable 71/02/65, to which had been added the white tactical band marking on the fuselage. The addition of white to the rudder however was not correct for the Mediterranean Theatre of Operations and in contrast other Bf 109s, just visible in the background, each wore only the fuselage white band marking. (F. Smith)

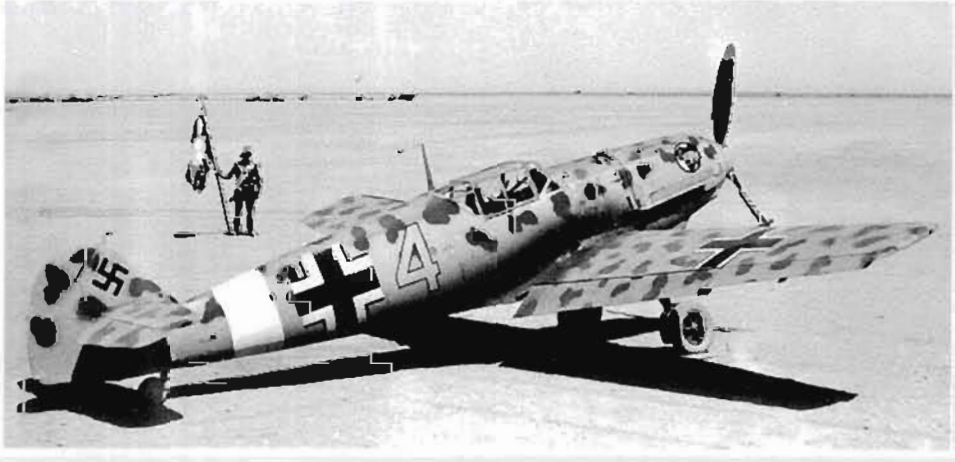
LEFT AND ABOVE: Unprepared for such a theatre of operations, initially the Luftwaffe had employed three new tropical colours – a sand yellow, which matched exactly the shade of the North African sand, a deep blue for under surfaces, with a third colour, olive green, for mottling. Eventually, the first two had been replaced with a deeper sand colour and a paler blue. These photographs of Bf 109 E-4 trop, 'White 3' of 1./JG 27, provide a unique opportunity to examine the earlier form of camouflage colours as well as the random pattern of mottles. Repainting was carried out in Sicily, with aircraft being rotated from the battlefront as conditions allowed. Careful examination of the wings show the distinct difference in application, the port one having mottles applied in a line roughly parallel to the leading edge. The starboard wing applications were more random – the result of the usual practice of having two painters working at the same time, one each side of the aircraft. The horizontal tail plane surfaces also have different styles of mottle. (F. Smith)



ABOVE AND RIGHT: In these two views, one of 'White 6', the other of 'Black 8' of 2./JG 27, the differences are again apparent. On the latter aircraft, the upper surface mottle had been carried down to the mid-line of the fuselage. The style of mottling on each aircraft was different.

ABOVE: This view of 'White 3' and 'White 8' of 1./JG 27 illustrates the process of repainting on rotation. The nearer one is in full tropical camouflage while the other still retains its European scheme.

RIGHT: This photograph of a Bf 109 E-3, 'Yellow 4' is one of the relatively very few to show the first style of application of tropical colours to the machines of JG 27. The distinctive shape of the patches of the 80-colouring and the high demarcation line of the 78/79 division are clearly illustrated. Note the mint condition of the camouflage but worn propeller paintwork, the latter not having been repainted.



ABOVE: The practice of changing major components to keep aircraft serviceable without having to send them back to a repair facility was essential for JG 27 during its early period of deployment to North Africa. This Bf 109 E, 'White 7', had its entire empennage replaced with one taken from an aircraft that had already been repainted in the tropical colours of 79/80. The style of large patches of 80 was limited to the first Bf 109 Es sent for repainting in Sicily. This process of exchanging parts often produced hybrid colour schemes. (K. Smith via D. Vincent)

Aircraft due to be re-camouflaged had to be ferried back to Sicily for the task and it would have been foolhardy to send them off singly for such an extensive sea crossing, especially as Allied fighters were out on shipping attacks of their own. At least a Rotte of two aircraft would have been used, and sparing two aircraft at a time, for a period of at least several days, was asking much with the then current intensity of air operations. All of this points to the repainting being accomplished over several weeks rather than a few days. May, which was a much quieter month as the British withdrew two of their fighter squadrons and paused to regroup their forces for a new offensive, appears to have been the most likely time for the majority of the Bf 109s to be sent to Sicily for repainting.

The first examples of desert camouflaged Bf 109s are unlikely then to have been seen before early May. The well known photographs of 'Yellow 4', photographed in colour with the service standard and often used in conjunction with the comment that it was taken in April, shows an aircraft in mint condition but with propeller blades that have heavy wear on them. Just when this photograph was taken is not known for certain, but given the state of operational flying in April it is most likely that this was taken in May during the relative lull in fighting.

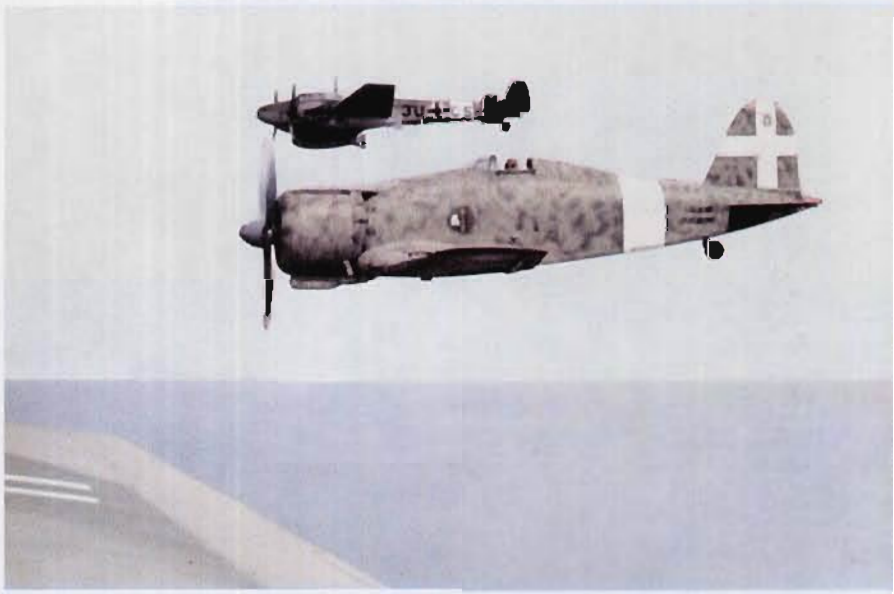
On 3 April, the Iraqi politician Rashid Ali Gailani had seized power in Baghdad, declaring his sympathy for the Axis powers, and by the end of the month the state of unrest had worsened, Iraqi troops having surrounded the British base at Habbaniyah. No. 4 Flying Training School was in occupation of the base and fired on their besiegers at first light on 2 April. Meanwhile British troops at Basrah moved to relieve the base and suppress the rising.

Sonderkommando Junck was formed to act as an air support unit for the Iraqi forces. Initially it comprised 14 Bf 110 Cs from ZG 26, (12 of them seconded from 4. Staffel), and seven He 111 H-6s from 4./KG 4. Later five He 111s and 20 Ju 52s were added and at least one Ju 90 provided additional logistical support. All were to operate bearing Iraqi national markings.

In Athens, the German marking and unit codes on the Bf 110s were painted out using 65, and in most instances replaced with Iraqi national markings, at least on the wings, along with fin and rudder striping in the national colours of black, red, white and green, the latter foremost. The existing European camouflage of 71/02 was retained, in some instances oversprayed with a thin application of 02. The unit's well known 'shark's mouth' marking was retained in most instances, though at least one aircraft had it roughly painted over. Oddly, while the yellow markings employed for the invasion of the Balkans were overpainted, the white tactical marking employed earlier in the war and confined to the upper section of the fuselage, was retained. The effect, on some aircraft at least, was to produce a daubed, streaked finish where the new coat of paint still stood out from the more weathered background finish. In addition, 900 ltr wing tanks were fitted to each aircraft. On 11 May they left Athens for Mosul and Kirkurk in Iraq from where they operated briefly in support of the uprising. On 12 May, an He 111 delivered a German officer to help co-ordinate the air support.

These events coincided with British reversals under Rommel's onslaught, and the siege of Tobruk, which had commenced on 10 April. On 28 May, a squadron of Italian CR 42 fighters had arrived to help, but British troops reached the outskirts of Baghdad the next day and an armistice was signed on the 31st. All but one of the Bf 110s were damaged and abandoned, or destroyed. One, W.Nr. 4035, ended up in British hands, having made a belly landing near Mosul early in the ill-fated campaign. It was repaired, marked with British insignia and adorned with the name 'Belle of Berlin', and continued flying until late in 1942 before being written off after suffering undercarriage failure during its transfer flight to South Africa. In its original finish, the shape of the 'shark's mouth' marking could still be discerned where it had been overpainted, some of the red edging having escaped the rather hasty and randomly applied application. This aircraft also lacked any nationality markings other than fin and rudder striping in Iraqi national colours.

Meanwhile the Bf 110s of III./ZG 26 operating in North Africa had been repainted in solid 79 colouring on upper and side surfaces, with 78 replacing the 65-coloured lower surfaces. It is not clear when this was done, but judging by the Iraqi operational dates and details, it would not have been before May or early June. As far as can be determined, use of green mottling was not adopted for this aircraft type other than for some reconnaissance Bf 110s of 2./Aufkl.Gr.(H)/14 which integrated that colour in a fairly dense mottle over all upper and side surfaces.



ABOVE: Bf 110s also arrived in North Africa in full European camouflage, and underwent a similar process of repainting as time and battle conditions allowed. This Bf 110 D, 3U+CS of 8./ZG 26, being escorted by a Fiat G.50, wore 71/02/65, and as with the Bf 109 Es in the previous photographs, both types carried only the fuselage tactical marking of a white band. A more extensive set of tactical markings, specifically for the North African theatre of operations, would eventually be introduced.

RIGHT: European colours persisted for the most part for Luftwaffe aircraft based in Italy or Sicily during this period. This Bf 110 D from the Stab of an unidentified unit (but possibly ZG 2), was photographed in Sicily. The camouflage was the old 71/02 finish. (P.Hilt)

LEFT: This in-flight photograph of Bf 110, 3U+HR of 7./ZG 26 demonstrates the European camouflage of 71/02/65, with heavy mottling in both colours on the fin and rudder. Elements of this unit also saw service in North Africa where its camouflage was eventually replaced with a 78/79 finish. The white tactical band markings had been extended to accommodate half of the code, no doubt to make air-to-air recognition easier within the unit. (P. Hilt)

LEFT: The total unsuitability of European camouflage seen against the stark background of the desert is well illustrated in this photograph. While detail remained poor at such distances, the visual difference of the 70/71/65 finish of the Ju 52s and the distinct blue-greys of the Bf 110s of ZG 26 (one of the later arrivals in the new fighter colours of 74/75/76) is immediately apparent, just as it would appear to an Allied aircraft approaching the area.

BELOW: Bf 110 C, 3U+ZT, of 9. Staffel, III./ZG 26, was captured near Derna. An eyewitness account of this aircraft described it as having two-tone brown upper surfaces. The camouflage is rather dark and may have been in 79 and 80; the latter, when sprayed in thinned down form to produce the heavy side mottling, produced a brownish colour effect. (R. Franklin)

First official mention of RLM paints for tropical use occurred in the November 1941 issue of L.Dv.521/1, which stipulated colours 78, 79, 80 for *tropical aircraft* (an all encompassing term used in the same list that specifically defined both fighter and heavy fighter camouflage colours as 74, 75 and 76). Clearly the colours were intended for all classes of aircraft in tropical areas. No written colour descriptions were included in the text nor did the accompanying revised colour card include colour samples for these three new colours, which were named in the 1944 edition of 'Der Flugzeug Maler' as 78 hellblau (light blue), 79 sandgelb (sand yellow) and 80 olivgrün (olive green), but as mentioned earlier, no colour atlas was ever issued which incorporated colour chips of these lacquers.

No photographic evidence of colours 78 and 79 being applied to Bf 109 Es at *production* centres has been found so far. Photographic records of operational use of that type strongly support the contention that those seen wearing tropical camouflage were the result of repainting at Luftwaffe depots. Production of the E-series was slowly being phased out, though the series would continue in small numbers until early 1942. The F series were coming off the assembly lines in quantity by early 1941, and the first examples to be recorded wearing a 78/79-colour scheme occurred with the tropicalised version of the Bf 109 F-4 series.

The factory standard tropical scheme of solid 79 for upper and side surfaces with 78 for the lower surfaces seems then to have commenced with the Bf 109 Fs, a scheme also adopted for the Bf 110 Gs sent to that battle front. The 78 and 79 were applied in two distinct styles; on both types the upper surface 79-colouring was either taken right down to the lowest point on the fuselage, or to a demarcation line at the mid-point on the fuselage side surfaces consistent with the current European camouflage demarcation line. This variation appears to be dependent upon the source of manufacture of these pre-painted aircraft supplied from Germany, though both styles on the Bf 109 F-4 from the Erla plant have been noted.

Why the green component of the camouflage approved for tropical aircraft should have been excluded from use, both on fighters and bombers pre-painted at point of manufacture (He 111s, Ju 88s, and some Ju 87s also used the 78/79 scheme), is not clear. Terrain common to most operations along the North African coast included the sparse desert foliage that had instigated inclusion of a green in the original schemes. The same requirement applied to Sicily from where the Luftwaffe operated a range of types. Stocks of 80-coloured lacquer were available for addition to the basic scheme, as subsequent modified schemes show. It is probable that colour 80 was only ever intended for post-production application, but no RLM documentation has been found to confirm this contention. The only supporting evidence is the large photographic record, across several types, which consistently shows 80 in use only on 'field modified' schemes such as were carried out at rear echelon Luftwaffe repair depots and maintenance units, with the usual small allocation of the lacquer to front line units for touch up work.

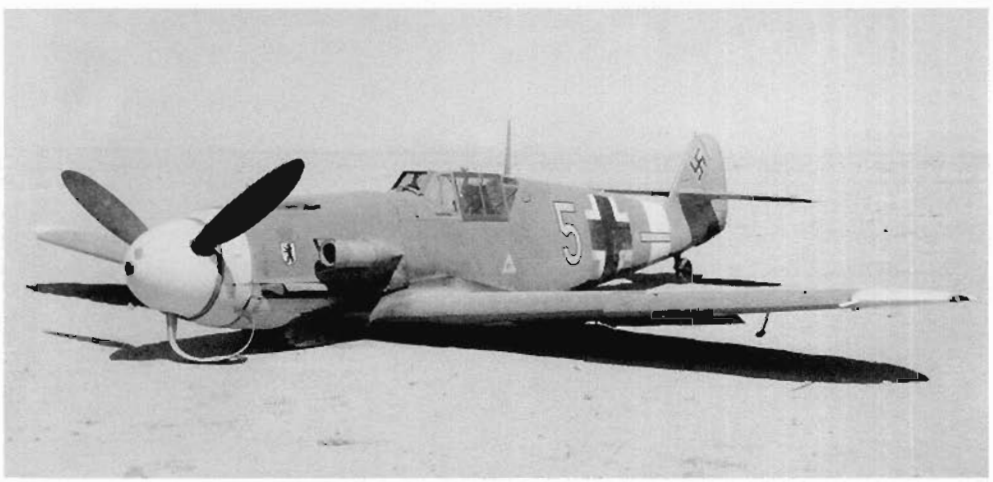
Tropical colours were also manufactured under licence in Italy. After the first stocks had been shipped to Italy in April 1941 a specialist named Baltaro, from the Fiat company, examined the paints and this eventually lead to manufacture being undertaken by the firm of Inves at Quattordio (Alessandria). These were manufactured to the RLM standard specification and were still being produced until at least 25 July 1943.[4]

In Sicily, where dust added its own colouring, II./JG 53 (which had moved to Comiso in early 1942), adopted a modified scheme of large sharp-edged segments of dark green for its recently received Bf 109 F-4 trop aircraft. The demarcation line on these aircraft was at the mid-point on the fuselage side surfaces, pointing to production aircraft painted in standard 78 and 79 to which large 80-coloured segments were added. This additional painting may have been carried out Comiso airfield but, if not, facilities were also available to the Luftwaffe at Catania, Palermo or Trapani.

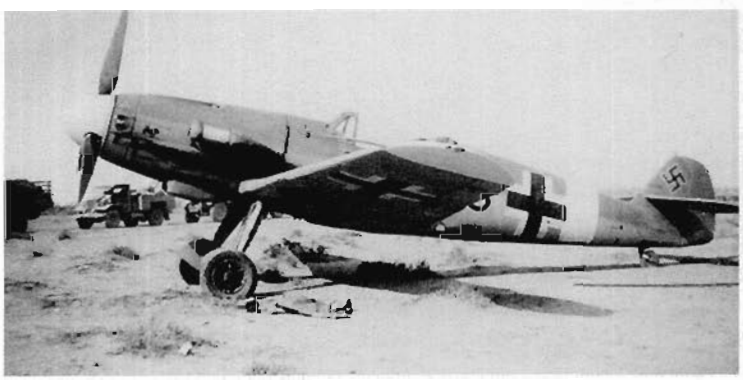
New Bf 109 F-4 trop aircraft, supplied to II./JG 3 at San Pietro in Sicily in April 1942, also arrived finished in a factory finish 78/79 tropical scheme, some receiving extra camouflage of 80 applied in 'ribbons. But as in North Africa, not all new Bf 109 Fs received additional 80-colouring.

In Italy, in addition to a number of permanent airfields with major facilities stretching from Sicily and along the mainland, the workshops of the SIAI factory at Vergiate, Augusta at Cascina Costa, and Caproni at Vizzola Ticino were also used by the Luftwaffe as repair shops and painting could be carried out at any of them. To the east, the same sort of facilities had also been made available by the Rumanian and Hungarian allies, these being in addition to facilities that had been taken over in Poland, Czechoslovakia, France, Belgium and Holland.

In the closing stages of the war in North Africa, the German retreat in Tunisia yielded a last haul of prizes for Allied air personnel. While the RAF made modest changes to their new charges, the American forces exhibited a decidedly more flamboyant approach, based in part on the sensible idea that such garish schemes acted as a good precaution from attacks by Allied fighters.



ABOVE: Once the RLM had standardised its tropical colours, two forms of factory standard application followed. One was a solid application of 79 on all upper and side surfaces with 78 lower surfaces as seen here on Lt. Mix's Bf 109 F-4 trop of 6. Staffel, II./JG 27, shot down near El Alamein on 14 August 1942. Note the increased size of the Balkenkreuz, a locally applied variation common to Bf 109s and Bf 110s in the final stages of the North African campaign. A full complement of white tactical markings was by then in use. (D. Vincent)



RIGHT: The second form saw the demarcation line raised to a line passing through the top arm of the Balkenkreuz marking, as seen here on this Bf 109 G-2 trop, 'Black 6', at Gambut. This form of application was also seen on some Bf 109 F-4 trop aircraft. (F. Smith)

RIGHT: A Prix de Guerre of the US Air Force in Tunisia. The airframe had been repainted in red by the Americans, with yellow leading edge to the horizontal tail plane and wings, but taken right through to the line of the main spar on the latter (in the same style as would be seen on Luftwaffe Fw 190s, with bare metal wing surfaces, in 1944/1945). A broad yellow band was also used to delete each Balkenkreuz marking on the fuselage. (J. Crow)

BELOW: Yet another variation on a very colourful theme of captured Luftwaffe fighters, in this instance a Bf 109 G-2 that had been treated to an overall finish of yellow with just the standard US Air Force markings added. (J. Crow)

RIGHT: Slightly less garish in colouring, this all white Fw 190 still showed the flair given to the repainting of aircraft captured by the US Air Force in Tunisia. In this instance, red white and blue was used in full patriotic fervour. The spinner is red, and red had also been used as a narrow stripe across the wing, just inboard of the tip area, as well as around the rear section of the fuselage. The fin and rudder had been treated to something approximating the American pre-war style of marking in red, white and blue. Just visible below the fuselage can be seen an RAF Spitfire in desert camouflage, with an RAF Beaufighter in European camouflage on the extreme left. (J. Crow)

RIGHT: German aircraft captured by the RAF were less flamboyantly treated. This Bf 109 F-4 Z Trop, 'Yellow 2' of an unidentified III. Gruppe, retained its 78/79 finish with just its national markings painted out and replaced by RAF roundels and fin flash.

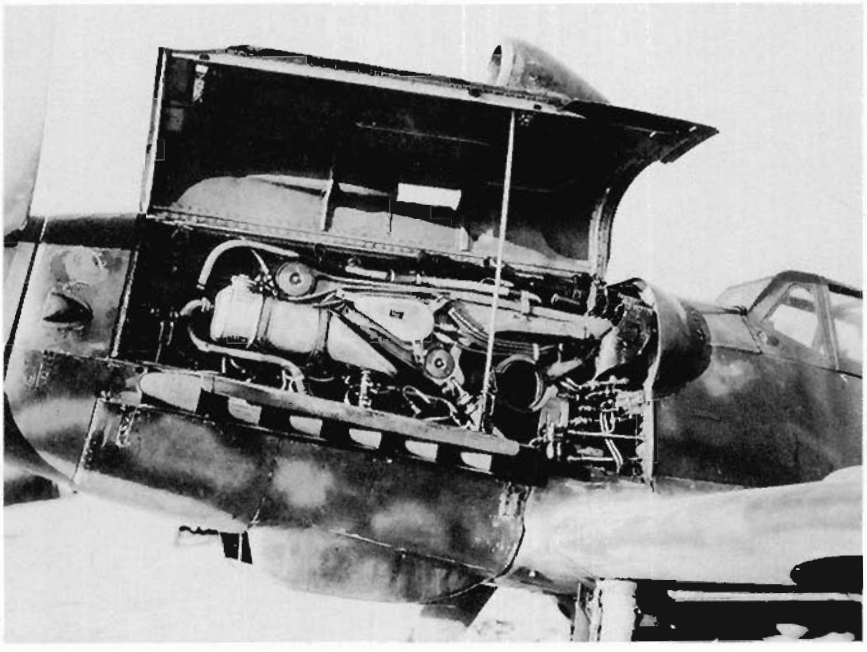
Use of Italian paint stocks

As previously mentioned, much speculation has attended the possibility of Italian paint stocks having been used for Bf 109 Es in North Africa in 1941. Italian paints eventually were used, but mostly as an addition to the existing Luftwaffe camouflage. German units based in northern Italy were under considerable pressure by mid-1944, and on 4 July the OKL had reached a decision to withdraw one fighter Gruppe, identifying I./JG 4 for transfer to Germany to re-equip. That order was subsequently revoked, then reinstated on 23 July, and extended to include I./JG 77. The aircraft of each Gruppe were to be handed over to II./JG 77 and II° Gruppo Caccia of the Aeronautica Nazionale Repubblicana (ANR) in a reshuffle of forces.

I./JG 4 had been stationed at Maniago, providing training for newly arrived pilots, sharing the base with III./JG 53 until that unit had left in early July. Photographic evidence shows both units had adopted Italian camouflage colours, mostly as an addition to parts of their existing Luftwaffe camouflage. The process appears to have started around May 1944, and included painting out the upper section on the white tactical marking band around the rear of the fuselage, or completely covering it in some instances, to make aircraft less visible at dispersal.

On 25 July, during a transfer flight to JG 77's base at Ghedi, Bf 109 G-6, W.Nr. 160756, of I./JG 4 landed at Santa Maria Capua Vetere, its pilot, Uffz. Dubois defecting to the Allies. The camouflage was subsequently reported to be [5] *"...top surfaces of fuselage mottled brown and green; underside duck egg blue..."* Close examination of the original photographs, and use of a neutral screen to check against a very good example of 02 inside the open engine cowling, shows the colours to be too light to be 79 and 80. The only practical alternative (given the location) was a combination of Italian colours then in use – Nocciola Chiaro 4 and Verde Oliva Scuro 2 – a mid-brown a little deeper in colour than 79, and a dark green. Because Italian paint colours could and did at times vary between manufacturers, unlike their German counterparts, it is not possible to give a precise reference for the paints actually found on this aircraft – the nearest would be FS 30219 and FS 34102. The precise dating negates any suggestions that the brown and green

LEFT: Uffz. Dubois' Bf 109 G-6/R3, W.Nr. 160756, 'Yellow 4' of 3./JG 4, at Santa Maria landing ground in Italy in late July 1944. Note the Italian style of camouflage, with the fuselage Balkenkreuz and the Hakenkreuz markings partly painted out and the wing upper surface marking almost undetectable. The circle of fresh 02 around the removable panel at the rear of the fuselage provides a good colour indicator. The small black numbers were marked on the original negative by the intelligence assessment team. (NASM via Dr. J. H. Kitchens & J. R. Beaman)



LEFT: A close-up of the nose section shows the lower extent of the Italian camouflage, which followed the Italian style of application of the period. The open engine cowling, with its sunlit area of 02 on the inside face, provides a colour comparison with the paler Italian colouring. The oil filler access panel, just behind the spinner, had a large patch of damaged paint revealing the 02-primer. Close examination of the original photograph also reveals that the Werknummer plate, just below the ammunition feed bulge, had been completely painted over, something not normally permitted on Luftwaffe maintained aircraft. (NASM via Dr. J. H. Kitchens & J. R. Beaman)

ABOVE: Taken moments after its pilot surrendered it on 25 July 1944, the style and positioning of the 'Yellow 4' marking can be seen. The relative brightness of that marking was in sharp contrast with the dark camouflage colouring. (NASM via Dr. J. H. Kitchens & J. R. Beaman)

ABOVE: The positioning of the underwing Balkenkreuz was slightly further outboard as noted, but the undisturbed background paint, indicates that the original 76-colouring had been retained. (NASM via Dr. J. H. Kitchens & J. R. Beaman)

LEFT: On the Italian front, fighters either wore desert colours or, more usually, retained standard 74/75/76 finish. This Erla-built Bf 109 G-2/R6 trop, W.Nr. 10639, 'Yellow 14' of III./JG 53, was captured in Sicily in late 1943. It wore an almost textbook finish of the latter colours, with alternate mottles of 74 and 75 on its side surfaces. Only behind the aircraft number had the colouring been intensified to present a darker background.

ABOVE LEFT AND RIGHT: Two further examples of Bf 109 G-6 aircraft wearing Italian-style camouflage colours of green and sand yellow. These two, 'White 7' and 'Yellow 8', were both serving with I./JG 4 at Cascina Vaga at the time they were photographed. Both were eventually handed over to the Italian ANR's II ° Gruppo Caccia in June 1944. Note the painting out of the Hakenkreuz marking on both machines, a practice seen on other Luftwaffe aircraft of this period in that theatre of operations; also the elimination of the top portion of the fuselage tactical white band marking. This improved the camouflage effect when on the ground – during what was a critical time for Axis aircraft at that period of the war. (F. D'Amico & G. Valentini)

colours were RLM colours 81 and 82, neither of which had been issued for use at that time other than for field tests with specific units.

Style of application of the colours also was distinctively Italian, with upper surface colouring taken right down the fuselage and over the radiator. The national markings under the wings appear to have been re-marked slightly further outboard, in the position normally occupied by the Fasci on Regia Aeronautica aircraft, but that is difficult to verify. The description of 'duck-egg blue' for the lower surfaces is intriguing as the prevailing Italian colour was a grey, which would seem to indicate that the lower surfaces had retained their original Luftwaffe 76-colouring. As the reason for modification of the upper and side surfaces had been for improved ground protection camouflage, leaving the lower surfaces in their original colouring would have been both acceptable as well as saving time and materials.

Fuselage and wing upper surface markings (especially the latter) had also been overpainted with camouflage in the style then current on some Italian fighter aircraft. No white tactical markings had been applied to the airframe (in June Bf 109s of JG 53 at Maniago had had the marking painted out). The repainting of this aircraft was extensive enough to have required the resources of a workshop or repair facility. Probably it, and others from the same unit, had been worked on at an Italian depot as indicated by the style of application.

War on the Russian Front

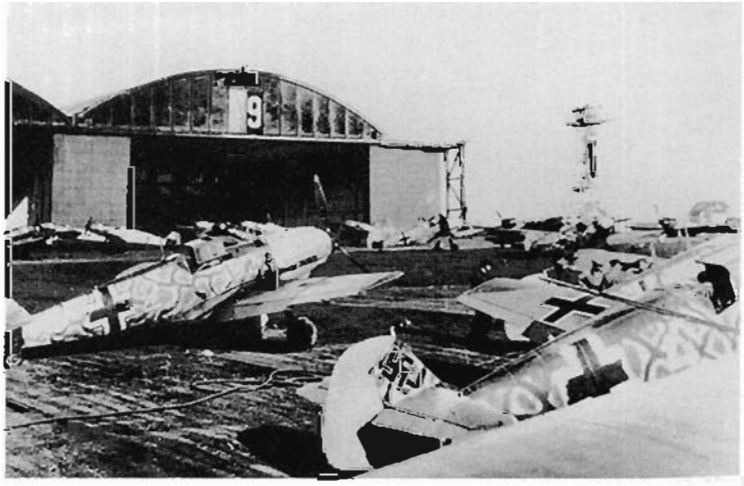
Moving back in time once more, to March 1941, orders had been given for rapid transfer of flying units from France and Germany to western Romania, and from Sicily and North Africa to Bulgaria in preparation for the invasion of Russia in June. The air war along the Eastern Front had also produced 'field' variations to factory standard camouflage schemes – some unit-generated, others possibly part of ongoing field-testing at RLM direction.

Aircraft transferred to the new campaign areas had retained their existing camouflage schemes, many of them still with modified schemes amongst the older aircraft. This suited the areas in which the fighting initially took place in 1941, but as German forces began to sweep through the opposition a situation developed, similar to that which had occurred over Poland. Initially air-to-air recognition became more important than ground or air concealment, but as the fighting slowed concealment in both environments once more took precedence.

JG 54 continued to feature camouflage experiments with its Bf 109 Fs, using a random style of application as well as colours. Each Gruppe however adapted its own distinctive camouflage pattern and colouring which seems to indicate some form of orchestrated broad scale field test – otherwise one might have expected more conformity between the Gruppen of a single Jagdgeschwader.

II./JG 54 retained its well established 'stone wall' design in 71/02/65 for its Bf 109 F-2s. This novel form of camouflage, which appears to have been a development from the distinctive cross hatching strokes of 71 used during the Battle of Britain on its Bf 109 Es, gradually disappeared as the Bf 109 F-4 began to replace the F-2, and was used only by II. Gruppe.

A brief section of colour movie footage of Bf 109 Fs of the Geschwader Stab of JG 54, photographed at Trakkahen on the Eastern Front, in June 1941, shows a camouflage of a brown and a medium dark green.[6] Choice of the colour range may have been influenced by Italian colours developed for use in country not dissimilar to that being



ABOVE: Units transferring to the Eastern Front in 1941 had retained their existing camouflage, though some had soon introduced their own modifications. These Bf 109 E-3s and -4s of II./JG 54 retained the unit's distinctive 'garden wall' side surface pattern. Upper surfaces were in 71/02 and those two colours had been used to produce the unique pattern. 71-colouring was used for the 'seams' with the central area of 65 broken by a patch of 02. Note the fuselage Balkenkreuz marking on the nearest aircraft that was in the process of being remarked. Rudder and cowling tactical colouring was 04.

encountered by the Luftwaffe. However, by that time stocks of tropical colours were in use. Still photographs taken from the colour footage are flawed by the usual colour changes inherent in any colour process, especially one of that vintage; a colour shift is discernable to skin tones of the people in the photographs, as well as the sky colouring.

Another influencing factor is the highly reflective surfaces produced by polishing of the entire airframe to gain performance. Beeswax was the usual approved polishing agent, normally confined to use on training gliders of the period; however, the similar product produced by DKH pre-war, weather protection surface polish Nr 5005, may have been employed. Like beeswax, it solidified and required heating (or dilution with a dedicated thinning agent) to return it to a liquid state for application. The original instruction was to ensure that not too much was applied or polished too heavily with a damp cloth since that produced a shine.

The reflective qualities, whatever their source of origin, mirrored the surrounding colours of sky and earth; all of which influenced the final colour perception. Allowing for the other factors mentioned, as well as checking the standard 02-colouring on internal sections in the engine bay area, it is possible that the colours 79 and 80 were used. The dark green 80-colouring certainly falls very closely within the ambit of green shown in the footage. The square background area of the Hakenkreuz shows also the original colouring (76) of the fin where the emblem had been masked out for repainting, providing another small assessment of the colour shift.

BELOW: This Bf 109 G-2, 'White 2' of 5./JG 54, shows the tone of the darker colour more clearly. The 02-painted area on the cowling had been roughly done, the spray marks clearly showing the underlying original dark colouring in places. The very dark colour may have been 80 as this was available to maintenance units in the front line areas. The wing upper surface indicates that the original camouflage pattern had been retained in this instance though the colours had been altered. The broad yellow tactical band marking was placed under the Balkenkreuz, possibly to make the latter more easily seen during air combat.

Given JG 54's association with RLM field tests in the past, choice of testing the then recently released tropical colours in the Russian landscape, rather than confining them to desert areas, may have been dictated by E-Stelle, Travemünde as a process of evaluation. The same colours had been introduced into North Africa only some weeks before. Italian experience, with a very sophisticated range of camouflage colouring based on the long occupation of Cyrenaica, must have been considered by the RLM, there being little value in ignoring such successful field developments of an ally.

ABOVE: JG 54 was renowned for displaying individual camouflage schemes. Here Major Hannes Trautloft stands in front of his Bf 109 G-2 at Siwerskaja; it wore what appears to be an extremely dark overall finish (possibly 80) segmented with a lighter colour that tonally appears to be 02. Examination of the photograph shows that the lighter segments had been sprayed over the underlying dark colour. The camouflage pattern was composed of much larger segments than normal, with sharp delineation between them.

The time period is also significant, for this was the opening phase of war on the Eastern Front when German forces swept through the Russian defences amidst the heat and dust of the Russian summer, marked by dry powdery earth with strong elements of browns and greens – similar geographical colouring to North Africa and Southern Italy and Sicily. Such complete repainting of the airframe would also have had to be done at a Luftwaffe maintenance or repair depot as the main aircraft manufacturing plants were not used for such 'one-off' schemes.

Other aircraft of the unit wore a continuous soft-sprayed application of green along the entire spine of the fuselage and over the rudder. This extended down the fuselage sides to about the mid-line position and faded out to a soft edge, fringed with a few mottled patches, to blend into the 76-colouring. The green used was a light, relatively pale tone that does not match any existing RLM colour of that period, but is similar to the pre-war 62-colouring. As with the application of some of the earlier colour schemes, side surface colours were taken right down to the bottom edge of the fuselage.

Another colour photograph, taken some time after June 1942, of 9./JG 54 Bf 109 G-2s shows a standard camouflage pattern, with upper surface colouring taken down to the bottom line of the fuselage, but using a brown and a green. While colour-shift problems caution against a definitive identification of the two colours, the brown is almost certainly 79 and the green probably 80. The battle situation in Russia had changed in the year or so that separated the two colour photographs, but the general colouring had remained reasonably consistent, only the change in the line of the upper surface colouring having changed, something attested to on a wider scale by black and white photographs of the unit's aircraft.

ABOVE: One of JG 3's Bf 109 F-4s painted in the unusual combination of colours in which the unit had received its new aircraft on formation at Wiesbaden-Erbenheim. This aircraft was captured by the Russians after it had force-landed. The three colour combination is particularly noticeable on the horizontal tail surfaces.

ABOVE: A pair of Fw 190s of 1./JG 54 display their unique camouflage style and colouring. The original photograph was distinctly deficient in yellow but careful examination reveals a mixture of a dark green, a paler green and patches of a mid-tone brown. Traces of the latter colour can be detected on the tip of the fin and rudder, along the spine of the aft section of the fuselage and below the cockpit, and in two areas on top of the fuselage forward of the cockpit. The aircraft behind more clearly shows areas of brown at the tip of the rudder, below the Hakenkreuz marking, on the rear of the fuselage, the rear of the canopy fairing, below the cockpit and on the top of the engine cowling. Compare the solid white square behind the Hakenkreuz of the rear aircraft with the one on the nearer aircraft that had had its white border partly painted out. The two greens on the nearer aircraft were 62 (82) and 64 (83) while the brown appears to be 61 (81). The aircraft behind has areas of what looks more like 79 (below cockpit and on rear section of fuselage) in combination with 62 and 64.

The tropical colours of 79 and 80 thus appear to have been sustained by JG 54, only the style of application showing any distinct variation. Another variation on this type of colouring however had occurred when I./JG 3 formed at Wiesbaden-Erbenheim in late April 1942 for posting to the Eastern Front. While still there, it received the new Bf 109 F-4 trop from the Erla Maschinenwerke, built at their Leipzig Heiterblick plant. The Luftwaffe ferrying unit, II./FLUG. 1., was also based at Wiesbaden-Erbenheim, which was an assembly point for new aircraft awaiting transfer to operational units. The Bf 109 Fs had been produced wearing standard tropical camouflage of 79 upper surfaces and 78 lower surfaces with the division along the bottom line of the fuselage side surfaces. To that original scheme had been added large areas of three other colours.

This odd scheme has produced much speculation as to the identity of the additional colours. Given that the aircraft were fighters, it is unlikely that colours 70 or 71 were involved, particularly as a suitable green for fighters was already in use. The darkest one appears to be far too dark to be 74 and was probably 80. Comparison with the black of the Balkenkreuz marking on the fuselage is useful. The remaining two colours have been identified in other writings as 74 and 75. They have about the correct normal tonal relationship between those two colours and they were the only realistic choices left from the then current range of fighter camouflage colours. If these were the colours, it made an interesting combination of air and ground defensive colouring.

While this unusual scheme exhibited minor variations between individual aircraft, the pattern overall was otherwise consistent. Wiesbaden-Erbenheim was a long way from where the aircraft were produced, and such one-off schemes were not usually done at production centres. If 80 was the darkest colour used, then that also points to the work not having been done at the Erla plant. Wiesbaden-Erbenheim was a permanent airfield, with closed hangars and workshop facilities and the changes had probably been done by one of the specialist Luftwaffe mobile repair and maintenance units. III./JG 3, which was to accompany I. Gruppe to the East Front, also received its new Bf 109 F-4 trop fighters in desert camouflage and they were also repainted using the same colours and pattern.

The scale of both instances, and the German location for both instigation of the scheme and its application, point strongly to a continuing official field trial pursuing a more flexible camouflage scheme for the Russian front based on tropical colours, with some form of accommodation for the air-to air aspect. Regulation greys 74 and 75, suited to the western European topography and weather conditions, had proved mostly inappropriate to the field needs of units operating over a landscape that shifted from temperate green to semi-arid in summer. Also battle conditions called for tactics far removed from the great aerial confrontations taking place by day over Germany, and the occupied countries in the West, where air-to-air concealment still prevailed as the primary objective.

Greens had replaced some of the greys producing a combination of the two colours on upper and side surfaces, effectively taking colour schemes back to their 1940 state. Examples of dark greens of indeterminate nature, possibly 80 and another green, in conjunction with 75 or 02 for upper surfaces also appeared as units strove to modify their aircraft camouflage schemes. Bf 110-equipped units also found greys unsuitable and adopted greens for their modified schemes.

The recently recovered entire airframe of an Fw 190 A-5 of 4./JG 54, which crashed near Leningrad in July 1943, forms a significant final step in this picture of experimental camouflage patterns and combinations of colours. Areas of extremely well preserved colours, where natural conditions favoured their survival, have provided a very clear confirmation of the colours in use. While there has been some colour change, the extent has been minimal and the original colours can easily be determined. The dark brown was what would soon be identified as 81, the mid-green was 82, and the tan colour was the current 79. What this – and earlier evidence shows – is that JG 54 had been using the pre-war colours of 61 and 62 (soon be reissued under the new designations of 81 and 82) for some considerable time, plus the desert colour of 79. For any unit to have access to the two obsolete colours would have required both RLM approval and assistance since such extensive repainting would have required the facilities of a Luftwaffe depot. Obtaining the colours in the quantities required to totally repaint a number of aircraft would not have been a problem for a specialist maintenance unit as the paint manufacturer needed only to substitute the pigment and adjust the balance of lacquer ingredients, something that occurred normally in the course of producing the standard range of camouflage colours. This was something done when export orders of German aircraft called for colours no longer in use by the Luftwaffe, for example, the Bf 109 Fs supplied to Hungary in October 1942, which employed the old 61/62/63/65 scheme. This is where the RLM connection is inescapable, reinforcing the fact that JG 54 had had RLM approval for field tests of colours and camouflage schemes. The August 1943 RLM announcement that colours 81 and 82 were ready for introduction at some future date was a bare month away from the date of the crash. While the Russian Front field tests appear to have always been aimed at finding a suitable camouflage for that theatre of war, events in Western Europe were soon to make their application more universally appropriate as the war turned against Germany and the scale of air attacks on Luftwaffe bases increased.

Most replacement aircraft for the Eastern Front however had continued to arrive in a standard 74/75/76 colour scheme; field-developed schemes and RLM-instituted test schemes having produced no standard replacement colour scheme at point of manufacture. That decision would finally be reached and promulgated in August 1943, but without any further action for implementation until a year later, as detailed in Chapter 6. While many aircraft remained in the standard all grey colour scheme, some units had continued to employ minor modifications, providing a wealth of variations. Such limited local flexibility had been exercised through rear-echelon depots, but eventually the RLM called a halt to the practice, making unit commanders seek prior approval for any modification to standard colours or patterns.

On 5 April 1944, during a raid by B-24s of the US Fifteenth Air Force against Ploesti, the force was attacked by approximately 15 Bf 109s near Vis, in Jugoslavia. Pilots of the escorting 71st FS later reported that two of the attackers were brown and grey in colour. The fact that both colours were identified, on two different aircraft, by more than one American pilot, makes it probable that they had to have been reasonably clearly seen to be identified with such consistency. The Luftwaffe unit involved has not been identified, but it adds another account of the appearance of a hybrid scheme on the Eastern Front.

ABOVE: The Me 262 V-3 was first flown in early 1942 and as such carried standard fighter camouflage for the period – 74/75 with a slight mottling in both colours applied to blend upper and side surface colour transition. The nose cone was finished in 70, probably to give the impression of a conventional spinner to prying eyes. The engine cover was finished in ground defensive camouflage of brown and black, the same RAL colours used for the wheel covers.

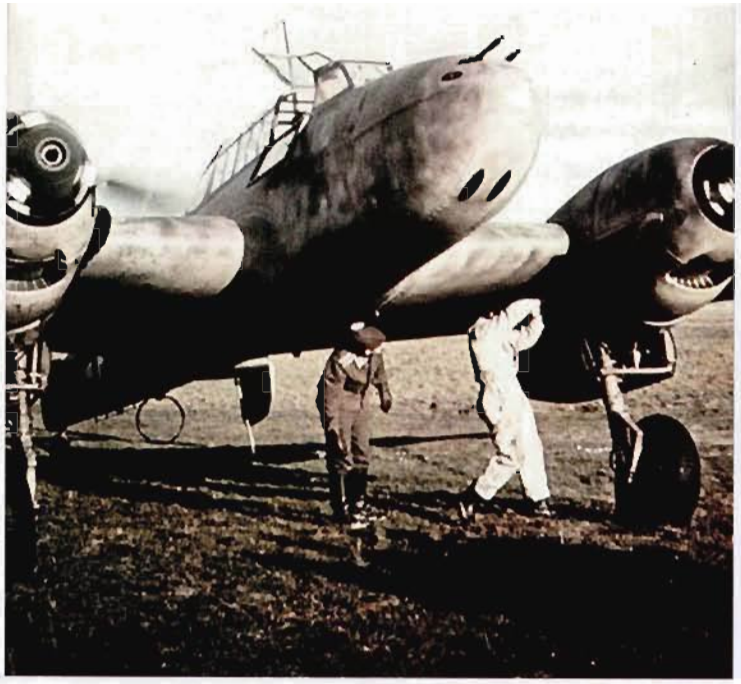
What the basis of the brown was is unknown and any suggestion would be no more than speculative. JG 51, based just south of Belgrade in the summer of 1944, had some of its aircraft in non-standard colours, including two browns, but these appear to have been of Italian origin, matching more closely Italian paint colours. Italian paint manufacturing plants were in the north of the country and still functioning; the supply lines to the east were still operating and the distances were relatively small. The brown colouring definitely was more useful, especially during the dry, dusty conditions of the Jugoslav summer.

Need for a ground defensive camouflage scheme had certainly become far more pressing on the Eastern Front than in the Reich. Barely 600 of the available fighter strength of 1,800 aircraft were on the Eastern Front where, by July 1943, the Russian counter-offensive had forced the Germans to adopt a defensive strategy. Russian air power also had been growing steadily, both in numbers and effectiveness, and their aircraft were to dominate the air war from then on. Adoption of a ground defensive camouflage therefore had been focused on the Eastern Front campaign, especially with the onset of the major offensive launched by Russian forces in August 1943.

War over the Homeland

In contrast, the USAAF daylight offensive over Germany was still facing strong defence from Luftwaffe fighter units. Long-range escort fighters, which would dramatically shift the balance of the bombing campaign, would not appear until the end of 1943. One result of that onslaught would be to produce one further known application of an RLM-approved colour scheme adapted for a specialised purpose. In late 1944 the G-6/AS and G-10 versions of the Bf 109 would be issued to form special Staffeln within several of the Reich Defence units. They were employed as escorts for the heavily-armed and armoured Fw 190 A-8/R-8s used to attack USAAF bomber formations, the Bf 109s opening a path through the American fighter defence screens. For that role the Bf 109s were repainted overall in monotone 77 grey colour, making them as difficult as practicable to detect prior to their attack. However, with the extreme simplification and rationalisation policy, and the general reduction of lacquer types per se, it is possible that some were simply left in their base coat of 76 overall, as noted below.

The Fw 190s and Bf 109s of the home defence units had continued to wear the 1941 scheme of 74, 75, 76 with 02 and 74 as a mottle on the side surfaces. That scheme had predominated until late 1943 when the effects of the austerity campaign began to bite more deeply.



ABOVE: With the shift to 74/75/76 for fighter aircraft, the style of camouflage for this Bf 110 became much lighter in appearance as seen on the Bf 110. Note the spinner colouring of 25, indicating that this was a Stab machine.

BELOW: Spinner markings were one form of rapid identification. Here a Bf 109 of 7./JG 54 has the forward section of its spinner re-sprayed after being masked out into a two-thirds/one-third proportion with white used for the smaller segment. Note that only the forward portion of the spinner was divided up for repainting, the rear portion retaining its 70-colouring. This may have been application of the 1941 revised spinner marking directive that had ordered painting in a two-thirds black/one-third white ratio. Restricting the change to the front section was not correct if that was the case. Note the extremely heavy wear on the propeller blades showing that this aircraft had considerable flying time. The spray equipment was part of the standard kit issued to maintenance personnel for minor painting tasks.

BELOW: On the French coast, Fw 190s were engaged in interception duties. This Fw 190 A-4, 'Red 6', possibly of 2./JG 26, carried additional camouflage in the form of 74-streaks applied to the vertical tail surfaces and the underside of the engine cowl, in both instances over the top of the 04 tactical markings.

LEFT: Remains of 'Black 27', probably a Bf 109 G-6/AS, brought down in the late spring of 1944. It wore the overall high-altitude grey colouring of 77. Several Jagdgeschwadern had Staffeln dedicated to these duties. (M. Payne via J. Prien)

RIGHT: One of 14.(Sturm)/JG 3's heavily armoured and armed Fw 190 A-8/R-2s, caught on film at Schongau in August 1944 as its pilot, Uffz. Oscar Boesch prepared to enter the cockpit. 'Black 14' had a very dense camouflage scheme of what appears to be 74/75 with an application of both colours over the side surfaces that all but obscured the underlying 76, achieved by misting out the edges of the mottling. The 76 can be seen in a more pristine form on the engine cowling. (S. Santos)

LEFT: A most unusually modified camouflage. The fuselage of the Fw 190 appears to be finished in a base coat of 82 with long thin patches of 81 added in semi-linear fashion. The fin and rudder lack anything but the 82-colouring, but around the Hakenkreuz the original 76 can still be detected. In contrast the wings and engine cowlings appear to be in very dark colours; possibly a much denser application of 81 and 82. (J. Crow)

LEFT: A line-up of Me 262 A-1a's of Erprobungskommando 262 at Lechfeld in 1944, illustrating the close conformity of style of application of the 74/75/76-colouring, with soft mottling between the upper solid camouflage and the side surfaces. There are two patterns present, the A and B form mirror images of each other; the first and third aircraft have one form, the second and fourth the other (detail is too poor to determine what the remainder wore). This was normal, RLM approved practice at some production centres. The first two aircraft were W.Nr. 1700071 and 170067; all wore the narrow yellow 04-coloured fuselage band marking common to the unit's aircraft.

RIGHT: In April 1943, 10./JG 1 had been renumbered 1. Staffel, resulting in the IV. Gruppe circle emblem being painted out with 02. 'Yellow 4' in the background had on its rear fuselage and vertical tail surfaces a very dense mottle applied over a dark base colouring, possibly 02 as it matches closely the overpainting of the IV. Gruppe marking. Note the variation in intensity and positioning of the side surface mottling and the painting of the engine cowlings in white. 'Yellow 8' had its entire upper surface camouflage on the fuselage painted in close loops of colour, producing the effect of an intense mottle of tiny 76 spots. (E. Mombeek)

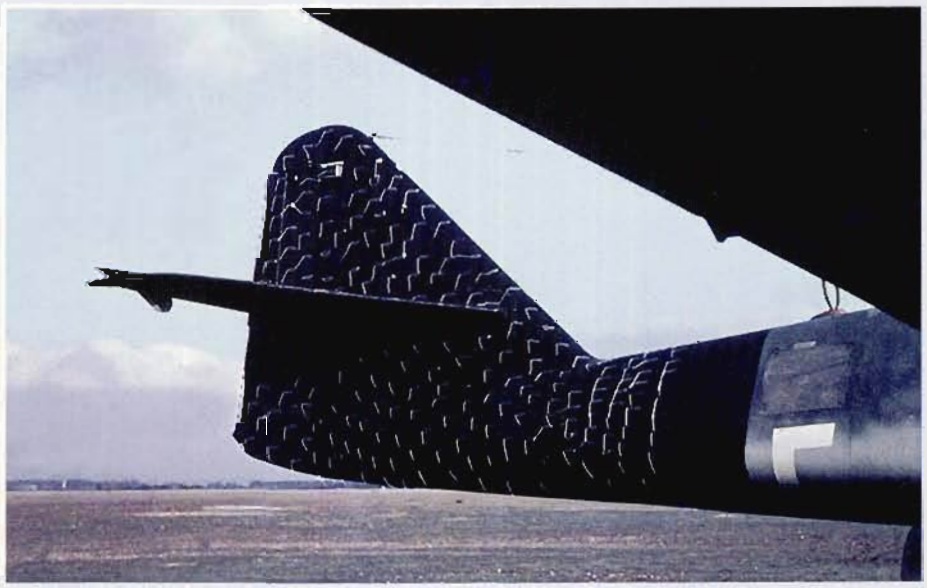
RIGHT: Found abandoned at a production centre, this Fw 190 A was finished in standard 74/75/76. The presence of the Stammkennzeichen marking, BG+KQ, dates the aircraft's construction to around July/August 1944, the regulation withdrawing the use of those markings having been promulgated in the Sammelmitteilung of 1 July 1944 and there was usually a two month grace period for adoption of the requirements listed.

ABOVE: An Fw 190 photographed at its production facility, marked with Stammkennzeichen DN+FV and prepainted with its tactical band marking for deployment to the Mediterranean theatre of operations. Camouflage was standard 74/75/76 with mottling in the two upper surface colours.

RIGHT: The seventh of the series production Me 262 A-1a aircraft, W.Nr. 130012, VI+AL, seen here after a crash-landing on 1 June 1944. The overall finish was 76; the large red '6' was the Messerschmitt company test number.

LEFT: Amongst radical design concepts for advanced forms of fighter aircraft was the Argus pulse-jet powered Me 328, seen here, mounted on the Do 217 K V3. The Me 328 did not wear standard day fighter camouflage, but rather a darker set of colours. This made sense in the interests of static camouflage requirements between flights. Had the contemporary 74/75/76 finish been used, it would have revealed the shape of the diminutive rocket fighter against the darker background of the upper surface colouring of 70/71 camouflage on the carrier aircraft.

THIS PAGE: The standard 74/75/76 finish was still in force when Me 262 A-1a, W.Nr. 170056 (the second V2 prototype), was being used to test a FuG 218 radar installation. The Versuchs number was composed of the identifying 'V' followed by the last three numerals of the Werknummer. The rear half of the fuselage was painted black and had white wool tufts attached to record the airflow pattern changes produced by the nose radar. The interior of the gun bay doors, the support rod and the torsion tubes to the nose section were all in 02, but the cockpit section bulkhead was unpainted. The replacement nose cap housing the radar was painted in RLM 70.



As recorded in Chapter 5, some 75/76 overall schemes had appeared well before promulgation of the August 1944 *Sammelmitteilung*, 74 having started to disappear much earlier. As a result, some fighter schemes had been reduced to a 76-overall finish with 75 used to form the dark segments. Unlike other theatres of operations, the all-grey scheme had remained effective for the air battles over Germany but the increasing pressure of the bombing offensive in 1944 had gradually forced the pace of change. The primary need then was for ground concealment from air attack and 83 had been introduced to replace 74, combining with 75 to form a compromise ground-air scheme not too dissimilar to the old 70/71 finish. Further pressures to rationalise lacquer production and stocks, and an ever-increasing need for ground concealment, had finally precipitated a shift around September to 81/82/76 as the official standard for all classes of aircraft, once more returning Luftwaffe fighters to a full ground defensive camouflage scheme. However, 83 continued to be seen in the production cycle for a long time, sometimes as a principal colour, sometimes in combination as a mottling colour.

The Fw 190 D-9, W.Nr. 601088, held at the National Air and Space Museum in Washington, a former JG 26 machine, used 81 in combination with 82 and 83. Thomas Dietz, Museum Specialist at the facility, made the following comments about colour photographs of this machine, taken in 1966 or 1967:

> *"...the aircraft's finish was in rather poor condition. It was, however, still possible to assign a Munsell value of 5 GY 2/2 to the green on the cowling. This is a close match for 83, but a poor match for 70. One of the shots clearly shows a patch of 81 near the top of the starboard side of the vertical stabilizer, confirming the use of 81 there. The green on the rear part of the fuselage is clearly a bit lighter than the 83 on the cowling. It could only have been 82."* [7]

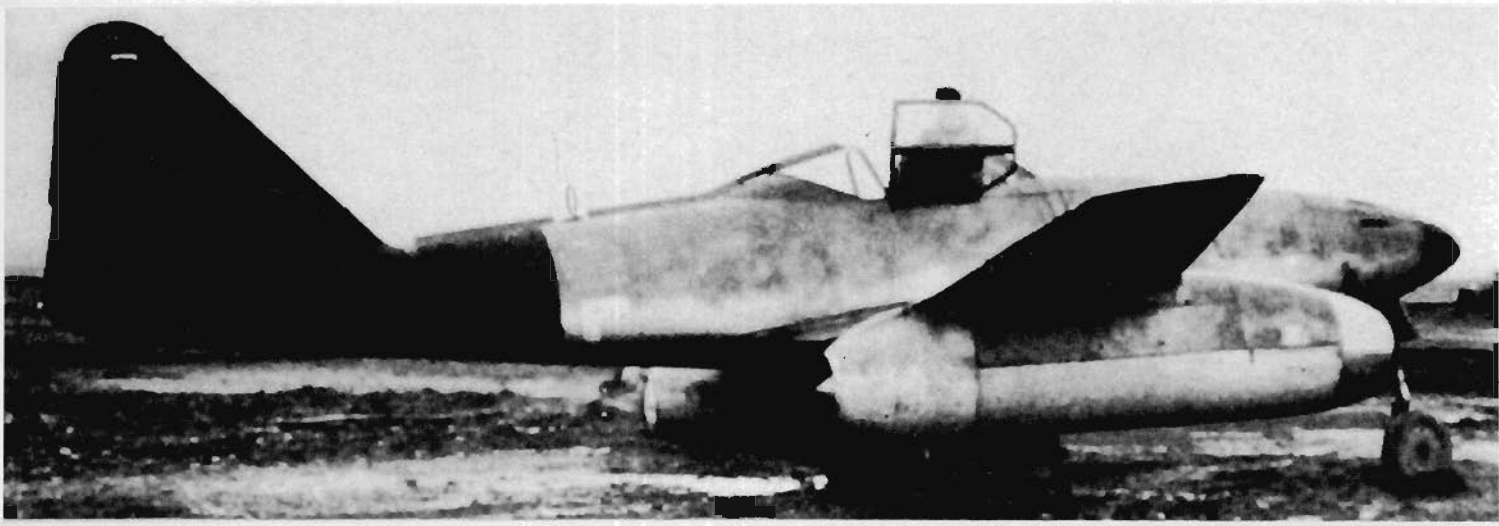
Presence of 81 in that instance may have been restricted to just the tail unit (possibly a colour-mismatched sub-contracted component). The degree to which components were sub-contracted cannot be over emphasized - or the potential for colour mismatching when such items were delivered already painted to final camouflage stage. In May 1944, Focke Wulf's Marienburg assembly line's only sub-contractor for tail assemblies, based at Posen, was put out of production by bombing. The situation was immediately rectified, by transferring supplies to Marienburg of the same finished components from both the Arado and Fiesler licensee complexes, (this had been the rationale behind Milch's strategy for the reorganisation of the industry). The shift in supply source continued while the Posen plant facilities were salvaged and set up again in dispersed sites and commenced production once more.

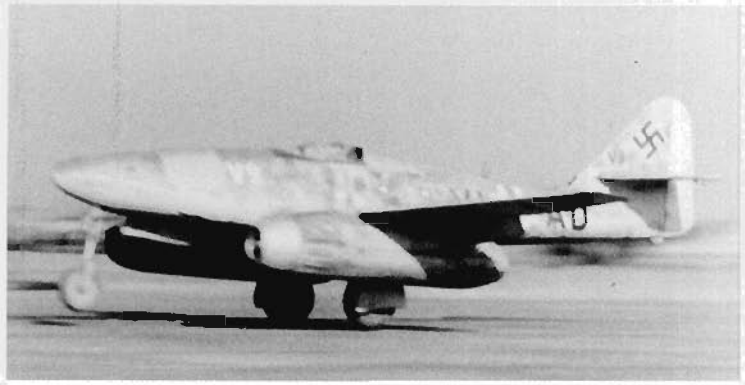
Dispersal had proved an effective countermeasure and the number of small companies involved had increased. For example, within a space of a year, Focke-Wulf factories and subsidiaries increased from five to twelve. While the transportation system remained effective, it worked well, but when transportation was badly disrupted, as happened from 1944 onwards, the Achilles heel was bared. Not only were there problems getting finished components to the main manufacturing centres, but also problems supplying materials to the sub-manufacturing centres to produce the components. Lacquer supplies were part of that problem.

An Fw 190 D-13/R 11 that had been produced in March 1945 illustrates just how widespread the system had become by war's end. The fuselage of W.Nr. 836017 had been licence built by Weser Flugzeug G.m.b.H at Nordenham. Final assembly had been undertaken by the Arbeitsgruppe Roland, a consortium comprising the Junkers plant at Bernburg who made the wings, A.T.G. at Leipzig who made the tail unit assembly, and Siebel at Halle who made fuselage and wing components, (A.T.G and Siebel also produced sub-components for the Junkers consortium). Each of the major components supplied were built from smaller components manufactured by sub-contractors. The web extended very widely - and so did the resultant problems. Late in the war Messerschmitt's Me 262 final assembly lines experienced problems with accuracy of assembly of some major components because of problems of maintaining jig accuracy across its dispersed sites. The Australian War Memorial example, W.Nr. 500200, has its tail unit visibly out of line vertically with the fuselage structure - a generous application of filler, covered by the usual fabric sealing strip, was all that had been applied to correct the problem. If major components could be so ill-affected by the problems, then it is not hard to understand how maintaining camouflage integrity across such a supply system of sub-components could lead to hybrid colour combinations at times.

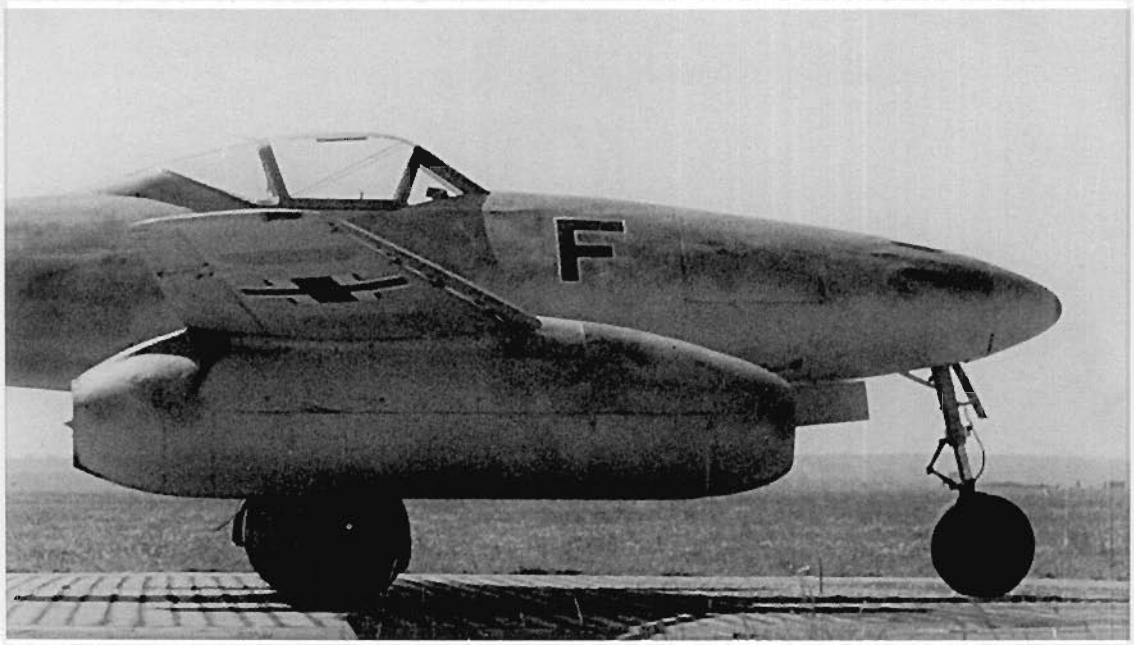
Some speculation continues about a scheme that used 70 or 71 in combination with either 82 or 83 for fighter aircraft. The July 1944 *Sammelmitteilung*, besides making it clear that colours 81 and 82 were replacements only for 70 and 71, also included provision for trading away small stocks of any surplus 70 or 71. This has lead to the suggestion that the very dark and mid-tone colour combination seen on some late- war Bf 109s, and possibly some Fw 190s, was a combination of 70/82 or 71/82.

BELOW: As part of a series of trials to investigate directional stability, W.Nr. 170056 had the rear part of its fuselage painted black, a carryover from the period when this aircraft was used for airflow trials when fitted with radar antennae (see photograph page 168). The white wool tufts had been removed, but the black paintwork remained. With white wool tufts in place, it provided a visual record of the airflow over the empennage surfaces. Note the narrow fillet addition to the upper section of the fuselage, from the cockpit aft, and the enlarged rudder trim tab. The front section of the starboard engine was in bare metal, a consequence of the repeated engine changes necessary for the type.





ABOVE AND ABOVE RIGHT: The Me 262 V 9, W.Nr. 130004 and Me 262 C-1a V 186, W.Nr. 130186, demonstrate the stark difference between mid and late-war camouflage colouring. The V 9 wore standard 74/75/76, finish while V 186 had a dense camouflage of 81/82/76. Note the reversal of fuselage Balkenkreuz marking colouring between the two colour schemes. The change to the defensive colouring on the V 186 is interesting given that, W.Nr. 130179, serving with Kommando Schenk, had the old 74/75/76 scheme. This points to re-camouflaging at least of some test aircraft with 81/82/76.



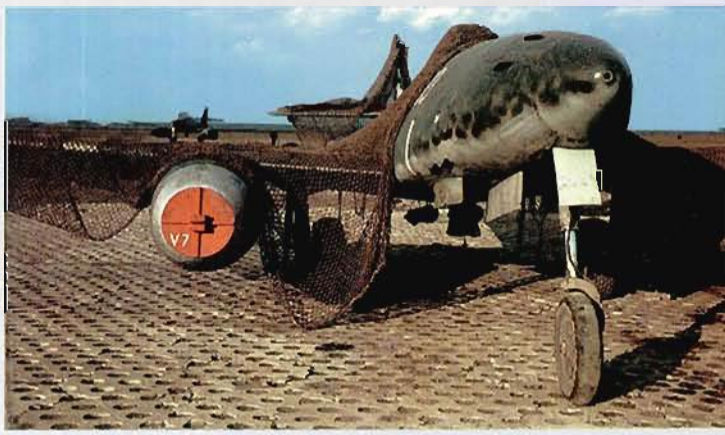
LEFT AND ABOVE: W.Nr. 130179, marked with a 'Black F' thinly outlined in white, photographed in July 1944 while serving with Kommando Schenk. The stark difference in colouring with that of the V 186 is evident, yet only seven aircraft separate the two.

RIGHT AND BELOW: By June 1944, six of the original V series aircraft had been destroyed, their replacements no longer carrying the simple 'V' numerical sequence marking system. Instead the last three digits of the relevant Werknummer were used with the letter 'V' as seen here on the replacement, V 167, W.Nr. 130167 for the original V 5. (Note the repetition of the last three digits '176' on the rear of the fuselage.) The nose cone was fitted with a test probe at the time. It had first flown on 31 May, probably its initial production acceptance check flight, yet, as assessed from laboratory analysis of an original high quality colour slide, its camouflage was clearly 81/82/76. Initially, probably it had retained its overall 76-finish as had happened with the S1 to S7 (Serien – Series) aircraft that first flew in April and May 1944. There is a possibility that 81 and 82, though not intended initially for fighter aircraft, were made available for test aircraft because of their constant exposure as prime targets for Allied observation and air attacks. If so, they may have been the first fighters to receive approved allocation of the new colours.

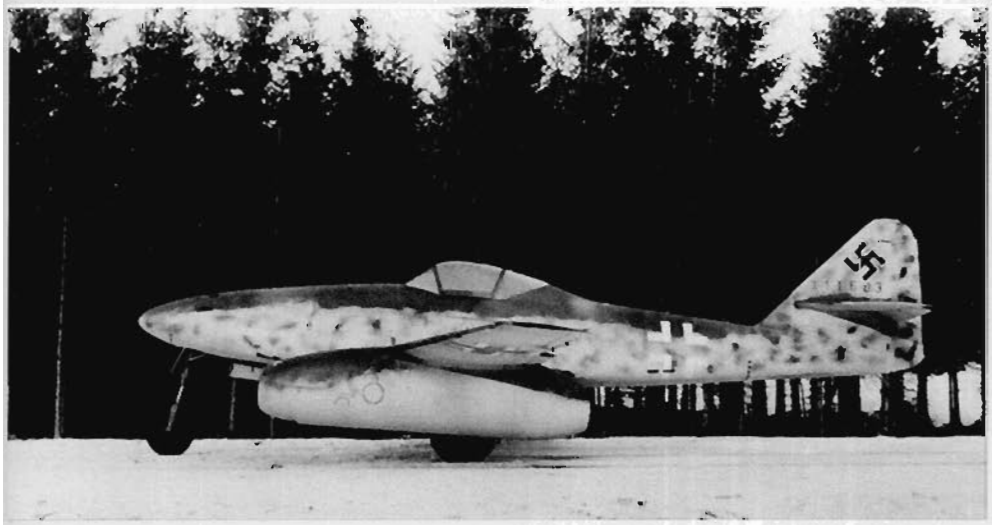
ABOVE: The durability of the camouflage lacquers was tested by the much higher speeds achieved by the Me 262. The extensive test regime (some 300 flights) completed by the V167 produced clear evidence of wear and tear, not just to the cockpit rim, which received damage from feet, but also to the framework of the canopy's fixed section. The Messerschmitt veteran company test pilot Karl Baur is in the cockpit.

LEFT: Colour changes had occurred during the 303 test flights completed by V 167. At the time of this photograph the nose cone and the port engine had both been replaced. The front section of the engine was bare metal, a common feature as this was part of the actual engine structure. The engine side panels, and the one just forward of the wing, were in 02.

THIS PAGE: This series of three colour photographs of the replacement V 7 aircraft, W.Nr. 170303, shows the dense mottling of the 81/82 camouflage, brought right down the sides of the fuselage for better static concealment. The Wikingerschiff bomb racks were left in bare metal with the last three digits of the airframe Werknummer marked on them. The starboard rack has '8 303' stencilled in black on it, ('8' denoting Messerschmitt in RLM documentation). The fin and rudder colouring of very pale 76 is in stark contrast to the rest of the airframe. Note also that the distinctive pattern on the fin and rudder would indicate that this aircraft was at one time attached to Kommando Nowotny before being returned to Messerschmitt as a test aircraft.



ABOVE: Me 262 A, W.Nr. 110813, had been used as a development aircraft for bomb trials in mid-1944. The two 250 kg bombs are mounted on Wikingerschiff bomb racks. Later, the aircraft served with Kommando Nowotny as 'Green 3'. Camouflage is 74/75/76, with a high demarcation line between upper and side surface colouring.



ABOVE: W.Nr. 110813 as 'Green 3' in service with Kommando Nowotny. Note that by then both engines had been replaced with the front section of each engine, which formed part of the engine as delivered, being left in bare metal finish.

LEFT: Me 262 A-1a, W.Nr. 111603, showing the style of camouflage pattern and application that conformed with the main production phase, 81/82/76 finish with a high demarcation line between upper and side surface camouflage areas.

The presumption that stocks of 70 and 71 were traded away to fighter production centres is however flawed.

Firstly, disposal of surplus stock applied only to aircraft using 70/71 (bomber, transport and liaison aircraft) and contemporary fighter camouflage remained distinctive, and was already undergoing its own processes, 83 having already superseded 74. Surplus stocks of 70 or 71 were not likely to have lasted for very long given that the RLM directive applied only to the *excess* of one or other colour that could not be used up in combination with either 81 or 82.

An interesting example of how long 83 lingered in the system was provided by Me 262 A-1b W.Nr. 500071 of 9./JG 7, that landed at Dübendorf airfield on the morning of 25 April 1945. Camouflage was described in the official report as *"Matt finish thinly applied paint. Upper surfaces moss green with olive green patches/light blue underneath."* The colour description 'moss green,' in international colour standards such as Munsell or Methuen colour systems, is described as a medium tone green very similar to 82. The olive colouring was 83. There is no way that the reporting officer could have mistaken the rich brown of 81, had it been present, for any shade of green. A poor quality colour photograph of the aircraft, even allowing for the colour shift, still shows those colour distinctions.

W.Nr. 500071 provides a useful time marker. From listings of production test flights carried out at Obertraubling, and comparing them with the data in the log book of test pilot Herr Lohmann,[8] W.Nr. 500067 was flight tested on 20 January, and 500078 on 23 January 1945. From this it would be reasonable to assume that W.Nr. 500071 was test flown between those two dates, and produced a few days earlier – say mid-January- and 83 was still being used. Ken Bokelman examined surviving parts of the original airframe of W.Nr. 500071 (set aside in storage during refurbishment of that aircraft for display purposes) and confirmed that the colours were 82 and 83.

There are also examples of late 1944 production Bf 109 G-series aircraft employing a 75/83 finish in conjunction with 76 for the fuselage under surfaces, and bare metal surfaces for the wing underside. Some of those supplied to the Italian ANR confirm this. Stocks of 83 had obviously been relatively large, large enough to remain in use, combined with excess 75 stocks, to the end of 1944.

These colour schemes provide an example of the mix of the older greys with some of the newly introduced colours as well as just a mix of the newer colours. By the end of 1944, colours 75, 81, 82 and 83, in one combination or another, were in evidence on fighter aircraft. Though attrition eventually weeded out many of the earlier hybrid combinations, some survived to the end.

Recycling

The closing months of the war produced some hybrid schemes as the practice of recycling salvaged components had become more prevalent (but by then with less care for colour matching). While earlier in the war rebuilt aircraft had still received a contiguous new camouflage application, by late 1944 the inevitable supply problems and pressures to conserve lacquer stocks and labour had resulted in rebuilt airframes receiving a minimum re-camouflaging, resulting, as shown below, in mixed colour schemes. The parts in question had been either refurbished or checked for their airworthiness.

The Australian War Memorial's Bf 109 G, W.Nr. 163824, is a unique example of that process. Built as a G-6 in May 1944, part of a batch of 550 Gustavs from the Messerschmitt works at Regensburg, it originally had been camouflaged in a standard 74,75,76 scheme and allocated the Stammkennzeichen NF+FY. Subsequently, the airframe had been converted to G-6/AS configuration, but suffered damage to the rear section of the fuselage in a ground collision during a ferry flight transfer on 12 August 1944. With 30 per cent damage it was sent by ground transport for rebuilding by

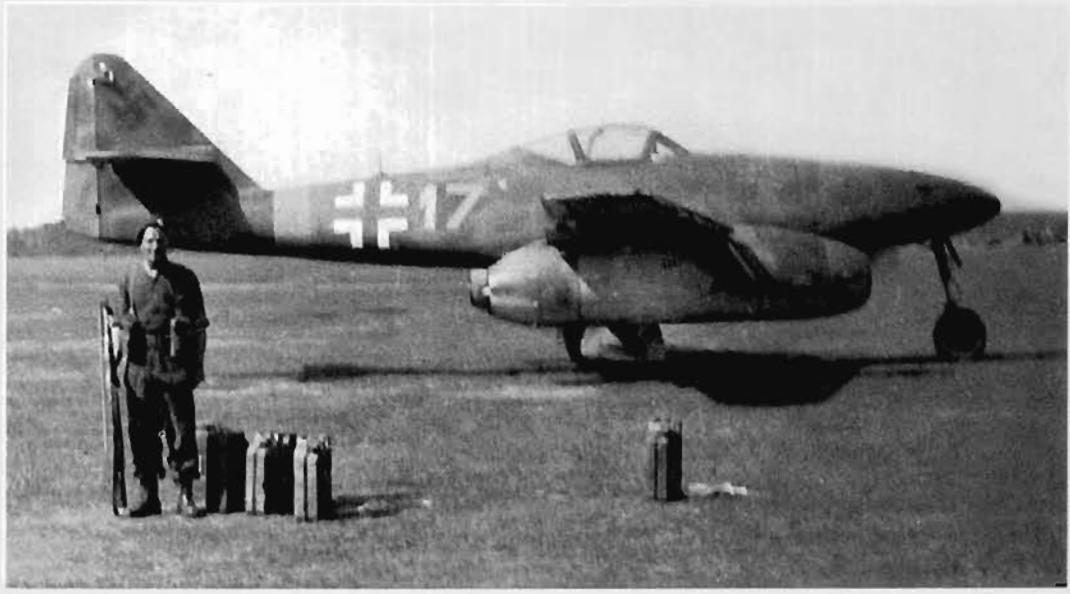
ABOVE AND RIGHT: Two views of Me 262 W.Nr. 500071, 'White 3' of 9./JG 7, which landed at Dübendorf airfield in Switzerland on 25 April 1945. The camouflage of this aircraft is particularly significant – 82/83/76 – as described in the text. The blue and red Reichsverteidigung band markings of JG 7 are painted around the rear section of the fuselage. The white wing and fuselage Balkenkreuz were of correct form, but the underwing markings were simple solid black crosses on the bare metal wing surfaces. The misalignment of the fuselage marking resulted from use of a replacement access hatch door. The '3+I' markings were in white, with the '3' repeated on the nose wheel door.

RIGHT: Depending on light conditions the 81/83 scheme could look almost monochromatic, as seen here on Me 262 A-1a, W.Nr. 112385, 'Yellow 8' of 3./JG 7. The Reichsverteidigung band around the rear fuselage is red and blue.

LEFT: In this view, the light shows up a little more contrast between the two upper surface colours of 81 and 83. The lower section of the nose cone and the engine cowlings were painted in 76, but the remainder of the under surfaces were in bare metal. The sealing filler paste lines below the wings can just be determined. The filler was a pale grey colour in its natural state, lacking the aluminium bronze content of earlier years which gave it a better matching metallic look.

RIGHT: This Me 262 A-2a, possibly W.Nr. 170311, was photographed at the Leipheim production facility. It wore the low contrast 81/83 finish. The 'grid square' effect of the filler paste can be seen on this aircraft, which also shows, that other than for the nose cone, the fuselage had not been primed with an 02 undercoat. The engine nacelles were undercoated and lower surface colouring has been applied to these and the nose cone. Undersurfaces are bare metal other than for the filler paste over the panel joints.

RIGHT: Me 262 A-1a, W.Nr. 500210, one of five belonging to Gefechtsverband Hogebak which surrendered at Fassberg on 8 May 1945. This was from the same production batch as the Me 262 A-1a W.Nr. 500200, now held by the Australian War Memorial, and used the same type of camouflage; first a coat of 81 over upper surfaces with 82 employed over that to produce a slightly lower contrast colour scheme. The dull lighting at the time that the photograph was taken makes the finish appear to have even less colour contrasts. Only the lower section of the nose cone and the engine panels were camouflaged, possibly with the same green-blue colouring found on the W.Nr. 500200, the rest of the under surfaces being left in bare metal.



LEFT: This Me 262 A-2a of III./KG 51 wore 81/82 camouflage with either 76 or the green-blue colouring on the sides and part of the lower surfaces. The very dark 81-colouring can be seen on the wing root and upper forward section of the port engine nacelle. Discernible sections of the wing upper surface camouflage identify this scheme as prior to the revisions introduced on 23 February 1945. The rudder, and that of the aircraft on the left, was yellow, as was the tip of the nose cone. Note how the general camouflage pattern had been raised up the sides of the fuselage, producing pale side surfaces aft of the wing. The white outline Balkenkreuz marking was almost indiscernible. (H. Fröhlich)

LEFT: Bf 109 G-10/R2 W.Nr. 770269, 5F+12, and Fw 190 A-9, 'Red 5', which surrendered at Fürth in May 1945. The Fw 190 had a relatively light camouflage using 81 and 82 on the wings, tail plane and forward area of the fuselage, but relying on just 82 and a soft overspray of 02 for the rear half. The original 76 colouring can be seen in places on the fin and rudder, particularly around the area of the Hakenkreuz. The 02 spray had also been used on the undercarriage fairing, toning down the brighter colouring of the 76 to produce a better ground defensive camouflage.

LEFT: Salvaging Bf 109 E, 'White 14' of 1./JG 26, that had been badly damaged in a crashlanding during the French campaign in 1939 or early 1940 being transported across German territory to a depot where it would be examined, assessed for repair or dismantling into components for re-use with other damaged aircraft. By late 1944 such recycled parts were finding their way into the main production cycle.

RIGHT: British troops stand on a flat car bearing a Bf 109 G-6 that had been captured in transit, salvaged for repair. The style of camouflage, with crisp division between upper and lower surface colours, and a very round style of mottles, was characteristic of two production centres, Erla and WNF, Erla's 411000-412000 and WNF's 440000-441000 production blocks both showing this style of finish. Photographs of Bf 109s wearing this distinctive style of 74/75/76 finish all seem to date from around the early part of 1944.

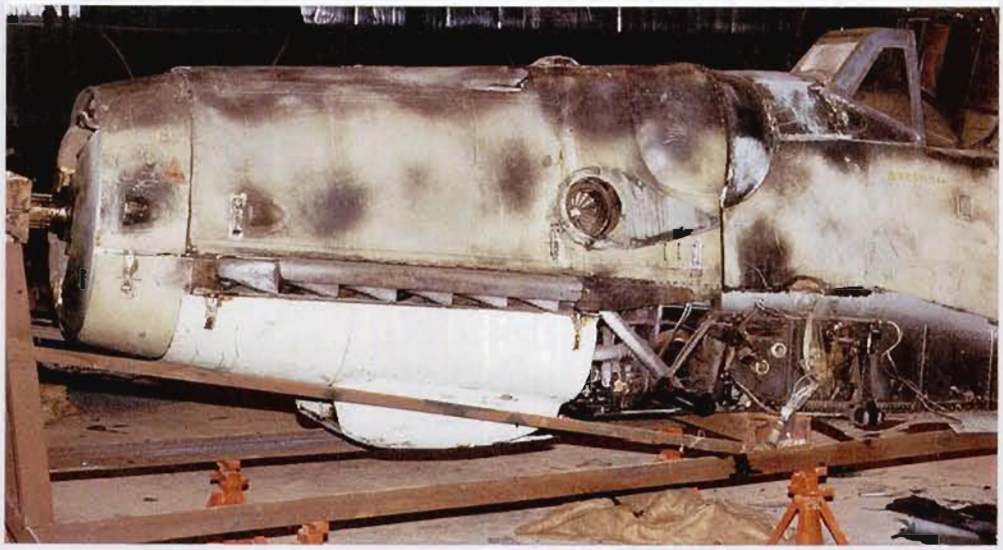
Ludwig Hansen & Co., Flugzeug-Reparatur-Werk at Münster. Overall, at various centres, only 460 airframes were converted to G-6/AS configuration. This one however was intended to be returned to its original G-6 configuration, probably destined for training use, but ended up retaining some G-6/AS components (possibly due to pressure on the supply system as its re-conversion was not completed until the end of December - over four months later).

A DB 605 engine had been installed again, the engine modification plate of the replacement (Werknummer 78246-A-1) recording that it incorporated all type modifications from February 1943 to September 1944, with the majority being incorporated into the engine assembly system in April 1944. No overhaul or rebuild markings were present so it was a new engine. The rear part of the bulged fairing sections associated with the AS modification had been removed from the fuselage, and standard engine cowlings fitted. Where the rear fixed section of the bulged fairings had been removed, from beneath the cockpit quarter-light, the rivet holes had been filled and the interior walls of the cockpit repainted. However, both the larger Fo 987 radiator and the VDM 9-21259 A broad blade propeller had been retained, along with the Erla canopy that had been fitted to the original G-6 airframe during construction. The tall fin and rudder assembly, standard for the DB 605 AS engine installation in the G-6/AS, had been replaced with recycled Bf 109 F components. The horizontal tail plane and both wings were recycled parts from other G-model aircraft.

The fuselage, originally 74/75/76, had been sprayed with 81 in conjunction with an unidentified black-grey colouring on upper surfaces, and the unidentified green-blue colouring on sides and lower surfaces. Stammkennzeichen markings had been removed in accordance with the revised markings' regulations promulgated in July 1944. The style of application of the 81 showed clearly the spray action of the aircraft painter, and was thin enough in places for the original grey camouflage colour to be determined. The removable ammunition boxes access cowling immediately in front of the windshield was a recycled part painted in 78, the colour being visible where the thin black-grey respray had been scuffed. Mottling in 'spots' of the same black-grey was applied to the port side but very few had been added on the starboard side. That had been done using too low a spray pressure, which resulted in a very coarse application and a colour shift.

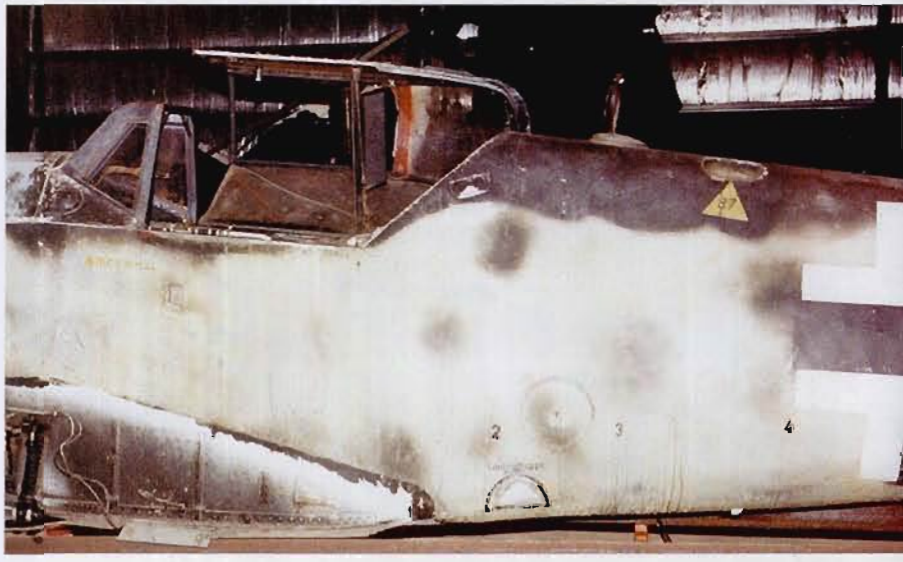
Below the cockpit edge, on the port side, is a yellow triangle with the markings 'M.C.Y. 31.12.44', all hand-painted by brush. (M.C.Y. was the code for Ludwig Hansen & Co. Flugzeug-Reparatur-Werke in Münster, and 31 December the date recording completion of the work). The Balkenkreuz markings on each side have their centre applied in 22, but the plywood radio hatch was a replacement part with its centre in 66.

The tail unit, from a Bf 109 F, had been repainted in green-blue on its lower section with 02 above the horizontal tail plane, the contrast between the two colours being quite distinct. A very light over-spray of the black-grey used for the mottling had been added over the 02 of the front section, becoming thicker and darker at the fin leading edge. The original Hakenkreuz marking was faintly visible beneath its replacement. The fin interior was finished in a lighter shade of 02, visibly distinguishable from the darker colouring of the 02 inside the wings (which were of later manufacture). This recorded the shift from the matched 02 of earlier years to the relaxed 1943 standard for 02 where that colour was used internally. The rudder, also recycled, had been damaged and very poorly repaired with a large section of fabric on the starboard side stitched together and painted a medium grey over which 76 had been hand-brushed. Those repairs had been made after

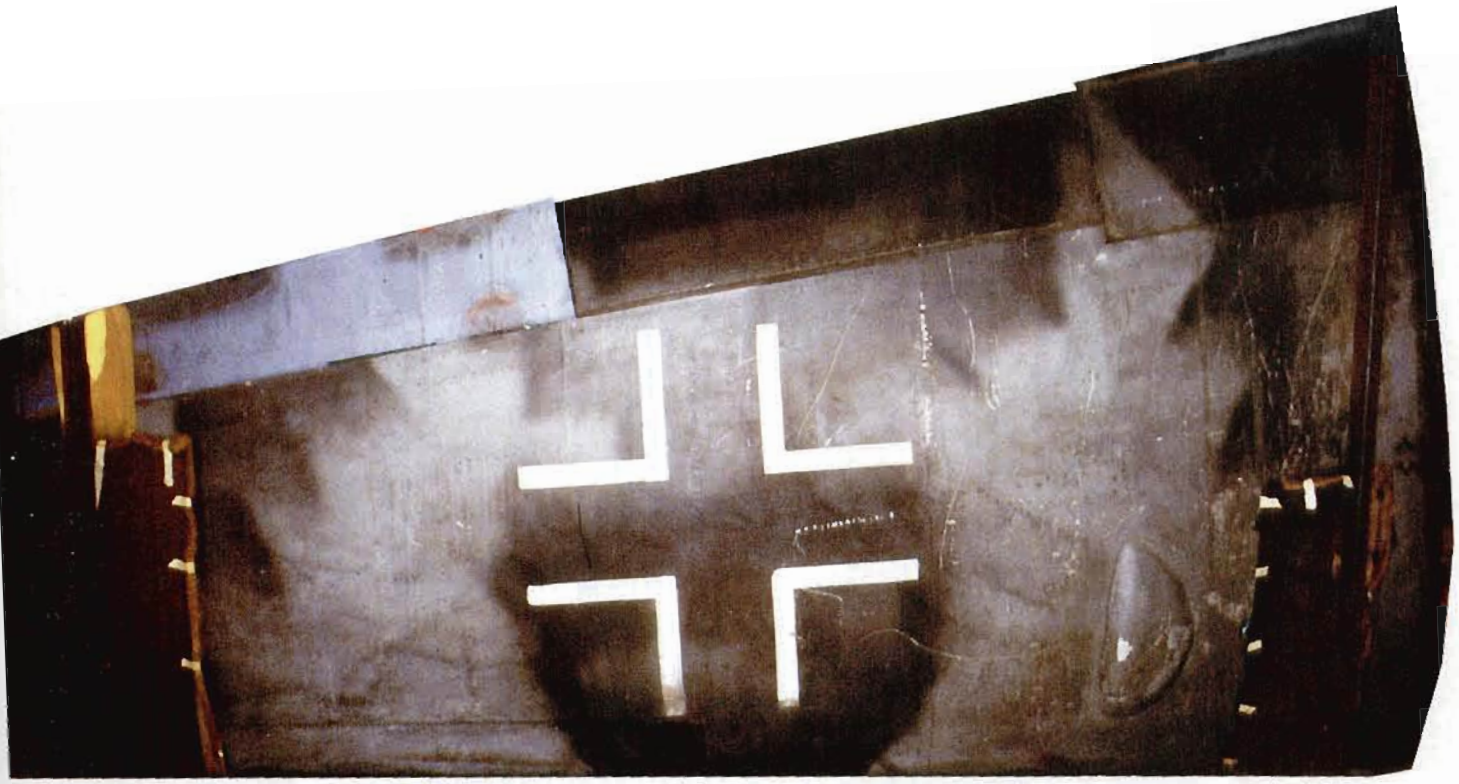


LEFT AND BELOW: The main fuselage of W.Nr 163824 showing the green-blue side surface colouring that contrasts markedly with the 76-coloured engine lower cowling. The brown-violet colouring on the nose section, and above the Balkenkreuz marking stands out against the black-grey colouring. Cockpit framing is in standard 66. The recycled ammunition bay top cover has its original 78 tropical blue colouring exposed where the black-grey colour has been scuffed off. (K. Ginnane)

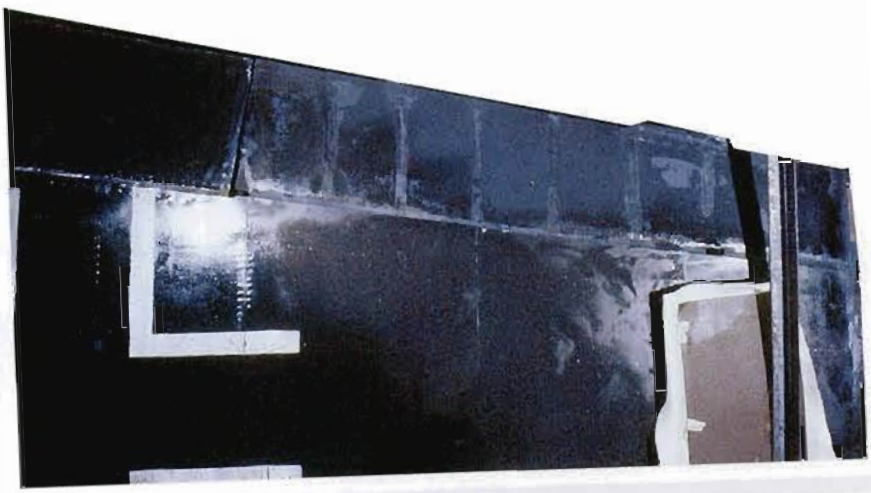
ABOVE: A close-up detail of the sprayed 83 on the rudder showing the coarse application caused by using too low a pressure with the spray gun.



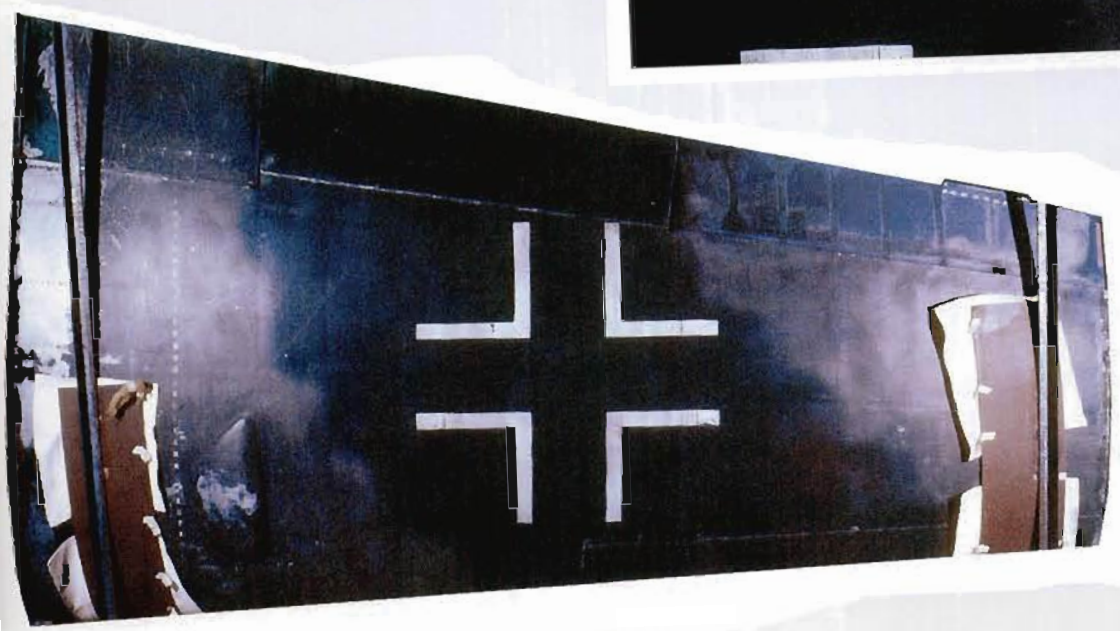
LEFT AND RIGHT: The tail unit, a complete sub-component, in this case a recycled one from a Bf 109 F, and a recycled rudder. A strong overspray of 02 had been used as camouflage above the tail plane with the unidentified black-grey colouring added to the fin boot. The latter colouring also had been applied along the lower section of the leading edge of the fin. The rudder is in 76 with 83 used as short, sprayed stripes. The rather crude fabric repair on the starboard side had been roughly brush painted with 76. The repair on the port side had been primed with red-oxide coloured lacquer obscuring the last three hand-painted digits of the Werknummer, only 163 being just discernible. The incorrect style Hakenkreuz marking and Werknummer had been applied by stencil. Note particularly the strong colour difference between the 02 above the tail plane and the lower colouring and the original shade of 76 of the rudder.



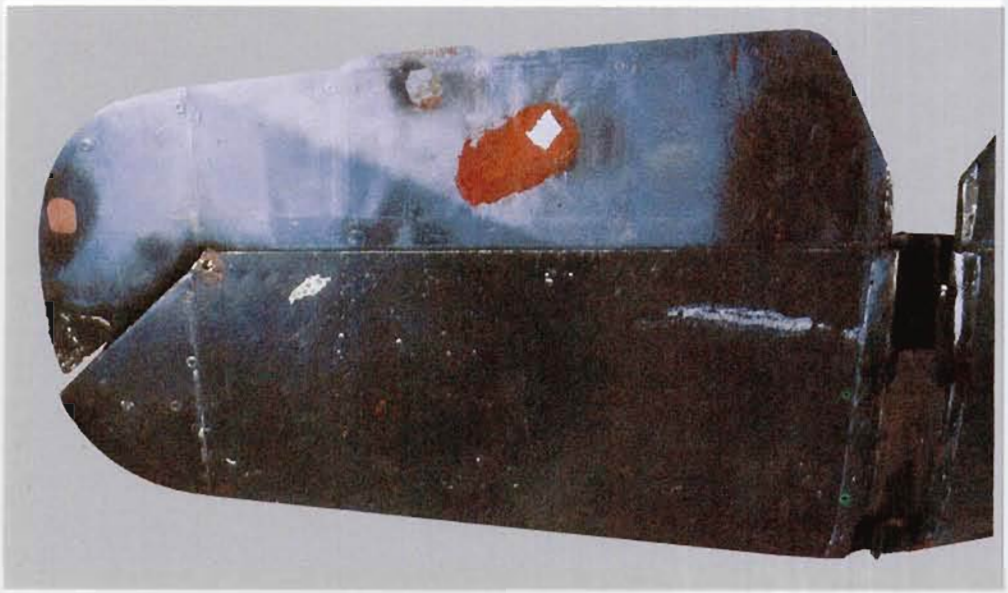
ABOVE: The starboard wing upper surface showing the original high-altitude 77-grey finish over which the unidentified black-grey colour had been sprayed, overlapping the leading edge of the white outline Balkenkreuz marking. The aileron is in 75.



BELOW: The port wing in contrast looks much darker, finished in 81 and 83. Note the apparent colour shift in the 83, which appears to take on a darker tone.

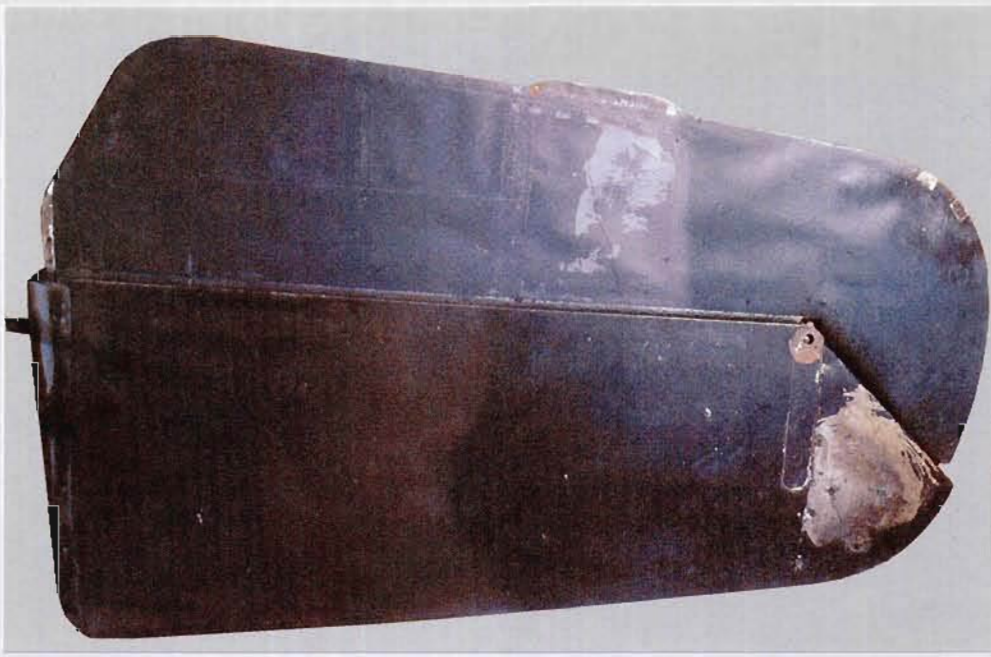


ABOVE: A close-up detail of the aileron showing the low colour contrast between the 81 and 83 and the medium contrast between the 81 and the 75 on the aileron. A fine spray of demineralised water was used to bring out the full spectral quality of the lacquer colours.



LEFT: The starboard tail plane upper surfaces with low contrast 81/83 finish on the fixed stabiliser and 74/75 on the recycled elevator. Note the crude repairs using the unidentified black-grey colour.

RIGHT: The port tail plane upper surfaces with 81/83 finish on the stabiliser and the recycled elevator in 75/82.



BELOW: This view of W.Nr. 163824 shows the 81/black-grey camouflage as well as the reduced amount of mottle on the fuselage side surface compared with that of the starboard side. The white number '441039' on the broad-blade VDM 9-12159 A propeller is the Werknummer of another Bf 109 G-6 that had surrendered its recycled propeller to this machine. This illustrates how parts were identified for the rebuilding cycle of each individual machine.

application of the new colour scheme, possibly a result of transport damage or bombing to the basic colouring 76 over which short, sprayed strokes of 83 had been added. On the starboard side the rudder horn fabric shows its original 78 colouring.

The fixed horizontal tail surfaces, originally in 74/75, had been re-sprayed with a solid application of 83, the inboard sections had then been sprayed with 81 and the 83-coloured outer sections sprayed and the unidentified black-grey. On the starboard elevator, the overlap between the two colours was quite broad and the underlying 83 had influenced the final colour. The port elevator was a superseded type; originally in plain 75, it had its outer end sprayed in 83. Its under surface was a light blue-grey that matched closely the colouring below the starboard wing and the oil cooler, and positively identified as 76. The starboard elevator had been left in its original 74/75 combination. Three repairs had been coated in red oxide primer with 81 sprayed on one of them. The undersurface of the starboard elevator had a thin application of the unidentified green-blue colour, which was also applied to the under surface of the fixed section of the horizontal tail plane. Over this, and extending to the leading edge of both elevators, is a thin, patchy coat of a varnish-like substance with a distinct yellow colouring.

Both wings were recycled components unmatched for camouflage (each had been marked with the two-letter code 'VE' identifying them as strengthened wings). The starboard one was painted a consistent solid cold grey colour of relatively light tone, not even vaguely close to any of the listed RLM greys on the L.Dv.521 1941-issue colour card. This was the 77 finish used for high-altitude operations. A zigzag-edged application of the unidentified black-grey had been added producing a slight over-spray on part of the white outline-form Balkenkreuz, confirming that the wing had originally been used in its monochromatic colouring, (a photograph of another Bf 109 G with identically marked and mismatched camouflage patterned wings, fixed in the same port and starboard combination, indicates that this aircraft was not unique in that respect). The style of paint application is usually associated with Messerschmitt's Erla plant, but the colour itself identifies the application as having been done by the Hansen repair facility. Wing tip and aileron upper surfaces were a slightly lighter shade of 75. The under surfaces of the wing and aileron were a very light shade of grey-blue 76. The aileron shows traces of a light blue (possibly the earlier shade of 76 or 78) and a thinly applied light olive green (possibly 80 or 83).

The unidentified black-grey colouring, used fairly extensively on parts of the airframe was quite distinct from the 66 of the external cockpit framing and matched none of the RLM standard colour swatches used in the detailed examination. Its origin was almost certainly the Hansen facility, a compromise that matched nothing official and highlighted the desperate state of the supply situation to such secondary production facilities.

The aircraft's port wing upper surface lacquer sequence was examined at one section; from bare metal upwards it was 02, 75, 74, a thick coating of a brown, then the current finish of 81 and 83. Stencilled in red inside the wing root section, is a triangle and the marking (M.C.Y. 20.11.44). The aileron upper surface is a light shade of 75 with an area of 81 overspray, while the underside is 76. The outboard edge has a red triangle, M C.Y and an indecipherable date. The under surface of the wing is green-blue over the original 76-colouring. The original 76-colouring of the wing tip had been painted in 04, then green-blue painted quite thickly.

This aircraft provides good empirical data on both the extent of recycling and/or rebuilding and the mismatch of colouring. The standard grey colours that appear on this aircraft exhibit a subtle variation from the colour atlas standard, being either slightly lighter or darker, but still close enough to be positively and easily identified. Indeed, without resorting to the RLM standard colour chips, the variation would not have been noticeable. The variations appear to have been original and not due to fading or oxidising.

The Final Phase

There have been some speculative opinions appear in print about main aircraft plants using non-standard colours. Like all myths, there is a grain of truth involved, but not of the type or scale inferred. The Australian War Memorial Bf 109 does show some visible and consistent subtle differences between the colours used and the official standards. However, seen in isolation it would be hard to pick any differences and it was only by having the official colour standards available for direct checking that the author was able to detect them.

The suggestion that RAL stock was obtained and used to tint lacquer stocks at the aircraft factories [9] does not stand up to scrutiny, as the formulae quoted earlier in the work for some well used colours show. The complexity and secrecy surrounding the ingredients of each supplier involved would have made it difficult enough. Determining the necessary colour pigmentation needed and obtaining constant reliable quantities of both base stock and pigment stock, especially later in the war, would have made it a process fraught with severe problems. To that add the rate of aircraft production and quantities of paints required each day and it becomes apparent that it was a complexity that no aircraft manufacturing plant would have willingly even contemplated.

The main reason for the subtle differences between standard colours applied at different aircraft manufacturing plants is less mysterious. The simple act of preparing paint stocks *on a large scale* could and did produce very minor variations. Even a slight excess of thinner could quite easily account for the colour shift and it is hard to criticize a manufacturing system, working to such extent under wartime conditions, for failing to get the proportion of thinner 100 per cent correct with every batch of lacquer mixed. It is also possible that a slight excess was deliberately employed to extend the stocks; the thinner was purchased separately and mixed later with the pigmented lacquer stock (which may be the basis of the anecdotal evidence for paints being prepared by the aircraft manufacturer, as mentioned above). Given the quantities involved this could have made a significant saving in materials while making almost no visible difference - and it did not alter the effectiveness of the camouflage or its qualities. Whether such was done for economy of materials, or profit margin is not known.

The RLM approved tables accompanying viscosity flow metre tests also allowed a small margin of error in mixing quantities, so it was not an unexpected subtle variation. Failing to stir in all the pigment in each batch could also produce the same effect, but that is less likely on such a consistent scale, and the pressure to utilize to the full all resources militates against such a wasteful practice. Lacquer was supplied in relatively small size tins, ensuring that the last of the pigment was always included when the tins were poured into the larger pressurized spraying tanks with their mechanical stirring system. This may have involved adding a little thinners to each tin and swirling it around to remove the last of the pigment. A simple, consistent practice like that could also add to the slight over-thinning process.

Two distinct shades of 02 were found on the Australian War Memorial aircraft; multiple large specimens of both came from the interior of the aircraft and wing where they had had no exposure to light and were protected from most atmospheric changes. A light and a dark form of this colour has been noted many times, examples being available from the many samples still in existence. The colour variation was one that had occurred at point of manufacture of the paint stock rather than from field conditions or factory mixing factors, resulting from the 1943 decision to split use of 02 into two categories, (a) as a colour matched camouflage lacquer, or (b) as an internal colour with the matching requirement relaxed.

Examination of the way in which this aircraft had been rebuilt, and the manner in which the various components had been re-camouflaged, reveal an industry under extreme pressure, particularly the recycling section of that giant industry, with a camouflage paint system at sub-manufacturing and recycling plants sometimes operating outside

parameters in place since 1936. Not only were standard paints applied in non-standard fashion, standard colours were sometimes subtly changed, and some non-standard colour mixes were in limited use at some facilities where stocks were stretched to the limit late in the war. This aircraft's rebuild and repainting had been completed on 31 December 1944, by which date at many sub-centres, the camouflage and paint system can be said to have almost slipped from the control of the RLM.

The main airframe manufacturing plants however still managed a reasonable degree of standardisation. While OS-Liste requirements remained in force, some small variation in colour combinations (not variations in the colours themselves) did occur at point of manufacture that did not result from the random aspects of sub-contracted parts supplied in non-matching schemes. The official camouflage specification for the Me 163 stipulated 81/82/76 finish but the Australian War Memorial's Me 163, while conforming accurately to the set camouflage pattern and painting directive of 81 and 82 for its upper surfaces, used the unidentified green-blue colour for its lower surfaces. The fact that the metal section of the lower surfaces were so small, and the shape of the fuselage sections making the area below the wings part of the side surfaces, accounts for why this type did not employ bare metal lower surfaces.

In contrast the AWM's Me 262, W.Nr. 500200, built around late January 1945, conformed fully to the instruction calling for conservation of strategic materials. Consequently the lower surfaces of the wings and fixed horizontal tail plane, and the main section of the fuselage, are in bare metal that extends up to a point level with the top edge of the wing root. The nose section, a sub-component, however was finished in an undercoat of 02 and then painted completely in the unidentified green-blue, as were the engine cowlings and undercarriage doors; the latter being made of wood qualified for painting as a protective measure. The fuselage otherwise lacked any undercoat other than for brush priming in 81 of the filler used on all vertical joints. Brush size was approximately 25 mm. Upper surface colours were a mixture of 81 and 82, but applied, as was now normal practice very thinly over bare metal, which produced a colour shift. The 81 had been applied overall first and then 82 in segments over that base colouring. The thin nature of both applications added to the colour shift of the 82, slightly darkening it.

The successful Focke-Wulf company trial of using bare metal under surfaces for a batch of 50 Fw 190s had been swiftly applied to the fighter production system, with rapidly increasing numbers of Fw 190s leaving the production line minus lower surface colouring other than a for 76 applied to wooden parts. Initially, the transition between upper surface camouflage and bare metal was done by taking the darkest of the camouflage colours about 30 or 40 cm round the leading edge of the wing and onto the bare metal. On the wing tip, the colour was usually taken around the tip in an arc extending back to the aileron line to accommodate the pronounced dihedral angle, reducing the reflective qualities of the bare metal when seen from side on to the aircraft. However, the long undercarriage configuration, and subsequent high angle of attack of the wings when on the ground, exposed the underside front section of the wing area, compromising the camouflage to some degree, especially in low angle light conditions of morning and evening. This was rectified by using 76-colouring (or the unidentified green-blue in some instances) extending aft to a line roughly along the line of the front spar, which remedied also the problem of reflections from the undercarriage fairings when the aircraft was on the ground. On most aircraft the underside of the engine cowling also received a thin coat of camouflage for the same reason.

When the Fw 190 D series aircraft had entered service, the entire engine unit had been built and supplied complete with cowlings, and camouflage had been used on the lower panels. The colour seen on the engine lower surface panels on many such aircraft was the green-blue colouring, perhaps indicative of the end-users of the surplus stocks of that obsolete colour. Interestingly, that area was identified as bare metal on the Ta 152 camouflage drawing of 1 November 1944.

Late production Bf 109 aircraft were slower to adopt the bare metal finish, but there is clear evidence that a large number were finished in such fashion; probably from around October 1944 onwards. Occasionally a mixed finish was seen, the last section of the fuselage immediately below the tail plane (from frame 9 aft), being bare metal on some otherwise fully camouflaged machines. That possibly resulted by default, as the tail assembly was a sub-manufactured item delivered pre-painted, with camouflage applied only above the fixed horizontal tail surfaces. It remains

LEFT: Fw 190 D-9, W.Nr. 500571, 'Black 12' at Fürth at the end of the war. The main airframe was camouflaged in 81/82/76, but the 76 side surfaces had been toned down with a thin, sprayed coating of 02. The engine cowlings, which were supplied with the engine as part of the complete power unit, had a solid application of 82 on the upper surface and the unidentified green-blue colouring on side and lower surfaces. The colour difference is best assessed by comparing the 76 of the rudder with the area around the exhaust stubs on the engine cowling. While some aspects of the chemistry in 76 changed with a partial shift to use of Hansa blue in place of Cobalt blue very late in the war, it required long exposure to produce a greenish tinge to the colour – and the attrition rate did not favour such a time factor in many cases.

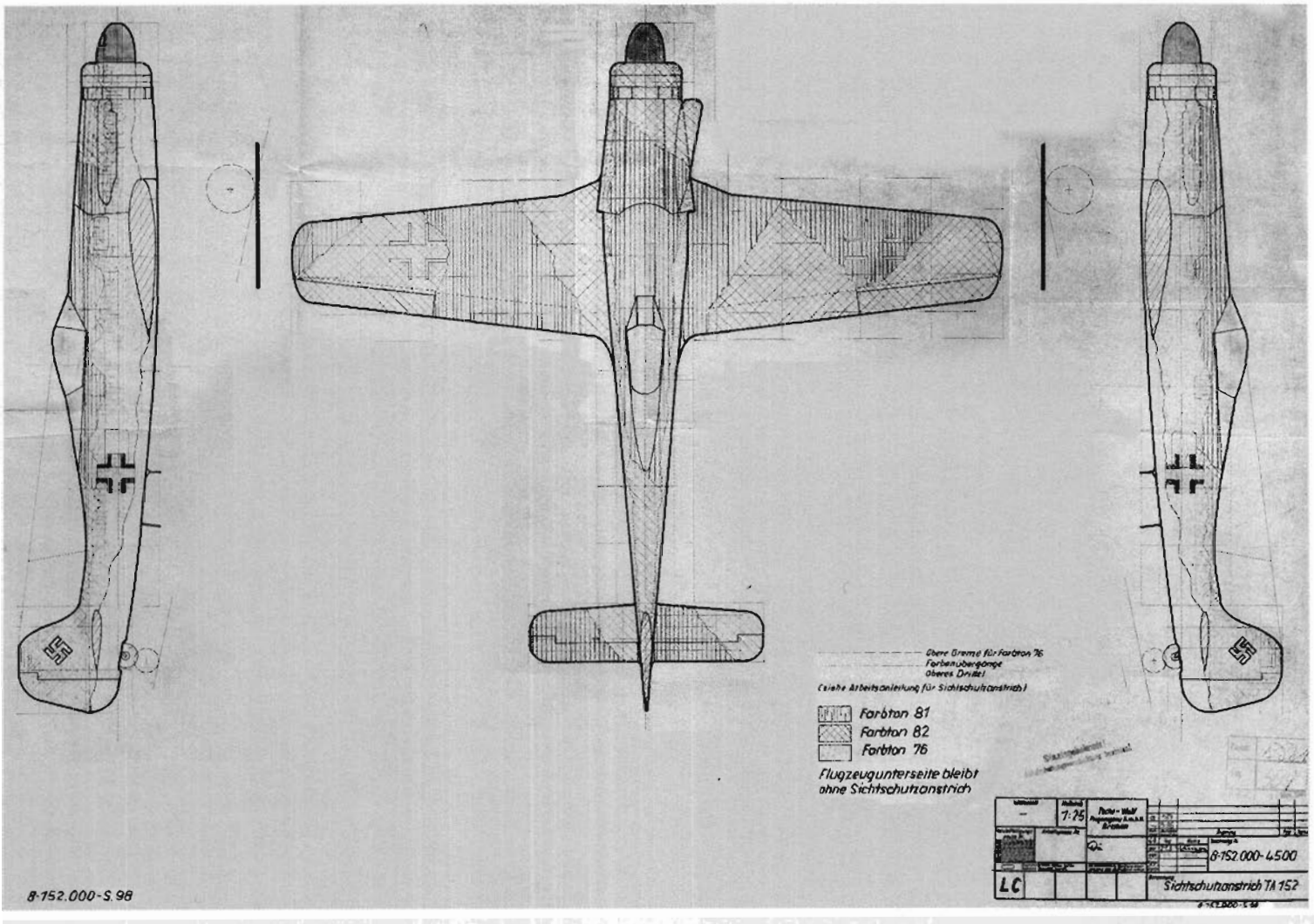
speculative whether or not the lower surface of the horizontal tail plane on such aircraft were also left in bare metal. Unlike Fw 190s, because of their flatter ground angle, Bf 109s and Me 262s had not required addition of paint to the forward section of the wing lower surfaces.

Among the experimental types of aircraft in advanced prototype development status was the BV 155 high-altitude fighter. As noted in an earlier chapter, the RLM directive of 13 September 1944 covering the finish for this type included elimination of painting on all under surfaces, providing a fairly positive time marker for the general shift to bare metal lower surfaces. Upper surface camouflage was to be in 81 olivbraun and 82 hellgrün with side surfaces mottled in the two upper surface colours.

The revised 1944 camouflage directive for the Ta 152 (Drawing No. 8-152.000-4500) denoted individual colours by varying forms of cross-hatching on the drawing with Farbton 81, 82 and 76 recorded beside each individual sample in the legend, no written colour description for each being added. The colours 81 and 82 were restricted to the upper surfaces with 76 on the side surfaces and a prominent note on the legend stated 'Flugzeugunterseite bleibt ohne Sichtschutzanstrich' (under surfaces to remain without camouflage). The original document was promulgated on 21 March 1944, but had then been amended as shown by an over stamping next to the drawing legend in the bottom right hand corner. It included the data 'Satz 509' (change 509), 'Pause E881' (variation E881), 'Datum 1 Nov. 1944' (date 1 November 1944). What is also significant about this drawing is that it shows how high up the bare metal area was taken. Collectively, that revision to the extent of the upper surface camouflage, plus the designation of the camouflage colours 81 and 82, and the deletion of under surface colouring, illustrates how existing camouflage diagrams were simply modified, rather than entirely new drawings being issued. The original March 1944 drawing had designated colours 74, 75 and 76, with the latter shown for all under and side surfaces, the form of camouflage seen on the contemporary Ta 152 prototypes. That was amended in the revised drawing by adding a clear demarcation line for the 76-lower edges where it met the bare metal sections.

Changes to these drawings required only erasure of the tonal marking for the 76 below the newly inserted demarcation line and removal of the original '74' and '75' designations, and replacement with '81' and '82'. The addition of the notation about no under surface colouring required no other changes to the existing drawing. Lettering and numbering on these documents were usually done by means of stencils, as the drawing shows. The addition of details about no under surface colouring verifies also that the document had been changed from its original form as the bare metal under surface trials had not commenced until mid-July, and results of the field-testing could not be assessed until about late September or October. Lack of any written colour description for either RLM colour designation number occurs on such documents more often during the final months of the war. Given the contention over the actual colour descriptions of these colours it is interesting to reflect that, after some initial confusion, written descriptions eventually proved superfluous.

Standard Ta 152 Splinter Pattern



Production deliveries of Bf 109 Ks had begun in mid-October 1944 and some examples were clearly in a combination of 81/82 on upper surfaces as were some deliveries of the contemporary Bf 109 G-10s and G-14s; reliable examples of fabric samples and major components substantiate this. However, proof that some Bf 109 Ks were wearing an 82/75 upper surface camouflage, in conjunction with 76 lower surfaces, is also authenticated from surviving fabric samples, verifying the instruction to use up stocks of 75 colouring. Other combinations of surplus lacquer stocks, such as 83/75 were also used on the late production Bf 109s, while the very low contrast ground defensive colour combination of 81/83 being seen on some Me 262s and Fw 190s.

ABOVE: 'White 3', a late production Bf 109 – either a G-10 or a G-14/AS belonging to the 1. Staffel of an unidentified Jagdgeschwader – one of two that crash-landed behind Allied lines at the end of the war. The camouflage was 83/75/76, with a soft-sprayed application of 02 over the side surfaces to tone down the 76-colouring. The 'yellow' elevator was, in fact, just the yellowish-muddy spray that had been thrown up during the belly-landing. The Balkenkreuz and Hakenkreuz markings were of correct style. The presence of just a spiral spinner marking, and no yellow tactical markings, indicates that the aircraft had been serving with a unit on the Western Front, yet it lacked any Reichsverteidigung band markings, something that became more frequent in the closing weeks of the war. (J. Crow)

BELOW: The second aircraft to crash-land was 'White 8', also a 1. Staffel machine, and presumably from the same Jagdgeschwader. A Bf 109 K-4, it had a camouflage that appears to be of darker combination, possibly 81/83. The lower side surfaces of the fuselage were 76, but again the yellowish mud thrown up during the belly-landing has added a yellowish colour to the undersides. Again the aircraft lacked any Reichsverteidigung markings. (J. Crow)

The November 1944 camouflage directive, D.(Luft) T.2335 issued in December 1944, for the Do 335 heavy fighter, had listed the camouflage colours as 81 dunkelgrün, 82 dunkelgrün and 65 hellblau. The latter was specified for use until all remaining stocks had been used, after which 76 was to be substituted (though bare metal surfaces did finally supersede the 76 instruction). The first prototypes of the new heavy fighter, the first fighter for that company, had used not the prevailing fighter colours of 74/75/76, but the contemporary bomber finish of 70/71/65. The company no doubt had received permission to employ such colours, probably because of the small quantities of paint that would otherwise have had to be acquired for a design not yet approved for manufacture. The fact that the company had used two greens for its main production aircraft series (all bombers) since 1938 may have inadvertently influenced the incorrect written descriptions.

The Do 335 A-02 heavy fighter, captured by US forces, was examined in detail before its shipment to Oberpfaffenhofen [10] in the early 1970s for restoration. The original finish was light green 82 and dark green 70, one of the two combinations permitted for using up old stocks of 70 or 71 with the new colours of 81 and 82. As such the aircraft, in its original colours, was a rare surviving example of that policy. It was subsequently restored in accordance with the November 1944 camouflage directive, D.(Luft) T.2335, using colours 81 and 82. Comparison with original wartime black and white photographs of the aircraft confirm a low contrast scheme, the actual camouflage pattern being difficult to discern. The propeller blades, in 70, provide a good colour check for nearby parts of the structure. With 65 still being specified for the under surfaces, the Do 335 carried a completely unique set of colours.

The camouflage scheme for the Me 262 had also been revised, as of 26 September 1944, with colours stated correctly as braunviolett and hellgrün (see page 79). That directive in turn had been revised and a new one issued on 23 February 1945 that stipulated the same colours for all upper and side surfaces; however, lower surfaces were no longer to be painted other than for the wooden undercarriage doors (which then replaced the metal ones), the metal RATO panel, and the undersides of the engines. It should be noted that such revisions did not always precede the actual physical change to camouflage, and Me 262 production had already moved to use of 81 and 82 by the date on the September camouflage document. This seems simply to be a case of formalisation of verbal instructions that would have required nothing more extensive than a hand-written amendment to the RLM colour code numbers on the contemporary camouflage drawing. A letter subsequently confirming that instruction, and a revised copy of the document with the amendment date included in the legend in the lower right-hand corner, was all that was required to formalise the changes. On the production lines, a simple change of colour of lacquer stocks supplied to the painters would not have required any changes to painting practices.

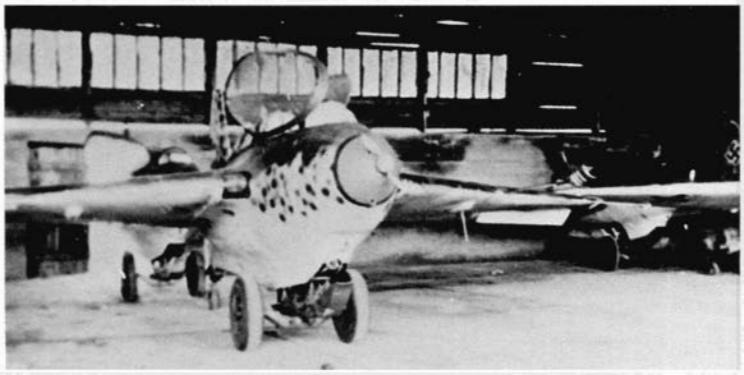
No factory directive has been located for the Bf 109 K, which appeared wearing a 75/83, 75/82 or an 81/82 finish on upper and side surfaces. Dispersal of production facilities was reflected in this model with pre-camouflaged sub-components at times being colour mismatched, producing hybrid camouflage examples. One last significant change occurred from about late February – early March 1945 with upper surface camouflage being extended down the sides of the fuselage to produce an improved ground defensive scheme.

Surviving photographic evidence for the Me 163 B-0 series of Erprobungskommando 16, the test unit charged with bringing the aircraft up to operational standard, shows all were initially in 76-overall finish with only black Stammkennzeichen marking for identification (this was replaced). Some early, but unsuccessful, attempts at operational interceptions were flown in May by these aircraft in this finish. This colouring was later replaced around September 1944 with a full defensive

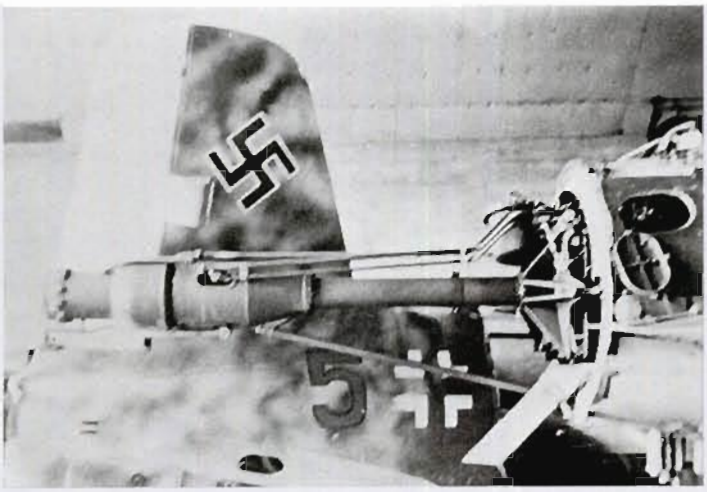
ABOVE AND LEFT: Two photographs of Me 262 W.Nr. 110604. The camouflage of 81/82/76 can be seen more clearly in these photographs, taken during routine production acceptance testing at Lechfeld. After completion of its acceptance flight, this aircraft had been marked with a red '1' number in preparation for its transfer to 11./EJG 2.

RIGHT: The prototype aircraft of the Me 163 B series retained their overall 76-finish until August 1944, by which time camouflage was considered essential. Seen here is the V 35, W.Nr. 163 10044, GH+IN. The rudder was a replacement, still in dark red-brown fabric primer.

LEFT AND BELOW: Two photographs of the Me 163 V 45, W.Nr. 163 100 54, which carried the Stammkennzeichen PK+QP until all the test series aircraft had been allocated a new form of identification; 'C1' followed by a two-digit number sequence and PK+QP had become C1+05. The 'C1' code was marked in black, one quarter the size of the individual code, as per the new regulations, while the two-digit number was marked in white on each aircraft. The camouflage was 81/82/76, the tall tail surfaces mottled with both colours.



LEFT: The diminutive Me 163, of mixed wood and metal construction, received full camouflage despite the austerity measures. Issued to JG 400, this particular machine wore an 81/82 camouflage with spots of both colours applied to the nose area. The nose cone was 04 with a 23 coloured line dividing it from the camouflage.



LEFT: The rear section of the fuselage of Me 163 B 'Red 5' of JG 400, showing the heavy mottling of 81 and 82 over the base green-blue colouring of the fin and rear fuselage. The rudder was a replacement still in 76. The Hakenkreuz marking was an obsolete form, but the Balkenkreuz marking was correct for the period.

RIGHT AND BELOW: Me 163 B, W.Nr. 191907, formerly on the strength of JG 400, camouflaged in 81/82 to the RLM stipulated standard pattern. The starboard side of the fin and rudder had a dense mottle of full strength 82 (bottom left and top right) with some very thinned out 82 in the centre over the green-blue base colouring, and just a touch of very weak strength 81 at the centre of the fin. On the port side, the 82 was confined to a solid mass at the tip of the fin, with a very thinned out application used as a mottle on the remainder of it. The rudder had been sprayed with a similar combination to that used on the starboard side, very thinned out 82 at top and bottom with weak strength 81 in the centre, but applied in more linear form. This unmatched style of application and colour density illustrates differences resulting from the common practice of two men painting an airframe simultaneously, one each side. (G. Bell and N. Daw)

camouflage in the revised 81/82 scheme on upper and side surfaces. The application was a solid one, with only some rudimentary mottling added to the vertical tail surfaces to break up their stark mass, though at least one had its fin and rudder also painted in solid camouflage colours. At that point, a rudimentary unit code system had been introduced to replace the Stammkennzeichen markings following formal instruction in July 1944 to all manufacturers and units to remove such markings.

Meanwhile, 20./JG 1 at Wittmundhafen had been renamed I./JG 400 in February, formal notification being sent on 1 March 1944, and the unit received its first operational Me 163 B on 10 March, five more aircraft being delivered over the next five to six weeks. Flying had commenced on 15 March, but a subsequent order forbade the unit to attempt any operations for the duration, excepting training flights.

This indicates that production aircraft were being delivered in the contemporary camouflage finish of the period - 74/75/76. Further development work on the Me 163 B was cancelled in April and industry told to concentrate on delivering production aircraft to contemporary standards; further indication that more aircraft were to be seen in the existing fighter finish. Amongst the few positively dated photographs is one showing the first Klemm-built Me 163 B delivered to EKdo. 16 at Bad Zwischenahn in January 1944. It was finished in 76 with a broken mottle of 74 applied over the upper and side surfaces, including fin and rudder. Wing upper surfaces are harder to distinguish, but it does show a solid application in two colours, presumably 74 and 75. This distinctive style of application seems to be characteristic of Klemm production. While the bulk of the Me 163 B production cycle would wear 81/82/76, it is clear that those upper surface colours could not have been in use that early in 1944 on production aircraft.

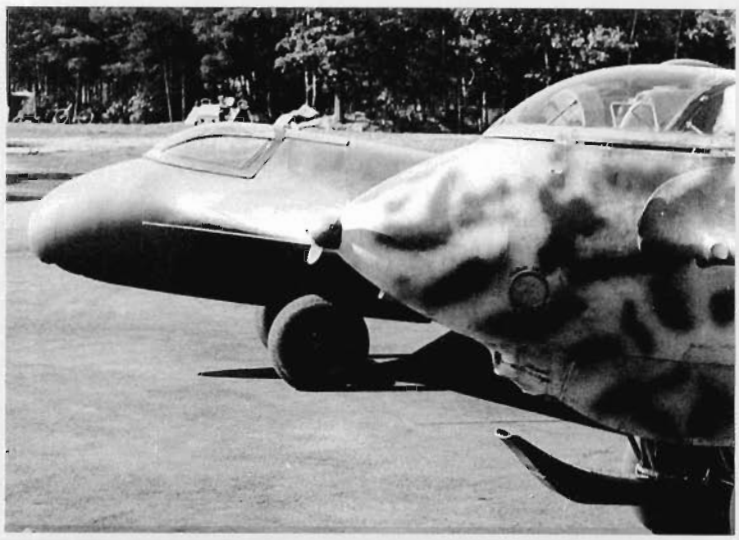
Apart from a single, distant, sighting (an EKdo.16 machine) reported by a Liberator gunner on 21 April, the first combat encounters with the type occurred on 28 July when an escort of eight USAAF P-51s, of the 359th FG, sighted five Me 163s at 32,000 ft during a sortie to Merseburg to bomb oil installations. The subsequent debriefing reports of the P-51 pilots included the comment *"...camouflage was rusty brown and highly polished."* At first glance this appears to be perhaps an 81/82 upper surface finish, yet the date is far too early; fighter aircraft would not adopt the 81/82 finish until September at the earliest. It is possible that it was a 75/83 scheme, but even then the chance that the Mustang pilot could identify the brown component of the green under such circumstances stretches credibility.

One possibility is that this might have been the red-painted machine flown by Wolfgang Späte, the well-known painting episode having taken place at the beginning of May; but there is no evidence to prove that it still retained that colouring in July. Had it done so the red, with a high degree of beeswax polish on it, may have been sufficient to generate the remarks from the P-51 pilots - but there is nothing to support this assumption. I./JG 400 and Ergänzungsstaffel/JG 400 had transferred from Bad Zwischenahn to Brandis early in July, which eliminates them as being the source of the aircraft described, and the last operational sorties from Wittmundhafen had been flown on 7 July. However, 2./JG 400 was established at Bad Zwischenahn at the beginning of July, but had no aircraft of its own. The fact that the P-51 pilots had been able to see both its colour and highly polished surfaces makes it difficult to fault their colour description or identification of the type. Whatever its nature, the 'rusty brown' colour remains a mystery. A second encounter had occurred during a raid to the same target the next day, with an Me 163 being claimed as destroyed in the Wilhelmshafen area (again an area covered by the Bad Zwischenahn and Wittmundhafen airfields). That would seem to point to Ekdo.16 being the only probable source of the aircraft encountered.

Reference to the highly polished finish is significant. Eventually, painting for this fighter required a final coat of wax, usually beeswax, something confirmed by a former German national who had been employed in the production of the Me 163. He informed the author that great care was taken with these machines to ensure as perfect a surface finish as possible. In particular, any small indentations on the front sections of the wings were carefully filled and polished with 000 gauge steel wool and waxed to reduce drag. The visibly polished finish referred to in the debriefing report confirms the extent to which efforts were made to maintain the aerodynamic efficiency of the Me 163. While the result of polishing negated some of the ground defensive camouflage effect, which required a matt finish, flight efficiency was of more importance. That care had not been always present earlier in the production cycle. The monthly report for May covering EKdo.16 had noted several faults, including a total disregard for surface treatment of the fuselage, citing raised joints, lack of filler, un-faired canopy hinges (which were quite large), a poorly fitted skid, and use of 'normal' paint which peeled off in large flakes. The term 'normal' is ambiguous, meaning that the normal aircraft lacquer peeled off, not some specialised finish. The poor adhesion problem was probably related to the reduction in use of primer finish for metal. The wooden wings were given the standard wood treatment finish prior to final painting, but priming for metal parts, other than 02 on the armoured nose cap, had been eliminated.

The slow rate of supply from the manufacturer meant that the 81/82/76 finish was the most common for those Me 163s which entered operational service. The final factory camouflage scheme for the Me 163 specified 81/82 for upper surfaces with 76 for lower surfaces. Some production centres added dense mottling to the nose area forward of the wing and also to the vertical tail surfaces. In most

ABOVE: Me 163 B W.Nr. 440014 of 2./JG 400 was a Klemm-manufactured aircraft, its style of camouflage being very similar to that shown in the photograph of W.Nr. 440165. However, as Werknummer blocks were not issued sequentially, for security reasons, it is not possible to determine how closely together the two aircraft were manufactured. The unit records indicate that 2./JG 400 had been equipped with some Klemm-built Me 163 Bs by mid-year, prior to the change to 81/82/76 for fighter camouflage. The very dark mottles on these early machines were a solid application of 74, which contrasted strongly with the pale washed out 76-coloured background. An area of 75 can be seen just in front of the cockpit.



ABOVE AND ABOVE RIGHT: Two photographs showing an Me 163 A and the first Me 163 B, W.Nr. 440165, delivered from the Klemm factory in January 1944. The latter had a camouflage of 74 mottle over 76 on the fuselage, and what appears to be (logically) a splinter pattern of 74/75 on the wings. The high contrast between the mottles and the background colour resulted from the use of very dense mottles of solid 74.

instances this was done using a combination of the two upper surface colours. Given that there is evidence from the surviving records of EKdo.16 that its aircraft had been given full defensive camouflage (74/75/76), and allocation of the unit code 'C1', by the third week in August, final revisions to the camouflage scheme for the type must have been formulated by September, (the RLM directive issued on 13 September 1944 for the experimental BV 155 stipulated colours 81 and 82).

The initial 'Oberflächenschutzliste 8-162' of 9 January 1945 for the He 162 evinced a distinct change in this part of the production cycle. For the first time since introduction of the revised camouflage grids of 1937, use of the standard grid system to define areas of colour had been abandoned, replaced by a schedule of colourisation of individual airframe components. Again no written colour descriptions were given in the seven-page schedule, which may be summarised as follows; outside metal joints and rivet heads were to be sealed with filler paste but no undercoat was specified, and only a single sprayed coat of each camouflage colour was to be used. The upper third of the fuselage was to be 82 merging, by means of a curved line, into the undersurface colour of 76. The engine was to be 81 overall, port wing uppersurface 82 and starboard wing 81; undersurfaces 76. Landing flaps were the reverse of the wing colouring, i.e., port flap 81, starboard flap 82 with lower surfaces 76; the leading edge upper and lower colours merged in a 25 mm line. Ailerons, which were interchangeable, were 82 on both upper and lower surfaces. The port horizontal tail plane was to be 82, starboard 81. Port elevator 81, starboard 82 with lower surfaces 76. Leading edge to be painted with a line of 76 sprayed by a 50 mm onto upper surface colour. Vertical tail surfaces and rudders were to be 76 overall. The cockpit interior and wheel wells were to be finished with a single coat of 66.

That new system may have been intended eventually for a wider range of aircraft types. Had it been more universally adopted, it would have eliminated the hybrid schemes that were resulting from the sub-manufacturing process. It would also have eliminated the need for any form of camouflage drawing.

The conservation of strategic materials directive specified painting only wooden components on lower surfaces and the above schedule did stipulate that parts made from aluminium were to be left unpainted. However with all-wood wings, forward fuselage and tail unit, the diminutive He 162 left little but its metal rear fuselage under surface to be devoid of paint. Possibly for ease of production the entire under surface was painted. Some captured examples examined wore the unidentified green-blue colour as recorded by British artist C. Rupert Moore who took colour samples, but whether that colour was used exclusively for the small numbers of this type completed, or in addition to 76, has not been determined. The new camouflage directive obviously entered the system after some production machines had been finished because examples were seen wearing a camouflage pattern similar to that seen on other fighter types, with segments of colour along the fuselage and across wings and tail plane.

The Bachem Ba 349 was also nearing service debut. Its category was unique, this diminutive manned rocket interceptor being classified as a missile because of its single sortie capability, but its role technically was still that of a day fighter aircraft. Prior to entering this final phase, it had worn no camouflage, retaining an overall finish of 02 or 05 but during the last days of its test cycle the type had received a rudimentary camouflage of 82 applied as a dense, sprayed scribble pattern over the overall finish of 76 on the upper and side surfaces. The choice of 82 appears to have been influenced by this type's need for some form of ground defensive camouflage because of its unique fixed launch properties. On the test airframes, lower surfaces, from the trailing edge of the wings to the nose cone, were divided longitudinally on the aircraft centre line and painted 22 black to port and 21 white to starboard. This was done for easier telemetry tracking. No national markings were added, though the intention to recover the main part of the airframe after each sortie may have changed that once the type entered operations. In accordance with the contemporary directives to preserve wooden components by painting, the lower surface black/white colouring also would have been replaced by 76.

A similar role was intended for the piloted version of the V-1 missile, the Fi 103 A-1/Re 4, 'Reichenberg'. It too was treated superficially as a fighter aircraft and as such had a camouflage using 82 as the base colour with mottling in what appears to be 83 with lower surfaces being 76. (The two-seat training version, wore a sombre 81/83 low contrast camouflage, possibly because of its un-powered glider-like role). Like the Ba 349, the Reichenberg's fixed launching requirement called for a ground defensive camouflage.

Even in the last months of the war the bulk of aircraft *in general* had maintained a fairly consistent standard with regard to the camouflage patterns employed for each type, though the type of standard pattern application could vary, i.e., high demarcation or low demarcation on fuselage side surfaces etc.

The exceptions however were just that, exceptions, and by their very nature stand out in any photographic record; these changes and additions had been produced after they left the main production centres, reflecting attempts by specific maintenance and repair units to meet more localised battle needs. For example, there were instances where Me 262s had been delivered in camouflage that was subsequently judged to be unsuitable and additional colouring had been added to provide a better ground protective finish. Often that was nothing more than a spray of another colour to break up the mass, or ragged lines of another colour over the base colours - in each case the amount of alteration was relatively minimal and with the Me 262s operating from a few permanent airfields in Germany, the work probably had been done on site. But for the most part, the system of standard camouflage for fighters had endured to the end.

1. David Vincent interview with E Heydrich.
2. PRO/AIR ??/226.
3. Dr. William Berge research.
4. Ferdinando D'Amico research.
5. PRO/AIR 24/592.
6. Dr. James H. Kitchens correspondence.
7. Thomas Dietz correspondence.
8. Philipp Hilt research.
9. K. Bokelman correspondence.
10. T. Dietz correspondence.

THIS PAGE: This underground production plant in a salt mine at Egein in Austria, held approximately 40 He 162 A airframes under construction when the site was captured in April 1945. The neutral coloured plasticised sealing paste, applied to the rivet and nail heads along frame lines, can be seen. Applied with a spatula, its was then sanded back to a smooth finish. The metal rear fuselage section on the nearest aircraft had line after line of the black identifying code numbers (RIGHT) for the grade of aluminium sheet used. Under certain lighting conditions marks such as this tended to show through the very thin, single-coat lacquer finish of the final camouflage. Internally the airframe was left unpainted.

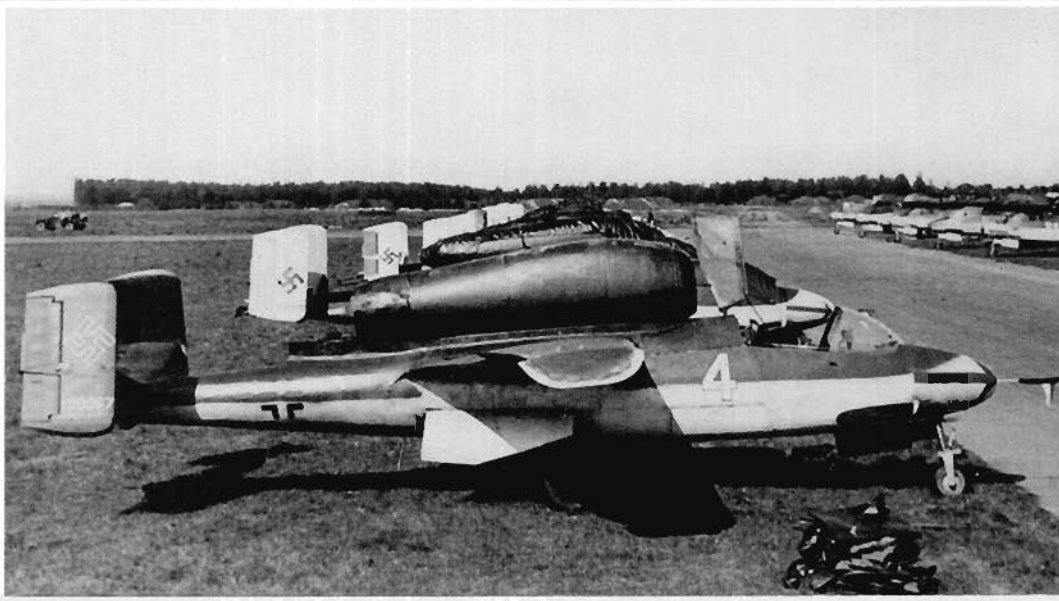
LEFT: The third Junkers-built He 162 A-2, W.Nr. 310003, produced in late February/early March1945, and armed with two MK 108 30 mm cannon. The diminutive airframe of mixed wood and metal construction resulted in the type being camouflaged on all surfaces despite austerity measures then in force. Although the official painting schedule for the type called for an 81/82/76 scheme, upper surface camouflage here was the low contrast 81/83, with possibly green-blue lower surfaces.

RIGHT: A rare colour photograph of an He 162, 'Yellow 4', W.Nr. 120067, of 1./JG 1 showing the 81/82/76 scheme. The final painting instruction for this type had set down a system of component colouring, rather than the usual random shape pattern in the two upper surface colours. However, close examination of this photograph, and also a black and white photograph of the same aircraft, taken at Leck in May 1945, show that the 81 and 82 had been applied in the old standard style. The entire tail plane section had been replaced, the original one, bearing the Werknummer in white and a white outline-style Hakenkreuz, had both surfaces of the fin and rudder assemblies in full camouflage. Note the large area of red oxide metal primer on the tail cone of the engine, showing the poor adhesion of the baked black stoving enamel finish used for this heat sensitive component. (S.Coates)

RIGHT: Another well colour balanced photograph of an He 162 A-2 on display post-war. The 81/82 upper surface colours can be determined as well as the green-blue lower surface colouring. Compare the latter with the intense blue of the sky. By the time this aircraft had been built, 76-colouring had been reduced to a greyish-white colour with only a touch of blue in it.

LEFT: In this line-up of aircraft of 1./JG 1, the variation in demarcation between upper and side surface camouflage can be seen. Positioning of the unit emblem and aircraft identification numeral also varied. Note also the anachronistic Balkenkreuz marking on the fuselage of the nearest aircraft.

RIGHT: In the original photograph of these I./JG 1 aircraft, the colour division between the 81 and 82 camouflage could just be seen on 'Yellow 4', (see also photograph page 191) showing that the factory had not strictly adhered to the camouflage directive. The 81-segments run from the nose cone back to the fixed section of the cockpit glazing, and from just below the tail pipe to the end of the engine support fairing. The different finish to the wingtip and leading edge of the wing may be compared with aircraft in the previous photograph, the lower surface green-blue colouring being brought around onto the top surface to a depth of 50 mm as per the He 162 painting schedule introduced on 9 January 1945. The upper and lower surface colour division line was also different.



LEFT: The same machine, W. Nr. 120067 'Yellow 4' of JG 1, photographed under different light conditions after transfer to Kassel. Lack of 02-undercoat before application of the single coat of each camouflage colour allowed the filler paste lines to show through at this angle, making an interesting comparison with the previous photograph. The arrow marking was applied in red RLM 23.

LEFT: In complete contrast with the more often seen standard form of camouflage, this Fw 190 A-8, of II./JG 1, had an intense mottle of 81 over the basic camouflage of 82/83, producing a strong ground defensive camouflage. The original camouflage scheme segments can just be discerned on the wings but, as usual, the horizontal tail surfaces had been left untouched, retaining their plain 82/83 finish. (E. Mombeek).

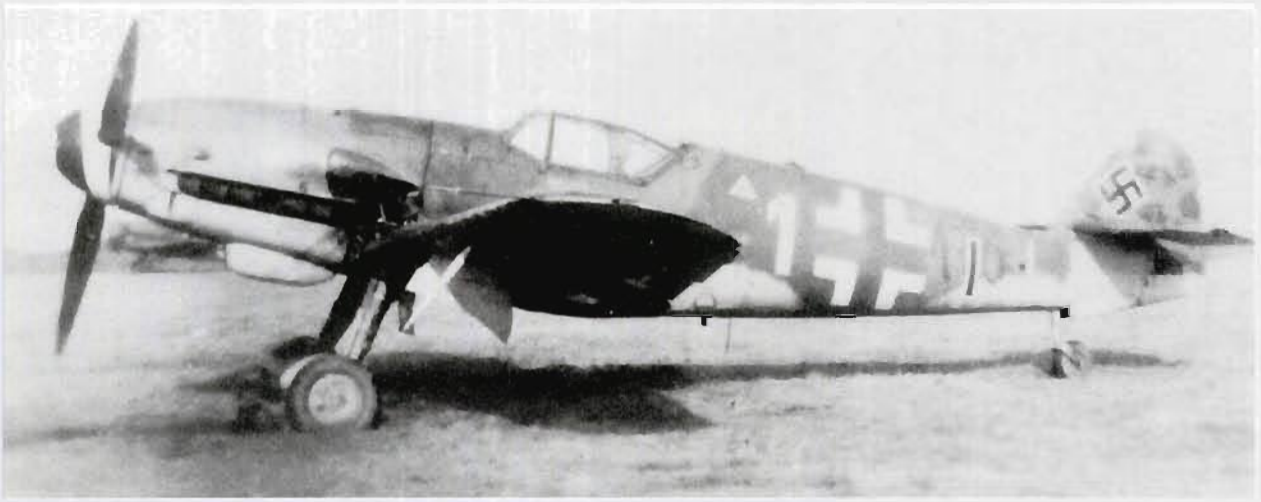
BELOW: Another Fw 190 A-8, W.Nr. 736336, 'Yellow 4' photographed at Fassberg, had camouflage of 82/83 with mottling in both colours. The 83-colouring predominated along the fuselage spine, mottling over the small areas of 82 and toning down the latter. Again, mottling and soft spraying with 83 on wing upper surfaces had almost obliterated the soft-edged segmented pattern, but the paler 82-colouring could still be seen as lighter coloured areas (note the inboard section of the port aileron). Side surfaces were in 76. (D. Vincent)

LEFT: A group of Fi 103 Re 4s, the piloted version of the flying bomb, gathered at a dump at war's end, possibly at Kassel where specific aircraft of interest were brought for possible onward shipment to the USA and the UK. Several styles of camouflage were used for the Fi 103, the earliest production machines using just a straight-line division between upper and lower surface colouring along the fuselage central horizontal datum. Later production batches showed a more varied form of camouflage, from dense mottling to the more minimalist style shown here. Often, mismatching of wings and horizontal tail surface and fuselage components produced some hybrid schemes, but it was of little consequence given the expendable nature of the weapon. While the piloted version of the weapon had all been produced at Dannenburg, even there different production batches displayed specific camouflage styles. These machines were late production weapons. Note the dense colouring used on the nose cone, a sub-component added after assembly of the remainder of the airframe. The camouflage was 76 with thin lines of 82 in a scribble pattern. The darker colouring of the nose cone appears to be 83 rather than 81. (S. Coates)

ABOVE: From the same batch, this part airframe shows the centre section and nose sections with their different camouflaging. The solid 83-colouring of the nose section had streaks of 82 added to roughly blend the upper and lower surface colours. The centre section had the same minimalist random lines of 82 over 76 as seen in the previous photograph. (S. Coates)

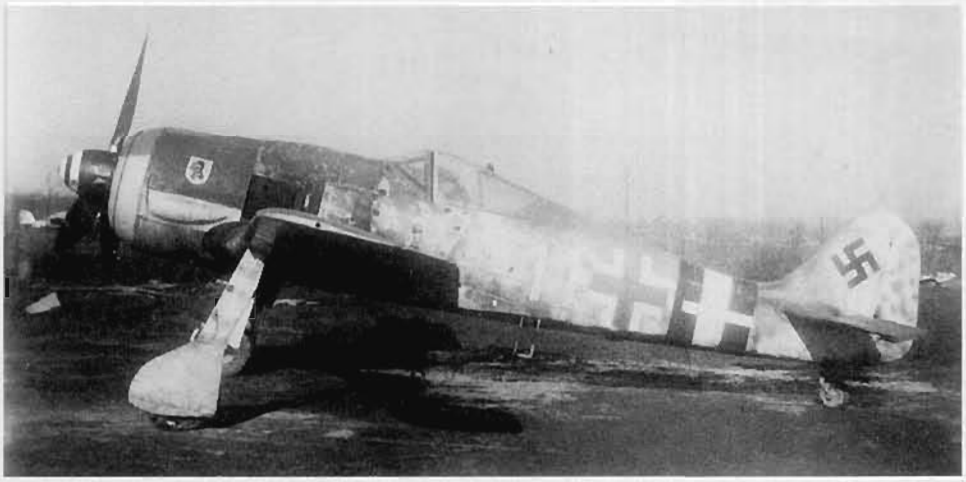
ABOVE: On the far left of this view of a group of surrendered aircraft is Bf 109 K-4, W.Nr. 334183 (marked on the fin tip, and in larger numerals at the base of the rudder), the seventh produced. Note the distinct variation in camouflage style with the fuselage lower surface colouring, brought right up to a very high demarcation line with a sharp edged division. Richness of tone of the side surface colouring indicates green-blue rather than the colder 76, while upper surface colours were 82/83. The fin and rudder of both machines wear identical forms of camouflage; they are sub-components produced with a stencil, painted before delivery to the final assembly plant. However, in this case the fin, while colour- matched to the rudder, was not from the same batch; the mottle did not match up, an anomaly occasionally seen on other Bf 109 Ks. The last three digits of the Werknummer, '183', had been hand-painted on the rear of the fuselage, at about the same angle and in similar style to that on Uffz. Deskau's machine, reinforcing the fact that they had originated from the same production centre. The He 219 airframe in the foreground had a 76 overall finish lightly mottled with 75 as did the Ju 88 G night fighter on the far right. (S. Haggard)

LEFT: Somewhat more consistent with camouflage patterns, if not always the colours used, were the late war piston engine fighters. Fw 190 D-9, W.Nr. 601444, had standard 74/75/76 finish with a solid application of the darkest colour forward of the canopy. The shattered canopy has exposed the 66-coloured, elongated headrest.
(P. Miller via M. Olmstead)



ABOVE: Bf 109 K-4, W.Nr. 334176, 'Yellow 1' of 11./JG 3. Photographed at Pasewalk in April 1945, it was camouflaged in 75/82/76 on upper and side surfaces, with the darker camouflage brought down the fuselage side behind the white outline form of the Balkenkreuz marking to provide a dark background. The last three digits, '176', of the Werknummer, had been roughly painted aft of the marking, an incorrect practice that became common at some Messerschmitt Bf 109 production centres after July 1944 when Stammkennzeichen markings were deleted for security reasons. The order required only the full Werknummer to be marked, on either side of the vertical tail surfaces, but this was increasingly implemented as shown here, stencilled in black at the base of the rudder, where the 76 camouflage ended. The use of three digits as quick identification had long been an 'in-house' production practice for Messerschmitt factories, but the marking was normally lost beneath the final camouflage. Retaining this form of identification as a permanent feature was peculiar to Bf 109s. The underwing Balkenkreuz marking was the simplified, but incorrect form, using only the black central cross section. The Hakenkreuz was also incorrect for the period, it being the obsolete earlier form. The pale white vertical stripe next to the tie down hole at Frame 8 was not part of the unit markings. Its purpose is unknown but it may have been a trestle support point marking – if so, it was unique. (Martin Deskau)

LEFT: Proof positive of at least one of the late war camouflage colour combinations used on Bf 109s. The rudder from Hptm. Müller's late-model Bf 109, either a G-10 or K-4 variant, showing the base colour of 75 with stencil applied patches of 82. The pilot was the commander of I./NJG 11 at the time that he was flying this aircraft and the rudder was removed from it on 27 April 1945. Previous illustrations of this rudder sometimes have been misinterpreted as showing 81/82, the result of having been photographed in late afternoon sunlight, rich in orange light. The yellowish stain along the bottom edge is caused by deterioration of the lacquer film used in this paint. (via JaPo Publications)



LEFT: Gefr. Wagner's Fw 190 A-8, W.Nr. 681437, 'White 11' of 5./JG 4 captured near St. Trond in Belgium following Operation Bodenplatte on 1 January 1945. Camouflage pattern and colouring was standard, 74/75/76 with soft mottling in both colours, this being an older aircraft produced before the new camouflage changes had come into full effect. The port side engine cowling panel, bearing the unit badge, was a replacement in solid 74-colouring. On the starboard side, the upper surface camouflage line came down only to the top of the exhaust panel. The 900 mm Reichsverteidigung band was black/white/black. (F. Smith)

LEFT AND BELOW: These two colour photographs of the same aircraft help illustrate the overall finish of W.Nr. 681437. Note the starboard side of the engine cowling retains its original panel. This swapping of parts could produce some unusual camouflage effects. The black/white/black Reichsverteidigung markings were 900 mm wide. (Col. Leo C. Moon)

LEFT: Some of the more radical camouflage schemes seen on Me 262s were simply looser applications of standard colours. This machine of the Stab JG 7 had had its original high demarcation pattern and softer, side mottling overpainted with streaks of 82 and then 81 to break up the pale side surfaces. Close examination of the fin shows where 82 had been sprayed in a block and then streaked with 81 to almost eliminate the original 76 colouring. This appears to have been a late war conversion to improve static camouflage. The Hakenkreuz marking had probably also been repainted in white in the process. A '3' outlined in white was marked beneath the unit badge. The unit's blue and red Reichsverteidigung band was marked around the rear of the fuselage.

RIGHT: The two contrasting camouflage schemes seen here on these Me 262 A-1a aircraft of JG 7 illustrate the growing proliferation of modified camouflage styles that marked the closing months of the war. The aircraft in the background had an 81/82/76 scheme, with some mottling in both colours to soften the stark whitish-grey colouring of the late war 76. The nearer aircraft utilised the same colours, but applied both as solid applications, the contrast between the 81 and 82 being more readily seen than in more usual camouflage applications to the type. The bands of 81 were extensions of the main blocks of that regulation camouflage pattern colour. (P. Petrick)

LEFT: Another JG 7 Me 262 A-1a, camouflaged in a similar style to the previous JG 7 example. The mount is that of the Geschwaderkommodore, marked with white-edged black rank markings and with a pale outlined small '4' below the unit badge. It had had its basic 81/82 camouflage heavily modified by adding a dense mottle of 81 to most of the airframe sides and upper surfaces. The Hakenkreuz is backed by an area of 82, no doubt being left to frame the marking. Two darker shades can be detected on the rudder so 83 might also have been employed in the scheme, and that would account for the near monochromatic effect of the general camouflage. Close examination does reveal that the very darkest areas on parts of the fuselage are in fact composed of two dark shades of colour. The side area of the engine is in 76 but lower surfaces were most likely bare metal, other than for the nose section. The blue and red Reichsverteidigung marking has a ragged line of pale colour just aft of its trailing edge, possibly 76, with a small area of 82 at the base of the fin. Why this odd combination was used is unknown, as it could have had little value with regard to the overall camouflage finish.

THIS PAGE AND OPPOSITE TOP: Fated never to enter service in numbers, the Ta 154 however had had some minor operational service during field-testing. This Ta 154 A-1/R1 day fighter, W.Nr. 320003, found abandoned, had camouflage of what appears to have been 76 closely mottled with 83. Note that the engine cowlings had a much paler mottle of 83 while the nose section of the airframe was in 76 with only patches of 02 primer. Over the 83 mottle, a spray of two other colours had been applied to various major sections of the wing, fuselage and tail plane. The deliberate omission of a small area of 76 on the leading section of the fin may have been intended to break up the outline of that large element of the airframe. Close examination of the wings shows that the lighter of the two other colours had been applied over much of it, with the same colour taken right down the starboard, but not the port side of the fuselage, which remained in 76. This was probably 82 because the darker mottle shows through it. The distinctly darker section on both the starboard wing and horizontal tail surfaces was probably 81. Examination of the horizontal tail plane shows the port side had a mottle of 83 with 82 sprayed over it, while the starboard side fixed section had the same colouring, plus a dark section of 81. Paradoxically, the elevator had a large section of its base 76 colour showing with no mottling, only a segment of 81 across it. The fact that that segment does not line up with the same colour on the fixed section indicates that it was a replacement item, probably from another airframe. The trailing edge wing/engine fairings had also been cannibalized from another machine. The consistency of colour combinations on those other parts points to a general adoption of this combination of 81/82/83/76 for the type. (D. Wadman)

BELOW: A clear example that late production Bf 109s were also appearing with bare metal under surfaces to their wings. Part of a production batch of Bf 109 G-10s from the WNF factory, the airframe closest to the camera provides clear detail of the pre-painted aileron and elevator components, in very pale, almost off-white 76, and the bare metal surfaces of the remainder of the wing. Note the use of 76 sprayed as a rough border to the wing radiator fitting, possibly as a very crude form of sealing the joint between the two surfaces from excess moisture. The circular open hatches beside the radiator have their inside surfaces painted in 02 (the form that did not require precise colour matching). The other apparent 'colours' on the metal surfaces were simply produced by the different surface texture of each section. The overall camouflage of the aircraft was 75/82/76. Note the retention of the one-quarter to three-quarters white to black, spinner colouring on this and the aircraft to the right. The aircraft was photographed at Letnany airfield, in Czechoslovakia at war's end. (JaPo Publications)

APPENDIX

Export Colours

The steady increase in German manufacturing capacity during late 1930s allowed export of some versions of its aircraft, a policy actively encouraged by the German Government in its continuous quest for foreign currency credits against which to buy much needed raw materials.

Where the government of the country placing an order for aircraft did not specify a camouflage finish, the aircraft were delivered in the contemporary Luftwaffe colours; RLM 02 for maritime aircraft, or standard 61, 62, 63, 65-colouring for bomber aircraft. While the German Government allowed use of any of its existing Luftwaffe range of colours, where camouflage patterns were used on exported aircraft, they were not to be those in use by the Luftwaffe. This resulted in a range of distinct variations, from sweeping curves to straight, soft-edged geometric patterns. The only exception so far found to this rule was the first Do 17 K delivered to the Royal Jugoslav Air Force, in October 1937. The finish of 61, 62, 63, 65 was applied in the official Luftwaffe pattern for the type; the reason for this however, may have been the approaching change over to as 70, 71, 65 -finish for all classes of aircraft in 1938. (The initial order for 20 Do 17 Ks were built in conjunction with the Luftwaffe's Do 17 M variant, using the designations, Do 17 Kb-1 (bomber), Do 17 Ka-2 and Do 17 Ka-3 reconnaissance variants. The Do 17 K was also built under licence at the State Aircraft factory at Kralijevo from 1939, some 70 being in service by the time that German forces invaded the country in April 1940).

A letter written by the Swedish Air Ministry on 6 April 1938, addressed to Warnecke und Böhm, makes direct reference to use of that firm's Ikarol series of paints for corrosion-proofing of metal surfaces on the Ju 86 aircraft purchased.[1] Sweden had been the first to order aircraft from Germany, a contract for a single Ju 86 having been placed in June 1936, with delivery being made in December of that year. Further deliveries of Ju 86s had been made in 1937 and the aircraft wore soft-edged, slightly curving segments of 61, 62 and 63 with 65 lower surfaces. The Hungarian government also placed an order, for 24 Ju 86 K-2s, the camouflage being almost identical in form to that used for the Ju 86s of the Swedish order. Eighteen He 46eBu short-range reconnaissance aircraft, ordered in 1935, were delivered to the Bulgarian Air Force in 1936, once again the suffix ('Bu' in this instance) identifying the country of contract. This consistency of style of application indicates that there was some form of basic 'export-style' pattern adopted by some German manufacturing firms. This may have been done simply for efficiency, as each order would require a pattern to be prepared.

If the purchasing government specified a colour or colours other than the standard Luftwaffe range, existing German lacquer stocks were specially tinted to produce the required camouflage colours. This was simply a matter of producing a pigmentation formula to add to the standard base stock lacquer.

In addition to aircraft, Germany also exported spare parts, guns and munitions, but in 1937 a crisis situation had arisen. Aircraft production had been increasing in line with the military expansion plans, but a critical shortage of foreign currency credits threatened the supply of imported raw materials needed to keep the production cycle continuing. As a result the government boosted export sales even further, ultimately making Germany the leading exporter of aircraft.

In that year alone, 48 Ju 86s (sold to Sweden, Portugal, Chile and Austria), 24 He 111s (ten of which were sold to China), 19 He 46s (to the still clandestine Hungarian Air Force, the Magyar Királyi Légierö, and a part of 36 ordered under the designation He 46eUn – 'Ungarn' for Hungary), 15 He 70s, 12 Fw 58s, 12 Hs 123s, six Do 17s, three Ju 52/3ms and two Ju 87s were sold abroad. Recipient countries were Hungary, Turkey, Japan, Sweden, Austria, Rumania, South Africa, Spain, Argentina, Jugoslavia and Holland. Such was the need for foreign currency that the restriction on exporting the latest model of any aircraft type was further refined to the latest sub-model. Even that restriction was bypassed for countries deemed to be distinctly pro-German, such as Turkey, Hungary and Jugoslavia. By the following year, 1938, primary sales were built around aircraft in which the RLM had no particular interest, for example, 50 He 112s to Spain, 11 Ju 90s and 20 Fw 200s were approved for sale. RLM interest in the Fw 200 in particular would change in the coming years. The total volume of aircraft sales relatively was never large compared to other exports, but it earned a respectable income in foreign exchange between 1933 and 1938.

It has been recorded in many books and by many authors, including this writer, that a special group of RLM 'export' colours had been developed for export aircraft, namely RLM 64, 67, 68 and 69. The colour chart in the 1936 RAL document 'B. Richtlinien für die Entwicklung geeigneter Flugzeuglacke' – (Criterion for the appropriate development of aircraft lacquer), identified colours 64, 67, 68 and 69 respectively as dunkelgrün, weiß, schwarzgrün and dunkelgrün. Repetition of the same general colour description – dunkelgrün – for 64 and 69 underlines the lack of definitive written description at times, not only between contemporary documents, but also within some documents. The positive identification of those colours has now made it clear that no special colours had been designated for exported military aircraft types (seecolour chart). The RLM (Surface Protection List), issued in 1937 for supply to the Dutch of Do 24 Ks, clearly illustrates this point.

In 1937 the Royal Netherlands Government had placed an order for an advanced flying boat to replace its obsolete Do Wal aircraft, which equipped its marine force based in the Dutch East Indies. The resultant design became the Do 24 K, and 18 (W.Nr. 761 to W.Nr. 778) were ordered direct from the manufacturers with licence construction rights for a further batch. The RLM 'Oberflächenschutzliste' issued on 4 October 1937, and approved on 21 October, laid out the usual full painting schedule using RLM approved German lacquer stocks, but colour-matched to the MLD, the Marine Luchvaartdienst (Dutch Naval Air Service) standard of the period, i.e., light grey upper and side surfaces, with silver for under water surfaces.

The contract stipulated that the final external finish for all upper surfaces on Werknummern 761, 762 and 765 to 778 inclusive, would be '1 x Ikarol Decklack II hollandgrau 103/2 spritzen' (a single coat of Ikarol coat finish in Dutch grey using paint stock type 103/2 in a sprayed application). On Werknummern 763 and 764 the final coat was to be '1 x DKH Nitroemaille Hollandgrau L 40/52 spritzen' (a single coat of DKH

nitro-enamel lacquer in Dutch grey using paint type L 40/52 in a sprayed application). Underwater sections of all 18 aircraft were to be finished with, 1 x Ikarol Decklack silber 111/S spritzen' (a single coat finish in silver paint type 111/S in a sprayed application). The reason for the change from Warnecke & Böhm lacquers to DKH stock for upper surfaces is not explained, but both lacquers were interchangeable and may simply reflect a better purchasing price arrangement with DKH. In both instances the lacquer designations used identified only the non-pigmented base stock. Had 'Hollandgrau', the colour specified, been one available from normal RLM or RAL listed colours, it would not have required a specific designation, listed not once but twice.

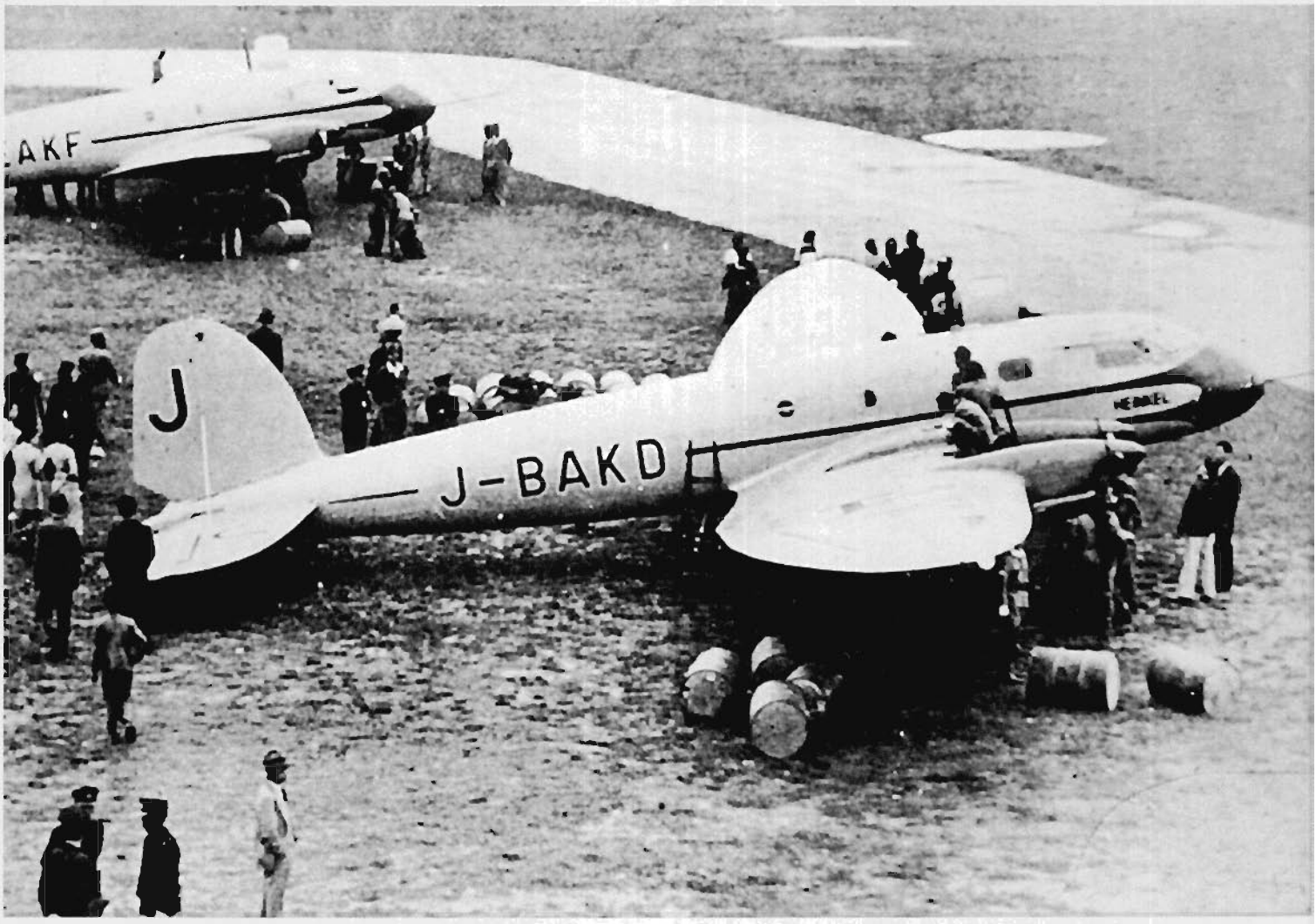
As a further example of the flexibility of the paint finishes requested at times, the He 46eUn aircraft, mentioned earlier, had been supplied wearing the Luftwaffe colours 61, 62, 63, 65, but applied in a soft-edged wavy pattern. The same style and four colours also were used for some of the Bf 109 F and Gs supplied later to the Hungarians, as well as for the Ar 96 As that they received, several years after the withdrawal of colours 61, 62 and 63. That flexibility remained possible because for those three colours the pigmentation formulae were still held by the various paint manufacturers. In addition, the colours themselves were also part of the national standards authority, RAL colour standards, so a precise match for each colour always existed. For the paint manufacturing company supplying the lacquers, it required nothing more than an adjustment of the individual colour pigmentation formula to rectify any colour influence of the current lacquer base stock. (The pre-war lacquers, in use when 61, 62, and 63 had been the Luftwaffe standard colours, had changed by the mid-war period as detailed in Chapters 4 and 5).

The soft-edged form of pattern adopted for export demonstration aircraft made accurate reproduction more difficult than its Luftwaffe angular equivalent, but this mattered little. The very small number of German owned and based demonstration or display aircraft also used distinctive, non-standard camouflage patterns. The Do 17 P displayed at the XVIe Salon de l'Aviation in Paris, in November 1938, wore camouflage of 61, 62, 63 applied in a soft-edged wavy pattern with lower surfaces in 65. Comparison with the pattern on the Do 17 Z-0 (D-AIIB), used for export sales demonstrations in late 1938/1939, shows some variations while adhering to the same colours and generally the same colour areas. Two pre-production Ju 86 E-0 aircraft, registered D-ALOH and D-AS??, used as demonstration machines, had a quite different style of camouflage application from those of the Do 17 P demonstration aircraft, more similar to the Swedish Ju 86 K pattern in 61/62/63 with 65 lower surfaces, indicating that each aircraft firm had its preferred 'in-house' style of pattern.

The Swedish Air Force eventually took delivery of 38 Ju 86 K aircraft and photographs of some of the different aircraft from this batch show that each aircraft had a slightly different pattern, a result of the relatively random nature of these patterns. There is some evidence from these photographic sources to indicate that the Luftwaffe system of using mirror image patterns had also been utilised on occasions. Exports of Ju 86s had also been made to Austria, Portugal, Chile and Hungary. Austria however received only one machine before the Anschluss, this Ju 86 being delivered in either treated natural metal finish or overall 63-colouring. The Hungarian machines used 61, 62, 63, 65 with upper surface colours in the same style of camouflage pattern and application as seen on the Swedish machines, as also did the Portuguese Ju 86s.

Junkers had also exported numbers of Ju 87 Bs to Italy, Bulgaria, Romania and Hungary; the surviving photographic record is sparse, but those supplied to Hungary show a scheme using colours 61, 62, 63, 65 with a soft-edged wavy pattern. This consistency of colours used on the various aircraft types purchased by the Hungarian Government illustrates both the preferences shown by some countries and the ability of the various manufacturers to comply with such requests. However, once the Luftwaffe three-colour upper surface scheme became redundant, that change was also reflected on late export aircraft, but interestingly, not on some of its display aircraft. The Ju 87 B-1 made its first public sales appearance in Western Europe as a static exhibit at the 1939 Brussels Air Show. It wore an upper surface finish that incorporated three colours using a more linear - but still not ruler-straight

BELOW: Turkey also bought the CH 132 for its domestic airline needs. Again the overall finish was identical, pale grey with black trim, the rudder being used in similar style to that of the Swiss to display the national identity, in this instance with the star and crescent national emblem of Turkey. The rudder colouring was red.



edges as in the Luftwaffe - soft-edged, pattern in 61, 62 and 63, with 65 for the lower surfaces. The aircraft carried no military markings (even though it had a bomb fitted), only the civil fin and rudder marking of a red banner with white disk and black Hakenkreuz.

The Hs 126 had also appeared as a static exhibit at the Brussels Air Show. It too wore a variation of the 61/62/63/65 scheme in the form of a non-standard, but this time, straight edged, splinter pattern. The Greek Government had placed an order for 16 aircraft, which were exported in the same camouflage colours and pattern of the display aircraft under the designation Hs 126 K. The constant use of the suffix 'K' for all export types signified 'Krieg' (war) to identify that the particular exported aircraft was a military type, a somewhat superfluous designation given that even the 'civil' designs of the day were disguised military types. (This did raise some unintended confusion within the western press once war broke out, most published photos in reports of the early months constantly adding 'K' to most types of German bomber aircraft.)

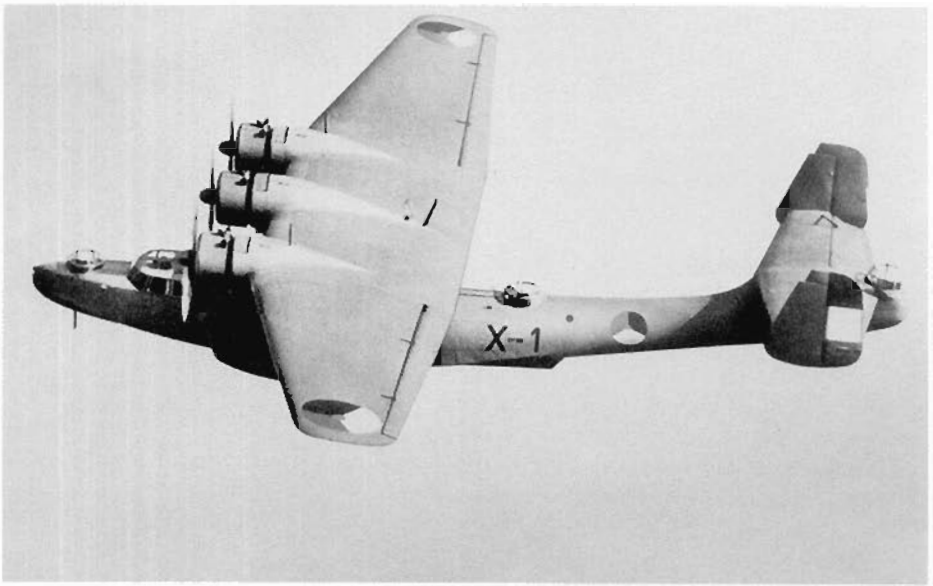
Exports also went out from the Dornier and Heinkel works, Do 17 Ks going to Jugoslavia and He 45s, He 46s, He 51s, He 70s and He 112s, in varying numbers to Hungary, Spain, and Romania. These appear to have used the standard three upper surface colours of 61, 62 and 63 with 65-coloured lower surfaces. Some examples, such as the He 45s delivered to the Royal Hungarian Air Force, had the same wavy pattern but with a crisp division between colour areas. The Do 22 three-seat reconnaissance and light attack aircraft, having been rejected by the RLM, was then cleared for export sales, and orders were received from Jugoslavia, Greece and Latvia. The first production model flew in July 1938 and photographs of the Do 22 Kj (the 'j' designating Jugoslavia) show it finished in 63-overall colouring.

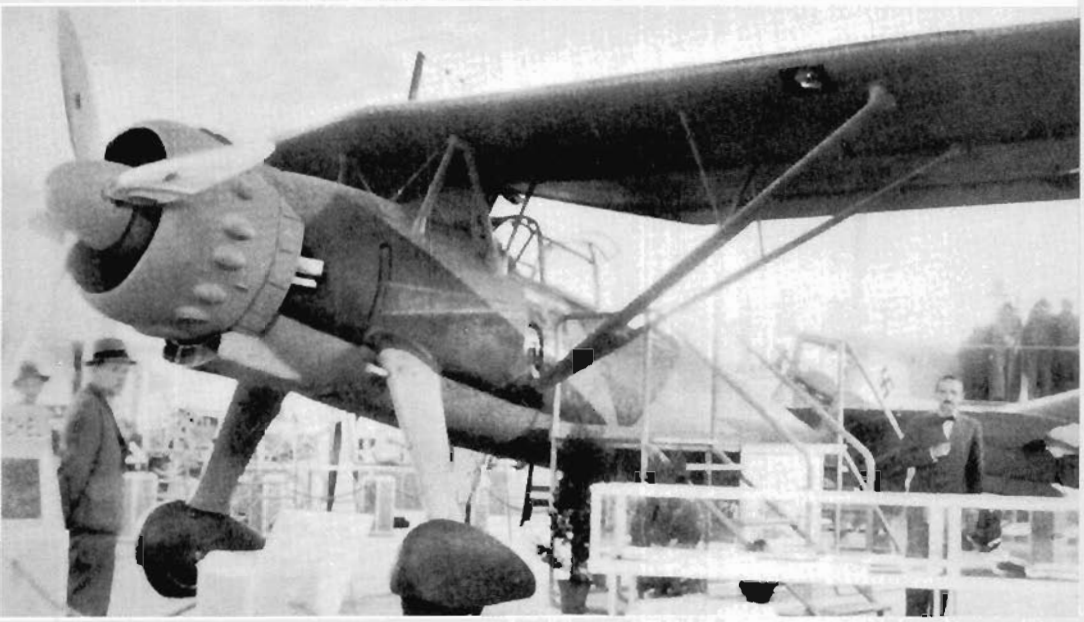
The onset of war finally put a stop to exports as German manufacturing industry expanded to keep pace with war needs and the inevitable rising attrition rate. Quite a number of additional aircraft, most of them fighters, were supplied to Axis partners as the war progressed, but those transactions were done on a different basis. While most were delivered in contemporary Luftwaffe camouflage, some, such as Bf 109 Gs supplied to the Royal Hungarian Air Force, were repainted in camouflage of the recipient country's choice. But even that aspect eventually changed very late in the war, with Luftwaffe camouflage becoming the universal standard for all such transfers of aircraft to the Axis allied forces.

ABOVE: The elegant He 116 design arose from a 1936 requirement by DLH for a four-engine long-range aircraft for its proposed Far East mail service flights. The high altitude engine designed specifically for the type never reached production status, but the He 116 V2 (alias A-02) and V4 (A-04) aircraft, fitted with Hirth HM 508C engines, were evaluated by DLH. Flying in the company colours, respectively they were registered as D-AJIE 'Schlesien' and D-ATIO 'Hamburg'. The Japanese government ordered two He 116 A-0s and these were delivered in colouring very similar to DLH grey with black trim, as J-BAKD (named Nogi) and J-EAKF (Togo). They left Tempelhof airport on 23 April 1938, reaching Tokyo six days later. Manchurian Air Lines operated them on the Tokyo-Hsingking route.

1. Michael Ullmann research and correspondence.

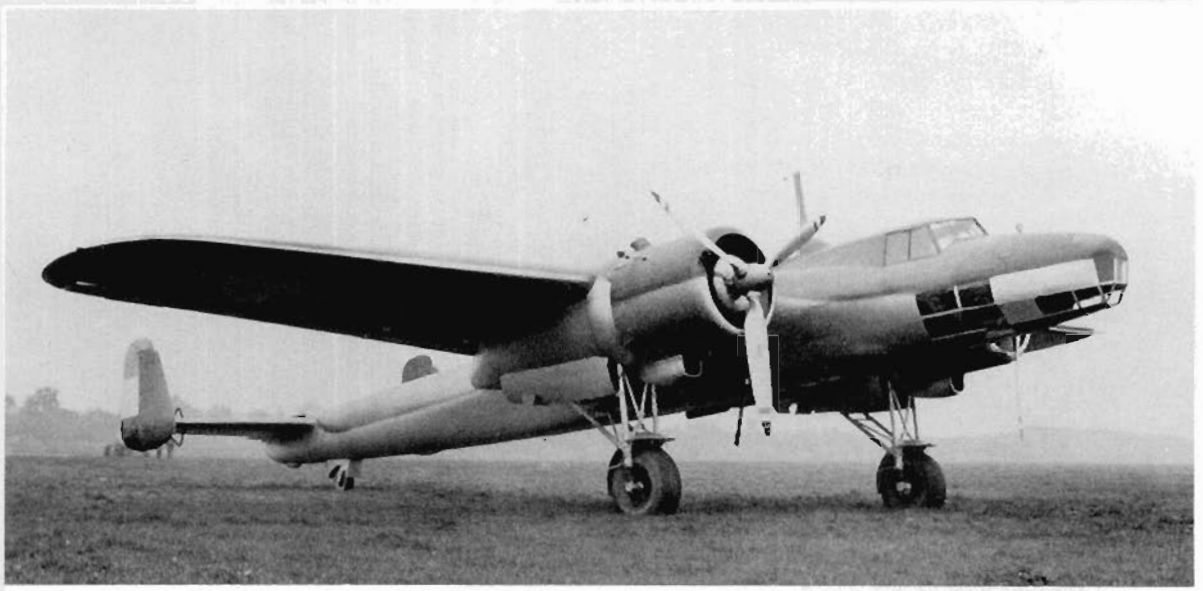
RIGHT: Eighteen Do 24 seaplanes were ordered by the Royal Netherlands Government in 1937, for use in the Dutch East Indies, and were supplied under the designations Do 24 K-1 and K-2 (the latter having more powerful engines fitted). Formerly the Do 24 V3, which had flown as D-AYWI, this was the first machine to be delivered to the Dutch. The paints used were of German origin, but tinted to the colour specified by the Dutch Ministry of Defence. The 'X1' marking was the code allocation for this type by the Dutch, the serials running from X-1 to X-37, (some of the intended production of 48 fully licence-built D 24 K-2s supplementing the original 18 German-built machines). Some of these aircraft were subsequently lost during a refuelling stop, in Broome harbour when the Japanese struck targets in north-western Australia. They were still packed with civilian refugees who had just been flown down from the fall of Java, and the death toll was extremely high. Others were taken over by the RAAF. (J.Radziwill)



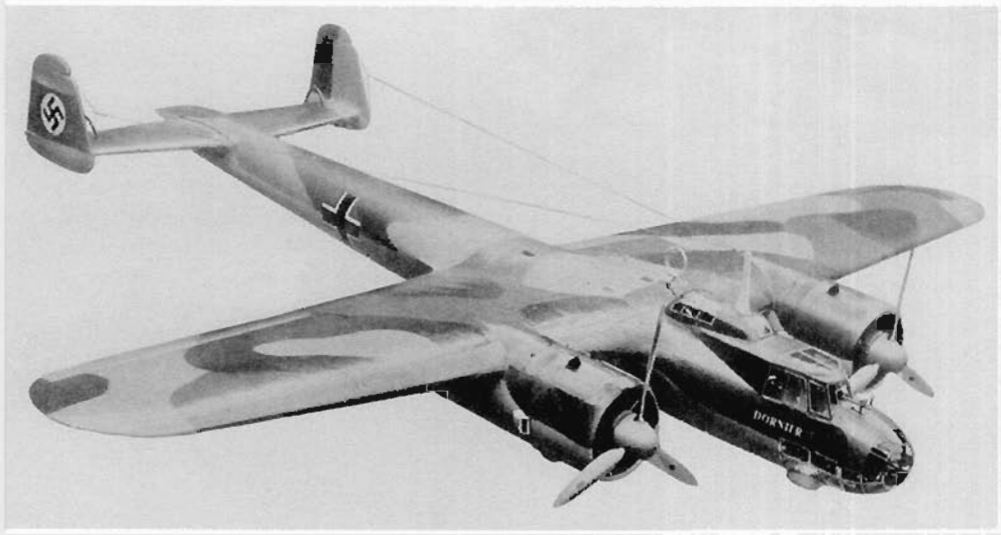


LEFT: As part of ongoing German export sales, the Greek government had purchased sixteen Hs 126 A-1s. This example, displayed at the static exhibition of the 1939 Brussels Air Show, had a splinter pattern of 61/62/63 with 65 lower surfaces, but used a camouflage pattern not standard for the Luftwaffe. The continued use of the these obsolete colours for export aircraft would continue on into the war period.

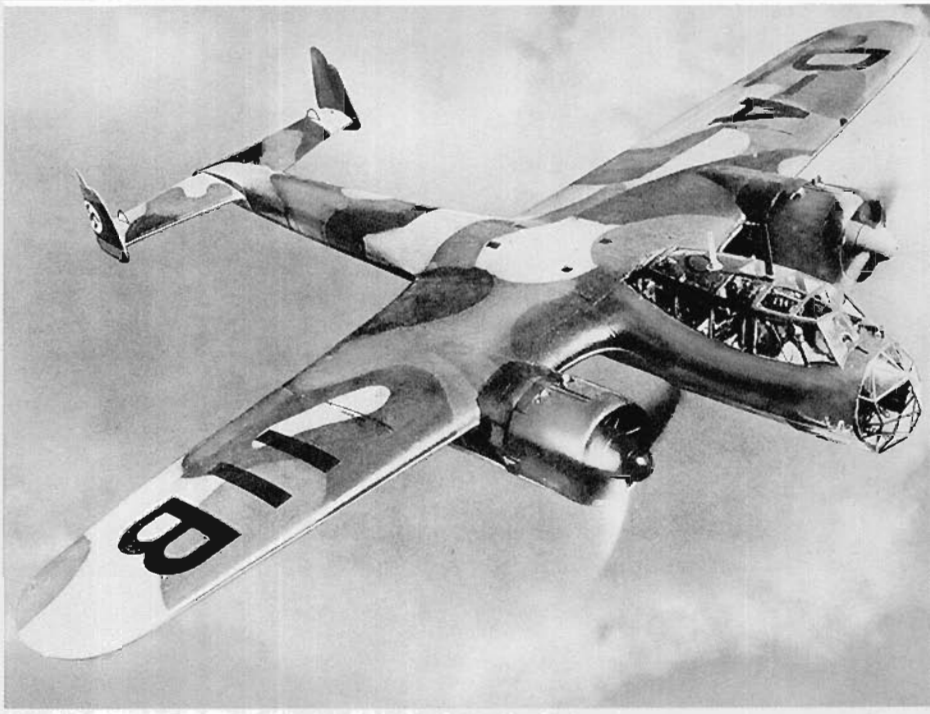
RIGHT: The Do 17 K was manufactured as an export model built in conjunction with the Luftwaffe Do 17 M variant. Twenty aircraft had been ordered in mid-1937 and the airframes were fitted with licence-built Gnôme-Rhône 14 N1/2 engines manufactured in Rakovica, near Belgrade. The early deliveries retained standard Luftwaffe 61/62/63/65 camouflage. (J.Radziwill)



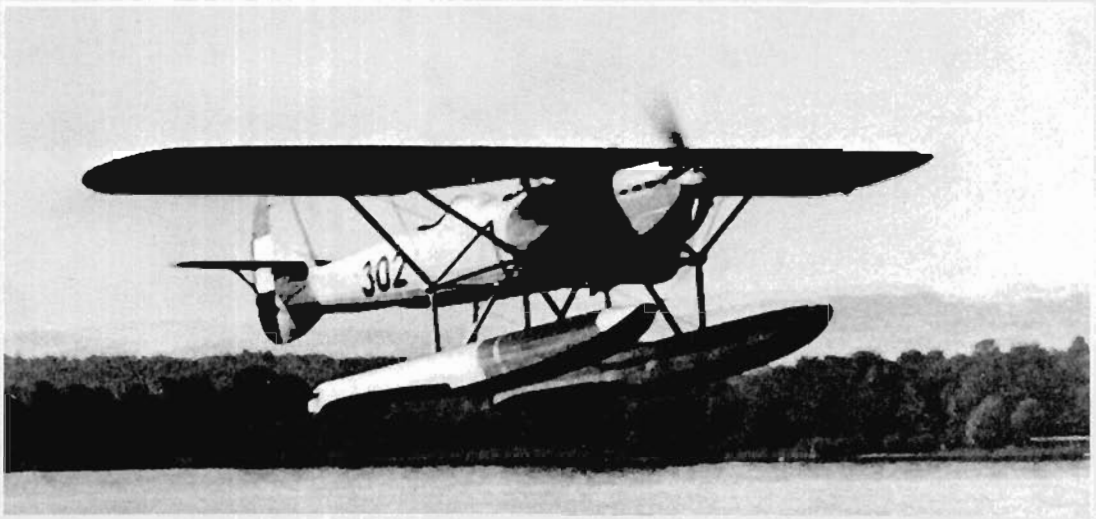
RIGHT AND BELOW: These two photographs of the Do 17 P, displayed at the XVIe Salon de l'Aviation in Paris in November 1938, illustrate the continued use of colours 61, 62, 63 and 65, but in a pattern that owed little to the superseded Luftwaffe geometric patterns. The two views allow comparison of the entire scheme with the one shown in the next photograph.



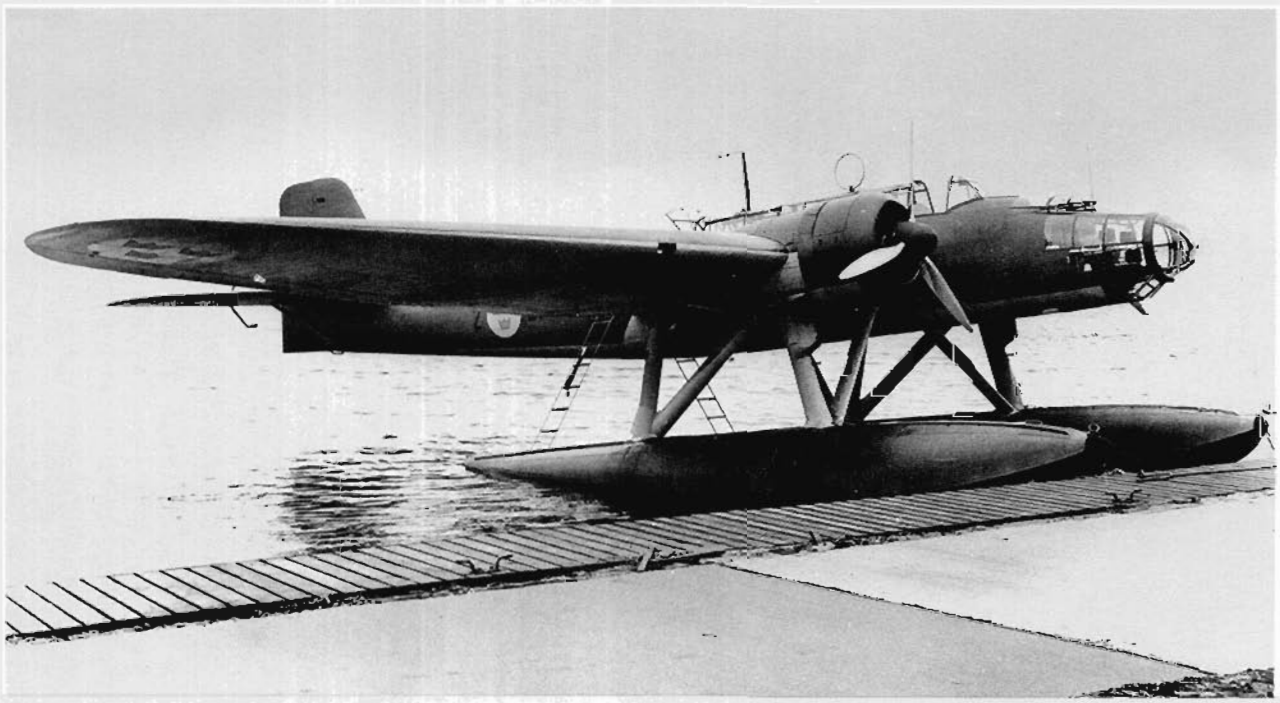
RIGHT: The pattern could vary slightly, as shown by this photograph of the Do 215 V1, D-AIIB, used for sales demonstration flights. Both the colours and the general area of use were approximately the same as on the Do 17 P displayed in Paris, but application of the pattern had been made free-hand rather than with the precision of the contemporary regulation-style RLM patterns for Luftwaffe aircraft.

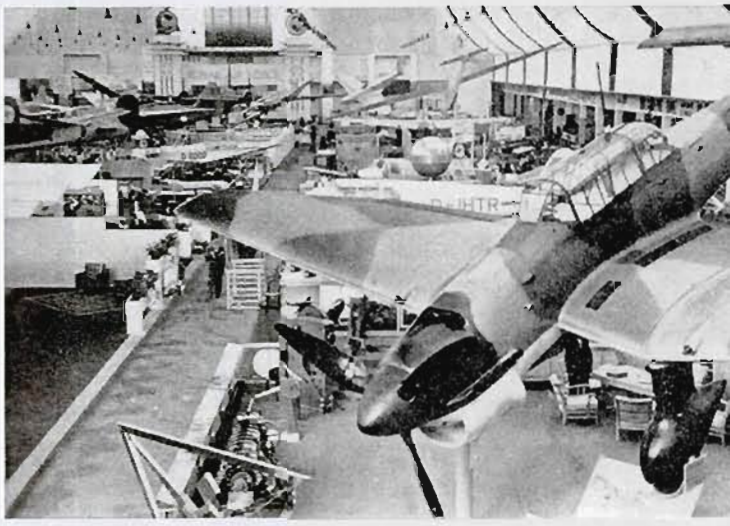


RIGHT AND BELOW: The first 12 Do 22 Kj floatplanes (the 'j' in the designation indicating Jugoslavia) were ordered by the Royal Jugoslav Naval Air Service and deliveries commenced in 1938. Manufactured at Friedrichshafen, further orders were placed by Greece (Do 22 Kg) and Latvia (Do 22 Kl). Overall colouring of the Do 22 Kj variant was standard RLM 02 with the addition of the Jugoslavian national colours. The black '302' marking was the Royal Jugoslav Air service code allocation. (J. Radziwill)



BELOW: The Swedish Government ordered several examples of the He 115 A-2. This aircraft, the first to be delivered, had a finish of 62 for upper surfaces and 65 for lower surfaces. The Swedes had favoured a brown-grey colour, but using 62 made it compatible with the colours already in use on its Ju 86s. The preferred colour raises an interesting point. The Dutch Do 24 Ks wore a grey that is described by people who were present at Broome, when some of the aircraft arrived packed with civilians, as "mud and cream". Taken in isolation the term appears incongruous, and hardly seems to accord with the usual meaning of 'grey', until one examines the stated colour preference of the Swedes for a 'brown-grey'. In that context, the description makes more sense.





ABOVE AND RIGHT: Two views of the Ju 87 B displayed at the Brussels Air Show in 1939. The colours were 61, 62, 63 for upper and side surfaces with 65 for the under sides. The pattern used was quite unique, using soft and in places, slightly curved, lines of demarcation. The undercarriage spats were 'split' vertically with 61 at the leading edge and 62 for the rear half. This was the first time the type had been publicly displayed at one of the major Western air shows of the period, but examples had already been sold to pro-German allies to the east.

LEFT: Bf 109 Fs supplied to the Royal Hungarian Air Force were finished in 61, 62, 63 and 65. In addition to the white cross on a black square markings the aircraft were also marked with Hungarian national colours of red, white and green across the horizontal and vertical tail surfaces. The same camouflage colours and markings were used for some of the Bf 109 Gs supplied to the Hungarian forces, but later deliveries retained their contemporary Luftwaffe camouflage of 74, 75 and 76. The national colours were not marked across the tail sections of those aircraft; camouflage needs having become the primary requirement by that stage of the war.

RIGHT: The Ar 96 A aircraft operated by the Royal Hungarian Air Force wore the same four colours (61, 62, 63 and 65) used on their other aircraft purchased from Germany. On each type, the style of application was very similar, with soft wavy-edged demarcation between the three upper surface colours, as shown here. The horizontal band markings were red, white and green. This aircraft was part of the force fighting on the Don Front in September 1942 and carries the yellow band marking for the Eastern Front Axis forces supporting the Luftwaffe. The presence of the old style aircraft maintenance schedule record, stencilled in black on the rear section of the fuselage, was probably one of the last times this form of marking was seen on front line aircraft.

APPENDIX

Interior Colours

At the time of the National Socialist rise to government in 1933 aircraft interiors were a mixture of doped fabric or silver, dependent upon the age of individual aircraft, more recent construction having moved to the silver finish. The latter colour then served for some years as a general-purpose finish for all internal surfaces including the engine-bay where in-line engines were fitted.

The 1936/37 painting schedule for the He 51 C and D contained no specific reference to overall internal colouring, specifying only the finish for individual components and the general finish for fabric surfaces. The internal framing in the cockpit area was silver (Nitro-Lasurlack silber V 192), while the battery housing was finished with a coat of grey-coloured, oil-based lacquer (Avionorm Ölgrund grau Nr 5759) followed by a coat of pale grey-coloured acid-resistant lacquer (Avionorm Decklack hellgrau Nr 1791 säurefest). The instrument panel was given two sprayed coats of matt grey lacquer (Avionorm Decklack Nr.702/3850 grau-matt).

The engine bay was finished with a sprayed coat of light grey-coloured oil-based lacquer (Avionorm Ölgrund hellgrau Nr 5759), a coat of silver nitro-cellulose lacquer (Avionorm Nitro-Declack silber Nr.1708) and a final coat of silver nitro-cellulose (Avionorm Nitro-Lasurlack silber V 192).

The advent of all-metal aircraft in 1936 precipitated a move to RLM 01 silber (silver) for internal surfaces throughout the fuselage structure, other than for the entire cockpit area, not just the instrument panel, in RLM 66 (RAL 7019) black-grey. This is recorded in the 1937 painting schedule for the Do 17 E, which stipulates a single coat of DKH-Einschichtmetallack 432 Ton 66 (single coat lacquer 432 in tone 66) thinned with DKH-Einheitsverdünnung E 52/50, and applied as far back as Frame 7. Aft of that, a single coat of DKH-Einschichtmetallack 432 silber E 50/20 was applied.

By 1938 internal colouring had changed to 02 for all classes of aircraft. Lacquer 7105.02 (Ikarol Metalldecklack RLM grau 103 f J) was specified for land aircraft and 7107.02 (Ikarol Decklack RLM grau 103/2) for seaplanes. However, by then a new single coat primer lacquer 7110.02 (made by Warnecke and Böhm) was being introduced as a universal internal/external primer-finish for both land and seaplanes. As a result no further stocks of the older finish were issued, but remaining stocks of 7105.02 ad 7107.02 had to be used up before adopting the new finish.

Only aircraft instrument panels were then painted dark grey, using lacquer 7107.66. The same colour also had been used for the exposed face of aircraft instruments, but with a crinkle finish developed by Herbig-Haarhaus from a mixture of phenol formaldehyde resins mixed with 3 to 5 per cent of raw Tung oil.

For maintenance purposes individual instrument locations were marked with an alpha-numeric code that identified the service to which they were attached. These usually were hand painted in white or, occasionally, yellow alongside each instrument or switch, but as the war progressed sometimes decals were utilised.

This system was standardised right across the service and used the following groupings. **A** – electrical current supply and storage (e.g., batteries), **B** – circuit breakers for main electrical system, **C** - lighting (internal and external), **D** – heating (e.g., pitot tube), **E** – electrically operated ancillary services (e.g., undercarriage and flaps, airscrew pitch change), **FT** (usually recorded only as **F**) – radio equipment, **K** – circuit breakers for electrically operated trim controls, **L** – blind flying instruments, **M** - engine instruments (e.g., temperature gauge for oil), **P** – weapons (e.g., gun sight, cannons), **R** – release circuits of disposable weapon loads (e.g., rockets, bombs), **S** – fusing circuits for disposable weapons. Notations referring to cockpit fittings were applied by hand, stencil or decal, colouring usually being white, but with red used for all emergency services. Individual instruments had their outer rim painted in a colour that either related to their function or denoted limitations beyond which the particular system was not to exceed. As a sub-contractor supplied item, instruments arrived marked, where applicable, with external identification colouring around the rim, e.g. brown for oil, green for coolant, yellow for fuel etc. The colours were from the RAL system as specified in the DIN L5 specification, and not the very similar colours of the RLM 21 to 28 range.

The November 1941 issue of L.Dv.521/1 specified 7122.–, a new single coat lacquer, to replace 7110.– for internal finish of metal aircraft, but still retaining colouring of 02. All cockpit areas visible through a glazed covering were to be finished overall in 7107.66, principally as an anti-glare measure, but also so as not to compromise the external camouflage finish - thus returning to the standard set for the Do 17 E in 1937. Lacquering of battery storage areas was identified as requiring 7119.–, but other documents refer to this acid-resistant lacquer in combination with colour 41, a medium grey that had first appeared on the 1936 colour atlas. However, in the absence of a specified colour, the natural colouring of the lacquer was considered sufficient for that purpose.

By then engine bays were also finished in 02 (silver having been completely withdrawn for that purpose), as were weapons bays and undercarriage housings. The engine firewall usually was left in bare metal on the side facing the engine but lacquered in 02 on the cockpit side. Pipelines continued to be marked according to the specific DIN L5 colour code originally introduced in 1927, but with the 1935 revision that had specific dimensions for the actual area of marking. That process, like so many others, began to disintegrate after late 1944 and colouring identification marks returned to something approximating the original 1927 standard with just a random section of colour being applied in the appropriate sequence. Engines, in addition to their metal identification plate, had their serial number applied, generally in white or yellow, on the port side of the block, or the upper surface, on in-line engines, and on the front face of the crankcase on radial engines.

Crew seating structures usually had been coloured 70, but after the imposition of restrictions for use of that colour in July 1944 colour 82, appears to have gradually replaced it for those items in some late production aircraft. Use of 66 for the cockpit interiors seems also to have declined in the closing months of the war, despite 66 still being specified for cockpit interiors in painting schedules as late as January 1945. Late production aircraft, including many rebuilt from recycled components, used a dark green, the same colour recorded for airfoil-shaped painted areas where wing and horizontal tailplane structures met the fuselage. It was a

colour from the range used for internal purposes (RLM 40 to 59) but its specific numerical designation has not been determined.While findings in the report on the German paint industry, mentioned in Chapter 1', identified 66 (RAL 7021) as 'sea green', the green colouring referred to here - seen first hand by the writer in more than one aircraft - was quite distinct from the 66 used in other areas of the same aircraft.

Austerity measures and general shortages in the last few months of the war also lead to some non-standard finishes being employed. The AWM Bf 109 G, W.Nr. 163824, has the back of the pilot's seat sprayed with a very thin coat of black nitro-cellulose lacquer which has a definite low sheen finish; possibly 7160.22. From frame 7 aft, the interior metal of the fuselage is bare other than for frame 8, a replacement still in 02. Forward of frame 7 the lower sides of the fuselage were sprayed with a thin, coarse coat of a pale greenish-blue colour up to the stringer line running along the top edge of the radio access hatch. Between frames 5 and 6 the colour had only been applied to the starboard side, i.e., the area directly opposite the radio access hatch opening. This thin spray appears to have been highly dilute colour, possibly done when spraying of the green-blue colouring to parts of the fuselage were completed, simply utilising the last dregs of paint, when cleaning out the spray gun - a crude form of anti-corrosion protection in the lower areas where moisture usually gathered.

Returning to 1942, ways were being sought to reduce further the range and extent of lacquer finishes and internally aircraft had offered opportunity to save on materials. An order issued in July 1942 had stipulated that crew compartments were to receive only one coat of 7107.66, instead of the previously prescribed two. That was forerunner to a slow tide of austerity measures that became far more extensive in 1944, by which time the type of lacquer used for internal finish had again changed; a single coat camouflage lacquer finish 7101.– being substituted to reduce yet again the range of lacquers employed.

Directive Az. 70 K 10.11 GL/C-E 10 Nr. 4235/44 (IVE), issued by the Technisches Amt on 10 March 1944, dealt with internal painting of landplanes with steel or Elektron finished parts:

"...lacquer 7101 (colours 99, 66 and 02) previously used only as a primer, replaces lacquer 7121. This results in a substantial economy of 7121 (smooth finish), more than half of which was previously used for interior finish. This measure ensures the availability of 7121 for camouflage paint and results in a useful saving of time. Henceforth it is forbidden to use 7121 and 7122, colours 66 and 02, once existing stocks have been exhausted...

Internal painting of landplanes of all metal construction in future has consequently to be as follows:

A) Two coat procedure (for Steel and Elektron)
1) single coat 7101.99
single coat 7109.02 or 66 or
2) single coat 7101.99
single coat 7101.02 or 66 or
3) two coat 7101.02 or 66
B) Single coat lacquering
single coat 7101.02 or 66"

(The continued specification of 02 for interior painting mentioned here appears to run contrary to the much earlier instruction specifying replacement of it with 66 for cockpit interiors. It should be remembered though that use of 66 was confined to any cockpit area visible through a clear covering; 02 was used for remaining portions of the main airframe access areas, e. g., crew access areas in types such as the Ju 52, He 111, He 177, Fw 200 etc., beyond the externally visible area of the cockpit.)

That substitution however had come under further review within six months, with the issue of *Sammelmitteilung Nr. 2* of 15 August 1944 stating in part:

"Replacement of 7101.02 by 7101.66

Lacquer 7101.02 was prescribed for aircraft interiors. Following extensive rationalisation measures, most interior painting has been eliminated. The principal requirement is now for anti-glare painting of the cockpit in colour 66. In order to simplify storage and achieve a rationalisation in the painting industry, all remaining interior painting will be done in 7101.66. Available stocks of 02 may be used up."

The final decline of 66 as an overall internal finish for cockpits was probably related to this final order and the problems associated with stocks of 7101.-. That lacquer, in colour 66, was retained until the end for instrument panels and consoles but had been replaced, in some instances, for other parts of the cockpit by the green colouration mentioned earlier.

With that measure in place, the interior structure of aircraft, other than for the cockpit area, was left in bare metal, corrosive influences to metal surfaces no longer being considered a factor worth treating because of the aircraft attrition rate.

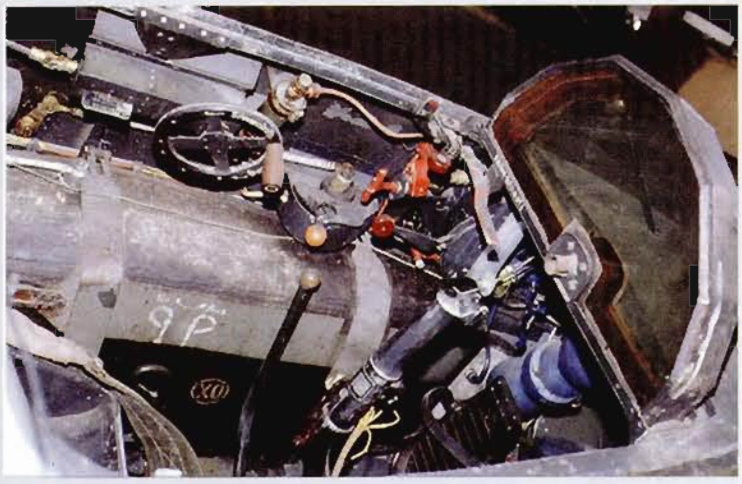
Wooden airframes had continued in production and use from 1933 to 1945, gliders and sailplanes as well as cargo gliders all using that form of construction. Lacquer 7140 (Herboloidlack BC 6929) originally had been listed in the 1937 edition of L.Dv.521/3 (issued for repairs to aircraft), and also in the 1938 edition of L.Dv.521/1 for internal and external painting of wooden aircraft decking. No colouring had been specified, hence the absence of the colour designator symbol "-" Eventually, Flieglack 7171.27 replaced it for internal lacquering of wooden parts. It was not listed in the November 1941 edition of L.Dv.521/1, so presumably it had come into use in 1942.

The entire painting procedure had been revised in March 1943 with introduction of the .99 suffix to replace the old 'period dash' marking for a wide range of lacquers. Internal wooden parts were to be lacquered using 7171.99, replacing 7171.27, but, as usual, only after stocks of the latter were exhausted. Samples of wood from aircraft of this period show that instead of the previous solid, opaque 27 yellow colouring, the greenish-yellow finish appeared, produced by using first a coat of lacquer with a yellow tinge of colour followed by a coat of lacquer with a greenish tinge.

ABOVE: A restored Ju 87 B-1 instrument panel with instruments, placards and fittings in original condition, showing the overall RLM 66 background colouring, black instrument bezels and added colour to the rim of selected instruments. The four instruments below the blind flying panel are (left to right), fuel, combined fuel/oil pressure, oil temperature and coolant temperature gauges, each of which has its relevant DIN L5 colour marking around the rim. The red delineated white portions on the two right hand gauges mark the optimum operating range for each. The radiator flap selector, top right, was also painted with its relevant colour of green. Other than for these small islands of colour, instrument panels and instrumentation were a sombre combination of RLM 66 or black. (P. Cohausz)

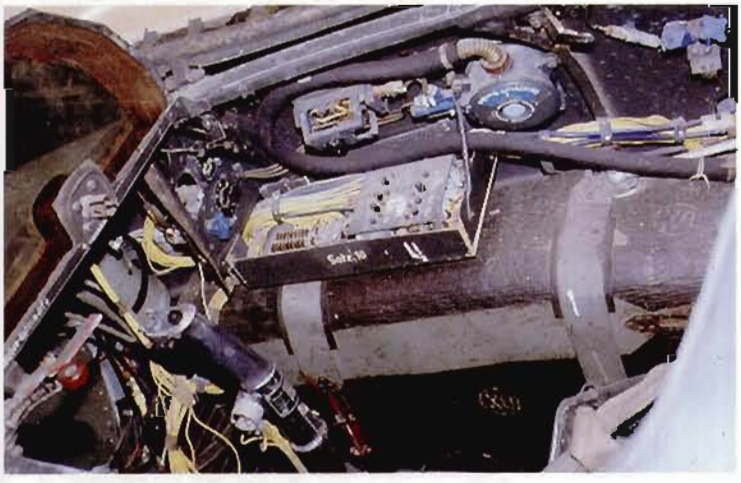
Cockpit areas on high performance gliders had to be lacquered in 7171.99, followed by 7172.99 and then a final single coat of 7174.02. Cargo and troop transport gliders were collectively treated as front line aircraft and as such had used 66 for internal colouring in the cockpit area.

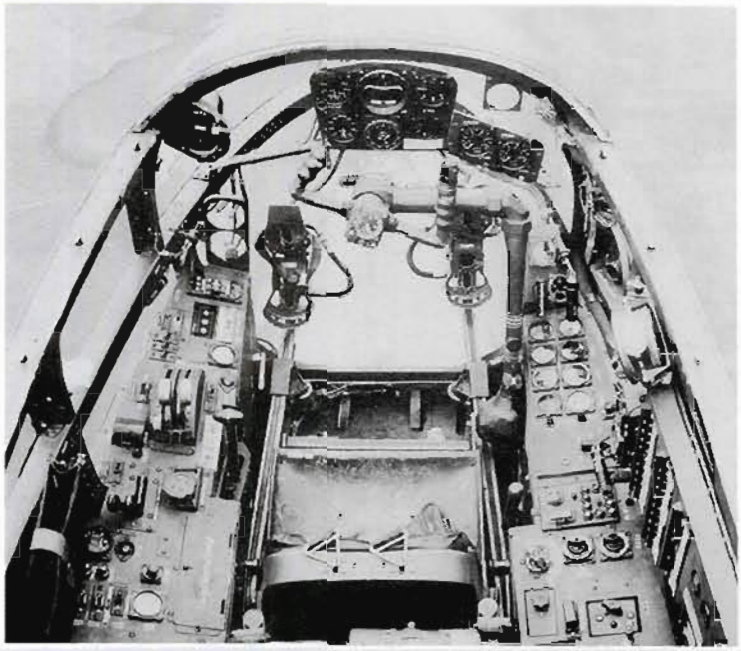
Large transport aircraft had retained internal colouring in their cargo bays, a result of being built before the final austerity restrictions had taken force. Some VIP transports also had non-standard internal colours. For instance, Himmler's Fw 200 C-4, W.Nr. 176, coded GC+AE, was finished internally with polished wooden panelling, grey upholstery and high-gloss grey painted areas - a colour scheme that possibly tailored individually to suit Himmler's tastes. The aircraft was part of the Regierungstaffel that had operated the VIP flight consisting of several Fw 200 aircraft.



ABOVE: Port side view cockpit of Me 163 B, W.Nr. 191907, taken before restoration of the instrument panel and some fittings. Note the colour used both for cockpit wall and top rim, the pilot's seat and the edging to the armour plate glass screen is dark green and not regulation 66. The oxygen bottles and piping are painted in regulation 24 blue with a 21 white-coloured band around the middle bottle. The cockpit locking lever, emergency jettison lever, fuel switch, throttle, and take-off dolly jettison handle are all painted with 23 red. Instruction markings are all hand-painted in white. Note the lightweight brown Bakelite rudder pedal with its Argus emblem in the centre.

BELOW: Starboard side view of the same aircraft shows the rest of the oxygen equipment fitting. The main fuse box, with its wooden top panel removed, is also painted in the same dark green as the cabin interior. The straps holding the internal tank are in regulation 41 grey. The red anodised colouring is a preservative coating.





ABOVE: Cockpit of an Ar 234 B showing the wooden sub-panels, housing flight instruments and tachometers, mounted on an internal frame. White hand-painted alphanumeric codes identify almost every item including electrical services managed from the control yoke. Overall colouring was 66.

ABOVE: The rear section of the cockpit of Bf 109 G, W.Nr. 163824, showing the external non-standard black-grey camouflage colour which however substituted reasonably well for the regulation 66 in this instance. A very thin, roughly sprayed coat of the dark colouring had also been used inside the locker space.

1. B.I.O.S. 365 No. E.1462 German Aircraft Paints.