

GERMAN PRIMARY BATTERY INDUSTRY

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BRITISH INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

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GERMAN PRIMARY BATTERY
INDUSTRY

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INTRODUCTION

THE PRIMARY BATTERY INDUSTRY IN GREATER GERMANY

The Primary Battery Industry in Greater Germany was made up of a few large plants, several medium sized and many small plants. The largest in the British Zone was HABAPA with an output of 1 million cells per month.

The largest production was by the Pertrix group with an output of 20 million cells per month, with the Daimon group second at 11 million cells per month; these are in the Russian area. The next in order of size were Zeiler, Baumgarten, Bumke, Koch und Kruger, Accumulatoren (Vienna) and Dametz with outputs varying from 3.3 to 1.1 million cells per month. Franke's output of layer cells was 1.1 million per month.

The distribution of the industry in terms of production capacity is given in the following approximate survey which was obtained from The Control Commission for Germany (Berlin).

Production for Last Quarter of 1942 in Millions of Cells

	Berlin Sector	Zone	Total	% of Total
Russian	62.4	13.5	75.9	67.5
French	17.0	.25	17.25	15.5
U.S.	7.0	6.67	13.67	12.0
British	-	5.74	5.74	5.0
Totals	86.4	26.16	112.56	

Three firms (Pertrix, Zeiler, & Bumke) accounted for 55% of the total whilst a further two (Daimon and Koch & Kruger) accounted for 19%.

Habafa were the only manufacturers of large cells for telephone use etc. in the British Zone and had an output of 240,000 per annum.

Tables of production figures are given in Appendix I.

INTERROGATION OF DIRECTOR SCHENKEL

BERLIN N4. CHAUSSEE STRASSE 8

(Director of Hermann A. Bumke GmbH)

OBJECT

To obtain information on the activities of the German Primary Battery Industry.

DATE

3rd and 4th January, 1946.

INTRODUCTION

Schenkel was the Controller of the German Dry Battery Industry during the war; he was responsible for the distribution of contracts and allocation of materials. In all there were 67 primary battery firms in Germany and a schedule giving the information obtained regarding average production rates is given in Appendix I. In general, it was understood that 78-300 was the average number of operators required per million cells per month, depending upon the size of the factory. According to Schenkel the damage sustained by the Berlin factories was as follows:-

Daimon	100%	out of action
Erfurt	100%	" " "
Zeiler	100%	" " "
Pertrix	60%	" " "
Panisch	100%	" " "
Ballhausen und Meyer	O.K.	
Berliner Batterie Fabrik	30%	" " "
Bumke	10%	" " "
Koch und Kruger	80%	" " "

He also stated that 85% of the remaining plant in the Pertrix factory - including the layer cell plant - had been removed by the Russians. It was not possible to check this as the Pertrix factory is in the Russian area and is "blocked".

Bumke and Autom, the battery plant makers, had the same managing director but he sold his interest before the war and thus Siemens-Halske obtained control at this stage.

SUMMARY

The interrogation covered the following aspects of the primary battery industry:

- (a) Specifications, etc.
- (b) Air-depolarised construction.
- (c) Inert cells.
- (d) Cells for low temperature use.
- (e) Layer cells.

- (f) Cartons and boxes.
- (g) Miscellaneous types.
- (h) Formulae.

SPECIFICATIONS, ETC.

The batteries supplied to the German Forces were of standard commercial construction and quality, being manufactured to Specifications DIN VDE 1210, 0807, 0807K.

These specifications give details of nomenclature, cell and battery dimensions and tests, e.g. a standard 120 volt battery:-

BD.120 (type number) made up of cells 19.6mm Dia x 56 mm High, 80-off. Test condition - discharge for 4 hours per day, 6 days per week at 5mA constant current.

minimum performance - 260 hours (14 days after manufacture),
 *250 hours (after 6 months storage at normal temperature)
 End point - 50% of nominal voltage.

Storage tests were carried out on a small scale usually for three months, and although this time was sometimes extended to six months, it was never longer as during the war they were not able to cope with the work involved. A rough figure of 10% loss of capacity after six months storage was assumed but the Wehrmacht were dissatisfied with the results of the firms laboratory tests and instituted large scale tests in huts to obtain more precise information. This work was commenced fairly late in the war and the results are not known. No tropical storage tests were made.

AIR-DEPOLARISED CONSTRUCTION

Because of the extreme shortage of manganese dioxide, during the war the firms were forced to proceed with the development of the air-depolarised type of cell, even for the smaller sizes. Apart from this no development of the conventional can type of cell was permitted.

At suitable discharge rates it was claimed that the discharge voltage characteristic was flatter than that for the manganese-dioxide cell since the initial super-voltage is not present and it was thought that this would tend to increase valve life. In general the air-depolarised cell was considered to be better than the manganese dioxide cell for D.T. applications but inferior as a lighting battery.

After storage for one year in his opinion an air-depolarised battery should give the same discharge performance as a fresh one, if the drying out of the electrolyte could be prevented. The quality of the battery depends almost entirely on that of the active carbon and the manufacture is almost an experimental operation involving a fair amount of trial and error.

In A.D. high tension batteries breathing of the cells was facilitated by the use of a pierced cardboard top washer. The normal pitch sealing on top of this washer was omitted so as to permit ready access of the air to the cells when put into Service. The outer carton was sealed and provided with a tear-off strip.

More moisture is required in the electrolyte than in the dolly and this had proved to be the stumbling block in efforts to develop an inert air-depolarised cell. No tropical tests were made and the battery was known to be useless at -15°C .

The following comparative performance figures were claimed for fresh H.T. batteries using cells 19.6 mm. Dia. x 56 mm. High approximately when discharged for 4 hours per day, 6 days per week:-

<u>Discharge Rate</u>	<u>Type of Cell</u>	<u>Hours Discharge to 50% Initial Voltage</u>
5 mA	Manganese	300 - 500 (usually 400)
5 mA	A.D.	300 - 500 (usually 400)
15 mA	Manganese	80 - 100
15 mA	A.D.	100 - 150

INERT CELLS

In Bumke inert cells the normal method was to wrap the dolly in absorbent paper which acted as a wick when the cell was filled and ensured that the added water was thoroughly distributed throughout the cell.

When making up the electrolyte the potato starch (only used due to shortage of Tragantine) and salammoniac were mixed dry and when heated to $60 - 70^{\circ}\text{C}$. a cake is formed which is subsequently milled.

Attempts to make an inert air-depolarised cell had not met with success as the water, when added tended to penetrate into the dolly and clog the pores. They had tried wrapping the dolly in paper, which had been saturated in oil or paraffin, but the internal resistance had been too high.

They had not attempted an inert H.T. battery, but thought that although it might be done in the laboratory it would not be a practical proposition for general use.

CELLS FOR LOW TEMPERATURE USE

On the subject of batteries for use at reduced temperatures, Schenkel said it was known that the normal Pertrix battery with magnesium chloride electrolyte was satisfactory and no work had been done on this during the war. He denied the suggestion that glycol or other substances were added to improve the low temperature working

characteristics. He said that if anything other than the pure electrolyte were used the internal resistance would be increased.

LAYER CELLS

Serious development work on layer cell batteries commenced in 1942 largely as a result of batteries which they had captured. Two firms only were concerned with this work, Pertrix and Franke. Pertrix copied the American design (Ever-Ready in approximately 136 size) but Franke developed a form of their own employing two zinc cups and an active carbon depolariser. (See figure 5 on page 56).

These batteries were apparently an urgent operational requirement for the German Army for small field wireless sets. Neither type was completely satisfactory but the development was given top priority and greatly increased production planned in 1944.

Pertrix in conjunction with I.G. Farben developed a carbon coating method in which a mixture of 90% Oppanol B200 and 10% Trolitul Normal heavily loaded with graphite was calendered into sheets and subsequently calendered on to the zinc.

In the original Franke design the carbon coating was obtained by a mixture of paraffin wax and graphite but they are understood to have changed to the graphite-oppanal sheeting method.

Considerable difficulties were experienced with the prevention of electrolyte leakage whilst at the same time providing means for the cells to "breathe", as activated carbon was being employed as the de-polariser.

In the Franke cell the zincs were in the form of rectangular metal cups, one containing the paraffin wax and graphite, whilst the other contained the electrolyte. The active carbon was made up in brick form and closed between the cups.

Pertrix are now working on the Franke design, endeavouring to overcome the leakage troubles.

Schenkel gave the following performance figures from memory, for batteries discharging at 40 mA for 6 hours per day, 6 days per week to 50% initial voltage:-

A.D. normal round cell	40 - 45 hours
Normal cells (manganese)	25 - 30 hours
Franke layer cell (2" x 1½" approx.)	60 hours

The layer cells are not better than the can type cells at 5 mA. as they dry up much more rapidly.

CARTONS AND BOXES

Schenkel said the batteries were made up in cartons, in accordance with normal commercial practice, and no attempt had been made to use metal or plastic boxes, nor to hermetically seal batteries. Intercell insulation was ordinary wax impregnated cardboard. He believed that a single cell used for torpedo duties had been put in a metal case but he had no details.

MISCELLANEOUS TYPES

Schenkel knew of the Schmid hand-lamp, but had no precise details. He knew that they had been ordered but for some reason they proved of no use for the Army and very few were actually made.

During the war years Schenkel said no research was done on normal types of cells but special problems such as the layer cell were given to Pertrix and Franke whilst high performance short duration projects were given to Siemens-Halske, Schmid and Lange.

FORMULAE

The following information was obtained from Schenkel and Dr. Ploetz (of Bumke) and is understood to be used by Bumke:-

Standard Depolariser Mix for H.T. Cells

Manganese (Caucasian)	50 parts
Graphite (Kropfmühl)	8 "
Acetylene Soot	2 "
Sal-ammoniac	4.5 "
Damping electrolyte	8-10% (varied in normal way to suit pressing)

(When Griesodyn (activated manganese) is used soot is increased to 4.5 parts).

Lighting Cells

Manganese/Carbon ratio reduced to 3 to 1 and Sal-ammoniac increased up to 8 parts.

A.D. Mix H.T. Cells

Graphite	2 parts
Soot	0.8 "
Active carbon (Elorit S.T.)	30 "
Sal-ammoniac	16 "
Damping electrolyte	13.5 litres (adjusted to suit pressing)

Damping Electrolyte

Water	72.2 parts
Sal-ammoniac	18 "

Damping Electrolyte (contd.)

Zinc chloride	5.7 parts
Calcium chloride	3.9 "
Mercuric Chloride	0.22 "

Electrolyte

At present Bumke are using a two solution cold set electrolyte as follows:-

Solution 1

Water	51.4 parts
Sal-ammoniac	17 "
Zinc Chloride	10 "
Mercuric Chloride	0.26 "
Wheat flour	21 "

Solution 2

Calcium Chloride Solution 1.33 s.g.

In practice two volumes of Solution 1 are used with one volume of Solution 2. The setting time is 10-15 minutes at normal room temperature.

When a cooking electrolyte is required Solution 1 is used alone.

INTERROGATION OF DR. DROTSCHMANN, PRIMARY BATTERY

CONSULTANT OF RAHNSDORF, BERLIN ON 6th January, 1946.

OBJECT

To obtain information regarding primary battery development in Germany.

INTRODUCTION

It was known that Dr. Drotschmann had once been employed in England as a chemist to a primary battery firm and prior to the war had a primary battery consultant practice in Berlin. He had written numerous articles on all aspects of dry battery manufacture and had recently published a textbook on the subject. He was now working on primary batteries with the Russian authorities in Berlin.

DEVELOPMENT OF LAYER CELL IN GERMANY

Dr. Drotschmann stated that only two firms viz. Pertrix and Franke had been engaged in the development and production of layer batteries. Both firms started by copying the batteries made by the National Carbon Company, of America, and, according to him, the results were satisfactory. Later in the war the supplies of manganese dioxide became very scarce and both firms began the development of "air-depolarised" (A.D.) layer cells. At first, both firms tried to apply A.D. technique to the American design. Although the cells gave good outputs when fresh, bad failures showed up after 6-9 weeks storage at normal temperatures. In the Pertrix cells, the major cause of failure was the drying-out of the electrolyte impregnated paper between zinc and depolariser.

Franke then changed the cell construction completely but Pertrix attempted to improve the original design. The Franke first redesign suffered from leakage of electrolyte and short circuits between cells. A further change in design, mainly to increase the length of the leakage path, was made and an increase in "shelf-life" to 4-5 months at normal temperatures was obtained. Development was at this stage when the war finished.

Dr. Drotschmann then stated that Pertrix were abandoning their original construction (similar to American cells) and would copy the Franke design.

A typical performance of the Franke layer cell measuring 60 mm x 47 mm x 6 mm thick was stated to be 2.5-3 A.H. at 40 mA continuous discharge to 0.9 volts per cell. Dr. Drotschmann considered that the resistance between the carbon layer and the zinc to be the limiting feature of any layer design.

A description of the two makes of layer cells is given in Appendix II.

METHODS OF CONNECTING LAYER CELLS IN STACKS

The method of connecting cells together in stacks

differs in the two makes.

Pertrix mix graphite with a viscous grade of Oppanol (a plastic made by I.G. Farben at Frankfurt-am-main and roll the mix out with calender rollers to a thickness of 0.2-0.3 mm. The sheet is then examined visually against an illuminated background for pinholes and afterwards rolled onto a sand-blasted zinc sheet. The graphited zinc plates used in the cell assemblies are then punched out of the zinc sheets.

Dr. Drotschmann thought that Oppanol was a preparation of polyvinyl acetate and the grade used was Oppanol B.3.

In the Franke design, paraffin wax is used as the binding agent for the graphite and the mix is pressed into flat sheets of the requisite dimensions for the cell assembly. Embedded into the graphite sheet are connecting wires which passing through the Vinidur cell seal make a pressure contact with the base of the zinc cup of the next cell.

DEVELOPMENT OF AIR-DEPOLARISED CELLS IN GERMANY

To conserve stocks of manganese dioxide, considerable efforts were made to apply the "air-depolariser" technique even to small can-type cells. The successful development depended largely in designing the cells to breath sufficiently to permit effective air depolarisation and yet to be sealed sufficiently to limit "drying-out" of the electrolyte. Dr. Drotschmann stated that a porous sealing compound was used for this purpose. (N.B. This does not agree with information from other sources which stated that cell sealing consisted of a cardboard washer only.)

The fragility of the dolly called for special presses and wrapping machines and a quick setting electrolyte is needed to prevent too much moisture being absorbed by the dolly.

The larger size "A.D." cells were good and Dr. Drotschmann thought they might well replace the equivalent manganese dioxide cell but in the smaller sizes ("normal" size and under) there is little likelihood that they will be a serious competitor.

METHODS OF TESTING ACTIVE CARBON

The success of the "A.D." cell depended largely on the active carbon used. So far no satisfactory test existed to determine the suitability or otherwise of active carbons for battery use. In Germany before the war, the active carbon was made by heating sawdust to a temperature of 900-1000°C. During the war, peat turf was used but was not so effective; a cell which previously gave 4-5 hours discharge through 15 ohms for 10 min/day had its output reduced to 2½-3 hours.

Dr. Drotschmann is working to find a satisfactory test for active carbon for battery work. He has tried the decomposition of H_2O_2 and polarographic methods but found them unreliable. He is now working with hydrazene sulphate but is not confident of success.

He stated that the bulk of the active carbon used in Germany was supplied by a firm named Lurgi in Frankfurt-am-Main.

SETTING AGENT IN ELECTROLYTE

Wheat flour was still used in the electrolyte wherever possible. Potato starch had been used and a slight increase in the output of fresh cells obtained. The storage life, however was poor.

DEVELOPMENT OF ZINC-LEAD DIOXIDE COUPLE

Dr. Drotschmann had used a zinc-lead dioxide electrode couple for radiosonde batteries. He had found a form of zinc which he claimed resisted the effect of 30% Sulphuric acid solution for 3 months at room temperature and was prepared by heating the zinc to 110-120°C and maintaining it at that temperature for 1 hour during amalgamation and then allowing it to cool very slowly to room temperature. The amount of mercury used was very small, 0.2% by weight, and the zinc was originally very pure.

He had tried no other electrode couples neither had he any knowledge of a stannic oxide cell developed in Germany for heavy current short duration outputs for which we required information. Tin, he stated, was always in very short supply.

DEVELOPMENT OF BATTERIES FOR LOW TEMPERATURE USE

Dr. Drotschmann knew that a requirement existed in Germany during the war for cells of batteries which would operate at very low temperatures. He stated that, as the magnesium chloride electrolyte used by Pertrix in their cells was superior to the normal ammonium chloride electrolyte this firm made no change whatever in their normal production samples to meet this requirement.

He added that Pertrix were using unwrapped dollies in all their cells, both ends of the dolly being dipped in paraffin wax. They were not stored before assembly into cans as was current practice in most firms.

He did not know whether any other manufacturers had produced low temperature cells.

Interrogation of Professor Dr. Erich Lange at
the Physical Chemistry Department of the University
of Erlangen 6th and 7th December, 1945.

Dr. Lange had before the war studied polarisation problems theoretically and in 1941 was asked by the Luftwaffe to develop cells for very high discharge currents with a life of only a few minutes.

In May 1945 the results of his preliminary investigations were published in a booklet of 47 pages "Über Hochleistungskelten" by Nagel, Deutsche Luftfahrtforschung Forschungsbereit Nr. 1804/11. The dioxide cell was the most promising system. The lead dioxide could be prepared by the anodization of lead in an electrolyte of twice molar sulphuric acid with 12.2 grms of sodium perchlorate per litre. The current density was 0.5 amps. per sq. dm. and was passed for one hour. It was essential to remove all traces of perchlorate from the prepared lead dioxide and this was effected by a double discharge and recharge.

Subsequent work was initially limited to this system and though no specification for storage life was ever made it would appear that Dr. Lange vaguely appreciated that such a requirement might be made since he observed that if the dioxide deposit after the final charge was washed in water the storage life was less than if it was washed in dilute sulphuric acid. Nevertheless no accurate checks were ever made and the only information Dr. Lange had was that the storage life might be a few weeks if the cells were made up completely dry. It was found impossible for mechanical reasons to work with large sheets of lead foil unless the lead contained at least 0.5% antimony. On the other hand too much antimony led to formation troubles, about 0.7% was considered the optimum. Traces of zinc and mercury in the lead prevented the preparation of good electrodes.

Cells were made up of an overall size 10 cm. x 5 cm. x 0.5 cm. containing ten formed lead foils and eleven zincs with unglazed paper separators. The best electrolyte was four molar sulphuric acid and currents of 25 amperes for about one or one and a half minutes were obtained at about 2.3 volts. Attempts were also made to use nitric and perchloric acids but these were not as successful as the sulphuric.

No consideration was given to the practical problems of the introduction of the electrolyte in service and in all experiments it was introduced by pipette.

Experiments were also carried out on lead dioxide directly deposited on carbon or iron from a solution of lead nitrate but no very serious work was carried out. It was proposed to use nitric acid as electrolyte and it was realised that diffusion of lead ions would have to be prevented or treeing would take place on the zinc.

Electrolyte circulation was considered and it was thought that if the discharge current density was kept sufficiently high satisfactory results might be achieved. It would appear however that they were, in fact, not achieved.

Later owing to the shortage of lead some experiments were carried out using manganese dioxide coatings deposited as described in "Electrochemie Wasseriger Losungen" by Fritz Foerster. These deposits were made on to carbon coated zinc foils. Various coatings were made up by Dr. Lange using graphite, soot and a resin binder but the most satisfactory results were obtained with a coating supplied by I.G. Farben, Bitterfeld.

Originally cells were discharged using sulphuric acid (4 molar) electrolyte but better results were obtained when ammonium chloride was added. Outputs of about 12 amps. for 1.8 minutes were obtained at about 1.68 volts (current density about 1.2 amps. per sq. dm.).

General Conclusions

The terms of reference given to Dr. Lange were so vague that it is not surprising that only vague results are available. In any case it would appear that work in the U.K. and U.S.A. on these systems was further advanced than at Erlangen. None the less it is recommended that Dr. Lange be interviewed by the Universities Sub-Committee.

LABORATORIUM PROFESSOR ALFRED SCHMID, G.m.b.H.

4. Alpsteinweg, Constance, Baden

(Target No. C.1/517) ?

OBJECT

To obtain information regarding the research and development work carried out in the battery field.

PERSONNEL INTERVIEWED

Professor Dr. A. Schmid (Swiss)
Dr. A. Lauermann.

DATE

17th, 20th and 21st December, 1945.

INTRODUCTION

Professor Schmid stated that he was at one time Professor of Electrochemistry at Basle University and had given a series of lectures on this subject at Columbia University U.S.A. He has been specialising in electrochemistry for the last 25 years. In 1940 he formed the above company to exploit his researches; an Institute was set up in Berlin-Zehlendorf comprising seven laboratories, workshop, offices, etc. In the middle of 1944 a second smaller Institute was set up at the above address, to which the main equipment of the laboratories was evacuated.

SUMMARY OF ITEMS WHICH HAVE BEEN UNDER DEVELOPMENT

- (a) Primary batteries for low current (lighting) applications.
- (b) Primary batteries for heavy discharges of short duration.
- (c) Primary batteries for continuous heavy discharge.
- (d) The "Chlorine" battery.
- (e) Plastic cement.
- (f) Synthetic cast resin.
- (g) Cold setting varnish.
- (h) Homogenous wood.

PRIMARY BATTERIES FOR (RELATIVELY) LOW CURRENT APPLICATIONS

Professor Schmid's aim was to produce a commercially attractive cell with a better voltage regulation characteristic than the conventional Leclanche type of dry cell.

To fulfil these requirements it was obviously essential to employ a more efficient depolariser (i.e. a more powerful oxidising agent) but to avoid the use of materials which were either expensive or not readily available in Germany.

He surveyed the possible combinations and concluded that electrodes of zinc and carbon with an electrolyte

consisting of an acid solution of either hydrogen peroxide or sodium chlorate would most nearly satisfy these requirements.

Sodium chlorate, in particular, was extremely cheap and freely available in Germany and he, therefore, decided to concentrate on this material as his depolariser.

He first tried a solution of sodium chlorate with a high sulphuric acid concentration but found that, although the initial efficiency was high the sodium chlorate rapidly decomposed with the evolution of chlorine di-oxide and chlorine.

A reduction of the acid concentration in order to reduce the rate of decomposition of the chlorate seriously impaired the efficiency.

To improve the efficiency he therefore introduced a small proportion of a ferrous salt to act as a catalyst. This improved the depolarising efficiency but resulted in accelerated corrosion of the zinc electrode.

To overcome this difficulty he decided to add sufficient phosphoric acid to form a complex salt with the iron. Although the attack on the zinc was considerably reduced it was still appreciable. His next step was to try to develop a material which as a small addition to the electrolyte, would form a protecting molecular film over the surface of the zinc.

Professor Schmid claims, in fact, to have discovered a series of such substances which he calls "Stabilons". He describes them as bipolar organic compounds but is not prepared to disclose their exact composition since he hopes to exploit them commercially. He considers that these compounds should have an application in conventional dry cells and is, at present, trying to sell the idea to the Soc. Anon. Leclanche in Switzerland.

In spite of these modifications to the original electrolyte the corrosion of the zinc, when the cell is on open circuit, is still too severe to permit a reasonable shelf life. In order therefore, to prevent zinc corrosion when the cell is not in use a special construction is adopted whereby, when the cell is inverted, the electrolyte falls into a reservoir out of contact with the electrodes.

As far as could be ascertained Schmid's electrolyte "Galvanol" was made up as follows:-

Sulphuric acid	20%
Sodium Chlorate	10%
Ferrous Sulphate	5% (up to)
Phosphoric acid	3% (for every 2% of ferrous sulphate)

An organic stabiliser: Very small quantity.

One application for these cells was in a two-cell battery for a handlamp (Kippleuchte). The zinc electrode is in the form of a rod which is secured in position by means of a screwed plastic locking ring, the carbon electrode is in rectangular form surrounding the zinc. So as to keep the electrolyte out of contact with the electrodes, the latter occupy only about half the height of the container, whilst the electrolyte is contained in the lower half. When it is decided to switch the lamp on the cell is inverted, the electrolyte flows between the electrodes and a current flows in the lamp circuit.

The containers have been made in polystyrene and PVC.

The initial P.D. of the battery in the handlamp is 2.4 volts and the discharge current is approximately 0.2 ampere. It is claimed that the discharge characteristic is very flat and a discharge life of 20 hours is obtained when the end point chosen is 2.0 volts. The voltage falls rapidly after it has passed below 2.0 volts.

Figures 1 and 2 on pages 21 and 22 show the nature of the discharge characteristics and the variation of voltage with temperature. They should be taken as a guide only as they were obtained from a single cell of which the previous history was unknown.

The battery can be regenerated by refilling with fresh electrolyte after discharge, and the zinc needs to be replaced after every third discharge; the carbon is inexhaustible. The cells are sealed as excessive gassing on discharge is prevented by the "stabiliser". In addition to the cell incorporating the tipping principle a cell was also made in which the electrodes occupied the whole of the height and the electrolyte was inserted from some external source when the cell was required for use.

The following particulars of these cells were obtained:-

	<u>Kippelement</u>	<u>Füllelement</u>
Cell dimensions	$\frac{17}{16} \times \frac{17}{16} \times \frac{43}{4}$	$\frac{17}{16} \times \frac{17}{16} \times \frac{43}{4}$
	H over terminals	H over terminals
Voltage	1.25 volts	1.25 volts
Weight	137 grams	196 grams
Ampere hour capacity	1.98	3.56
Watt hour capacity	2.2	4.0
Cubic cm/ah	87	49
Cubic cm/wh	79	43
Ah/kg	13	18
Wh/kg	15	20
Electrolyte in cubic cm	50	90

THE SCHMID CELL (FROM KIPPLEUCHTE)
 DISCHARGED CONTINUOUSLY AT 20°C
 VARIATION OF CURRENT AND VOLTAGE WITH TIME

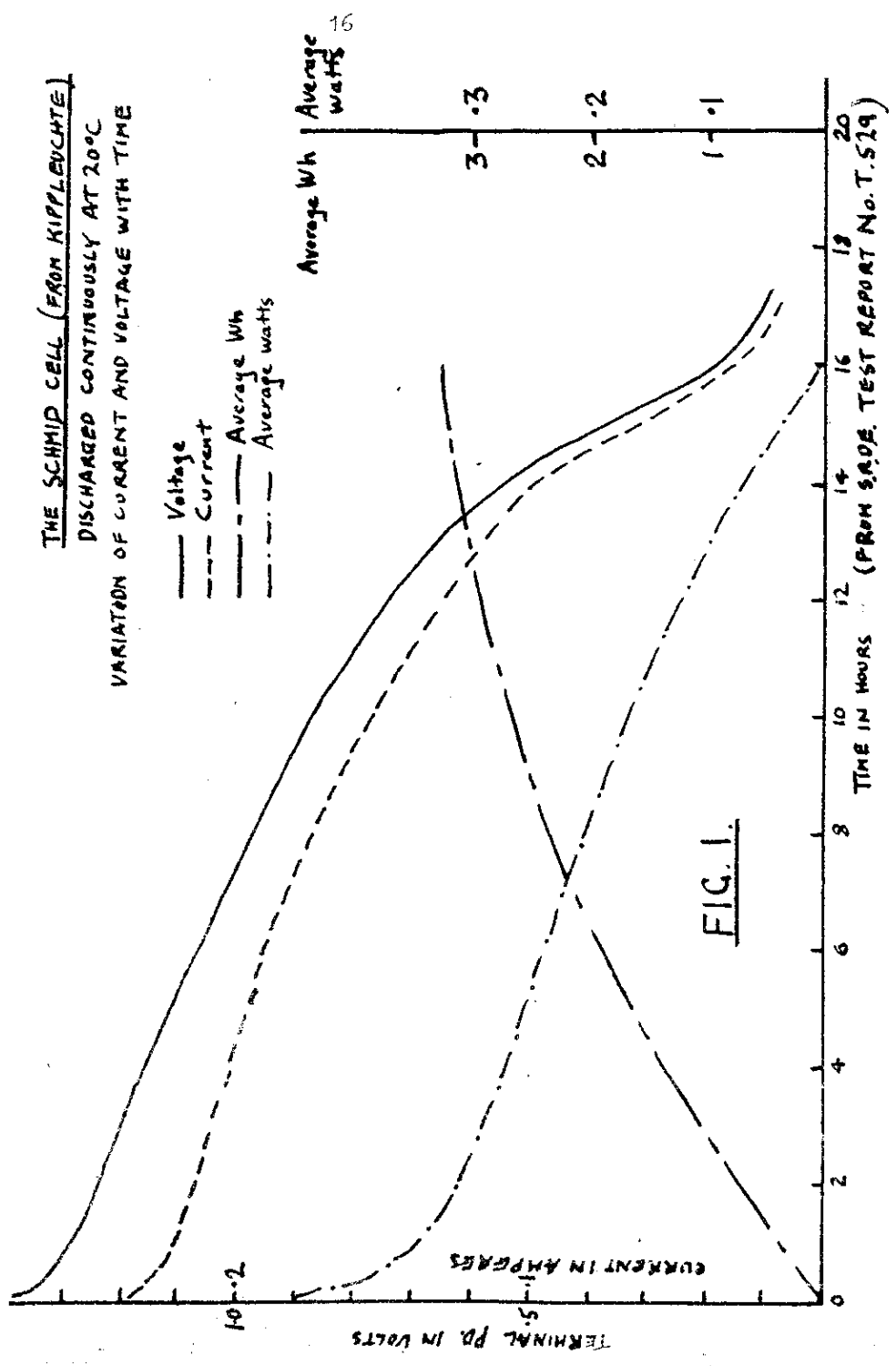


FIG. 1.

TEST REPORT No. T. 519

THE SCHMID CELL

VARIATION OF OPEN CIRCUIT VOLTAGE WITH TEMPERATURE

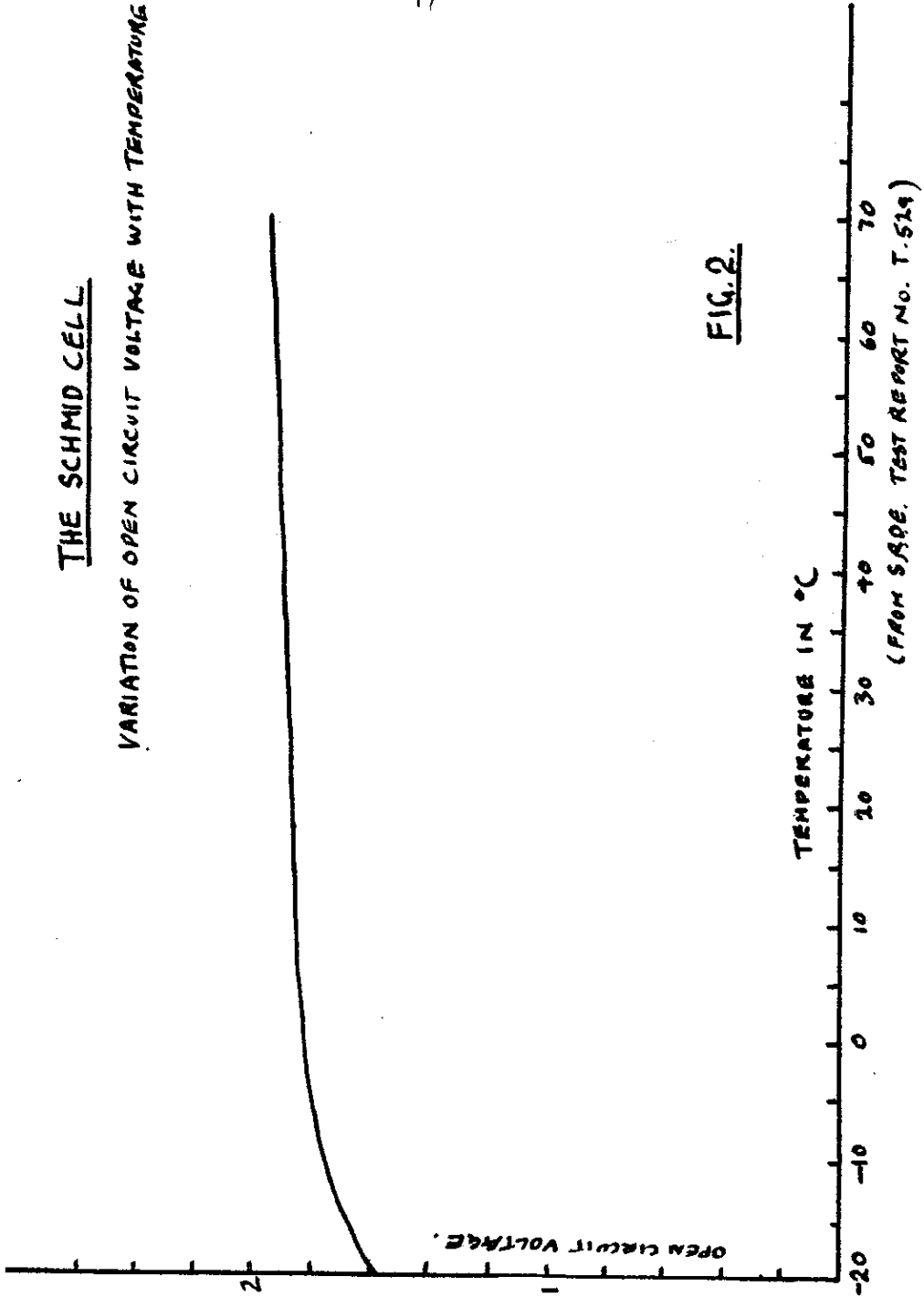


FIG. 2.

(FROM S.A.P.E. TEST REPORT NO. T. 524)

PRIMARY BATTERIES FOR HEAVY DISCHARGES OF SHORT DURATION

The principle of the cell was applied to the development of batteries for the power supply in Goliath robot tanks. The tank employed three 25 volt batteries and a discharge life of 5 minutes was required. Schmid used what he called a semi-duplex electrode. This was a carbon plate backed by a zinc sheet, the edges of which were turned over to grip the carbon plate. The flat surface of the carbon plate was insulated from the zinc by insulating varnish so that contact was made at the edges only. The edges were then sealed with varnish to prevent ingress of electrolyte between the carbon and the zinc. These plates were mounted approximately 3/16" apart in a container - there were no individual cell boxes.

Filling of the battery was effected from a cylinder mounted above it: the electrolyte was allowed to enter about 5 minutes before the battery was required for use.

The temperature range of the battery was stated to be 0°C. - 40°C. The following data was obtained:-

Discharge Life	5 minutes
Voltage	28-24 volts
Current	25 amperes
Ah capacity	2.08 Ah
Wh capacity	54.2 Wh
Grams/Wh	287g
Grams/Ah	7.5Kg
Wh/kg	3.5Wh
Ah/kg	.13Ah
weight	15.6 Kg

PRIMARY BATTERIES FOR CONTINUOUS HEAVY DISCHARGE

These batteries are intended for single cycle operation and employ elements similar to those in the handlamps previously described except that in the first type the box height is reduced by half as the tipping principle is not required; there are no facilities for changing the zinc electrode. There is a glass tube connection in the form of an inverted U between each cell and its neighbour. The tube connection to the end cells is brought out through the side of the battery and when the battery is required for use the electrolyte is pumped through the tube thus filling the cells. The whole battery was moulded in a plastic compound which set hard.

The following data was obtained:-

	<u>Type CZ 0.5</u>	<u>Type 24 ZC 2</u>
Discharge Life	60 minutes	30 minutes
Voltage	18-14 volts	28-22 volts
Ampere hour capacity	.5 Ah	2.25 Ah
Watt hour capacity	13 Wh	58.5 Wh
Grams per Wh	19	232
Grams per Ah	5	6.15
Quantity of electrolyte	360 cc	2200 cc

	<u>Type OZ 0.5</u>	<u>Type 24 ZC 2</u>
Weight	2.5 Kg	13.8 Kg
Dimensions	70x280x120 mm	?

Figures 3 and 4 on pages 24 and 25 show discharge characteristics for these batteries at various temperatures.

It is usual to fill the batteries with electrolyte about 30 minutes before use and Schmid said that they had been designed for the temperature range -15°C. to $+40^{\circ}\text{C.}$

THE "CHLORINE" BATTERY

Schmid has also been developing zinc-carbon batteries with chlorine depolariser for the supply of heavy currents for extended periods e.g. for traction purposes. The underlying principle is that the electrolyte (hydrochlorine acid - saturated with chlorine) is continuously circulated between the actual battery and a chamber in which it is re-generated with chlorine. The make-up of the battery is essentially similar to that of a filter-press. Electrolyte is lead into the interior of the carbon electrodes and diffused through the pores into the space between the carbon and zinc electrodes, leaving the battery through ducts in the plastic separators. It is then forced through a spray nozzle in a chamber filled with a chlorine atmosphere and passes from this through a cooling condenser to a reservoir. From this reservoir it is pumped back into the battery. A constant flow of continuously regenerated electrolyte is thus obtained.

The carbon electrodes are made up by combining two carbon plates, each having the necessary cavity and ducts to form a hollow carbon box with electrolyte inlet ducts. The outer edges are sealed with wax or plastic so that electrolyte can only pass through the porous carbon into the electrolyte compartment between the zinc and carbon faces.

A small laboratory model 5-cell battery, made up in this way, with glass electrolyte reservoir, chlorine saturation vessel, etc. and a plastic circulating pump was claimed to give the following performance:-

<u>Volts</u>	<u>Amps</u>	<u>Watts</u>	<u>Watts/dm²</u>
7.4	35	254	14.1
5.7	60	342	19
2.8	99	277	15.4
2.4	106	254	14.1

The active surface area of each carbon electrode was 1.70 sq. dm. (overall size 15x20 cm). The electrolyte charge was approximately 8 litres and the rate of circulation 2.2 litres per minute.

Following on the success of these experiments Schmid was called upon to construct a larger model for a particular

SCHMID FULL BATTERY TYPE 24 CZ 0.5

VARIATION OF VOLTAGE WITH TEMPERATURE WHEN DISCHARGED AT 0.5 AMP

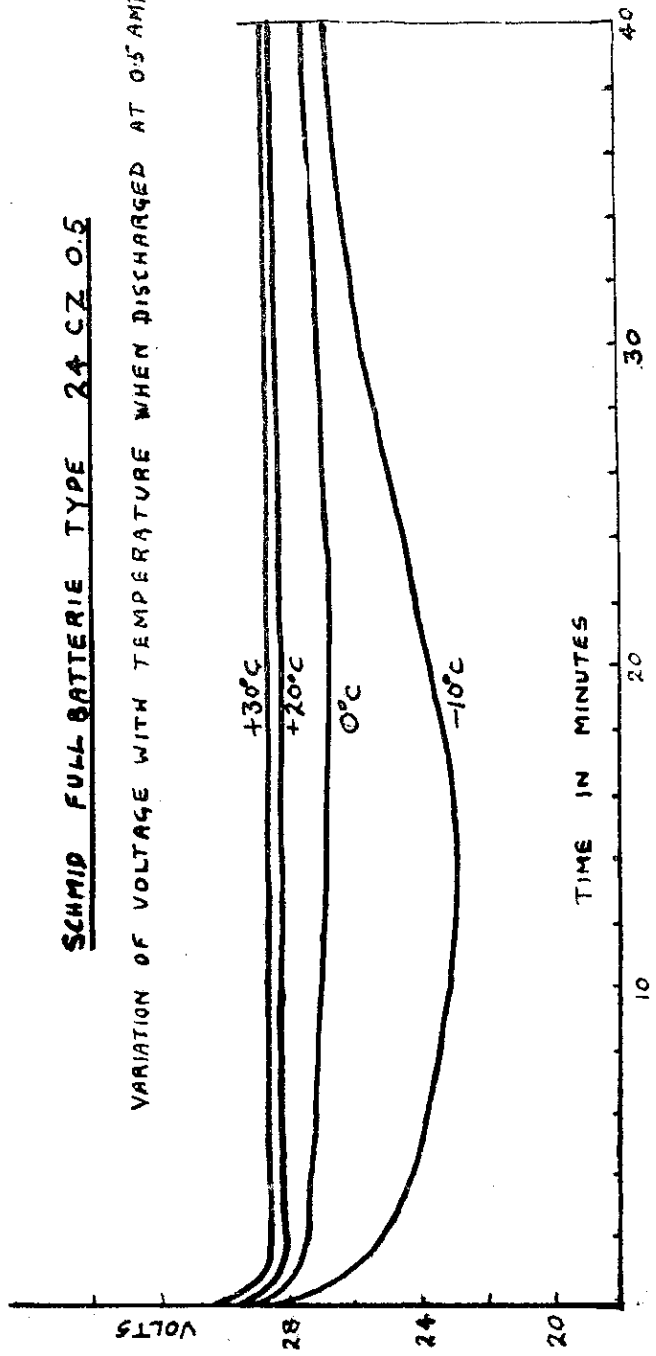
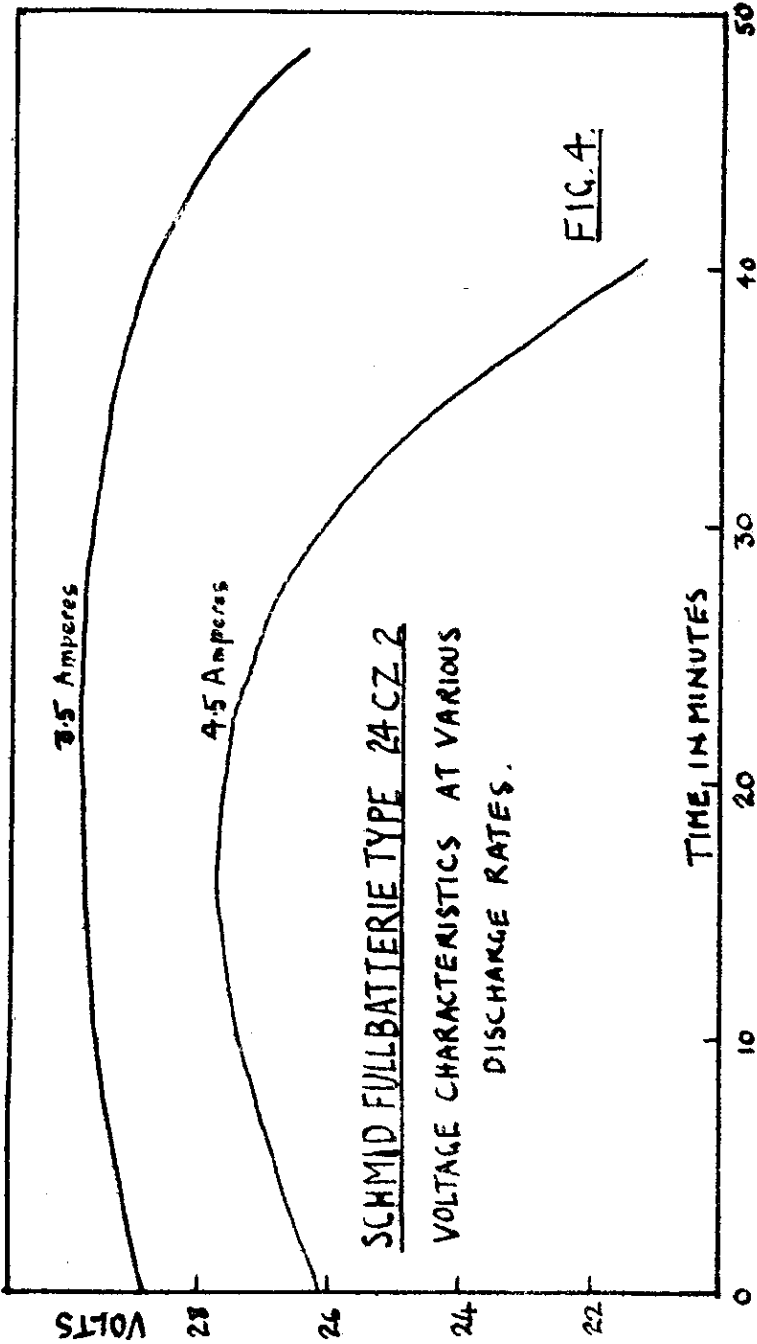


FIG. 3.



(TAKEN FROM CURVE BY ELEMENTA BATTERIE SAU)

FIG. 4.

SCHMID FULL BATTERY TYPE 24-CZ-2
VOLTAGE CHARACTERISTICS AT VARIOUS
DISCHARGE RATES.

application (believed by him to be the propulsion of midget submarines). This required an output of 20 K.W. (220 amps. at 90 volts) for 50 hours.

Optimum dimensions for carbon-plate manufacture were 40 x 23 x 0.6 cm. giving a working surface of 37 x 20 cm. It was therefore proposed to use 120 cells in series-parallel to give 90 volts (1.5 volt/cell). A 5-cell battery was made up for test purposes on the same lines as previously described. Construction of a full-size model was interrupted by the end of the war.

Schmid had calculated that the complete installation, including all necessary pumps reservoirs, chlorine bottles, etc. would weigh approximately 5200 Kg. of which 3100 Kg. would represent consumable zinc, electrolyte and chlorine. He claimed the following comparison with lead-acid accumulators of equivalent performance:-

	<u>Accumulator</u>	<u>Chlorine Battery</u>
kg/KWh	25	5.2
cdm/KWh	8.5	4.5
kg/KW	1250	260
cdm/KW	434	225

FIRM

Siemens-Halske AG.
Siemenstadt, Berlin.

DATE

3rd January, 1946

OBJECT

To ascertain whether this concern had carried out any research or development work on primary cells, with special reference to high current short duration types.

PERSONNEL INTERVIEWED

Dr. Benkurt - Director
Dr. R. Hoffmann - Electrochemist

GENERAL

It was ascertained that this firm had carried out work on primary cells for special duties, and this had reached finality in March, 1945 but had never been put into production. None of the people engaged on the project were available in Berlin but it was reported that Dr. Rummel who had knowledge of it was at the Siemens Electro-Medical branch at Erlangen.

DOCUMENTS

It was reported, and subsequently confirmed, that the complete set of documents, including manufacturing drawings, covering this project had been removed from safe by the Air Disarmament Flight in Berlin. They have been evacuated through B.A.F.O. channels under the following reference:-

"ADF/1/BERLIN/72
SIEMENS-HALSKE, WERNERWERKE EL. FORSCHUNGS LABOR".

RECOMMENDATIONS

After a thorough investigation of the documents, if necessary, Dr. Rummel should be interrogated.

Date: 29.11.45

Report No. VI

1. Nature of Target

Battery factory.

2. Title

JOSEPH HEGGE, BATTERIE UND ELEMENTEFABRIK.

3. Location

LOBBERICH, RHINELAND.

4. Description of Plant

There is no automatic machinery here, production being carried out by hand operations only. The maximum output is 15,000 cells per day but they are hardly working at all now.

5. General Remarks

No items of special interest.

Date: 26.11.45

Report No. VII

1. Nature of Target

Battery factory.

2. Title

J. CARSTENS & CO.

3. Location

FALKENREID 74. HAMBURG.

4. Condition of Target

Damaged and not working but trying to restart in a very small way.

5. People Interrogated

J. CARSTENS - Proprietor and Manager.

6. Description of Plant

The only items of interest are two Hasse auto dolly presses and two Swiss (S.I.S.) tyers.

7. Technical Data

(a) Composition of electrolyte:

Water	100 parts
Sal-ammoniac	30 "
Zinc chloride	16 "
Mercuric chloride	"a few grams"
Flour	33 $\frac{1}{3}$ %

(b) Mix

Manganese Dioxide	100 parts
Graphite	25 "
Soot	5 "
Sal-ammoniac	10 "

These formulae and the make-up of the cells is conventional.

8. General Remarks

They used to produce 200,000 cells per week and used to supply cells to Schroder of Lubeck for assembly. The anticipated output when the factory recommences is 50,000 per week.

Date: 26.11.45.

Report No. VIII

1. Nature of Target

Battery factory.

2. Title

HAMBURGER BATTERIE FABRIK ("HABAFAB")

3. Location

HEPPENDORFER WEG 56 HAMBURG

4. Condition

Slight damage to building but plant intact.

5. People Interrogated

Director and technical staff.

6. Description of Plant

Main items of interest were:-

- 3 - Hasse auto dolly presses
- 5 - Auto-tying machines (S.I.S.)
- 7 - Semi-automatic presses of various types (1 power driven).

7. Technical Data

(a) Electrolyte

Material	Type of Coil		
	Normal (Pocket lamp)	Mono	Radio
Zinc Chloride	1080	1733	25
Calcium Chloride	150	300	6.5
Mercuric Chloride	13	26	600
Sal-ammoniac	4360	8133	248

8. General Remarks

(a) Their maximum output at present is 10,000 cells per day on semi-automatic machinery, using up present supplies of zinc cans etc.,

Original output 100,000 cells per day.

(b) Types manufactured:-
Pocket lamp
Torch
Radio

(c) At present they are making in addition to the above a small number of air-depolarised cells for the German Post Office. The shortage of manganese was stated to be the reason for the manufacture of this type and a special low current bulb was used in conjunction.

(d) It was stated that during the war no development or research work was permitted, all energies being concentrated on the production of a few selected types. No special types for the German forces were made at this factory.