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MANUFACTURE OF METALIZED PAPER CAPACITOR UNITS ROBERT BOSCH, STUTTGART

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

REPORT ON MANUFACTURE OF METALIZED PAPER FIXED CAPACITOR UNITS BY THE ROBERT BOSCH COMPANY STUTTGART, GERMANY

Reported by:

FRED E. HENDERSON, U.S.

on behalf of the

U.S. Technical Industrial Intelligence Committee

CIOS TARGET NO. 1/112
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COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

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PERSONNEL OF INVESTIGATING TEAM

Fred E. Henderson, U.S.

TARGET

Office of Robert Bosch Company
Stuttgart, Germany
Dispersal Plant
Tubingen, Germany

PHYSICAL CONDITION OF TARGET

The main plant at Stuttgart is proably 98% destroyed, however, they have about 60 Dispersal plants located within a 50 mile radius of Stuttgart.

PLANT PERSONNEL

The following personnel were interviewed:

Dr. Wild - Director of Research
Dr. Dipper - Assistant Director of Research
Dr. Dorn - Research Specialist on Fixed Paper Capacitors

RESUME OF INTELLIGENCE GAINED BY INVESTIGATION

Several years ago The Robert Bosch Company undertook the development of fixed paper capacitors which had the metal foil used in the conventional fixed paper capacitor replaced by the application of a very thin metallic coating directly onto the paper dielectric. This Company has produced many millions of these condensers for use in both alternating and direct current circuits with very satisfactory results. After a careful study of the manufacturing processes involved in the production of this type of conden and an evaluation of the advantages and economies which can be gained by the use of this type of condenser as compared with the conventional type the following recommendation is made. If a manufacturer of fixed paper condensers in the United States wished to go into the production of metalized paper condensers and was willing to spend about 25,000 dollars for the design and production of the two special machines, he would be in a position to produce fixed paper capacitors which are about 40% smaller than the paper and foil type and which could be produced at 20% reduction in cost. These advantages would very quickly pay for the investment in the special

machines required.

The metalized paper condenser heals automatically after an electrical breakdown occurs due to the fact that the very thin metal film completely evaporates around the point of breakdown so that an adequate insulating margin has again been established, and thus innumerable breakdowns may occur before the effective area of the condenser plates has been reduced to the point where they will no longer produce satisfactory capacity values. Due to this characteristic metalized paper capacitors may be operated at from 20 to 50 per cent higher voltages than is possible with metal and foil capacitors.

MANUFACTURING PROCESS

The metalized paper condenser uses kraft paper .0003" thick as the diaelectric upon which the metal coating vaporized. The quality of the paper is controlled by applying a 500 volt breakdown test to all of the paper used. This is accomplished by passing the paper between two moving foil electrodes. The paper travels between the electrodes at the same speed as the electrodes so that the entire surface is exposed to the breakdown voltage for a period of about three seconds. This test set is equipped with a counter so that the number of breakdowns which occur per unit area is a measure of the quality of the paper. This test also burns out any metallic or ionized particles and thus produces a better quality of paper for the condenser unit.

The kraft paper is varnished on one side in a special varnishing machine at a speed of one meter per second. In principle this machine is a rewinding machine which takes the roll of 360 mm. wide kraft paper and rerolls it on to another roll. This machine is equipped with a vaporizing oven which toughens the paper and tends to remove any static charges. This minimizes the tendency of the paper to curl up as it passes thru the machine. Cellulose nitrate varnish is used. The path of the paper as it passes thru the varnishing machine is from the supply roll thru the vaporizing oven, then thru a series of rolls on to the varnishing roll, (this roll is about $\frac{1}{4}$th submerged in the varnish container) where

a relatively thick coating of varnish is applied, then over a scraping edge which removes a large portion of the varnish, (the varnish removed drains back into the supply container) then over a rotating scraper which has four blades, (this still further reduces the amount of varnish left on the paper and aids in working the varnish into the pores and imperfections of the paper) then thru a circular oven in which the paper is heated to a temperature of 110 degrees C for about 5 seconds and is then passed thru a flat oven about 2 meters long thru which 60 degrees C air is circulated. The paper is perfectly dry when it is rewound onto the take-up roll. The 360 mm. wide roll is slit into three 120 mm. wide rolls just before it reaches the take-up roll. There are several companies in the United States that have machines for applying a thin varnished coating to condenser paper.

The condensers as produced by The Bosch Company are of the extended foil type so that one edge of the side of the paper to be metallized must be kept free of the metal for a distance of about one sixteenth of an inch from the edge. This is accomplished by applying a coating of oil on the edge of the paper so that the metal will not adhere to the paper in this area.

METAL VAPORIZING MACHINE

This machine is also in principle a rewinding machine except that all of the mechanism must be enclosed in a vacuum chamber capable of being evacuated to a pressure of .1 mm. of mercury. The speed of the paper thru this machine is 6 meters per second so that it has to be a very well designed machine from a mechanical standpoint. The zinc metal is melted in an electrically heated pot type furnace which has a special nozzle type opening in the top thru which the zinc in vapor form passes directly onto the paper. This furnace is equipped with water cooling coils for rapid control of the temperature, the need for which will be pointed out later on in the description.

This machine is equipped with two insulated metal rolls spaced at a distance of 25 mm. apart. The metalized surface of the paper is held in intimate contact with these two rolls as it passes thru the machine. The two

metal rocls are connected into one arm of a wheatstone bridge so that the DC resistance of the metal coating between these two rolls can be observed continuously on the bridge galvanometer. This provides a means of determining the thickness of the metal coating continuously. The speed of the take-up roll on this machine is controlled by means of a magnetic brake operated thru a hand-controlled potentiometer. Thus you will see that the operator of this machine has three specific controls for obtaining the desired product. The water cooled coils on the zinc evaporating furnace gives rapid control of the temperature so that the quantity of zinc vapour generated by the furnace can be changed quickly. The magnetic brake controls the speed which the paper passes over the nozzle of the vaporizing furnace. Finally, the wheatstone bridge tells the operator whether or not the desired thickness of coating is being obtained. The zinc coating is held to a thickness of .0001 mm. or less.

The path of the paper thru the metalizing machine is from the supply roll to the wheel type applicator which applies the oil coating one-sixteenth of an inch wide to the edge of the paper, then over a series of rolls which lead the paper directly over the nozzle of the metalizing furnace, then over the insulated rolls which are part of the wheatstone bridge circuit, and finally onto the take-up roll which completes the operation. The paper is pulled thru the machine by rotating the take-up spool with a crank that extends thru the back of the machine. This crank is sealed into the vacuum chamber by merely enclosing it in a flexible metal hose, one end of which is soldered to the outside of the vacuum chamber. The outer end of the crank is mounted in a ball bearing race which is secured to the inside of the flexible metal hose. The crank is rotated by attaching it to the periphery of a rotating disc. This appeared to be an ingenious means of operating moving parts in a vacuum chamber. The winding operation is standard procedure except that the metal foil is folded on itself 1/16" along the edge.

The leads were attached to the condensers by soldering them to bridges of tin-lead alloy which had been sprayed onto the ends of the condenser unit by the Schoop's process. The bridges are produced by assembling a number of the condenser units in a special pressing fixture which applies a pressure of 15 kilograms per square centimeter

which prevents the metal applied by the Schoop gun from penetrating in between the layers of the condenser unit. Two bridges are built up on each end of the unit. A lead wire is soldered to both bridges on the same end of the unit. The purpose of the two bridges is to obtain a very low inductance value since they very effectively short circuit each turn of the condenser unit and at the same time provide a very satisfactory method for attaching lead wires. The drying, vacuum impregnating, potting and sealing of the units are no different for this type of condenser than the standard paper and foil condenser.

RECOMMENDATION

A company who contemplates undertaking the manufacture of metalized paper condensers should arrange to send an engineer to the Bosch plant to make a thorough study of the metalizing machine before undertaking the design and construction of a machine for this operation, or obtain one of the machines from the Bosch Company.

Note: An effort is being made to have the metal vaporizing machine removed from The Bosch Plant and delivered to the Signal Corps Radio Laboratories, Fort Monmouth, N. J. See attached copy of Dr. Glasgow's letter to Major General V. L. Van Deusen dated July 23,1945.

COPY

July 23, 1945

TO: Major Gen. G. L. Van Deusen
Chief, Engineering & Technical Service
Office of the Chief Signal Officer
Pentagon Bldg., Room 3E-348
Washington 25, D. C.

SUBJECT: Shipment of German Capicator Machine to Ft. Monmouth

1. The writer has recommended to Col. Urhane and Major Neal Crane, Technical Liaison Division, O C Sig. O, Hq. Com. Z, APO 887, that the Signal Corps evacuate for shipment to Ft. Monmouth one machine and the control equipment for the manufacture of paper capacitors from the Bosch plant at Stuttgart, Germany.

2. The process is covered by U.S. Pat. 2,244,090 in the custody of the Alien Property Custodian, who has requested TIIC to secure additional information on the process, which has been done by investigator F. E. Henderson, loaned by the Western Electric Co. His report on the process should be available from TIIC, Washington, in about 30 days. Mr. Henderson may be reached for first-hand information, if and when desired, at the Point Breeze plant of Western Electric at Baltimore after 20 August.

3. Bosch states that they have furnished about 40 million capacitors of this type to the German military. The units are far more compact than anything we have produced and are familiar to all Signal Corps personnel who have examined captured German radio equipment. However, an important item that is probably not known is that they are self-healing on repeated breakdowns caused

by over-voltage surges. The value of this feature, if true, is too evident to be dwelt on here.

4. This self-healing feature probably explains the Germans would risk using a single sheet of 0.4-mil Kraft paper as a suitable capacitor dielectric for a m imum working voltage of 250-dc.

5. The salient features of the construction are these. An extremely thin film of bakelite varnish is applied to one side of the paper, following which zinc vapor is applied in a vacuum. The thickness of the zi film on the paper is about 2 microns. Consequently, should a voltage break-down occur, due to a pin hole o weak spot in the dielectric, the extremely thin film of zinc acts as a fuse and the capacitor practically alway "burns open" instead of a short-circuiting, as is the c with the conventional rolled paper, metal foil, capacit

6. The remainder of the construction features ar adequately described in the patent. The machine for ac plishing the above operations is very ingeneously desi and for this reason it is considered desirable to have one available for examination in the event manufacture of these capacitors in the U.S. is decided upon.

7. It is recommended that SCGSA be requested to investigate the information referred to in Para. 2 as it becomes available and to furnish their comments and recommendations as to the practicability of initiating the manufacture of these capacitors in the U.S. either by means of a development contract, or other suitable means.

Dr. [illegible]
Consultant
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