FINAL REPORT No. 307.
ITEM No. 31.

GERMAN SECONDARY BATTERIES (WITH SPECIAL REFERENCE TO THOSE USED BY ARMY SIGNALS)

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON: H. M. STATIONERY OFFICE.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
32 Bryanston Square, London, W.1.
Ambassador 2861, Ext 636

BIOS FINAL REPORT NO. 307.

entitled

"GERMAN SECONDARY BATTERIES"

E R R A T U M

Amend "2 volt 18 A.H." on line 4 of paragraph 2, page 1 of BIOS Final Report No. 307 to read "2 volt 19 A.H."

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Reported By

R W.H. Couzens, M. of S.

BIOS Target Numbers
C31/104, C31/1260, C31/737, C31/2056, C31/1035,
C31/105, C31/107, C31/2057, C31/141, C31/2055

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

32, Bryanston Square, W.1.

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Personnel of Team

R.W.H.COUZENS, M. of S.

1. Object of Visits and firms visited

The object of the visits hereinafter reported upon was to investigate the German production of Secondary Batteries with particular reference to portable types for Army Signals use.

The firms visited were:-

Gottfried Hagen. A.G. Koln Kalk.
Dynamit, Troisdorf.
Accumulatoren Fabrik. A.G. Hagen.
Concordia Electrizitats. A.G. Dortmund.
Accumulatorenwerk. Hoppecke.
Accumulatoren - Fabrik. Wilhelm Hagen. Soest.
A.E.G. Berlin
Accumulatoren Fabrik. A.G. Berlin
Robert Bosch. A.G. Stuttgart.
Columbus Werke. Ludwigshaven.

2. Summary

It appears that only one type of portable lead acid battery was made in large quantities in Germany for Army Signals use, namely the 2 volt 38 A.H. type. Small quantities of a battery of similar design but of 2 volt 18 A.H. capacity were ordered, but apparently did not come into general use.

The A.F.A. Hagen, however, state that they made a considerable number of portable batteries of the alkaline type for the German Army and the explicit instructions on the label of the 2 volt 38 A.H. cell, warning users not to fill this cell with alkaline liquid, indicates that both types were used. From conversations with representatives of firms it also appears that more of the alkaline than of the lead acid type were used as portable batteries. A detailed report upon the production of alkaline batteries is being made by another team of investigation.

It is understood that reports have been made upon most of the firms mentioned above by previous investigators but special points of detail hereinafter mentioned emerged from this investigation.

Visits to Firms C31/104

(a) Gottfried Hagen A.G. Koln Kalk

The works of this firm are at 95-101 Rolshover Strasse, Kalk, and the following members of the firm were seen on 7/1/46:-

Herr Heinrich Osterpey - Director
" Fritz Schucht - Secretary
" Karl Goldschmidt - Battery Works Manager

The lead battery works had been badly damaged and the alkaline works destroyed whilst the rubber works had also been badly damaged. Traction batteries were being made with MIPOLAM (a form of P.V.C.) containers obtained from I.G.Farben the plates being pasted by hand (pasting machines and grid casting machines were not working). The Separators were of perforated corrugated MIPOLAM with wood veneers peeled from white wood and chemically treated at these works.

The Laboratories were destroyed but it was stated that the lead and paste were tested daily.

A dispersal factory at Rosrath about 10 Km distant is now producing starter batteries under the Military Government and it was stated that details of the paste used had been given to the Military Government.

The following details were obtained of the 2 volt 38 A.H. Lead Acid cells supplied for the use of the German Army Signals to Government design, and known as "2.B.38" cells:-

(a) The container was of MIPOLAM obtained from Dynamit of Troisdorf 6.3/8" x 3.5/8" x 6.5/8 high overall and approximately 3/16" thick. The container was delivered to the battery makers complete with instruction label, lid with lead inserts connecting from pillars to screw terminals with blue and red terminal nuts at one end of the lid protected by a projection on the moulding above and between the terminals. A steel handle was sprung into holes in a recess in the lid into which it folds down after use. The container was said to be stronger than moulded rubber, but

would not stand dropping from any height

(b) The plate thickness was 4.5 mm negative and 5.0 mm positive spaced at 4.3 mm, four positive plates per cell.

(c) The separators were glass wool sealed with bitumen at the edges (to withstand the vibration test mentioned hereafter) and wood veneers.

(d) A Non Spillable device, separate from the filling plug, was supplied with the lid and is of a small size but is such that the battery may be inverted without spilling acid. The filling plug is solid MIPOLAM and red marks on the side of the case, which is translucent, indicate the permissible acid level.

(e) This was the only type made by this firm for German Army Signals and no tests of materials or performance were stated to have been made at the factory. No special working gravities were recommended for high or low temperature conditions and inspection was "Delegated" by the authorities towards the end of the war.

3. (b) Dynamit A.G. Troisdorf (Near Koln) C31/1260

This factory was visited on 7/1/46 to investigate further the containers for the 2 volt 38 A.H. cells mentioned above and the persons seen were:-

Herr Meines - Director, Plastics Section.
" Tensi - Manager, Moulding Works
Dr. Rohn - Chemical Director

The firm is one of the I.G.Farben group and is under Military Government Control and the chemical side of the production has been reported on under Item No. 2 File No. XXIV - 3.

They moulded up to 12,000 per month of the containers and lids in MIPOLAM for the 2 volt 38 A.H. cells which were delivered to the different battery makers. They also moulded a comparatively

small number of the 2 volt 19 A.H. type of a similar design later in the war.

The labels are printed on paper and then covered on both sides and stuck to the box with MIPOLAM solvent, which is believed to be Chlorinated to P V.C. to 60% Chlorine content and soluble in Methylene Chloride generally known as "after chlorinated P.V.C "

It was stated that each container was tested for mechanical strength. It was inverted on a tray of sand and a round weight of 5 Kg was dropped on to the bottom of the box from a height of 15 cm. Some boxes would stand a drop of 90 cm.

The softening point of the material was said to be 78°C and it is said to become very brittle at - 20°C. They had been informed that the batteries were satisfactory in the African campaign but had no information about the Russian campaign.

Dr. Rohn stated that they made perforated corrugated separators also of the same quality material as the containers, and that they were calendered at 180°C.

The moulding works were only producing a small quantity of miscellaneous mouldings to Military Government requirements.

3. (c) Accumulatoren Fabrik A.G. Hagen C31/737

The works are at Dieck St. Hagen and three persons were seen on 8/1/46:-

Herr	Hardt	Directors
"	Bischoff	Directors
"	Arnold	Manager Lead Works
""	Schulte	Manager Submarine Works
"	Katz.	Manager Alkaline Works
Dr.	Enden	Manager Rubber Works.

This is the oldest of the A F.A. group of seven factories and was started in 1888. At present they are employing about 1,900 men but during the war they employed up to 5,700 and produced up to

12,000 tons per month of lead acid batteries, chiefly for submarines, torpedo traction, stationary and mining work. They also produced the lead acid batteries for the "V.2" Rockets.

The separators used during the war were perforated corrugated IGELIT (a form of P.V.C.) for general use and hard rubber for submarine and other batteries, which were liable to get hot, with wood veneers. It was stated that the IGELIT became deformed with heat and the separation was thereafter impaired. The veneers were of Port Orford Cedar until stocks ran out, and then of German Pine peeled. Those for Submarine batteries were 0.8 mm thick and were treated with caustic soda but veneers for smaller batteries were 0.28 mm thick and were untreated.

Microporous rubber separators were made and used before the war particularly for mining and submarine types but lack of latex prevented their use during the war.

Grids had 6% antimony which they consider sufficient though the grids seem very soft after casting, but it was alleged that they harden with time. The grids for traction and mining types are sand blasted and the negative plates for these are grooved.

It was stated that the number of plates in submarine batteries was increased from 23 plates to 33 and 44 plates during the war to give greater capacity, but the life was thereby reduced from 3 years to $1\frac{1}{2}$ years. These batteries were also made at Posen and Hanover and 30 to 35 per month were delivered.

The following details were obtained of the batteries supplied for the "V.2" Rockets:-

The plates were 92 mm x 154 mm. The 3 positive plates were 1.6 mm thick and the negatives 1.3 mm thick, spaced at 1.5 mm. The separators were of hard rubber perforated with wood veneers and the output was 100 amps for $4\frac{1}{4}$ minutes with voltage drop from 1.64 to 1.34 volts per cell at 0°C or 100 amps for $5\frac{1}{2}$ minutes with voltage drop from 1.78 to 1.39 volts at 30°C. 8 cells in hard rubber containers were fitted in an iron case.

Another size of battery was fitted in a similar iron case and had 3 positive plates per cell 50 mm x 80 mm with the same thickness and spacing as above. This gave 50 amps at 30°C for 2 minutes 13 seconds with voltage drop from 1.74 to 1.48 per cell or 10 amps for 26 minutes 18 seconds with voltage drop from 1.96 to 1.66 volts.

These batteries were only required to give one discharge and a rubber membrane was said to have been fitted in the vent plug to prevent spilling of electrolyte, but allow escape of gas, and 1% of carbon was added to the paste for these (and also for torpedo cells).

They were the only types of lead acid batteries supplied by these works to the German Army and they do not yet know the use to which the second type was put.

The Harris refining plant for lead was being brought into operation, and a grid casting machine and a box grid casting machine of their own make were working. There were also one American and one French pasting machine.

Alkaline batteries were supplied for Army Signals use and for use in mines. The normal nickel cadmium type were made at Hagen and the sintered plate type at Hanover. It was alleged that the negative plate of the latter type loses capacity and that the cause of this is not yet known.

For Army use it was stated that the following alkaline portable types had been supplied, the quantities to be regarded as approximate only as the statistical details are said to have been destroyed

Capacity n	Carrying Case	Approx. Number
12 volt 30 A.H.	Oak with front and top hinged	29,750
12 volt 28 A.H.	Steel	17,000
12 volt 15 A.H.	Wood	5,000
4.8 volt 5 A.H.	Rubber lined and rubber covered steel.	8,000
4.8 volt 10 A.H.	Ditto	64,000
2.4 volt 28 A.H.	Ditto	360,000
2.4 volt 56 A.H.	Steel rubber covered	27,000

Natural rubber was used at first and then "Buna" for protection of the steel cases.

Other sizes of alkaline batteries were made in larger quantities for the Luftwaffe and in small quantities for the Navy.

A number of 90 volt 1 A.H. batteries were made in IGAMID (A form of P.V.C.) containers and assembled into wood boxes for Naval use.

There were no non spillable devices other than the vent plugs with rubber membrane.

The output of alkaline batteries during the war was said to be 2,500,000 ampere hour capacity per month and is now 300 A.H. per month.

The Rubber works contains the usual calenders, vulcanizing ovens, moulds, etc. and has been reported upon by other investigators.

3. (d) Concordia Electrizitats A.G. Dortmund C31/2056

The works are at 231 Munster Street and Herr Apelt, Director was seen on 9/1/46.

Miners Lamps are made here. The containers are pressed out of steel and welded up. The nickel cadmium plates are obtained from the A.F.A. at Hagen and assembled into these containers. The capacity of the batteries was said to be 2.4 volts 21 A.H.

The firm is also permitted by Military Government to make Fire Extinguishers and they used to make acetylene lamps and air filters for mines.

About 250 persons are employed and the production is about 30% of normal due to damage by bombing and the fact that they sent machines to Thuringia in the Russian zone and cannot get them back.

3. (e) Accumulatorenwerk Hoppecke Carl Zoellner and Sohn C31/1035

The works are situated at Hoppecke Westfalen, near the Station, and the persons seen on 10/1/46 were:-

Herr Hellmuth Zoellner	-	Director
Dr. Hochne	-	Chief Chemist
Herr Hohmann	-	Works Manager

The firm moved to Hoppecke from Cologne in 1927 and is now producing car starter batteries at the rate of 800 to 1,100 per week under British Military supervision. The only portable battery for the German Army Signals produced was the 2 volt 38 A.H. cell exactly similar to those produced at Hagen Koln Kalk works, the containers being supplied by Dynamit.

They produced some hundreds per month of special battery understood to be for use in Armoured Fighting Vehicles of capacity 12 volt 125 A.H. Single cells of wrapped ebonite were plated in a steel box of about 16 B S. gauge with a compartment for each cell. The overall dimensions were 497 x 252 x 194 mm high (all ± 1 mm). The box had no lid but had a carrying handle of canvas covered with synthetic rubber. A battery with acid in it weighed 53 Kg. This battery was produced late in the war.

There were also two types of 12 volt 162 A.H. batteries one with similar cells in a wood box 2 cm thick with fixed handles and the other in a hard rubber monobloc container with sliding handles at each end. The dimensions of both types were 490 x 292 x 252 mm high. The weight empty was 60 Kg.

The plates in the above batteries were 2.3 mm thick and the s.g. of the electrolyte was 1.28.

Containers of wrapped ebonite and also of moulded bitumen and asbestos composition were made at these works; the latter were stated to have a good impact strength but Dr. Hohne said that they tended to buckle in hot climates. It therefore appears that they are inferior to the containers used for British Signals Batteries. Other containers of the hard rubber type were purchased from the

Continental Co , of Hanover. Some MIPOLAM containers were also used for traction batteries.

Separators for starter and traction batteries were perforated MIPOLAM or DECELIT with veneers of beech peeled. The veneers of 0.4 mm thickness in small batteries are not treated but those of 1.0 mm and 1.2 mm thickness for starter and stationary batteries are treated.

The Antimony in the grids varied from 8% to 5% according to the supply position.

Lead ball machines and ball mills are installed, and a new Belgian grid casting machine, which has not run successfully yet.

In the small, but apparently efficiently run, laboratory, research is carried out and materials and paste are tested and routine life tests are also made.

3. (f) Accumulatoren-Fabrik Wilhelm Hagen, Soest. C31/105

This works was closed down by the Military Government but Dr. Konig Chief Chemist was present on 11/1/46.

He stated that they had made the 2 volt 38 A.H. Signals battery in the following numbers:-

5,000 in 1938
1,000 per month in 1939/40
2,000 " " " 1941/43

when production of this type was stopped at this firm. The initial capacity was said to be 42 to 43 A.H , but no life tests were made. The separators were obtained from the A.F.A. Company and the containers from Dynamit.

For starter batteries the containers were obtained from Continental Hanover, no tests were made on these. For traction batteries IGELIT containers were used.

The antimony in the grids was stated to be 8% for starter batteries and 5% to 6% in other types. The connectors had 5 to 6% in them.

The separators were generally of IGELIT with 0.4 mm veneers of beech untreated and bought locally. The veneers for storage and traction batteries, which were thicker, were peeled at another factory near Soest Station. The building in which the wood veneers are peeled and treated and one with 3 ball mills in it are the only buildings which are not completely out of action at the Station site owing to bombing and shelling.

The output of starter batteries was 600 per day and fell to 200 per day. They say they could now make 100 per day.

Routine life tests from normal production were made on about 4 batteries per month for 50 cycles of charge and discharge and on special batteries and new types tests were taken to 100 cycles. Typical figures of a batch of tests results were:-

1st cycle	discharge	capacity	106%	to	92%	of	rated capacity
50th "	"	"	104%	to	101%	"	" "
80th "	"	"	90%	to	65%	"	" "

3. (g) A.E.G. Berlin C31/107

The head offices are at Hohenzollern Dam 150 where on 15/1/46 the following persons were seen:-

Dr. Krebs - Director
Herr Friebe - Factory Manager
Dr. Nippold -

They stated that they have never made secondary batteries either of the acid or alkaline type nor have they made any parts for them.

They made electric vehicles at Henningsdorf, the batteries for which were of the lead acid type and were supplied by the A F.A. group of companies.

3. (h) Accumulatoren Fabrik A.G. Berlin C31/2057

The original offices at 3 Askanischer Platz close to the Anhalter Station are completely destroyed and the offices were found at Kreuzburg St. 30 on 15/1/46. The secondary battery works are at Wilhelminenhof St. 68/69 Oberschoneweide.

The following persons were seen:-

Dr. Gemershausen	-	Director
Herr Ruschweih	-	Secretary
" Schmittermair	-	Engineer
" Nippe	-	Sales
" Spengler	-	Works Manager

The factory at Oberschoneweide is occupied by the Red Army and access was not allowed by the Major in charge.

The firm's representative stated that 90% of all machinery and equipment had been removed by the Red Army so that production is now only 10% of war production, which was 80,000 to 100,000 per month in 1944. The labour employed in 1944 was 751 Males and 469 Females. Some of the technical staff and records were taken to Hanover before Berlin was occupied. There is a repair shop under the office building at Kreuzburg St. in which typical batteries were seen.

It appears that during the war they made batteries for starters, aircraft, Post Office and Signals. The 2 volt 38 A.H. type for Army Signals was made to the same specification as other firms and in the same way, the containers being supplied by Dynamit Troisdorf. They had a contract for the 2 volt 19 A.H. type of similar construction, it was stated that the contract was for 3,000 cells and was not complete, the 2 volt 38 A.H. cells being supplied instead.

For starter batteries the containers were of hard rubber supplied from Hanover and Hagen works. Some starter batteries are made in glass containers, said to be unsatisfactory for low temperature conditions.

The separators for all types (except the 2 volt 38 A.H.) were perforated DECELIT, from I.G.Farben, with thin veneers of poplar or pine said to have been treated in all cases.

Plate thicknesses used were in 2.3 mm for starter batteries up to 87.5 A.H., 3.1 mm for the 90, 105 and 150 A.H. types, 2.5 mm for the 94, 108, 122, 162 A.H. types, and for the 12 volt 120 A.H. type for Armoured Fighting Vehicles, and 1.2 mm down to 1.0 mm for aircraft batteries.

The Antimony content of grids varied from 7% to 4%, as laid down by Government Authorities from time to time, and of connections 6%.

The majority of the plates were machine pasted but the thin plate aircraft types were hand pasted.

Aircraft batteries had a non-spill device similar in principle to that on the 2 volt 38 A.H. cell and to those used in Great Britain, and some cells for radio use were made with Keiselguhr and glass wool between the plates (5 A.H. capacity).

Inspection by Government Authorities required about 0.2% of production to have a capacity test of 3 or 4 cycles. As a routine test by the firm for their satisfaction 0.1% had a life test, in which the battery was charged and discharged until the rated capacity was reached, after this 20 cycles of charge and discharge were given during which the capacity was required to be not less than the rated capacity.

The discharge test for starter batteries was carried out at 30 times the 10 hour rate current, at 20°C and at 10°C.

In this test the following were the voltage requirements for a 6 volt battery:-

20°C		-10°C	
After 15 secs.	5.22 volts.	After 15 secs.	4.6 volts
" 1 min.	5.16 "	" 1 min.	4.54 "
" 6 mins.	4.5 "	" 3.5 mins.	4.2 "

The corresponding requirements for British Vehicle batteries is a discharge at the same rate as the German but at -30°C for 5 seconds after which the voltage must not be less than 4.2 volts.

The dimensions and weight were laid down for aircraft batteries and the weight of lead content for starter batteries.

3. (i) Robert Bosch A.G. Stuttgart C31/141

The offices are in the air raid shelters at Seiden St. owing to the condition of the remainder of the premises, and here the following persons were seen on 23/1/46:-

Herr Winter, formerly in charge of Production of batteries but now of Ignition, plugs, switches and horns.

Dr. Callsen, now in charge of Production of batteries, dynamos, regulators and starters.

Herr Knozele - Technical Assistant

At the works at Feuerbach the following were seen:-

Dr. Habler - Chemist

Herr Hattinger - Works Manager

It was stated that this firm co-operated closely with Lucas (England) on technical matters in connection with batteries before the war. They make only the car starter and motor cycle types of battery.

The containers were of hard rubber, obtained during the war from Continental Hanover, but now made in the "Insulation" section of the works at Feuerbach, when all mouldings for magnetos and for their other products are made. They have also used containers of bitumen and asbestos similar to those made by Lucas before the war.

They have standardised on 2mm thickness for plates in all starter batteries, spaced at 2 mm. The antimony in the grids is

said to be 8% (they allege that they changed from 3 mm plates to 2 mm to maintain the percentage of antimony) and in connectors 6%. They did not, however, as stated below continue to produce batteries after February 1944 and this may be the reason for the percentage of antimony being maintained.

Separators are all DECELIT with veneer of poplar treated with caustic soda in all cases. Glass wool was said to have been tried without success.

No non-spillable devices were used, and the specific gravity of electrolyte was 1.28 for all conditions, though it was understood that a gravity of 1.23 had been used in Tropical conditions.

Tests had been made for low temperature work down to -30°C. They had found that a discharged battery freezes at -10°C but the plates are not damaged, and that it is impossible to charge a battery below -20°C owing to "priming" (discharge of electrolyte through the vents). No special paste was used for batteries for these conditions.

Steps were taken to prevent starter batteries from freezing on vehicles. On lorries the batteries were put in wood boxes and a petrol lamp (on the "Davey Lamp" principle) was used. On Armoured Fighting Vehicles the boxes of iron were lined with slag wool and an electric resistance heater plate was provided below the battery.

Life tests are made by charging and discharging a battery at the 1-hour rate until it only gives $\frac{1}{3}$ of its rated capacity. 100 cycles of charge and discharge are considered satisfactory but 200 cycles are sometimes obtained.

The production from the works was about 10,000 per month during the war until February 1944 when production of batteries stopped by order of the Government and the labour was transferred to other Departments. Production started again in June 1945 and rose to 4,500 last month with 70 men in the works and 8 on test and inspection. The laboratory was demolished by bombing.

They had two lead pots working for casting grids and a small Bosch type of machine for casting grids which is not in operation.

An ingenious design of machine made by Bosch casts all the connectors, terminal posts, etc.

A pasting machine from Hagelucken and Dietzel of Gevelsberg was giving very even results and a similar machine was not working. Scales are provided for checking the plates and no hand pasting is done.

No lead ball mills are installed and the oxide is purchased. There is a vertical mixer for the red oxide and a horizontal for the grey.

The ovens are heated electrically owing to lack of gas. The negatives are dried in a vacuum oven for 8 to 10 hours at 100°C after forming and the positives on rotary grids passing through an electric oven at 190°/220°C in 7 minutes.

The ovens and forming tanks are on the first floor some distance from the casting and assembly space. A conveyor 100 metres long was formerly in use between these departments but is now out of action.

On the assembly line there is a tank with orifices in the base whence compound is released, when a handle is pulled, and falls into the appropriate places on the battery below the tank in a series of small streams.

There are also brushes wiping the terminals and connector bars of batteries as they pass along on the belt and indicating by a loud buzzer if a short circuit exists. The existence of a circuit from plates to terminals is checked on each battery by "prods", and an air pressure test at 1.5 lbs. per. sq. inch for 2 seconds is applied to test the sealing.

When unserviceable batteries are returned to these works the old Containers are re-used but no use is made of the plates which are sold for scrap lead.

There is a proper exhaust system of ventilation in this factory and generally it appeared to be the best of those investigated and mentioned herein.

3. (j) Columbus Werke Ludwigshaven C31/2055

These works are situated off Frankenthaler St. Ludwigshaven and Herr Otto Wolpert was interviewed on 25/1/46.

He said that dry batteries were made at these works until 1938 under the direction of Herr Albrecht. Otto Wolpert purchased the works at that time for the manufacture of Testing machinery for Hardness (Brinnell and Rockwell), Springs, and Impact tests. The manufacture of batteries was then stopped at these works and testing machines alone were made.

The firm is now known as "Otto Wolpert - Ludwigshaven".

100 testing machines per month were produced before the war and about 110/120 per month during the war. Now they make about 10 per month for the French Navy and also do repair work on machinery. They state that they have 100 men available for employment and a stock of raw materials (except coal) to last a year, so that they could return to normal production if they could get fuel for heating and 60 further skilled men, and if they could deliver their products elsewhere than to the French zone of occupation.

4. Main Technical Features of German lead/acid Batteries

(a) Boxes

No special enclosed boxes of the portable type used by the Royal Corps of Signals were supplied by the battery makers in Germany for lead acid batteries. The 2 volt 38 A.H. and 2 volt 19 A.H. types had a handle incorporated with the container and a 12 volt 125 A.H. type of battery, used in Armoured Fighting Vehicles, and consisting of six single cells fitted into a partitioned steel box without lid, had a rubber covered canvas handle.

A considerable number of Alkaline batteries were fitted in

rubber lined and rubber covered steel boxes, some in oak boxes with lids, others in steel boxes, and a few in soft wood boxes.

(b) Containers

The 2 volt 38 A.H. and 2 volt 19 A.H. containers were apparently designed and specified by the Army Authorities and were all produced by one firm. They were of MIPOLAM, which is translucent and a form of P.V.C., of a neat design, with the terminals at one side protected by the moulding, and a steel handle sprung into and folding down flush into a groove in the lid.

Containers for lead acid batteries apart from the above were mostly of the car starter monobloc type, moulded from rubber composition. The 12 volt 125 A.H. and 12 volt 162 A.H. types above were seen in single cells, the former in a steel and the latter in a wood box.

Traction batteries are being produced in MIPOLAM and IGELIT single cell containers, which are said to be more expensive but stronger than the hard rubber type.

One firm produced containers of moulded pitch and asbestos and were confident of the impact strength, but said that buckling of the walls was likely in warm climates. Another firm said that they had also produced this type of container exactly like Lucas (England) type as produced before the war.

The containers used are, therefore, inferior to these used by the Royal Corps of Signals during the war.

(c) Non Spillable Devices.

The 2 volt 38 A.H. and 2 volt 19 A.H. cells were the only lead acid types, apart from aircraft batteries, which were fitted with non spillable devices. These were designed on the same principle as those used in British batteries, and the cells are completely non spillable.

It was stated that the battery for the "V2" Rocket, which was required to have only one discharge, had a soft rubber membrane type of device similar to those on Alkaline cells.

The Alkaline batteries had plugs which were stated to be only "semi non spillable".

(d) Plates

The plates in lead acid batteries varied in thickness from 5.0 mm positives and 4.5 mm negatives with a pitch of 4.3 mm in the 2 volt 38 A.H. Signals cells to 1.6 mm positives and 1.3 mm negatives with a pitch of 1.5 mm in the batteries for "V2" Rockets. The usual car starter types of batteries had plates of 2.0, 2.3, 2.5 or 3.1 mm and those for aircraft 1.0 to 1.2 mm in thickness.

In British batteries for Signals use none had plates as thick as the German 2 volt 38 A.H. cell. The thickest British positive plate being 3.969 mm in the 2 volt 75 A.H. cells and the thinnest plates 2.381 mm in the 12 volt 75 A.H. batteries.

(e) Grids

It appears that the amount of antimony which was allowed to be used in the grids was specified by the German Government from time to time and varied from 8% to as low as 4% towards the end of the war.

The grids were sandblasted by the A.F.A. group of firms for the larger, traction, type of plates to obtain the better adhesion of the paste. The negative plates were grooved by these firms also for the traction batteries.

(f) Separators

An extensive use was made of IGELIT, DEGELIT, MIPOLAM, and ebonite, all perforated and corrugated, with wood veneers. (The first three were stated to be I.G. Farben products and a form of P.V.C.) Some firms say they treat all their wood veneers to eliminate the acid from the wood but others treat only those thicker than 0.28 mm.

Microporous rubber separators were used before the war but their use had to be abandoned at the outbreak of war owing to shortage of pure rubber. No evidence could be found of a synthetic rubber microporous separator at any of the works visited. Glass wool with wood veneer was used in the 2 volt 38 A.H. Signals cells but was not in general use.

(g) Specific Gravity of Electrolyte

The working (fully charged) specific gravity of the electrolyte was 1.27/1.29 for signals and starter batteries, 1.24 for traction types and small cells, and 1.20 for plant batteries.

One firm stated that a specific gravity of 1.23 had been used in the tropics (reports from the Middle East to the British War Office also mentioned this figure) and that they had learned from a captured document that the Russians had used 1.31 s.g. in North, 1.29 in Central and 1.27 in South Russia.

(h) Tests

It was stated that no life tests were made at the firms works for or under the supervision of the Government Authorities, nor were they informed of the results of any carried out by the Inspecting Authorities. Certain firms stated that they carried out life tests regularly for their own information, and the different methods are described herein.

A proportion of the 2 volt 38 A.H. Signals cells were subjected to a vibration test for four hours on a tray mounted on four cams, one at each corner, each corner being lifted and dropped in turn at a speed of 130 lifts per minute. Five cells per month were tested in this manner at each works, apparently to see whether the glass wool separators were displaced or disintegrated, whilst ten cells per month were given a capacity test, and others were taken away by the Inspecting Authority for life test.

The weight was considered important and the weight of the 2 V. 38 A.H. cell is 3.6 kg without acid.

5. Conclusion

From the foregoing it appears that only one type of lead acid secondary portable battery was used generally by the German Army Signals and this was not as robust as those coming into production in Great Britain at the end of the war. The Alkaline type which is more robust by reason of its material and construction than the lead acid type was used to a far greater extent by the Germans than by us. Thus it is likely that problems of breakage of batteries did not airse to any serious extent.

The separators generally used in lead acid batteries probably had a longer life than the wood separators used in Great Britain, but they are not as good as the porous synthetic rubber separators now being produced in England.

The containers for lead acid batteries were not as robust as the British type made for Signals use.

No advance, therefore, comparable with that made in England appears to have been made in the lead acid manufacture and the only advance importance in alkaline batteries appears to be the development of the sintered plate, the advantage of which is still in doubt.

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