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GERMAN SECONDARY BATTERY INDUSTRY

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

GERMAN SECONDARY BATTERY INDUSTRY

Reported by

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BIOS TARGET NUMBERS

12/166, C31/737, C12/265, C31/1255, C31/105, C12/273, 12/168, C31/1038, C12/274, C31/2525, 12/167, C31/104

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
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Refer also to FD 394/51 which is also FB 99432.
entitled "DURAC NICKEL CADMIUM ALKALINE BATTERY.
BIOS F/R. 708 (B TK 158) German Alkaline Accumulator Industry
" " 384 (B TK 200 2) German Battery Electric Vehicles and the German Storage Battery Industry
" " 411 (B TK 64) Miscellaneous Electrical Factories in the British American Zone

Object of Trip

The object of this trip was to investigate the activities of the various German Secondary Battery Factories during the war and in particular to find out any technical advances in the way of new batteries, new types of known batteries and new methods of construction developed during the war years. Special attention was paid to batteries for Naval use.

The following factories were visited:-

A.F.A. Accumulator Factory at Hagen	12/166, C31/737
A.F.A. Accumulator Factory at Stöcken, Hanover	C12/265, C31/1255
Accumulator Factory, Wilhelm Hagen, Soest	C31/105, C12/273
Accumulator Works of Carl Zoeller, Hoppecke	12/168, C31/1038
W. Seippel G.m.b.H. Bochum	C12/274, C31/2525
Gottfried Hagen Aktiengesellschaft Koln-Kalk	12/167, C31/104

Summary

Of these factories the first named is by far the most important from the technical point of view, most of the research and development work was done here, it has been about 50% damaged by air attack and most of the technical records have been destroyed. The A.F.A. Factory at Hanover is the most interesting from the production angle, although the dispersal of the buildings prevented the use of continuous flow methods.

In the lead acid secondary battery field the Germans show no technical advances over current British practice. The problems of suitable alloys for the grids (antimony being in short supply) and of separators for large cells remain virtually unsolved.

The use of alkaline secondary batteries was limited during the war years by the shortage of nickel, but the development of a light weight battery using sintered plates and so dispensing with the usual heavy metal grids represents an advance not known in Great Britain.

This latter subject has been adequately covered by Mr. Follett of M.A.P. and is not treated in detail in this report.

A.F.A. Accumulator Factory Hagen

This was the nerve centre of the German secondary battery industry prior to and during the war. The factory has been considerably damaged during three air attacks and although still capable of producing lead acid batteries the nickel plating plant and the plant for the production of nickel oxide for alkaline batteries has been completely destroyed. A new plant for the production of alkaline batteries is under construction at Letmathe a few miles away but this is not yet complete.

The laboratory buildings were destroyed by air attack together with most of the records, although some work was still carried on in two basements. Prof. Baas is available and can give information on most technical matters.

During the war it appears that none of the service departments made specific requests for any type of special battery. In general batteries for naval purposes were required to have a low hydrogen evolution on open circuit, but this point was not covered by any specification test and any tests that were made were purely laboratory tests, the firm has, however, apparently made no progress in this matter during the past 10 years.

Torpedo Batteries

The original design of torpedo battery was kept to throughout the war, but the naval staff were continually asking for increased duration of discharge and this was eventually met by producing a larger cell with an increased number of plates. Typical performance curves are attached to this report.

In an attempt to increase the capacity still further experiments were made in which concentrated acid was added to the cells during the run. The attached curves show the experimental results obtained with the original torpedo cell (13T 210, 13 positive plates) and with the larger cell (17T210, 17 positive plates) from which it will be seen that considerable increases in capacity could be obtained by this means. Experimental batteries were made to employ this method of obtaining increased capacity. Concentrated sulphuric acid formic acid were held in separate containers and were brought into contact after a pre determined time by the explosion of a cartridge which broke membranes in the walls of the acid containers, the mixing of these acids generated a gas pressure which forced the sulphuric acid through a system of mipolam pipes to receptacles on top of the cells, these receptacles were fitted with a float valve which closed the supply pipe when the receptacles were full. All the batteries etc. at the accumulator factory were destroyed, but some batteries were delivered to the Torpedo Experimental Establishment at Eckenforde.

Submarine Batteries

For submarine batteries the emphasis was placed on high rates of discharge for short periods of time and this was met as far as possible by using the thinnest possible plates and separators. But no new developments were apparent. Typical performance curves are attached to this report.

Lead Acid Batteries - General

Little research has been carried out during the war years, the general demand has been for increased production of batteries and all alterations and improvements have been made with the minimum disturbance to existing designs. No attempts were made to produce special batteries for high or low temperature work.

Two problems to which considerable attention has been given are the elimination of antimony from the lead alloy used for casting the grids and the production of satisfactory separators.

The first problem arose from the shortage of antimony in Germany, other alloys had been tried in pre war years and found unsatisfactory, with the result that during the war apart from some minor work on lead calcium alloys, efforts were concentrated on progressive reduction of the antimony content of the alloy. During the latter period of the war the percentage of antimony had dropped to 5-6%; except for the torpedo batteries where 8% was still used. It was stated that this 5-6% antimony alloy was quite easy to cast by hand, but that it was not satisfactory for automatic casting. Methods of casting followed normal practice.

The production of suitable separators, followed from the exhaustion of supplies of Port Orford Cedar from America. Various woods were tried of which white wood, poplar, pine and beech were the best. But the wastage in slicing these woods was very large and the thinnest corrugated separators were usually 0.2 mm. thicker in these woods than in Port Orford Cedar.

Microporous rubber had also been used very satisfactorily, but the use of this material ceased owing to shortage of supplies, and no satisfactory material could be produced from Buna. Microporous polyvinvl chloride was unknown.

It is noteworthy that very little use was made of glass wool in any of the large cells. The usual procedure was to use a thin veneer of white wood or pine in conjunction with a perforated corrugated separator of Buna or polyvinyl chloride.

Paste formulae methods of pasting and formation did not differ from normal British practice. Large Harding mills were used for the production of grey oxide for the negative paste, for the positive paste there was a preference for grey oxide made in small mills.

Alkaline Batteries

Alkaline batteries of both the Edison and Ni Fe type were manufactured by this firm until the plant for the production of nickel oxide was destroyed by air attack. The general manufacturing processes have not altered since originally introduced. The only point of interest is that to economise in nickel, the containers for small alkaline cells were made of plastic material (Mipolam or Trolitol) and although the larger cells were in the standard steel containers, the exteriors of these containers were not nickel plated, but painted with a synthetic lacquer of the chlorinated rubber type. A small 1Ah cell in a plastic container for use in controlling torpedoes and mines was of interest as a neat production job, but otherwise there was no battery of particular interest.

The outstanding development in alkaline batteries, is the light weight cell with sintered plates. This was developed at Hagen although manufactured at Hanover. This battery has already been reported on by Mr. Follett of M.A.P. but the details are briefly as follows:-

> Pieces of iron gauze are cut to the size of the plates required and are edged with steel tape, this is then thinly nickel plated. The plates are then gently pressed into nickel carbonyl powder (positives) or copper nickel (2%) powder (negatives) weighed and then sintered into a compact porous mass in a reducing atmosphere at 900-960°C. The porous plates are then vacuum impregnated in a solution of nickel nitrate for the positive plates or cadmium chloride for the negative plates, and then electrolytically developed to nickel oxide or cadmium sponge, this process is repeated until the plates have attained a certain weight, when they are assembled together as cells in Trolitol containers, with 1 mm. diameter Trolitol threads between the plates as separators, and given three or four forming charges and discharges. The electrolyte consists of caustic potash solution of specific gravity 124-125 with the addition of 4 grams of Lithium hydroxide per litre.

This battery is undoubtedly the greatest and only advance made by the German secondary battery industry during recent years, but it is felt that even so it is not yet perfect and has been rushed into production to meet a particular military requirement. One present weakness is the possible disintegration of the positive plate and loss of capacity of the negative plate.

<u>A.F.A. Accumulator Factory Stocken near Hanover</u>

This factory which is probably the most modern secondary battery factory in Germany, has only suffered slight damage, only the lead refining plant and one formation room have been damaged.

Technically this plant is of little interest, being designed purely for the large scale production of batteries. It is not, however, a particularly well planned factory. The different buildings are about 100 metres apart and inside the buildings there is no attempt at obtaining a smooth flow from raw materials to finished batteries. The plant is quite modern but most of the casting and pasting is carried out by hand.

The main point of interest in this factory is the production of the light weight sintered plate alkaline battery. This is quite a small plant but it is well designed for continuous flow production. Herr Desenis is in charge of this plant and has apparently been responsible for the erection of most of the recent alkaline battery plants in Europe.

Carl Zoeller Accumulator Factory Hoppecke

This factory is well away from most German industrial districts and is completely undamaged. It is, however, of little interest from the Services point of view. A few small batteries for radio purposes were made. But this firm was chiefly engaged in the production of large stationary batteries, electrical vehicle batteries, starter batteries and portable batteries for radio and hand lamps. Batteries of this latter type were the only ones supplied for Naval use.

The construction of all these batteries was perfectly normal and there were no points of outstanding interest.

This firm in common with all other firms had reduced the antimony content of their grids to 5 or 6%. They had also experimented with lead calcium alloys in co-operation with Metallgesellschaft A.G. at Frankfurt, the effects of adding traces of copper, nickel, manganese and tin to the lead calcium alloys had also been tried, these experiments were not completed and the results were not immediately available. But further information is being obtained on this subject, although it is not considered to be one of any importance.

W. Seippel G.m.b.H. Bochum

This firm was reputed to make batteries but on investigation it was found that although they had at one time made lead acid batteries, for some years past they had only assembled starter batteries, and alkaline batteries for miners hand lamps.

Wilhelm Hagen Accumulator Factory Soest

This firm had two factories in the town, the more modern factory had been completely destroyed by air attack whilst the second factory was very severely damaged.

The peacetime production was devoted entirely to the production of traction, starter and stationary batteries, during the war this was supplemented by radio and tank starter batteries and later the more modern factory went into production of torpedo propulsion batteries, but only 20 of these were produced before the factory was destroyed.

This factory carried out no development work on its own account, and the torpedo batteries were produced to a detailed manufacturing specification supplied by the A.F.A. factory at Hagen, which also supplied certain ingredients for the paste. Consequently this firm is of little technical interest. Due to the severe damage to both factories most records have been lost.

Here as at all other factories there has been a progressive reduction on the antimony content of the lead alloy grids from 8% to 5 or 6%.

Gottfried Hagen Aktiengesellschaft Koln-Kalk

This firm manufactured alkaline and lead acid batteries, but the alkaline plant was completely destroyed in 1943 and later the lead acid battery plant was severely damaged and had been put out of production for some months prior to the end of the war. The only batteries supplied by this firm for naval use were normal type stationary batteries and electric truck batteries.

The main work of this firm was the production of electric vehicle batteries and train lighting batteries.

It was stated that they had refused all contracts of a military nature at first as the profits were too small, but later in order to obtain supplies of raw materials they had been forced to abandon this attitude and began to produce aircraft batteries and tank starter batteries, but their main production was still large stationary and traction batteries.

Production methods followed normal practice and as far as the batteries were concerned there was no originality either from a technical or a production angle.

There was little to be seen relating to the production of alkaline batteries, but here too no novelty was apparent. Both Edison and NiFe types were produced and all the raw materials, except the nickel flake, which was obtained from A.F.A. at Hagen, were manufactured locally.

A point of considerable interest was the containers for the lead acid batteries, these were made of mipolam. For small cells the material was yellow in colour and quite flexible rather like celluloid, whilst for larger cells it was black and hard more like ebonite. Joints were made either by hot air welding with sticks of mipolam or by cement.

This firm also carried on quite a large business in coating large metal articles with protective finishes of rubber and similar materials, and in the fabrication of large articles for chemical plant from mipolam.

General

This survey of the German secondary battery factories showed little or nothing in the way of technical developments, apart from the light weight alkaline cell with sintered plates.

No particular requirements for special batteries appear to have arisen, although in the realm of small special duty batteries it is possible that information might be obtained from the A.F.A. factory at Oberschönweide, Berlin, as it is known that reserve batteries of the zinc/sulphuric acid/lead peroxide type were manufactured at this factory for use in radio sonde apparatus.

The concentration of Naval production in two factories only, A.F.A. at Hagen and Hanover, is rather surprising (the production of Wilhelm Hagen Factory, Soest only came about after the A.F.A. Hagen works had been damaged), but it is believed that there was at least one other factory in Polant (Posnan?) which was also engaged in the production of naval type batteries.

The production of stationary batteries was unexpectedly high and remains unexplained.

The production of traction batteries was also high, but this was apparently the result of the large number of electric vehicles run on local journeys to save petrol.

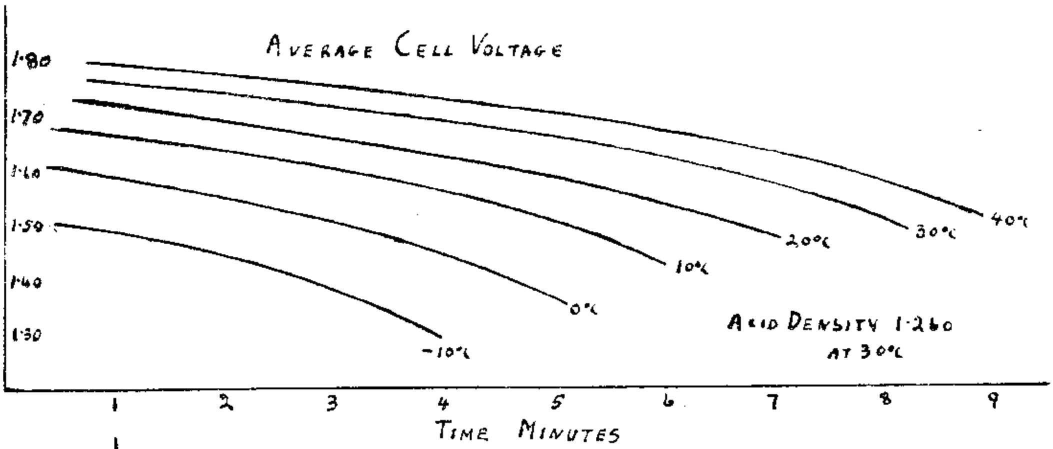
It was noteworthy that practically every factory was self contained as regards production of plate groups, containers and separators. Even the A.F.A. factory at Hanover, which ajoins the Continental Gummiwerke A.G. where containers are produced, has its own plant for the production of containers.

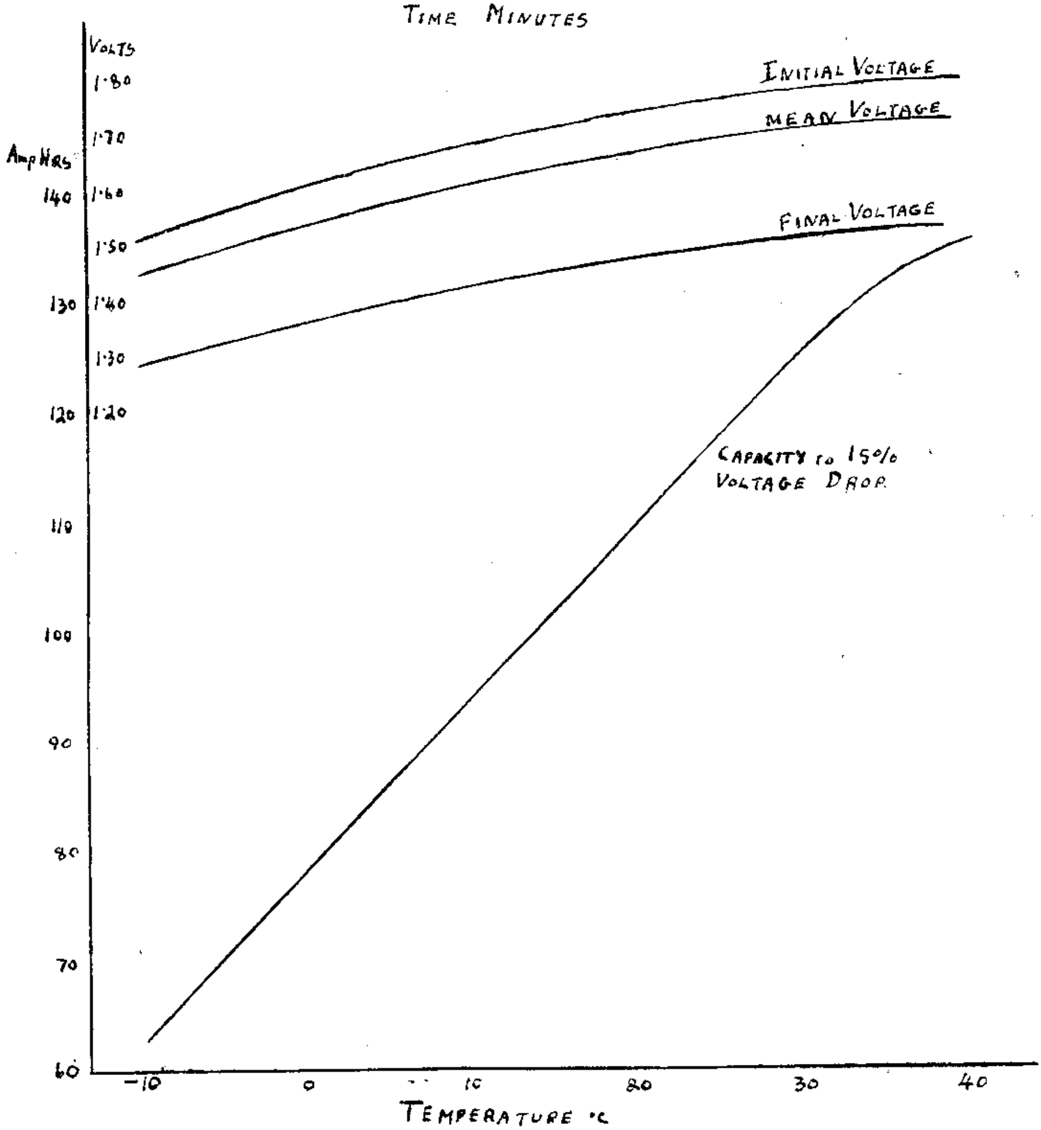
The only exceptions are:-

Wilhelm Hagen Factory at Soest no production of containers
Gottfried Hagen A.b. Koln-Kalk no production of separators

It had been hoped to include a survey of the primary battery industry in this report, but as most of the factories were in the Berlin area of Polish or Russian territory this has not been possible.

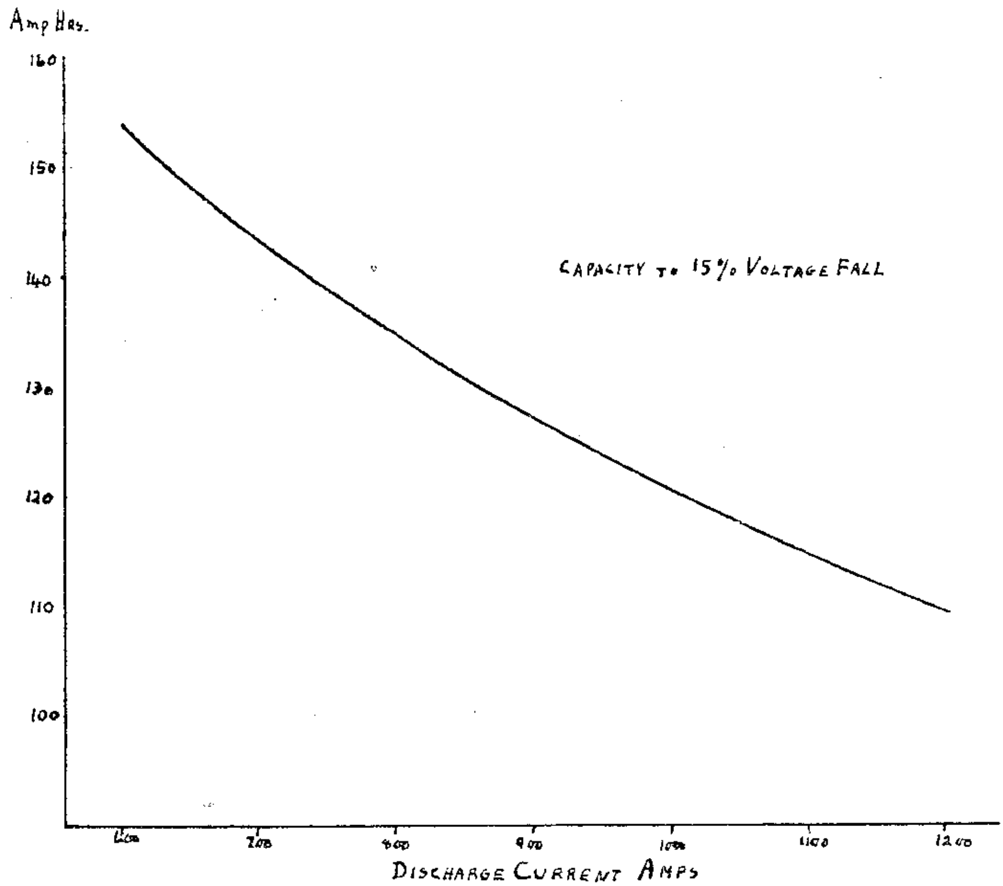
EFFECT OF TEMPERATURE ON VOLTAGE AND CAPACITY OF TYPE 17 T210 CELLS.
3rd DISCHARGE AT 930 AMPS

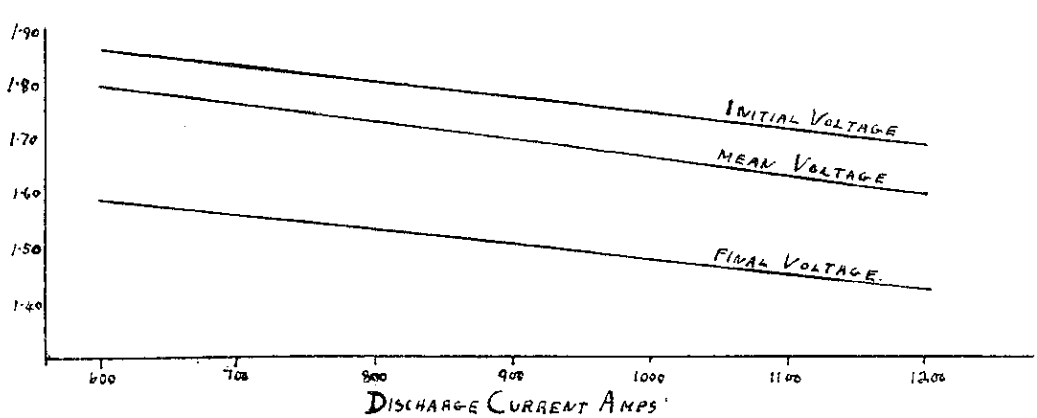


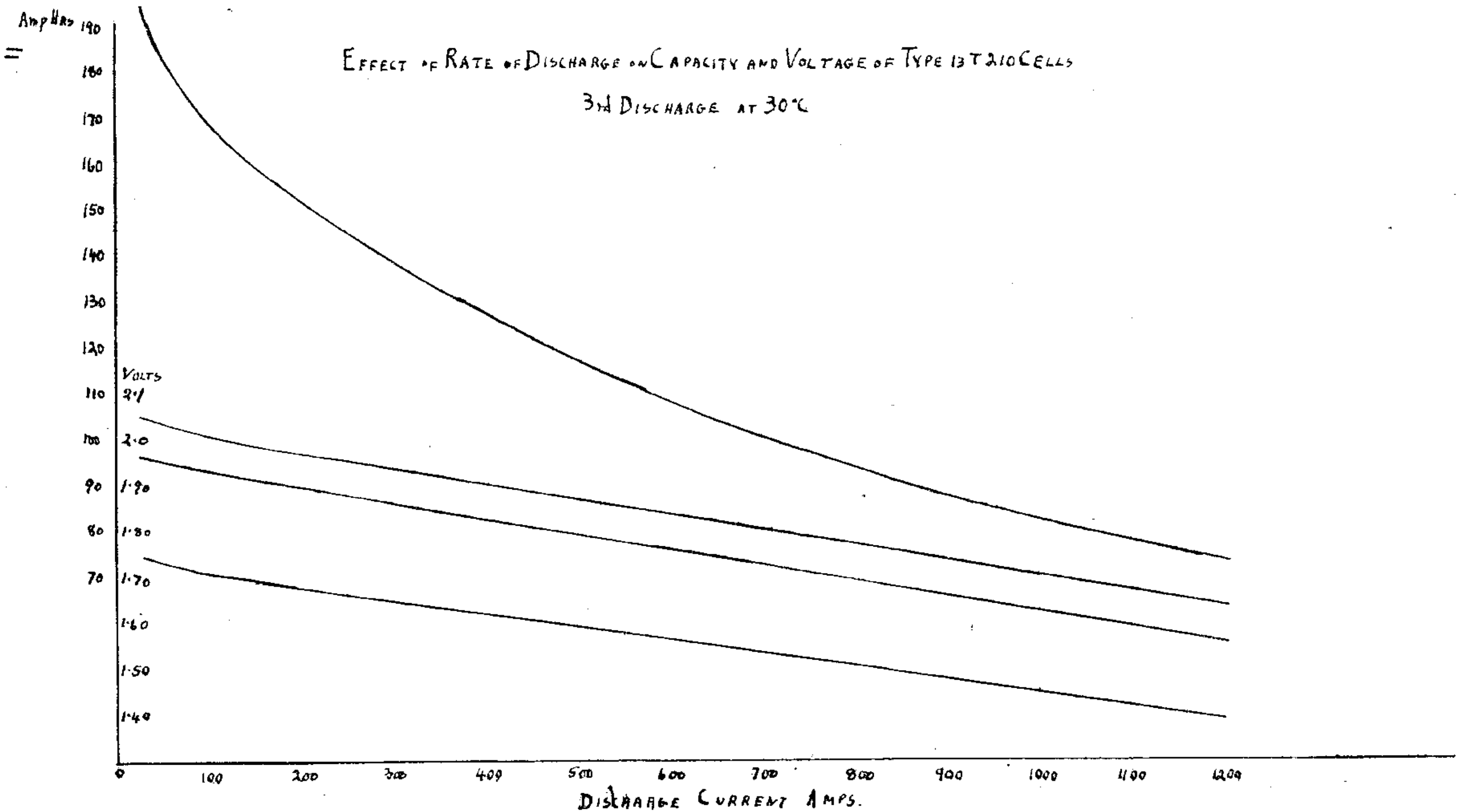


Effect of Rate of Discharge on Capacity and Voltage of Type 17 T210 Cells

3rd Discharge at 30°C

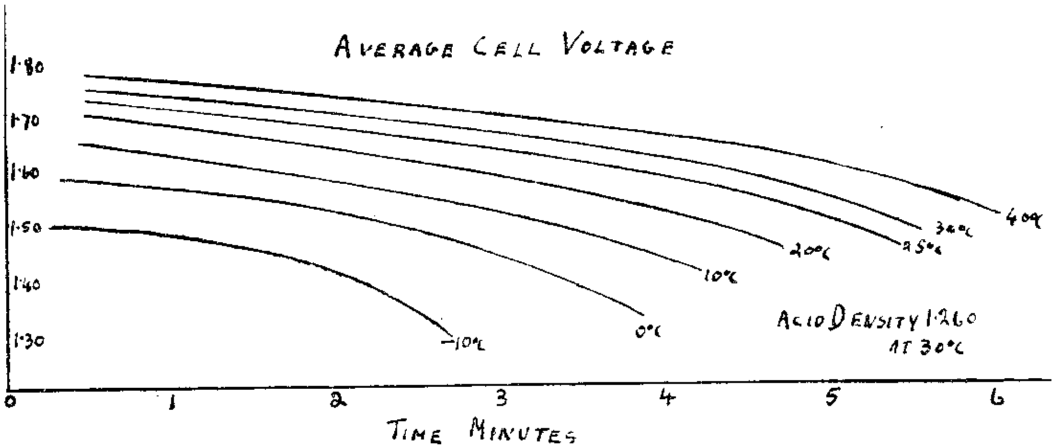


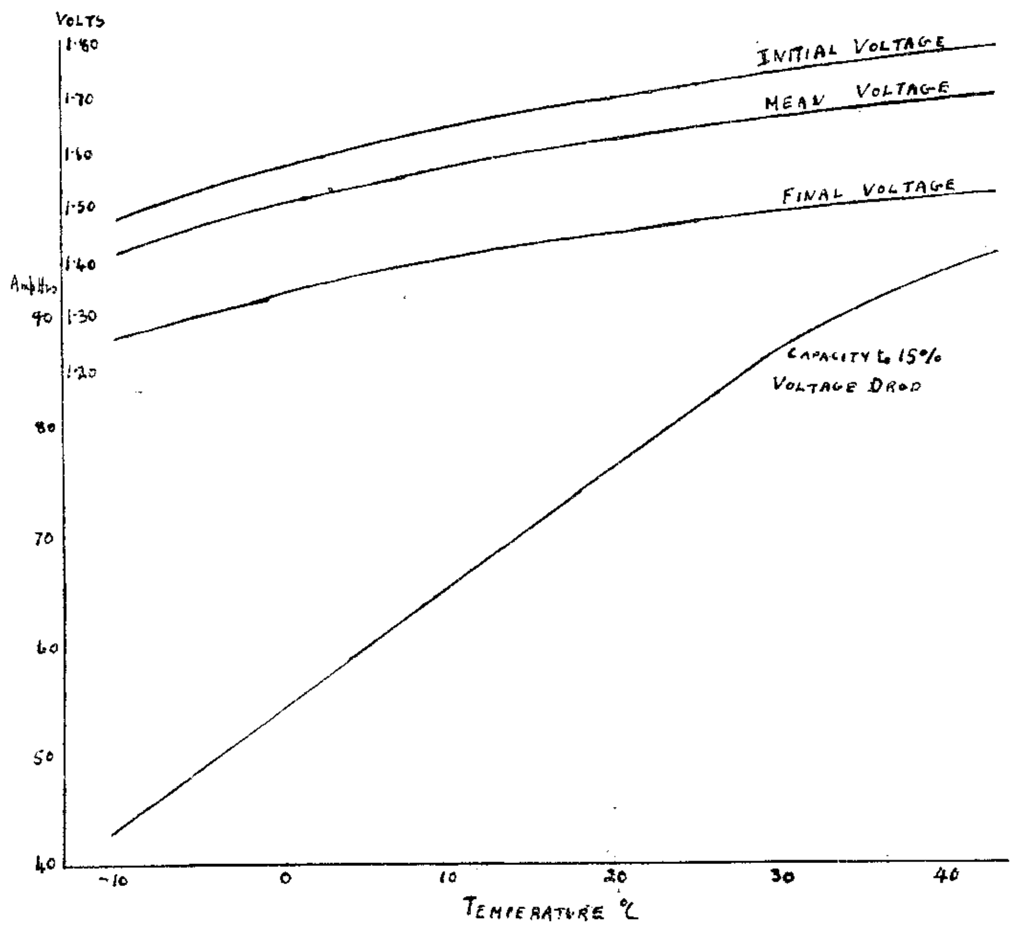




Effect of Rate of Discharge on Capacity and Voltage of Type 13 T 210 Cells
3rd Discharge at 30°C
Amp Hrs
190
180
170
160
150
140
130
120
110
100
90
80
70
Volts
2·1
2·0
1·90
1·80
1·70
1·60
1·50
1·40
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Discharge Current Amps.

Effect of Temperature on Voltage and Capacity of Type 13T210 Cells. 3M Discharge at 930 Amps

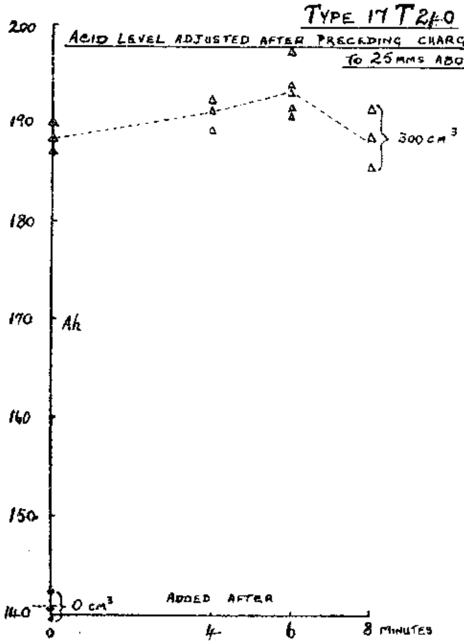


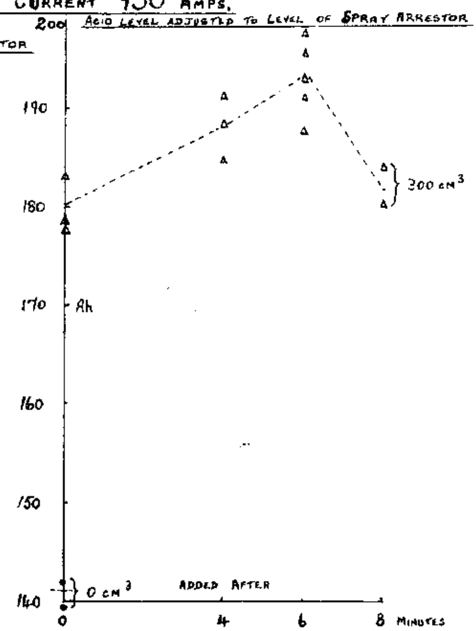


Nr. A.4349c 3. Discharge of T. Cells Initial temperature 30°C.

At different times varying amounts of concentrated Sulphuric Acid (1780 gms/Litre, Temperature 25°C) were added.

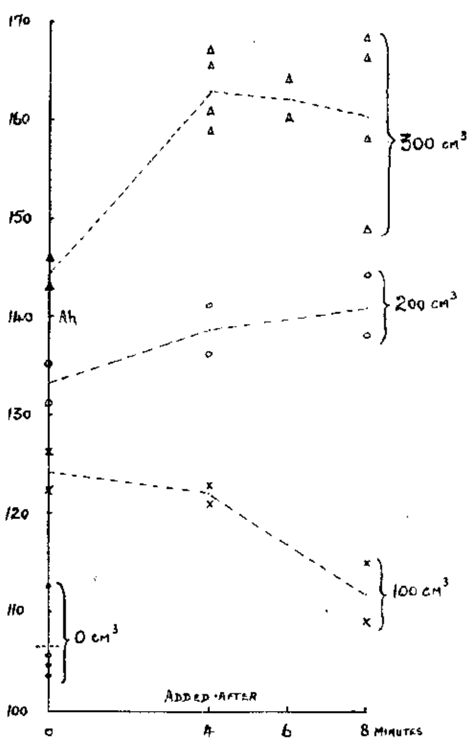
Type 17 T 240 Discharge Current 930 amps.



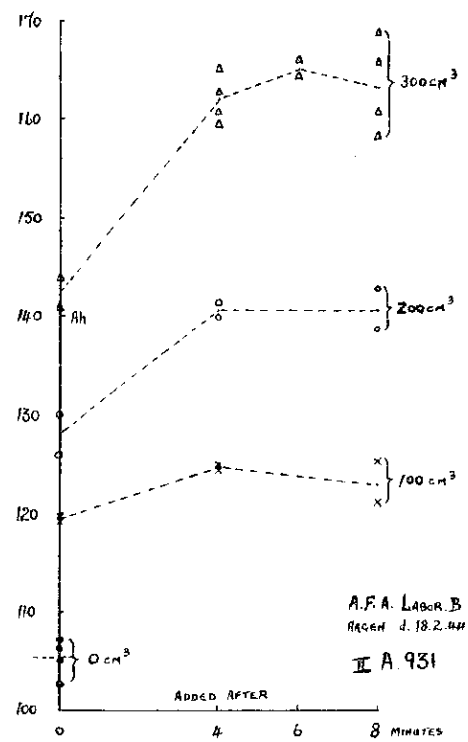


Type 13 T 210 Discharge Current $\frac{13}{17} \cdot 930 \approx 710$ Amps.

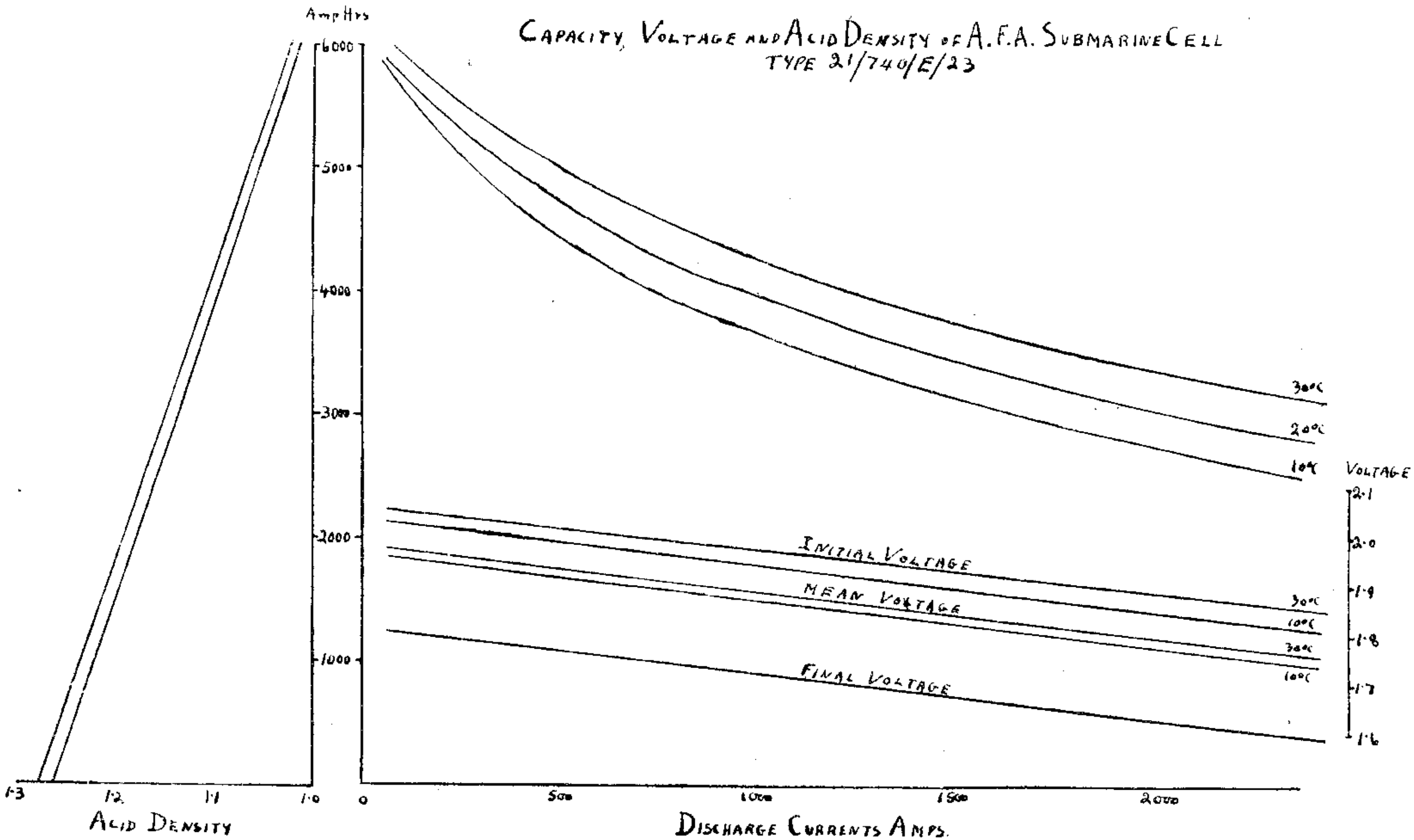
Acid level adjusted after preceding charge to 25 mms above Spray Arrestor



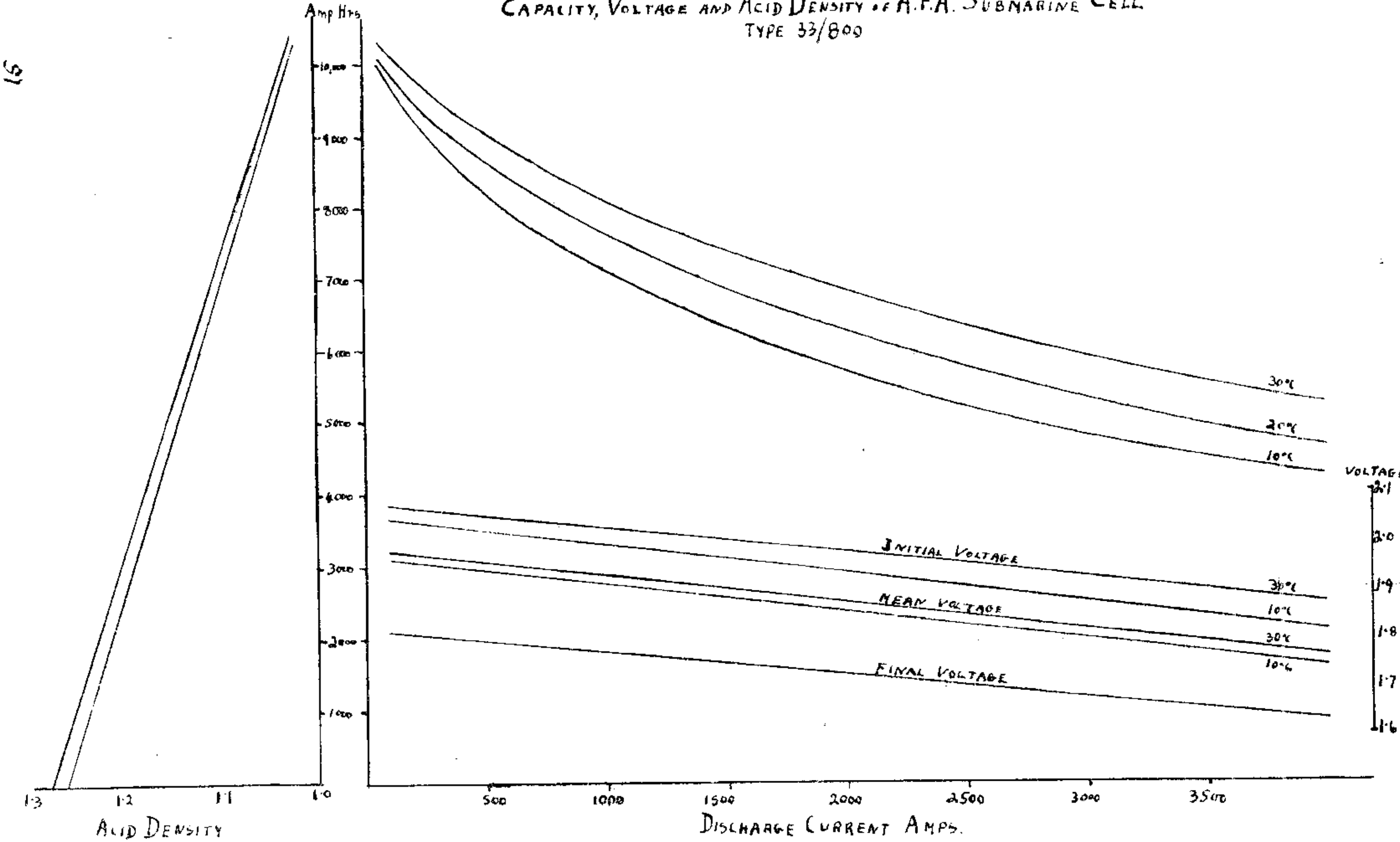
Acid Level adjusted to Level of Spray Arrestor



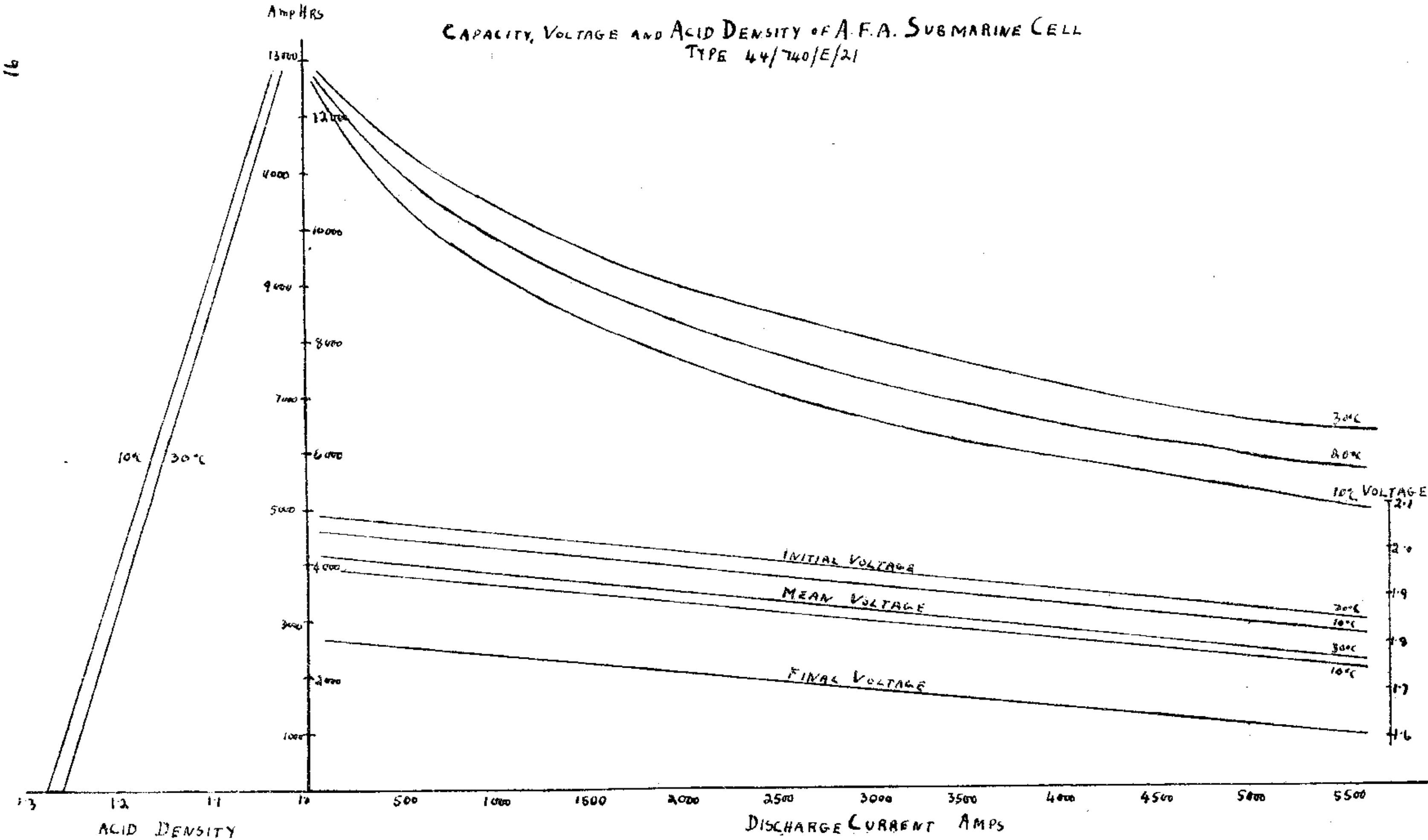
A.F.A. Labor. B
Abgen. d. 18.2.44
II A 931


CAPACITY, VOLTAGE AND ACID DENSITY OF A.F.A. SUBMARINE CELL
TYPE 21/740/E/23
Amp Hrs
6000
5000
4000
3000
2000
1000
30°C
20°C
10°C
VOLTAGE
2·1
2·0
1·9
1·8
1·7
1·6
INITIAL VOLTAGE
MEAN VOLTAGE
FINAL VOLTAGE
30°C
10°C
30°C
10°C
1·3
1·2
1·1
1·0
ACID DENSITY
0
500
1000
1500
2000
DISCHARGE CURRENTS AMPS.

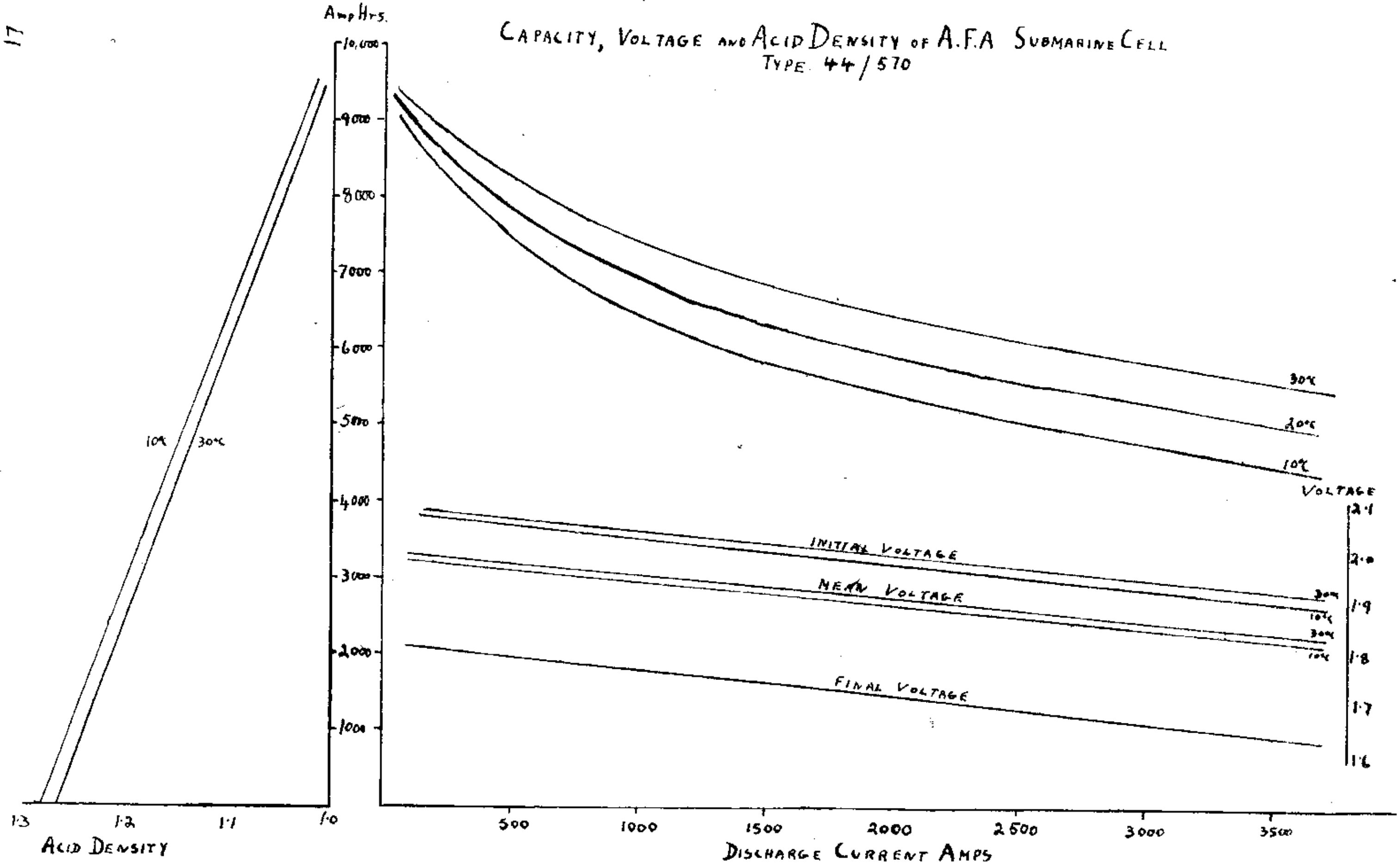
Capacity, Voltage and Acid Density of A.F.A. Submarine Cell
Type 33/800



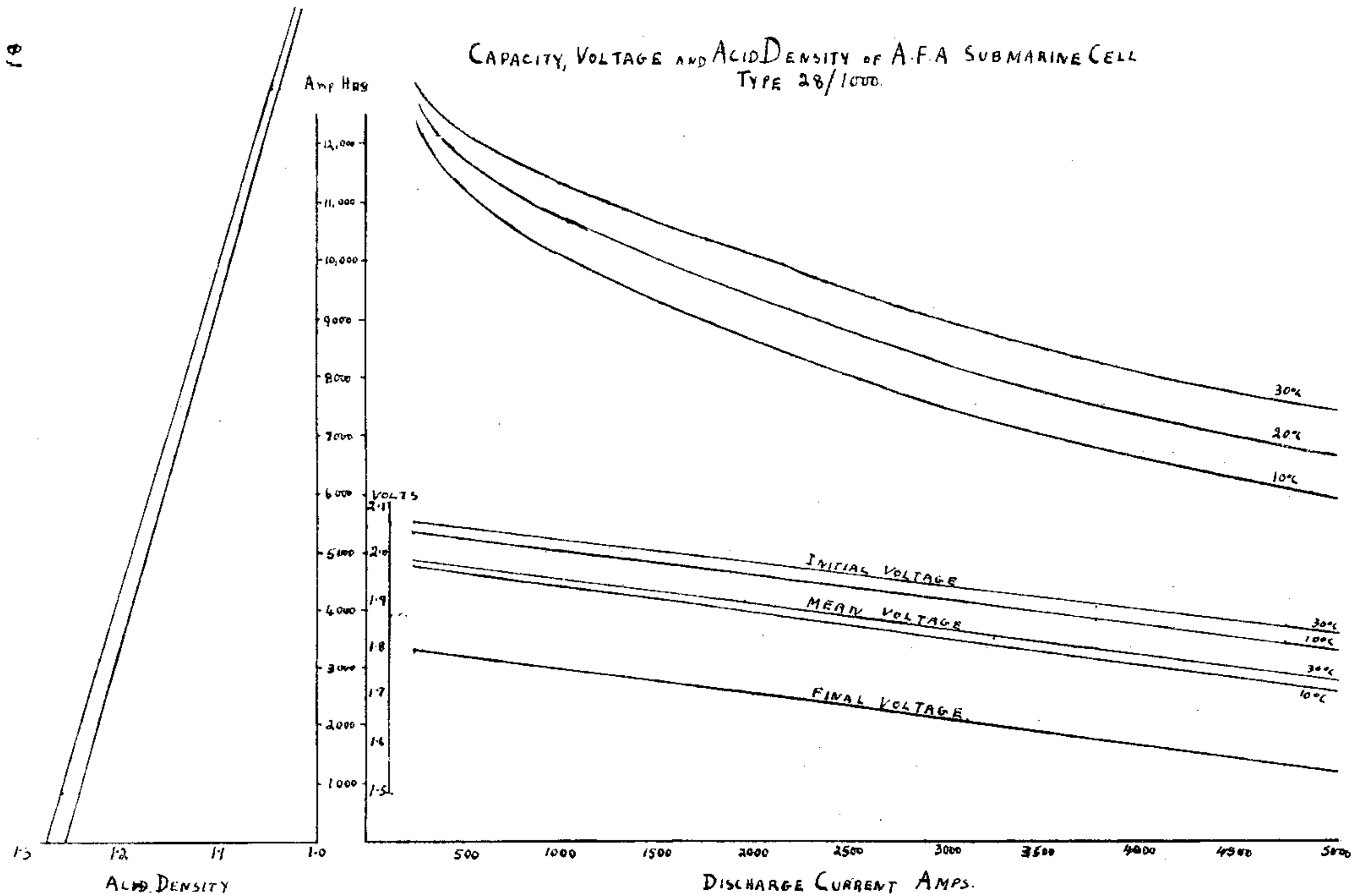
Capacity, Voltage and Acid Density of A.F.A. Submarine Cell
Type 44/740/E/21



Capacity, Voltage and Acid Density of A.F.A Submarine Cell
Type 44/570



Capacity, Voltage and Acid Density of A.F.A Submarine Cell
Type 28/1000.



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