FINAL REPORT No. 365
ITEM No. 22.

GERMAN AIRCRAFT PAINTS.

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BRITISH INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

LONDON : H. M. STATIONERY OFFICE.

GERMAN AIRCRAFT PAINTS

Reported by

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B.I.O.S. Black List Item 22

MISCELLANEOUS CHEMICALS

BIOS Target Numbers

C22/804, C22/396, C22/2093, C22/2081, C22/2195, C22/2910, C22/2194, C22/2908, C22/1913, C22/2911, C22/2909

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TABLE OF CONTENTS

Personnel of Team

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Report on German Aircraft Paints

B.I.O.S. Trip 1348

18th October to 10th November 1945

Object of Visit:

The visit was made with the primary object of obtaining technical information, from a limited number of previously selected targets and others of immediate opportunity all in the British Zone of occupation, about the types of paint used on aircraft by the German Air Force during the war. The investigation was also intended to cover sealing compounds used for high-flying aircraft with pressurised cabins. Information was also required on test methods and relevant special apparatus. The restricted nature of the enquiry led to the team being selected from M.A.P. personnel.

Summary:

German aircraft paints and dopes were made by a number of firms to whom the recipes and special materials were supplied.

Technical information, including recipes and literature, were obtained, and samples of finished products and raw materials were earmarked for evacuation.

Targets visited and persons interviewed:

Firm or Establishment	Individual	Date
Dr.Kurt Herberts & Co. Christ buch 25 Wuppertal - Barmen C22/804	Dr. Hoffman Dr. Hoffman and Herr Moll Dr. Hoffman	22nd Oct. 23rd Oct. 30th Oct.
Vorwerke u. Sohn Oberelichtenplazor-strasse 336 Wuppertal - Barmen C22/396	Dr. Feuchter and Herr Kleine Dr. Feuchter	23rd Oct. 30th Oct.

Firm or Establishment	Individual	Date
Herbig Haarhaus A.G. Vitalistrasse 222 Koln - Bickendorf C22/2093	Dr. H.F.Sarx and Dr. Heidkamp Dr. H.F.Sarx and Dr. Heidkamp	25th Oct. 29th Oct.
Theodor Kotthof Hitzelerstrasse 41/45 Koln-Raderthal C22/2081	Herr Cottaeus Herr Wesputat (at Schladorn) - am Sieg	26th Oct. 29th Oct.
Spies Heckler & Co., Rader Faler strasse 91 Koln - Raderthal C22/2195	Dr. Thamm and Herr Hecker	26th Oct.
Court & Bauer A.G. Oskar - Jagerstrasse 166 Koln - Ehrenfold (Office: Kaiser Wilhelm Ring - Koln) C22/2010	Fraulein Bauer	26th Oct.
Boer u. Sohn Laderstrasse Koln - Kalshauren C22/2194	Works Foreman	29th Oct.
D.V.L.Travemunde C22/2908	Herr Fischer Fl/Lt. Symen 2801 Wing RAF	5th Nov.
Gustav Ruth Temperol Werke, Feldstrasse 136/142 Hamburg-Wandsbeck C22/1913	Dr.Erich Asser Sr. Dr.Asser Jr. and Herr Th.Ruth	6th Nov.

Firm of Establishment	Individual	Date
Detmolder Lackfabrik Niesen and Sohngen, Detmold C22/2911	Mr.Campbell & Mr.Hammond Control Commission (Aircraft) c/o 2002 Group RAF, Detmold	9th Nov.
Schafferhenrich & Co. (Cabinet Makers) Detmold C22/2909	ditto	9th Nov.

General:

The German Air Ministry in 1936 asked firms to submit aircraft painting schemes for approval. The firms supplied samples of their products with working instructions, to the D.V.L. at Travemunde where laboratory trials, followed by trials on actual aircraft, were made. The firm of Warnecke and Bohm Weissensee-Berlin apparently submitted some of the most successful schemes embodying special paint ingredients such as synthetic drying-oils, resins and plasticisers. The special ingredients were supplied variously to the other paint makers (see Appendix V) by firms more in the nature of chemical manufacturers. In Hamburg for instance about 10 paint making firms sub-contracted during the War to Warnecke and Bohm of Berlin. Their technical activities are now co-ordinated by Dr. E. Asser of Messrs. Gustav Ruth - Hamburg, to serve the purpose of the Allied Military Government.

At nearly all targets reference was made to substitute drying oils, linseed oil and particularly China Wood oil being in poor or indifferent supply. Dehydrated castor oil and tall oil products from Swedish sulphate wood pulp were used. Oiticicia oil was imported from South America. For quick drying paints extensive use was made of synthetic resins including nitro cellulose, urea, melamine and phenol formaldehyde, oil modified PF, oil modified alkyd etc.

The policy of the suppliers of all those special synthetic products appeared to be to withhold from the sub-contractors essential information on composition and to modify this where necessary in the light of complaints from the customer firms.

Many of the firms visited were in production on a limited scale, supplying paint and distemper to the orders of the Allied Military Government or the Services, depending on the extent of war damage to the plant, and drawing on ever-dwindling stocks of raw materials which had survived.

The manufacturers visited in no way confined their attention to aircraft paints only but as a rule supplied products for a wide range of customer requirements.

Evacuation:

A copy of the German Air Force General Specification for Painting Aircraft was obtained. Samples of ingredients and finished products, where these were of interest, were selected at firms for onward transmission through official B.I.O.S. channels to the Royal Aircraft Establishment, South Farnborough, Hants, where it is hoped to make trials. For copies of some relevant recipes and formulae obtained from the firms see Appendices I, II, III and IV. Other literature to be sent on consists of two books on paint testing and ingredients from Detmold, a description of the paint testing method employed at Travemunde by the German Air Ministry, and a report on heat reflecting paints from Herberts of Wuppertal. Laboratory testing apparatus and small scale mixers, cone-mills, and grinding rolls were in evidence in a number of paint firm laboratories and some useful physical testing apparatus for rubber products in the laboratories of Vorwerke u. Sohne in Wuppertal. No attempt was made however to earmark such laboratory equipment for evacuation as this would require a separate investigation in conjunction with the Military Government Control Commission with whom rests the decision on what scale German firms are allowed to continue working. Arrangements were made for the evacuation of one item of equipment however from D.V.L. Travemunde as this is unlikely to interfere with a peace-time economy - a Schopper Dahlen bursting strength tester for the measurement of tautness of doped fabrics. For tabulated list of items to be evacuated see Appendix VI.

Items of interest:

1. "Polystahl". Information already exists on this resin.

See C.I.O.S. Report file 22/XXVII/39. I.G. Uerdingen - G.M.Kline.

" " " XXIX/12 Tetrahydrofuran - Roberts.

Report of interrogation MAP 28 Sept. 45. Dr. Kuch - Thomas, Pryor, Gordon and Earwicker.

This information indicated that it could be used either as an adhesive or as a paint resin, enabling painted

surfaces to be glued together or paint to be applied over glue-contaminated surfaces. Further information from targets now investigated was either entirely lacking or very scanty, but detailed manufacturer's information on the properties and methods of use of "Polystahl" glue were obtained from Schafferhenrich & Co. Detmold (See Appendix VII). Herberts of Wuppertal had made some tests but were of the opinion that the material, in the form supplied to them, could not be both a protective and an adhesive and that, although the idea seemed good, the products would have to be further modified and developed. Herbig-Haarhaus of Koln had made experiments, also on a laboratory scale, and considered that the scheme was feasible for wooden aircraft. It was never, to their knowledge, finalised for production and would not be of particular value for metal aircraft. They thought it was a modified U.F. resin and might be able to find samples of some of the components ('Desmophen' - I.G. Leverkusen) if these had survived air raid damage.

2. Fireproof paints and dopes. These materials had been supplied to the order of the German Air Ministry by two of the firms investigated for use on certain wooden aircraft and for fabric control surfaces on wood and metal aircraft.

Herberts of Wuppertal had produced products based on cellulose acetate and polyvinyl chloride. They know that the latter did not give a good tautening effect but did not think this was of major importance where unsupported fabric surfaces were small in area. They knew of a green lacquer supplied by Herbig Haarhaus of Koln for use on the Gotha glider and said this was based on P.V.C. They had a poor opinion of its fireproofing properties on wood where the weight ratio P.V.C/cellulose was very low. Herberts had tried bonding together veneers already fireproofed (by well known methods employing ammonium salts etc.) but this was not successful.

Herbig Haarhaus of Koln claimed to be specialists in fireproof paints and dopes (originally developed for use on airships), and in this connection had several other firms working under licence to them at one time; they understood that Herberts only made paints for metal aircraft. Their fireproof products had the general trade name of "Herboloid" and were based on polyvinylchloride

and after-chlorinated polyvinylchloride. These resins were supplied to them by I.G.Bitterfeld under the general trade-name "Vinoflex", the Type N "25 secs" grade being used in tautening dopes. The stability of this resin depended on after-chlorination being pushed as far as it would go to give a product containing 60 to 66% total chlorine. It was claimed that the greater the chlorine content, the greater was the stability of the product. I.G. did not disclose the manufacturing details of the resin to Herbig Haarhaus but were willing to modify the proportions to suit requirements. Deliveries were checked on receipt by a viscosity test on a solution of the resin in xylol + ethyl or butyl acetate. The tautness of fabrics doped with the Herboloid scheme was tested by the firm and said to be satisfactory up to temperatures of 100°C. The firm had heard of one complaint from the Luftwaffe in Bulgaria but this was later shown to be due to structural faults in the aircraft rather than to the dope. D.V.L. to whom the firm originally sent their products for approval had given a satisfactory report as a result of tests at tropical temperatures. D.V.L. Travemunde later gave the team a modified opinion on the tautness of the firm's Herboloid dope scheme. The scheme when thoroughly dry was said to have satisfactory tautness except in bright sunshine. Gotha gliders painted with Herboloid products were said not to ignite when hit by shot (? incendiary).

The original scheme for fabric consisted of three coats as follows:-

Grundlack (Spaanlack) - the first tautening coat; this was made with Vinoflex Type N 25 secs, red oxide of iron pigment and a very small amount of G.B.Ester Wacker (a high boiling point ester) as plasticiser. The correct grade of Vinoflex was stated to be important.

Zwischenlack - intermediate coat; this employed Vinoflex PCU Type H, aluminium pigment and Clophen A.60 or Albanol as plasticisers, these being respectively a chlorinated diphenyl and tricresyl phosphate supplied by I.G.

Deck Lack - top coat. This contained Vinoflex Type N 25 secs. and a complex mixture

of pigments for colouring purposes together with small amounts of G.B. Ester or Albanol.

The first coat was applied by brushing. The remaining coats were sprayed. Surfaces were not rubbed down but smoothed by brushing with solvent.

The firm had no reason to believe that the plasticisers migrated from one coat to the other nor did they believe in the theory propounded in some quarters for nitro cellulose that they formed loosely combined compounds with the resin. Towards the end of the war owing to shortage of supplies, a modified one-dope scheme was in use. They also made lacquers for metal aircraft. These were made under licence from Warnecke & Bohm, from Synthetic resins (alkyd-phenol) and oil, and were called "Ikarols". The activities of Herbig Haarhaus in the field of metal lacquers are exemplified by the following precis of an article by one of their chemists Dr. H.F. Sarx in Korrosion u. Metallsch. Bd. 20 (1444) Nr. I.S. 60/63.

"Properties of lacquers for stampings"

By stamping lacquers are understood lacquers which adhere firmly to tin-plate after stamping, pressing or drawing operations. This requirement (? adhesion) is most particular for deep drawings where sharp edges are involved, the lacquer film being either highly stretched or compressed. Other requirements of such a film are outstanding tenacity, toughness and tear resistance. Strongly elastic properties are not by themselves sufficient because in the stretched state the film tends to rupture over sharp edges, an effect which may become more evident on storage. In this connection it is better to arrange for a plastic film capable of deformation under load. Thin films have a better performance than thick ones.

Up to the year 1936 available stamping lacquers were based exclusively on oil. At a later date these were replaced by the essentially more suitable synthetic resin lacquers based on alkyd resins, manufactured from fatty acids, phthalic acid and glycerine.

A recent satisfactory inovation is an oil free synthetic resin lacquer."

Typical recipes are given at Appendix II.

3. Nitro-cellulose and other cellulose ester dopes. All the firms visited had on record the fact that they supplied nitro-cellulose varnishes before and during the war, see Appendix IV. Specific mention of their use on aircraft was made by Herbig Haarhaus, Herberts and Ruth, see Appendices I, II and III. In general these three all agreed that N.C. by itself gave poor protection to wood, that for use on metals the film must be elastic over a wide temperature range and that for metal aircraft other resins produced by Warnecke and Bohm of Berlin were superior to N.C., in respect of adhesion to metals in particular. Herbig Haarhaus produced a N.C. varnish plasticised with tricresyl phosphate (Albanol-I.G.) or phthalic acid esters (Palatinols-IG) said to be useful on automobiles and flexible at low temperatures. Herberts made two N.C. varnishes for wooden aircraft to be applied over a special water proofing primer; the first varnish was based on a mixture of N.C. and a compatible alkyd resin with red iron oxide pigment; the second was based on N.C. alone with camouflage pigments and was designed to give a very smooth surface. Herberts had been connected with the tautening N.C.lacquer development since the days of dirigibles and had made such lacquers for aircraft pre-war; since then however less N.C. was used for aircraft and more cellulose acetate. Ruth of Hamburg made a pigmented aircraft varnish based on a mixture of N.C. and polycyclohexanone and another of special interest based on a mixture of N.C. with a non-drying glyptal resin which contained, in addition, a proportion of propylglycol. This latter varnish was used over normal aircraft finishes when it was desired to apply subsequent coats of water emulsion temporary camouflage colours, the hydrophylic properties of the propyl glycol enabling the latter to "take" in the first instance and to be readily removed subsequently. Reference was made at Ruths to the N.C. lacquers produced by Atlas of Bremen and by Nobel.

4. Protection of wooden aircraft.

The finish applied to Mosquito aircraft was adversely commented on in most German quarters. Laboratory tests based on wood and plywood panels coated with normal N.C. finishes showed that considerable amounts of water were absorbed on immersing the panels in water. The lack of adequate protection of end grain in particular was in

their opinion deplorable. The problem was not altogether an easy one but according to Dr. Hoffman of Herberts they had obtained a good measure of success with a scheme of their own which depended on first applying a penetrating varnish of phenol formaldehyde to which phosphoric acid hardner was added before use. This was then followed with a coat of "filler" containing N.C., alkyd resin and iron-oxide, and finally by a straight N.C. lacquer with pigments. The last coat gave a smooth finish of good aerodynamic properties. The scheme could be modified with respect to the number of coats of each lacquer depending on the type of wooden structure and its vulnerability to the weather. Herbert of Wuppertal and Ruth of Hamburg supplied these products. Fabric covering was not practised owing to the shortage of fabric.

Ruth admitted that the shortage of drying oils such as tung or linseed and the long time required for them to dry had something to do with the introduction of the P.F. lacquer and hardener.

Herbert and Ruth were of the opinion that apart from the use of good paints, the ability of wooden aircraft structures to remain serviceable under adverse weather conditions was bound up with the selection of good quality wood and the use of water-resisting synthetic resin adhesives for bonding plywood and making glued joints; Tego film (Dynamit A.G. Troisdorf) for plywood and Kaurit cold setting glue (U.F.) were given as examples of suitable bonding materials.

5. Heat reflecting paints

A certain amount of work had been done on this subject and the connection between the heat reflecting properties of paint surfaces and their reaction to infra red photography was understood. Glasuritwerke - Hamburg, Herbig Haarhaus and Herberts had made experiments but all were of the opinion that the matter was "a bit of a flap" on the part of the German Air Ministry who soon lost interest in it. I.G. said the pigments were complicated and difficult to make. Herbig Haarhaus had tested a number of pigments supplied by I.G. They were not a success photographically. Herberts however had apparently pursued the matter more deeply and had obtained a measure of success. Their chemist Dr. Hoffman in his researches showed that the pigments were most important, their reflecting properties depending on the crystal shape, and

that the source of infra-red used in any series of tests could be a matter of controversy. Common salt was a very good material from the reflecting point of view but was naturally not a suitable pigment for paints. Zinc chromate was considered to be very good. Apart from their use on aircraft, heat reflecting paints had other applications. It was stated that as much as 12% could be lost by evaporation in conveying petrol in rail tank wagons from Rumania to Germany. Dr. Hoffman had been discussing new patents with the German Patent Office in Berlin. He had written up his researches and the paper would be available to those interested; it is being evacuated.

6. Petrol Resisting Paints

Spies Hecker of Koln had specialised in petrol resisting, flexible, stoving lacquers for use on aircraft jettison tanks (and others) made from mild steel. Protection against corrosion was naturally important and tanks were coated inside and outside. The resins chiefly used were oil modified phenolics suitable for stoving, and were supplied under the names "Durophen 308V hard" and "Durophen 195V soft" by Dr. Kurt Albert of Wiesbaden. They were similar in general character to that firm's "Albertols" but the "Albertols" were chiefly air drying. Durophen 308V was supplied as a liquid containing 21% of oil and 35% of butanol. The oil was China wood oil originally but later had been substitited by dehydrated caster oil of the Schrieber type having drying properties similar to those of Tung oil. Deliveries were tested for solid content and acid number. The varnishes were made by melting the resins, running in the solvents, adding the pigments and grinding on a one-roll mill. The following recipes were given for undercoat and top coat together with recommended stoving times.

	Undercoat	Top coat
Red iron oxide	170 kg.	85 kg.
Durophen 308V	325 "	284 "
Durophen 241V	97 "	170 "
Durophen 195V	65 "	114 "
Butanol	33 "	10 "
Solvent naphtha B.P. 132°C.	310 "	337 "
Stoving times	½ hr. 180°C.	1 hr. 180°C

The finished products were tested by preparing films on iron sheets 1 m.m. thick. Continuity of the film was tested electrically at 4 volts with a search probe. Flexibility was tested by the Ericcson indentation method at normal temperature using an impression of 4 m.m. diameter for stoving lacquers and 8 m.m. for air-drying lacquers. In addition separate films were prepared by air-drying on gummed paper followed by removal in water and stoving. The films were tested in the Rumpometer at 0°C. The test methods employed were those described in

Physical & Chemical Examination of Paints, Varnishes, Lacquers & Colours - Gardner. 7th Edition 1935.

Published by The Institute of Paint and Varnish Research, N.Y.

The firm made no products for aircraft other than the above stoving lacquers nor did they make paints for aluminium or wood. They made no electrical insulating varnishes. At one time they prepared their own blown castor and linseed oils.

None of the other firms visited, except Herberts, claimed to have made paints which were specifically petrol-resisting.

7. Paints for Metal Aircraft:

Information given under "General" indicates that the firm of Warnecke and Bohm Weissensee Berlin submitted a scheme to the German Air Ministry in 1936 which was approved for general use on metal aircraft as a result of tests by the D.V.L. and that various paint making firms in Germany were in fact sub-contractors to Warnecke and Bohm, or worked to that firm's recipes. Their trade-name "Ikarol" covers finished varnishes and constituents. They supplied artificial resins to Herbig Haarhaus, Herberts, and Ruths among those targets visited. Formulations from Herberts and Ruths are appended, see Appendices I and III. Herbig Haarhaus supplied their Herboloid lacquers for metal aircraft in addition to other paints. W & B Resins No.600, No.200 and No.100 M. are most used.

The exact compositions of these resins are not known but Herbig Haarhaus believed them to be oil-modified phenol-alkyds. Ruths were of the opinion that the oils used were China wood and boiled linseed and that resin and sulphur were also used in their preparation. The presence of sulphur was considered to account for their good adhesion to light alloys. The supply position of the normal drying oils for paints deteriorated in Germany during the course of the war and references were made to the growing use of synthetic drying oils. It is not improbable that these synthetic products were used in the preparation of drying-oil modified alkyd resins. The choice of these particular resins was considered logical in view of their shorter drying time in comparison with orthodox mixtures of natural resins and drying oils and generally comparable weathering properties. Economy in drying oil, natural or synthetic, was also said to be possible by the use of such resins.

Herbig Haarhaus used oiticicia oil imported from South America and a Schieber dehydrated castor oil supplied under the trade name of "Synourin" oil by Noury and Van Der Lande of Uerdingen. Spies Hocker were of the opinion that dehydrated caster oil was recently used as a substitute for China wood oil in the Durophen stoving resins which they bought from Alberts and Wiesbaden. Ruth of Hamburg used a dehydrated castor oil supplied under the trade name of "Castrol" by Louis Blumer of Zwickau in Saxony. Spangenbergwerke of Hamburg supplied Tall oil products derived from Swedish sulphate pulp liquors.

The necessity for a paint film which gave a very smooth surface and remained elastic at low temperatures was stressed at various targets. This was a requirement arising from the increasing use of very fast, high flying, night fighters. For filling in rivet holes, etc., Herberts supplied a quick drying putty based on polyvinyl chloride and Herbig Haarhaus a putty based on chlorpolyvinyl chloride. The adhesion of these fillers to metal, and of subsequent paint coats to the fillers, was said to be good and never gave cause for complaint.

Herberts volunteered the information that the prevention of rough corrosion products on light alloys was very important and an unprotected aircraft capable of 700 km/hr. might lose as much as 50 km/hr. due to drag when covered by corrosion products. Very smooth,

unprotected surfaces were very prone to corrosion. The authority for these statements is not known but there appears to be some truth in the information that schemes for protection based on anodic coating were turned down on account of the shortage of electricity in Germany.

8. Camouflage:

A pattern card is attached to the German Air Ministry General Specification for Aircraft Lacquers L.Dv.521/1 Behandlungs and Anvendungsverschrift fur Flugzouglacke Teil I Motorflugzouge Nov.1941, shows white, silver, red, green, black and a range of tinted greys from light to dark.

The type of paint or lacquer is defined by a four figure number followed by a two figure number denoting the colour. The interpretation of these by the manufacturer will be evident from specimen formulae supplied by Herbig Haarhaus Herbert and Ruth, see Appendices I, II and III.

For a short time Herberts had supplied a special night black. There was much difference of opinion in the German Air Ministry on its usefulness and it was generally concluded that it introduced too much drag. The Germans had not enough aircraft to devote large numbers of any one type of specific purposes such as night-bombing, calling for highly specialised camouflage of a permanent character. The I.S.238 formula of Ruth described at Appendix III and at "3. Nitrocellulose" above gives the properties of a lacquer applicable to paint surfaces giving a surface film suitable for use with temporary camouflage distempers.

Apart from the camouflage of aircraft, more general information on the subject was discussed with Herbig-Haarhaus. They said that the Germans had a high opinion of methods employed in Britain and soon learned much from them. This was appreciated by the paint industry who later received orders for very large quantities of camouflage paints and distempers. These could be made cheaply and quickly from a wide range of raw materials and brought in big profits. Oil bound distempers were used on buildings and runways though

they had a comparatively short life on the latter. The use of grass fertilisers was practised. Certain tar products though useful on grass had an adverse effect on grazing cattle and sheep, and molasses residues were employed in spite of their evanescent properties during wet weather. For many purposes, however, net was the most useful material.

9. Sealing Compounds:

Information on pastes or putties, for rendering air-tight the cabins of high-flying aircraft, was obtained from two sources. The information from Herbig-Haarhaus of Koln was meagre and to the effect that such a product had been made by the Berlin branch using a special vinyl resin as far as was known. This work had been done by their Dr.Kurt Hofer at Berlin, engaged on aircraft specialities.

Herberts of Wuppertal had more direct information. They made a product called DKH 8800 employing aluminium leaf pigment, a mixed polymer of ethyl and isobutyl acrylates (Acronal 4 - IG) together with volatile solvents, see Appendix I. This product was applicable by a spatula or brush to rivetted and other joints in light alloy. It had good adhesion to metals and remained flexible over a desired temperature range of -80°C. to +120°C. The coating had good resistance to the fluids normally encountered on aircraft and no complaints had been received on this account. Fuels containing aromatics had a slight softening effect as had also alcohol. The effect of ethylene glycol was not known. Three coats were normally applied over joints. No difficulty was experienced in painting over treated joints with standard aircraft paints and dopes. The material was easy to make and production depended only on supplies of the Acronal resin from I.G. at Leverkusen.

A paste of the nature of DKH 8800 had several advantages over rubber sealing gaskets previously used; it was readily applied during or after the making of the joint and very useful where irregular non-standard repair patches had to be applied. As new types of aircraft were evolved it was not found economical to produce rubber gaskets in the large

number of different shapes and sizes involved. The paste was said to be used on the Messerschmidt 109G and on the Folke Wulf 190 after trials made by D.V.L. at Travemunde. There had been some differences of opinion among aircraft manufacturers on the necessity for using the compound. Junkers, subcontracting to Messerschmidt said they could do without it but this opinion was based only on the production of a few prototype pressurised machines. Messerschmidts themselves did not like to have to use it but it had been applied to approximately 2,000 aircraft by the end of 1943.

Laboratory tests of the compound were made on a rectangular metal box, the compound being applied to two longitudinal rivetted lap seams on the two largest faces respectively. An excess internal pressure of one atmosphere was built up over a period of one minute from an air reservoir and the pressure allowed to drop to normal over a further period of one minute. The box deformed under pressure, bulging to the extent of 2 cms. This pressure cycle repeated 8,000 times resulted in a loss of only 5% of the air. The test was made at all temperatures within the range -80°C. to -120°C. This form of test was made by Herberts and by D.V.L. Travemunde. A copy of the report from the latter was promised. No vibrations corresponding to those met with on aircraft were applied during the test but subsequent trials on actual aircraft at Travemunde gave satisfactory results.

10. Rubber, Tapes, etc.:

The subject of sealing compounds was discussed with Vorwerke u.Sohne of Wuppertal but their activities appeared to be confined to the manufacture of moulded rubber articles and adhesive tapes. They also manufactured expanded rubber sheets. Their expanded rubbers were made in a range of stiffnesses and densities. Though the firm had supplied to the orders of the German Air Ministry, they understood that their products were used solely for heat insulating purposes on aircraft produced by Heinkel and Junkers. The adhesive used in affixing these products to metal wood and phenolic resin bonded fabric sheet

was "Desmodur" (-IG Leverkusen). The firm were aware of the inflammable nature of their expanded products and their lack of resistance to the action of petrol.

The expanded materials contained discrete cells and during the manufacture nitrogen under several hundred atmospheres pressure was employed. Samples were shown of flexible expanded sheet from Buna S which could be produced in pieces 100 cm. x 65 cm. and in thicknesses from approx. $\frac{1}{8}$" upwards. Smaller samples of stiff expanded material approximately $\frac{3}{4}$" thick were shown in densities of 0.08, 0.1, 0.23, 0.26. Densities of 0.05 could be made but their value was conjectural. The samples were in sandwich form with skins of aluminium, wood or "Bakelised" fabric, fixed by means of "Desmodur".

The firm used Buna synthetic rubber supplied by I.G.Holst (and natural rubber when available) for their various products -

Hoses	Buna SS and S
Soles and heels	" S3 or S
Tyres	" S3 + some SS
Insulating tapes	" SW
Adhesive plasters	Oppanol 200 or natural rubber when available, alternatively polyisobutylene

Adhesive tapes were made on a narrow fabric of regenerated cellulose coated with adhesives prepared from:-

(a) Medical tapes	natural rubber of Oppanol or polyisobutylene
	natural resin (colophony)
	lanolin
	zinc oxide
	paraffin
(b) Insulating Tapes	Oil
	Mineral rubber (Synthetic Asphalt = oil, airblown at high temps.)
	Chalk

The standard tape was 2 cm. wide. Adhesion and insulation tests were made from time to time to check normal

production. Frequency of inspection was greater after any change in production methods or materials.

Adhesion Test: The tape was rolled up on a mandrel under a tension of 4 kgm/2 cm. at a speed of 50 cm/min. It was then unrolled at constant speed (20 cm.per min.) and the tension required to peel it off was measured (1.45 kilos).

The test was made at 20°C. on specimens before and after ageing.

Electrical Test: The tape was wound on a hollow brass mandrel approximately $2\frac{1}{2}$ cm.O.D. in spiral fashion allowing an overlap of two thirds the width of the tape. A metal clip was then placed on the outside, and a high voltage (A.C.) applied between the clip and the mandrel.

The standard voltage was 1000 and the tape had to withstand this for 5 mins.

Normal production batches could withstand much higher voltages, of the order of 2,500.

The opinion was expressed that flexibility in plastics over wide temperature ranges depended mainly on the plasticiser and that for "Plexiglas" an ester of aceto-acetic acid was useful.

An interesting side-light on the visit to Vorwerke u. Sohn was an interview with Dr. Feuchter, an enthusiastic research worker in the rubber field. He had published papers in "Kaoutchouc" and "Kolloid Zeitschrift (Chemische Beiheft) " in 1923 and 1929 on the phenomena associated with "recked" (stretched) rubber. His co-author for the 1929 paper was Dr.Hasser of America who had made the X-ray study.

11. Miscellaneous Technical Information:

This was either volunteered by the firms or arose during visits to them on the subjects above.

The value of anodic coatings on light metals as an aid to the adhesion of paint films was recognised by Ruth and Herbert.

None of the firms visited had made luminous paints or appeared to be interested in them.

"Aviatin" dopes had been made by Theodor Kotthof of Koln - Raderthal but the firm had evacuated all their technical records and technicians to Ermannsdorf-Saxony now in the Russian Zone. Herr Cottaeous at Koln and Herr Wesputat at Schladorn were entirely non-technical and could give no helpful information. They said that Dr. Jung at Ermannsdorf was the authority on technical matters.

A spot welding flux for ferrous metals was made by Herbert under the trade name "Standoplast". This consisted essentially of synthetic fatty acid from the Fischer Tropsch process carried out at Witten. The fatty acid mixture as produced was fractionally distilled, the lower molecular weight acids being used in the production of soap and synthetic edible fats and the residue (C_{20} to C_{28}) being used by Herbert in "Standoplast". This was claimed by them to give excellent results in welding and to act as a rust preventive on other iron surfaces. D.V.L. Travemunde gave a satisfactory report of the material. It was said to be superior to lanolin as a protective for aircraft ferrous metals, an important point for the Germans who desired a longer life from their machines than the British. It was largely used in the manufacture of "V1" and "V2".

Chlorinated natural rubber paints had been made by Herbig-Haarhaus, Herbert and by Court and Bauer. Herbert had supplied this during the war to the German Navy for use on submarines as a protective for iron against corrosion by battery acid. The resin was "Pergut" - IG. Chlor-Buna was now all used for tyres.

Antifouling paints had been supplied by Herberts containing the mercury and copper salts of the high molecular fatty acids used for their "Standoplast". Such paints had to be applied on top of a special insulating varnish on light alloys to prevent corrosion. Laboratory tests (salt spray and temperature humidity cycle) were carried out by the firm, and

exposure tests in the sea were made by D.V.L. at Travemunde and in the North Sea. Ruths made ships-bottom paints using resins supplied by Warnecke and Bohm, but knew of mercury-containing paints made by F.A.C. Van der Linden & Co., Hamburg. (Manager, Herr Vorsmann).

Wrinkle finishes (for aircraft instruments, etc.) were made by Herbig-Haarhaus from mixtures of P.F. resins with 3 to 5% of raw Tung oil. The best drier was a cobalt compound.

Heat and electrically conducting paints were made by Herbig-Haarhaus, the pigment being the finely powdered material used for collector rings and brushes on electrical apparatus.

For out of doors use on electrical gear Herbig Haarhaus made lacquers from asphalt + 5% processed linseed oil. The films did not melt in the sun. During the war bitumen paints were used. Wire enamels were also made by Herbig Haarhaus from phenolic resins or oil varnishes having quick drying characteristics.

Silicones were not used commercially in Germany.

Polystyrene was used in the treatment of fabric to produce synthetic leather.

Phenolic resin lacquers had been supplied by Ruth for the treatment of magnesium but this was not an aircraft application.

12. Laboratory Apparatus; Small Scale Apparatus and Plant in Factories:

Air raid damage made it impossible to obtain a clear overall picture of the laboratory apparatus and plant at the targets visited.

Herberts of Wuppertal however had not suffered much damage to the offices and laboratories. These were situated in a building of three stories very well lit by natural daylight. The laboratories were

very well equipped for the analysis of raw materials and research on new materials and processes. The small scale apparatus was of a high standard of excellence and included a very useful bank of steel roller mills. The small scale was extended to part of the factory where oil cooking pots were in evidence for the making of trial batches. An "oven" with a working space of about 8 cu.ft. was used for tests from -80 to +120°C. and was particularly useful for the "Abdichtungspaste DKH 8800". The factory was situated on a hillside and made use of gravity for the flow of liquid products.

Herbig Haarhaus appeared to have had a similar good laboratory but this had suffered to a considerable extent although the offices were still in good order.

Vorwerke u. Sohne had been damaged by fire but the fabric of the factory had been extensively repaired. In the adhesive tape section the tapes were wound on a spider as in British practice but benzene was recovered from the drying rooms by absorption in activated charcoal. In the insulating tape section solvents were removed on the coating machine and recovered. The laboratories in an older part of the factory were in good order and contained apparatus for a full range of tests on adhesive tapes and moulded rubber. This apparatus escaped major damage during air raids by being kept in a cellar. At some firms the damage had been such that the firm had evacuated everything that could conveniently be removed to new factory sites in the east. (This included items of plant, stocks, records and the technical staff). In these cases all now appeared to be in the hands of the Russians.

13. Large Scale Plant:

The paint-making plant seen at the various Works was generally of well-known types. Gum-running in varnish making was done by the "English method" in gas-heated kettles. Pigment pastes were kneaded in machines of the Werner-Pfleiderer type, and ground on steel roller mills; single roller mills were commonest but 2- and 3-roller mills were seen. Ball Mills (steel) were used in some places.

13. Large Scale Plant (Contd.)

Gustav Ruth of Hamburg had a very useful cooking pot with condenser, heater and cooler for the controlled air-blowing of drying oils. The process could be completed in 2 to 3 hours instead of the usual 24 hours.

APPENDIX I

Aircraft Lacquers, Sealing Compounds, primers, etc. Formulae from Dr.Kurt Herberts & Co.,Wuppertal Barmen

NOTES: Four figure number = type of lacquer) German Air Ministry
Two " " = shade) Specification

Acronal 4	=	mixed polymer from ethyl and isobutyl acrylates made by I.G.Bitterfield.
Abdichtungspaste	=	sealing compound for pressurised aircraft.
Glastal-Einlassgrund	=	vitreous penetrating base - first coat in waterproof scheme for wood.
Durophen 263 D	=	phenolic resin modified with drying oil - Dr.Kurt Albert, Wiesbaden.
Plastophal	=	U.F.resin. I.G.Ludwigshaven and Oppau.
Hardner	=	Phosphoric acid
K.M.Harz	=	melamine formaldehyde resin - I.G.
Palatinol B.B.	=	benzyl butyl phthalate
Ikarol	=	trade-name Warnecke and Bohm
Kunstharz A.W.2.	=	cyclohexanone-formaldehyde resin - I.G.
Kunstharz 100 m.	=	Warnecke and Bohm resin said to be drying oil modified phenol alkyd with resin and sulphur.
K.30	=	benzine B.P.80 - 102°C.
Nachlauffettsaure	=	2nd runnings fatty acid
Caput mortuum	=	dead black pigment Fe_3O_4 + MnO_2

POLYSTAL

INFORMATION SUPPLIED BY SCHAFFERHENRICH & CO., DETMOLD (Translated)

Application

For high-duty cold-glueing of wood in aircraft, automobiles, ships and wooden structures.

Properties of the glued-joint

In the viscous unattached condition, plastic Polystal glue withstands completely the action of cold and boiling water, and makes extremely strong joints. In consequence of its stability to heat, moist air, mildew and bacteria, full resistance to weather is given in unfavourable circumstances.

At places of thick masses of glue ("Glue nests") a high tenacity is also obtained. The additional layer of glue does not cause increased wear of working tools.

Working method

The three products Polystal UI, Polystal UII and Polystal Accelerator "Green" are required.

Polystal Accelerator "Green"

The accelerator solution is prepared ready for use by dissolving:

20 parts by weight Polystal Accelerator "Green" (powder) in 80 parts by weight cold or warm water.

This accelerator solution can be kept for any length of time in a closed vessel (glass flask).

Composition of Polystal Glue

To 100 parts by weight of Polystal UII are added 40 parts by weight of Polystal UI (in that order).

Composition of Polystal Glue (contd.)

Instead of weights, volumes may be used, when it becomes:

100 volumes Polystal UII, 40 volumes Polystal UI

After well mixing the components, the glue is ready for use.

At a temperature of 20°C., the Glue base is to be used within 10 hours. The period of use is curtailed at a higher temperature, the containing vessel being cooled by immersion in cold water if necessary.

The Polystal accelerator "green" solution is applied to one of the surfaces to be glued together by means of a brush, sponge, or by immersion. Four hours at the latest after the application of the accelerator, the time of pressure is to be doubled.

The Polystal UI/UII mixture is applied to the other wood surface by a spatula, glue-roller or a brush. Within an hour after the application of the glue pressure is applied.

Duration of Pressure

2 hours at 20°C. Wood and Ambient temperature.
3 " " 10°C. " " " "
6 " " 5°C. " " " "
overnight at temperatures below 0°C.

Previous treatment of the Wood

Soft woods and absorbent hardwoods are roughened in the direction of the grain with sand-paper No. 4 or 5. Particularly smooth and close hardwood, like Ash, Birch, Lime and others are scored by means of a fine toothplane. A high glue strength is also obtained with smooth, not too rough, saw-cut surfaces.

Reglueing

Unstuck layers of Polystal glue can be glued together again without damage. The accelerator is accordingly applied to the roughened or gluefree surface.

Glue containers

Especially convenient glazed earthenware pots with an internal conical shape (Suppliers: Annaloerger Steingutfabrik A.G.Magdeburg) allow easy removal of the residual glue by immersion of the pot in hot water.

Brush and Spatula cleaning

The tools used for the application of the glue are cleaned immediately after use with Polystal thinner.

Storage of the Glue

Barrels containing Polystal UI and Polystal UII are always tightly closed immediately after removal of the adhesive. Penetration by moisture (also from the air) is to be prevented, since this greatly reduces the mobility of Polystal II and the life of the glue base.

Polystal UI and Polystal UII, like Polystal thinner, are inflammable, and are not therefore to be used near naked lights or fire.

For observation

In consequence of the solvent content of Polystal UI and UII (Ethyl Acetate), the Workshops are to be well ventilated, and precautions are to be taken against fire risk.

Naturing time of the mixture amounts to one hour before the use of the glue.

49182/1350/18.3.46./PSC/27.59.2.