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ITEM No. 31

MISCELLANEOUS ELECTRICAL FACTORIES in the BRITISH AND AMERICAN ZONES.

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BRITISH INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

MISCELLANEOUS ELECTRICAL FACTORIES

in the

BRITISH AND AMERICAN ZONES

Reported by

Lieut Comdr C.G.Lloyd - R.C.N.V.R.
N.L.Kusters - N.R.C. Canada.

BIOS Trip No. 1054

BIOS Item No. 31
Machinery and
Mechanical Equipment

BIOS Target Nos:

C31/141	C31/1810	C31/37	C31/380
C31/382	C31/369	C31/1255	C31/1509
C31/272	C31/383	C31/2374	C31/1667

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
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Personnel of Team

Lieut Comdr C.G.Lloyd - R.C.N.V.R.
N.L.Kusters - N.R.C. Canada.

Refer also for further information to :-

Bios F/R. 884 (B T-240 2) German Battery Electric Vehicles and the German Storage Battery Industry

" " 467 (TK b 885) German Secondary Battery Industry

" " 708 (B TK 158) German Alkaline Accumulator Industry

FD 344/51 (PB 99432) Durag Nickel Cadmium Alkaline Battery

1. <u>Firm</u>

Robert Bosch G.m.b.H. C31/141

2. <u>Location and Persons Interviewed</u>

<u>Main Plant - Militärstrasse - Stuttgart</u>

Mr. Dipper - Asst. Technical Director
Dr. Dorn - Inventor of metalized paper condenser
Mr. Gundert
Mr. Callsen - Generators, Starters
Mr. Müller-Schoen - Condensers

<u>Feuerbach Plant</u>

Mr. Schüle - Managing Director, Insulating Section

<u>Ebersbach Plant</u>

Metallized Paper Condensers

<u>Bempflingen Plants</u>

Commutator Assembly - not visited

3. <u>Conditions of Plants</u>

Main plant almost completely destroyed. Feuerbach plant partly bombed, Ebersbach plant intact.

4. <u>Employees (formerly)</u>

7000 in Stuttgart, 8000 in Feuerbach, 60,000 in all Germany

5. <u>Products made</u>

Ignition equipment, spark plugs, fuel injection equipment, aircraft generators, starters, headlights, windshield wipers, capacitors.

6. <u>Items of Interest</u>

(a) <u>Mica Substitute for Commutator Insulation</u>

Consists of three layers of impregnated glass fibre pressed together and heated similar to canvas base backelite. The impregnation compound is a backelite resin with a maximum amount of ceramic filler. Full information on manufacturing and composition can be found in report CIOS XXVII - 43 by F.E.Henderson. This substitute has lower dielectric strength and heat resistance than mica but is more uniform and easier to handle. It is used in motors and generators upto 110 volts and will be used in the future. The commutators must be under cut to prevent burning.

(b) Aircraft Generators

Aircraft generators seemed to be behind in design. Cotton or synthetic silk insulation was used but no glass. The shortage of copper forced them to use aluminium for the field windings. The increased resistance of the field windings necessitated connecting the two field sections in parallel rather than in series and using two regulators to control the current rather than one. For 3000 watt rating, 30 volt max, 105 amps, 4000/6000 rpm, the weight was 17.8 kg and the dimensions approximately 12" long, 8" diameter.

For starters aluminium was used in the armature and "Cupal" sections were used between the commutator and the aluminium conductors.

(c) Metallized Paper (M.P.)Condensers

The M.P. condenser is a paper insulated condenser of which the metal electrodes are obtained by vaporising zinc on theinsulating paper. It is claimed that these condensers are only about 50 to 60% as large as the conventional metal foil paper condensers of the same capacity and voltage rating. This ratio in volume is claimed to be maintained from the lowest voltage rating up to 1000 volt. For higher voltages, several lower voltage condensers are used in series. These condensers are claimed to possess self healing properties when temporarily subjected to overvoltages.

7. Manufacturing

Two types of condensers are made: single-layer and multi-layer condensers. In the single layer condensers, two metallized paper strips are used with no additional paper insulation. In the multi-layer condensers additional plain paper layers are used in between the metallized paper layers for additional insulation.

The metallizing is done on paper of two thicknesses: 8 and 14 micron (1 micron equals 0.001 mm). The single layer condensers built with 8 micron metallized paper are rated at 150 volt. Higher voltage ratings are obtained by multi-layer construction. The separating layer of plain paper being about 10 micron thick.

The paper which is metallized is a kraft paper and is previously coated with a nitro-cellulose varnish with high dielectric strength. The metallizing is done on the same side the varnish coating is applied. This varnish coating process increases the thickness of the paper by only 0.5 to 1 micron.

The metallizing is done in a vacuum of 0.1 mm Hg (minimum). The speed with which the paper strip is going through the metallizing machine is manually regulated in order to get a foil resistance of one ohm between the two opposite edges of a square. The metallizing is performed in two operations - first silver with zinc. The amount of silver deposited is negligible as far as the conducting quality of the coating is concerned. It plays only a catalytic action which will be explained later. The main coating is zinc. The silver is evaporated in a cavity of a carbon conductor heated by the passage of electric current. The zinc is evaporated in a pot heated by electric resistor elements. The sides of the pot are water cooled.

The condensers are wound on standard winding machines. Both ends of the condenser are sprayed with lead (schooping) forming the two electrodes of the condenser. Afterwards they are vacuum impregnated with wax. The condensers are then subjected to the "Ausbrennung" process.

8. <u>Details of the "Ausbrennung" Process</u>

(a) <u>For single layer condensers</u>

The condensers are subjected to 24 shots by a 10 times larger condenser charged to a D.C. voltage of about 450 to 550 volts. The series resistance is of the order of 12 to 20 ohms. The condenser under test is shunted by a resistance of the order of 100 ohms.

This arrangement provides a sharp wave front for both the leading and trailing end of the impulse wave.

The condensers are then tested for insulation resistance and capacity and rejected if not within the permissible limits. All these operations are performed on an authomatic machine.

(b) <u>For multi-layer condensers</u>

These condensers are subjected to 3 times rated voltage (D.C.) for 3 minutes with a resistance of 1.5 megohm and a neon bulb in series. The dimming of the neon bulb indicates that the condenser is in good condition. If the neon bulb stays lit the operator presses for a short time a button short circuiting the 1.5 megohm resistor. This burns away the existing short circuit in the condenser and after releasing of the button the neon bulb gradually dies out as the condenser is charged. The internal resistance ofthe D.C. source is high enough to prevent damage to the condenser while the button is pressed.

9. <u>History of the development</u>

In the conventional metal foil paper condenser the thickness of the metal foil is limited by the mechanical strength necessary for manufacturing and handling of the foil. When metallized paper is used this limitation disappears completely.

As the first M.P. condensers were made and experimented with, it was soon realized that they possess the amazing characteristic of being self-healing when subjected to overvoltages of short duration. This property is due to the fact that the metal foil is so thin, that the zinc coating is evaporated away from the breakdown point in the paper, thus leaving the damaged part of the dielectric alone and out of the circuit. The only remaining indication being a slight decrease in the capacity of the condenser. This healing by evaporation of the zinc coating should take place before the rest of the dielectric is damaged and for this reason it is desirable to have the zinc coating as thin as possible. A certain thickness is however necessary in order to provide sufficient conductivity of the condenser electrodes. It was found that a resistance of one ohm between the opposite sides of a square was a good compromise.

It was found that there was a considerable discrepancy between the measured conductivity of the zinc coating and the conductivity computed from the weight of zinc deposited, as measured by chemical methods. This was attributed to the fact that the zinc was deposited in globular form with restricted conductivity between the individual globules. This theory was substantiated by the fact that the zinc coating looked slightly blue. By depositing the zinc in very high vacuum in the laboratory a white deposit of zinc could be obtained, in which case the measured and computed values of the conductivity checked. The high vacuum necessary for obtaining this result was considered impractical in a manufacturing process. However, a precoating of the paper by a trace of silver was found to produce the same effect. The action of the silver is catalytic in this respect, that the increase in conductivity obtained is considerably larger than the amount of silver consumed would provide by itself.

The first M.P. condensers built were multi-layer condensers. As the demand for low voltage paper insulated condensers rose, Mr. Dorn tried to develop a single-layer condenser with a paper thickness of 8 micron. At that thickness it was found that the density of conductive spots in the paper was extremely high (of the order of one per square cm). This high density convinced Dr. Dorn that the limit for cellulose type of insulation had been reached. It was then that he developed the varnish coating method. This coating reduced the number of conductive paths by a much greater factor than could be obtained with paper by the same increase in thickness. A reduction factor of about 200 was obtained in the density of the conductive paths by an increase in thickness of 0.5 to 1 micron.

The varnish treatment of the paper has reduced the number of conductive paths in the paper but has not eliminated them entirely. This makes the single-layer condenser when wound not yet fit for service. These conductive paths have to be "burnt out". This is done by the "Ausbrennung" process, which, in the case of the single layer condenser is actually a production process. This "Ausbrennung" process is nothing else but the use of the self healing properties of the condenser in order to get the desired leakage resistance. The minimum rejection leakage resistance for the single layer condenser was 300 megohm-microfarad.

For multi-layer condensers the "Ausbrennung" as described above is not a production process but a check on the self healing properties of the condensers.

The question may arise as to why the "Ausbrennung" for single layer condensers has to be performed at the factory, and under rigidly controlled conditions of sharp wave front at both the leading and trailing end of the impulse wave, rather than to let it happen when and where the condensers are put into service. The answer to this question is that the manufacturer does not know the type of service the condenser is going to be put into, and that there are limitations to the self healing property of the condenser. When used at very small voltages, such as 6 volt, it appears that the circuit cannot provide enough energy to heal the bad spots in the condensers. A gradual decomposition takes place and condensers have exploded under such service conditions. A sharp wave front at both the leading and trailing end of the wave, provides maximum leakage resistance to the condensers.

It is quite obvious that for low voltage ratings a considerable reduction in volume can be reached by this method of construction as compared to the conventional construction. It is surprising, however, that the same reduction factor can be maintained up to voltage ratings of 1000 volts and even higher. It appears that this is due to the fact that for the higher voltage ratings one can rely with safety on the self healing property of the condenser thus making it possible to stress the dielectric to a higher value than would be permissible for the conventional paper condensers.

1. <u>Firm</u>

Brown Boveri Co. (BBC)

2. <u>Location and Personnel Interviewed</u>

C31/1810 <u>Head Office</u> - Heidelberg, Keplerstrasse 87

Mr. Sidney Brown, visiting from head firm in Switzerland
Mr. Mönnich
Director Deichmann
Mr. C.Kneller, Stability expert

C31/37 <u>Mannheim Plant</u> - Käferthal - Mannheim
(Transformers and large rotating equipment)

Director Max Mayer
Mr. Weiss, Transformer design

C31/380 <u>Stotz - Kontakt G.m.b.H.</u> - Heidelberg - Pfaffengrund
(small switches and control gear)

Mr. Sartorius, plant manager
Mr. Schilling, design engineer of voltage regulators.

<u>Gross Auheim Plant</u> nr Hanau
(Circuit breakers, control gear, refrigerators and stoves)

Dr. Warlimont, director
Herr Körner, Production Engineer
Herr Hassler, from Heidelberg office
Herr Eisele, Test Department
Herr Müller, Test Department.

<u>Other Branches not Visited</u>

Stotz Kontakt - Eberbach - nr Heidelberg
Electric Furnaces - Dortmund
Induction Heating - Kelheim (nr Regensburg- Mr. Schneider
Rectifiers (Steel Tank) - Lampertheim-Mannheim- Mr. Mayer - Delius
Rectifiers (Glass Bulb) - Berlin

3. Conditions of Plants

Kaferthal - Mannheim

Badly bombed, expecially the new transformer assembly shop. Some sections of motor factory in working order. There were 3500 employees and now 1300.

Stotz Kontakt - Pfaffengrund - Heidelberg

Undamaged. It had 1500 employees and now 400, mainly women. The voltage regulator section of this plant is an old sugar factory nearby (undamaged).

Gross Auheim Plant

Undamaged.

4. Transformer Construction

Core laminations are insulated with paper .04 mm thick. Conductors are insulated with wrapped paper but no varnish is used. The coils are vacuum dried and then oil impregnated. Continuous windings are used where possible to avoid joints in the conductor. Paper cylinders not bakelite treated, are in general use. Tap changing under load was by quick-change resistance switching, with separate resistors mounted on top of the mechanism. Three phase transformers are used up to 100,000 KVA. They are generally three legged except for the 100,000 KVA "Wander-transformator" which has a five legged core. No shielding was used up to the highest voltage of 220 KV. This is probably influenced by the extensive use in Germany of Person coils. The "Wander-transformator" mentioned above is one of Germany's worthwhile electrical developments. It is a transportable three phase transformer, completely built within the railroad profile including bushings, pumps and cooling fans. For transportation it is suspended between two specially designed railroad cars. Maximum capacity 100,000 KVA.

No aluminium conductors were used in transformer construction.

5. Motor Construction

There was nothing unusual observed. Aluminium conductors were used in the smaller sizes.

6. Testing Equipment at Käferthal - Mannheim

There had been two high-voltage testing transformers built in Switzerland with 750 KV in one unit. Two were cascaded for 1.5 million volts. The windings were in oil and the core in air. Both transformers were ruined by bombing. There had been an impulse generator for 1.8 million volts.

7. Stotz Kontakt - Pfaffengrund - Heidelberg

A full line of switches, no-fuze breakers and small control devices were made. Catalogues were obtained. Voltage regulators were made in the adjoining plant. Magnetic as well as thermal overload protection is used even in the smallest type of no-fuze breakers.

The voltage regulators were of the well known Brown Boveri rolling sector type design. The same mechanism was used in an automatic cynchroniser.

A quick acting reverse current relay was of interest. Operating time - .002 sec. According to Stotz this relay was quite generally used by Telefunken for the protection of their rectifier tubes in transmitting stations.

8. Submarine Switchgear

The following equipment was seen :-

(a) Camshaft operated controller for the main motors of the 750 ton U-Boat. This submarine is of the twin screw type. Each screw is driven by a twin electric motor with two commutators. The submarine is equipped with two 110 volt batteries. There is one controller for each twin motor. This controller provides possibility of connecting both batteries and motors in series or parallel with or without a single step starting resistor in series. This can be done for both directions of rotation. Field control for the motors is also provided. The whole unit including automatic circuit breaker is contained in a frame 4½' high x 5½' long x 2' wide approx. Rated current: 1000 amps.

The main component of this controller was a very compact, mechanically operated, 1000 amp contactor made by Siemens Schuckert in Berlin. The main contacts of this element were silver plated and stationary. Contact was made by two silver plate rollers. The arcing contacts were copper and could be replaced. Snap action at interruption was produced by a magnetic circuit holding the arcing contacts closed. This magnetic circuit was excited by the load current so that this snap action was adjusted to the current to be interrupted. One of these contactors was removed.

(b) Automatic circuit breakers for 1000, 3000 and 4500 amps, 220 volts DC. These circuit breakers were not shockproof. They were locked in when attacked.

(c) Auxiliary motor starters. Single resistance step was used. A position was provided for exciting the field through a series resistance to keep themotor dry when not in use.

(d) Shock testing equipment had been removed. No concrete information about German Navy shock testing specifications could be obtained. According to the BBC people two types of tests were carried out; a vibratory shock test and an impact shock test. The vibratory shock test was carried out by mounting the equipment on a flexibly mounted platform which was struck by a falling hammer through an anvil plate flexibly mounted to the platform. The impact test consists of dropping the whole equipment including a mounting platform from a height of six feet. The fall is broken by a downwards projecting shaft hitting a block of lead. The depth of penetration of the shaft into the lead is used as an indication of the shock intensity. Approximate dimensions:-

Projecting shaft:	30 mm diameter
Block of lead :	60 mm thick
	200 mm square

As maximum acceleration values measured on this type of equipment figures of 500 g to 5000 g were quoted depending upon the frequencies involved.

9. <u>High Voltage Circuit Breakers</u>

Oil circuit breakers are made up to 10 KV, 500 MVA interrupting capacity.

From 10 to 30 KV water breakers and air blast breakers are made. Above 30 KN air blast breakers alone are used. Oil-poor breakers used to be manufactured in the latter range, but have been discontinued in favour of the air blast breaker. The reason given was danger of explosion. Air blast circuit breakers were built up to 220 KV, and 2.5 million KVA interrupting capacity. A 400 KV breaker was designed but never built. All research work was done in Switzerland.

Experience with 220 KV circuit breakers had shown the production of very high overvoltages due to thelow internal damping present in a 220 KV system. These overvoltages were causing flashovers and in order to remedy this situation as resistor was introduced into the circuit before the final interruption of the arc. This introduction of the resistor in the circuit is done without mechanical motion by the stretching of the arc produced by the air blast. It was found later that this resistor increases the interrupting capacity of the breaker considerably (50% in some cases). This resistor was therefore introduced in all the air blast circuit breaker.

The latest design 220 KV air blast circuit breaker uses multiple interruption with condenser type voltage divider. This design is based on the following experimental results reported by H.Thommen in "BBC Nachrichten" Oct/Dec 1943. The fundamental circuit breaker experimented with consisted of two contacts one of which is a plate with a hole, theother being a solid rod covering the hole. The air blast is so directed as to blow the arc through the hole.

(a) The interrupting capacity variation with the contact separation presents a maximum. This maximum is reached for a separation too small to safely withstand the voltage without air blast, once the breaker has been opened. A disconnecting switch is used to provide the required separation in the open breaker.

(b) For the same air consumption, the interrupting capacity presents a maximum for a certain voltage. This leads to the multiple interruption construction which, when equipped with efficient voltage equalizer, provides the possibility of testing individual component parts of a large breaker. The moving parts are also very light so that extremely rapid reclosing can be obtained.

10. High Voltage Testing Transformer

This transformer was intact.

Manufacturer: Hochspannungs Gesellshaft, Köln-Zollstock.
600,000 volts - 200 KVA - Oiless

Barrel winding are used on the two legs. They are cross connected. The cross connectors are spring loaded telescoping rods and pull out of place readily for easy dismantling and repair. Size is approximately 18 feet high with center barrels approx 6 feet in diameter.

11. Load Ratio Control Gear for Transformers

Two types are manufactured for use in transformer neutral and for use in floating winding. The units seen were rated 37 KN 640 amps.

12. Electric Stoves

These were being made under the tradename "Sigma". Insulation of oven was aluminium foil only. Enamel was poor. Elements were not seen but were solid top type with resistance wire beneath in ceramic insulation.

13. Refrigerators

Larger commercial models were being made. The finish was poor. The thermal insulation material used was extremely light. It is an IG Farben product called "Iporka" supposed to be very good in performance.

1. Firm

C31/382 Siemens Schuckert Transformatorenwerk

2. Location

Nurnberg, Katzwangerstrasse 150

3. Personnel Interviewed

Mr. Rebhan - Manager
Mr. Ibler - Transformer Design
Mr. Born - Engineer

4. Condition of Plant

Approximately 60% bombed

5. Products Made

Transformers of all sizes from 25 watt to 100,000 KVA - 40% of total German Transformer production

6. Transformer Construction

(a) Cores - Silicon steel, with water-glass insulation burned on, giving a better space factor than paper, formerly used. A flux density of 14-15,000 gauss was used. The steel had a loss of 1.1 watt/kg at 10,000 gauss.

(b) Conductors - Copper was preferred when available but aluminium was used due to the shortage of copper. Aluminium conductors had been used in transformers up to 60,000 kva. Aluminium conductors reduced the rating of a transformer by about 20%. Another bad feature of aluminium on a conductor material is its lower mechanical strength. For this reason the permissible temperature rise under shortcircuit, specified by VDE at 250°C after 5 sec for copper, had to be reduced to 200°C for aluminium conductors. This often required larger conductors than would be necessary for the normal full load temperature rise of 70°C in the conductor. (Standard oil hotspot rise was 60°C max)

Copper and aluminium were joined together by resistance welding under pressure. Aluminium conductors were welded together by gas welding.

(c) Insulation - Paper is wrapped on the conductors the conductors are wound on a mandrel and then placed over soft paper or pressboard cylinders in assembly. No varnish impregnation is used except for oilless transformers. Oilless transformers are made up to 800 kva, 6000 volts, though a special job had been made up to 20,000 volts. As the use of Peterson coils in power transmission is common, no graded insulation was used. All transformers were fully insulated for rated voltage.

(d) Shielding - A minimum amount of shielding was used at 100 KV and higher. A ring, connected to the line terminal, was placed around the two end pancake windings in order to distribute the impulse over the first few windings.

(e) Windings - No continuous windings were seen. They were made in sections and brazed together.

Tank sides for medium size transformers were made by continuous bending of sheet steel and then welded. Forced air cooling gave approximately 30% increase in capacity. Current densities in copper were 2-4 amps/mm^2. Latter figure is for forced air cooling.

(f) Load Ratio Control - Made in 300 and 600 ampere sizes and mounted on an insulating structure for use up to 100 KV. Its insulation was designed for a maximum voltage of 2000 volts per step, and employed quick (1/100 sec) switching with resistance. Four contacts were used on each switch, two main and two auxiliary. Formerly reactor coils were used for switching, which were left in the circuit.

7. Testing Laboratory Equipment

High voltage transformer for 1.6 million volt, 1500 KVA continuous in one unit. The transformer is built for outdoor use. The tank is at mid-potential and the transformer is equipped with two identical bushings. It was completed in 1939 and damaged by the RAF to the extent that both bushings need replacing. A picture of this transformer is included. Each porcelain supporting column is made up of two sections. Each section is about 7-ft high.

The laboratory was equipped with two impulse generators, one indoor and one outdoor.

Indoor impulse generator (1 million volt
(7000 watt-sec

Outdoor impulse generator (3 million volt
(42,000 watt-sec.

The latter was completed in 1935 and is fully described in "Siemens-Zeitschrift" Nov 1935 p 504-511. Three million volts were reached in 15 steps of 200,000 volts. For each step there were four 100,000 volt 0.14 microfarad condensers in series-parallel. The condensers were of the oil impregnated paper type. The rectifier provided 200,000 volts symmetrically with respect to ground. Resistors for limiting the condenser charging current were liquid, with distilled water, glycerine and "weinsteinsaure", 20,000 ohms each. The cost of the total total outdoor construction was only about 50% of an equivalent indoor installation. It was however admitted, that an indoor generator was very superior. Both impulse generators were damaged considerably.

1. Firm

C31/382 Siemens Schuckert Motorwerk

2. Location

Nürnberg, Landgrabenstrasse 94 - 100

3. Personnel Interviewed

Dr. Haas - Manager

4. Condition of Plant

Completely destroyed. Employed formerly 2000 people, now 100.

5. Products Made

A.C. motors and generators 10 - 2000 Kw. Smaller and larger sizes were made by Siemens in Berlin, D.C. machines in Vienna since 1938.

6. Insulating Materials

Dr. Haas explained there were three classes of insulation for rotating equipment in Germany: Class A - 60°C rise, Class B - 80°C rise and Class C - 120°C rise. For the first cotton, artificial silk and artificial wool were used; for the latter two, non-organic materials such as glass fabric and asbestos. The same binder was used throughout, a synthetic lacquer with a minimum amount (2 - 3%) of natural oil being preferred. There was no evidence of any knowledge of silicones. An additional insulation class, Ah, was introduced during the war using enamelled wire and tri-acetate paper. The temperature rise for this class was 80°C. Class C motors had been used since 1934 and had given excellent results.

Research was carried out on the use of extremely thin (.003 to .005 mm) glass sheet pasted on paper as a substitute for mica. The cost was about three times that of mica. A special type of glass was used with good electrical properties at the higher temperatures.

7. Conductors

Copper was preferred but aluminium was used because of the shortage of copper. Aluminium conductors were used in stators and field coils, and, of course, in squirrel cage rotors, but never in D.C. armatures because of the difficulty of connecting to the copper commutator. Where connections were necessary between copper and aluminium it was achieved by butt or spot welding.

No use was made of aluminium conductors insulated only by an aluminium oxide coating. This was tried but was not successful even in oil-immersed motors because of the tendency of the oxide to crack on bends.

Aluminium conductor motors were made in the same frames and sold for the same prices as copper conductor motors up to 20 Kw. This was achieved mainly by cutting down on theinsulation but also by the fact that aluminium conductors are more flexible. They can be pushed into position rather than hammered, leading to easier assembly better space factor and the possibility of using enamelled wire for greater diameters than for copper (up to 1.7 mm diameter for aluminium andonly 1.2 mm diameter for copper).

8. Bearings

Generally ball or roller bearings, sleeve bearing from 1000 Kw up. Shielded ball bearings were not used.

9. Special Motors.

For airplane model work small water cooled motors were made - (150 HP, 24,000 rpm).

Dynamometers up to 150 Kw were made with commutator speeds up to 90 meters/second (8000 rpm).

1. Firm

Siemens Schuckert

2. Location

C31/369 Mulheim (Ruhr)

3. Personnel Interviewed

Mr. Klosterberg - Turbine design engineer
Mr. Eppelsheimer- Engineer in charge of manufacture.

4. Products Made

Steam turbines (radial, axial and Ljungström)
Turbo generators
Turbo-generator exciters

5. Points of Interest

A 40,000 kva, 10,000 volt, 3000 rpm turbo generator was seen under construction. Very good workmanship was observed. The largest turbo generator made at this plant was 80,000 kva, 3000 rpm for the power station at Schelle, Belgium (1936).

Aluminium conductors have never been used. It was feared that the larger elongation and contraction by temperature variation would damage the insulation in turbo machines, where the conductors are very long. The only insulation material used for slot insulation was mica.

1. Firm

A.F.A. Accumulatoren Fabrik Aktiengesellschaft

2. Location

C31/1255 Hannover - Stockener Strasse 351

3. Personnel Interviewed

Herr Bronstert - Technical Director
Herr Kann - Asst. Technical Director
Herr Desenies - in charge of alkali battery manufacture

4. Condition of Plant

One building of many hit, remainder almost intact. 6000 people had been employed, mainly imported labour (D.P's).

5. Products Made

Lead-acid submarine and torpedo batteries, alkali batteries for aircraft. The latter batteries are of a new type and are called "DURAC". The firm is now producing car batteries.

6. Technical Information

(a) Submarine Batteries - Submarine batteries are lead-acid, using wooden separators next to the negative plate, followed by an igelit spacer. Igelit is a poly-vinyl-chloride plastic by I.G.Farben. It is used in the form of a thin, perforated and currugated sheet. White pine or fir is used for the wood but American cedar is preferred. The cases are hard Buna S, with a soft rubber liner.

Two sizes were made:-

(1) 44 MAL 740

Dimensions of one cell: 379 x 621 x 913 high
Weight of one cell: 598 Kg filled
Capacity: 20 hours at 565 Amps

(2) 2 x 21 MAL 740

This is a two cell unit producing 4 volts.

Dimensions of one unit: 379 x 621 x 913mm high
Weight of one unit: 610 kg filled
Capacity: 20 hours at 270 amps

For the grids a 6% antomony lead was used. The positive plate paste contained no activating materials. The negative plate paste was of the following composition.

0.6 lignin
0.167% Barium sulphate
0.083% lamp black
The balance being lead-dust.

All these components are mixed in the dry state before the addition of acid.

(b) Torpedo Batteries - Torpedo batteries are also of the lead-acid type. Wood separators are used but in place of igelit, hard rubber is used as second separator.

Thickness of plates: 1.5 mm
" " wooden separator: 0.25 mm
" " hard rubber separator: 1.8 mm

This separator is a perforated and corrugated hard rubber sheet. The sheet is 0.4 mm thick and the total depth of corrugation is 1.8 mm.

Two banks of 26 cells each are used in series. Heaters are placed between the cells to keep the battery at 30°C before launching. Two types of batteries are made:

(1) 17 T 210

1 battery equals 2 banks of 26 cells each plus one additional unit of 2 cells.

Dimensions of one bank: 1420 x 380 x 325 mm high
Weight of one bank: 330 Kg dry
Dimensions of one additional unit 380 x 134 x 325 mm
Weight of one additional unit: 27 Kg dry
Capacity: 8 minutes at 930 amps

(2) <u>13 T 210</u>

1 battery equals 2 banks of 26 cells each
Dimensions of one bank: 1300 x 380 x 320 mm high
Weight of one bank: 267 kg dry
Capacity: 7 minutes at 800 amps
Specific gravity of electrolyte when charged: 1.280

The reason for the use of hard rubber instead of igelit separator is the following: It was found that with igelit separators a small amount of Chlorine was in solution in the electrolyte. This chlorine does not affect the plates as long as the battery is kept charged. In the discharged condition however, the plates disintegrate slowly. Such a condition, although of no importance for submarine batteries which are kept charged, could not be tolerated for torpedo batteries. A.F.A. admitted that they were taking a chance in using igelit separators in car batteries.

In order to increase the initial capacity of the batteries, 1% lamp black is added to the positive plate paste. This lamp black, acting as a conductor, accelerates the forming of the plate. It is oxydized during the forming leaving no trace and thus increasing the porosity of the plate.

In addition to the old, well-known activating agents a new one "lignin-sulfo-säure" is used in the negative plate paste. This activator is used in the form of a solution while the other activators (barium sulfate 0.37% and lamp black 0.19%) are mixed in dry condition. Information as to the source and method of using this activator was obtained.

(c) <u>"DURAC" Batteries</u> Refer also to FO 394/51 (PB 49432)

This is a new, plate type, alkali battery developed jointly by A.F.A. and I.G.Farben. Research work was started in 1931. The positive plate was developed long before the presently used negative plate. It is felt that the performance of this negative plate is not yet satisfactory.

In order to reduce the high internal resistance of the common alkali battery, the active material is deposited chemically on a vary porous metal grid, obtained by the sintering process.

Advantages claimed :-

(i) Practically indestructible
(ii) Low internal resistance so that it is suited for starting airplane engine
(iii) High low temperature performance
(iv) Efficiency comparable to lead-acid battery

No specific performance data could be obtained They are available in the parent firm in Hagen. It was claimed however that a Durac battery of same capacity at room temperatures as a lead-acid battery, weighs about 10% more, but its low temperature (-20°C) output is about three times greater.

(d) Positive Plates

Pure nickel powder is used for the positive plates. The sintering is done in a mould without pressure. As reinforcement and terminal connection a frame, covered with a wire mesh, is used, both in nickel plated steel. Sintering is done in a reducing atmosphere at a maximum temperature of 360°C for 1½ hours. A porosity of about 75% is obtained. It is claimed that a 60 x 78 x 2 mm plate possesses a total active surface of five square metres.

The plates are then vacuum impregnated with nickel nitrate. Afterwards they are dipped in a sodium hydroxide solution which gives a deposit of nickel hydroxide on the sintered grid while soldium nitrate goes in solution. In order to prevent clogging of the pores during this chemical reaction, a current is passed from the plates. The gas formation by electrolysis keeps the pores open. After a washing with water to eliminate the soldium nitrate, the same impregnation process is repeated three more times in order to produce a sufficiently thick coating of active nickel hydroxide. The plates have a green colour at this stage.

(e) Negative Plates

The sintering is done in the same way as for the positive plates except that a mixture of copper (70%) and nickel powder (30%) is used. The sintering temperature is 920°C.

For the impregnation of the negative plates a solution of cadmium chloride is used to give a deposite of cadmium hydroxide. The hydrogen produced at the plates by electrolysis reduces this cadmium hydroxide to cadmium. After impregnation the plates look grey; when brushed, they have the appearance of metallic cadmium.

(f) Separator

For separation the negative plates are wrapped with a few turns of igelit cord 0.8 mm diameter.

Electrolyte in battery:- Potassium hydroxide
Voltage per cell:- 1.2 volts at mid-discharge

(g) Formation of plates

The plates are formed in the assembled battery. The following cycle is used :-

1 charge	2 amps	10 hours
discharge	"	3 hours
2 charge	"	7½ "
discharge	"	5 "
3 charge	"	7½ "
discharge	"	to 1.1 volt per cell

7. Storage

It is recommended that the batteries be stored in the discharged condition. When stored in the charged condition a decrease of the capacity occurs. Measurements have shown that this is due to a loss of capacity in the negative plate. This loss can be recovered by a very deep discharge of the battery. This is one of the main disadvantages of this battery which A.F.A. hopes to overcome. A new durac battery has a capacity of about 120%. After about one month in the charged condition the capacity has descreased to about 80% By a deep discharge a capacity of 100% can be obtained. This 100% can be regained at any time of the life time of the battery.

1. Firm

Voigt und Haeffner A.G.

2. Location

C31/1509 Frankfurt a/M, Hannau Landstrasse 117/119

3. Personnel Interviewed

Dr. F. Jordan - Director of Research and Testing
Dipl.Ing.K.Autenrieth - Testing Engineer
Ing. L.Haag - Switchgear, Design Engineer
Ing Rosenow - L.T. Design Engineer

4. Condition of Plant

75% bombed; employed 4000 people in peace, 7000 in war.

5. Products Made

HT and LT Switchgear at this plant. Small switches and wiring devices made at Langen near Darmstadt. Heating devices made at Soden Salmunster, nr Hanau.

6. H.V. Circuit Breakers

The firm has been concentrating lately on oil-poor ("minimum oil") circuit breakers, with blast effect produced by the pressure of the arc working a spring return piston. The firm used to make water and air-blast circuit breakers but consider the oil-poor type to be superior in operation. It is more reliable than the air-blast breaker and does not require an air gap as does the water breaker. The latter breakers are also more expensive to build than the oil-poor type.

Heating elements of the "Calrod" type are called "Backer". They are made by filling steel tube with a mixture of magnesium oxide powder and water. The tube is then baked in an autoclave at 400 deg C. This converts the magnesium powder into magnesium hydroxide. This magnesium hydroxide is larger in volume than the original filling and completely fills the tube. Latterly the resistance element was an aluminium-steel alloy in lieu of a chrome-nickel alloy. Dr. Jordan claims it was almost as good. This "Calrod" type heating element is considered too expensive for German domestic equipment and is used in industrial equipment only.

It is of interest that all motor protection equipment was provided with both thermal and magnetic tripping devices.

7. Testing Facilities

(i) High Voltage Installation

Two high voltage transformers of 500,000V each to give 1,000,000V in cascade.

Manufacturer - Hochspannung Gesellschaft Köln-Zollstock.

Rating: (500,000 Volts max
(300 KVA

These transformers are oilless. Their construction is of the core type, with barrel winding on each leg. Each layer of windings is on a herkolite cylinder, each cylinder being shorter than theother as the diameter increases. The windings on the two legs are cross-connected. The highest voltage layer has a shield in the form of three or four copper strips, each about four inches wide. Both transformers had been damaged and were dismantled.

An electrostatic voltmeter built by Hartmann and Braun had been used up to 1,000,000 Volts. It consists of two spheres, one of which is movable to adjust the measuring range. Part of one of the spheres is suspended by a spring and its attraction to the other sphere is measured with the aid of a mirror deflecting a light beam.

(ii) Circuit Breaker Testing Installation

This installation consists of a generator with small driving motor, a specially designed three phase transformer for testing up to 60 KV and two single phase standard transformers for testing up to 200 KV.

Generator

Manufacturers: POGE - Chemnits

Smooth rotor machine

Driving motor- wound rotor induction motor - 1500 rpm

No flywheel was used.

Three Phase Transformers:-

Manufacturer:- Frankfurter Transformatoren Fabrik
M.TOPP und Co.

Rating:- 150,000 KVA for 0.4 sec
Prim. voltage : 18 x 0.7 KV with a max of 6.3 KV
Sec. voltage : 18 x 3.325 KV with a max of 59.85 KV
Prim. Amps : 18 x 6873 amps
Sec. Amps : 18 x 1447 amps
Frequency: 50 cycles
Internal impedance: 9.4%
Weight : 45 metric tons

The transformer was of the oilless, core type construction each core carrying 18 twin pancake type windings, each pancake consisting of a primary and a secondary winding wound in a formed bakelite insulator. Both primary and secondary are completely reconnectable. According to Mr. K. Autenrieth 400,000 KVA was reached with the combination of this transformer and the generator.

8. <u>"Packetschalter"</u>

The "Packetschalter" is a layer built rotary switch. These switches are built with a maximum of about 10 layers on one shaft. By gear coupling of several shafts up to about 200 circuits can be operated by one handle. One switch was seen rated 600 amps, 250 volts. It was of a three layer construction about one foot diameter and 10" high including handle. Some switches were equipped with a solenoid operated interlock.

As insulating material some bakelite was used but mostly urea-base plastic.

As conducting material copper was used and copper to copper contact in the switches. For connection to aluminium cable the switches were provided with lugs made out of "Cupal". This is the trade name of an A.E.G. product consisting of copper with a thin layer of aluminium rolled on. This metal is used whenever copper and aluminium conductors are connected together in humid atmospheric conditions. It appears that under those conditions an electrolytic action takes place between the two dissimilar metals causing corrosion. When "Cupal" is used no moisture can possibly penetrate to the contact point of the dissimilar metals and corrosion is thus eliminated.

1. Firm

Felton und Guilleaume Carlswerk A.G.

2. Location

C31/272 Köln/Mulheim

3. Personnel Interviewed

Dr. Meyer
Dr. Kieser - Director of Laboratories
Dr. Leilich - plastics
Herr Buedscheid - Manufacture of Power Cables

4. Products Made

Electric cables of all kinds.

5. Information Obtained

(a) Lead Substitutes for Cable Covering

Research was carried out on lead substitutes for covering cables. Aluminium had been experimented with and very good results obtained. It is applied in the same way as lead. It was found that the higher temperatures and pressures required did not damage the insulation. The covering thus obtained was lighter and more flexible. Dr. Meyer feels that it is the covering of the future. It has not yet been in production.

The vapor transmission of various plastics was measured and it was found that "Opanol" (Poly-is-Butylene) was best suited for cable covering. It was however never used in quantity. The only lead substitute put on the market was the "Bital" covering. This covering consists of three layers of aluminium foil separated by a bituminous coating. Bitumen was used in preference to plastics because of its lower vapor transmission (about 1/7 of P.V.C. plastics). Later the aluminium foil was replaced by metallized paper. This covering is used without additional protection for indoor cables or on cables with nonhygroscopic insulating material, such as telephone cables with "Vinifol", "Igelit" "Luvitherm", "Styroflex", "Triacetatfolie" and impregnated paper. For outdoor cables using dry paper insulation a layer of Igelit (P.V.C.) is used under the "Bitual" covering. Such a separating layer is also used for high voltage indoor power cables in order to prevent the mixing of the paper impregnating oil and bitumen of the covering. This mixing lowers the dielectric strength of the insulation and decreases the viscosity of the bitumen.

(b) Power Cables

High voltage power cables for A.C. were made up to 110 KV. They were gas pressure cables laid in pipes with nitrogen gas.

Like Siemens and A.E.G., an experimental length of cable had been supplied for use at 200 KV d.c. to ground (Elbe-Berlin project.) This cable was of conventional construction (without gas pressure) and used dry paper insulation, vacuum impregnated. For this cable a voltage gradient was used three times greater than the gradient used in similar construction for a.c. applications. The high voltage gradient is made possible by the following facts.

1. R.M.S. and peak voltages are equal with d.c.
2. Absence of dielectric heating
3. No danger of ionisation in eventual airgaps produced by the expansion of the lead cover.

For greater flexibility large conductors were made in three sections, each section being either stranded or solid. An interesting machine was seen for rolling the three components in the required sector form and twisting them together to form the final conductor.

(c) R.F. Cables

F & G cables are the same design as Siemens, though no cables were made during the war. They, like Siemens, prefer styroflex to other dielectrics. For solid dielectric flexible cables "Opanol" is used for insulation.

(d) High voltage testing equipment

3 transformers in cascade 300,000 volts each
1 oilless transformer 200,000 volt
1.2 million volt Impulse generator

The cold cathod ray oxillograph by Hochspannungs Gesellschaft, Köln, had been removed to a place now occupied by the Russians. In the impulse generator, coils of High voltage cable were used as capacitors.

1. <u>Firm</u>

CONZ Elektricitäts Gesellschaft

2. <u>Location</u>

C31/383 Hamburg

3. <u>Personnel Interviewed</u>

Dr. Voswinkel, Director
Herr Wächtler, Production Manager
Dr. Gross, Design Engineer

4. <u>Condition of Plant and Products Made</u>

The buildings have suffered little damage. The company is at present mainly engaged in repair work. In normal times it produces A.C. and D.C. motors, generators and converters, in sizes from $\frac{1}{4}$ KW up to 100 KW.

The classes of insulation used were A, Ah and a very few class B (V.D.E. classification).

Class A :	Cotton - paper - etc. Room temp: 35°C	 Rise: 60°C
Class Ah:	Enamelled wire - tri-acetate sheet Room temp: 35°C	 Rise: 80°C
Class B :	Asbestos - Glass Room temp: 35°C	 Rise: 105°C

From the table above it appears that the Germans design their motors for lower room temperatures. The maximum total permissible temperature is however nearly the same as our North American practice. For submarine motor design a room temperature of 45°C was specified.

The only points of interest worth noticing weretheir aluminium squirrel cages for large motors which were welded, and a compensated A.C. generator manufactured for the Wehrmacht as moveable supply of A.C. power in the field. (30 KVA - 380 volts - 3 phase). This machine was of the rotating armature type. It was equipped with four slip rings and small commutator. Rotating with the armature were three resistors connected in series with each phase at the neutral point. The voltage across these resistors was rectified by the commutator and used in a special winding on the exciter for compensating purposes. No test results could be obtained but it was claimed that the voltage drop was not more than 5% at full load, 80% power factor.

1. <u>Firm</u>

Hochspannungs Gesellschaft Fischer und Co.

2. <u>Location</u>

C31/2374 Köln-Zollstock. A dispersal plant is located at Hannoversch-Münden, Wilhelmstrasse 5 (not visited).

3. <u>Personnel Interviewed</u>

Prof. Fischer - Transformers
Dr. Buchkremer - Cathode Ray Oscillographs

4. <u>Condition of Plant</u>

Nearly completely destroyed

5. <u>Products Made</u>

Specializes in oilless high voltage testing transformers (up to 600,000 volt in one unit). Also power transformers, induction regulators, reactors and cold cathode ray oscillographs.

6. <u>High Voltage Cathode Ray Oscillograph</u>

No cathode ray oscillograph was available for inspection, but the following constructional details were obtained.

Horizontal construction
Accelerating potential: 60 KV
Aluminium cathode
Max. voltage on deflection plates: 2 x 150 KV
Max. sensitivity: 5 volt/mm
Size of photographic plates: 6 x 9 cm
A writing speed of 30,000 Km/sec was clearly visible on the photographic plate.
Total length of beam: 1200 mm.

The high maximum potential of 150 KV on each deflection plate was made possible by the use of a very high vacuum in the deflecting tube. In the cathode chamber, however, a sufficient amount of gas has to be available for electron production by ion bombardment of the cold cathode. For this reason the tube is provided with two independent pumping installations maintaining a vacuum of 10^{-2} mm Hg in the cathode chamber and 10^{-3} to 10^{-4} mm Hg in the deflection chamber. Sufficient reduction of the deflecting sensitivity at high test voltages is obtained by increasing the deflection plate separation and by shielding.

As the deflecting plates are separated they move within a ground connected shield. In this position only part of the electrostatic lines of force affect the electron beam and the deflection sensitivity is thus greatly reduced.

The tube is made of steel in order to provide shielding from external fields. Double magnetic focussing is employed. A spark gap sweep circuit and a calibrated variable frequency oscillator are built in.

1. Firm

Hartmann and Braun

2. Location

C31/1667 Frankfurt a/M, Falkstrasse 5.

3. Personnel Interviewed

Herr H. Müller - Sales Engineer

4. Size of Plant

Single shift capacity (previously 4500, now 450)

5. Condition of Plant

Company report says buildings 57% damaged, machinery 10% (consider latter figure low).

6. Dispersal Plants

Hochheim, Offenbach, Lauterberg, Brunswick.

Full report made 21 Aug 45 to Production Control Subsection, Office of Signal Officer, HQ 7th Army.

7. Products Made

Full line of high class electrical instruments and measuring equipment such as voltmeters, ammeters, wattmeters, frequencymeters, recording meters, galvanometers, thermo couple thermometers, platinum and nickel resistance thermometers, remote reading humidity indicators potentiometers, precision shunts and resistors, high voltage compressed nitrogen condensers. Heat control equipment, flow meters, manometers.

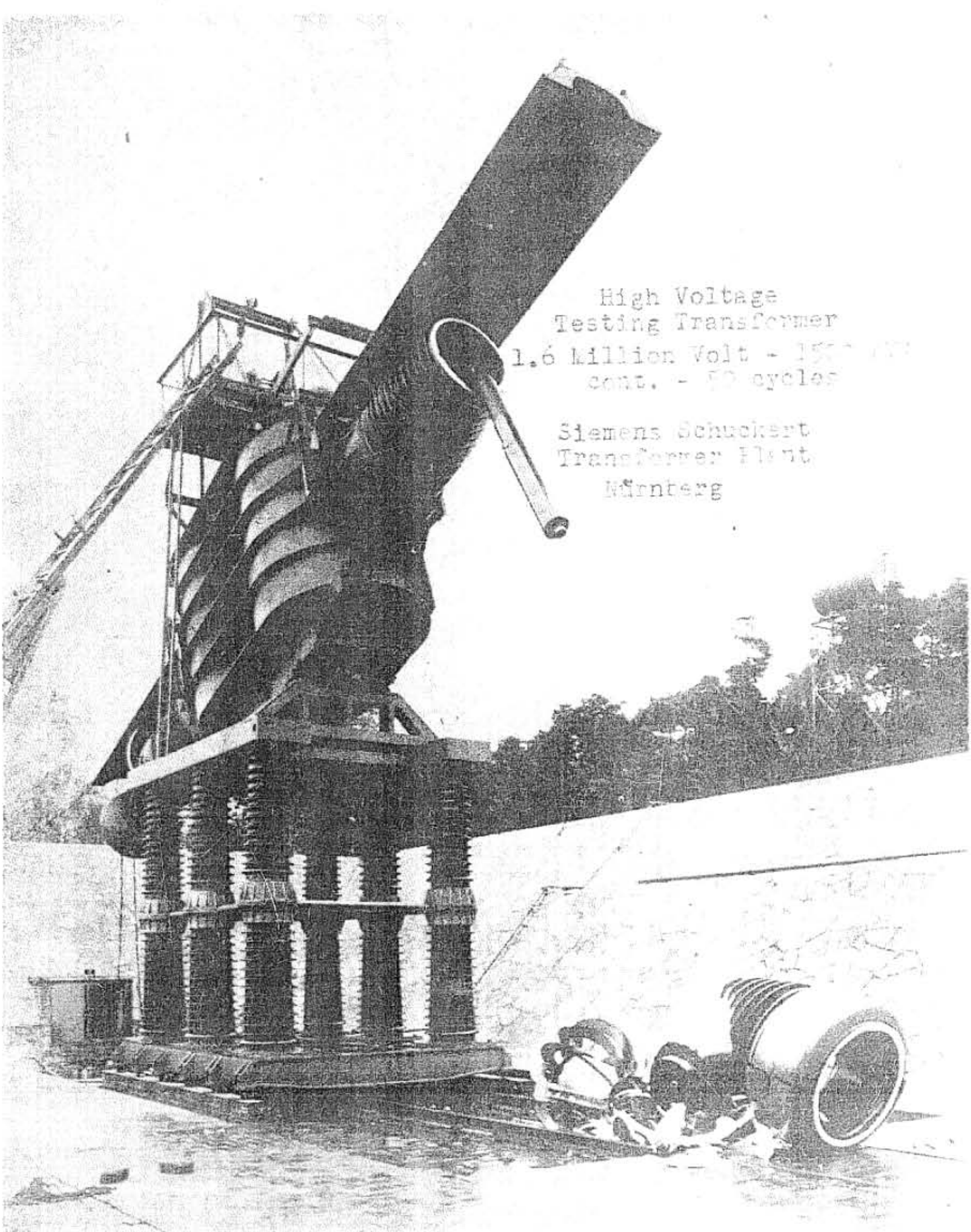
8. Points of Interest

Light-beam type instruments
Megger with built-in 500 volt power supply using batteries, synchronous vibrator and filter condenser.
Electrostatic voltmeters with 20 volt full scale deflection.
Pressure and pressure differential measuring apparatus of simple design. It consists of a hollow ring partially filled with mercury. A wall separates the spaces above the two free mercury surfaces. The

whole ring is suspended on a knife edge and is made bottom heavy. If a difference in pressure is introduced above the two free mercury surfaces, the mercury shifts and the ring tilts. The angle of tilt is calibrated in pressure difference.

The tachometer generators made by Hartmann and Braun were of the AC type. They were used in connection with a vibrating reed frequency meter or a rectifier type voltmeter. As standard reference for the calibration of their tachometers a vibrating string was used.

During the war the firm was making electrical indicating instruments for the German Navy. No special construction was used to make these instruments shock-resistant. No information could be obtained regarding German Naval instrument specifications. Mr. H.Müller could only inform us, that the instruments were tested for vibration and shock. All vibration testing equipment had been destroyed. The shock tests were carried out at the Voigt und Haeffner plant. This shock testing equipment had also been destroyed. According to Mr. H.Müller, the instruments were tested only up to 20 g.



High Voltage
Testing Transformer
1.6 Million Volt - 15[illegible]
cont. - [illegible] cycles

Siemens Schuckert
Transformer Plant
Nürnberg

Impulse Generator
3 Million Volt - [illegible]
Siemens Schuckert - Transformer Plant [illegible]