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RESTRICTED

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

Subject: Target Report - Japanese R.F. Transmission Lines, Wave Guides, Wave Guide Fittings, and Dielectric Materials.

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

1. Subject report, covering Target E-20 of Fascicle E-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. E.E. Schwalm, USNR, assisted by Lieut. W.G. Lamb, USNR, and Lt.(jg) S.H. Kadish, USNR, as interpreter and translator.

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JAPANESE R.F. TRANSMISSION LINES, WAVE GUIDES, WAVE GUIDE FITTINGS, AND DIELECTRIC MATERIALS

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

FASCICLE E-1, TARGET E-20

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE R.F. TRANSMISSION LINES, WAVE GUIDES, WAVE GUIDE FITTINGS, AND DIELECTRIC MATERIAL

In the design and manufacture of radio frequency transmission lines, Japanese design engineers were thorough and capable from a theoretical standpoint, but lacked the mechanical skill to put their ideas into practice. Japanese manufacturing establishments were of little help; most finished products appeared crude and amateurish by U.S. standards.

This report covers Japanese naval technique in transmission lines, coaxial lines, wave guides, line fittings, duplexers, phase shifters, and kindred subjects. The use of polystyrene as dielectric material for coaxial lines is also discussed.

Theoretically, the work was good, but practically the test equipment was simple and inadequate for making the necessary precise measurements. Consequently, the Japanese never were quite certain of their results. Nothing of more than casual interest was discovered.

TABLE OF CONTENTS

REFERENCES

Location of Target:

Headquarters of Second Naval Technical Institute, Kanazawa, YOKOHAMA.

Meguro Office of Second Naval Technical Institute, Meguro, TOKYO.

Tsukishima Experimental Station, TOKYO.

Naval Fighter Director Station, CHIGASAKI, Kanagawa Ken.

Japanese Personnel Interviewed:

Vice Admiral T. NAWA, Chief of the Radar and Communications Section of the Second Naval Technical Institute.

Capt. Y. YAJIMA, Administrative Ass't to NAWA.

Capt. H. TAKAHARA, Radio and Radar Research Engineer.

Capt. Y. ITO, fundamental research in centimeter techniques.

Lt. Cdr. S. MORI, specialist in centimeter techniques.

Lt. Cdr. S. MATSUI, installation specialist, radio and radar.

LIST OF ENCLOSURES

(A) List of Documents forwarded to WDC through ATIS.

(B) List of Equipment forwarded to NRL.

LIST OF ILLUSTRATIONS

INTRODUCTION

Transmission lines, both as circuit elements and the means of getting energy from one point to another with minimum loss, are one of the more important phases of radio and radar technique and a thorough investigation of Japanese techniques along these lines was conducted.

Laboratories were visited, personnel interrogated, and equipment inspected. The following report covers the findings of the investigating group. Documents which were seized and which are referred to in Part I and Part V have not been translated, but will be available at WDC in the event detailed information is desired.

[illegible]

[illegible]

[illegible]

Freq.(MC)	Length (M)	Impedance (e)	Attenuation Beaded(db/m)	Attenuation Solid(db/m)
1.39	43.85	81.5	.00506	.016
2.80	43.85	80.9	.00747	.023
4.20	43.85	80.9	.00965	.030
5.60	43.85	80.6	.01186	.035
100	0.613	81.2	.0569	.20
400	0.613	81.2	.160	.51

So far as is known, no active work was done on coaxial lines having a characteristic impedance other than 75 ohms.

Experiments were conducted on a coaxial line which had the inner conductor suspended from a spiral-wire form supported by silk threads impregnated in polystyrene. The wire form was covered with copper braid. No data is available on the voltage rating and losses of this line. Additional data which shows the construction of this line is available in NavTechJap Document No. ND-6206, "High Frequency Cables, Handling of Simple Terminals", and NavTechJap Document No. ND21-6207, "Methods of Moisture Proofing High Frequency Cables."

The Japanese had no coaxial lines and connectors for high voltages of the order of 5000 volts or those which have a very low attenuation characteristic. There were no lines which could withstand temperatures above the melting point of polystyrene or which had any delay characteristics.

C. Air Insulated Lines

No wartime use was made of air-insulated coaxial lines in which air was the principal dielectric material. Lines of this type were never considered for use at high frequencies.

Part II - WAVE GUIDES AND FITTINGS

Wave guides were manufactured in the 10 centimeter band only. Both rectangular and circular wave guides were used. The circular type was used most frequently because of the comparative ease with which it could be installed (i.e. with bands and rotary joints). The material used for construction was either brass or aluminum with silver plating applied to the inner surface at joints and critical points. In order to retard corrosion which caused considerable trouble, the inner surface was zinc-plated. A rectangular wave guide was used, however, in the latest type of 10cm equipment, the Mark 3, Model 2 (See NavTechJap Report, "Submarine And Shipborne Radars," Index No. E-01), and experiments were being conducted toward a more extensive use of this type.

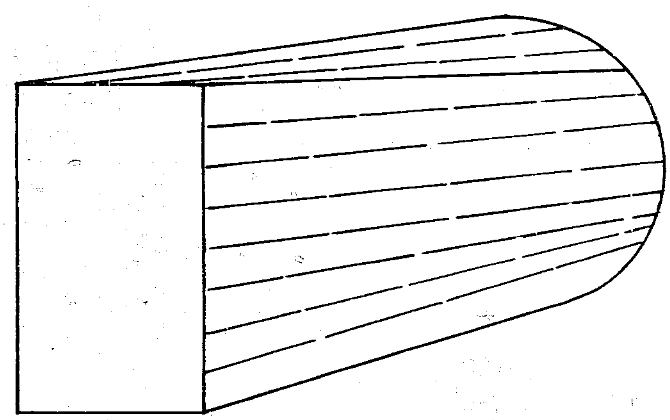
As there was some difference of opinion on the part of designers, it appears that the finer points of wave guide design had not been investigated. Trial and error methods were used to determine the form and dimensions of wave guides and fittings. Standard wave guide dimensions were as follows:

Rectangular: Breadth - 100mm
Depth - 70mm
Thickness- 5mm

Circular: Diameter - 80mm
Thickness - 5mm

No attempts were made to design a rotary joint for rectangular wave guides. On that equipment for which rectangular wave guides were used, a transfer section from rectangular to circular wave guide was inserted below the rotary joint. This transfer section was a simple tapered section as shown in Figure 2. Its form was determined by trial and error.

FIG. 2



TRANSFER SECTION FROM CIRCULAR TO RECTANGULAR WAVE GUIDE

NavTechJap Document No. ND21-6232.3-1 gives dimensions of circular and rectangular wave guides and shows the construction of a transfer section.

The maximum wave guide run considered allowable on a shipboard installation was 10 meters. Installations were always planned to reduce the wave guide run to a minimum. Theoretical losses were calculated, but no experiments were carried out to check these calculations. A standing wave ratio of 80% was considered good.

No X-band wave guide had been manufactured. Plans for X-band equipments had not been put on paper at the end of the war.

The Japanese had no flexible wave guide or wave guide made of multi-metals or of plastic material.

Additional data is available in the following documents (see Enclosure A for titles):

<u>NavTechJap Document No.</u>

ND21-6052
ND21-6174
ND21-6175
ND21-6178
ND21-6232.1

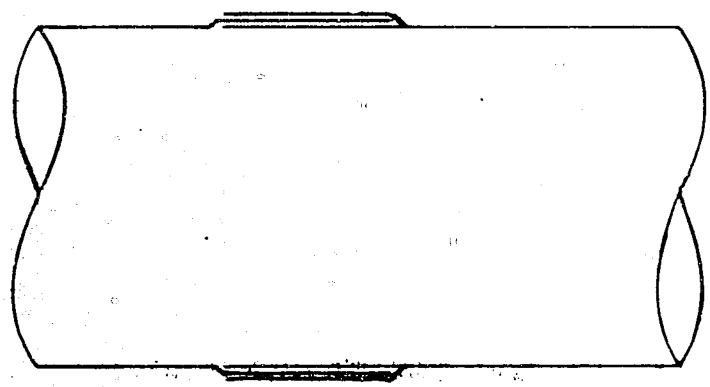
Part III - ROTATING JOINTS AND DUPLEXERS FOR TRANSMISSION LINES

A. Rotating Joints

Three types of rotating joints were used: capacity, inductance, and contact; the first two for use with meter wave radars, which use open wire transmission lines, and the latter for use with centimeter wave radars. Of the three, the contact type (See Figure 3) was considered the most efficient.

The contact type rotary joints had standing wave ratios greater than 75%, inductive reactance of less than 5 ohms and voltage ratings as high as 3,000 volts.

FIG. 3



ROTARY JOINT FOR CIRCULAR WAVE GUIDE

B. Duplexers

The principle of duplexers was well understood, although no use was ever made of an anti-TR box. Three types of duplexers were used: one for meter wave equipments and two for centimeter wave equipments.

The meter wave type is conventional in design. Two gas discharge tubes were used: types b1 and b2. These tubes had chrome steel, barium-tipped electrodes and used argon gas. Tube life was approximately 100 hours.

One centimeter wave duplexer was conventional, using a stub supported section of wave guide and a gas discharge tube. This tube used hydrogen gas and had an indefinite life. Characteristics of this tube are discussed in NavTechJap Report, "Japanese Electron Tubes," Index No. E-13. Experiments using water vapor as the gas in gas discharge tubes had been conducted but the results are unknown.

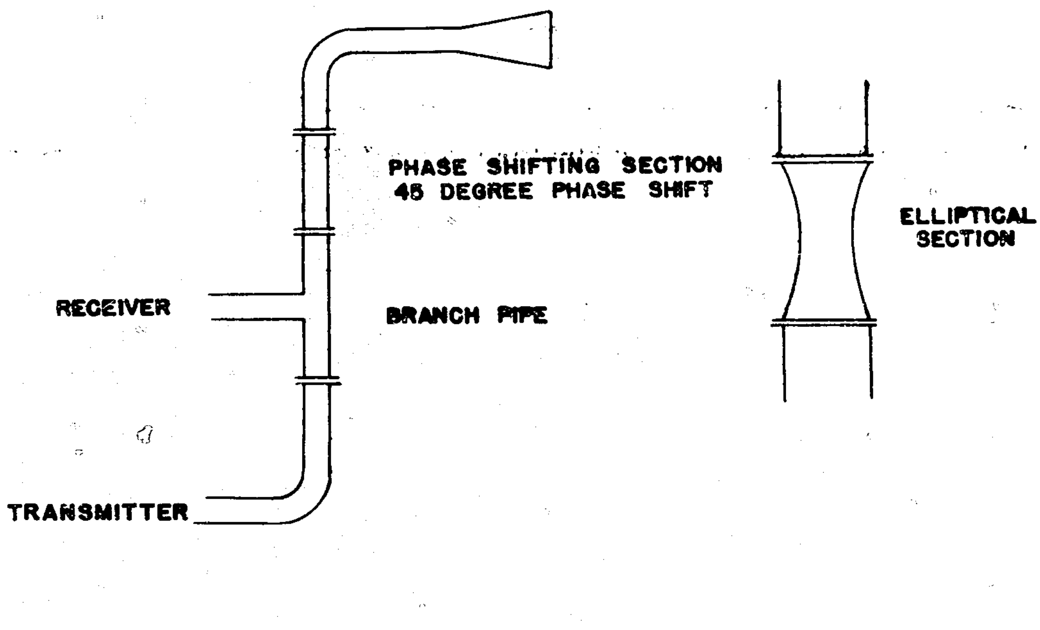
The duplexing scheme used on the Mark 2, Model 2 radar for submarines is of special interest. This equipment had an antenna consisting of only one horn. Figure 4 is a sketch of this duplexer.

A 45° phase shift section was placed in the circular wave guide above the branch pipe between the transmitter and antenna. This phase shift section was circular on both ends and elliptical shaped in the center. Vertical polarization existed in the wave guide between the wave guide from the transmitter to the phase shift section. The wave guide from the branch pipe to the receiver was horizontally polarized.

Transmitted energy was shifted 45° in the phase shift section to circular polarization, then radiated. Received energy, which was circularly polarized, was shifted 45° to horizontal polarization and passed off through a rectangular window to the receiver. Thus a duplexing action occured without the use of a gas discharge tube or spark gap.

Additional data on branching wave guides is available in NavTechJap Document No. ND21-6052, "Theory of design and calculation of the branching wave guide".

FIG. 4



PHASE SHIFTING DUPLEXING SYSTEM

Part IV - DIELECTRIC AND PLASTIC MATERIALS

Polystyrene and steatite were the principal compounds used for insulating and dielectric materials. Experiments were made on the use of polystyrol, polyethylene, polyisobutylene, styrol resin, phenol resin, and other special plastics. Of the above, none were in general use except polystyrene and steatite. The only R.F. transmission lines and video lines in use were those using polystyrene which are described in Part 1.

No dielectric material was used in radomes. No radomes were in use and none were projected. It was intended to use horns on all new centimeter radars.

All highly conducting materials of good optical transparency for use in cathode ray tubes and vacuum tubes are discussed in NavTechJap Report, "Japanese Electron Tubes," Index No. E-13.

Research data and experimental results on dielectric ceramic and insulating materials which have properties of temperature resistance, low loss at high frequencies, high dielectric constant, etc. will be found in the following documents listed in Enclosure (A): (See Enclosure A for titles)

NavTechJap Document No.	NavTechJap Document No.
ND21-6019	ND21-6201
ND21-6024	ND21-6203
ND21-6025	ND21-6204
ND21-6029	ND21-6205
ND21-6064	ND21-6207
ND21-6197	ND21-6218
ND21-6198-1	ND21-6219
ND21-6199	ND21-6224
ND21-6200	

Part V - MISCELLANEOUS

A. Twisted, Balanced Lines for Video and R.F. Circuits

No twisted and balanced lines were used for other than conventional purposes in receivers and amplifiers.

B. Impedance Matching Networks and Devices for Wide Band Radio and Radar Systems

No impedance matching devices other than conventional types, except in the duplexer described in Part III. Rotary joints and fittings are discussed in in Part III. Broad band antennae are discussed in NavTechJap Report, "Japanese Antennae", Index No. E-16.

C. Test Equipment

Test equipment, particularly for radio frequencies, was of poor quality. Test equipment techniques had not been fully developed. Test equipment is discussed in detail in NavTechJap Report, "Japanese Radio Frequency Measuring Technique", Index No. E-22.

D. Special Problems on Ship and Submarine Transmission Lines

No unusual or superior methods of pressure-proofing and water-proofing transmission lines were discovered.

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED TO WDC THROUGH ATIS

NavTechJap Document No.	ATIS No.	
ND21-6206	3462	High frequency cables: Handling of simple terminals.
ND21-6207	3463	Methods of moisture proofing high frequency cables.
ND21-6232.3-1	3406	Wave guide dimensions.
ND21-6052	3265	Theory of design and calculation of the branching wave guide.
ND21-6174	3268	Ring wave guides and reflectors.
ND21-6175	3269	Study of circularly polarized electromagnetic wave.
ND21-6178	3272	Study of the propagation characteristics of circularly polarized electromagnetic waves in the atmosphere.
ND21-6232.1	3406	Radar No. 32 installation and wave guide prints.
ND21-6019	3449	Comparative test results of laminated phenol resin plates and powder phenol resin.
ND21-6024	3450	Test results: High-frequency insulator manufactured by TOKYO Radio Manufacturing Company.
ND21-6025	3451	Test Results: Hitlex manufactured by the HITACHI Company.
ND21-6029	3452	Report on test results of styrol-resin.
ND21-6064	3453	Study of special insulators: Methods of producing polystyrol.
ND21-6197	3454	Study of the composition of polyethylene.
ND21-6198	3455	Study of the maintenance of water repellancy of paraffin in sea water.
ND21-6199	3456	Experiments on deterioration of steatite cable insulators due to sea water.
ND21-6200	3457	Experiments on laminated phenol resin.
ND21-6201	3458	Comparative test results of Japanese manufactured steatite.
ND21-6203	3459	Results of polystyrol tests.

ENCLOSURE (A), continued

NavTechJap Document No.	ATIS No.	
ND21-6204	3460	Tests of rubber insulated wire for navy use.
ND21-6205.1-.2	3461	Experiments on rubber insulated wire for navy use.
ND21-6207	3463	Methods of moisture-proofing high frequency cables.
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.
ND21-6224	3466	Polyethylene polymer used for high-frequency electric cable study.

ENCLOSURE (B)

LIST OF EQUIPMENT FORWARDED TO NRL

NavTechJap Equipment No.	
JE21-6020	Sample of Japanese Coaxial Line.