B.I.O.S. FINAL REPORT No. 1324

ITEM No. 31

GERMAN RADIO FREQUENCY CABLES

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BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

Price 12s. 6d. net

S.O. Code No. 51-3275-2

GERMAN RADIO FREQUENCY CABLES.

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B.I.O.S. TRIP NO.1176.

B.I.O.S. Target Nos:-

See Pages. 1,2,

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

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(Deposited at Board of Trade, Documents Unit, Landowne House, Berkeley Square, W.1.)

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1. INTRODUCTION.

The party left England on the 15th September 1945 and returned individually on or about 13th October 1945. A list of the drawings and documents collected during the course of the tour is given in Appendix IV; these documents are deposited with the B.O.T., Documents Unit. The targets investigated are listed below. The numbers 1 - 32 used in parentheses throughout this Summary Report, refer to the individual detailed Field Reports. These Field Reports are included as Appendix I to the present report and should be consulted for further details of interesting points. In studying these reprts it should be appreciated that the accuracy of specific figures quoted by those under interrogation is sometimes questionable since most of the personnel interrogated were speaking without documentary evidence; it was invariably stated that such documents had already been removed.

1. Professor Esau, Admiral J. Gladenbeck, Dr. S. Mullen
   C31/6771 C31/6772 C31/6773

2. I.G. Farben, Weinheim. C31/1614

3. V.D.M. Sud-Deutsche-Kabelwerke A.G., Nechar Steinach Nr. Mannheim. C31/1613

4. P.T.R. Heidelberg. C31/6768

5. V.D.M. Sud-deutsche-Kabelwerke A.G.,Mannheim (Main Works). C31/723

6. I.G. Farbenindustrie, Ludwigshafen. C31/675

7. Sud-deutsche-Telefon-Apparate-Kabel and Drahtwerke A.C., Nuremberg. C31/724

8. Kabel and Metallwerke Neumeyer A.G. Nuremberg. C31/1520

9. N.A., Herzogen-Aurach bei Erlangen. C31/6774

10. Kabel und Leitungswerke (Siemens) A.G. Neustadt-bei-Goberg. C31/1612

11. Telefunken, Berlin. C31/6770

12. Dr. Rosbaud, Berlin. C31/6769

13. Siemens Kabel Gemeinschaft, Berlin. C31/4649

14. A.E.G. Berlin. C31/1553

15. Felten & Guilleaume, Koln-Mulheim. C31/272

16. Dinamit A.G. Nr. Koln. C31/4172

17. Rheinische Kabel, Koln. C31/708

18. Siemens und Halske A.G., Hamburg. C31/1762

19. Telefunken, Hamburg. C31/5608

20. Nord deutsche Seekabelwerke, Nordenham-i-Oldenberg. C31/700

21. Hermann Borstoff, Hannover. C31/1186

22. Norddeutsche Kabelwerke, Berlin. C31/826

23. Lorenz A.G. Lorenzweg, Berlin. C31/527

24. Dr. Bushbeck, Ex Telefunken. C31/6775

25. Dip: Ing: Gottschewski, Friedeman-Berlin. C31/6776

26. Reichspost (Ober Post Direktion), Berlin. C31/6777

27. Guido Horn, Berlin. C31/5100

28. Froitzheim und Rudert, Berlin. C31/598

29. Lignes Telegraphiques et Telephoniques, Conflans-St. Henorine. Nr. Paris. C31/6778

30. Dr. Buckholz, Heidelberg. C31/6779

31. Reichspost Zentral Amt, Berlin. C31/6781

32. D.V.L. Berlin. C31/6780

33. Dr. Viehmann. C31/6782

34. Professor Kupfmuller. C31/6783

2. GERMAN R.F. CABLE FIELD.

2.1. Organisation.

The survey is complete with two exceptions, namely that no Service Establishments were in being at th time of the visit, and that we were unable to visit the Kabelwerk Vacha in the Russian Zone.

A few senior service executives (Esau, Kupf muller, Gladenbeck and Viehmann) were interrogated and l us to the opinion that there was no centralised authorit for R.F. cable development such as we had in this countr and that the initiative for such development was largely with the Equipment manufacturers. Towards the end of t war, in August - November 1944, the Kriegsmarine made sc attempt at standardisation and issued a list of standard cables. A precis of this document is given in Appendix II and contains much useful information. The prime mov in this standardisation was a Herr Brandt, and after his death, a Herr Seibert. We were unable to locate the latter.

The lack of a co-ordinated development and directive authority had the result that individual cable makers tended to further develop those types for which they were well known in the broad-band communications a television fields prior to the war. Thus, Siemens, A.E Norddeutsche Berlin, Felten and Guilleaume and Norddeuts Seekabel. A.G. were responsible for the majority of Air- spaced types, while Kabelwerk Vacha A.G. were responsib for perhaps 80% of the solid dielectric types.

All efforts to visit Vacha, which is in th Russian Zone, failed, and the inability to interrogate their technicians constitutes a most important gap in t investigation.

Among the equipment companies, Telefunken responsible for much valuable work, particularly in the provision of specifications for R.F. Cables and of test equipment. Lorenz appear to have worked on cable desi for high-power broadcast transmitters, but no trace was found of their information on cables for higher frequencies.

2.2. Personalities.

The list of personalities given in Appendix III includes all personnel interrogated, and also people to whom reference was made but who could not be located. Among the people included in this list, the Mission considers that the following people are of outstanding importance in the field under investigation: their specialist activities are indicated below:-

Meinke ...... Cable Tests and Test Equipment (11)

Bushbeck ...... Cable Tests and Test Equipment (22)

Weissfloch ...... Theory.

Kaden ...... Theory.

Droste ...... Theory. (8)

Erich Muller ...... Cable Design and Tests. (14)

Heinrich Riedel ... Tests.

Peters ...... Tests.

Ochem ...... Screening.

Gutzman ...... High Power Cables. (21)

Seibert ...... Service Organisation.

Ernst Fischer ..... Manufacturing Technique. (13

Kohl ...... Manufacturing Technique.

Horn ...... Manufacturing Technique and Materials (18)

Berger ...... Materials. (2)

Heering ...... Materials. (13)

3. GERMAN R.F. CABLE DESIGN.

3.1. General.

Greater emphasis was laid on semi-air-space construction than in this country where solid construction was practically universal for Service use on account of greater robustness and reliability.

The possible explanation is that the Germans had considerable experience in semi-air-space types prior to the war for television and broad band telephony, secondly they lacked good solid dielectrics, and thirdly they may have sacrificed robustness, and reliability to obtain extra low loss and flexibility. Assuming that the German cables were sufficiently reliable and robust for practical purposes there is an obvious lesson here for our own designers.

Many of the cables we examined have been previously described in R.A.E. Report No. Rad. 250 dated February 1945. We were however able to obtain further details regarding these cables, and in addition we examined several types which had not previously been described. The questions asked in Paragraph 5 of that report were put to all interrogated, and the answers are incorporated in this report, although some of them are negative.

Amongst outstanding developments were high-power cables for broadcast transmitters (11,14, 21 and 22). These, with one exception, were semi-air-spaced types and unsuitable for frequencies greater than approximately 1000 Mc/s. (11)

Generally, the German practice of using air-space constructions will be of greater interest to British manufacturers than to the Services, and the most useful application for these types will probably be found in the post war commercial fields, e.g. television, broad-band telephony, aerial feeders for ground stations.

3.2. Inner Conductors.

Copperweld was extensively used for fine wires, as in low capacitance cables, and there were interesting composite constructions for heavy single conductors. Details of one such construction "Protopal" will be found in the Siemens Report (13), although the construction was also used by A.E.G. ("Walzen" - 14)

Felten and Guilleaume (15) Norddeutsche Seekabel A.G. (18) and other smaller firms. There is little doubt that these constructions ("Protopal" and "Walzen") were first introduced because of shortage of copper, but when used with a copper outer and aluminium inner it has the advantage of lightness, and when used with a copper outer and steel inner, as in submarine cable applications, it has the advantage of great tensile strength.

Another interesting development was the use of H.F. Litz conductors in high power cables to give reduced losses up to several Mc/s (21 and 22).

For the largest types of cables, braid and helically corrugated longitudinal tapes have been used to secure attractive electrical and mechanical characteristics (14). Tape braided inner and outer conductors were also used by Vacha.

3.3. Dielectrics.

3.3.1.

Solid dielectrics were almost invariably mixes of Oppanol (Polyisobutylene) and Polystyrene, of which most manufacturers used the 60/40 (Vacha) and Decelith 90/10, although it was stated that Vacha used 70/30 (13 and 6) Oppanol of molecular weight up to 300000 was quoted as being used (21) although I.G. Farben (2 and 6) referred to a molecular weight of 200000 as the highest commercial grade. The interesting feature of these dielectrics is their flexibility over the required temperature range, and the possibility of applying the material in the form of longirudinal tapes (13 and 20). Less attractive features were their low maximum operating temperature, and their non-adhesion to the conductor, which coupled with poor rigidity, was liable to cause cavities near the inner conductor. Towards the end of the war, Lupolen (polyethylene) had been partially developed, but no large scale cable production using this material was undertaken owing to shortage of supplies and to difficulties of exact processing caused by wide molecular weight dispersion (6 and 2). The power factor of this Lupolen at 4 to 6 times 10^{-4} (6) was comparable with figures obtained in U.K. in the early days, but was inferior to British production of similar date. No very low values were claimed by the Germans, and the statement was repeatedly made that samples of polythene cable salvaged from destroyed British aircraft were electrically and mechanically superior to German Lupolen.

3.3.2. <u>Semi-air-spaced dielectrics</u>.
Semi-air-spaced constructions were as follows:-

Type	Material	Effective permittivity	Remarks.
Bead or Thimble	Polystyrene or Ceramic		A.E.G. and Vacha and Sud-deutsche
Disc Spacer	(a) Ceramic (b) Polystyrene disc spacers had been developed experimentally.	1.06 1.07	A.E.G. (14) Siemens (see remarks in footnote.) When used with Styroflex tapes.
"Styroflex"	(a) Orientated polystyrene threads and tapes	1.16-1.20	Gives extremely light cable but dimensional accuracy scarcely adequate for cm. working
	(b) Superposed narrow polystyrene tapes with medium length lay.	1.3-1.35	Present submarine cable construction (18). May be of interest for long lines.
Thread	Cartwheel construction of silk thread (Fadenkabel) (22)	1.0	This construction was deleted from Service Preferred List probably due to fragility and sensitiveness to moisture.

The polystyrene disc spacers developed by Siemens were claimed not only to have a low permittivity but also to eliminate reflections (by their construction and by their spacing in the cable) up to 2000-3000 Mc/s. (13 and 14).

3.4. Outer Conductors.

3.4.1. Braids. Substitutes for tinned copper wire braids, e.g. tin lead alloy on copper (5), plain copper, zinc, aluminium and aluminium magnesium alloys (Aldrey or Legal) were used, probably due to lack of material, as their use was not favoured. Low filling factors were general, e.g. 60% filling factor was quite widely used, being justified b screening tests and good R.F. conductance. No explanation was found for the difference in the number of wires per pic between right and left hand lays, and for high-filling-fact long-lay braids observed in captured Vacha cables. No trace of these unusual features have been found in other than Vac production. The use of copper tape braids was regarded as a purely wartime expedient, as they were said to age badly(20 Vacha experience and data would be valuable.

3.4.2. Helical tapes. Long-lay tapes and wires were found fairly satisfactory electrically at low frequencies, but we not satisfactory above a few Mc/s and were also mechanical unsatisfactory for flexible cables (22).

3.4.3. Longitudinally applied outer conductors. Interesti types originally developed for wide-band communications we Schalenkabel (14) and Sickenkabel (Siemens 13), but the former type is now obsolete and replaced by Rohrkabel. The former firm also circumferential or helical grooves for large cables. On small power cables a tape applied longitudinally and folded round the core (the join having double lap turned down till it was almost flush with the circumference) was used occasionally as outer conductors although usually used as sheath (8).

3.5. Protective Coverings.

These were, in the main, of P.V.C. (under the names of Mipolam, Igelit and Vinnol) but the following materials were also used in some instances.

Oppanol Mixes.
Stabol.
Buna.
Polythene.

The P.V.C. is stabilised by either sodium carbonate alone or together with Phenyl Indol. The plasticiser Palatinol F was claimed to be of low volatility and to have a low crack point (2, 6) and appears worthy of further study, w the object of manufacturing in England, provided that the

German claims are found to be true. No information could be obtained concerning the poisoning of dielectrics by migration of the plasticer from the sheath.

4. <u>CABLE MANUFACTURE</u>. The team's survey cannot be accounted completely representative of the R.F. Cable Industry, since Vacha was not visited and since all the cable-making plant in the Siemens and A.E.G. factories had been evacuated by the Russians. The prime object of the visit was to study R.F. cables developments rather than cable-making machinery, which subject has been covered adequately by other teams (see Report 179). The opinion gained of other manufacturers plant and technique was not impressive, but the following interesting developments were noted:-

4.1. The wide use of wire braiders of moderately high speed manufactured by Guido Horn of Berlin and by Freitzheim & Rudert of Berlin.

4.2. An experimental straight through plastic extruder, designed by Rohbock of I.G. Farben and being developed by Hermann Berstoff, Hannover (6 and 19).

4.3. Longitudinal multi tape cover for large diameter cables.

4.4. Longitudinal metal tape cover and seaming machine by Schumag (8).

4.5. Alternative to Pyrotenax (although not used as R.F. cable). (13)

5. <u>CABLE SPECIFICATIONS</u>. No trace was found of the existence of any detailed Government specifications for R.F. Cable, except the O.K.M. preferred list and it is probable that most cables were made to cable-makers own specifications, i.e. as proprietary articles to meet requirements stated by equipment designers. No information would be obtained of a requirement for cables to work in high temperatures. A few cable specifications by Telefunken were studied, and it was noted that they included two commendable features:-

(a) <u>Uniformity</u>. It is required that the cable be tested when terminated in its nominal Z_0, and have a standing wave ratio of not greater than 1.1 over a wide frequency range (350 to 1500 Mc/s). It is believed that the uniformity achieved was not, however, at all superior to those attained by British cables. This is believed to be due partly to the constructions which they adopted and partly due to the fact that the materials available to the German manufacturers were not entirely satisfactory.

(b) Screening. Definite values of "coupling impedance" were required from specific cable types. It was apparent that quantitative measurements of screening were made by many laboratories (19). It is likely that this work was directed to a specific purpose, although no demand by equipment designers was discovered for better screening such as might be obtained by double braided cables, although Telefunken (11) had realised this to be a problem. A few coaxial cables having a double screen were found (13) A.E.G. (14) stated that at 10 Mc/s the addition of an iron screen to an existing copper braid screen gave no improvement in screening.

Manufacturers' Identification Markings.

The internationally known V.D.E. code of coloured threads was used by all cable-makers until quite late in the war. Subsequently a secret R.L.M. (11(b)) was adopted. Since R.F. cables were not rigorously standardised and invariably contained individual cable-makers idiosyncrasies, identification in the U.K. was invariably easy and found during this trip to be accurate. Details of the R.L.M. code were not discovered, but no great importance is attached to them.

6. STANDARDISATION.

Before the War most transmission cables conformed to a characteristic impedance of 70 ohms, due no doubt to the emphasis on minimum attenuation for long distance broad-band cables of essentially air-spaced design A considerable amount of test gear came to be built for testing cable systems having this impedance.

At a later stage in the War, the engineers concerned with high power transmission wished to adopt an impedance of 60 ohms or lower in order to improve the power handling capacity of cables and to permit the use of cables for parallel loads (120 ohms). The O.K.M. were persuaded to adopt a value of 60 ohms as a standard impedance for all transmission cable, but owing to the shortage of suitable test-gear this standardisation was not implemented in practice. It is now considered by many that an impedance lower than 60 ohms is necessary for high-power transmission so that the arguments in favour of a single standard of characteristic impedance would seem to be weakened.

For low-capacitance cables, the O.K.M. attempted to standardise on an impedance of 150 ohms to replace cables ranging from 120 to 200 ohms. The adoption of this impedance pre-supposes an air-spaced construction.

7. TESTING EQUIPMENT. Considerable and efficient work had been done by Telefunken to provide a standard standing-wave gear for measurements in the decimetre band, resulting in a very soundly designed equipment. In the centimetre band however, the design of equipment was not outstanding, although useful instruments were made by Rhode and Schwarz (22). Staggered step couplings between the line and the cable under test were preferred to cone couplings owing to the accuracy required in machining the latter (11 & 14). The remainder of the measuring gear by Telefunken, for practical testing, is highly noteworthy (11).

. CABLE ACCESSORIES. No intensive study of these was made during this investigation and this field has been covered by a subsequent Mission. Note was made of two ranges of plugs and sockets (by Telefunken and Lorenz) for use in the decimetre band. Adaptors to suit the Telefunken test line were available, which facilitated accurate testing and adjustment of equipment. The standards of mis-match in the decimetre band were good, but it seems doubtful if the designs would be adequate for the centimetre bands.

The wide use of air-spaced cables requires terminations possessing a high degree of water-tightness. This was sometimes achieved, but at the expense of very complicated design (13). Precautions for electro-magnetic screening were not good (31). Clamped joints to the cable braids were preferred, both for copper and aluminium braids since it was found that soldering caused embrittlement in the former case and corrosion in the latter case (31).

. WAVE GUIDES. In the course of the trip, two types of flexible wave guide (13) were observed. These were being developed experimentally by Siemens and were of the folded helical tape variety, protected by steel wire braiding. The impression was gained that wave-guide development was not very advanced and the use of flexible links had not yet come into operational use.

10. CONCLUSIONS. Whilst a great deal of useful information has been collected by this trip, it does not reveal noteworthy advances in design, manufacture or testing of R.F. Cables insofar as they bear on Service problems.

While it is realised that the time spent with each individual was too short to extract all the information which he should have possessed, with the consequence that this report therefore lacks those details, it is generally felt that a satisfactory compromise was achieved.

APPENDIX I.
Index of Field Reports.

APPENDIX I (Contd.)

B.I.O.S. TRIP No. 1176.
FIELD REPORT No. 1.

Visit to Schloss Transit Camp at Kransberg to Interview Professor Esau.

Tuesday, 18th September 1945.

Preface.

The intention was to obtain a preliminary account from Professor Esau of the "set up" of the organisation dealing with the design, manufacture and supply of R.F. cables in Germany during the war, together with the names of prominent people associated with such an organisation.

On arrival at the castle it was found that Professor Esau was in hospital at Bad Neuheim suffering from a contagious skin infection, but the Commandant, Lt. Co. Henderson offered to go with us to the hospital and see whether Professor Esau could be interviewed. In the meantime he had a Dr. S. Müller and Admiral Gladenbeck at the camp and thought they might be of assistance to us. These two people were interviewed and later Professor Esau was interviewed at Bad Neuheim.

Dr. S. Müller.

Dr. Müller had been associated with the development of Ceramics until 1935 in assocation with Dr. Scheid, Director and Engineer of the Hermsdorf Plant. Dr. Scheid was the inventor of "Steatite" ceramics, and Dr. Müller thought he was still alive.

So far as Dr. Müller knew, the Hermsdorf Plant and also the plant of the Steatite Magnesia A.G. of Lauf near Nuremberg were still in existence, and they had both been used for the production of ceramics used in H.F. and H.T. applications. He suggested that we try to contact Dr. Scheid.

Between 1935 and the outbreak of the war Dr. Muller had been Editor of the Electrotechnische, Zeitschrift.

During the war he had been associated with General Martini in the development of A.A. Radar equipmen but was not familiar with the cable side.

As the result of our questions it appeared that there had been little or no attempt to form a centralised organisation which would correspond to our Inter-Service and manufacturer's committees. He stated that the orders were issued to a main contractor such as Telefunken, who were then responsible for the solution of all problems of designs, manufacture and testing in conjunction with their sub-contractors.

He named a Mr. Brandt, Supervising Engineer of Telefunken as a useful contact for further details.

With regard to testing, Dr. Müller stated that a certain amount of testing of equipment and components was carried out by No. 3 Anti-Aircraft School at Heiligen See (Nr. Berlin) under Capt. Hoffmann.

Liaison between the services and industry was effected through the Technischer Amt of the Air Ministry and the Bau Aufsicht der Luftwaffe (B.A.L.)

Gladenbeck.

Gladenbeck was Assistant to (Professor) Küpfmuller, the Scientific Advisor to the Kreigs Marine. Until 1942, Gladenbeck was in the Reichspost Research Institute and then became chief of the Reichsforschung Anstalt at Berlin Machtnow. He stated that Telecommunication problems were handled by the 2nd and 3rd divisions of Reichspost Zentral Amt at Tempelhof.

He referred to the design of a television cable capable of carrying 200 speech channels and a television carrier at about 4 Mc/s.

Professor Esau.

Professor Esau was in a poor state of health, and although fully co-operative, was difficult to interv

He stated that he had no intimate knowledge of cable applications but could refer us to people concerne with their developments. The most knowledgeable man in this field was Dr. Cords, an old student of his. Cords was associated with Norddeutsche Kabelwerke of Berlin and subsequently became Director of Getewendt near Reichensberg, Sudetenland.

Telefunken and Vacha were the two firms most actively engaged in the R.F. Field.

He stated that Dr. Pferstorff, Chief of Laboratories, and Dr. Scheibe, a specialist in H.F. measurements, who were his assistants at the Reichsanstalt would be able to throw more light on cable matters. He understood that they were evacuated to the British or U.S. Zones, probably to Heidelberg.

He also mentioned a Dr. Erwin Marx of the Electrotechnische Dept. (P.T.R.) who was concerned in this field. He thought that Professor Marx was at Braunschweig.

Dr. Esau was very keen to discuss his work on non-reflective absorptive coverings, from which it transpired that all electrical measurements in his laboratories were made on slabs of dielectrics and not on cables.

The measurements were made in specially lined rooms made non-reflective by first lining with metal, e.g. steel, and then with sheets of a special material of very low reflective power. These sheets were about ½ cm thick and spaced from the metal lining by about 2½ cm., the intervening space being filled with steel wool. By this means it had been possible to obtain a reflection coefficient of the order of 0.5% but for improved mechanical characteristics and for submarine protection a somewhat different material was employed with a reflection coefficient of the order of 5%.

From the measurements of the (1) reflection and (2) absorption coefficient, it is possible to calculate all the primary characteristics, including P.F.

This matter has been fully investigated and reported on by a previous team of investigators. It was also published in H.F.M.

B.I.O.S. TRIP No. 1176.
FIELD REPORT No. 2.

Visit to I.G. Farben at the factory of Carl Freudenberg, Mulheimerstrasse, Weinheim.

28th September 1945.

Persons Interrogated:- Dr. Berger.

This section of the I.G. Farben laboratories temporarily at the above address owing to insecurity at Ludwigshaven. Dr. Jorden was unwell and in any case was a specialist of lacquers. His chief assistant, Dr. Berger, in charge of the plastic laboratories was however available for interrogation.

The following information was elicited.

1. LUPOLEN (Polythene).

1.1. The plant at Ludwigshafen was capable of an output of 10 tons per month. Fuller details could be obtained at Ludwigshafen from Dr. Hengsternberg and Dr. Würstlin, physicists.

1.2. The average MW of the product was between 26,000 and 30,000 but the molecular spread was very wide. Oxygen is used as the catalyst and the pressures employed are between 1,000 and 2,000 atmospheres.

1.3. Polythene was largely supplied to Nordenham for H.F. Cables (?). Supplies had also been going to Walter of Kiel who used it with various proportions of Oppanol (polyisobutylene) for mouldings. The covering of metals to prevent corrosion: (resistance to HNO_3 and H_2O_2)was mentioned as another application.

2. P.V.C. etc.

2.1. Unplasticised P.V.C.

2.1.1. Articles were fabricated from pressed sheet by a rough shaping process and finally compression moulded, e.g. soap boxes, chambers (night pots).

2.1.2. <u>Thin sheet and tape or ribbon.</u>

2.1.2.1. The P.V.C. powder is milled at 140°C. into rough and somewhat brittle sheets, 0.5 mm thick, and passed to a mill at 200°C. where it is compressed and orientated mostly longitudinally.

2.1.2.2. The foil is used for wrapping food in place of tin foil, and even as a straw substitute for weaving into baskets and hats. It could also be used as a cable wrapping though this was not mentioned.

2.1.2.3. The plant for making the foil is at Troisdorf, (Dynamit A.G.) near Cologne, and also at I.G. Ludwigshafen.

2.2. <u>Plasticised P.V.C.</u>

The usual plasticiser employed is Palatinol F. 40 parts to 60 parts of resin. Palatinol F. has a low volatility (less than 3% loss in weight after 11 days at 90°C. in the plasticised P.V.C.)

Its crack point (impact) is about -30°C. but by the addition of Plastomoll (a solid composition of butadiene and an ester of fumaric acid) the crack point could be reduced to -45° to -50°C.

Palatinol F. is an ester of phthalic acid and an alcohol lying between C_7 and C_{12} made by oxidising paraffin wax and reducing the product with hydrogen. Palatinol F. can either be made from synthetic Paraffin derived from carbon monoxide at Levna or from the residual waxes from brown coal: the usual grade by MP - 60°C.

There was no knowledge of the "poisoning" effect or migration of this or any other plasticiser from the P.V.C. to other dielectrics adjacent. Mention was however made of the following multilayered insulation upon cables. 1st covering polythene, 2nd covering un-plasticised P.V.C. (presumably Orientated), 3rd covering plasticised P.V.C. as a sheath.

The resistivity of P.V.C., plasticised with Palatinol F. was about 10^{12} ohms/cm cube with a maximum value of 10^{13}. The standard D.R. test for cables called for 2.5 megs-km at 20°C.

The stabiliser used by I.G. was Phenyl Indole known as Stabiliser I (I) and the quantity used wasfrom .3 - 5% of the polymer. It was used in conjunction with sodium carbonate or sodium phosphate (acid phosphate formula given as NaHPO4 but presumably Na_2HPO_4.

ODD NOTES.

(1) Mipolam was standardised as P.V.C. 84% Acrylic ester 16%.
(2) Copolymer polyvinyl chloride and acetate, usually 90-10 is made by I.G. at Hochst.
(3) Vinylidene chloride or Saran known as Diorit in Germany was only made experimentally.
(4) Oppanol V - Butadiene (small quantity) and Oppanol M.W. 200,000 is Vulcanisable.
(5) Another toughened oppanol contains 10% Polythene.

(6) The standard Oppanol for cables has M.W. 200,000.

(7) Styrene for electrical purposes was used by the block (thermal) process, and EF does not mean 'emulgator Frei' as is often stated. Actually, the E stands for emulsion process and the latter following is a grading letter F or H.
The block Styrene has a number following it.
No. 1 was the first product not entirely satisfactory
No. 2 was a copolymer.
No. 3 is the present standard and production was at the rate of 300 tons per month.

Information on Styrene could be obtained from Dr. Hengsternberg or Dr. Wrustlin both physicists at Ludwigshafen.

APPENDIX I. (Contd.)

B.I.O.S. TRIP No. 1176.
FIELD REPORT NO. 3.

Visit to Suddeutsche Kabelwerke at Nechar Steinach.

20th September 1945.

This was found to be a section of the main works at Mannheim and which had been evacuated to Nechar Steinach under a dispersal scheme: it occupied a portion of the premises of a tannery. At the time of the visit only a small quantity of machinery was found there, the remainder having been returned to Mannheim: no technicians were present. No work was in progress all the plant having been dismantled.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 4.

Visit to PTR at Volkschule: n. end of Steubenstrasse. Heidleberg.

20th September 1945.

See Report by R.H. Ranger Lt.Col.Signal Corps U.S. June '45.

Persons Interrogated:- Dr. Adelsberger, Dr. Helmholtz, Mr. Forger.

COMMENTS ON THE TARGET.

The target was found without difficulty from the rough position obtained in London although no information was obtained from the T. forces in Bad Oyenhausen or Frankfurt. The apparatus brought from Zeulenrode by Ranger had not been completely unpacked as the team expected to be moved to new quarters.

RESULT OF THE INTERVIEW.

The purpose of the interview was to examine in more detail the measurement work at high frequencies carried out by this team and its possible application to the testing of cables. It was found that although apparatus had been made for the measurement of impedance at 6 cm. and 1.6 cm. it had not been used for the testing of cables, but only for measuring the impedance of components such as valves.

The method used was that involving the measurement of the voltage distribution along a coaxial line by a travelling detector. The lines had the following dimensions.

(a) For wavelengths down to 6 cm.
Outer conductor 2 cm. diameter, inner conductor o.6 cm. diameter. Length of travel of detector 30 cm.
(b) For wavelengths near 1.6 cm.
Outer conductor 1 cm. inner conductor 0.3 cm.

Length of travel 15 cm.

The lines had been lost on the way from Zeulenrode and therefore could not be examined.

A discussion of the other work of this team is contained in a separate report.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 5.

Visit to V.D.M. Sud-Deutsche Kabelwerke, Waldhof Strasse, Mannheim.

21st September 1945.

Persons Interrogated:-

(1)	Dr. Wanner	Managing Director.
(2)	Dr. Raymond.	Works Manager.
(3)	Mr. Bock	Ober Engineer.
(4)	Dr. Schwedler	Chief Chemist.
	Mr. Doerr.	Interpreter.

1. PREFACE.

It was established that this company are not manufacturers of R.F. Cables. Their main interest in plastic materials was in connection with:-

(a) Aircraft Ignition Cables.
(b) Field cable.
(c) Lighting cables.

Our interest being primarily confined to R.F. cables, and bearing in mind that another Mission is investigating these general cables, we add the following notes of our discussion for purposes of confirmation.

2. IGELIT.

2.1. They plasticise a certain amount of their own material for aircraft cable and gave the following formula

75.3% P.C.U. (I.G. Farben Resin from Bittersfelde)
24.2% ED 242 Plasticiser.
0.4% Titanium Dioxide.
0.1% Dyestuff.

They could not offer any details of the P.C.U. or ED 242 as these were purchased outside. It could, however, be stated that the P.C.U. is a straight P.V.C.

2.2. Field Cables.

The plasticised material is purchased from Hemmeyer Núremberg. They thought the formulae was:-

81.0% P.C.U.
19.0% ED 140 Plasticiser.

Again they could give no details of these materials but they thought that ED 140 was a stearic ester of Tetra-hydroforan.

2.3. Igelit MP.

All copolymers of Igelit are followed by the letters M.P., which stands for mixed polymer.

3. LUPOLEN.

This is the trade name given to the German Polyethylene. It is manufactured at I.G. Farben at Ludwigshafen. Sud-Deutsche have not used the material for production and their laboratory experience was confined to experiments for an improved Field cable.

In this connection they mentioned that they had tested a sample for 6 months in water which gave an insulation value of 30,000 megohms.

4. OPPANOL.

It was stated that Oppanol had been used with Buna for ignition cables to produce a mix having better resistance to ozone and better ageing properties. The molecular weight of the Oppanol was 100,000 - 200000.

5. BRAIDING.

With regard to Braiding it was stated that their invariable practice was to have the same number of "picks" for left-hand and right-hand lays.

Their first preference was for tinned copper wires but shortage had gradually forced them:-

(a) To a tin-lead alloy on Copper.

(b) To plain copper.
(c) To aluminium.
(d) To aluminium-magnesium alloy (Aldrey (V.D.M.) Legal (Siemens))

6. EXTRUDERS.

We were given a drawing of the scroll and head of a 60 m.m. Extruder. It was steam heated machine and the main dimensions were:-

(a) Scroll Diameter	60 m.m. = D
(b) Length of scroll	370 m.m. = 6.1 x D.
(c) Description of "	2 Start thread.
(d) Depth of Thread	Approx 8 m.m.
(e) Pitch of Thread	72 m.m.
(f) Temperature of Feed.	140°C. (afterwards found to be rather an over-estimate, the real figure we suggest is about 100-110°C).
(g) Temperature at Die	160°C.
(h) Temperature of Steam	160°C. (8 Atmospheres).

A gas jet was fitted at the outlet die, but due to failure of the gas supply an electrical element had subsequently been fitted.

No screens were incorporated either at the end of the scroll or in the head.

7. LONGITUDINAL MACHINES.

No attempt had been made to process P.V.C. on longitudinal machines.

8. VISIT TO FACTORY.

We then went round the Factory.

Laboratories and material stores had been damaged by air attack but they stated that no machines had been lost.

The factory normally employed 1500 people, but owing to shortage of raw materials less than 300 people were being employed at the time of our visit.

Generally, there was little of unusual interest.

Extruder. One 60 m.m. Extruding machine was working. The material, P.V.C., in the form of cut sheet about 80 to 100 mils. thick, was being pre-heated in an electrically heated oven and fed direct to the machine. This particular machine was manufactured by Berstoff of Hannover and was the only machine fitted with a roller feed. The overall diam. was 0.060 inch and the output speed 100-150 metres per minute. A synchronised drive was fitted to extruder and take up, the extruder speed being independantly variable.

Braiding Machines. A design of textile braiding machine and another for wire braiding installed since the war and manufactured by Guido Horn of Berlin were of interest. The light was bad but we attempted a photograph of each machine. The output was stated to be 200 metres per hour running at a speed of 100 - 150 R.P.M. They had no catalogues or drawings, these having been surrendered to Klopsch, U.S. Group Control Council, Metal Division, Industry Branch, Administration Bldgs., Room 230, Höchst.

Spark Testing Machines. An interesting design of spark testing machine, alleged to be completely safe from the operatives' point of view, and fitted with automatic cut-out, was being used. It is called a "Trockenprufer" and was manufactured by Koch & Stetzel A.G. of Dresden.

Generally speaking, all those interrogated showed a desire to co-operate, but from our point of view they had little of interest to impart.

APPENDIX I (Contd.)

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 6

Visit to I.G. Farbenindustrie, Ludwigshafen.

21st September 1946.

Persons interrogated:-

(1) Dr. Hengsternberg	Physicist - his work was largely limited to Molecular weight measurements. His assistant Dr. Würstlin was in charge of electrical measurements and was at Worms, but was not interrogated because his measurements were confined to frequencies of 1 Mc/s or lower.
(2) Dr. Adolf Schwarz	Chemist - very knowledgeable and co-operative, speaks English well.
(3) Hr. Rohbock	Engineer - very knowledgeable and co-operative. Speaks English perfectly.
(4) Dr. Hirth (assistant to Dr. Kling.	P.V.C. expert. Not helpful and would not speak English.

The following information was elicited.

1. ELECTRICAL MEASUREMENTS.

1.1. Only measurements at frequencies up to 1 Mc/s were made at I.G. and the team decided that a detailed study of measuring methods would be of little interest to the Mission.

2. STYRENE.

2.1. Nomenclature.

Polystyrene E.F. is emulsion made (E signifies Emulsion) and the F grade has the highest molecular weight of the E type at 1,000,000.

Polystyrene 1, 3 and 4 are made by the block or thermal process and

P3 is the highest M.W.

P4 is an experimental type having M.W. about 350,000

2.2. Cross linking.

Some experimental work had been done to control cross linking by the use of divinyl Benzene but with little success.

In order to control the thermoplastic and electrical properties of Styrene, D.V.B. was kept to a minimum particularly in grade 3. Cross linkage was measured by comparing calculated Molecular weight determined by

a) ultra centrifuge.

b) viscosity of solutions

any difference in the values being attributed to cross linkage (i.e. high viscosity).

Presence of D.V.B. controlled by measurement of absorption of Hg line 314.

2.3. The softening temperature of polystyrene was raised by copolymarising with vinyl/carbazol or acryl nitryl. This has fair electrical properties.

3. H.F. CABLES.

3.1. It was explained that the following sequence had occurred in Germany in the design and use of H.F.Cables.

3.1.1. Nord Deutsche Seekabelwerke - styroflex spiral and other styromic spiral and disc type, air spaced cables.

3.1.2. Kabelwerke Vacha: mixtures of Oppanol B 60 parts and Styrene 3 40 parts (maximum operating temperature said to be 80°C). Permittivity 2.3: power factor .0004 (20°C) - .0005 (100°C) at frequencies 800 - 1,000,000 c/s.

3.1.3. Deutsche Celluloid Fabrik, Eilenberg, nr. Leipzig: mixture of about 90 parts Oppanol B and 10 parts Polystyrene 3.

In the last case the material was both extruded and also made into tape for covering longitudinally and by lapping.

3.1.4. Beyond this information little or nothing appeared to be known of H.F. Cable manufacture except that it was thought that Vacha and Norddeutsche Seekabelwerke also used mixtures of Oppanol and Lupolen for H.F. Cables though the use by the latter is in contradiction to information obtained direct from NSK by Dean to the effect that no solid polythenic type H.F. Cables have been made at N.S.K. except experimentally and this statement was confirmed by the lack of wire braiding equipment in the factory at Nordenhaus. Various properties up to 70/30 (P.I.B./Polythene) were used.

4. LUPOLEN.

4.1. Production rate said to be 5 tons per month.

4.2. Molecular weight said to be 12,000 - 15,000 with a softening point of 106°C.

4.3. Extrusion temperature 160° - 170°C.

4.4. Control of physical properties by a folding test on foil as follows:-

0.5 mm. foil folded in paper testing machine until break. Target 1000 folds - often reaching 5000 folds on test if MW is high enough. Little appears to be knpwn of the variation of extrusion properties with molecular dispersion.

4.5. No stabiliser is used.

5. OPPANOL.

5.1. A = 100,000 M.W.
B = 200,000 M.W.

5.2. Stabiliser = 0.1% tertiary butyl, phenyl sulphide similar to the American stabiliser except butyl substituted for Amyl.

6. P.V.C. OR IGELIT.

6.1. Nomenclature.

6.1.1. PCU types F, R, G and K (Straight P.V.C.)
F for films (lowest M.W. (K values)
R for tubes (and known as Vinidur.
G for the rubber substitute industry - intermediate M.W. (K only)
K for cables highest M.W. (based on K value) and beat for low cold flow and highest resistivity.

6.1.2. M.P. type is 80% P.V.C. plus 20% acrylic ester.

6.1.3. Luvitan is the first of unplasticised P.V.C. and made by calendering on 4-bowl calender at 140°C. and very high pressure (strongest type of calender) and passing over hot plate at very high speed at 260°C., either orientated by stretching or un-orientated. Use is made of a herring bone surface for about 1/3 of the passage to secure wrinkles. The orientated film is cut into tape and has been thus used for insulating field cable by lapping Machine from Gendorf, Upper Bavaria (calenders by Berstoff). This film is made at

(1) I.G.F. Anorgana, Gendorf, Upper Bavaria.
(2) Dynamit A.G., Troisdorf, Nr. Cologne.

6.2. Stability.

6.2.1. The stabiliser employed was either Sodium carbonate or Sodium Phosphate - no admission of the use of other stabiliser was accepted even after actually referring to the possible use of an Indole type of chemical.

6.2.2. Stability is measured by heating the resin in an oven at 160° - 175°C. until HCl is evolved, as detected by bubbling through Silver Nitrate solution.

The value for acceptance is not less than 15 minutes, whilst the value usually obtained is 80 minutes.

6.3. Mixtures or Compounds.

Not a lot was known since the resin and plasticiser (usually Palatinol F) was sold to other companies. It was

believed that the Field Cable material was
79-81% P.C.U.
20% ED Plasticiser.

6.4. Palatinol F. is the IG preferred plasticiser and is the phthalic acid ester of the first run-up of an alcohol produced by reducing the oxidation products of paraffin. It has from C_6 - C_8 carbon atoms.

7. EXTRUDERS.

7.1. I.G. Engineer Rohbock had invented a special die for use with a straight through machine. The machine was made by Berstoff of Hanover.

The invention consisted of an accurately-made positioning centred die and point supported upon a spider which, while loosely fitting into the end of the scroll by means of a taper fit did not rotate. The wire passes through the scroll but some of the material in the extruder leaks past the loose fit into the nose of the steady-point and this causes a rather high tension on the copper.

The advantages of avoiding the cross head are obvious in reducing pressure and "dead" spots thus eliminating the decomposition of the material due to over-heating. Output was high for a 60 mm. machine which was said to produce Field wire at 200 ft/min. with hot feed.

7.2. Cold feedmachines had been used but without great success. (Fully plasticised feeding was strongly recommended for P.V.C.). These machines were made by Heydrich in Berlin (60 mm. scroll) and under licence by Kleinewefers of Krefeld, who made layer machines.

8. DIORIT OR VINYLEDENE CHLORIDE. had been experimented with but no great success was achieved.

9. LUVICAN, was polyvinyl carbozole. It had been produced for higher temperature working for condenser foils but was not successful.

10. HIGH TEMPERATURE PLASTICS. Nothing of interest was elicited.

11. NYLON OR IGAMID.

11.1 Nomenclature.		Description.
Igamid A)	for Injection moulds (Perifol)	"A" is a condensation product of Adipic acid and hexamethyline diamine.
B)	B has been used successfully for continuous driving belts A is harder than B.	"B" diamine is a condensation product of E-amino caproic acid.
6A	Similar to American type for textiles.	Condensation of 6 of A and 4 of B
6C	Soluble type (in methanol and water)	
85B	Thermoplastic type, experimental only. It ages (cross links) badly on storage and becomes impossible to extrude. Foil made by extrusion and blowing.	Condensation of 85 parts Capro Lactane. 25 Hexamethyline diamine
U		Super Polyurethanes.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 7

Visit to Suddeutsche Telefon-Apparate-Kabel-Und-Drahtwerke A.G. (TKD)., Nuremberg 2.
Monday, 23rd September 1945.

The following members of the management were present:-

(1) Dr. Wienstein ------------- Managing Director.
(2) Herr Stofler -------------- Sales Director.
(3) Dr. Rohnhild -------------- Director of Tubes.
(4) Herr Hutter --------------- Lawyer.
(5) Dr. Muschweck ------------- Technical Secretary.
(6) Dr. Mader ----------------- Technical Director R.F.
(7) Herr Oeser ---------------- Technical Director L.F.
(8) Herr Kielmann ------------- Works Manager.

It was soon apparent that Nos. 2, 3 and 4 and 5 would be of little assistance to us and they were dismissed without having taken part in the discussion.

It was stated that TKD had made no R.F. cable: a certain amount of cable for the equipment which they produced had been obtained from Kabelwerk Vacha. They had made plastic covered Field Cable (Mipolam and Igelit), and also paper telephone cable.

Among the equipment produced by them was:-

"Wurzburg" (supplied without connecting cables and antenna)
"Erstling" for aircraft (IFF): 125/158 Mc/s.
Fu.G.10 test-set for Erstling.
Meteorological Receiver for "Radio Sonde".
Fu.G.23: Emergency transmitter for sea-going use.
Repeaters and Filters for Reichspost use.
Power-level meter for carrier frequencies (5-115 Kc/s):
level -4 to plus 3 nepers.

Dr. D. Mader and Mr. Wucherer.

Testing gear for Erstling incorporating ceramic beaded R.F. cable was observed in the laboratories: this merely measured the power output of the equipment. It was noted that most of the equipment in the laboratories was designed for testing carrier terminal equipment and no V.H.F. gear was observed.

A Siemens & Halske Bridge for use up to 10 Mc/s was set up for use: a short sample of the low-capacitance leads used was taken. Samples of the ceramic-beaded cable used in the test sets for Erstling and Fu.G.10 and also the solid dielectric cable used in Erstling were also taken.

In the course of further enquiries, a circular letter dated October 1944, issued by the Office of the Four Years Plan, was noted in a file and to this was attached a complete list of future standard R.F. cables, based on 60 and 150 ohms impedance. Second category cables were also listed and other valuable data included commercial type numbers corresponding to the official types, notes explaining the significance of code letters, specifications and drawings. All details were abstracted and are attached as Appendix II to the present report.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 8

Visit to Kabel-und Metallwerke Neumeyer A.G. Nuremberg.

Persons Interrogated:-

Dr. Hans Fischer - Technical and Managing Director.
Dr. H.W. Droste -- Director of Laboratories.
Herr Schlump ----- Engineer.

1. They stated that only one type of cable for H.F. use was made by them, i.e. type LN28180 (Vacha type No. 435). This cable was made to a Vacha specification and was a disc type with "Frequent a" thimbles.

The core is made in 30 metre lengths which are jointed together into 500 metre lengths for braiding and sheathing and then cut into 7½ metre lengths, all joints being cut out. The braid contained the same number of wires in the L.H. and R.H. lays and the firm appeared to be unaware of a construction using different numbers of wires. They suggested that this construction might be due

(a) to peculiar fabrication difficulties (this does not seem reasonable).

(b) to save copper.

Reference was made to a publication by DVL at Adlershof in ENT (1940) dealing with cover factor.

2. They used standard developers in their P.V.C. mixes, the plasticisers being made by Deutsche Hydrierwerke of Dessau.

e.g. 60% P.V.C. Type K	)It was stated that no
15% TCP	)stabiliser other than already
15% Palatinol F	)in the P.V.C. was used.
10% Palatinol HS	)

The above mix gave the following Physical Characteristics:-

150-180 Kgs/sq.cm.	Tensile
200-300%	Elongation.
- 20°C.	Cold crack (bending not impact)
70°C.	Softening ($2\frac{1}{2}$ metres are laid over a knife edge and loaded by the cable or by the same weight as the cable).

A lower cold crack material has been produced by using ED236 which they believed to contain a fatty acid although they did not know any details of it. This material had a crack point of -40°C to -50°C.

It was stated that no materials having a higher softening point than 70°C had been produced.

A mix with only 20-30% deformation containing 20% plasticiser was used for field cables.

Experimental work had been done on Lupolen but supplies were insufficient for production.

3. The following details were noted during inspection of the factory:-

1) Longitudinal metal tape covering machine made by Schumag of Aachen.

2) Annealing Furnaces (electric with gasified atmosphere) made by Widerstand of Hannover.

3) Speed measuring unit by Schaeffer and Budenberg comprising measuring unit in metres and speed counter in metres/min. The measuring unit could not be returned to zero and it was stated that a subsidiary pre-set counter was used with other machines.

4) Wire drawing machine reducing 1.4 mm. wire to 0.15 mm. in 22 passes.

5) Extruder temperatures

Barrel	120°C
Entrance to Head	120°C
Rolls	140°C - 160°C

6) Braiders by Froitzheim-u-Rudert of Berlin, Weissensee.

7) Styrene beads by Verein Gablonger Spritzgussfabriken of Gablonz, Thuringia.

4. The following persons were suggested as knowledgeable on R.F. Cables:-

Dr. Kohl	- Technical Manager	- Vacha.
Mr. Peters	- Physicist	- Vacha.
Dr. Kieser	- Physicist	- F. & G.
Dr. Mayer	- Development Manager	- F. & G.
Dr. Kaden	- Physicist	- Siemens.
Mr. Wuckel	- Manager of Laboratories	- A.E.G.

Copies of document 1, 2, 3 and 4 (Appendix IV) were taken.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 9.

Visit to N.A. Herzogen Aurach bei Erlangen.

An attempt was made to contact this firm on the basis of information obtained from B.I.O.S., London. There was no knowledge of the firm's existence locally and it would appear that the records in London are in error.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 10.

Visit to Kabel and Leitungswerke (Siemens A.G.) Neustadt Nr. Coberg.

Persons Interrogated:-

Mr. Hypradt Tech.Director (Very knowledgeable and collaborative speaks no English).

Mr. Raw Cost Accountant (Speaks English fluently).

1. The factory employs about 1,500 workpeople and is owned 100% by Siemens & Halske Berlin, although it functions as a completely separate company.

2. High frequency cables are not, in general, made by this Company but they have made certain R.F. cables and sleevings for use by Siemens & Halske for incorporation in their equipment. The cables were designed at Siemenstadt which is a much larger organisation employing 10,000 people.

3. The cables, particularly the Styroflex tube types were believed to be used by S. & H. for connecting apparatus to antennas.

4. The following cables and sleevings were examined and it was said that it comprised the complete set which were made in this factory, (samples of each type were brought away).

4.1. Type No. SAL 504 (Z) KLN

This is a Styroflex tube type with copper braid into which the conductor is drawn before use - it is made in lengths of 30 - 40 meters.

Styroflex spiral is heated to 40 - 50°C. to fix it in position and the details of the machine were taken by Mr. Smith of Callenders. The machines had not been used at Neustadt but had been sent there from Berlin (presumably rescued from bomb damage). Over the Styroflex spiral there is a red tape said to be of Cellophane (is this Styroflex?).

Over the copper braid there is a transparent tape said to be Styroflex (is this Cellophane?), and the final covering is a textile braid and lacquer (16 coatings).

4.2. Type OCKY (Pd H).

Notes. It was not known why a Styroflex tape was used around the conductor and under the P.I.B. - Styrene mixture (Decolith ex Celluloid Fabric) which formed the main insulation and which was applied longitudinally in about four layers. The braid has an even number of wires in the stitches and is covered by a P.V.C. sheath composition, made at Neustadt, to the following formula:-

PCU	80.4	ex I.G.F.
ED140/C	18.9	ex Hydrier Works Dessau.
TO_2	.3	
Colour (grey)	.4	

Specn. for ED.140 B.P. 200 - 210°C.
Solidifying Pt. -35°C.

Note. They had tried ED236 and T.C.P., but it was not so satisfactory a mix as the above, which is very resistant to cutting and yet meets the -35° crack.

The following are the physical and electrical characteristics of the Igelit (P.V.C.)

S.G.	1.4
Low bend Temperature	-30°C
Low temperature impact	-17°C
Deformation at 100°C	9% (see note below)
Tensile Strength	270 Kg/cm^2
Elongation	220%
S.R. @ 20°C.	5×10^{12}

Note on Penetration test.

A length of cable 3.2 m.m. field wire is looped loosely around a 10 c.m. mandrel and the two ends tied together and a 5 Kg weight is suspended at the bottom of the loop. The penetration now is measured after 1 hour at 100°C.

Note on ED. 140.

In the opinion of Hypradt, ED140 is the best plasticiser available in Germany (before the war they preferred pure cocoanut oil). As far as he knew it was an ester of a fatty acid.

Note on Igelit.

For field wire they preferred to use the Igelit sold and mixed by Neumeyer because they did not have faith in the material and preferred to put the responsibility for its suitability on Neumeyer who had had it approved.

4.3. Various P.V.C. and rubber (semi-hard) tubes with conductors loosely inserted, covered with copper braid and a lacquered textile braid.

Samples were brought away but the cable was not considered important and no specifications were obtained.

5. A very hurried visit was made to the factory (Messrs. Smith and Lythgoe had already spent some time and taken considerable notes), and the following machines were examined.

5.1. Styroflex machines (particulars obtained from Messrs. Smith and Lythgoe).

5.2. Extruders, fed from a second similar machine, the latter being fed on machines with 3" scrolls, sheet (rolled up) from an oven.

Temperature of material from oven about 100°C.
" " " " 1st extruder about 130°C.
" " " " final extruder about 160°C.

The machines were oil heated with electrically heated dies. No Strainers were used and the resultant cable was very smooth and free from unheated 'pips'.

The remainder of the machine was orthodox except that the American system of a take up at right angle was used and the standard American two drum change over reeling system was evident.

The capstan drum on the machines for light cable was interesting since it was of hollow light metal constructure in drum form with soft rubber face and fairly hard rubber flanges. It was very light.

Speed control was from a panel by the extruder and all points on the machines were temperature controlled and temperature dials visible on the panel.

A large machine with very heavy haul off was also noted.

5.3. Longitudinal covering machine.

A quick glance at all of these machines revealed no unusual features. It was a 24 wire machine.

5.4. Longitudinal metal tape covering and seaming machine. This was made by Schumag of Aachen, Rhineland, and was similar to that seen at Neumeyer from which firm drawings were obtained (Item 1 Appendix IV).

5.5. Spark Testing equipment.

A rather unique electrode system was noted and which consisted of a number of different sized copper spirals on a rotating drum. The drum is rotated until the correct size comes opposite the fair lead.

The machine is fitted with automatic stopping and braking devices which are brought into action if a spark occurs.

Note. In extruding Field Cable approx. 4 faults per mile were found as an average.

6. In regard to Siemens-Halske of Berlin, the following names were received:-

Herr Kurt Wagner	SK2 Dept.
Ernst Fischer	Tech. Director.
Dr. Hosse	Plant Engineer.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 11(a)

Visit to Telefunken G.m.b.H., 8, Max Strasse, Schonberg.

5th October 1945.

1. Persons Interrogated:-

Dr. Gothe	Personnel manager, non-technical.
Dr. Franz	Speaks English perfectly and is very well informed on Technical matters.
Mr. Burckhardtsmeyer (Asst. to Dr. Bushbeck)	High Power Transmitters.
Mr. Pirck	H.V. Pulse Cables.
Dr. Grassnick	Cable installation.
Dr. Muth	

Reference was also made to the following personalities at Telefunken

Dr. Protze	Naval equipment. To be interrogated later.
Herr Brandt	In charge of Television Lab. until 1943 when he replaced Dr. Runge as Head of Dept. for H.F. Development. Essentially administrator. Alternatively reported now at Munich or in junior position with Post Office in Rhineland.
Dr. Berndt	Antenna systems development. In Berlin, but not now connected with Telefunken. Address unknown.
Dr. Knoll	Interested in electronic components of television at Munich.
Dr. Spiegel	Decimetre Relay Stations:

2. R.F. CABLE DESIGNS.

2.1. Telefunken did no more than design certain early cables which were manufactured by other companies, notably A.E.G. Later they specified requirements (Zo and dimensions) to cable companies, such as A.E.G., Siemens and, for flexible cables, Vacha.

2.2. Telefunken have published before the war details of their articulated construction with metallised frequenta discs (Schallen Kabel). They were used for broad-band, broadcast and television antenna leads, but were limited by discontinuities to about 50 Mc/s. The following sizes were mentioned:-

(i) Inner Conductor 5 mm. Outer Conductor 17 mm.
(ii) Inner Conductor 15 mm. Outer Conductor 48 mm.
(iii) Inner Conductor 28 mm. Outer Conductor 95 mm.

The last mentioned cable was used for high-power broadcast transmitters but was ultimately discarded in favour of rigid lines (see 2.3) which were considered easier to repair. The bending radius of (iii) was 1.6 to 1.7 metres; they therefore require large drums and are heavy to transport. The inner conductor of (iii) has been melted under load due to mismatch introduced by articulated joint. On the other hand, Dr. Franz stated that he had successfully used 500 metres of buried Schallen Cable at Helsinki in connection with 9-metre Beacons. Attenuation of these lines was almost completelylimited to that due to normal copper loss.

2.3. For high-power broadcast transmitters, the following rigid copper coaxial lines of 60 ohms were used:-

I.C. 35 mm.	O.C. 100 mm.:	load up to 100 KW.
" 72 "	" 196 "	" " " 100-300 KW.
" 100 "	" 280 "	" " " 500 KW.

The sections are in lengths of 5 metres with expansion joints every 50 metres. The line is supported every 5 metres on rollers: the expansion joints consist of concentric sliding tubes, slotted and held in contact by bands of spiralled wire. The frequenta insulators are metallised at each conductor boundary (silvered with copper plating) and supported by bands of spiralled bronze wire. The normal points included a section split horizontally to facilitate connection of the inner conductor.

2.4. The antenna cable for the 100 KW, 200-2000 metre station at Berlin-Tegel was Vacha No. 766. A helix of

Litz conductors was wrapped around a core of insulating material, provided with a covering of bright grey rubbery material (permittivity 2.2, believed to be Oppanol mix). The outer conductor was a spiral of overlapped copper tapes with further insulation, lead sheath and armoured protection. The dimensions were believed to be approximately as follows:-

Inner Conductor:	16 mm. diameter.	x
Outer Conductor:	33 mm. diameter.	
Overall Diameter:	55 mm. approx.	

The electrical characteristics:-

$Z_0 = 60$ ohms
Attenuation 0.1 nepers/km at 1 Mc/s.

x This dimension should probably be 8 mm. (see Lorenz report 23) otherwise the impedance figure would be inconsistent with the dimensions.

2.5. Vacha type No. 925 was used for 50 cm Wurzburg (8 KW) and Mannheim (16 MW). This 70 ohm cable was standardised for all ground stations except for I.F.F., which used polystyrene beads and an impedance of 200 ohms.

2.6. For A.A. Radar, up to 250 KW peak, a beaded cable of 70 ohms and 20 cm. overall diameter was used.

3. STANDARDISATIONS.

Up to 1943, a characteristic impedance of 70 ohms was used. The high power transmitter groups asked for a change to 60 ohms because 140 ohms was too high for coaxial lines when parallel lines were used. The decimetric groups agreed to this standardisation but, because impedance measuring gear was based on 70 ohms, were never able to implement this decision.

4. DOUBLE SCREENING.

Telefunken had realised that interference was likely to be a problem and tests had been contemplated. Interference between cables of communication sets in aircraft was considered probable but the direct coupling between antennae was held by Dr. Franz to be much greater.

It was stated that double screened cables were only used experimentally, but subsequent interrogation brought the attached Telefunken report (E.C. Bericht No.063). This would appear to indicate that considerable effort was directed towards improvement of cable screening.

5. 50-cm COMMUNICATION APPLICATION.

A 50-cm 9-channel frequency modulated communications system, Rudolph, involved a cable problem which was solved after some development work. This arose from the use of a self-excited oscillator which was without amplifiers or buffer stages, on account of a lack of suitable valves.

The system consisted of a chain of relay stations of small power (7-9 watts) with a range of perhaps 70 km. Directional antennae were mounted on fixed masts of 23 metres height. Since the cable lengths were of the order of 200 half wavelengths, mismatches greater than 10% (reflection coefft. 20%) were able to cause frequency instability. No serious trouble was experienced in service, electrically or mechanically; the telescopic masts were used in Russia where temperatures of -50°C might be encountered.

6. TESTING METHODS.

6.1. Resonance methods were used up to 300 Mc/s. Attenuation was determined from the width of resonance/frequency curve and Zo from velocity of propagation and frequency.

6.2. Rohde and Schwarz have developed R.F. bridges for use up to 100 Mc/s.

6.3. Meinke and Kleen have developed LOTOS for accurate measurements of impedance at decimetric waves. A model of this is with Cables Section, Radio Department, R.A.E. The following comments were made by Dr.Franz:-

The best accuracy obtainable at Telefunken was ± 1% at 50 cms. The line was held at the measuring end by threads arranged like the spokes of a bicycle wheel. This had no measurable mismatch. A solid spacer with recessed inner conductor was also used (the optimum diameter ratio for minimum mismatch was determined experimentally).

The characteristic impedance of the line including slot was determined by moving a short-circuiting piston in a similar line without slot connected to measuring side of test line; the change of standing wave with position of short-circuit is noted. The slot caused a change in Z_0 of about 2%.

Cone couplings were used initially, but difficulties were found in machining accurate linear cones. Staggered steps were then adopted and it is claimed that no measurable discontinuity between cable and line is present down to 20 cms.

Various detector heads are available for use:-

20 cm. (19 - 23 cm. band).
50 cm. (-)
60 cm. (night-fighter band)
80 cm. (GEMA band)

The SA 102 diode (1.9 volt filament) is used as detector throughout the range. Capacitive rather than direct coupling between the carriage and the outer conductor of the line is considered an important feature for stability.

Schmied and Meinke developed a circular form of line with rotating probe amplifier and oscilloscope, called AUTORA. It was very well matched at 50 cms and was well adapted for practical use in lining up 70 ohm systems. Considerably more than one hundred models should be in existence.

(e) Bridges for use at 50 cm (KALLA) had been developed, using Siemens carbon-coated ceramic resistors. It measured mismatch to about 10%, but did not indicate the phase relationship of the mismatch.

APPENDIX I.

B.I.O.S.TRIP NO.1176.
FIELD REPORT NO.11(b)

Visit to Telefunken G.m.b.H. 8 Maxstrasse, Schöneberg
BERLIN.

9 - 10th October 1945.

1. PERSONALITIES.

1.1. The present information was obtained from Drs.Franz (theoretical work), Muth (night-fighter gear) and Protze (naval equipment). It supplements that given in report of visit on 5th October 1945.

2. R.F. CABLES.

(a). Schallen Cables.

The specified attenuations of 2 sizes of this type of cable are as follows:-

Attenuation in nepers/km.

Frequency Mc/s.		Type 15/48	Type 28/95
0.6		0.054	0.036
1.0		0.082	0.055
3.0		0.15	0.070
6.0		0.21	0.142
10.0		0.28	0.185
20.0		0.40	0.270
30.0		0.50	0.330
30.0	(theoretical)	0.50	0.26

(b). Ordinary ignition cable was used for the transmission of uni-directional pulses in the case of Wurzburg. Dr.Muth stated that a large Vacha cable of unknown size and type, was used in other sets.

(c). The 50-cm 9 channel communications system referred to in para. 6 of the previous report is Rudolf. A similar system Michael operates at 60 cm. and has 1 telephone and 2 telegraph channels. Frankfurt operated at 20 cm, but was abandoned as insufficient power was produced with the valves available at that time.

(d). To avoid identification by the enemy of the manufacturer of cable captured by them, the specifications called for the insertion of coloured threads to a RLM (Reichs Luftwaffe Ministerium) code rather than the internationally known VDE code. Details of the RLM code were claimed to be unknown apart from Vacha (green-yellow-red).

(e) "Stabol" has sometimes been used as a sheathing material instead of lead, as for the "Schallen" cable. Some trouble from cracking of this covering had been encountered in naval installation. The exact composition is unknown but it has been stated to be a poly-acrylate derivative.

3. R.F. MEASUREMENTS.

3.1. Lotos has an inner conductor made of silvered ceramic (calit) to ensure straightness and absence of sag. Dr. Muth had the impression that the diameter of this rod was exact to 0.001 mm. The temperature coefficient of expansion of ceramics is usually low, and approximates to zero in the case of Ardostan. These rods were made by Hescho and also by Steatite-Magnesia.

3.2. Lotos Z (10 cm gear) has a similar inner conductor. The accuracy of measurement at 9 cm is of the order 3-4%.

3.3. Cable measurements were normally made by swinging the frequency.

3.4. Frequency was measured by the following methods:-

(i) Beat tone oscillator by Rohde & Schwarz.
(ii) $\lambda/4$ line with adjustable piston.
(iii) Concentric cavity resonator (as on Wurzburg).

3.5. Triode oscillators providing several watts are used down toabout 20 cms; kystrons are used at higher frequencies

3.6. No work on corona in R.F. cables was known to these Telefunken engineers.

3.7. Two methods of measuring discontinuity of decimetre waves were recommended by Telefunken and called for by them in their specification:-

3.7.1. The cable or accessory is terminated in its nominal characteristic impedance and the standing wave observed.

3.7.2. The cable or accessory is terminated in an adjustable short-circuited coaxial line ("Blindspritze"). The position of a voltage node before the item under test is plotted against the position of the short-circuit: the mismatch can be calculated from the deviations from a straight line ofslope unity.

The following is a typical specification. With a maximum mismatch of 1.03 in the measuring gear, a mismatch of 1.10 with the item under test may not be exceeded in the range 20-90 cm.

4. PLUGS AND SOCKETS.

It would seem that two ranges of matched-impedance plugs and sockets were used by Telefunken and Lorenz in the decimetre range. They are sometimes known as "9.4/30" and "3/18" from the dimensions (in millimetres) of the conductors at the plug and socket interface. An interesting feature of the right-angle adaptors is the use of a cut-away inner conductor, presumably to reduce the mismatch. Full details of these ranges were not obtained.

5. NAVAL COMMUNICATIONS EQUIPMENT.

The following information was obtained from Dr. Protze and may be unreliable because he was responsible only up to the output of his transmitters and had nothing to do with the trunks or antennae.

5.1. Trunks Connecting Transmitter to Antennae.

Originally German ships had untuned antennae and trunks in the same way as British ships. But for Graf Spee the distance between Transmitter and antenna was so long (45 m) that an antenna tuning capacity of 330-385 pF in 15-18 steps over the range 100-600 Kc/s by means of a motor-driven switch was used.

5.2. Cables used as trunks.

At a later stage, for destroyers, an attempt was made to use an air-spaced "Schallenkabel". This was considered feasible because destroyers were confined to the 600 kc/s end of the band where radiation efficiency is high and therefore the power out-put of the transmitter could be reduced by the regulator which worked on the screen grid of the last stage and which could be pegged at any desired maximum vålue. The capacity of this cable is about 53 pF/metre.

Lengths of this "Schallenkabel" were made up in the A.E.G. factory complete with terminations which sealed the cable and which were applied under controlled humidity conditions so that the inside of the cable was dry. In fitting these complete connectors to ships, careless handling was liable to create cracks in the outer waterproof sheath, and failures occurred due to moisture penetration.

5.3. It was then decided to use solid cables to eliminate moisture problem so the firm of Vacha developed an Oppanol dielectric cable of about 60 mm. o.d. with a 6 mm conductor, and having a capacity of about 55 pF/metre (sample obtained from A.E.G.)

Dr. Protze stated that most German ships are fitted with the above solid cable, except for destroyers fitted in the later stages of the war, which were given existing stocks of "Schallenkabel". This was done primarily because of a shortage of Oppanol due to bombing of the I.G. Farben in 1944.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
Appendix to: FIELD REPORT NO. II.

Precis of Telefunken - E.C. Bericht No. 063 (Dr. Hans Meinke and Dr. Dorothea Wendt).
dated
22nd February 1943.

Measurement of the screening effect of cable coverings at Decimetre Waves.

This report deals with the screening effect of cable coverings. At low frequencies the screening effect is determined quantitatively by the coupling impedance per cm cable-length. In these measurements the outer of the cable is used as inner conductor to an outer conductor (Fig. 1). If a current I flows in the I.C. of the cable being measured, a disturbing voltage Vs per cm cable-length will exist in the outer conductor. The interference effect is then given by the coupling impedance.

$$R_k = V_s/I$$

Measurements at low frequencies are described by H, Ochem H.F.T. 48 (1936) 182. This method is extended in the following to decimetre waves, by taking account of the non-uniform current distribution even with very short cable samples. For given R_k and I, the interference voltage for very short cables is given by

$$V_s = I.R_k.l.$$

For greater lengths, a formula given by H. Kaden ENT 13 (1936) is used.

A screened signal generator serves as voltage source (Fig. 2). Its output provides (through previous calibration) a known open-circuit voltage V_1, with measured internal resistance R_1 = 70 ohms. Voltage V is measured accurately with the help of the known capacity voltage-divider (see Bericht EC 058). The H.F. is passed to the measuring apparatus through a cable of Zo equal to 70 ohms. The cable is connected with a separating wall (Trennwand) to which the O.C. of the cable under test is soldered. The change of angle (discontinuity) of the inner conductor of the incoming cable to the cable under test is arranged as a quadripole of Zo = 70 ohms (see Bericht EC 032). The cable under test has Z_o = 70 ohms and is short circuited The complete circuit is therefore perfectly matched. The maximum current is therefore the short-circuit current I_k and is equal to $V_{1/Zo}$

In Figure 3, if the short-circuit current at x = 0 is I_k the current I_1 in the cable with increasing x varies according to a cos-function.

$$I_1 = I_k \cos \frac{2\pi x}{\lambda_1} = \frac{U_1}{Zo} \cos \frac{2\pi x}{\lambda_1} \quad \ldots\ldots\ldots (1)$$

λ_1 is the wavelength in the cable which is measured with a standing wave. Then if ℓ_1 is the electrical length of the voltage node (including the angular change of cross-section then

$$\frac{\lambda_1}{\lambda} = \frac{\ell}{\lambda/2 - \ell_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Owing to the imperfect screening effect of the outer conductor, the cable current produces an electromagnetic field outside the conductor which is measured in the following way (see sketch). The outer concentric system is led through a 70 ohm cable to a receiver of input impedance 70 ohms. The voltage V_2 is indicated on the output of this receiver. The relationship between V_1 and V_2 is a measure, for a given cable-length, of the quality of screening of the cable. Since only the voltage relationship is of interest only a relative calibration is necessary and this can be done simply and accurately. Since V_2 is small, care must be taken to avoid leakage elsewhere (the screening of the transmitter is most important). To check this short-circuit the input of the cable under test and the receiver should indicate nothing.

COUPLING IMPEDANCE.

It is next assumed that the cable is leaky only at point x. The cable current I_1 at x creates a disturbing voltage V_s which is directly proportional to I_1 or,

$$V_s/I = R_k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Owing to the weak couplings, I_1 is independent of the outer circuit. The equivalent circuit is as given in Figure 4.

The internal resistance of the E.M.F. V_s is given by the left of the disturbing point, a length $(l - x)$ of shirt-circuited line. This operates towards the right directly into the resistance Z. The internal resistance is therefore independent of the point x of the disturbance To proceed it is necessary to replace the known E.M.F. V_s by an E.M.F. V_s' at the short-circuit where $x = l$, which is equivalent to V_s (that is producing similar currents and voltages in the load resistance). The voltage V_s is the open-circuit voltage appearing in the conductor at the point x if one removes the conductor and the load resistance to the right of this point. The new voltage source V_s' must also produce the open-circuit voltage V_s at the point x and have zero internal resistance since to the left it is placed directly at the short-circuit. The voltage distribution on the open-circuited conductor is then given by

$$V_s' = V_s \cos \frac{2\pi}{\lambda} (l - x)$$

and from (1) and (3) $= V_1 \frac{R_k}{Z} \cos \frac{2\pi}{\lambda} (l - x) \cos \frac{2\pi x}{\lambda_1}$ (4)

λ is the wavelength in the outer conductor. On account of the zero internal resistance V_s' is proportional to the input resistance of the receiver which amounts to 70 ohms and independent of the position of the disturbing voltage. If one considers a disturbance distributed along the length of a conductor, as with uniform leaky cable coverings, at each point x a disturbing voltage corresponding to the current I_1 exists according to (3) which may be transformed in accordance with (4) to the end of the conductor. In this case let R_k be the coupling impedance per cm of cable length and the cable-length constant. I_1 is dependent on x in accordance with (1). The disturbance at the point x of the length dx produces, according to (3) and (4) the voltage.

$$dV_s' = \frac{R_k}{Z} \quad V_1 \cos\left(\frac{2\pi x}{\lambda_1}\right) \cdot \cos\left(2\pi \cdot \frac{l - x}{\lambda}\right) \cdot dx$$

Total disturbing voltage amounts to

$$V_s' = V_2 = \frac{R_k}{Z} \quad V_1 \int_0^l \cos\left(\frac{2\pi x}{\lambda_1}\right) \cdot \cos\left(2\pi \cdot \frac{l - x}{\lambda}\right) \cdot dx$$

The interference effect of the cable will be measured by the relationship

$$V_2/V_1 = \frac{R_k}{Z} \cdot \ell \cdot F\left(\frac{\ell}{\lambda} \cdot \frac{\lambda_1}{\lambda}\right) \quad \ldots\ldots\ldots\ldots\ldots (5)$$

From the measured value of V_2/V_1, the value R_k is easily calculated as a cable constant. The correction factor F is necessary on account of the non-uniform distribution of the current,

$$F\left(\frac{\ell}{\lambda} \cdot \frac{\lambda_1}{\lambda}\right) = \frac{1}{2\pi\ell} \cdot \frac{\lambda\lambda_1}{\lambda^2 - \lambda_1^2} \left[\lambda \sin\frac{2\pi\ell}{\lambda_1} - \lambda_1 \sin\frac{2\pi\ell}{\lambda}\right] \quad (6)$$

If the cable length ℓ is small by comparison with the wavelength ($\ell < \lambda/_{12}$), the following approximations hold:-

$$F\left(\frac{\ell}{\lambda} \cdot \frac{\lambda_1}{\lambda}\right) \approx 1 \quad \text{and} \quad V_2/V_1 = \frac{R_k \cdot \ell}{Z} \quad \ldots\ldots\ldots\ldots (7)$$

For the special case $\lambda = \lambda_1$, one reaches for (6) the indeterminant value of 0/0, a new formula gives

$$F\left(\frac{\ell}{\lambda}\right) = \frac{1}{2} \cos\frac{2\pi\ell}{\lambda} + \frac{\lambda}{4\pi\ell} \sin\frac{2\pi\ell}{\lambda} \quad \ldots\ldots (8)$$

An evaluation of F is given in Graph 1. F is always smaller than 1 and decreases with increasing length. This applies to the cable lengths suitable for these measurements so as to obtain the greatest value of V_2 From (5) we have

$$V_2/V_1 = \frac{R_k \lambda}{Z} \quad \frac{\ell}{\lambda} F\left(\frac{\ell}{\lambda} \cdot \frac{\lambda_1}{\lambda}\right) \quad \ldots\ldots\ldots\ldots (9)$$

While $\frac{R_k \lambda}{Z}$ is a constant, the greatest disturbing voltage is produced if $\frac{\ell}{\lambda} \cdot F$ is a maximum. This function is given in Graph 2. The position and magnitude of the maximum is dependent upon the ratio λ/λ_1. A value of $\ell = \frac{\lambda}{6}$ approximately is used.

TABLE - DATA RELATING TO GRAPHS 1 AND 2.

ℓ/λ	Function (F) for various values of λ_1/λ					Function ($F \ell/\lambda$) for various values of λ_1/λ				
	0.6	0.7	0.8	0.9	1.0	0.6	0.7	0.8	0.9	1.0
0	1.0	1	1	1	1	0	0	0	0	0
.02	.98	1	1	1	.99	.020	-	-	-	.026
.04	.945	-	-	-	.98	.038	-	-	-	.046
.06	.90	-	-	-	.955	.033	-	-	-	.057
.08	.83	-	-	-	.92	.066	.068	.076	.072	.073
.10	.76	.79	.83	.86	.875	.075	.0795	.082	.085	.0865
.12	.655	.71	.755	.795	.82	.0795	.085	.090	.0955	.098
.14	.56	.615	.67	.725	.755	.0775	.0855	.093	.101	.105
.16	.45	.52	.58	.65	.685	.071	.0825	.0925	.102	.1085
.18	.335	.42	.49	.57	.615	.060	.075	.0865	.1015	.110

DETAILS OF SOME SCREENING MEASUREMENTS.

(1) Vacha Cable. 925K.

Description 1: I.C. Copper 2.5 ∅
2: Trolitul Perlen (10.5)
3: 8 tapes 4 mm wide with long lay (10.5)
4: 1 tape 10 mm wide with short lay (11.5)
5: Wertmaschiges (? open mesh) wire braid (12.5)
6: Protective covering (blue) 15.5 mm ∅

Coupling Impedance.

Condition	R_k (ohms/cm)
Normal	0.011
Without wire braid (parts 1-4)	0.040
Without outer copper tape (parts 1-3)	1.3

In the condition without wire braid (parts 1 - 4) a hole of about 10 mm in the outer copper tape gave a coupling impedance R of about 0.15 ohms that is a cable current of 1 amp would produce an outside disturbing voltage of 0.15 volts. Small errors in the screening therefore create a noteworthy deterioration of the screen effect.

(2) Description: Vacha Cable 976 S.

1. I.C. Copper 1.8 mm ∅	1.8
2. Oppanol	
3. 24 tapes 1.5 mm wide (tightly braided)	9.5
4. Protective covering (blue)	16 mm ∅

Coupling Impedance.

Condition.	R_k (ohms/cm)
Normal 1 - 4	0.002
1 tape removed	0.04
2 tapes removed	0.10
3 tapes removed	0.22

1 tape cut through gave an additional coupling impedance of R_k equals 0.015 ohms.

(3) Description: Vacha Cable 976 D.

1. I.C. Copper 1.9 mm ∅	1.9
2. Oppanol	
3. 24 tapes 1.5 mm wide (open braid)	10.5
4. Wire braid	11.5
5. Protective covering (blue)	16 mm dia.

Coupling Impedance.

Condition.	R_k (ohms/cm)
Normal 1-5	0.004
Without wire braid 1-3	0.055

With 976S the braid consisted of similar tapes with short lay, the braid with cable 976D was made with long lay and regular gaps resulted from it.

(4) Description: Vacha Cable 435 J.

1. I.C. Copper 1.2 ⌀	12 mm
2. Ceramic Beads	
3. Tightly wound wire braid (120 wires 0.2 mm ⌀)	6.5
4. Protective covering (blue)	

Coupling Impedance.

Condition.	R_k (ohms/cm)
Normal	0.042
5 screening wires removed	0.10
10 " " "	0.18
15 " " "	0.41

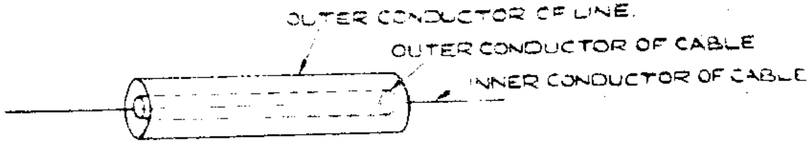


FIG. 1.

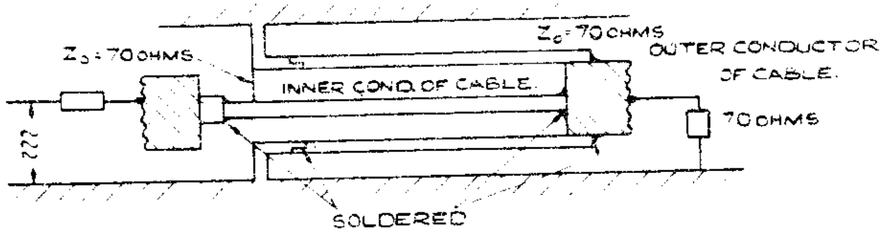


FIG. 2.

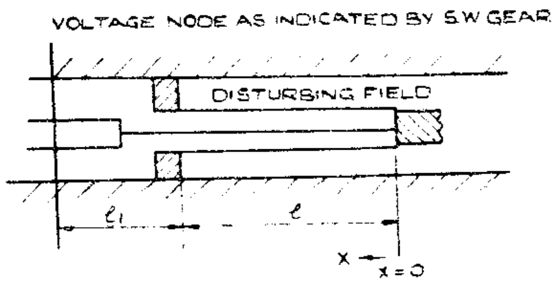


FIG. 3.

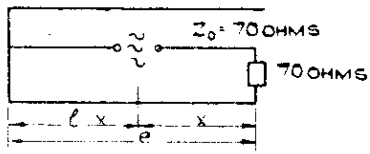


Fig. 4.

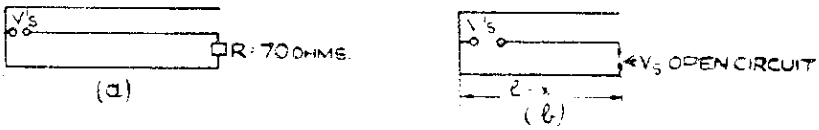
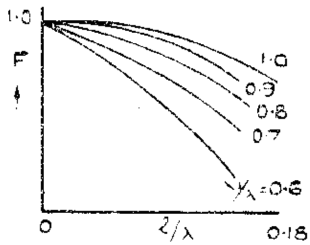
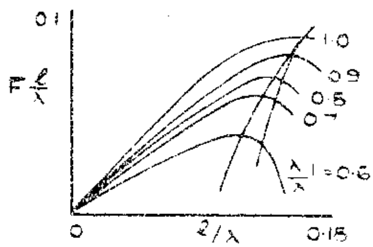


Fig. 5.

Graph 1.



Graph 2.



APPENDIX I.

B.I.O.S. TRIP NO. 1176
FIELD REPORT NO.12.

Dr. Rosbaud,
1, Boltzmann Strasse,
Dahlem, Berlin.

Dr. Rosbaud has been for many years technical reader for the publishing firm of Julius Springer. Several visits were made to Dr. Rosbaud (30.9.45., 7.10.45 and 10.10.45), whose general acquaintance with scientific personalities in Berlin made him invaluable in helping to trace individuals. Dr. Rosbaud was very co-operative.

APPENDIX I.
B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 13.

Visit to Siemens Kabel Gemeinschaft, Gartenfeld, Berlin.

Monday, 1st October 1945.

Persons Interrogated:-

Dr. Thürmel.
Dr. Fischer, head of Labs.
Dr. Ohmsted, Technical Development of Cables.
Dr. Lintzel, H.F. testing.
Dr. Tamm of the Central Laboratory was present at the latter part of the session (in the afternoon).

1. Dr. Thürmel, Director of Cobles, stated that all insulating materials used for H.F. cable construction were of the hydrocarbon type.

e.g. Styroflex from Nordenham (owned 50/50 by F. & G. and Siemens).
Styroflex is also made at C.G.L.T.T. near Paris, Feldkirch, near Bregenz, Austria and at a firm in Saxony.

Decelith (Oppanol B 90%, Polystyrene 10%)
Lupolen had been used only experimentally: I.G.F. had been advised of the importance of Polyethylene but had not listened.

Regarding Vacha, Dr. Thürmel advised the interrogation of Dr. Kohl (originally a Siemens man) and Dr. Jordan, the chief of Vacha. He also referred to the great competition between Vacha and Siemens.

He stated that the Kabel Gemeinschaft had been formed to combine the cable interests of Siemens & Halske and Siemens Schuckert.

2. Wave guides (Hohl Kabel).

Flexible wave guides both circular and rectangular had been constructed but not used operationally, by winding a short lay spiral of "Z" section tape 14 mm. x 0.15 mm. as in Figure 1, and by covering overall with copper wire braid.

The circular guide was 24 mm. or 24.5 mm. in internal diameter and had at 10,000 Mc/s attenuation of 30 Nepers/km. as compared with a copper tube of like dimensions having = 10 N/km.

There was also an aluminium tube construction which can be coiled.

Lengths of these guides, up to 50 metres had been made.

Termination for these guides had been designed and made by Telefunken but were not water-tight and Siemens had improved on the design and made models which were quite water-proof.

3. Flexible H.F. Cables (concentrics).

These cables were split into 3 types:-

3.1. Type 1. Used only in short lengths for frequencies up to 10,000 Mc/s, the construction being as shown in Fig. 2.

Effective Permittivity	2.3
P.F.	0.001 (at 600 Mc/s)
Zo.	60 ohms.
Attenuation	8.5 N/km at 100 Mc/s
	250 N/km at 10000 Mc/s.

P.F. was determined by measuring attenuation after the braid had been replaced by a solid copper outer (or lead)

Three types of this cable were made, all identical except for the centre conductor.

(a) Solid.
(b) Strand 1 plus 6.
(c) Strand 1 plus 6 plus 12.

The braid had a lay of 25 mm. but this was controlled by the machines available, they would have preferred a longer lay. Right and left stitches had the same ends of wire (4). They did not believe that Vacha used a different number of ends for U.H.F. cables and did not know why they employed such a construction for other frequencies.

3.2. Type la.

This cable was an alternative to type (1) and had t the same dimensions, but the insulation consisted of two layers of 18 (6 plus 12) long lay Styroflex strings (diam. .040") in place of the Styroflex tape and solid Decolith. For some unknown reason the diameter over the P.V.C. had been reduced to .345", as measured.

The following electrical characteristics were stated to apply.

Effective Permittivity	2.1.
Zo.	60 ohms.
P.F.	0.0005 (100 Mc/s)
Attenuation	7.8 to 8 N/Km at 100 Mc/s.

In applying the Styroflex strings or threads no heat was used to set them in place but the heat conducted from the P.V.C. during extrusion was found sufficient to set them.

Ionisation voltages (the initiation of ionisation was measured by P.F. rise at 50 c/s) for these cables were said to be:-

6000 v. for type 1.
3000 v. for type la.

Notes.

Certain similar types of cables were seen but with a second outer conductor (screen) insulated from the front by either Decelith or bitumenised paper. Oppanol B plus Carbon black (Protodur) was also used as a substitute sheathing material. Nothing appeared to be known of the screening effect realised but published articles by Drs. Kaden and Wild were referred to. These men worked at the Central Laboratories at Munich.

Attenuation measurements at 100 Mc/s were made on 10 metres of cable and a diode detector was used. The S.W. ratio was of the order 10 : 1. The law of the detector (with diode or crystal) was checked by examining the shape of the voltage distribution curve with the measuring line short circuited.

3.3. Type 2.

For longer length used at 2000 - 3000 Mc/s, the type shown in Figure 3 was used.

Over the discs and under the conductor (not shown on the Fig. 3) there were 2 Styroflex tapes 0.1 mm and three Styroflex threads 0.8 mm.

It had been found that the disc spacing should be less than $\frac{\lambda}{3}$ to avoid trouble from reflection.

The trolitul discs were as shown in Figure 4 and were injection moulded from Polystyrene P.3 or P.4. in an "Isoma" machine made by Braun of Chemmitz, Saxony.

Protopal. A trade name for a copper coated aluminium wire used partly to conserve copper and partly for lightness. It is made as follows:

A groove is cut in the aluminium wire and the copper tape placed round it as in Figure 5. The composite conductor is then drawn down in an ordinary wire drawing machine (22% reduction) and annealed at 500 to 600°C. Inner cores of iron and zinc have also been used. The shape of the groove is important as otherwise it tends to open.

Electrical characteristics of Type 2.

Effective permittivity	1.07
Zo.	70 ohms.
	0.115 N/Km at 1 Mc/s.

Attenuation target was 5 N/Km at 1500 Mc/s but owing to shortage of time it was not measured; it was probably about 5.5. N/Km.

3.4. Type 3.

Similar construction to Type 2 but with Styroflex construction as in the broad band cables. The pitch of the "sicken" was reduced from 18 mm. (broad band cables) to 12 mm. Effective Permittivity 1.17: Styroflex tapes 0.1 mm. thick: Styroflex threads 0.7 - 0.8 mm. diameter: attenuation 4.5 N/Km at 600 Mc/s. 7-8 N/Km at 1500 Mc/s.

4. Measurements.

Information obtained from Mr. Lintzel. Cables were tested for electrical characteristics at frequencies between 100 Mc/s and 10,000 Mc/s a voltage distribution method being used. The measuring line was 2 metres long for the measurements at 100 Mc/s, a 10 metre length of cable being used. At 10,000 Mc/s the measuring line was a waveguide. The detector used in the latter case was a crystal, a diode being used for the lower frequencies.

For the majority of cables, routine tests were made at low frequencies only, the high frequency tests being made only for experimental work and for special cables. The tests were not believed to be very thorough and it was thought that better methods and apparatus were used at Vacha.

For checking the effect of discontinuities in the cable the input impedance of a length of cable terminated by its characteristic impedance was measured over a range of frequencies and the quality of the cable was judged from the variations obtained. These were of the order of 5% at 3,000 Mc/s for a good cable. Styroflex cable had 5% non-uniformity at 600 Mc/s: solid dielectric cables were usually lower.

FIG 1.

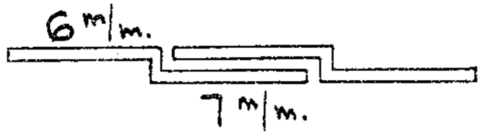


FIG. 2.

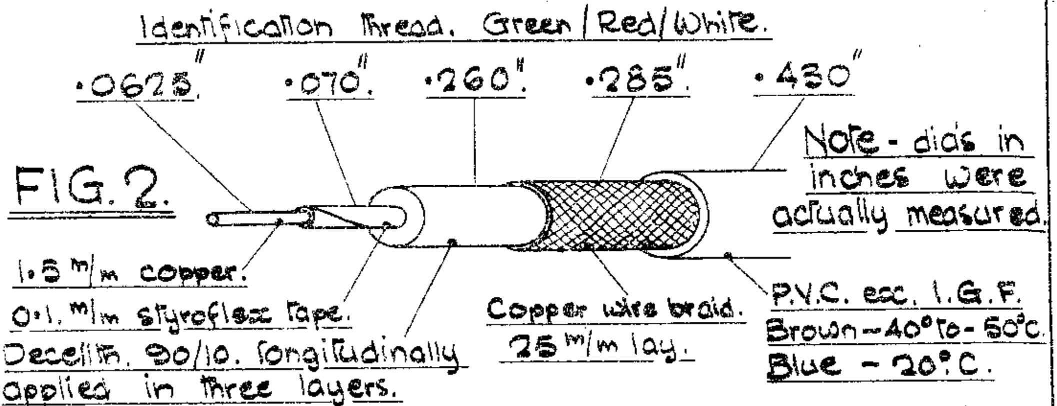
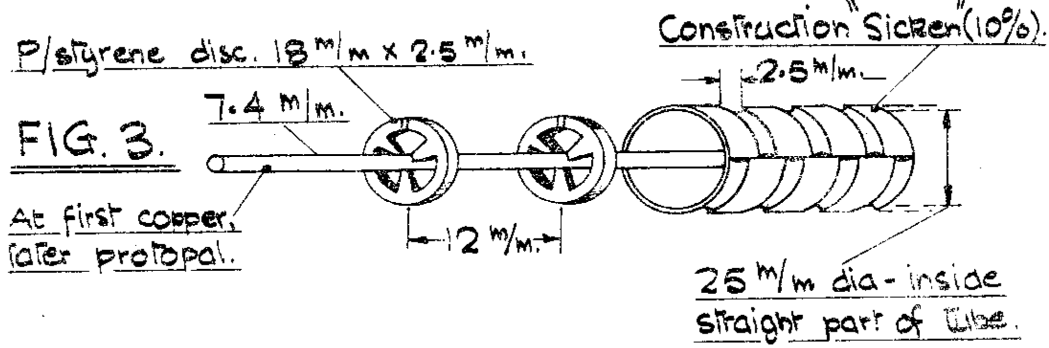
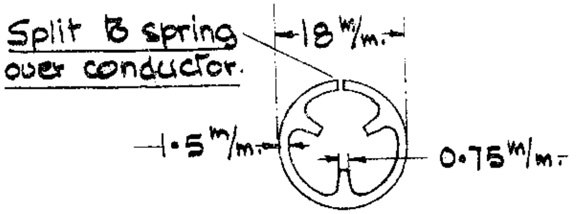


FIG. 3.





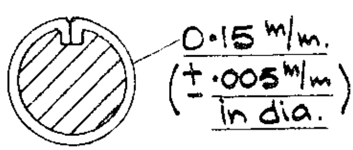


FIG. 4.

FIG. 5.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.

FIELD REPORT NO.14(a)

A visit to A.E.G., Oberschönweide, Berlin.

3rd October 1945.

1. Personalities.

1.1. Dr.Wuckel had been head of Department of A.E.G. dealing with television cables, but is now travelling bteween Thuringia, Hamburg and Berlin, endeavouring to collect technicians to re-open Communications Technique Laboratory at Drontheimer Strasse, North Berlin.

1.2. Dr.Erich Muller had been the expert on R.F. Cables under Wuckel. (See 1.4.)

1.3. Dr.Dahl is now director of A.E.G. Cable Works.

1.4. Dr.Brunnckow is dead. He had been chief of a group dealing with cables in Speer's War Organisation, and had been assisted by Muller.

1.5. Dr.Cords had been chief engineer of Norddeutsche Kabelwerke until a year ago, when he left to head a firm Getewendt, which is in some way connected with a communications group of the S.S. The location of this firm is said to be at Reichenau, near Gablonz, Sudetengau.

1.6. Dr.Wegener is now chief engineer of Norddeutsche Kabelwerke. He came from Heinrich Herz Institut.

2. General.

A.E.G. was originally associated with Telefunken, who ordered development of cable, and who were chief users. The link between the two firms was broken at Government request.

3. Cables for Services up to 25 Mc/s.

3.1. The following high-power transmitter cables have been made by A.E.G.:-

Item	Description of Cable.	Test Voltage	Attenuation at 1 Mc/s (Nepers/Km)	Service	Power Transmitted
A	4.8cms.dia. over discs of Frequenta (Schalen Kabel)	5 KV at 50 c/s	0.082	Used up to 10 Mc/s	10 KW. CW.at 20 Mc/s
B	9.5 cms over discs of Frequenta (Schalen Kabel)	20 KV DC	0.055	Nauen. Zeesen	50 KW MCW 25 Mc/s 10 KW MCW
C	4.8 cms over outer layer of solid Decelith tape wound 2 cms over inner layer of solid Oppanol plus 15-20%. Ozokerite Corrugated inner and outer. Oppanol sheath armoured.	12 RV RMS at 50 c/s	0.15	Intended for 20 KW Mobile Trans-mitters of which were made and are now in England.	20 KW at 25 Mc/s.

3.2 Cable A was the one used in the German Navy as a "trunk" to connect 800 watt transmitter to its aerial. It was never pressurised because it was not airtight.

3.3. Cables A and B were made with central conductors of different constructions for different services:-

(i) Aluminium rod with copper sheath folded rount it, with seam joint folded over and rolled down into the aluminium.

(ii) Iron rod with copper sheath, the whole rolled down (waltzen).

(iii) Jute centre or paper centre with aluminium sheath.

3.4. In Cable B the current of 20-30 amps (30 KW at 25 Mc/s) raised the temperature by 30°C through skin effect.

3.5. In Cable C the inner conductor was corrugated copper on a former of Igelit MP, although Buna was found to be better because it stands a higher working temperature.

3.6. The information on Schalenkabel obtained from A.E.G., Telefunken and Dr.Bushbeck is summarised in an appendix to report No.24.

4. Cables for 50 cms Radar.

Second cable developed by A.E.G. had single strand inner conductors, with dielectric of polystyrol discs and outer screen formed of two halves of solid copper with grooves, held together by wire.

Reflections due to the grooves and discs were encountered at wavelengths shorter than twice the distance between discs which was 10 cms.

5. Cables for 9 Cms.

A.E.G. made a solid dielectric (Oppanol) cable for Rotterdam which was designed by Dr.Kohl of Vacha, with a stranded inner and braided outer. The chief problem in making this cable was obtaining uniformity of impedance.

6. For 3 Cms.

Dr.Buchholz worked on the theory of waveguides and experiments were made on them by Dr.Muller assisted by Dr.Heinrich Riedel.

7. Twin Cables.

7.1. A.E.G. experimented with twins 12 years ago, but did not adopt them for telecommunications or for television, because they have a higher attenuation than a coaxial system.

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7. Twin Cables.

7.1. A.E.G. experimented with twins 12 years ago, but did not adopt them for telecommunications or for television, because they have a higher attenuation than a coaxial system.

7.2. Muller said that tests made on captured British twins having red and white cores, showed differences, notably in the matter of power factor, between the two cores.

8. Cable Screens and Outer Conductors.

8.1. Outer conductors of braided copper ribbons result in lower attenuation and better screening than those of braided copper wire (see article by Dr. Viehmann in E.N.T. for 1938). Compared with a solid copper sheath a ribbon braid gave 10-20% higher attenuation, and a wire braid gave 30-40% higher attenuation, (but see Report No.20). The latter is a function of the lay; a longer lay gives lower attenuation than a short lay, but no optimum angle was found. Buchholz has said that it is impossible to calculate effect of lay.

8.2. Screening was tested by Dr.Meinke.

8.3. Double-screened cables (1 copper and 1 iron screen) at 10 Mc/s gave no improvement in screening over single copper screen.

8.4. Paper published in A.E.G. Mitteilung in 1938 and also in Eurspaische Fernsprech Dienst by Wuckel and Muller gave figures of far-end cross-talk on Berlin-Munich cables (separate go and return cables) of 16 nepers/10 Km at 1 Mc/s and 13 nepers/10 Km at 100 Kc/s. The near-end cross-talk was 2 nepers/10 Km less than above figures.

8.5. In 1934 the A.E.G. construction was the "Schallen-Kabel", while Siemens used the styroflex thread with a copper tape outer.

For 1935 A.E.G. changed over to the "Rohrkabel" construction, while Siemens went to the "Sickenkabel". (See Report Nos. 13 and 24).

8.6. In "Schallen" cables the attenuation is a function of the contact between joints, which is worse in large than in small cables. The "Schallen" cable construction is very stable, and gives a very uniform Zo (within 3% over the range o.5-4 Mc/s), whereas the original Siemens tape construction gave 10" non - uniformity. Attempts to use an aluminium resulted in contact difficulties, hence copper was used.

9. Measurements and Measuring Methods.

9.1. See articles by Weissfloch of Funkstrahl (Julius Pintsch) in Zeitschrift für H.F. Technik.

9.2. Accuracy of measurement of Zo at 30 cms was plus/minus 5%.
Accuracy of measurement of attenuation at 30 cms was plus/minus 10%.

9.3. Attenuation measurements were by standing-wave method, using a diode detector at 50 cms, and a crystal at 30 cms. The measuring line was calibrated before connecting the cable. The cable coupling was stepped in preference to being conical, although the latter had been used.

In measuring flexible cables with solid Oppanol dielectric, 50 metre lengths were used, and the attenuation found to be 9-10 nepers/Km. Attenuation at 10 cms was measured, and power factor thence deduced.

9.4. Impedance measurements were carried out at 1 Mc/s by resonance method, the capacity being measured at 800 c/s.

Non-uniformity of impedance was measured by varying the frequency of the system.

Non-uniformity of impedance is a function of the cable length: they measured 3-5% for 10 metre lengths, and 10-15% for 100 metre lengths (?200-300 Mc/s).

Non-uniformity of impedance also increases with frequency, and different batches of cable were found to have resonant frequencies, varying widely from batch to batch. At 15 cms and 12 cms the non-uniformity was considerable.

9.5. H.T. pulse tests on solid dielectric cables(used at 10-12 kV for 1 microsecond) were made at 30% above working voltage.

9.6. Dielectric and braid losses of flexible solid cable at v.h.f. were deduced as follows:-

(i) The braided screen was replaced by a solid copper cylinder, and the attenuation was measured at 1 Mc/s and again at v.h.f. At 1 Mc/s the loss is assumed to be all copper loss, which is known to increase as the square root of the frequency, hence its value at v.h.f.

can be calculated. The differences between the latter value and the cable loss measured at v.h.f. therefore gives the dielectric loss at v.h.f.

(ii) Then the solid copper sheath was replaced by the braided screen, the v.h.f. loss measured again, and the braid loss thus found at v.h.f.

10. Mechanical and Physical Tests.

10.1. Low Temperature Tests.

Normal plasticised Igelit cracks at - 20°C., but specially plasticised Igelit cracks at -40°C. Bending tests are carried out by bending the cable round a cylinder of 10 or 20 times the diameter of the cable.

Shatter tests are done by dropping a weight on to the cable. Igelit will shatter, but Decelith does not.

10.2. Change of Attenuation with Bending.

After bending solid dielectric cable 500 times round a cylinder 20 times the diameter of the cable, the attenuation increased by 10%. After 700 bends the inner conductor broke.

In service use the plug or socket connection breaks before the cable.

10.3. High Temperature Tests.

After heating the cable to 80°C. over a period of 2 hours, the attenuation was found to be 30% higher than at room temperature. No long-term tests of P.V.C. covered cable were carried out.

11. MATERIALS.

11.1. Ribbons of Decelith supplied from Eilenborg had been covered with a hygroscopic powder (perhaps zinc stearate or talc) which was intended to prevent sticking but which results in increased loss. Decelith was therefore asked to use Quartz-mel instead; ordinary quartz powder was found to be impure and also hygroscopic.

11.2. Muller said that no moisture absorbing material is applied under the Igelit sheath because the latter is "quite impermeable".

11.3. Lupolem had been experimented with, but found to have worse electrical and better mechanical properties than Decelith. Its losses varied greatly from batch to batch. It was used as dipole sheathing material for protection against weather, and some Lupolen-covered wires were manufactured.

11.4. Styroflex losses increase above Polystyrol losses at 10 cm, believed to be due to orientation of the molecules by stretching in forming the thread.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO.14(b)

Visit of Dr.Erich Muller (Late of A.E.G.) to F.I.A.T. Forward.

10th October 1945.

1. ROTTERDAM/BERLIN EQUIPMENTS.

A.E.G., in common with Vacha and Siemens, had made connectors for the above equipment. Vacaha type No.976 and also a 3/18 mm cable (possibly Vacha type No.1193) were the types used. The A.E.G. versions had Decelith dielectric and brown P.V.C. sheath, suitable for -40°C working. The plug was integrally moulded to the cable with a mix containing Oppanol, Lupolen and Polystyrol.

In their measurements A.E.G. had dound both losses and reflections to be extremely low.

2. ROHRKABEL.

The spacers in this type and in the Sicken cable were at one time moulded on to the inner conductor. Latterly they have been moulded separately with a rounded clearance hole for the inner conductor.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 15.

Visit to Felten und Guilleaume - Mulheim Cologne.

Persons Interrogated:-

Dr. Hesse.	
Dr. Mayer	Director.
Dr. Kieser	Chief of Development Labs.

1. It was explained that this firm had not been engaged in the manufacture of high frequency cables, to their regret, because their share capital was largely foreign. This applied also to the Norddeustscher Seekabel Werke at Nordeuham which was half Siemens and half Felten und Guilleaume.

2. Their work had therefore been restricted largely to television cables for use at 4 Mc/s. This was of styroflex construction. They had made a whole series of cables in experimental lengths to compare different constructions and in particular to compare their construction with that of Siemens. The Siemens construction was found to be the better particularly in respect of uniformity at high frequencies. A whole series of samples were available for inspection.. The inner conductor was of aluminium with thin copper sheath, made in a rather different manner from Siemens. The aluminium was round rod and copper superimpcord with folded seam and then drawn down to circular section.

They gave the power factor of the styroflex cable as 2×10^{-4} and its effective permittivity as 1.17.

3. They had made only a few experimental lengths of cable using Lupolen, and had formed the opinion that it was a very suitable dielectric material for cables.

Their main interest in Lupolen was its application to submarine cables. The work on these was done at Nordenham.

4. The stretching of polystyrol and the manufacture

of thin sheets was also done at Nordenham. They had manufactured 0.01 mm. thick. They had some trouble with impurities and especially fine sieves were used. The technician at Nordenham who would be particularly useful is Dr. Heinz Horn.

5. They had (at Cologne) a series of delay cables with the inner conductor of a spiral of enamel wire and also one with a variable Zo designed as a gradual impedance transformer (E.F.D. March 1943). These had not been made in any quantity.

6. Some cable-making plant was inspected. For the application and winding of styroflex strip an ordinary telephone cable machine was used with the addition of a heating chamber (70°C - 80°C). The machines for lapping over the conductors were also seen.

The machines seen were old converted machines and not of particular interest.

The machine for making the corrugated outer conductor was examined (drawing requested of inside portion).

They had an extruder, patented by Heydrich, with full electric heating made by Kleinewefers, Krefeld. Screw 80 mm. diameter 800 mm. long.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 16.

Visit to Siemens Halske, Hamburg 6: Holstenwall 4.

Dr. Goushka was interviewed. He explained that the Hamburg branch was a sales office only.

Although there were technical people on the staff they could not add to the information obtained in Berlin. They supplied a note on the Siemen's cables but this contained no new technical information.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 17.

Visit to Telefunken, Hamburg, Ferdinand Strasse, 29.

10th October 1945.

Information received in Berlin indicated that Dr Meinke, who had done much theoretical work and was responsible for the design of the Telefunken cable testing equipment, might be found in Hamburg and that Dr. Kleen would in any case know his address.

On the first visit Dr. Kleen was out and the office staff did not give any information. On a later visit Dr. Kleen was seen. He was not sure of the address and wished to confirm with a Prof. Muller. He was not able to contact him by 'phone and promised to send the address to T. Force, Hamburg.

APPENDIX L.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 18.

Visit to the Norddeutsche Seekabelwerke A.G. Nordenham-I-Oldenberg.

1. GENERAL.

Persons Interrogated:-

Dr. Bernhard Boos ....Director.
Dr. Jules Engler ....Director.
Oberingeneur Aits ....Engineer.

In addition Dr. Horn, the inventor of "Styroflex" and Director of Felten-Guilleaume Carlswerke, Köln-Mulheim, was interviewed later at the home of Dr. Jules Engler. All personnel were anxious to collaborate to the fullest extent.

This factory had previously been visited in May or early June by Mr. Pond of the Distiller's Company and Lt. Reed R.N.V.R., Assessor, and in July by a mission comprising representatives of the War Office, the G.P.O. and Mr. J.M. Dean of T.C. & M. Co.

Norddeutsche Seekabel is a subsidiary jointly owned by Siemens Schuckert of Berlin and Felten-Guilleaume of Köln. In addition to the manufacture of audio-frequency dry core air spaced paper telephone cables they are well known for their "Styroflex" tape dielectric submarine communications cables, and this visit was made because it was thought that this Styroflex tape cable might, with substantial modifications lend itself to a design of high frequency cable. In addition it had been stated at I.G. Farbenindustrie that "Lupolen" had been supplied to the Norddeutsche Seekabel by I.G., and their experience with this material had not so far been investigated.

2. "LUPOLEN".

Dr. Boos confirmed that they had received relatively small quantities of this material from I.G. through the I.G. selling agents Messrs. Dynamit of

Troisdorf, Nr. Köln.

He stated that they had built a solid dielectric cable with Lupolen and another solid dielectric cable with a mixture of Lupolen and Oppanol. These cables had not been produced in any production quantity, nor had they been marketed or used by the Services. A sample of each of these cables was seen and it appeared that they had attempted to produce a cable approximating to the British Type U.R.34. Contrary to usual German practice for cables of this size the dielectric had been extruded, but from mechanical considerations alone it was obvious that they had not reached any high degree of perfection.

They were not in a position to make measurements higher than 1 Mc/s, and they confirmed that captured British cables in solid Polyethylene were electrically superior.

They had also attempted to produce sheet or tapes in Lupolen, a sample of which was brought away, but their experiments in this connection were in their infancy and they had not attained the degree of perfection characteristic of their production of "Styroflex". It was, however, interesting to note that the Lupolen sheet was processed on the machines used for the production of Styroflex, although it was thought that no particular advantage had been gained by orientating this material by stretching in both directions.

3. "STYROFLEX" TAPE CABLES.

For a full report on these cables, the reports issued by the two previous Missions should be consulted. The construction of the cable is discussed here because it is thought that cable engineers will readily visualise possibilities of converting it to high frequency use.

Two different sizes of cable have been made having respectively a 16.8 mm and a 22.2 mm. core. They were made in three types suitably armoured to withstand pressure at 75, 300 and 500 fathoms, but they stated that a successful cable could be manufactured to withstand 1000 fathoms.

The detailed construction of the three types is attached but from a high frequency point of view interest is restricted to the manufacture of the core.

3.1. Manufacture of Styroflex Tapes.

Polystyrene - Grade P3, product of I.G. Farbenindustrie, is fed to a screw extruder in the form of powder.

The material is fed through a hopper at the bottom of which a small screw feed is located to deliver the material to the main scroll. This is 200 mm. diam. x 450 mm. long, a relationship 2.25 : ;, which compares with from 6 : 1 to 12 : 1 for normal rubber and plastic extruders. The scroll is single start, reducing pitch and a buttress thread shape.

The extruder body is run at a temperature of 140°C. and the head at a temperature of 195°C. and uniform heat regulation is essential. This is obtained by cartridge type electrical heaters spaced uniformly round the body of the machine from the hopper to the die.

The projecting body of the die is wound with a further elements.

The styrene is extruded in the form of a tube approximately 50 mm. diam. x 1 mm. thick, which is immediately stretched laterally by drawing over a horse-shoe shaped spreader, the spreader being screwed into the front end of the die. The longitudinal stretching is governed by the speed of extrusion in relation to the speed of haul off.

Immediately the stretched and flattered tube leaves the spreader the sides of the tube are cut off, and the two tapes which remain are taken over separate nests of rollers to the winding up gear.

This very brief description does not give any indication of the many precautions necessary to ensure regularity of gauge in the final sheets, but when it is mentioned that each machine is housed in a separate cubicle, completely free from dust and draughts, and maintained at a temperature of 44°C (120°F) it will be obvious that many precautions are necessary.

The tapes are then cut on slitting machines following the well known Goebbels design and familiar to all who cut fine papers.

3.2. Laying up of the core.

From the detailed construction it will be noted that the cable comprises a copper-clad steel inner conductor with an air space dielectric of Styroflex tapes. Between 40 and 55 tapes, depending on the size of core required, of the required width and thickness are laid flat on each other and with their surfaces free to move over each other, and then wound on the inner conductor in the form of an open helix, 20 mm. pitch.

The laying up of the core is far more simple than might be supposed.

The Styroflex tapes are wound on steel bobbins $2\frac{1}{2}$" flange diameter x 4" wide x $1\frac{1}{8}$" barrell diameter, one continuous length of tape on each bobbin. The required number of bobbins or tapes are then mounted in a flyer, very similar to an air space telephone cable flyer, with the axis of the bobbin at right angles to the axis of the cable. The flyer is capable of accommodating 60 bobbins in 12 groups of 5.

The tapes are led to the front end of the flyer, through 5 gang guides, and down to a special forming spindle which is mounted coaxially around the inner conductor.

This special forming spindle is slotted in the form of a square thread with a 20 mm. pitch, and the tapes fall into place in the slot building up into a rectangular cross section. The speed of the machine is 1 metre per minute.

Over the open helix, four further Styroflex tapes are applied, the first two in opposite direction to the helix and the top tapes in the same direction as the helix.

Light tension is applied to the bobbins of tape by means of a spring loaded dibre washer engaging with the bobbin spindle and forming part of the bobbin bearings.

3.3. <u>Outer Conductor.</u>

The outer conductor comprises 8 butting copper tapes having a lay of approximately 12 inches.

From this point the make up differs for each type depending upon the armouring required, but this is not considered of interest from a R.F. point of view.

4. <u>ELECTRICAL CHARACTERISTICS.</u>

The characteristic impedance of the cable is 70 ohms and the attenuation 25 to 95 mN/Km over the frequency range 20 to 300 Kc/s.

The permittivity was stated to be of the order 1.3 to 1.35.

In conclusion it should be stated that the manufacture of this cable suggested a considerable amount of "know how", and if the cable is ever manufactured in this country it would be of advantage to bring Dr. Horn over in the early stages.

CONSTRUCTION OF POLYSTYRENE AND AIR-SPACED CABLES AS MADE AT THE NORDDEUTSCHE SEEKABELWERKE A.G.

STYROFLEX AIR-SPACED CABLE.

CONSTRUCTION.

Copper Wire:	5.0 mm solid. Weight 125 kg/m.
Styroflex tape spiral:	44-46 tapes 3.0 x 0.12 ..0.13 mm Not adhering. Lay 20 mm. Weight 33.5 kg/km.
Styroflex-Tape outer layer:	2 tapes, 20 x 0.12 mm. R.H. lay 30 mm. Weight 9.9 kg/mm (?)
	2 tapes, 20 x 0.12 mm. L.H. lay 27 mm. Weight 11.1 kg/km.
	16.8 mm Ø
Return Conductor:	8 copper tapes 6.5 x 0.3 mm, Applied L.H. lay 270 mm. Weight 13.9 kg/km.
	2 Excelsior linen tapes 40 x 0.15 mm, applied without overlap, R.H. lay. Weight 22.2 kg/km.
	18 mm Ø
Lead Covering:	Wall 2.3 mm. Weight 1665 kg/k.
	Ø over lead covering 22.6 mm.
Taping:	3 layers tarred paper 50 x 0.13-0.14 mm. Lay 32 mm, R.H.
	2 layers tarred jute, Lay 125 mm, one L.H. lay, one R.H. lay.

SINGLE ARMOURED CABLE.

Armour:	20 iron wires 5.0 mm Ø. Lay 447 mm, L.H.

Ø 40 mm.

Outer Tape:	2 layers of tarred jute. Lay 140 mm, one R.H. lay one L.H.
	Ø 44 mm.

STYROFLEX POLYTHENE CABLE 5.0/16 MM Ø

CONSTRUCTION.

Copper Conductor:	5.0 mm. Ø
Styroflex tape spiral:	42-43 tapes 3.0 x 0.12 mm. Lay 20 mm. L.H.
	Ø 15.8 mm.
	4 outer tapes 20 x 0.12 mm. R.H. lay.
	Ø 16.8 mm.
Return Conductor copper -	8 tapes 6.3 x 0.3 mm. Lay 272 mm. L.H.
	Ø 17.6 mm.
1 x Triacetatefoil	43 x 0.1 mm. Lay 67 mm. R.H.
4 x zinc foil	40 x 0.04 mm. Lay 55.5 mm. L.H. alternating with three layers of adhesive.
1 x Triacetatefoil	40x 0.1 mm. Lay 55.5 mm. L.H.
1 x steel tape	25 x 0.1 mm. Lay - 30 mm. R.H.
	Ø ra 19.5 mm.

The earth cable has, instead of the layer of steel tape a second outer layer of tricetate foil 30 x 0.1 mm. Lay 35 mm. R.H.

1 x special adhesive.

Polythene sheath:	Mix M.34	77% H.
		23% N.
		3% Oppanol.
		Ø 19.5/25.0 mm.

STYROFLEX AIR SPACED CABLE FOR WORKING IN 1000 m DEPTH OF WATER.

Steel copper 30%	5.8 mm ø
Styroflex spiral:	53-55 tapes, 3.5 x 0.14 mm. Lay 20 mm, L.H. lay.
	ø.21.2 mm.
Outer tapes:	4 tapes, 20 x 0.12 mm. Lay - R.H.
	ø 22.2 mm.

Finished armoured, etc., as required.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 19.

Visit to Hermann-Berstorff Maschinenbau-Anstalt G.m.b.H. Hannover.

Friday, 12th October 1945.

1. GENERAL.

This was a target of "Opportunity" to discuss details of an extruding machine viewed at the I.G. Farbenindustrie, Ludwigshafen.

We interviewed:-

Ingenieur Szozesny, a German of Polish extraction. He could not speak English.

2. MACHINE DETAILS.

The machine in question was designed by Dr. Rohbock of I.G. It was a straight-through machine, steam and hot water heated barrel with electrically heated core and die. The novel features were the means of keeping the core concentric with the die, and the means of registering the relative positions of core and die.

A sketch of the general arrangement of the machine was obtained (Numbered 6/18694 dated 20.9.1944) and a detailed drawing of the head (Numbered 6/18308-1 dated 21.1.43). These are classified as items 5 and 6 of Appendix IV.

It was understood that the special features were to become standard practice.

The dimensions of the scroll followed usual German practice, it being confirmed once again that little had been done to increase the length of scrolls for plastics extrusion. A reason for this was stated to be that the mixed polymers such as Mipolam, (copolymer of vinyl chloride and acrylic), were extruded with greater ease and at lower temperatures than straight P.V.C. With the introduction of P.V.C. they could not undertake the complete re-designing of the machine and concentrated on getting the extra heat at the extrusion orifice by lagging the die chamber with electrical elements.

2.1. Modification of core.

It is well known that straight through machines used for wire covering have in general suffered from the disadvantage of eccentricity of covering. This is brought about by the necessity of attaching the core to the scroll, with which it revolves, and in consequence any slight malalignment of the scroll is transmitted to the core which then runs eccentrically in relation to the fixed female die. It has therefore been general practice to use right-angle heads for wire covering, in which both die and core remain stationary and can be adjusted relative to each other.

The main advantages which would accrue from the successfull exploitation of the straight through machine principle would be :-

(a) An increased balance of forward pressure resulting in increased speed of extrusion.

(b) A machine lay out taking much less overall width.

Rohbock's device consists essentially of the introduction of a second non-rotating core housed in a special die-holder immediately behind the female die. It is shown quite clearly on Drg. No. 6/18308/1, from which it will be seen that a "spider" is used to attach the core to its housing, and through which the material passes on the way to the female die. Means are provided for adjusting the longitudinal relationship of the male core and female die, but the concentric relationship is fixed and concentricity obtained by the careful machining of the various details. The means adopted to close the space between the first and second cores to prevent feed back of material down the core tube will be described when considering the registering of these various components.

2.2. Registering positions of Cores and Die.

The drawing shows two large handles, one attached to the female die carrier and the other attached to the secondary core housing.

In setting up the machine the core attached to the scroll is first inserted with the secondary core housing and die holder detached. The secondary core is then fitted and the housing screwed roughly into position.

The female die is then inserted and the die holder fitted into position. As already stated the die cannot be adjusted for concentricity but the mean thickness of covering is regulated by the handle attached to the die carrier. A calibrated face plate is provided and the position of this handle for various thicknesses of covering can be recorded.

With the secondary core and female die in relative position, the handle attached to the secondary core housing is then used to slide the whole piece back against the scroll core. It will be noted that the back of the secondary core is chamfer bored to provide a nacelle for the nib of the scroll core.

The whole arrangement is quite ingenious and well designed.

3. <u>OTHER MACHINERY</u>.

This firm evidently specialise in the manufacture of machinery for the rubber cable industry, but an examination of the works (which had been partly destroyed by bombing) did not disclose anything of further interest.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 20.

Visit to Norddeutsche Kabelwerke, Berlin-Neukölln. Am Oberhafen.

1. Persons interrogated:-

Dr. Wegener	Managing Director.
Altmann	Chemist.
Freudenroich	Engineer.
Dambeck	Power Cable Engineer.
Lassen	Physicist, Test Dept.
Teske	Commercial Manager.
Hill	Liaison between commercial and technical sides.

2. STATE OF FACTORY:-

One machine for making "Fadenkabel" was in working condition. Three or four similar machines were believed to be at Luben on their way to an evacuation plant at Piermont (West Germany).

In another building most of the extruders and braiders were in working condition; some were actually producing plastic-covered wires and textile-braided cables, but raw materials were not available for the whole factory to be in operation.

3. GENERAL.

This firm also made cable couplings, plugs and sockets.

4. H.F. CABLE DESIGN.

Two main types are made, viz Fadenkabel and solid dielectric cables. Full details, descriptions and specifications were obtained. Twin cables are not now made.

5. OUTER CONDUCTORS AND SCREENS.

5.1. The firm demonstrated their preference for wire braids as against tape braids by showing how the latter sinks into the Oppanol dielectric. They now use a 60% coverage to save copper, as against the former 80% coverage.

5.2. Screening Efficiency.

Considerable work had been done on the measurement of this, by the method described in T.F.T. Bd. 33, Heft 7/8 (1944) 133-137. Measurements had been made up to 200 Mc/s, but the method could be employed at least up to 800 Mc/s.

6. MEASURING METHODS.

6.1. Attenuation is measured by the following methods:-

(i) Substitution method (or, more rarely, a Q meter method) up to 10 Mc/s.

(ii) Resonance method up to 100 Mc/s.

(iii) Standing-wave method up to 1000 Mc/s.

6.2. Nearly all their measuring apparatus was made by Rohde and Schwarz at their factory at 9, Tassils Platz, Ost Bahnhof, München. The laboratory is at Wolnzach, near Pfaffenhofen. The apparatus appears to be of very high quality, although evidently produced in reasonable numbers.

7. TESTS.

7.1. At low temperatures the cable was tested by a shatter test.

7.2. At high temperatures the cable was tested by VDE Spec. 0275/X.41.

7.3. Ageing tests at high temperature had not been carried out, but at room temperature no ageing had been observed.

8. MATERIALS.

8.1. Sheaths.

Buna S was used because of a shortage of the plasticiser required by Igelit. The Buna had a special vulcanising agent to permit of vulcanising at only 80° to 90°C. for 6 hours, in order not to soften the Decelith core. Buna S has advantages over Igelit at low temperatures.

8.2. Dielectrics.

They used Decelith O, which is Oppanol B 200 plus Polystyrol, and they added nothing to the mix.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 21(a)

Visit to Lorenz, A.G. Lorenz Weg 1, Tempelhof.

6th October 1945.

1. PERSONS INTERROGATED:-

(a)	Mr. Robertson (Swedish)	Patents: speaks very good English.
	Dr. Gutzman	High Power Transmitter Department.
	Dr. Seidelbach	Electro-acoustics, modulators.

(b) Reference was made to the following Lorenz engineers who were not available on the present occasion:-

Dr. Messner	Head of H.F. Department, Valves.
Dr. Kramer	Aircraft installations (R.F. cables); believed to be in Bavaria.
Dr. Wiessner	Screening tests of carrier cables, etc.
Dr. Schnabel	Radar.

(c) It was stated that Drs. Kohl and Peters of Vacha were most knowledgeable; Mr. Liebeknecht was not so important. Dr. Schuckardt was an owner.

2. H.F. CABLE DESIGN.

2.1. Lorenz developed and designed cables electrically and discussed requirements with Vacha. Lorenz differed from Siemens in favouring solid-dielectric cables and were able to show that a H.F. Litz conductor could more than compensate for the high permittivity dielectric in competition with air-spaced solid-conductor cable.

2.2. The Vacha Type No. 766 (the armoured version is coded No. 843) was then described:-

An Oppanol core of about 6 mm. diameter with hemp centre supported a "H.F. Litz" inner conductor. This comprises a number of stranded enamelled wires wrapped helically round the insulating core; originally these were of 0.07 mm. diameter, but subsequently they were changed to 0.04 mm. diameter. The "characteristic frequency" of the H.F. Litz conductor used was 1.5 Mc/s (see para. 3). Its total cross-section was 10 mm^2. The overall diameter of the inner conductor was 8 mm. and it was insulated with an Oppanol B/polystyrene mix to 32 mm. diameter. Originally Oppanol B 200 (mean molecular weight 200,000) was used and this was stepped up to 250 and 500 (Note: the higher molecular weights are less plastic). The outer conductor consisted of silver-plated copper tapes, 3.1 mm. wide, laid edge to edge with long lay, bound down with tapes, 20 x 0.25 mm. of short lay. A protective covering of Oppanol of inferior electrical quality and, in the case of No. 843 a galvanised iron-wire braid completed the construction.

The electrical characteristics were as follows:-

Effective permittivity:	2.25
Power-factor	10×10^{-4} best) at 6 to
	12×10^{-4} worst) 60 Mc/s
Characteristic impedance:	60 plus/minus 5 ohms.
Permissible loading:	500 Kw at 200 Kc/s.
	100 Kw at 1.5 Mc/s.

This cable was originally designed to carry 25 Kw at 1.5 Mc/s for mobile broadcast transmitters mounted on vehicles.

Deutschlandsender used two such cables in parallel to give 30 ohms. Three similar cables were used in parallel to transmit 1000 Kw at 15-60 Kc/s at Calbe (Milde) Naval Station.

Dr. Gutsman was not sure of the attenuation, but he believed that a 350 metre length of cable had a transmission efficiency of 92% at 350 Kc/s.

The short-time breakdown voltage of this cable was 42 KV at 375 Kc/s and short links to components such as capacitors were operated continuously at 7-8 KV without trouble. The B.D.V. is actually higher than with solid conductors because the Oppanol tape bedded itself against the projecting strands.

2.3. Another experimental cable was made for carrier work, which was designed to have only 10% change in attenuation over the range 0-300 Kc/s. This cable had Litz wire braid for the outer conductor as well as for the inner conductor.

2.4. An experimental cable to carry 50 Kw at 15 Mc/swas unsuccessful. In this case the inner conductor comprised a helix of solid wires 1.2 mm. diameter. The stiffness of these wires resulted in occasional movement of a wire outwards into the soft plastic material during service and so giving breakdown. Copper tapes 0.001 mm. thick were tried but enamelling at the edges was not good and contact between neighbouring tapes ensued. The use of high molecular-weight material might prove more satisfactory.

2.5. Another project, not implemented, was to load the cable inductively to give an impedance of 100 ohms and so increase the radiation efficiency of antenna systems at broadcast frequencies.

3. H.F. LITZ CONDUCTORS.

In a discussion on H.F. Litz conductors, Dr. Gutzman introduced the concept of "characteristic frequency" which he defined as the frequency at which the eddy current factor was 2: he stated that at one-third of this frequency the increase of resistance due to eddy current was 10%.

The use of this technique had resulted in the construction of coils in the Calbe equipment with a Q of 5000 and higher.

4. Vacha made Oppanol/Polystyrene mixes of their own and did not use Decelith (Deutsche Celluloide Fabrik). Cables made with it are flexible at -40°C.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.

FIELD REPORT NO. 22.

7th.,October 1945.

Visit to Dr.Bushbeck, 4, Erbacherstr,Grunewald.

1. Dr.Bushbeck worked on transmission on line problems in connection with the high power broadcast stations and obviously a first-class technician. He is enthusiastic about his work and has a pleasing personality.

2. 60-ohm H.P. TRANSMISSION CABLES.

2.1. Telefunken first used a 16/45 (?15/48) cable for transmitting a maximum power of 50 KW (telegraph) for Nauen.

2.2. The 28/94 mm. cable was used for higher powers, notably 50 KW carrier for Zeesen. The inner conductor was of interlocking copper tapes of the same type as the General Cable Corporation (U.S.A.) type H.H.* The Kalit (Frequenta) discs were silver-plated at the inner and outer conductor and provided with two spiralled wires at the inner conductor. The outer conductor comprised pairs of articulated semi-cylindrical plates (Schalen); the longitudinal joints of successive pairs were at right angles to one another. The cable was sometimes provided with a lead sheath or maintained as a flexible construction.

The discs could withstand 15 KV at radio frequencies, certainly at 27 Mc/s. The cable, however, failed after 3-4 years at 16-19 Mc/s - no failure occurred with 50 KW at 12 Mc/s or with 150 KW of the long wave Deutschlandsender.

* Heddernheimer.

Dr. Bushbeck was of the opinion that sparkover and burning resulted from the wear of the inner conductor as it moved in the insulator in the course of loading cycles. He conducted experiments subsequently with greased insulators in which the conductor was moved mechanically back and forth; he found that physical damage was caused after a total movement of 2 - 3 Km.

No contact trouble was experienced in the joints of the outer conductor, nor was electrical noise caused in receiving cable links in the short-wave range.

2.3. A solid dielectric (Oppanol) of 35 mm. diameter by Vacha (Vacha type No. 766) was used by Telefunken to transmit 100 KW carrier in the broadcast band. Conductor losses were 15% higher than for the ideal cable and at 50 Mc/s the dielectric loss was one half of the conductor loss.

2.4. Siemens Styroflex cable was only used for studio to station television links.

2.5. Copper or aluminium rigid lines were also used; these were mounted on rollers and thermal expansion was accomodated by providing bends in the run. Differential expansion of the inner conductor was taken up by bellows which were inserted in the inner conductor at some convenient point.

3. MEASURING METHODS.

3.1. Bushbeck H.F. Wattmeter.

In introducing a reply to questions regarding "Kalla", Dr. Bushbeck described an H.F. Wattmeter used to monitor broadcast transmission. This is based on the fact that the relationship (V plus/minus I.Zo = constant) holds at every point of a loss-less transmission line and is used to provide continuous indication of power and standing-wave ratio on a transmission line. A full description is given in a book, Fernsehen (Springer 1937) by Fritz Schroeter.

Wattmeters of this type have been built for 80 Mc/s, but could no doubt be designed for higher frequencies if required. The accuracy of the wattmeter for standing-wave ratios not exceeding 2:1 is very good, but is of the order 10-15% for greater mismatches. The wattmeter can be calibrated by passing the power into a water load.

3.2. Kalla.

Dr. Bushbeck was unable to give the exact schematic adopted in this equipment, but stated that it was based on the same principles as the H.F. Wattmeter. The basic circuit is shown in Fig. 1.

Measurements of V_1 and V_2 gives the mismatch on the line but not the phase of the mismatch. Diode voltmeters were used at lower frequencies, and crystal detectors of low capacitance at higher frequencies. In the latter case the response of the crystal was made linear by the insertion of a resistance in series with the detector.

Dr. Bushbeck had used this method up to 200 Mc/s but he was not aware of the maximum frequency at which the method had been used.

3.3. At 20 Mc/s he had used a rigid coaxial line with holes drilled in the outer conductor. By plugging in a probe with detector attached, he was able to establish the standing-wave induced on the line.

4. RESISTANCE TERMINATIONS FOR COAXIAL LINES.

By noting that in Figure 2 (a) is inductive and (b) is capacitive, Dr. Bushbeck had been led to establish the fact that a resistor, surrounded by a concentric cylinder in which the characteristic impedance of the air-space was $R/2$, was approximately a pure resistance. This solution is described in Hochfrequenz u. Electroakustik, 61, 1943 pp 96-100.

The same principle is used in terminations of coaxial lines by having the appropriate exponential form for an outer conductor of resistive material finally terminating in a resistance of the above form, as shown in Figure 3.

5. STANDARDISATION OF CHARACTERISTIC IMPEDANCE.

Dr. Bushbeck was questioned about the reasons for adopting 60 ohms as the standard impedance. He pointed out that for a given voltage, 60 ohms gave minimum stress whereas, for a given power load, 30 ohms was near the optimum impedance. For minimum heating of the inner conductor, which was often the limiting factor in operating large coaxial transmission lines with high powers, an impedance as low as 30 ohms was desirable.

Where two lines are used in parallel the impedance of air space coaxials cannot conveniently or efficiently be made greater than 120 ohms.

Dr. Bushbeck expressed the opinion that for high power work he would prefer to use an impedance of 45 or 50 ohms.

6. INTERESTING ANTENNA LAY OUT.

Dr. Bushbeck referred to an interesting layout adopted at a 200 KW Naval Station at Herzsprung near Angemunde (Berlin). This station had a quarter-wave aerial tuneable in the range 12-70 metres. The attached sketch Figure 4 shows the manner in which this load is automatically tuned to the 60-ohm transmission line as the length of the antenna is adjusted to the transmitter frequency.

In the earliest application of this design, the antenna was mounted on a tower and the inadequacies of the counter poises caused appreciable mis-matches. In the latest designs the system was mounted on hills with all but the antenna submerged below ground.

The transmitting station referred to above incorporates an R.F. wattmeter of the Bushbeck type. The R.F. stages of this equipment are undamaged although the master oscillator has been removed.

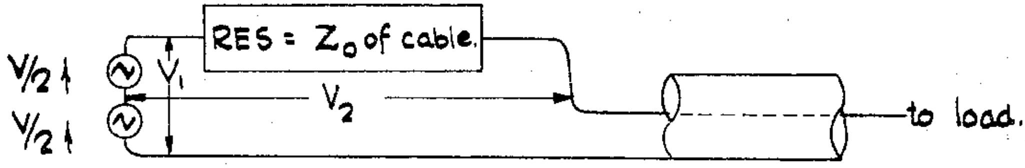


FIG. 1.

FIG. 2.

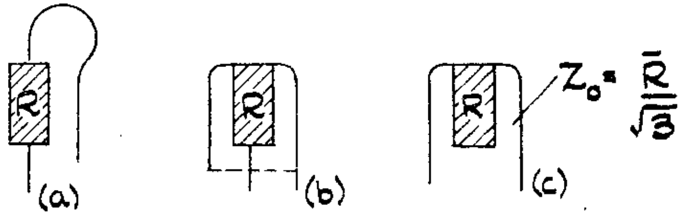


FIG. 3.

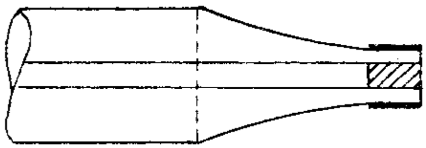
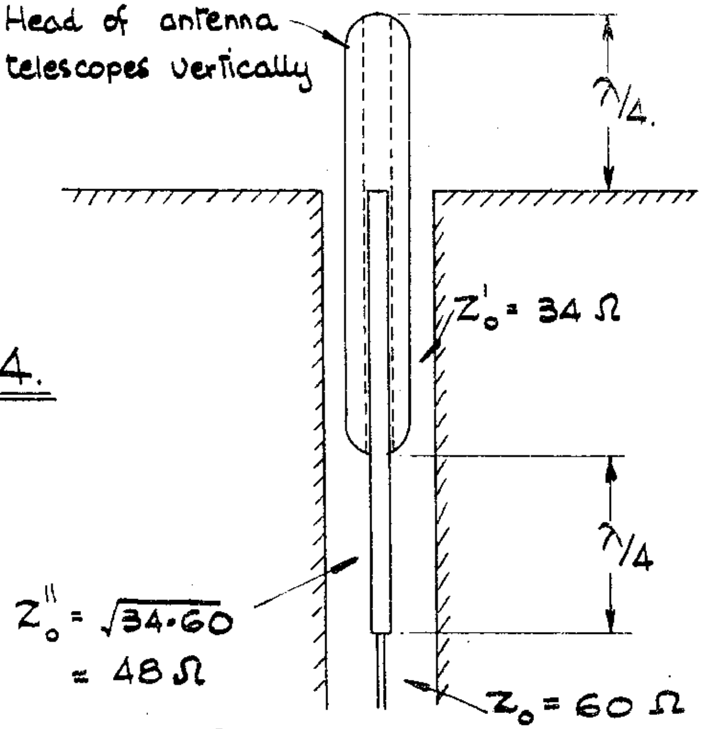


FIG. 4.



B.I.O.S. TRIP No 1176.

FIELD REPORT. No 22.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 23.

8th October 1945.

Visit to Dipl. Ing. Gottschewski, Sieglandes Str. 3.
Friedenau, Berlin.

1. Mr. Gottschewski was employed by the firm of Jordan who, besides manufacturing certain components, also represented a number of specialist firms, including Vacha.

2. In reply to questions regarding Vacha staff, Mr. Gotschewski stated that the most knowledgeable man was Mr. Heinrich Peters who was certainly in Dortmund at the end of August 1945 but who intended to return to Vacha. Max Maltzahn is dead. Other personalities are Schuckhardt (Commercial Director), Dr. Kohl, and Messrs. Severing and Rost (measurements).

3. Mr. Gottschewski was not able to be of assistance regarding technical developments of Vacha.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 24.

Visit to Reichspost (Ober Post Direktion), Heinrich von Stephen Str. (Gustloff), Charlottenburg, Berlin.

13th October 1946.

1. Dr. Decker of the above office was interrogated regarding operating experience on high frequency cables. Dr. Decker's only experience was with wide-band communication and television cables.

2. Dr. Decker stated that the wide-band communication system in Germany was laid in haste without proper test by Ohnesorge in order to win Hitler's favour. Burial of the cable in the neighbourhood of repeaters to a depth of 4 metres was specified as a precaution against sabotage during possible civil revolt, but in actual fact that figure was secretly altered by Dr. Decker to 2 metres to avoid practical difficulties. In open country the depth of laying was 1 metre. At least six men were killed in 1935 in digging the narrow trenches specified to save time.

3. The Berlin-Munich line started in 1935 was disastrous and more than 100 short-circuits had to be cleared from the Berlin-Leipzig stretch before transmission could be started. Siemens, Felten and Guilleaume and A.E.G. had equal shares in the supply of cable; the first two used "styroflex" cable with long-lay copper tapes, and A.E.G. supplied "schallen" cable.

Both types suffered from these short-circuits, which arose largely from unequal strengths of inner and outer conductors. The styroflex cable had the outer conductor and the steel-wire armour with opposite lays, thus twisting tended to extend the outer conductor relative to the cable length. The schallen cable gave trouble because of differential thermal expansion of inner and outer conductors. Most of the trouble occurred in the autumn when the temperature of the ground was falling fast.

At first repairs were made by locating the fault to a few centi-metres and by replacing the fault by a single joint. It was soon found that further faults occurred in the immediate neighbourhood of the repair and a directive was issued requiring that the cable for $2\frac{1}{2}$ metres on either side of the fault should be replaced.

4. In the Berlin-Hamburg link, and in the later stages of the Berlin-Munich line, the styroflex cable was altered to put the lays of outer conductors and armour in the same sense, and the lays were also shortened and adjusted to give minimum differential expansion. Dr.Decker stated that this change of lay raised the impedance from 65 to 72 ohms and also raised the attenuation appreciably.

With the schallen cable, the inner conductor was maintained under considerable mechanical tension from the moment of manufacture and was not jointed until at least three weeks after laying.

Experience with this line was reasonably satisfactory.

5. In the Berlin-Frankfurt and Vienna-Munich lines, new designs of cable were employed and no faults developed in service.

A.E.G. adopted their "rohr" cable which was wound on 220 cm. drums with 180 cm. belly. The distance between spacers was 60 mm. as compared with 75 mm. on early Berlin-Munich cables.

Siemens used their so-called "sicken" cable. Both types had an impedance of 70 ohms to a specified tolerance of plus/minus 2%. Dr.Decker believed that there was no significant difference in their relative screening efficiencies.

6. In the Frankfurt-Cologne line, aluminium was used for the outer conductor and aluminium with a covering of copper tape was used for the inner conductor to save copper. The aluminium conductors were soldered and these joints were quite satisfactory in service.

7. Electrical tests were carried out in the Reichspost laboratories up to 20 Mc/s, at which frequencies there were inappreciable reflections from the spacers.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 25.

Visit to Guido Horn, Langhausstr 125, Weissensee, Berlin.

12th October 1945.

1. Production of cable making machinery was discussed with Mr. Lippold of the above firm.

2. No developments have taken place during the War.

3. The factory was alsmost completely destroyed by air raids and the Russians have taken or destroyed many of their papers. They have a battery of four or five high-speed braiders of their own design operating to make shoe laces. They are engaged in rehabilitating their machinery and expect to start production by about February.

APPENDIX I.

B.I.O.S. TRIP NO.1176.
FIELD REPORT No.26.

Visit to Froitzheim and Rudert, Langhausstr 126-131 Weissensee, Berlin.

12th October 1945.

1. The subject of production of cable machinery was discussed with Werner Rudert and a brief inspection of the plant was made.

2. Their present productive capacity is now about 30% normal and this will be stepped up, according to present plans, to 50% by rehabilitation of plant damaged in air raids. It would appear that no machinery has been removed by the Russians to date.

3. Their normal monthly production of high speed braiders was of the order 25-50.

4. Catalogues of their pre-war range of cable-making machinery were obtained.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 27.

Visit to Lignes Telegraphiques et Telephoniques at Conflans, St. Honorine.

19th October 1945.

1. PERSONNEL.

Visit was arranged through Captain Gay of F.I.A.T. (French) at Hochst and through M. Brillien of the Ministere de la Production Industrielle (at 99 rue de Grenelle) with the firm's Managing Director M. Archange.

The processing of polystyrol was demonstrated and explained by M. Montoriol; its use in condensers was discussed with Mr. Dumas; and measurements on cables were discussed with M. Carmine. The commercial manager M. Jacquerinet was also seen. These gentlemen were extremely helpful and answered all questions fully.

2. PREVIOUS VISIT BY BRITISH MILITARY PERSONNEL.

It was learnt that British Army Officers had escorted a German engineer (horn) of Norddeutsche Seekabelwerke at Nordenham, on a visit to L.T.T. during the summer of 1945, at the request of [redacted] and in the presence of their representatives. The purpose of this visit was to disclose to S.T.C. and to L.T.T. certain details in the processing of polystyrol of which engineer Horn had kept them in ignorance during the war when he was their technical overseer. The personnel of L.T.T. are of the opinion that although Horn did explain certain things, he could have given more information if suitably encouraged.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 28.

Visit to Dr. Buchholz, Heidelberg, Rolleweg 12 Nr. Volkoschule.

22nd September 1945.

Dr. Buchholz had published theoretical work on cables, in particular on the effect of discontinuities and he was asked about the problems he had been investigating during the last few years. It seemed that in 1941 theoretical work on the development of cables was discontinued, because, he said, the Germans thought that they had won the war. He had subsequently made a theoretical study of the propagation of electromagnetic waves in a paraboloid, and for this work he had also done some original work on the theory of hypergeometric functions. These papers had been taken by American investigators. He had another copy of the one entitled "The axial symmetry of electromagnetic waves between confocal paraboloids with different methods of excitation."

Dr. Buchholz asked if we had any problems we would like him to investigate. The present investigators are not in a position to assess his value, but it was clear that the engineers at A.E.G. who were visited later held a high opinion of his theoretical work.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 29.

Visit to Reichspost Zentralmt, Ringbahnstr 126-134
Tempelhof, Berlin.

11th October 1945.

1. PERSONALITIES.

Dr. Klewe was interviewed. Dr. Klewe's work on interference between telephone and power systems is well known in England. He stated that Dr. Decker, Ober Post Direktion, Heinrich von Stephanstr. Charlotterburg was responsible for broad-band and television cables. Dr. Feise is Director of the present offices and Dr. Jaeger was in the Reichspost Ministerium.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 30.

Visit to Deutsches Versuchsanstalt fur der Luftfahrt.
Rüdower Chaussee, Aldershof, Berlin.

11th October 1945.

1. PERSONALITIES.

Information was given by Major Robertson that Dr. H. Viehmann had been evacuated to England. Dr. H. Schäffer has been associated with Viehmann in publications on electrical screening.

2. VISIT.

A visit was made to the laboratories, but we were informed by the Russian guards that the laboratories were Russian, and that no German technicians were there.

APPENDIX I.

B.I.O.S. TRIP NO. 1176.
FIELD REPORT NO. 31.

Interrogation of Dr. H. Viehmann, (Deutsche Versuchsanstallt fur der Luftfahrt, Adlershof, Berlin).

1. INTRODUCTION.

Dr. H.R.F. Carsten (B.I.C.C.) S/Ldr. R.C. Mildner (R.A.E.) and Mr. W.T. Blackband (R.A.E.) conducted this interrogation on behalf of the Inter-Service R.F. Cable Technical Committee. Dr. Viehmann was concerned with electrical interference problems in aircraft and his name was brought to the attention of the R.F. Cable Committee by reason of his published work (in collaboration with Dr. H. Schäffer, believed to be now in Braunschweig) on the screening effect of braids.

2. PERSONALITIES.

2.1. Dr. Viehmann mentioned that a colleague, Erwin Schmidt of D.V.L. had worked on Radar/Communications interference.

2.2. The two establishments, parallel to D.V.L., dealing with radio for the Luftwaffe were:-

(a) Radio
Erprobungsstelle der Luftwaffe
Rechlin, Mechlenburg
(Chief Engineer: Von Hauteville).

(b) Radar
Erprobungsstelle Verneuchen
Berlin
(Chief Engineer: Dr. Gresky)

2.3. Dr. Viehmann stated that all his files had been evacuated to the Luftfahrt Forschungsaustallt, Braunschweig. Dr. Viehmann is interested to see that they are recovered and would be happy to discuss them with interested parties.

3. RESEARCH PROBLEMS.

3.1. Substitution of Aluminium for Copper in Braids.

An alloy such as Aldrey or Legal 1 was used in sizes of the order 0.2 - 0.25 mm. diameter. Experience in mechanical handling and robustness was quite satisfactory. The mechanical characteristics of this alloy were approximately as follows:-

Strength:	30 kg/mm^2
Stretch:	5%
Dauerbiegensfestigkeit:	about 1/2 that of soft copper. (ultimate elongation 28%).

(Note: This last property was measured by successive bends of a wire, passing between two rollers and supporting weight equivalent to one-tenth of the ultimate strength, through an included angle of 30°).

3.2. Effect of Braid Design.

From the standpoint of screening, measured in range 0.2 to 20 Mc/s.

(a) the effect of braiding angle, investigated in the range 45° to 60°, is not important, but screening improves with increase of lay.

(b) an optimum screening was found for a filling factor of 60%.

(Note: This is consistent with R.A.E.'s observations of German practice with R.F. coaxial cables which have filling factors of about 60%. Dr. Viehmann had not tested balanced cables, where German practice has used filling factors of about 115% in certain designs).

(c) No ageing effects were noted with copper or aluminium braids.

3.3. Painting of Screens.

No deterioration of screening was found when braids were painted, they are not certain what the effects might be if the screens were removed and subsequently re-assembled.

3.4. Bonding.

Regulations required bonding of screens at 60 cm. intervals to the frame of the aircraft. This has no effect on the screening, but intermittent contacts, liable to cause noise, were eliminated.

3.5. Effect of Holes in Screens.

D.V.L. have investigated the effect of ventilating holes in screens and have determined the most suitable forms of baffle plates to restore the screening.

3.6. Screening at 500 c/s.

The Luftwaffe did not make general use of A.C. supplies at the higher power frequencies. A 500 c/s supply was used for a compass supply. Dr. Viehmann could not recall any interference troubles arising from this supply.

4. TERMINATIONS.

4.1. It is their usual practice to use clamped joints with both copper and aluminium since soldering is liable to cause embrittlement with the former and corrosion with the latter.

4.2. The most important principle in design of demountable connections is to ensure good contact all round the periphery.

4.3. Dr. Viehmann agreed that the major source of poor screening lay in the terminations and also that most German designs were poor. The only really satisfactory fitting which they had tested was a fireproof-bulkhead box by Bosch which was constructed of galvanised sheet steel. Siemens had continued to use anodised aluminium fittings in spite of V.D.L.'s adverse comments.

5. INTERESTING DEVELOPMENT.

On ignition systems they normally used rigid tube with seamless corrugated tubes for the flexible connections to spark-plugs and magnets.

Stimulated by the expense and short supply of these Tombac tubings, they had recently investigated a new type of corrugated tubing made in Chemnitz under Swiss patents. A double lapping of copper tapes, breaking joint by 50%, was provided with a helical corrugation.

(Note! A sample of this screen is held by Cables Section, Radio Dept., R.A.E.)

6. SCREENING MEASUREMENTS.

The efficiency of screening is defined in absolute terms by the evaluation of its coupling impedance per unit length: this practice is followed by very many other German laboratories and is now covered by a V.D.E. Specification (No. 087?). The general arrangement follows the usual German practice in screening measurements. The set-up was calibrated by substituting for the cable a coaxial line, the outer conductor of which is formed by a thin carbon film on a ceramic former (the total resistance of the outer conductor was of the order of 20 ohms).

APPENDIX L.

B.I.O.S. TRIP No. 1176.
FIELD REPORT NO. 32.

Interrogation of Professor K. Kupfmuller.
23rd October, 1945.

PRESENT. S/Ldr. Mildner (R.A.E.)
Mr. Blackband (R.A.E.)
Dr. H. Carsten (B.I.O.C.)

The present interrogation was conducted on behalf of the Inter-Service R.F. Cable Technical Committee.

Professor Kupfmuller was in charge of telecommunication research and development for the German Navy (N.V.K. Pelzerhagen) with the particular view of co-ordinating the scientific work. The discussion was of a general character.

1. CARRIER TRANSMISSION SYSTEM.

All development work was stopped in the first year of the war, the systems developed so far being considered adequate to cope with the requirements at that time. The systems are:-

(a) B., U., S., L. systems which are well known.

Very extensive use was made of the L. system (audio plus one carrier channel for light loaded cables).

(b) MG15 system originally developed for open wire lines gave satisfactory service after initial difficulties were overcome.

(c) TFA and TFB systems with go and return channel on the same line were portable systems particularly suitable for the army and for cases of emergency in ordinary postal telephoning.

Another TFC system was developed for go and return circuits in different cables, but never put into operation.

Details of the allocation of the carrier channels could be obtained from Siemens reports.

(d) Wireless decimeter wave system (code name "Rudolf") for long distance transmission within Russia and between Russia and the Atlantic coast, was operated in connection with nine channels of the U system for feeding and distributing over "local" cable circuits. Each U channel could be used either for telephony or three-channel telegraphy and were all fitted with scrambling devices.

(e) The application of a telegraph system - U. boat to shore, with time of transmitting the communication reduced to approximately 6 ms for a message of 20 words was found impracticable because of the poor insulation of the antenna. The system itself, however, worked all right, the signals being received by cathode ray tubes.

2 CABLES.

The development of R.F. cables was practically completed before the outbreak of war and only little was done during the war. Impedances were standardised to 60 ohms after much discussion. For reasons of economical cable design, Professor Küpfmüller would have preferred a standard impedance of 70 ohms. This applies especially to long distance cables with air-spaced dielectric. However, the decision was made in favour of 60 ohms in view of the requirements of equipment designers who preferred a lower value of standard impedance, even as low as 50 ohms.

In Siemens practice the design of Styroflex insulated coaxial cables with lapped strings and tapes, is still considered as the most suitable construction, the polystyrene bead insulation being only an experiment.

The outer conductor made of two semi-circular corrugated longitudinal copper tapes has proved far superior to helically lapped copper tapes, which caused considerable trouble.

No further development took place in recent years but Professor Küpfmüller expressed the opinion that there is still room for improvement in design. It would be desirable to reduce impedance irregularities; also, the problem of phase distortion, as far as transmission of television is concerned, is, in Professor Küpfmüller's opinion, still unsolved.

Experiments with 4 - core coaxial cables with special iron tape screening gave satisfactory cross-talk values, the near-end cross-talk being the most critical.

3. TEST EQUIPMENT.

The department for high frequency testing at S. and H. Central Laboratory, was removed from Berlin to Auch, (Czechoslovakia), and later to Munich. It is still there with a skeleton staff.

Members of the staff who could give useful information are Dr. Jaumann, Dr. Buchmann, Mr. Wild and Mr. Ochem. Dr. Jaumann, who is a specialist on H.F. bridge methods, developed a bridge for measuring at frequencies up to 200 Mc/s (?). (Topfkreisbrücke), which should be of great interest; also, a wave meter for the 8 - 12 centimetre range, accuracy 10^{-4}

Dr. Buchmann, who served as assistant to Professor Küpfmüller, is a specialist on broad band amplifiers. Messrs. Wild and Ochem are experts on screening methods for prevention of power and lighting interference in telecommunication lines. Dr. Buchmann is believed to be at Neustadt and the others at Munich.

4. PUBLICATIONS.

During the war, Professor Küpfmüller prepared a fourth and fifth enlarged edition of his text book on Theory of Electricity; unfortunately the sets were repeatedly destroyed by war action and he now possesses only a single copy of the second edition with hand written notes. He also wrote and completed a book on Theory of Telecommunication. The MSS. is in Wolfenbüttel. He does not think that this work could be printed in Germany.

Professor Küpfmüller, and generally the German scientists, have been unable to keep abreast with foreign publications. Professor Küpfmüller expressed his desire to adapt his new work to present day knowledge, once he had the opportunity of studying British and American literature published during the war.

5. Professor Küpfmüller stated that Messrs. Brandt and Seibert were at the O.K.M. (Ober Kommando fur der Marine) which was evacuated from Berlin to many other localities successively. He stated that Mr. Brandt committed suicide in 1944. He believed that Mr. Seibert was in Flensberg.

6. RECOMMENDATIONS.

(a) It is recommended that an attempt be made to locate Mr. Seibert of O.K.M. for interrogation.

(b) It is recommended that Dr. Buchmann, Dr. Jaumann, Mr. Wild and Mr Ochem be interviewed. The last three are of particular interest to the R.F. Cable Committee.

(c) It is recommended that further investigation be made of Professor Küpfmüller's manuscript in view of its possible wide appeal.

APPENDIX II.

GERMAN STANDARD LIST OF R.F. CABLES.

1. Two issues of this list were published, namely issue 1 of 1.12.42. and issue 2 of 15.9.44. The originals of these documents are held in the C.R.B. Library and are available for detailed inspection. The information contained in the second issue is abstracted in essential detail here.

The offices concerned in drawing up the present lists are:-

Oberkommando der Kriegsmarine (O.K.M)
Der Beauftragte für der Vierjahresplan Der General bevollmächtigter
Für technische Nachrichtenmitte (G.B.N.)
Hauptkommission Elektrotechnik (H.K.E.)

2. SUMMARY.

2.1. Covering letters.

(a) Letter from O.K.M. (signed Seibert) dated 17.11.44 covering enclosure of list.

(b) Letter from G.B.N. (signed Risemeyer?) dated 1.8.44 announcing introduction of list and its application.

(c) Letter from G.B.N. dated 1.8.44 (signed Risemeyer?) announcing introduction of 60 and 150 ohm impedance standards.

2.2. List of H.F. Cables for the Wehrmacht (Issue 2 of 15.9.44).

Arrangement of list.

Part I - contains the standard cables (Z_0 = 60 or 150) for all new developments.

Part II - contains cables not of these impedances, for maintenance purposes and developments of existing gear using non-standard cables.

The standard cables are coded in a manner which reveals the construction:-

1. Group 001 to 099 - Unsymmetrical coaxial cable $Z_0 = 60\Omega$, used for transmitter cable in matched systems. Carrier frequency cable.

2. Group 100 to 199 - Unsymmetrical coaxial cable $Z_0 = 120\Omega$, used for transmitter cable in unmatched systems or for parallel load service.

3. Group 200 to 299 - Unsymmetrical Receiver cable, $Z_0 = 150\Omega$, for unmatched systems.

4. Group 300 to 399 - Symmetrical cable for receiver or D.F. use.

5. Group 400 to 499 - Special Cables.

6. Identification of Armouring for cable constructions which remain the same.

a) Index 1 - Normal construction with sheath of insulating material (001.1).
b) Index 2 - Normal construction with sheath of thickened insulating material (001.2).
c) Index 3 - Armouring with iron-wire braid (Naval protection).
d) Index 4 - Armouring for laying in ground without (Moorschutz).
e) Index 5 - Armouring for laying in ground with (Moorschutz).
f) Index 6 - Armouring as light Submarine Cable.

Note that with Index 1 to 3 construction for normal cold conditions - blue sheath, suitable to -20°C. Construction for extreme cold condition - brown sheath suitable to -50°C. Special permission from G.B.N. for use of the latter is required.

In Parts 1 and 2 of the R.F.Cable list are compared the new and old nomenclatures of the cables, the firm producing the original cable and the specified properties.

<u>Special symbols used in the lists:-</u>

Inner Conductors:- M : Solid Conductor.
L : Stranded Conductor.

H.F. : H.F. Litz Conductor.

R.. : Tube-Conductor.

Insulation:- V. : Solid Insulation.

T.P. : Polystyrene Beads.

T.S. : Polystyrene Spacers.

K.P. : Ceramic Beads.

Faden : Thread Cable.

H.K. : Hollow Core (Cartwheel).

Stk. : Styro-Kordel.

Supplier:- the chief producer at the present time is indicated by the following code:-

A : A.E.G. Oberschöneweide.

F : Felten u. Guilleaume, Köln.

N : Norddeutsche Kabelwerke, Berlin.

S : Siemens Kabelgememschaft, Berlin.

V : Kabelwerke Vacha A.G. Vacha/.

Accessories. Preparation of a list of accessories is under way.

Explanation of the Classification of R.F. Cables used by Wehrmacht.

1. With the present issue (No. 2 of 15.9.44) the former issues of 1.12.42 becomes obsolete.

2. A cable can be used for purposes other than that given.

3. Bending Radius. The value given applies to single bends made during installation not to continuous bending. This refers particularly to cables of larger diameter and

stiff inner conductors.

4. Electrical Tolerances. Zo values are subject to a tolerance of plus/minus 5% (1 Mc/s). In so far as values of permittivity may alter due to supply difficulties for raw materials, larger tolerances may be necessary. In view of their possible effect on equipment, the supplier is to keep the user informed of such developments. Values for attenuation may be up to plus 10% high. Some cables in Part II, bearing commercial fabrication numbers, have Zo values subject to plus/minus 10%.

5. Insulation Resistance. Certain types of hollow-core and bead cables must be inspected for dryness before assembly of terminations. The I.R. must be at least 10^{10} ohm/m (sic) at high humidities.

6. Assembly. Care should be taken to avoid too small bending radii, or excessive heat in soldering.

R.F. CABLE FOR THE WEHRMACHT.

Issue 2.

For Service use only.

Electrical Data. Part I.

Berlin, 15th Sept. 1944

Type	Z	C	Attenuation, Nep/km. at					Permissible load in KW for matched service and 30°C temp. rise				Voltage kV peak at 300 Kc/s		Application	Remarks
	Ohms	pF/m	100 Kc/s	1 Mc/s	10 Mc/s	100 Mc/s	1000 Mc/s	100 Kc/s	1 Mc/s	10 Mc/s	100 Mc/s	Test	Working		
200.1 200.3	150	27	0,70	1,40	4,75	17,5								Empfangskabel	leichtes Empfangskabel
201,3 201,4	150	27	0,32	0,8	3,4	16,5								Empfangskabel	schweres Empfangskabel
202,1 202,3	150	23	0,12	0,39	1,5	7,8								Empfangskabel	
203.1	150	23,9	0,38	0,70	1,8	5,8		für Sendezwecke nicht vorgesehen.						Empfangskabel	biegungskonstant. Toleranz C = ± 1 pF/m Z = ± 8%
204,1 204.3	150	22	0,18	0,58	2,1	10,0								Empfangskabel	
300.1 300.3	150	27	0,14	0,48	1,6	5,3								Sym. Empfangs-kabel, leichtes Peilerkabel	
001.1 001.2 001.3 001.4 001.5	60	86	0,193	0,65	2,15	7,0		24,3	7,2	2,18	0,67	3,5	3,0	Konzentr. Sende-kabel	
003.1 003.2 003.3	60	85	0,205	0,72	2,5	8,6		22	6,25	1,80	0,52	3,0	2,5		Aus Rohstoffgründen mit Einschränkung austausch bar gegen Typ 435 c
004.1 004.3	60	67,5	0,107	0,365	1,23	4,18		35,8	10,8	3,20	0,94	2,75	2,5	Konz. Sendekab el	Im Dezimeterbereich brauchbar
005.1 005.3	60	86	0,17	0,78	3,6	14,5		33	7,18	1,55	0,39	6	5,5	Konz. Sendekab el	
006.3 006.4	60	88,5	0,069	0,23	0,76	2,5		116	34,8	10,5	3,2	20	17,5	" "	geeignet für kW-Sender bis 1 kW an nicht ange-passter Antenne
007.3	60	67	0,048	0,15	0,47	1,62		120	38,5	12,2	3,55	4	3,5	Konz. Sendekab el	Für Dezimeterbereich un-ter 375 Mc/s brauchbar
008.3 008.4	60	100	0,028	0,083	--	--		465	160	--	--	40	35	"	Für Frequenzen kleiner als 1500 kHz brauchbar
009.1 009.3	60	84	0,105	0,36	1,23	4,3		73,5	21,4	6,35	1,79	25	20	"	el. Angepasst an 006.
010.3 010.4	60	85	0,043	0,142	0,47	1,55		205	62	18,7	5,68	40	35	"	kW-Sendekabel für grosse Leistung, angepasst
011.1 011.3	60	86	0,175	0,595	2,05	7,2		45,8	13,4	3,9	1,11	20	17,5	"	auch für UK-Bereich
013.2 013.3	60	95	0,285	0,78	2,75	11,6		4	4	1,63	0,39	0,8	0,7	"	auch für UK-Bereich
014.4 014.6	60	89	0,085	0,285	0,95	3,2		85,3	25,4	7,63	2,77	15	12	Konz. Träger-frequenzkabel	
015.1 015.3	60	88	0,06	0,13	--	--		75	43	--	--	20	18	Konz. Tragerf-requenzkabel u Langwellensen-dekabel	bis 240 kHz Dämpfung konstant
016.1 016.2 016.3	60	85	0,177	0,52	1,54	4,4		34	11,5	3,9	1,36	6	4	Konz. Sende-kabel	im Dezimeterbereich brauchbar, Wellingkeit kleiner als 3%.

R.F. CABLE FOR THE WEHRMACHT. PART I.

MECHANICAL DATA.

For Service Use Only.

Berlin 15.Sept.1944.

Type	Construction	Inner Conductor diameter & type mm	Dia. under outer conductor mm	Overall Dia. mm	Smallest Bending Radius in mm	Weight in kg/m	Supplier	Application	Remarks.
200.1 200.3.	H.K.	0,3 M	6,0	8,5 + 1 11,0 + 1	75 100	0,1 0.30	V	Empfangskabel	
201.3 201.4	H.K.	0,6 M	14,5	21,0 + 1 23,0 + 1	150 200	0.74	V	Empfangskabel	
202.1 202.3	Faden	1,0 M	12,0	18,5 + 1 20,0 + 1	300 400	0.4 0.7	N	Empfangskabel	
203.1	T.P.	0.56 M	10,6	18,0 + 1	250	0,40	V	Empfangskabel	
204.1 204.3	Faden	0,6 M	11,2 11,2	13,0 + 1 15,5 + 1	250 300	0,21 0,43	N	Empfangskabel	
300.1 300.3	T.P.	2 x 1,5 M	12,0	14,0 + 1 15,5 + 1	100 100	0,25 0,39	V	Sym.Empfangskabel leichtes Peilerkabel	
001.1 001.2 001.3 001.4 001.5	V	1,6 M	7,0	9,0 + 1 11,5 + 1 13,0 + 1 15,0 + 1 16,5 + 1	75 75 100 100 100	0,2 0,2 0,3 0,49 0,34	V.N.	Konz.Sendekabel	Verlegung mit Langenzuschub in Schlangenlinie erforderlich.
003.1 003.2 003.3				8,5 + 1 19,5 + 1 10,5 + 1	75 175 100	0,12 0,13 0,23		Konz.Sende-und Empfangskabel	
004.1 004.3	T.P.	3,2 M	10,2	15,5 + 1 16,5 + 1	250 250	0,35 0,52		Konz.Sendekabel.	Torsionsfähig bis 30°/m
005.1 005.3	V	2,0 L	9,2	12,0 + 1 13,5 + 1	80 100	0,20 0,34	V	Konz. Sendekabel	Hochflexibel
006.3 006.4	V	4,2 M	18,2	24,5 + 1 26,5 + 2	300 400	1,0 1,15		Konz. Sendekabel	
007.3	T.P.	7,5 R	23,8	30,5 + 1	300	1,0	V	Konz. Sendekabel	
008.3 008.4	V	8,0 H F	33,0	40,0 + 2 44,0 + 2	400 500	2,9 3,3	V	Konz. Sendekabel	
009.1 009.3	V	5,0 L	22,0 22,0	26,5 + 1 28,0 + 1	300 400	0,9 1,1	V	Konz. Sendekabel	Für Tropeneinsatz
010.3 010.4	V	7,5 R	33,0 33,0	39,0 + 2 41,0 + 2	500 500	2,0 2,5	V	Konz. Sendekabel	
011.1	V	9,2 L	18,2	22,5 + 1 23,5 + 1	200 300	0,6 0,9	V	Konz. Sendekabel	Flexible Anschlubleitung für Normenkabel 006
013.2 013.3	K.P.	1,38 M	6,6	13,0 + 1 13,0 + 1	75 150	0,25 0,42	V	Konz. Sendekabel	
014.4 014.6	V	3,4 M	14,5	28,0 + 2 33,0 + 2	500 500	1,6 2,1	V	Konz. Tragerfrequenzkabel	
015.1 015.3	V	4,5 H F	17,0	27,0 + 1 27,0 + 1	300 500	0,8 1,7		Konz. Tragerfrequenzkabel	
016.1 016,1 016,3	V	2,3 M	10,0	14,0 + 1 15,5 + 1 15,5 + 1	75 75 100	0,28 0,33 0,43	V	Konz. Sendekabel	

R. CABLE FOR THE WEHRMACHT.

For Service use only. Electrical Data. Part II. Issue 2.

Berlin, 15.Sept.1944.

Type	Z Ohm	C pF/m	Attenuation, Nep/km at 100 Kc/s	1 Mc/s	10 Mc/s	100 Mc/s	1000 Mc/s	Permissible load in KW for matched service and 30°C temperature rise. 100 Kc/s	1 Mc/s	10 Mc/s	100 Mc/s	Voltage in kV peak at 300 Kc/s Test	Working	Application	Remarks.
1053	elektrische		Daten	verschieden Schaltung		je nach		Fur Sendezwecke nicht vorgesehen						Empfangskabel	
2H63 Mb	elektrische		Daten	verschieden Schaltung		je nach								Empfangskabel	
418	146	25,5	0,51	0,95	2,75	--								Schaltleitung	
967 c	98	51	0,54	1,2	3,7	14								Schaltleitung	(Impulsleitung)
400.1 400.2	120	40	1,0	1,2	3,2	15,5								Verbindungskabel f.Mess-.Prüfzwecke	Nur für Prüf - und Messzwecke
24652 Y	70	72		0,8	2,5	8,9	38		1,9	0,6	[illegible]			Antennenleitung.	
24821 Y	100	50		1,3	3,8	12,9	50		1,1	0,4	[illegible]			Antennenleitung.	
889	250	15,5													
301.3 301.4	335	12	0,193	0,46	1,76	--	--	Fur Sendezwecke nicht vorgesehen						Schweres Peilerkabel,symmetr.	
302.3 302.4	310	12	0,22	0,66	2,5	12	--							Symm.Peilerkabel	
296	215	20,5	--	1,47	3,4	--								Peilrahmenkabel	
402.1 402.3	215	17,5	0,52	0,87	2,25	8,8		Fur Sendezwecke nicht vorgesehen						Peilerhilfsantennenkabel	
401.1	elektrische		Daten	verschieden Schaltung.		je nach								Peilerrahmenleitung.	
100.3	120	43	0,022	0,15	--	--	--	568	83,5	--	--	40	35	Konz.Sendekabel	LW-Sendekabel f. nicht angepassten Betrieb
976 s 976 d 976 e 976 f	72	74,5	0,135	0,475	1,75	6,1								Konz.Sendekabel u.Impulskabel	
1000 i	70	72,5	0,21	0,70	2,35									Konz.Sendekabel	Als Ersatz für 435 i brauchbar
426	115	40	--	0,63	2,3	8,1								Konz.Sendekabel	
925 k	77	53	--	0,345	1,25	--								Konz.Sendekabel	
924	73	53	0,140	0,360	1,07	4,2								Konz.Sendekabel	
184020 18402F	70	50,5		0,16	0,52	1,7	6,1		22,0	7,0	2,0			Konz.Sendekabel	"Michaelkabel"
Ro A1 5,5/20	70	50	0,05	0,15	0,45	1,6	5,5	42,6	13,6	4,26	1,36	3,0	2,5	Konz.Send-u. Empfangskabel	"Michaelkabel"
Ri A1 5,5/18	70	50	0,05	0,155	0,49	1,7	5,5	42,6	13,6	4,26	1,36	3,0	2,5		
HF 5/18 956 K	220	16	0,9	1,2	2,75	--	--							Impulsleitung	
494	250	17	0,25	0,70	2,38			Fur Sendezwecke nicht vorgesehen						Empfangskabel	
Fe LD															
Fe P	180	20	0,18	0,5	1,8	9,2						1,2	1,0	Empfangskabel	
553 B	120	46	0,215	0,59	1,95	8,5								Empfangskabel	Ersatz für 770
96	145	27,5	--	0,87	2,35	--								Empfangskabel	
881	101	57	--	0,71	0,28	--								Sym.Empf.Kabel	

R.F. CABLE FOR THE WEHRMACHT.

For Service Use Only. MECHANICAL DATA. Part 11 Berlin, 15.Sept.1944.

Type	Construction	Inner Cond dia.& type mm	Dia.under outer conductor mm	Overall dia. mm	Smallest bending radius in mm	Weight in kg/m	Supplier	Application	Remarks.
381	K.P.	2 x 1,6 M	11,2	15,5 + 1	125	0,5	V	Symm.Empfangs-kabel	Ln 28189
1053	E.P.	3 x 0,6 M	11,9	21,5 + 1	175	0,84	V	Empfangskabel	3 adriges Perlenkabel
2H63 Kb	V	2 x 0,75L	5,2	14,5 +0,5		0,29	N	Empfangskabel	kältefester Mantel Flexibel
418	T.P.	0,4 M	5,5	6,0+0,5	15	0.04	V	Schaltleitung	
9670	V	0,5 M	4,5	4,8 + 1	10	0,04	V		Ln 28198
400.1	K.P.	0,56 M	9,0	10,5 + 1	75	0,16	V	Verbindungs-kabel für Prüf-u. Messzwecke	
400.2	K.P.	0,56 M	9,0	12,0 + 1	75	0,21	V		
24652 Y	V	1,1 M	6,6	9,5	30	0,13	S	Antennenleitung	flexibel, höhenfest,
24821 Y	V	0,5 M	6,6	9,5	30	0,11	S	Antennenleitung	langswasserdicht
889	T.P.	2 x 0,6 M	11,0	14,5 + 1	100	0,21	V		
301.3	H.K.	2 x 0,6 M	22,0	39,0 + 2	400	1,8	V	Schweres Peiler-kabel, symmetrisch	
301.4						1,6	V		
302.3	Faden	2 x 0,6 M	2 x 10,0	28,5 + 1	400	1,0	N	Symmetrisches Peilerkabel	
302.4	Faden	2 x 0,6 M	2 x 10,0	34,4 + 1	500	3,0	N		
296	T.P.	2 x 0,56M	9,0	11,0+0,5	100	0,14	V	Peilrahmen-kabel	Ln 28185
402.1	T.P.	0,3 M	12,3	14,5 + 1	100	0,19	V	Peilerhilfsan-tennenkabel	
402.3	T.P.	0,3 M	12,3	16,0 + 1	150	0,35	V		
401.1	T.P.	4 x 1,6M 1 x 0,3M	16,1	19,5 + 1	125	0,44	V	Peilrahmenkabel	
100.3	V	3,5 E F	67,0	78,0 + 4	500	7,2	V	Konz.Sendekabel	
976 s	V	1,8 M	10,0	14,0 + 1	60	0,27	V		Normale Ausführung
976 D	V	1,8 M	10,0	15,5 + 1	75	0,35	V	Konz-Sendekabel	Verstarkter Mantel
976 a	V	1,8 M	10,0	15,5 + 1	75	0,3	V		Kaltefest bis - 50°C
976 f	V	1,8 M	10,0	16,7 + 1	100	0,5	V		Verstarkter Mantel u. Armierung mit Eisendraht geflecht
10001	V	1,17 M	6,6	8,5 + 1	75	0,12	V	Konz.Sendekabel	
426	T.P.	0,9 L	8,7	10,6 + 0,5	75	0,13	V	Konz.Sendekabel	
985 K	T.P.	2,5 M	10,2	15,2 + 1	125	0,3	V	Konz.Sendekabel	Ln 28187
924	T.P.	2,5 M	10,0	14,3 + 1	70	0,3	V	Kon[illegible]ndekabel	Ln 28817
18402 C	St.K.	5,0 M	18,0	28,3	300	1,1	S	Konz.Sendekabel	flexibel
18402 F	St.K.	5,0 M	18,0	36,0	200	1,8	S	Konz.Sendekabel	nicht flexibel
Ro AL 5,5/20	T.S.	5,5 M	20,0	37,0	400	3,4	A	Konz.Sende U.	für Erdverlegung
Ri Al 5,5/18	T.P.	5,5 M	18,0	29,5	200	0,79	A	Empfangskabel	für bewegl,Einsatz
HS5/18	T.P.	0,3 M	12,2	17,0 + 1	150	0,3	V	Impulsleitung	Ln 28190
484	T.P.	2 x 0,6 M	11,2	21,5 + 1	175	0,80	V	Empfangskabel	2 adriges Perlenkabel
FsMD	Faden	0,6 M	13,0	20,0 ± 1	400	0,6	N	Empfangskabel	
Fs P	Faden	0,6 M	13,2	16,2 ± 1	400	1,5	N	Empfangskabel	
553B	K.P.	2 x1,38 M	11,2	16,0 + 1	125	0,6	V	Empfangskabel	Ln 28191
96	T.P.	0,56 M	8,7	10,6 + 0,5	75	0,13	V	Empfangskabel	Ln 28183

R.F. CABLE FOR WEHRMACHT

REFERENCE LIST TO PART I

For Service use only

Berlin, 15 Sept. 1914.

Current Standard Code	Z Ohm	C pF/m	Overall diameter mm	Original Commercial Reference	Z Ohm	C pF/M	Overall diameter mm	Remarks.
200.1 3	150	27	8,5 + 1 11,0 + 1	600 600 B	150	27	8,5 + 1 11,0 + 1	
201.3 4	150	27	21,0 + 1 23,0 + 1	E 505 E 505	150	27	21,0 + 1 23,0 + 1	
202.1 3	150	23	18,5 + 1 20,0 + 1	FM FMD	155	23	18,5 + 1 20,0 + 1	
203.1	150	23,9	18,0 + 1	806b	150	23,9	18,0 + 1	
204.1 3	150	22	13,0 + 1 15,5 + 1	GM GMD	157	22	13,7 + 1	
3001. 3	150	27	14,0 + 1 15,5 + 1	373 in 28182 373 a	150	27	13,5 + 1 15,4	
001.1 2 3 4 5	60	86	9,0 + 1 11,5 + 1 13,0 + 1 15,0 + 1 16,5 + 1	H 33/H 37 Mb 911 1 911 K 911 r	58 63	88 80	12,2 11,5 + 1 15,0 + 1	
003.1 2 3	60	85	8,5 + 1 9,5 + 1 10,5 + 1	1000 c = Lz 18180 435 c	58 55	88,5 97	9,5 - 1	1000c = Vollkabel 435c = Perlenkabel
004.1 3	60	67,5	15,5 + 1 16,5 + 1	925 k –	77	53	15,2 + 1	
005.1 3	60	86	12,0 + 1 13,5 + 1	1024 1024 B	50 60	86 85	12,5 + 1 13,5 + 1	
006.3 4	60	88,5	24,5 + 1 26,5 + 1	721 B 721 EA	59	88,5	28,0 + 1 34,0 + 2	
007.3	60	67	30,5 + 1	726	58	70,5	21,0 + 1	
008.3 4	60	100	40,0 + 2 44,0 + 2	766 843	60	100	40,0 + 2 44,0 + 2	
009.1 3	60	84	26,5 + 1 28,0 + 1	– 1099	60	84	28,0 · 1	
010.3 4	60	85	39,0 + 2 41,0 + 2	946 946 EW	60	85	42 + 2 47 - 2	
011.1 3	60	86	22,5 + 1 23,5 + 1	– –				
013.2 3	60	95	13,0 + 1 13,0 + 1	777 f1 777 B	51 56	110 96	13,0 + 1 13,0 + 1	
014.4 6	60	89	28,0 + 2 33,0 + 2	674 EA 674 UW	50	108	28,0 + 2 33,0 - 2	
015.1 3	60	88	27,0 + 1 27,0 + 1	932	60	88	27,0 + 1	
016.1 2 3	60	85	14,0 + 1 15,5 + 1 15,5 + 1	976 S 976 d. 976 e 976 f	72	74,5	14,0 + 1 15,5 + 1 15,7 + 1	

R.F. CABLE FOR WEHRMACHT.

REFERENCE LIST TO PART II.

For Service use only

Berlin, 15.Sept.1944.

Type	Z Ohm	C pF/m	Overall diameter mm	Original Commercial Reference	Z Ohm	C pF/m	Overall diameter mm	Remarks
2 H 63 Mb	Siehe unter Bemerkungen		14,5 + 0,5	2 H 63 Mb				el. Daten verschieden
418	146	25,5	6,0 + 0,5	418/o,4, Ln 28810	Werte und Abmessungen			
967 c	98	51	4,8 + 1	967 c, Ln 28198	wie nevenstehend.			
400.1	120	40	10,5 + 1	96 F	130	35	10,5 + 1	
400.2	120	40	12,0 + 1	626, Ln 28197	120	40	12,0 + 1	
24652 Y	70	72	9,5	24652 Y	Werte und Abmessungen			
24821 Y	100	50	9,5	24821 Y	wie nebenstehend.			
889	250	15,5	14,5 + 1	889	Werte und Abmessungen wie nebenstehend.			
301.3	335	12	39,0 + 2	P 463 B	Werte und Abmessungen			
301.4	335	12	39,0 + 2	P.463 L	wie nebenstehend.			
302.3	310	12	28,5 + 1	2 C M D	Werte und Abmessungen			
302.4	310	12	34,4 + 1	2 C P B A	wie nebenstehend.			
296	215	20,5	11,0 + 05	296, Ln 28185				
402.1	215	17,5	14,5 + 1	793, Ln 28186				
402.3	215	17,5	16,0 + 1	793	215	17,5	14,5 + 1	
401.1	Siehe unter Bemerkungen		19,5 + 1	960, Ln 28193	Siehe unter Bemerkungen			el. Daten verschieden je nach Schaltung.
100.3	120	43	78,0 + 4	979	120	43	78,0 + 4	
976 s	72	74,5	14,0 + 1	976 s, Ln 28818				
976 d	72	74,5	15,5 + 1	976 d, Ln 28818/1				
976 e	72	74,5	15,5 + 1	976 e				
976 f	72	74,5	16,7 + 1	976 f				
1000 i	70	72,5	8,5 + 1	1000 i, 435 i				1000 i = Vollkabel 435 i = Perlenkabel
426	115	40	10,6 + 0,5	426				
925 k	77	53	15,2 + 1	925 k, Ln 28187				
924	73	53	14,3 + 1	924, Ln 28817				
18402 c	70	50,5	28,3	18402 c				
18402 f	70	50,5	36,0	18402 F				
Ro AL 5,5/20	70	50	37,0	Ro AL 5,5/20				
Ri AL 5,5/18	70	50	29,5	Ri AL 5,5/18				
HF 5/18					Werte und Abmessungen			
956 k	220	18	17,0 + 1	956 k, Ln 28190	wie nebenstehend.			
484	250	17	21,5 + 1	484				
Fs MD	180	20	20,0 ± 1	As MD				
Fs P	180	20	16,2 ± 1	AS P				
553 b	120	46	16,0 + 1	553 b, Ln 28191				
96	145	27,5	10,6 + 0,5	96, Ln 28183				
881	101	57	15,5 + 1	881, Ln 28189				
1053	Siehe unter Bemerkungen		21,5 + 1	1053				el. Daten verschieden je nach Schaltung.

APPENDIX III.

GERMAN R.F. CABLE PERSONALITIES.

The following names of Scientists and Engineers connected with the development, manufacture and/or application of R.F. Cables was compiled as the result of contacts made during the visit. In this respect Dr. Busbaud of 1 Boltzmann Strasse, Dahlem, Berlin was most helpful.

NAME.	POSITION.	INTERROGATED.
Prof.Abraham Esau	Minister of State Sc:Advisor to Gov.	Yes
Admiral J.Gladen-back	Director of A.E.G. Asst.to Prof.Esau	Yes
Dr.S.Müller	Was Editor of Electrotech.Zeit	Yes
Prof.Busch		No
Dr.Ing:Bushbeck		Yes
Dr.Otto Cords	Was with Norddeutsche Kabelwerke later with Getewendt in Gablonz.	No
Mr.G.Gottschewski	Tech:Salesman for Paul Jordan.Deals with Vacha cables.	Yes
Dr.Rohde	Formed Sc: Inst. Firm of Rohde & Schwarz.	No
Dr.Schwarz		No
Dr.Viehmann	Deutsche Versuchs anstalt fur Luftfahrt	Yes
Prof.Kupfmüller	Siemens Konzern. war-time appointment as Sc: Advisor to Navy.	Yes
Prof.Weissfloch	Well-known theoretical work on Impedance relationship	No

NAME.	POSITION.	INTERROGATED.
Prof.Zenneck		No
Dr.Scheid	Inventor of Steatite Ceramic Dielectrics.	No
Mr.Brandt	O.K.M.	No
Mr.Seibert	O.K.M.	No

A. Telefunken, Berlin,

Herr Brandt	Oberingenieur	No
Dr.Knoll	Physicist	No
Dr.Maass	"	No
Dr.Franz	Expert in H.F. Theory.	Yes
Dr.Grassnick	Installation Expert.	Yes
Dr.Muth	Developed night fighter equipment	Yes
Herr Gothe	Personnel Manager	Yes
Dr.Meinke	Measurements Expert.	No
Dr.Rukop	Was General Man. and Physicist.Now retired to a Farm.	No
Burchhardtsmayer		
Pirck		

B. A.E.G. Berlin.

Dr.Dahl	Director of Labs.	No
Dr.Frerichs	Spectroscopist Kaiser-Wilhelm Inst.	No
Dr.Kalkner		Yes

NAME.	POSITION.	INTERROGATED.
Dr.Krugel		No
Dr.Erich Muller.	H.F.Cables	Yes
Prof.Carl Ramsauer	Director of Research.	Yes
Dr.Heinrich Riedel		No
Dr.Wuckel	Director of H.F.Dept.	No.
Dr.Buchholz		No.

C. Rohre Fabrik OberSchonweide (R.F.O.)Part of A.E.G. and located in Nazional Automobil G Bld.Ostend Str. Oberschonweide.

NAME.	POSITION.	INTERROGATED.
Dr.Frick	Director of Development Telephone Equip.	Yes
Dr.Kluge		Yes
Dr.Kotowski	Ex Telefunken	No
Dr.Steinmel	" "	No
Dr.Walter	" "	No

D.Siemens,Gartenfeld.

NAME.	POSITION.	INTERROGATED.
Dr.Schumann	Ass.Director of Cable	No
Dr.Erich Thurmel	Director of Cables	Yes
Herr Ernst Fischer	Technical Dir.	Yes
Dr.Hosse	Plant Engineer	Yes
Herr Franz Ohmstede	Technical Dept.	Yes
Dr.Heering	Chief Chemist.	No
Dr.Holzt	Asst.Chemist	Yes
Dr.Helmut Fischer	Chemist	No
Dr.Kaden	Physicist	No
Dr.Rudolf Tamm	Central Lab.	Yes
Herr Kurt Wagner	S.K.2.Dept.	No
Dr.Lüchen	Director	No
Dr.Lintzel	H.F.Testing	Yes

NAME	POSITION.	INTERROGATED.
E. Norddautsche Kabelwerke, Berlin-Neukolin, Am Oberhafen.		
Dr.Wegener	Managing Dir.	Yes
Herr Dambeck	Cable Engineer	Yes
Herr Altmann	Chemist	Yes
Dr.Larsen	Engineer and Physicist.	Yes
Herr Teske	Commercial Manager	Yes
F. Lorenz A.G.Lorenzweg,Berlin-Tempelhof.		
Herr Gutzman		Yes
Herr Kramer		No
Herr Messner		No
Dr.Peschke	Worked on Radar.	Yes
Herr Robertson	Patent Lawyer (Swedish)	Yes
Dr.Schnabel	Worked on Radar	Yes
Herr Seidelbach		Yes
Herr Weissner		No
G. Vacha-Rhon (Russian territory)		
Herr Wilhelm-Kohl	Technical Man. (Ex Siemens)	No
Herr W.Lisbeknecht	Chief Engineer	No
Dr.Max Maltzahn	Technical Dir.	No
Dr.Heinrich Peters	Physicist	No
Herr Rost	Asst.To Peters	No
Herr Schuchardt	Commercial Dir.	No
Herr Severing		No
Dr.Jordan	Managing Dir.	No
H. Sud-deutsche Telefon Apparate Kabel und Drahtwerke A.G. (Te-Ka-De, Nuremberg)		
Herr Kielmann	Works Manager	Yes
Dr.Madel	Design of Radio	Yes
Herr Oeser	L.F.Design	Yes
Dr.Weinstein	Managing Dir.	Yes
Herr Stefen	Sales Director	Yes
Herr Hutter	Lawyer	Yes
Herr Muschwick	Secretary	Yes
Herr Rohmhild	Tubing	Yes
Dr.Wucherer	H.F.Measurements	Yes

NAME	POSITION.	INTERROGATED
I. Kabel und Metallwerke Neumeyer A.G.Nuremberg.		
Dr.Hans Fischer	Managing Dir.	Yes
Dr.H.W.Droste	Mathematician & Head of Test Dept.	Yes
Herr Schlump	Works Manager	Yes
J. Kabel und Leitungswerke A.G.(Siemens) Neustadt-bei-Coburg.		
Herr Hypradt	Technical Dir.	Yes
Herr Rau	Accountant	Yes
K. Felten und Guilleaume Carlswerke A.G. Koln Mulheim.		
Dr.Ulfilas Meyer	Research Manager	Yes
Dr.Kieser	Physicist	Yes
L. Norddeutsche Seekabelwerke A.G.,Nordenham-i-Oldenberg		
Dr.Bernard Boos	Director	Yes
Dr.Jules Engler	Director	Yes
Dr.Heinz Horn	Managing Dir. of F & G Koln	Yes
M. I.G.Farbenindustrie,Weinheim,(Dispersal Laboratory)		
Dr.Jordan	Chief Chemist	No
Dr.Berger	Plastics Chemist	Yes
N. I.G.Farbenindustrie,Ludwigshafen.		
Dr.Heugsternberg	Chemist	Yes
Dr.Adolf Schwartz	Chemist	Yes
Herr Rohbock	Engineer	Yes
Dr.Hirt	Chemist	Yes
O. Hackethal Draht und Kabelwerke A.G.Hannover.		
Dr.Reusch	Technical Dir.	No
Dr.C.Zoehrer	Chief Chemist	No
Dr.Müller	Chemist	No
Dr.Roebemach	Commercial Dir.	No
Mr.Voges	Office Manager	No
P. Hermann Berstorff Maschinenbau - Anstalt G.m.b.H. Hannover.		
Herr Szozesny	Chief Engineer	Yes
Q. Dynamit A.G.Troisdorf near Köln.		
	Director	Yes
	Chief Chemist	Yes
R. V.D.M.Sud-Kabelwerke A.G. Mannheim.		
Dr.Wanner	Managing Dir.	Yes
Dr.Raymond	Works Manager	Yes
Dr.Schwedler	Chemist	Yes
Herr Bock	Sales	Yes

APPENDIX IV.

List of Documents and Drawings

1. General Arrangement Drawing of longitudinal metal tape covering Machine made by Schumag of Aachen.

2. Ultrahochfrequenz - Ubertragung langs zylindrischen Leitern und Nichtleiten - by H.W. Droste.

3. Die Losung angewandter Differentialgleichungen mittels. Laplaceschen Transformation statt durch Heavisidesche Operatorenrechnung by H.W. Droste.

4. Ein Satz der Laplaceschen Funktionen - Transformation uber die Aufteilung in Dauer - und Ausgleichsvorgang bei Gleich - und Wechselstrom und der Ausgleichssatz der Komplexen Umwandlung - by H.W. Droste.

5. Drawing No. 6/18694 dated 20-9-44 - Hermann Berstoff Maschinenbau - austalt G.m.b.H. Hannover.

6. Drawing No. 6/18308 - 1 dated 21-1-43 - Hermann Berstoff Maschmenbau - austalt. G.m.b.H. Hannover.

5273/47 7. Docket of Technical Information submitted by Siemens Kabel Gemeinschaft, Gartenfeld, Berlin.

5276/47

Including:-
a) drawings of water tight cable termination (plug).
b) list and specifications of R.F. Cables.
c) copy of report given to Mr. Swift, 11-14/8/45.
d) copy of report given to the Russian Military Authority.
e) copy of Service specifications for R.F.Cables for Wehrmacht, Luftwaffe. Kriegsmarine and Reichspost.

The above documents have been lodged at, Documents Unit, Board of Trade, Lansdowne House, Berkeley Square, London. W.1. under BIOS Registration number:- BIOS/DOCS1176/3133. All applications to inspect these documents should be accompanied by the above number.