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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

21 December 1945

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Electronic Equipment Construction Materials.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target E-19 of Fascicle E-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lt. Comdr. T.J. Glanville, RNVR, assisted by Lieut. R.C. Brooks, USNR.

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30616

JAPANESE ELECTRONIC EQUIPMENT CONSTRUCTION MATERIALS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE E-1, TARGET E-19

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE ELECTRONIC EQUIPMENT CONSTRUCTION MATERIALS

In the early part of the war it was the general policy of Japanese authorities to specify standard commercial materials of the types generally available before the war for the manufacture of electronic equipment. The apparatus produced was generally of robust construction and adequately equipped with instruments for calibration and adjustment.

In time certain standard raw materials became scarce. However, substitutes were developed and included in the less critical parts of the equipment, where their use would not impair working efficiency. Examples of such substitutes were plywood, used for secondary panelling, bakelite frames for condensers, and glass, ebonite or porcelain supports for components.

Japanese technicians appear, furthermore, to have been aware of the necessity for improving on current practice and for discovering satisfactory substitutes for scarce materials required for the more important functions. A certain amount of research was accordingly carried out in various laboratories, although little of this work appears to have reached a practical stage. In any case, much of it seems to have been based upon the published reports on similar experiments performed previously in western countries.

As a result, moreover, of the strict veil of secrecy which shrouded all service operations, there was a general lack of guidance and constructive criticism on the part of the armed forces, and research workers were therefore left in the dark as to specific operational needs and requirements. There is also evidence of a distinct gap between laboratory research and actual production. This was due, apparently, to a shortage of personnel with the requisite training and experience, to difficulties caused by bomb damage, to deficiencies in essential raw materials and to an absence of directives from the armed forces, referred to above.

It was not until January 1945 that research of this nature was placed on a satisfactory basis with the founding of the Second Japanese Naval Technical Research Bureau, with the objects of coordinating experiments in design and developing substitute raw materials. In view of the vicissitudes of the Japanese Navy at that time little attention was paid to shipborne electronic equipment. Most of the work was being directed towards airborne apparatus.

As for the armed forces, it appears that although junior officers entrusted with the operation and maintenance of equipment in the field made frequent complaints, these criticisms, with relatively few exceptions, were not allowed to reach a higher level or to become the subject of impartial investigations.

It is recommended that this report be read in conjunction with the referenced NavTechJap Reports, since the comments contained therein will assist in building up a general picture of this aspect of Japanese electronics.

TABLE OF CONTENTS

RESTRICTED

REFERENCES

Location of Target:

Tokyo Shibaura Denki K.K.
72, Horikawa Ku
KAWASAKI Shi
Kanagawa Ken.

Nippon Denki K.K. (formerly Sumitomo Tsushin Kogyo K.K.)
2, Mita Shikoku Cho
Shiba Ku, TOKYO To, and
1753, Tomogawa Mukai, Shimonumabe Cho,
KAWASAKI Shi, Kanagawa Ken.

Second Naval Technical Institute,
Meguro, TOKYO.

Japanese Personnel Interviewed:

Mr. S. HAMADA - Laboratory Manager, Tokyo Shibaura Denki K.K.
Dr. Y. NIWA - Engineering Manager, Nippon Denki K.K.
Dr. N. TANAKA - Radio Engineer, Nippon Denki K.K.
Mr. K. TSUBOI - Radio Engineer, Nippon Denki K.K.
Dr. K. KOBAYASHI - Assistant Superintendent and Carrier Transport Engineer of Tamagawa Plant, Nippon Denki K.K.
Vice Adm. T. NAWA, IJN - Officer in charge, Electronics Section of the Second Naval Technical Institute.
Capt. Y. YAJIMA, IJN - Second Naval Technical Institute.
Capt. H. TAKAHARA, IJN - Specialist in ferrous cores for R.F. coils at the Second Naval Technical Institute.
Mr. R. KIMURA - Specialist in ferrous cores for R.F. coils at the Second Naval Technical Institute.
Lt. Comdr. T. HYODO, IJN - Specialist in substitutes for mica.
Engr. H. SHINAGAWA - Second Naval Technical Institute.
Lieut. S. NAGAKURA

Related NavTechJap Reports:

Index No.	Title
E-15	Power Supply for Japanese Electronics.
E-17	Japanese Radio, Radar, and Sonar Equipment.
E-18	Japanese Radio Apparatus Construction Methods.
E-23	Japanese Insulation Materials.
E-28	Japanese Electronics - General.

LIST OF ENCLOSURES

(A) - List of Documents Forwarded Through ATIS to WDC.

LIST OF ILLUSTRATIONS

INTRODUCTION

The object of this investigation was to ascertain the nature and characteristics of the materials employed by the Japanese for the manufacture of electronic equipment, with particular reference to the development of substitutes for scarce commodities and to research with regard to materials for service under exceptional operating conditions.

Research laboratories and manufacturing plants were visited with these objectives in view, and information and explanations were obtained from technical personnel. Japanese electronic equipment was inspected and typical specimens selected for shipment to the United States for laboratory tests. Reference was also made to technical reports prepared by other Allied missions operating in Japan and to captured documents relating to research experiments and standardization of components.

The report which follows summarizes the results of the activities described above. In some cases notebooks and original documents belonging to the concern examined were not available. Consequently the informants had frequently to rely on their memories, and the facts and figures quoted in the attached report are therefore stated subject to this general qualification.

ATIG reports referenced in the report will be available at the Bureau of Aeronautics.

THE REPORT

Part I

FERROUS CORES FOR R.F. COILS

In the early stages of Japanese radar, the material generally used for dust cores was ferrous oxide (Fe_2O_3). It was ground to a 400 mesh granulation and pressed into forms without any binding agent. This type of core did not prove altogether satisfactory, however, because of its low temperature coefficient and because it required grinding and lacked machineability.

In January 1943, therefore, a series of experiments was initiated by the Japanese naval authorities with a view to discovering an oxide compound with a satisfactory temperature coefficient and μ (e) values comparable to those obtained by German and Allied cores. These tests consisted in taking a solenoid, selected at random, 30mm long and having a 10mm interval diameter, and testing it with different fillings at frequencies varying from 1 to 15 M.C.

The oxides used were those of iron, cobalt, copper, magnesium, and manganese, mixed in varying proportions by the Tokyo Electro Chemical Company, Ltd. Cobalt oxide gave fairly promising results but had to be abandomed on account of a shortage of cobalt. A mixture of the oxides of iron (FeO), magnesium, and copper was finally settled upon as a starting point, although the copper factor was eventually dropped with the view to improving the temperature coefficient.

The results of these experiments were expressed in the form of a graph in which the Qi value was plotted against the frequencies. The Qi figure was calculated:

$$Qi = \frac{Lt-Lo}{Rt-Ro}$$

where Lt is the total inductance,
Lo the inductance without the core,
Rt the total resistance
and Ro the resistance without the core.

The resultant graph of results yielded by the various mixtures is shown in Figure 1.

The first mixture used, designated by the manufacturers by the code DA, was in standard use throughout the war and gave a Qi value of 80 against μ (e) of 100. In February 1943 the latter had been reduced to 50, in conjunction with a Qi value figure of 110. The results achieved in August 1943 showed a good Qi value but a poor μ (e), while in November 1943 a mixture of FeO and magnesium oxide yielded a very high Qi with a μ (e) value of between 1.2 and 1.5. This mixture, it was considered by the Japanese technical authorities, could be used to advantage in radar components.

Parallel with the experiments described above, research was started in August 1943 on the use of carbonyl iron. The resultant curves were very flat and fell between the results yielded by American and German practice. The slight inferiority of the Japanese to the German is attributed to the fact that in the Japanese product the grain particles were slightly larger than in the German. The exact mesh figures are not available.

Meanwhile, in January 1945, a new mixture of FeO and magnesium oxide gave a μ (e) result of under 1.5. This seemed to indicate that it might be profit-

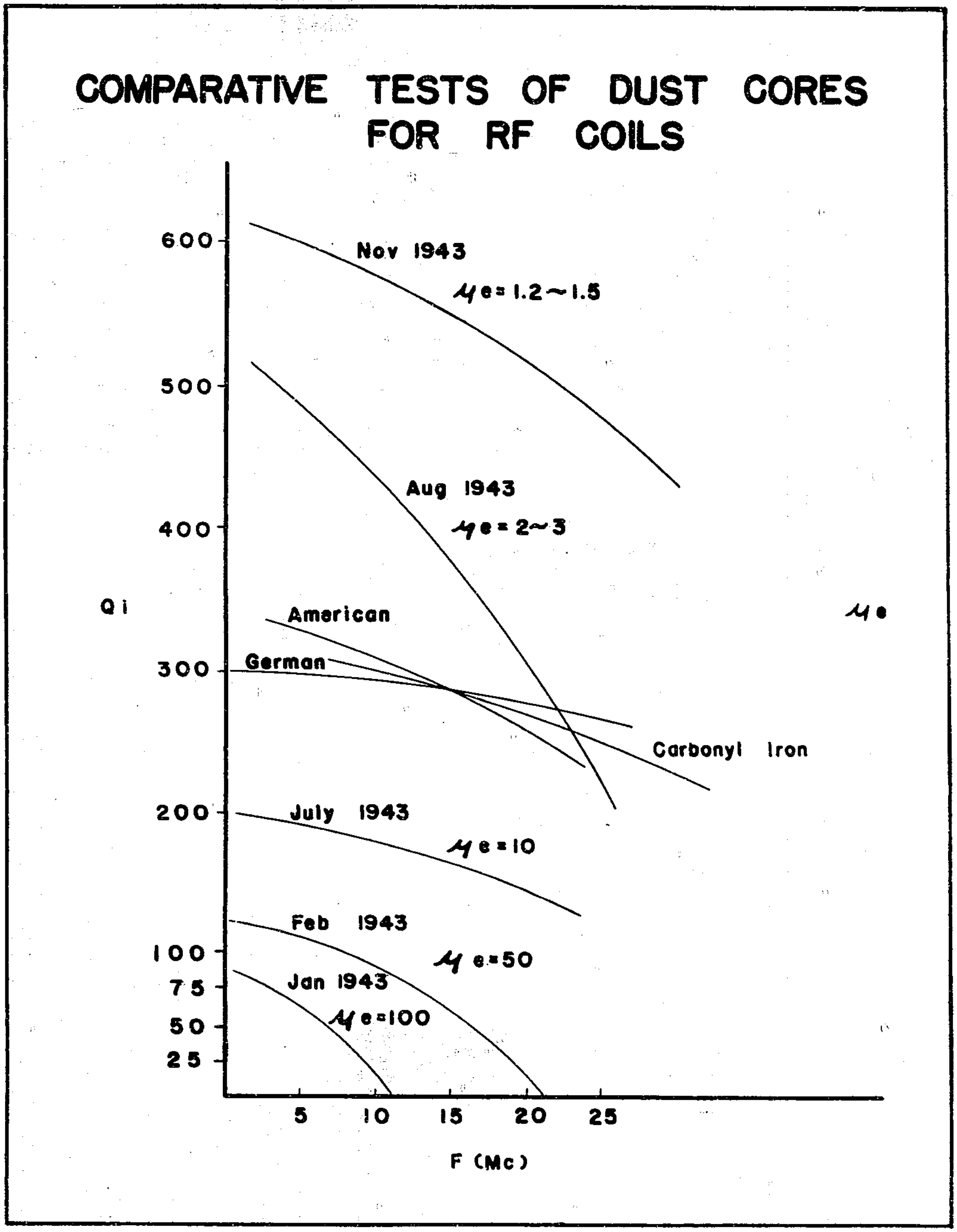
COMPARATIVE TESTS OF DUST CORES FOR RF COILS
600
500
400
300
200
100
75
50
25
Qi
μe
Nov 1943
μe = 1.2 ~ 1.5
Aug 1943
μe = 2 ~ 3
American
German
Carbonyl Iron
July 1943
μe = 10
Feb 1943
μe = 50
Jan 1943
μe = 100
5
10
15
20
25
F (Mc)

Figure 1

able to continue with the development of oxide compounds. It was decided, however, that sooner than waste more time on oxides, it would be more practical to concentrate on improving the μ (e) value of carbonyl iron. Since this is a function depending on compression, efforts were made to develop a finer degree of granulation.

A further substance which was used to some extent in commercially produced dust cores was "Sendust". This was originally developed by the Tohoku Imperial University at SENDAI and is manufactured by the Tohoku Kinzoku Co., SENDAI. It is a powder of high silicon steel and consists of carbonyl iron (85%), silicon (9.6%), and aluminum (5.4%). This alloy has high permeability and, since it could be readily crushed, was considered particularly suitable for dust cores. Laboratory tests showed, however, that its electrical qualities did not approach those of pure carbonyl iron.

To summarize, the material in general use throughout the war was that reflected in the lowest curve in figure 1. Experiments conducted with oxide mixture, carbonyl iron and Sendust secured substantial improvements in electrical performance but were not ready in time to be made use of during the war.

Reference should be made to ATIG Report No. 180, 5 Dec. 1945, "New High Permeability Magnetic Material."

Part II

DIELECTRICS FOR VHF PRACTICE

Dielectrics for VHF practice were generally acquired from commercial sources and consisted for the most part of polystyrene and steatite, with a dielectric loss varying between $2 \cdot 10^{-4}$ and $3 \cdot 10^{-4}$. Experiments were conducted with styrolresin, phenol resin, polystyrol, polyethylene and polysotilylene, but this research had not reached a practical stage by the end of the war.

Polystyrene was specified for coaxial lines and showed a characteristic impedance of 75 ohms and a dielectric loss of $2 \cdot 10^{-4}$ to $3 \cdot 10^{-4}$. In their earlier forms these lines were constructed with a solid polystyrene body surrounding the conducting material. Later this design was modified and succeeded by a standard model in which bell-shaped segments of polystyrene were mounted in series concentrically along the conducting material and shrouded by an insulating covering as shown in Figure 2.

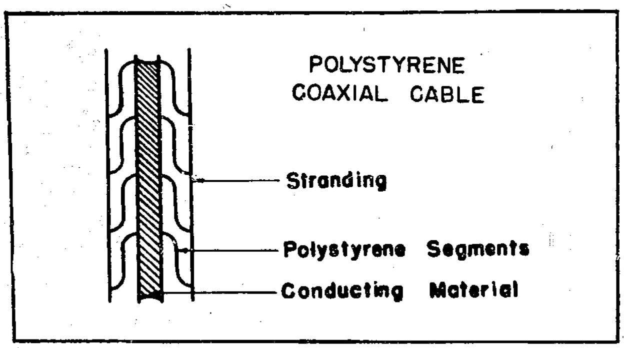

Figure 2

No progress appears to have been made with the use of air as an insulating material for coaxial lines.

Special forms of standard dielectrics in general use are reported to have been:

(a) Castor oil for use in large variable condensers, such as those used for transmitters.
(b) Bakelite mouldings for the frames of condensers. These are stated to have been satisfactory, since although the dielectric loss was higher than mica, for example, there was practically no disturbance.

The captured documents listed in Enclosure (A), Section 1, will furnish detailed information in regard to many aspects of Japanese research into dielectrics.

Part III

SUBSTITUTES FOR QUARTZ

Quartz became extremely scarce in Japan during the war years, and an exhaustive geological survey of the Japanese islands and certain other territory was accordingly undertaken with a view to discovering either fresh sources of supply of quartz itself or other forms of rock crystal approaching quartz in its qualities of low loss capacity combined with thermal stability and machineability. This search does not appear to have been particularly successful.

Meanwhile a program of research was instituted regarding the possibility of developing adequate substitutes for quartz from such raw materials as happened to be available.

It was stated that a great deal of thought was given to modifying the basic principles of certain parts of the equipment with a view to obviating the necessity for using quartz. An example of this practice was the use of magneto-striction in acoustic functions such as sound heads in sonar equipment. This system both avoided the use of rock crystals and in certain respects, such as length of ranging, gave superior results.

Generally, however, no satisfactory substitute was found for quartz. In certain cases it was found possible to use various forms of steatite, such as polystyrol; in others Rochelle salts, available in small quantities, were used.

Captured documents listed in Enclosure (A), Section 2, throw some light on this subject.

Part IV

SUBSTITUTES FOR MICA

Sheet mica is stated to have been very scarce in Japan, and its use was accordingly restricted from the first to details of equipment where high performance and precision were essential, e.g. certain types of vacuum tube. In the less critical parts of the apparatus, such as power packs, extensive use was made of micanite, a form synthetic sheet mica made by pressing flake mica with a binding medium of phenol resin.

As the war continued and the shortage of sheet mica became even more acute, research was undertaken to discover substitutes for mica in practically all of its uses.

For vacuum tubes, experiments were made with alumina film Al_2O_3, deposited by a process of electric oxidization. This idea did not progress beyond the laboratory stage, however, and so there was no industrial production. There is evidence of an attempt to produce sheet mica on a base of Al_2O_3, apparently in conjunction with a mixture of silica (SiO_2) and caustic soda.

For use in condensers, acetyl cellulose, containing an admixture of 0.5% polystyrene was adopted. There was a substantial industrial output of this product, which is stated to have yielded results approximaing those obtainable from natural mica. In addition, research was under way on a second substitute for mica for use in condensers. This consisted of a mixture of the following:

Titanium Dioxide (TiO_2)	82%
Quick Lime (CaO)	10%
Barium Oxide (BaO)	8%

It was specifically intended for small area, low inductance capacitors. It gave a K value of about 2000 and a dielectric loss of $80 \cdot 10^{-4}$. This last figure was admittedly poor, but under the specialized conditions of its intended employment this factor was not considered to be of any particular importance. These experiments, however, had not proceeded beyond the laboratory stage at the end of the war.

For general purposes, bakelite sheet, made from phenol resins, was adopted. Since the softening point of this material was rather low (80°C), particular attention had to be paid to pressing. The dielectric loss was rather higher than that of mica, but there was very little disturbance and its tensile strength was considered adequate.

Micanite was also used for some purposes. Reference has already been made to this substance.

No experiments seem to have been made with derivatives of phthallic acid, such as the glyptol resins.

In addition to the captured documents referred to above, those listed in Enclosure (A), Section 3, contain a certain amount of detailed information in regard to research on the subject of substitutes for mica.

Part V

MATERIALS FOR BRUSHES AND SLIP-RINGS

Brushes, slip-rings, commutators and other rotating parts for electronics equipment were acquired in the normal way from commercial undertakings, and so long as the equipment was not called upon to operate under exceptional conditions (e.g. at high altitudes) no particular problems appear to have been encountered.

When operations at high altitudes were envisaged, however, it was realized that experiments would have to be conducted on the subject of the wear and disintegration of brushes, and arrangements were made in a general way for a program of research. Other matters were found to be of more pressing importance, however, and the end of the war found little accomplished in this direction.

ATIG Report No. 195 (undated), "Investigation on Brush Wear on Electrical Rotating Machines", should be consulted.

Part VI

SPECIAL USES FOR PLASTICS

Plastics have been used by the Japanese in the manufacture of electronics equipment, particularly for small components and parts, such as brackets for vacuum tubes, small condensers, boxes, and on a larger scale, frames of large variable condensers. Attention was also paid to the possibilities of plastics when experiments were made with sound vibration and shock resisting materials.

It appears, however, that no systematic attempt was made to solve by the use of plastics the problem of saving weight and space while increasing strength and durability. According to one source, in fact, sufficient facilities do not exist in Japan for the manufacture of large plastic sections.

The documents listed in Enclosure (A), Section 4, should be consulted.

Part VII

PROCESSES ADOPTED FOR THE PRODUCTION OF LIGHT METAL DIE CASTINGS

Die casting of light metals were not adopted for naval use. Owing to the prevailing shortage of aluminum and other light metals, these materials were reserved almost exclusively for the air forces.

Such castings as were included in naval electronic equipment were usually normal castings of iron, although in certain cases these were replaced by fabricated sections of sheet steel.

A considerable amount of research appears to have been directed to problems connected with light metal alloys, however, and the following reports should be read in this connection.

ATIG No.	Title
198 (undated)	Light alloy problems and miscellaneous metals and alloys in Japan.
206 (undated)	Japanese magnesium casting alloys.
209 (undated)	Research of light metal works of the Sumitomo Chemical Co., Ltd., NIIHAMA.

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED THROUGH ATIS TO WDC

Section 1

NavTechJap No.	ATIS No.	Title
ND21-6008	3480	Comparative test results: Electrolytic capacitor.
ND21-6019	3449	Comparative test results of laminated phenol resin plates and phenol resin powder.
ND21-6023	3482	Comparative test results: Enamel coated fixed resisters.
ND21-6024	3450	Test results: High-frequency insulator manufactured by TOKYO Radio Manufacturing Company.
ND21-6029	3452	Report on test results of styrol resin.
ND21-6064	3453	Study of special insulators: Method of producing polystyrol.
ND21-6197	3454	Study of the composition of polyethylene.
ND21-6199	3456	Experimemts on deterioration of steatite cable insulators due to sea water.
ND21-6200	3457	Experiments on laminated phenol resins.
ND21-6201	3458	Comparative test results of Japanese manufactured steatite.
ND21-6202	3521	Research on methods of measuring high frequency cable.
ND21-6203	3549	Results of polystrol tests.
ND21-6204	3460	Tests of rubber insulated wire for navy use.
ND21-6205.1	3461	Experiments on rubber insulated wire for navy use.
ND21-6206	3462	High-frequency cables: Handling of simple terminals.
ND21-6218	3464	Studies on temperature characteristics of high-frequency insulators (First Report): Characteristic surface resistance of steatite.
ND21-6219	3465	Test results: NIPOREKKISU (Niplex) electrical insulating material.
ND21-6220	3486	Test results: Oil-filled capacitors used in communications manufacturing by the SUMITOMO Electrical Company.
ND21-6224	3466	Polyethylene polymer used for high-frequency electric cable study.

ENCLOSURE (A), continued

NavTechJap No.	ATIS No.	Title
ND21-6225	3487	Test results: Small type electrolytic capacitors.

Section 2

NavTechJap No.	ATIS No.	Title
ND21-6064	3453	Study of special insulators: Methods of producing polystrol.
ND21-6201	3458	Comparative test results of Japanese manufactured steatite.
ND21-6203	3459	Results of polysterol tests.
ND21-6241	3436	Study of Rochelle salts oscillation.

Section 3

NavTechJap No.	ATIS No.	Title
ND21-6008	3480	Comparative test results: Electrolytic capacitors.
ND21-6018	3481	Report of the standards committee on small paper and mica capacitors.
ND21-6019	3449	Comparative test results of laminated phenol resin plates and phenol resin powder.
ND21-6029	3452	Report on test results of styrolresin.
ND21-6200	3457	Experiments on laminated phenol resin.
ND21-6201	3458	Comparative test results of Japanese manufactured steatite.
ND21-6203	3459	Results of polysterol tests.

Section 4

NavTechJap No.	ATIS No.	Title
ND21-6019	3449	Comparative test results of laminated phenol resin plates and phenol resin powder.
ND21-6200	3457	Experiments on laminated phenol resin.
ND21-6252	3418	Research on sound and vibration absorbing materials (*Third report*): *Study on preventive* noise generated in the ship's sound room.
ND21-6253	3419	Research on sound and vibration absorbing materials (Fourth report): Absorption effects of saddle type shock absorbers.