B.I.O.S. FINAL REPORT No. 1771

ITEM No. 31

FUSES, ELECTRIC PROTECTION

FINE-SENSITIVE AND SURGE-RESISTING TYPES, BELOW 5 AMPERES, PRODUCED IN GERMANY

BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

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FUSES, ELECTRIC PROTECTION

FINE - SENSITIVE AND SURGE-RESISTING TYPES, BELOW 5 AMPERES, PRODUCED IN GERMANY.

REPORTED BY:-

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TECHNICAL INFORMATION AND DOCUMENTS UNIT,

40, CADOGAN SQUARE, LONDON, S.W.1.

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FOREWORD and SUMMARY

The purpose of this investigation was to examine the methods of manufacture of fine rated sensitive, delay-action (surge-resisting) fuses such as are used for the protection of radio and electronic equipment and devices, rated at 5 Amperes and below.

The generally accepted British method of manufacture of such fuses is by the use of fine drawn precise diameter wires of either pure metals or carefully controlled alloys, any delay or surge-resisting feature being introduced by the use of something added to the fine wire, either on the element itself or as a filler composed of chalk, marble dust, fine sand or of some other substance.

Before the war, when a British manufacturer was given the opportunity of quoting for fuses against a continental manufacturer, he had to quote to a sample or specification employing quite a different technique to that with which he was accustomed.

Quite often the tenderer was told that it was not sufficient to reproduce the electrical specification, and the fuse to be offered had to be similar in appearance to the continental sample.

It was never possible for British manufacturers to produce a fuse which (1) looked like the continental sample and (2) had the correct electrical characteristics, nor (3) to produce such a fuse at a competitive price.

This team was assembled to investigate the manufacture of these fuses, and on leaving this country it was expected that it would find some automatic method of manufacture which enabled these fuses to be produced at such low prices.

It is believed that a very thorough investigation was made, not only of the few German manufacturers known, but also of other fuse manufacturers whose names were received from the interrogation of suppliers of pieceparts such as pressed end-caps, and drawers of fine wire.

No automatic machinery was employed, their results being obtained by very cheap labour, cheaper materials, and apparently more tolerant designs.

It may be of fundamental importance to note that whereas British fuse manufacturers can obtain supplies of fine wires of 0.0004" diameter, and finer, and can handle such wires, the Germans appear to have difficulty in drawing, with any accuracy, wire finer than 0.01 m.m. for this application, but, more important, all those who were interrogated stated that with the cheap labour employed they would be quite unable to handle finer wires, even if such were readily available. Nevertheless, by the development of the temperature controlled solder technique they are able to produce surge-resisting fuses of as low a rating as 10 m.A. carrying. But at this low rating the accuracy leaves much to be desired. It should, however, be

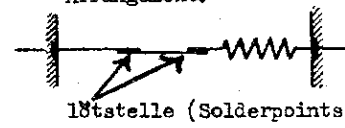
Wickmann
Werke A.-G.
Witten-Annen

Normal x blowing curve of Fine - rated Fuses
Abschmelzkurve normaler Feinsicherungen
5 ⌀ x 20 mm lg.
Trage ('Slow' characteristic)

500 089

BIOS/DOCS/2357/3371/72

Ausführung:
Arrangement.



20.1.39 dfr.

Minutes. Minuten

Zeit t Time

Seconds Sekunden

2 h
100
80
60
40
20
10
8
6
4
2
1
40
20
10
8
6
4
2
1
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
0.01
0.008
0.006
0.004
0.003

1 1.5 2 3 4 5 6 7 8 9 10 15 20 30 40 50 60 70 80 90 100

x Nennstrom

x carrying circuit.

realised that British single-filament fine-wire fuse-manufacturing technique generally sets a practical low-limit current of 30mA.-carrying (say, 60 mA. blowing-rating). In the higher ratings of this range, say up to 1 Amp. the British production is comparable, and it is cheaper to manufacture in Britain in the way that fuses are being made now. The German method tends to be advantageous for ratings of 1 Amp. and over, but it should be recorded that a comprehensive batch of Wickman fuses tested at R.A.E. did not appear to be very consistent.

Scrutiny of German catalogues shows that their surge-resisting fuses employing the temperature controlled solder method of construction are three times more costly for them to produce than their own straight-wire (not surge-resisting) fuses of comparatively high ratings. It is not very likely that we could improve the ratio by any appreciable amount. It is however thought that if British manufacturers cared to study the method, that they could probably make greater use of it than the Germans have done, to develop special characteristics, if such should be required.

GENERAL DESCRIPTION

One example of the type of fuse with which this report is concerned is shown in section and is described below.

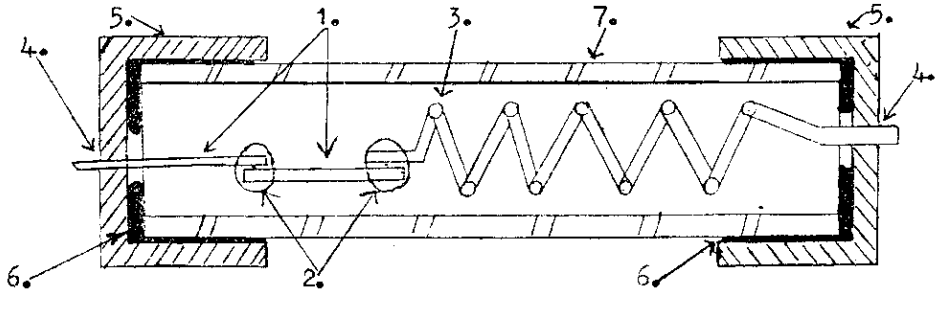
Pieces of suitable resistance wire (1) (1) are joined together by suitable temperature-rated (eutectic) solder (2) (2), between suitable metal caps (5) (5), cemented (6) (6) to a glass tube (7), with cap-soldering at (4) (4).

The spring (3) may or may not be of resistance material but is generally of stouter gauge than (1).

In operation, heat is generated in the wires (1) (1), and in the joints (2) (2), raising the temperature of (2) (2) which become soft and allow the spring (3) to pull them apart.

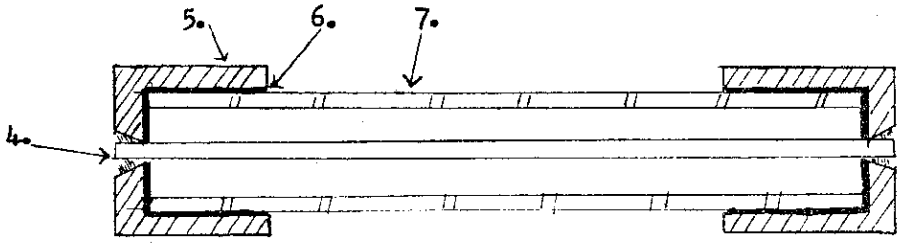
All such fuses operate on this principle although detail construction may differ. For example two springs of resistance material may be joined together by a single similar controlled low temperature solder joint. Such springs may be tensional or deflexional.

TYPE OF CONSTRUCTION MAINLY CONCERNED IN THIS REPORT :-



(Note: at limited overloading "fusing" per second does not take place).

STRAIGHT - WIRE (SINGLE FILAMENT) TYPE OF FUSE,
FOR COMPARISON.



Manaufacurers of Fuses (electric protection) visited

Name of Firm	Where situated	Personnel Interrogated	Product
Siemens-Halske	Berlin C 31/6958	Dr. Hoffmann	Heavy duty fuses
Siemens-Halske	Erlangen C 31/6959 nr. Nürnburg	Dr. Erich Evers & three technicians	"
Siemens-Halske	Munich C 31/6960	Dr. Hoelzler, Herr Wild, Specialists, & Martin Schucht	" +
Wickmann-Werke	Witten-Annen C 31/6961 Ruhr	Herr Ruche Herr Schmitt Herr Panhaus	Fine rated fuses
Wickmann-Werke	Herne Ruhr C 31/6962	Dr. Mulbach	
F. Shulte	Wipperfurth	Herr Schulte	Heavy duty fuses. Small production of fine fuses
Efen G.M.B.H.	Martinshal C 31/6963 (bei Eltville-am-Rhein)	Herr Bellen	Fine rated fuses
F. Dreischer	Rheyft C 31/6964	Herr Dreischer	Heavy duty fuses ✱
Wolfs & Weisse	Gummersbach C 31/6965	Managing Director	Heavy duty fuses ✱
Voigt & Hoffner	Frankfürt C 31/6966	" "	Heavy duty fuses ✱
Bosch G.M.B.H.	Stüttgart C 31/6967	Herr Paul	Automobile Fuses ✱

+ Designs (not models, nor production) of carbon-resistor delay-fuse, of similar performance to that described. This was seen to be similar to the "Slow-blo" model manufactured by the Littlefuse Co. of U.S.A.

✱ No further mention in this report.

Suppliers of Piece parts used in the manufacture of close rated fuses

(under 5 Amps.)

Name of Firm	Where situated	Personnel Interrogated	Product
"Stocko"	Sonnborn C 31/6968 Wuppertal	Herr Henkel (Manager)	Fuse caps
Pack & Vongehr	Derschlag C31/6969 Nr. Gummersbach	Herr Vongehr (partner)	Fine wire drawers
Rheinsche-Fein-Draht-Industrie	Bergneustadt Nr. Gummersbach C 31/6970	Dr. Schildbach (Director)	Fine wire drawers

No further mention of these visits in this report.

Firms listed but not visited for reasons stated

Name of Firm	Where situated	Products	Why not visited
Geber Kleinmann	Berlin C 31/3482	Small pressings	Russian sector = interminable delays.
Hugo Meyer	Berlin C 31/3481	Small pressings	
Adolf Kandulla	Berlin C 31/3174 C 31/6971	Fine-wire-handling machinery.	
R. Bogenschütz	Höchst-Frankfürt	Fuses	From information received, heavy duty fuses only.
Primus-Apparatebau	Mulacker C 31/6972	Fuses	
J. Meyer & Co.	StüttgartC 31/1771	Fuse caps	Lack of time - types of fuses not ascertained.
Jean Muller	Bingerbrüke, Rhein. C 31/1771	Fuses	

FIRM: Siemens-Halske A.G.,
LOCATION: Siemenstadt, Berlin;
PERSONNEL INTERVIEWED: Dr. Hoffmann

No fuses of the appropriate type made by them. All this firm used were purchased out from Wickmann-Werke, Witten-Annen, and from Efen, Eltville near Wiesbaden. No other circuit rupturing devices applicable to this enquiry available. Dr. Hoffmann stated that their foremost fuse experts were Dr. Hoelzler and Herr Wild both located at the Munich factory, and a Dr. Schultz now in the Russian zone at Weimar. and therefore unapproachable.

FIRM: Siemens-Halske A.G.,
LOCATION: Erlangen, Nürnburg.
PERSONNEL INTERVIEWED: Dr. Erich Evers and three technicians

Dr. Evers confirmed the statements of Dr. Hoffmann at Berlin. After some discussion on fuse design it was clear that no new ideas were to be obtained; none had evolved during the Hitler regime.

FIRM: Siemens-Halske A.G.,
LOCATION: Tel-Kirchen District, Munich.
PERSONNEL INTERVIEWED: Dr. Hoelzler, Herr Wild, Herr Martin Schucht

Dr. Hoelzler and Herr Wild were the fuse specialists of Siemens-Halske. They maintained that little development and no production existed on fuses of interest to this team. They confirmed that when previously used, such fuses were bought from Wickmann-Werke or from Efen.

Herr Martin Schucht described, and later forwarded a drawing, of a delay fuse with solder-joint, designed to rupture by accumulation of heat generated in an adjacent resistor, in the fuse-assembly. The usual spring was soldered to the cu-plated end of a carbon-resistor unit. This was seen by the team to be substantially the form and arrangement of the "Slo-blo" fuse manufactured by the Little fuse Corporation of the U.S.A.

FIRM: Wickmann-Werke
LOCATION: Witten-Annen, Ruhr.
PERSONNEL INTERVIEWED: HERR Roche (Manager, late A.E.G.)
Herr Schmitt (Elect. production engineer with seven years service)
Herr Fanbous (Charge hand also with seven years service)

Dispersal factory at Herne, Ruhr. Dr. Mulbach.

This firm undoubtedly shares with Efen by far the greatest proportion of the total German production of the type of fuse with which this report is concerned, and which is described and illustrated in general terms on pages 2 and 3. What was seen and discussed in this factory and the dispersal factory at Herne forms the basis of the report.

The factory undoubtedly was employed at one time on other light electrical work, mainly heavy duty fuses, high tension fuses and "Z" type screw in fuses, but at the time of the investigation, only sensitive-low-rating and principally surge-resisting fuses were in production, although a limited production of straight wire fuses was examined. The surge resisting type were well known to the investigators and are definitely a

speciality of this company. They have a worthy competitor in Efen of Martinshal, but the foreman there worked for Wickmann for many years, where presumably he learned the technique.

In the absence of any really-fine wire technique they have undoubtedly developed a very long way in the use of temperature controlled solders whereby they are able to make fuses commonly rated at 20 mA. carrying and even down to 10 mA. carrying, but the lower rating calls for very great skill on the part of the operator, accuracy leaves much to be desired and rejects are often very high. The proportion of various ratings to total production was given as

10 - 100 mA. = 10%

100 - 300 mA. = 20%

300 - 800 mA. = 50%

800 - 6 Amp. = 20%

Examples For the 10 mA rating they use a fine 80% - 20% nickel-chrome resistance wire (.0118 m.m. diameter) which is difficult to solder. For the 20 mA. rating they use fine constantan (or Eureka or 60% - 40% copper nickel) resistance wire, both with 80° or 90° C. - fluidus solder similar to a type of woodsmetal. The solder is of constant gauge, wound on reels, with alloy differing for various ratings. According to the Wickman drawings 20 milliamp fuses use Nickel-Chrome (.0118 m.m. diameter) and Nickel (.015 m.m. diameter) heater elements also. Herr Ruche quoted 80/20 Nickel Chrome for 10 milliamps and 60/40 Copper-Nickel for 20 milliamps. with 80°/90° solder.

Sequence of Assembly Springs are first coiled on a straight mandrel incorporating a short longtitudinal slot, at the centre of the mandrel, with grooves running partly round the mandrel at each end of the slot. The centre of the wire for the spring is placed in the groove, and the mandrel is revolved by hand to give the requisite number of coils. The wire is then removed from the mandrel, and the springs are parted at the centre of the straight portion (originally held in the slot of the mandrel) for jointing. The springs are then soldered to resistance wire, followed by wire to wire; such element assemblies are introduced into glass tubes, and metal caps ready lined with cement are fitted. After three hours air drying the spring is brought close to its cap and soldered thereto, the resistance wire is then pulled extending the spring and is soldered to the second cap. Apparently no special care is taken to obtain regular tension of the spring other than the mechanical limits provided by the assembly, and the length of the joint is gauged by eye.

Caps Caps are normally pre-coded by a clever yet simple machine, drawings of which are available.

Inspection Three fuses from each operator are tested at the commencement of the day's production, thereafter the only normal control is a 100% continuity test. The most outstanding feature of all these visits

was the apparent lack of close technical control such as is known in England.

+ Detailed Drawings of fuse assemblies and production layouts were available and copies have in fact been evacuated, but they were never in evidence in the factory and did not appear to be treated with respect even by those in charge of production. It was felt that for the purpose of the investigation, once the general idea was grasped, any British manufacturer intending to employ this particular technique would have no difficulty as it was known that a range of solders to temperature specifications were readily available in England.

Cement It is important to note that with such a fuse at least one cap must be cemented on after the element has been inserted in the tube. The cement must be air drying, baking might soften the low temperature joints which are the basis of the design. It is felt that this process could be improved. The cement used for fixing the end caps to the glass tubes is normally "chalk" (a natural mix of calcium carbonate and magnesium carbonate with further impurities) and sodium silicate, freshly mixed at the bench each hour. Rejects for loose caps are very low; less than 2% on hand-pull-test was confirmed.

Glass cutting For tubes they prefer soda glass, cut with polished hard steel wheels of about 10" dia. running at a speed of 2 - 3000 R.P.M., cutting 2500 pieces per hour with 2% rejects.

Production rates Normal gang is five girls, times given as girl-minutes.

(a) Twin spiral from cut lengths	17 G/mins. per 100
(b) Solder element assembly	23 G/mins. per 100
(c) Caps on glass with element in place 2 girls duplicating	57 G/mins. per 100
(d) Solder caps	27 G/mins. per 100
	124 G/mins. per 100

Thus, 2000 fuses are completed by five girls in approximately $7\frac{1}{2}$ hours with total rejects (from all causes) between 5% and 10%. Girls on (a) also perform (b) and (d).

Single wire fuses There is a fair production of straight wire fuses using wires not smaller than 0.01 m.m. These are made at the rate of 80 girl/minutes per 100 resulting in approximately 3000 for a 5 girl gang per $7\frac{1}{2}$ hour day, great care being taken to economise in the use of wire which (though cheaper than British wire) is dear as compared to labour costs.

+ See pages 10 & 11.

Earnings of operators At the time of the investigation average earnings were from 90 - 120 Reichsmarks per month. With the Reichmark nominally sixpence, this means between 45/- and 60/- per month, not per week. It is difficult to assess the real wages-worth of such figures which should be taken only as comment.

Export A factory of 180 girls makes well over half a million fuses per month. Both Wickmann and Efen appeared to achieve this figure, most of this production being absorbed by Germany. Not more than 10% is exported to Norway and Sweden. The investigators drew the information that the Philips company at Eindhoven supply France and Belgium, whereas the Balkan states have their own production.

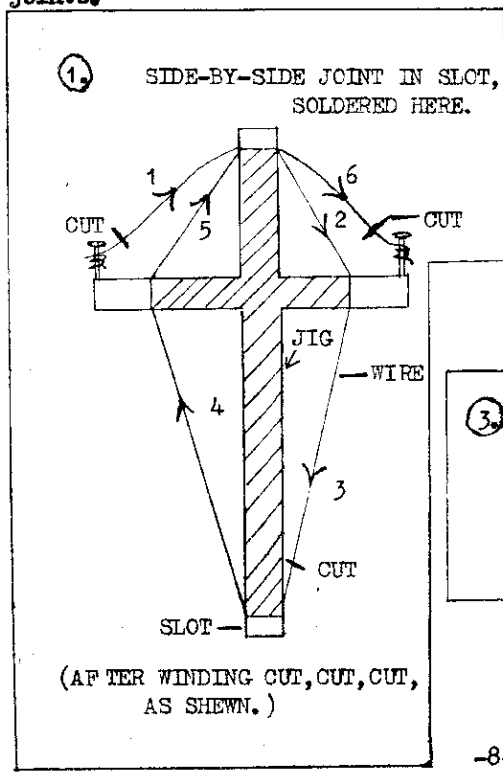
FIRM: Efen, G.m.b.H.
LOCATION: Martinshal, Eltville-am-Rhein, Near Wiesbaden.

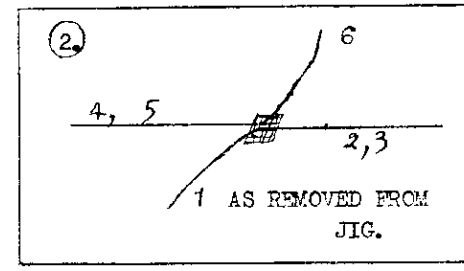
This firm were also in production with the type of fuse with which this report is concerned. The types, methods and information received were similar to those described in connection with Wickmann-Werke, with whom the works manager had previously been employed for many years. Their total production was comparable, in the region of half million per month.

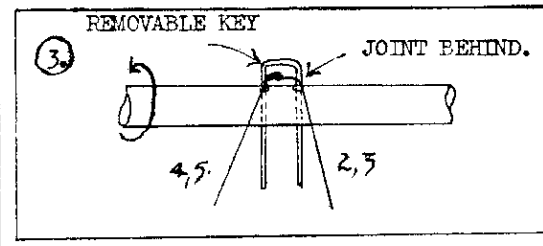
This was a very attractive modern and well-built undamaged manufacturing unit situated in a closely wooded valley surrounded by vineyards. It was the only sign of industrial activity in the vicinity.

The method of winding the springs and forming the soldered joint at the Efen factory differed from the Wickman method in the following respects.

The resistance wire was first wound on a complicated "oats-cradle" mandrel to form the soldered joint. The following sketch depicts the formation of one joint only, but the actual mandrel carried about six joints.







The wire and joint were then placed on a straight mandrel with a central removable key and the springs were formed by rotating the mandrel. The key is afterwards removed in order to withdraw from the mandrel.

This was thought to be a better 'production layout' than the Wickmann methods gave. Testing facilities were of a high order, but just as infrequently used.

FIRM: F.J. Schulte.
LOCATION: Wipperfurth, Rhineland.

Personnel interviewed:- Herr Schulte, proprietor and technician.

Under normal conditions the principal production here was heavy duty and high rupturing fuses. Originally this was a compact self contained factory, firing their own electrical ceramics from tools of their own manufacture. The factory had been badly damaged and all kilns destroyed. At the time of the investigation the only production was the type of sensitive and surge resisting fuses with which this report is concerned. Production was on an exceedingly small scale; nothing new was added to the information obtained from Wickmann-Werke. Cap-soldering was by high-Ampere low-Voltage conduction heating, caps being pressed on to stout prods.

The following documents have been lodged with:-
Technical Information & Documents Unit,
40 Cadogan Square, London, S.W.1.
Tel. KENsington. 5131. Ext. 105

Applications for permission to inspect these documents should quote the relevant BIOS Reference Nos:

BIOS/DOCS/2357/3371-

-/1	Coding machine for fuse caps.	
-/2	Soldering device for fuse elements.	
-/3	Specification cards.	(15 cards)
-/4	Eutectic solders.	(4 sheets)
-/5	Reference sheet for the use of sensitive delay fuse elements in plants of the German Armed Forces, etc.	(5 sheets)
-/6	Guiding principles for instrument fuses in remote signalling.	
-/7	Production time cards.	(12 cards)
-/8	Fuse elements for heat coil fuses.	(2 sheets)
-/9	Electric testing instructions.	
-/10	Cement (application of)	
-/11	Soft solders.	(2 sheets)
-/12	Glass tube (alterations of)	
-/13	Brass cap " "	
-/14	Cap " "	
-/15	Glass tube fuse.	(3 sheets)
-/16	Non-interchangeable heat coil fuse (sensitive type)	
-/17	Fuse FN 9.	
-/18	Glass tube fuse FN 6 " " " FN 12 " " " FN 1 " " " FN 3	
-/19	Non- interchangeable heat coil fuse FT 3	
-/20	Glass tune fuse FN 10 " " " FN 4	
-/21	Heat coil fuse FN 2 " " type FN 13	
-/22	Glass tune fuse type DKE.	
-/23	Non- interchangeable heat coil fuse FT 4	
-/24	Fuse elements type FH	
-/25	Resolderable fuse type GISX	
-/26	Glass tube fuse FN 5	
-/27	Brass cap	
-/28	Glass tube.	
-/29	Fuse elements for heat coil fuses (sensitive type)	(2 sheets)
-/30	Fuse elements for fuse (sensitive type)	
-/31	Glass tube.	
-/32	Cap	
-/33	Fuse elements for heat coil fuses (sensitive type)	(2 sheets)
-/34	Fuse elements for hear coil fuses	
-/35	Cap	
-/36	Glass tube	
-/37	Fuse elements for heat coil fuse (sensitive type)	(2 sheets)

-/38	Cap	
-/39	Glass tube	
-/40	Cap	
-/41	Glass tube	
-/42	Electric testing instructions.	
-/43	Glass tube	(2 sheets)
-/44	Cap	(2 sheets)
-/45	Glass tube	
-/46	Insert plate	
-/47	Brass cap.	
-/48	Glass tube	(2 sheets)
-/49	Fuse elements for heat coil fuses (sensitive type)	(3 sheets)
-/50	Cap	
-/51	Glass tube	(2 sheets)
-/52	Cap	
-/53	Fuse elements	
-/54	Distinguishing insert.	
-/55	Glass tube	(7 sheets)
-/56	Fuse element for heat coil fuses (sensitive type)	
-/57	Contact pin	
-/58	Insulating tube	
-/59	Insulating disc	(2 sheets)
-/60	Spring	
-/61	Disc	
-/62	Bushing	
-/63	Sleeve	
-/64	Electric testing instructions	(4 sheets)
-/65	Cap.	
-/66	Glass tube	(3 sheets)
-/67	Disc	
-/68	Fuse element	(2 sheets)
-/69	Fusing characteristics of element	
-/70	Fusing times for heat coil fuse FN 1	(3 sheets)
-/71	Glass tube fuse for FT installations in aircraft.	
-/72	Fuse curve of normal heat coil fuses.	
-/73	Current-time curve of heat coil fuses (sensitive)	(4 sheets)
-/74	Signalling techniques	(10 sheets)
-/75	Installation material, fuse elements for plug devices.	
-/76	Drawings of heat coil fuses placed at the disposal of the Military Government.	(3 sheets)
-/77	Individual parts for heat coil fuses.	

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