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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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20 December 1945

RESTRICTED

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

Subject: Target Report - Japanese Antennae.

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

1. Subject report, dealing with Target E-16 of Fascicle E-1 of reference (a), is submitted herewith.

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

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Captain, USN

JAPANESE ANTENNAE

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

FASCICLE E-1, TARGET E-16

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE ANTENNAE

Radar antennae in use were of five principal types: mattress arrays, ladder type broad-side arrays, Yagi and Yagi arrays, horns, and parabolic reflectors. In general, mattress and ladder type broad-side arrays were used with air search radars, Yagi arrays with AA fire control and searchlight control radars, and horns with centimeter equipments. Parabolic reflectors had not come into general use at the end of the war but had been adopted for use on several pieces of new equipment.

A broad band antenna (145mc to 155mc) for use with IFF equipment is described, as is a large cylindrical antenna 19 meters high and 17 meters in diameter. RCM antennae and an antenna for underwater long wave radio reception are discussed.

RDF and airborne antennae are only summarized. Detailed descriptions and analyses are available in NavTechJap Reports, "Japanese Airborne Radar", Index No. E-02, and "Japanese Radio and Radar Direction Finders", Index No. E-05.

The antennae inspected were without exception of simple design and mediocre construction. No unusual or exceptionally high performance antennae or components were found in production model equipments or in laboratories.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ENCLOSURES

REFERENCES

Location of Target:

1. Headquarters of Second Naval Technical Institute, Kanagawa, YOKOHAMA.
2. Meguro Laboratory of Second Naval Technical Institute, Meguro, TOKYO.
3. Tsukishima Naval Radar Experimental Station, TOKYO.
4. Naval Fighter Director Station, CHIGASAKI, Kanagawa Ken.
5. Yokosuka Naval Base, YOKOSUKA.
6. Kure Navy Yard, KURE.

Japanese Personnel Interrogated:

1. Vice Admiral (Technical) T. NAWA: Chief of the Radar and Communications Section of the Second Naval Technical Institute.
2. Capt. H. TAKAHARA: Head of Fourth Section of Second Naval Technical Institute (Radar intercept equipment, radio beacons and direction finders).
3. Capt. and Dr. Y. ITO: Head of First and Second Sections of Second Naval Technical Institute (Fundamental research). Specialist on centimeter techniques.
4. Comdr. ONO: Electronics Officer, Kure Navy Yard.
5. Lt. Comdr. (Technical) S. KATSURAI: Designer of (51), (61), and (63) radars.
6. Lt. Comdr. (Technical) S. MORI: Specialist on centimeter wave techniques. Worked on the (22) radar.
7. Lt. Comdr. (Technical) H. TSUJITA: Research worker on the airborne radars (FK-3), (FH-3), (FH-4), (H-6).
8. Lt. (Technical) K. OGATA: Research worker on centimeter wave land based radars.
9. Dr. K. TAKAYANAGI: Consultant on radar to Vice Adm. NAWA.

INTRODUCTION

The report which follows describes findings concerning Japanese antennae. Preliminary investigation disclosed that the antennae of primary interest were those in design and test stage. Therefore the bulk of the data presented on experimental antennae has been collected from the designers of Japanese naval radar equipment and their consultants.

Various laboratories, test stations, and pieces of equipment were inspected in order to verify the information given by the interrogated personnel. Operational data on experimental antennae could not be verified because such equipment had either been destroyed or rendered inoperative prior to the arrival of the investigators in the target areas.

The documents listed in this report have not been translated. They will be available at the Washington Document Center.

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[illegible]

THE REPORT

PART I - GENERAL

A. RDF Antennae

Although the Japanese have done considerable research on radio direction finders, all antennae inspected appear to be convential in design. Since the antennae are the most important components of PDF equipments, they are discussed in NavTechJap Report, "Japanese Radio and Radar Direction Finders", Index No. E-05.

B. Airborne Antennae

A considerable amount of research was done on airborne antennae. The bulk of this research effort was directed toward the improvement of Yagi and doublet type antennae and the adaption of these types to new radar equipments. Of principal interest is a revolving beam type antenna used with the Gyoku 3 radar installed in night fighter aircraft. It uses an omnidirectional Theta type antenna and doublet antenna with a goniometer coupler to produce the revolving beam. Enclosure (B) is a block diagram of the Gyoku 3 radar and includes a sketch of this antenna.

Airborne antennae are covered in detail in NavTechJap Report, "Japanese Airborne Radar", Index No. E-02.

C. Underwater Antennae

Japanese submarines were equipped with a receiver for underwater reception of a long wave signal (17.3 kc) from a transmitter on land. The original antenna used was the standard RDF loop. Later installations used a small compact dust core antenna which was suited to mass production. This antenna is discussed in NavTechJap Report, "Japanese Sonar and Asdic", Index No. E-10. Pertinent documents are as follows:

NavTechJap Documents No. ND21-6007
(See Enclosure (A)) ND21-6142
ND21-6268

D. Rotation Systems, Duplexers, and Rotary Joints

Antenna rotating systems were very elementary. Hand train was the principal method used. Most search sets were equipped with a motor to turn the antenna for continuous search. Synchro control of the antenna was used on only one piece of equipment, the (22) modified for fire control use on ships. This synchro system was custom built for each installation.

Duplexers were of conventional design in all equipments in which they were used except for the single horn modification of the (22 Kai 3) radar which used a polarization shifting duplexer.

No unique or particularly efficient rotary joints have been discovered. Rotary joints and duplexers are described in detail in NavTechJap Report, "Japanese R.F. Transmission Lines, Wave Guides, Wave Guide Fittings, and Dielectric Materials", Index No. E-20.

E. Miscellaneous

No antennae have been developed which permit simultaneous transmission and reception or which permit simultaneous lobe comparison.

No information is available which indicates that any work was done on variable frequency antennae.

No data has been discovered which indicates that any work was in progress on rapid scan antennae or on wave guide dielectric lens antennae.

Of general interest are theoretical studies on various types of antennae contained in the following documents:

NavTechJap Documents No.	ND21-6000 to	ND21-6044
	ND21-6000.14	ND21-6046
(See Enclosure (A))	ND21-6002	ND21-6047
	ND21-6015	ND21-6048
	ND21-6043	

PART II - AIR SEARCH RADAR ANTENNAE

Air search radar antennae were, with two exceptions, of conventional types familiar to any technician acquainted with American radars. The types of antennae most commonly used were mattress arrays of several sizes and configurations and a ladder type broadside array. *Yagi* arrays and parabolic antennae were used to a lesser extent on those radars which were used for purposes in addition to detection of aircraft. Duplexing systems in use are standard in every respect.

A. Mattress Type Arrays

Matress type arrays were used on the following radars:

Type 2 Mark 1 Model 1	(11)
Type 2 Mark 1 Model 1 Modification 1	(11-1)
Type 2 Mark 1 Model 1 Modification 2	(11-2)
Type 2 Mark 1 Model 1 Modification 3	(11-3)
Protype Air Warning Radar	(11-3 Kai)
Type 3 Mark 1 Model 1	(11 K)
Type 2 Mark 1 Model 2	(12)
Type 2 Mark 1 Model 2 Modification 2	(12-2)
Protype Mark 6 Model 2	(62)
Protype Mark 6 Model 3	(63)
Radar to Guide Boats	(TH)
Type 2 Mark 2 Model 1	(21)
Type 2 Mark 2 Model 1 Modification 1	(21 Kai 1)
Type 2 Mark 2 Model 1 Modification 2	(21 Kai 2)
Type 2 Mark 2 Model 1 Modification 3	(21 Kai 3)
Type 2 Mark 2 Model 1 Modification 4	(21 Kai 4)
Type 2 Mark 2 Model 1 Modification 5	(21 Kai 5)

The antennae used with all of the above radars are of conventional design except that used with the (62) and (TH) radars. All consisted of end-fed dipoles in various combinations using parallel wire feeders to the elements. Wire mesh was used as a reflecting surface. They were all horizontally polarized.

The (62) and (TH) radars used a vertically polarized broad band antenna which is discussed in Part IV.

The Type 2, Mark 1, Model 1 radar and modifications were equipped with large mattress arrays approximately 25 feet wide and 15 feet high. The characteristics of these antennae are well known since equipments of this series were captured early in the war. All of these antennae have separate transmitting and receiving arrays except the (11-3 Kai) which employed duplexing. Enclosure (M), "Table of Japanese Naval Radars", shows the type of antenna used with each radar and lists the salient characteristics of these antennae.

The (11 K) radar used an antenna composed of an array four elements wide and six high. Duplexing was employed. Enclosure (C) is a schematic diagram of this antenna. It shows the arrangement of the radiating elements and the sizes of the various components. Performance data is available in Enclosure (M). Additional information on this antenna is available in NavTechJap Document No. ND21-6277 (See Enclosure (A)).

The remaining mattress antenna of note is the one used with the (21) shipborne radar and its modifications. The first antenna of this series consisted of two separate transmitting and receiving arrays, each consisting of an array six elements wide and two high. This antenna was also used on the (12) and (12-2) land based radars. It was replaced on these pieces of equipment by the standard ladder type antenna because of its poor stability characteristics. In an effort to improve the performance of the (21) radar an antenna consisting of a transmitting array four elements wide and two high and a receiving array three elements wide and two high was designed. The next modification was an array four elements wide and three high which employed duplexing. This antenna was then modified to become array four elements wide and four high. The (21 Kai 4) and (21 Kai S) radars used this antenna. Figure 1 shows an antenna of this type as installed on the flight deck of CV KATSURAGI. It was intended to install a horizontally polarized version of the broad band antenna used with the (62) radar with the (21 Kai 5) radar. (See Part IV.) No shipborne installations had been made.

In spite of the numerous antenna modifications, the (21) radar and its modifications were never as successful as desired because the antenna was extremely difficult to tune and the rotary joint was unsatisfactory.

This antenna was also tested for use with a radar intercept receiver. NavTechJap Document No. ND21-6222, (Enclosure (A)), gives the results of this test.

Enclosure (M) gives performance data on these antennae.

Additional information on mattress arrays is available in the following documents, which are described in Enclosure (A):

NavTechJap Documents No. ND21-6065
ND21-6089
ND21-6090

B. Ladder Type Broadside Array

The ladder type broadside array was used on the following radars:

Type 2, Mark 1, Model 2, Modification 3	(12 Kai 3)
Type 3, Mark 1, Model 3	(13)
Type 3, Mark 1, Model 3, Modification 3	(13-3)

This array was used on 150 mc radars. It consists of an array of four steps of two elements backed by parasitic reflections. This array was considered very efficient. The (13) radar was the primary shipborne air search radar. Figure 2 shows the (13) antenna installed on the mainmast (looking aft) of CV KATSURAGI.

Figure 3 is a view of the foremast (looking aft) of DD HANAZUKI showing the (13) and (22) radar antennas. Figure 4 shows a mainmast installation of a (13) antenna on the same ship.

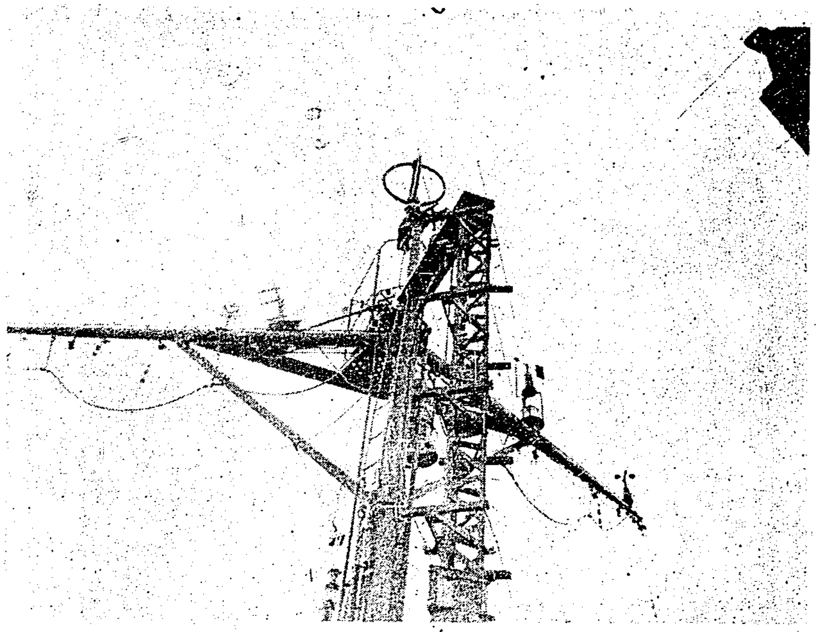


Figure 1
FLIGHT DECK INSTALLATION OF TYPE 21 RADAR
ON CV KATSURAGI

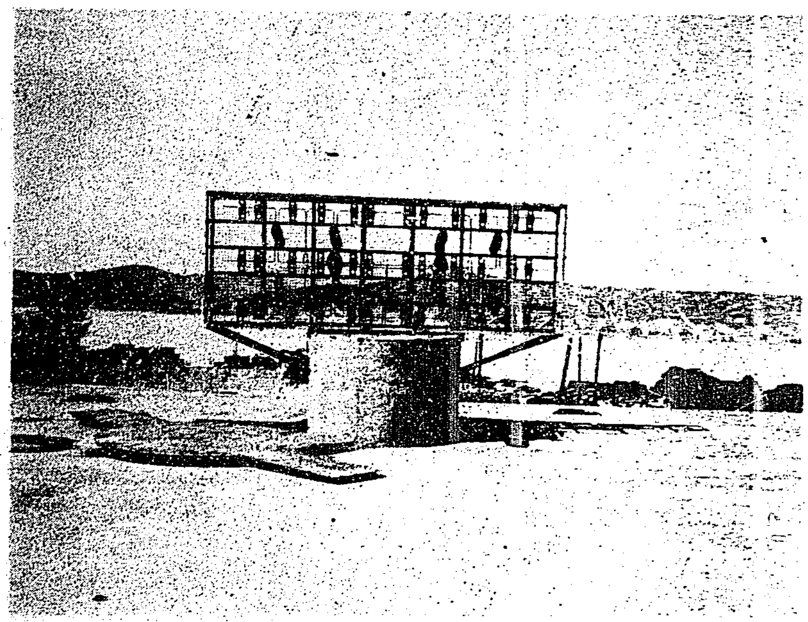


Figure 2
TYPE 13 RADAR ANTENNA INSTALLED ON MAINMAST
OF CV KATSURAGI

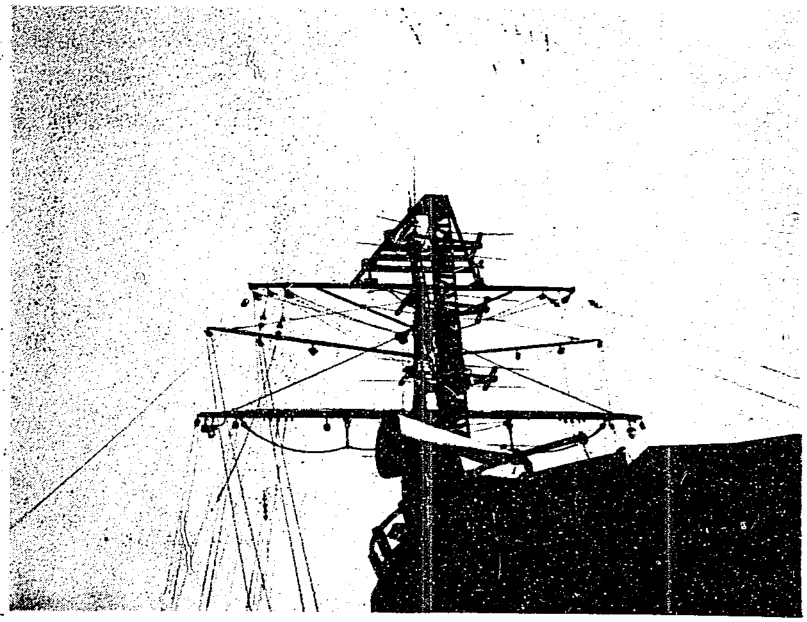


Figure 3

TYPE 13 AND 22 RADAR ANTENNAE ON FOREMAST OF DD HANAZUKI

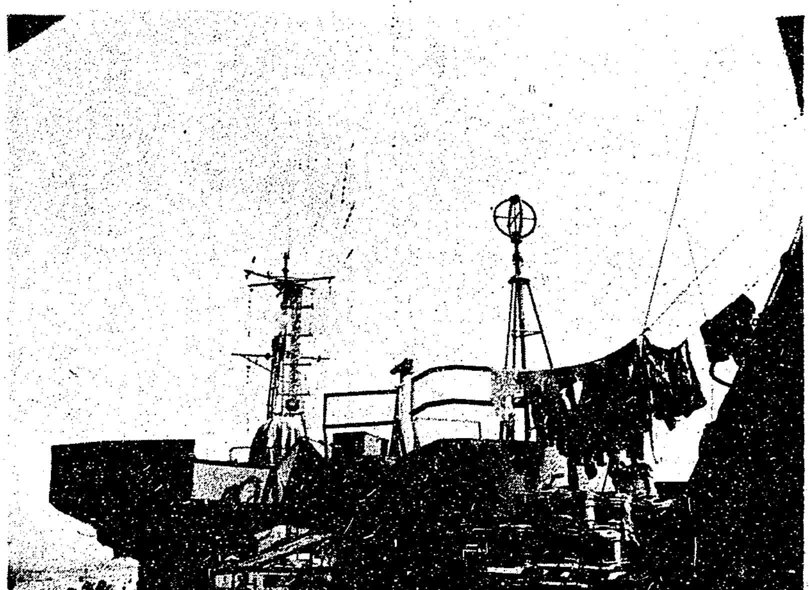


Figure 4

TYPE 13 RADAR ANTENNA ON MAINMAST OF DD HANAZUKI

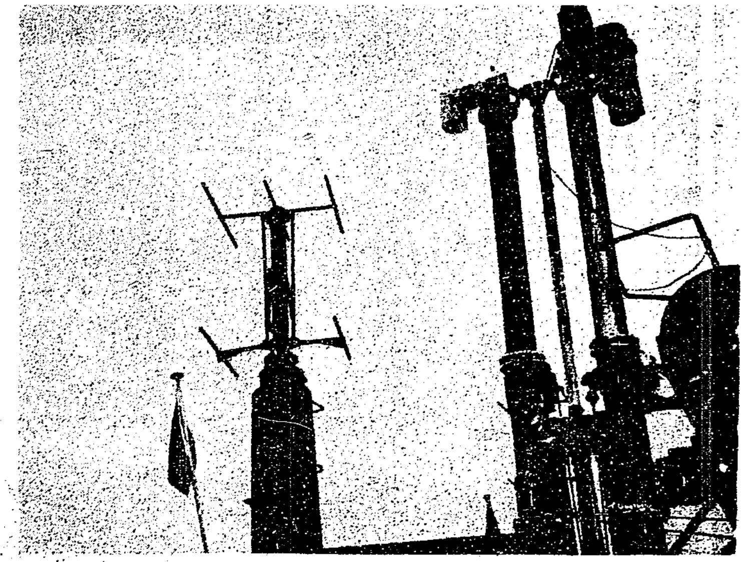


Figure 5

TYPE 13 RADAR ANTENNA AS INSTALLED ON A SUBMARINE

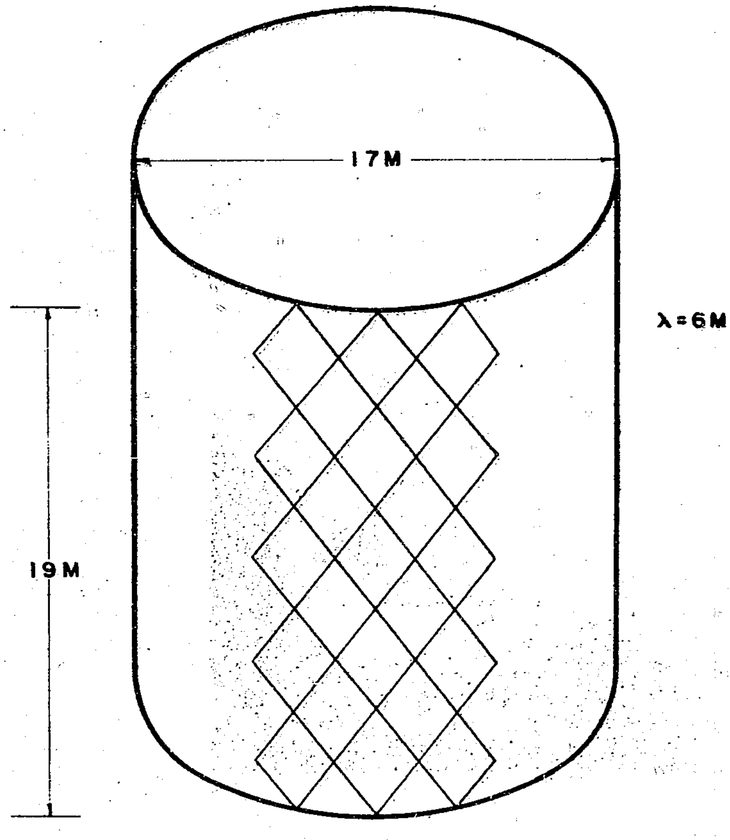


Figure 6

DIAGRAM OF EXPERIMENTAL CYLINDRICAL ANTENNA ARRAY

Enclosure (D) is an installation diagram of the (13) antenna. Enclosure (E) is a schematic diagram of the same antenna. These diagrams may be consulted for construction details of this antenna. See Enclosure (M) for performance data. Additional data is available in the following documents listed in Enclosure (A):

NavTechJap Documents No. ND21-6216
ND21-6216.9

C. YAGI Arrays

Yagi arrays were used principally on searchlight control and AA fire control radars. The only applications of this type of array for search purposes were on the (13) radar installation on submarines and on the Mark 1, Model 4 (14) radar which employs lobe switching. Figure 5 shows a (13) installation on a submarine.

D. Cylindrical Array

A large 6 meter cylindrical antenna was designed for 360 degree electrical scanning. This antenna is 19 meters high and 17 meters in diameter. It is composed of 24 vertical elements arranged as shown in Figure 6. It is horizontally polarized. A rotating goniometer located in the center of the array two meters from the base sweeps the beam by shifting the phase of the various elements. The main lobe is 18 degrees in the horizontal plane. The principal minor lobes are two 12% back lobes (one on each side) and two 9% side lobes in front. The theoretical gain is 18.7 db.; actual overall gain is about 16 db. This antenna has not progressed beyond the experimental stage. Since the only antenna built has been destroyed additional data is not available.

PART III. SURFACE SEARCH AND FIRE CONTROL RADAR ANTENNAE

A. YAGI Arrays

Yagi arrays were most frequently used on land based radars for searchlight control and AA fire control. When accurate bearing and position angle data were desired, the comparison method, using Yagi receiving arrays, was considered the most practicable. Lobing was always accomplished with receiving arrays only, on the theory that more accurate bearing determination was possible when lobing only with receiving antennae.

Yagi arrays were used on the following radars:

Protype Mark 4, Model 3	(L1)
Protype Mark 4, Model 3, Modification 1	(L2)
Protype Mark 4, Model 3, Modification 2	(L3)
Protype Mark 4, Model 1	(S3)
Protype Mark 4, Model 2	(S24)
Type 3, Mark 1, Model 3 when installed on submarines.	

Figure 7 shows a typical installation of the (S24) radar antenna to control an AA battery. Enclosures (N), (F), (G), and (H) are assembly and schematic diagrams of the transmitting and receiving arrays of the antenna shown in Figure 7.

Enclosure (I) is a schematic diagram of the (S3) radar antenna. This radar is the Japanese copy of the U.S. SCR 268.

Enclosures (J) and (K) are installation diagrams of the (L2) searchlight control radar transmitting and receiving arrays.

Performance and operational data on all the antennae discussed above are available in Enclosure (M).

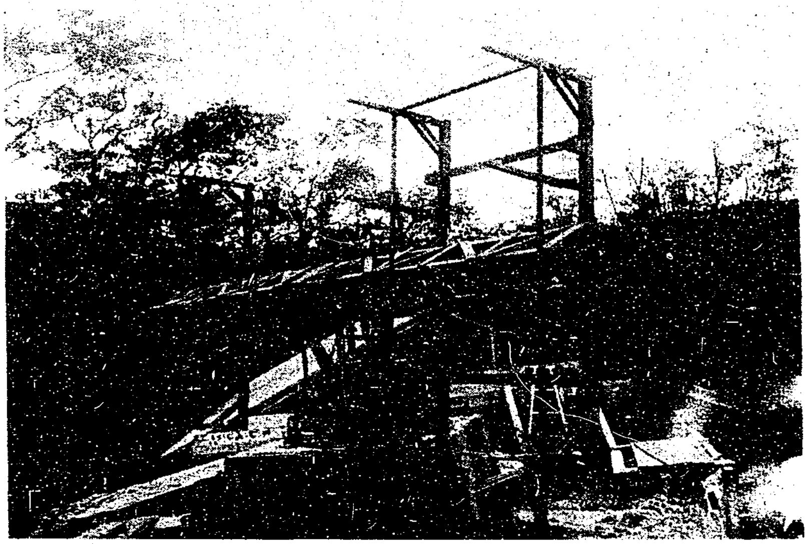


Figure 7

TYPE S24 RADAR ANTENNA

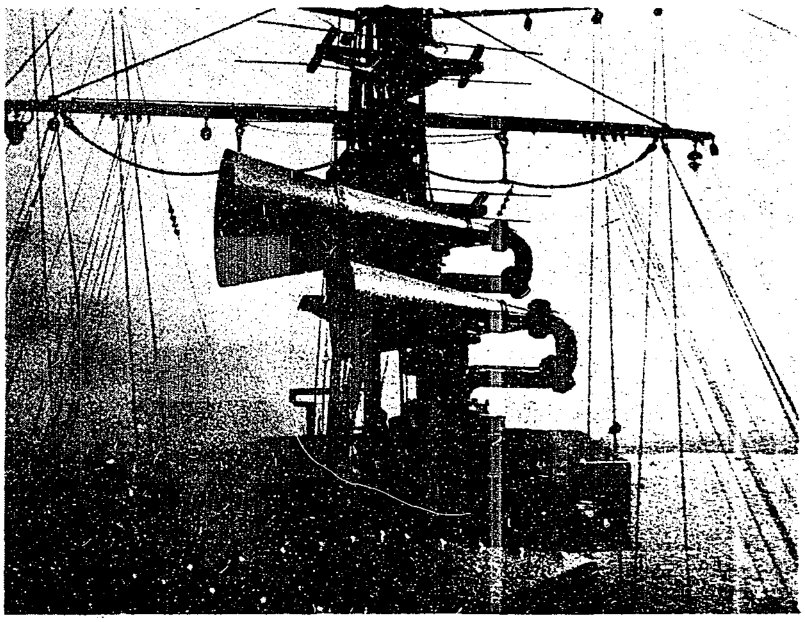


Figure 8

TYPE 22 RADAR ANTENNA MODIFIED FOR FIRE CONTROL ON DD HANAZUKI

(Looking Aft)

B. Horns

Horn type antennae were used on all 10cm radars which were operational at the end of the war. This type was favored over shallow parabolic dishes because of the resultant reduction in the number and size of side lobes. The first 10cm radar used a deep parabola 1.7 meters long and 0.8 meters in diameter at the open end. Because this antenna was too heavy and unwieldy for shipboard use, the shorter horn was developed.

Horn type antennae are used on the following radars:

Protype Mark 2, Model 2, Modification 2	(22 Kai 2)
Protype Mark 2, Model 2, Modification 3	(22 Kai 3)
Protype Mark 2, Model 2, Modification 3	(22 Kai 4)
Protype Mark 3, Model 2	(105 S2)
Protype Mark 3, Model 3	(105 S1)

Two horns were usually used, one for transmitting and one for receiving. However, some (22 Kai 3) radars installed on submarines used a single horn for both transmitting and receiving with a unique duplexing system which is described in NavTechJap Report, "Japanese R.F. Transmission Lines, Wave Guides, Wave Guide Fittings, and Dielectric Materials", Index No. E-20. The (105S2) and (105S1) experimental radars used three horn antennae, one for transmitting and two for receiving.

The (22) series radars were the only ones available for shipborne fire control. Installations intended for this purpose incorporated an enlarged and extended receiving horn in order to reduce to the size of the main lobe. Figure 8 shows a modified (22 Kai 4) radar antenna as installed on DD HANAZUKI.

It was the intention of designers to use horn type antennae on the projected X band radars.

Enclosure (M) gives performance data on the horn type antennae listed above.

Additional data is available in the following documents, listed also in Enclosure (A):

NavTechJap Documents No. ND21-6216.4
ND21-6231.1
to ND21-6231.4
ND21-6232.1
to ND21-6232.11
ND21-6237

C. Parabolic Reflectors

New development tended toward the use of parabolic reflectors where bearing and elevation accuracy was desired. Horn type antennae were unsatisfactory for fire control.

Parabolic reflectors were used on the following radars, all of which were experimental types.

Anti-Surface Warning Radar	(F8)
Type 3, Mark 2, Model 3	23(S8)
Protype Mark 2, Model 4	(24)
Protype Radar for AA Control	(S8A)
Protype Mark 6, Model 1	61(S8B)
Protype Mark 3, Model 1	(220)

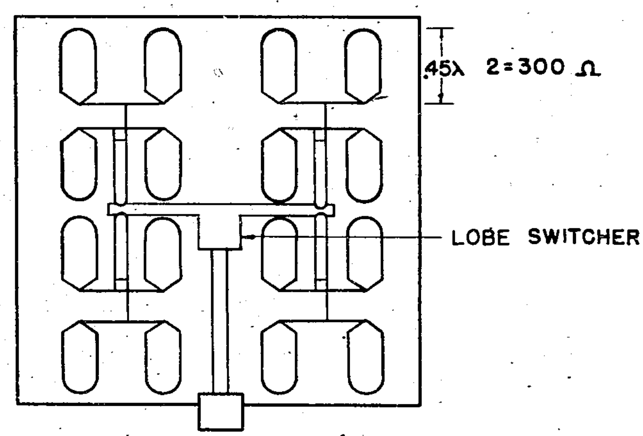
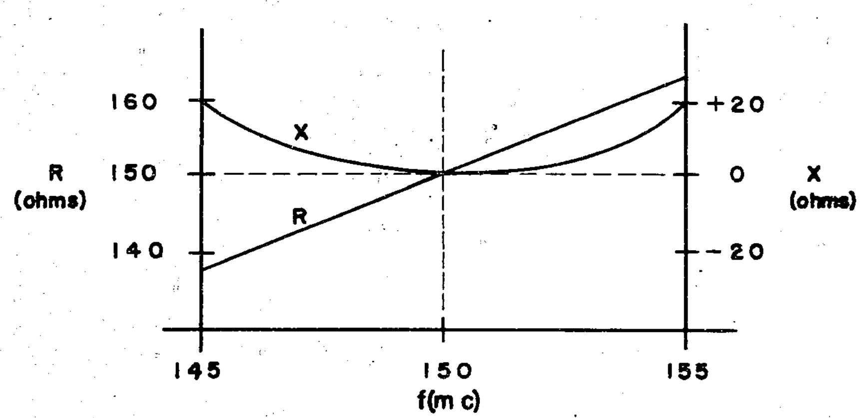


Figure 9

BROAD BAND ANTENNA ARRAY



FREQUENCY VS IMPEDANCE

Figure 10

IMPEDANCE DIAGRAM OF BROAD BAND ANTENNA

The (F8) and (23) radars used separate transmitting and receiving antennae 1.7 meters in diameter. The (24) radar used two antennae 2 meters in diameter.

The latest 10cm radar (220), intended as a replacement for the (22) radar on ships, has a 1.7 meter disk, a metaling dipole and duplexing. This equipment was in the test stage at the end of the war. It has been reconditioned and shipped to the the United States for analysis.

The (61) radar used a 0.7 meter disk which had a rotating dipole, hence rotating polarization. It was designed as a land based height finding radar. Its counterpart for ship board installation was the (23) radar which had a 1.7 meter disk and rotating dipole.

Nothing new or unconventional has been found in any part of these reflector systems. They were all of simplified design, were custom built, and were of wire mesh construction, except the (220) antenna which was made of perforated sheet metal. No evidence was found of the use of truncated parabolic reflectors. Performance data is available in Enclosure (M).

See NavTechJap Report, "Japanese Experimental Radar", Index No. E-12, for data on these radars.

PART IV. BROAD BAND ANTENNAE

The principal application of broad band antennae during the war was in radar intercept receivers. These are discussed in Part V.

The only other notable broad band antenna is one which was developed for use with the M13 IFF equipment. The airborne IFF equipment answered on a slightly different frequency from the radars which were used for the direction of friendly aircraft, so a broad band antenna was developed for use with this equipment. Broad band antennae were used as follows:

Radar	Polarization of Antenna	Wave Length	IFF Used
(62)	Vertical	2 meters	M13
(TH)	Vertical	1.5 meters	M13 with 65 meter code
(21 Kai 5)	Horizontal	1.5 meters	None

This antenna was broad banded from 145mc to 155mc. It consisted of 16 elements arranged as shown in Figure 9. Each element is .45 wave lengths long and has a characteristic impedance of 300 ohms. An input impedance curve is shown in Figure 10.

A similar antenna was built for the (21 Kai 5) radar except that it was horizontally polarized. This antenna was adopted in order to eliminate the tuning difficulties, excessive back lobe, and poor rotary joint of the antenna in use. It also had a better radiation pattern than the antenna last used.

Conventional lobing systems were used in these antennae. There was no program at the end of the war for the development of more broad band antennae. Performance data is available in Enclosure (M).

PART V. RCM ANTENNAE

Typical RCM installations consisted of two radar intercept receivers, one in the meter band and one in the centimeter band. Three antennae were used with these two receivers: an omnidirectional antenna and a directional antenna with the meter wave equipment, and a directional antenna with the centimeter wave equipment.

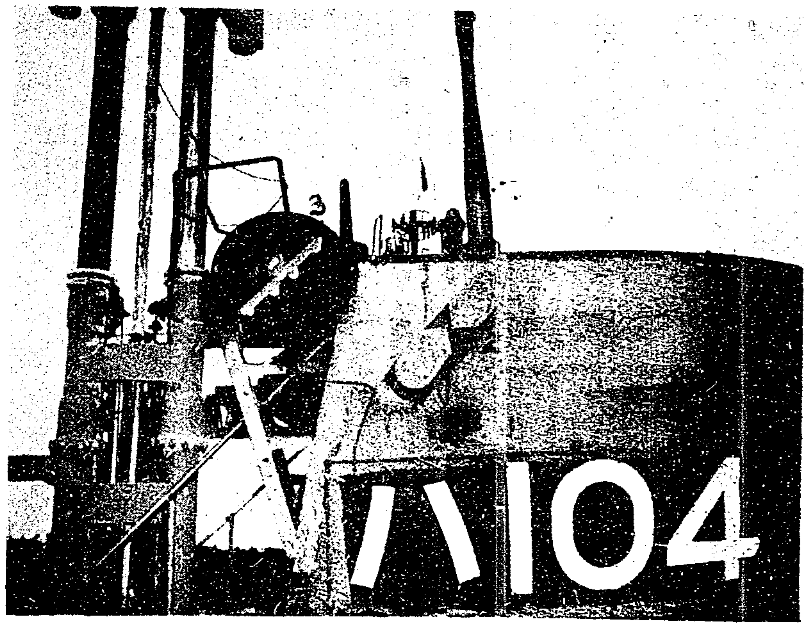


Figure 11

RCM ANTENNAE ON A SUBMARINE

1. *Metox Omnidirectional Antenna*
2. *Racquet Directional Antenna*
3. *Parabolic Antenna (4G)*

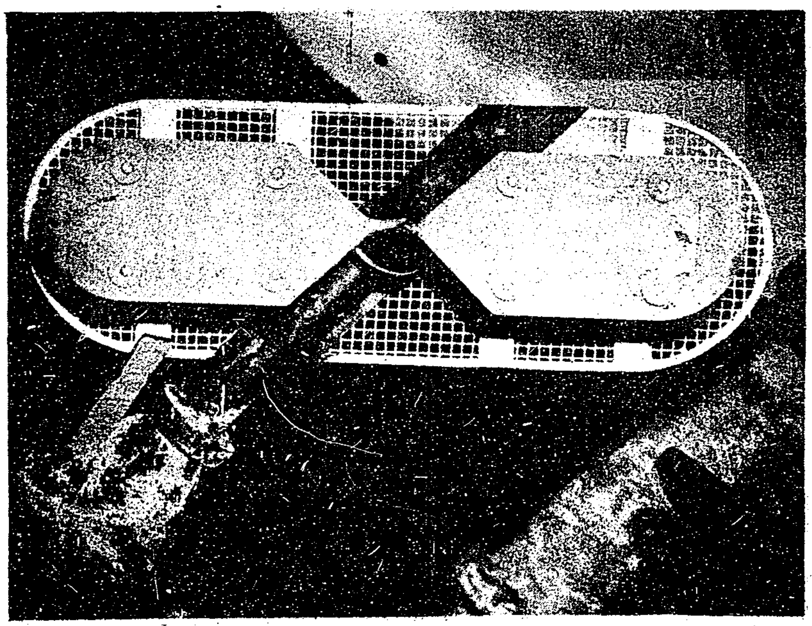


Figure 12

RACQUET TYPE ANTENNA FOR RADAR INTERCEPT RECEIVER

The meter wave equipment (E27) covered wave lengths from 0.75 meters to 4 meters. The metox omnidirectional antenna was used with this equipment to detect transmissions. The racquet type antenna was then used to determine the bearing of the transmission. The racquet antenna was sometimes placed on a rotatable pedestal and sometimes, particularly on submarines, fixed on either side of the superstructure.

The mark 49 antenna was used with the centimeter wave equipment which covered wave lengths from 0.03 meters to 0.80 meters. This antenna is a parabolic disk, 45mm in diameter. It has a crystal pickup located in front of the reflector between the antenna elements. The antenna, as used at the end of the war, was either held in the hand or fixed on either side of the superstructure.

Figure 11 shows a typical installation of RCM antennae on the superstructure of a submarine.

Figure 12 shows a racquet antenna on a rotatable pedestal. A rotatable pedestal with the Mark 49 and racquet antennae was in production but only one installation had been made at the end of the war. The prototype installation of these antennae and pedestal on a submarine is shown in Figure 13.

Two types of omnidirectional antennae were in the design stage at the end of the war. A spherical antenna was to be used with the centimeter equipment. A Theta type antenna was to be used with the (FTB) and (FTC) equipment, both new equipment in the meter band. Enclosure (L) is a schematic diagram of the (FTC) which includes a sketch of the Theta antenna and shows how it was to be used in conjunction with the racquet type antenna. No performance data on these two antennae are available.

Enclosure (M) gives performance data on the directional antennae discussed above.

Additional data on RCM antennae is available in the following documents listed also in Enclosure (A):

NavTechJap Documents No. ND21-6116
ND21-6154
ND21-6216.18
ND21-6234.1 to
ND21-6234.10
ND21-6276
ND21-6280

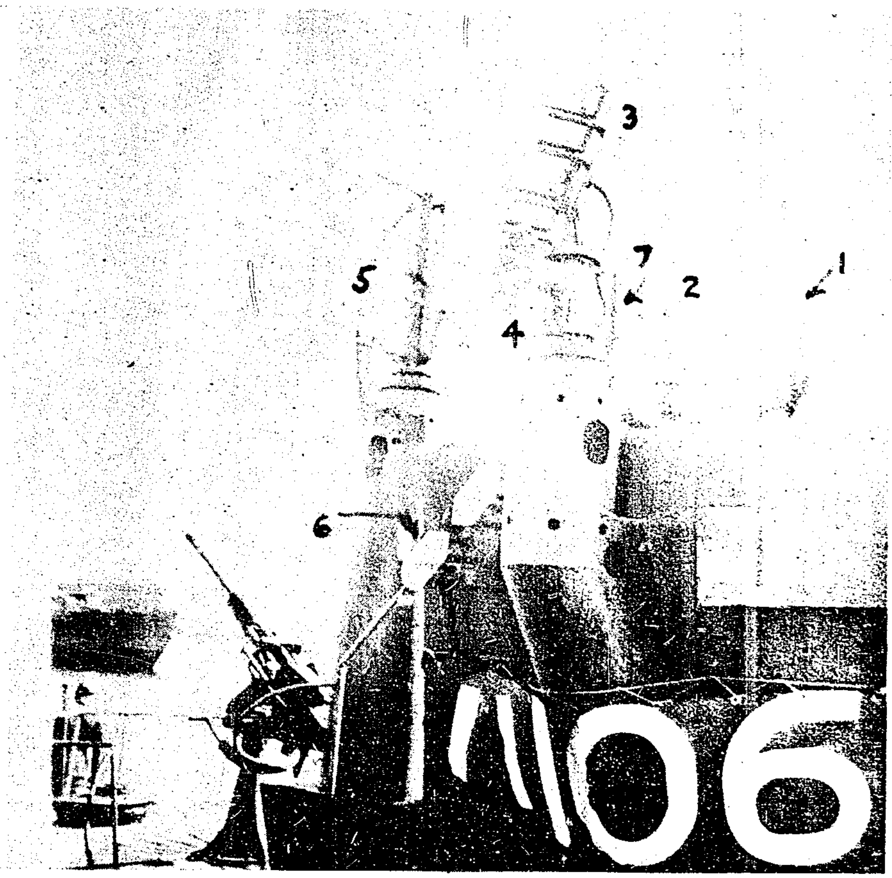


Figure 15

RCM ANTENNAE ON SUBMARINE

1. Underwater Antenna for Long Wave Receiver
2. Netox Antenna
3,4. Racquet and Mark 49 Antennae Mounted on Rotatable Pedestal
5. Type 3, Mark 1, Model 3 Radar Receiving Antenna
6. Racquet Antenna (Standard Installation)
7. Radio and Type 3, Mark 1, Model 3 Radar Transmitting Antenna

ENCLOSURE (A)

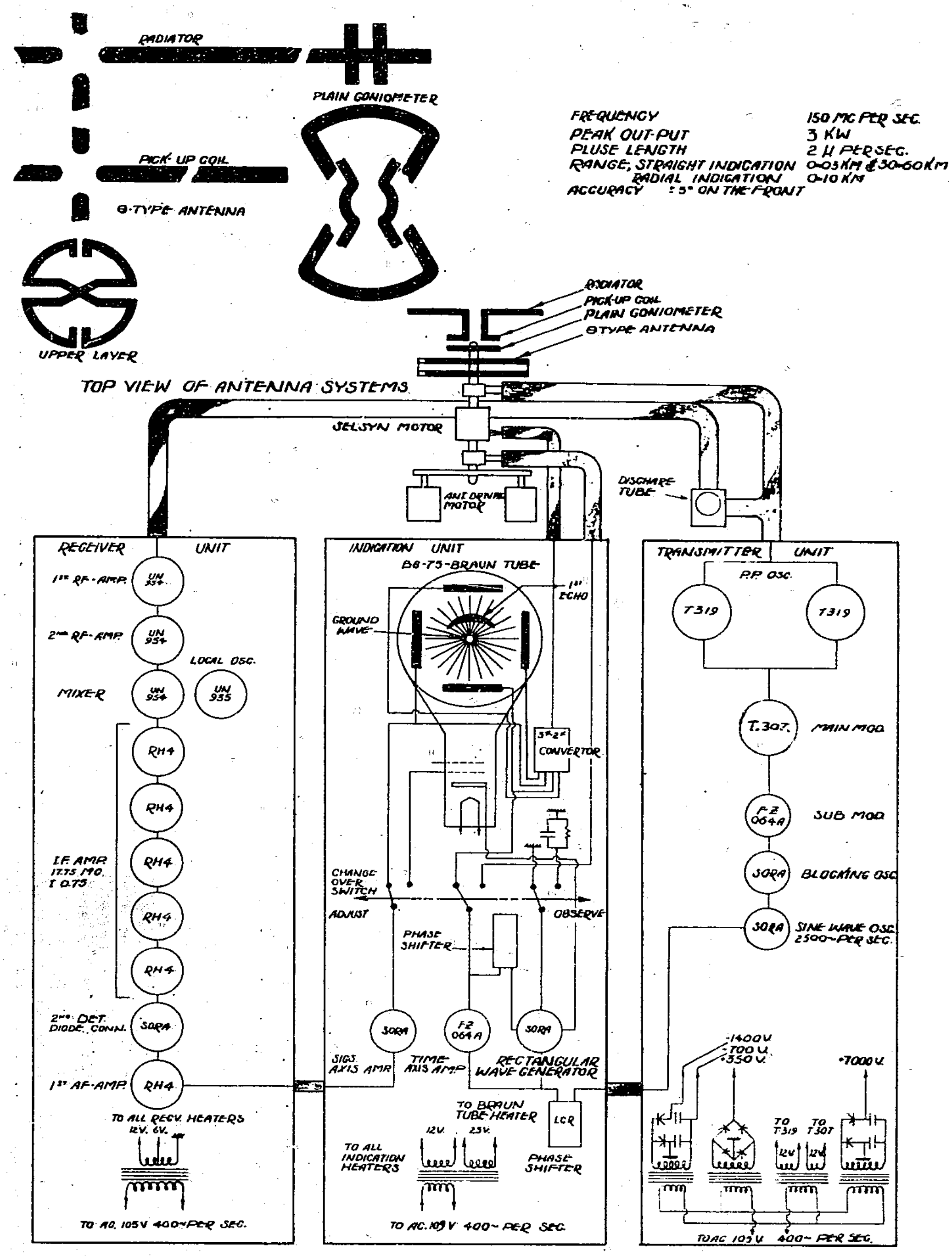
LIST OF DOCUMENTS FORWARDED TO WDC THROUGH ATIS

NavTechJap No.	Name	ATIS No.
ND21-6007	Results of Experiments Designed to Determine Depths of Underwater Radio Reception Using a Watertight Antenna.	3413
ND21-6142	Experimental Underwater Receiving Antenna, Type 3, Experiments on.	3415
ND21-6268	Powdered Cores for High Frequency.	3477
ND21-6000 to ND21-6000.14	Studies of Electromagnetic Field Disturbances, Parts 1 to 13.	3232
ND21-6002	Studies on Spherically Polarized Electromagnetic Waves.	3255
ND21-6043	Radiation Characteristics of the Polyphase Vertical Antenna.	3260
ND21-6044	Radiation Characteristics of the Star and Ring Shaped Polyphase Horizontal Antennae	3261
ND21-6046	Radiation Resistance of the Rotating Oscillation Antenna.	3262
ND21-6047	The Rotating Oscillation (Infinite Phase) Antenna.	3263
ND21-6048	Horizontally Fixed Symetrical Polyphase Antenna.	3264
ND21-6277	Modifications in the Installation of the Temporarily Designated Type 3, Mark 1, Model 1 Radar.	3367
ND21-6222	Performance Tests on the Type 2, Mark 2, Model 1 Antenna.	3533
ND21-6065	Antenna Arrays with Closely Spaced Elements.	3266
ND21-6089	Instruction Book on Antenna Switching Device used with Temporarily Designated Type 3, Mark 2, Model 1 Radar.	3344
ND21-6090	Antenna Coupling Device used with Type 2, Mark 2, Model 1 Radar.	3345
ND21-6216.6	Report on Installation of Temporarily Designated Type 3, Mark 1, Model 3, Radar Antenna Rotation Mechanism on Special Picket Boats.	3404
ND21-6216.9	Installation Report on (13) Radar Antenna.	3404
ND21-6216.4	Experimental Report on the D6 Rotating Mechanism and Manual Equipment.	3404
ND21-6231.1 to ND21-6231.4	Radar Mark 2, Model 2 Installation and wiring plans.	3364

ENCLOSURE (A), continued

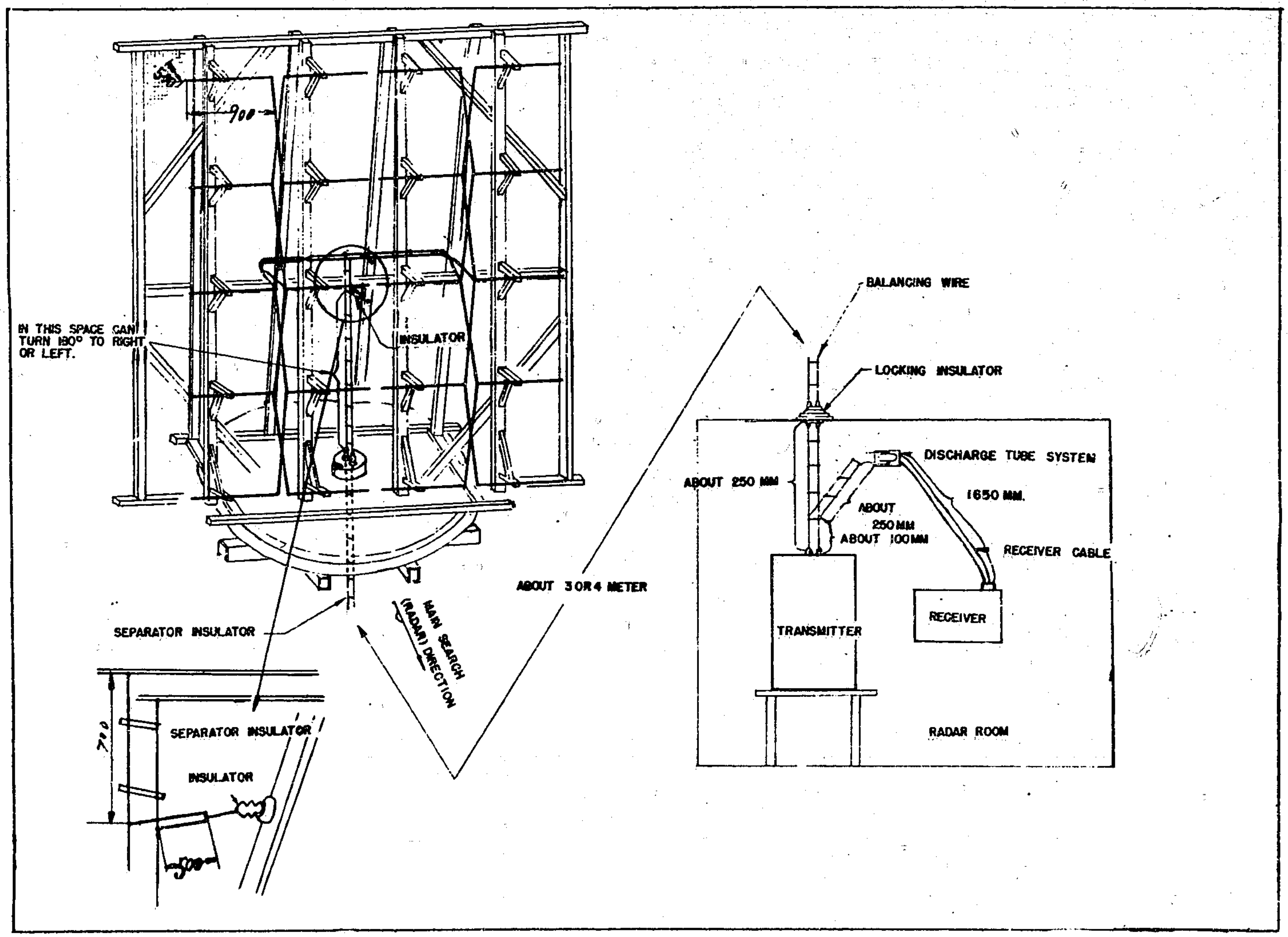
NavTechJap No.	Name	ATIS No.
ND21-6232.1 to ND21-6232.11	Radar Mark 3, Model 2 Installation and Wiring Plans.	3406
ND21-6237	Microfilm of Instruction Book on Temporarily Designated Mark 2, Model 2 Radar.	3411
ND21-6116	Tests on Radar Intercept Procedure.	3525
ND21-6154	Schematic Diagram of Type E-27 Intercept Receiver.	3535
ND21-6216.18	Experimental Report on Submarine Intercept Receiver Covered Antenna.	3532
ND21-6234.1 to ND21-6234.10	Intercept Receiver and Antenna Installation Plans.	3534
ND21-6276	Instructions for Installing Radar and Radar Intercept Equipment - Shipboard Installations.	3408
ND21-6280	Performance of Experimental Parabolic Antenna for Radar Intercept Equipment.	3410
ND21-6015	Stimulation of Infinite Phase Oscillation from Finite Phase Oscillation.	3258

ENCLOSURE (B)



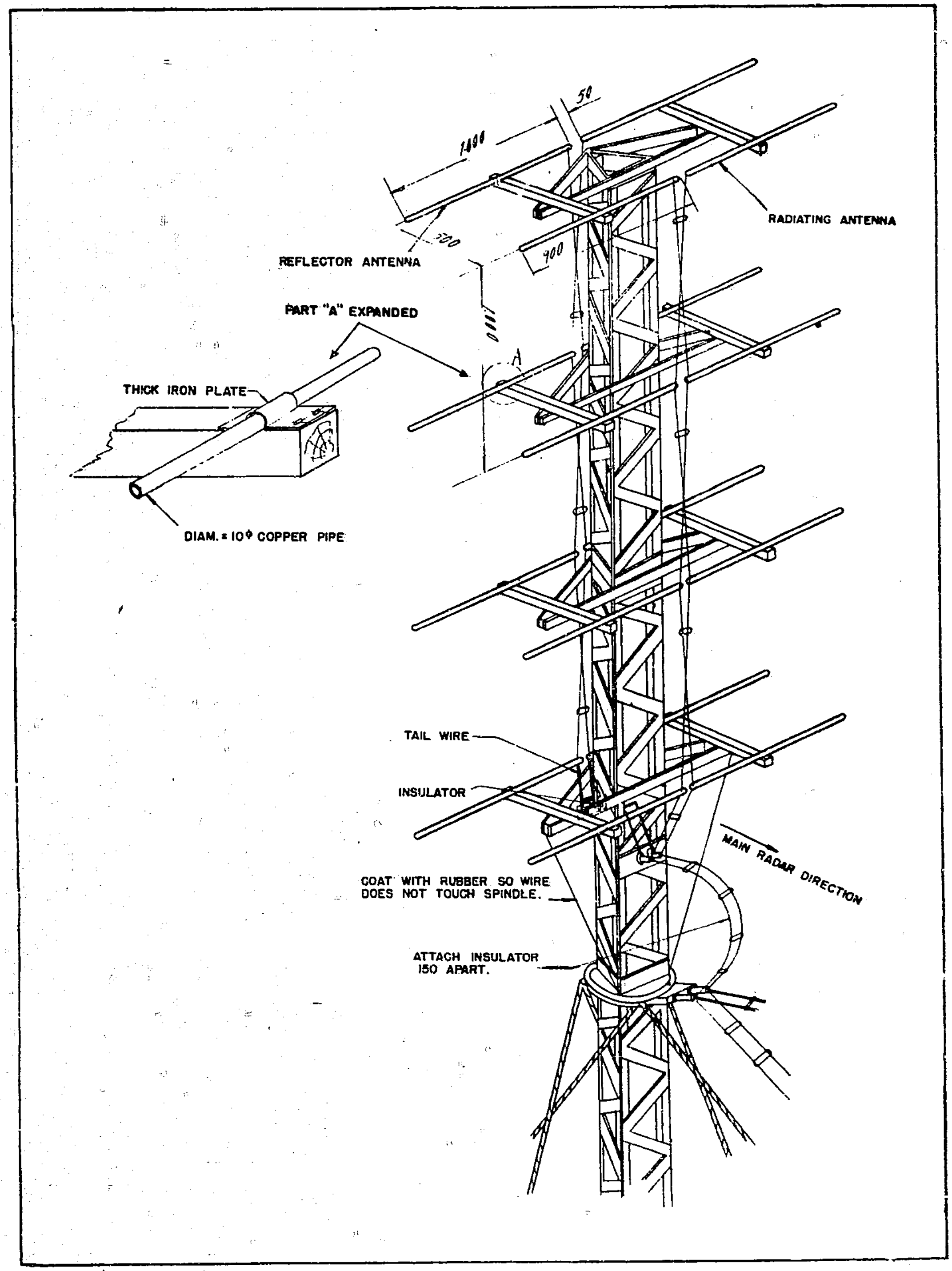
BLOCK DIAGRAM OF GYOKU 3 RADAR
SHOWING GONIOMETER COUPLED THETA TYPE ANTENNA

ENCLOSURE (C)



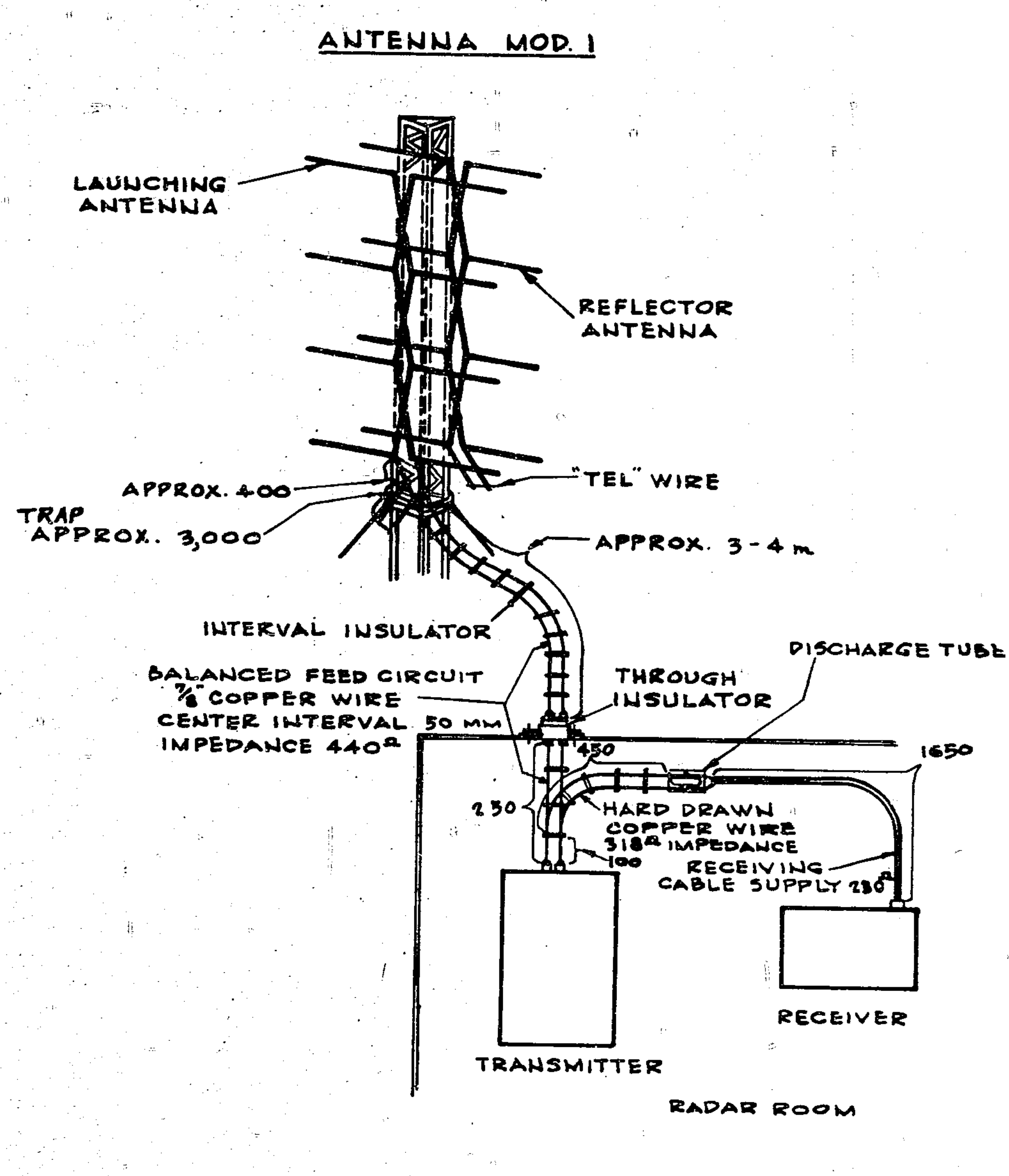
SCHEMATIC DIAGRAM OF TEMPORARILY DESIGNATED TYPE 3. MARK 1. MODEL 1 (11X) RADAR ANTENNA

ENCLOSURE (D)



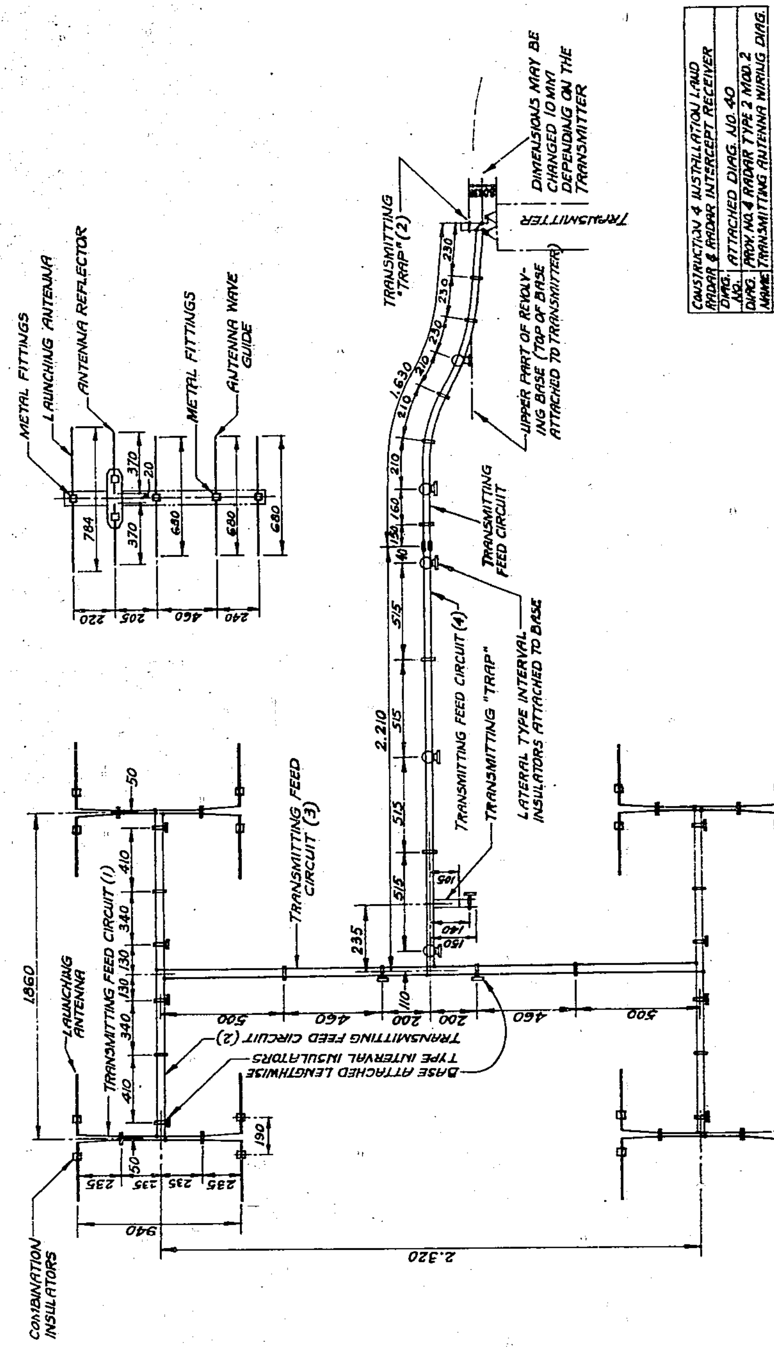
INSTALLATION DIAGRAM OF TEMPORARILY DESIGNATED TYPE 3, MARK 1, MODEL 3 (13) RADAR ANTENNA

ENCLOSURE (E)

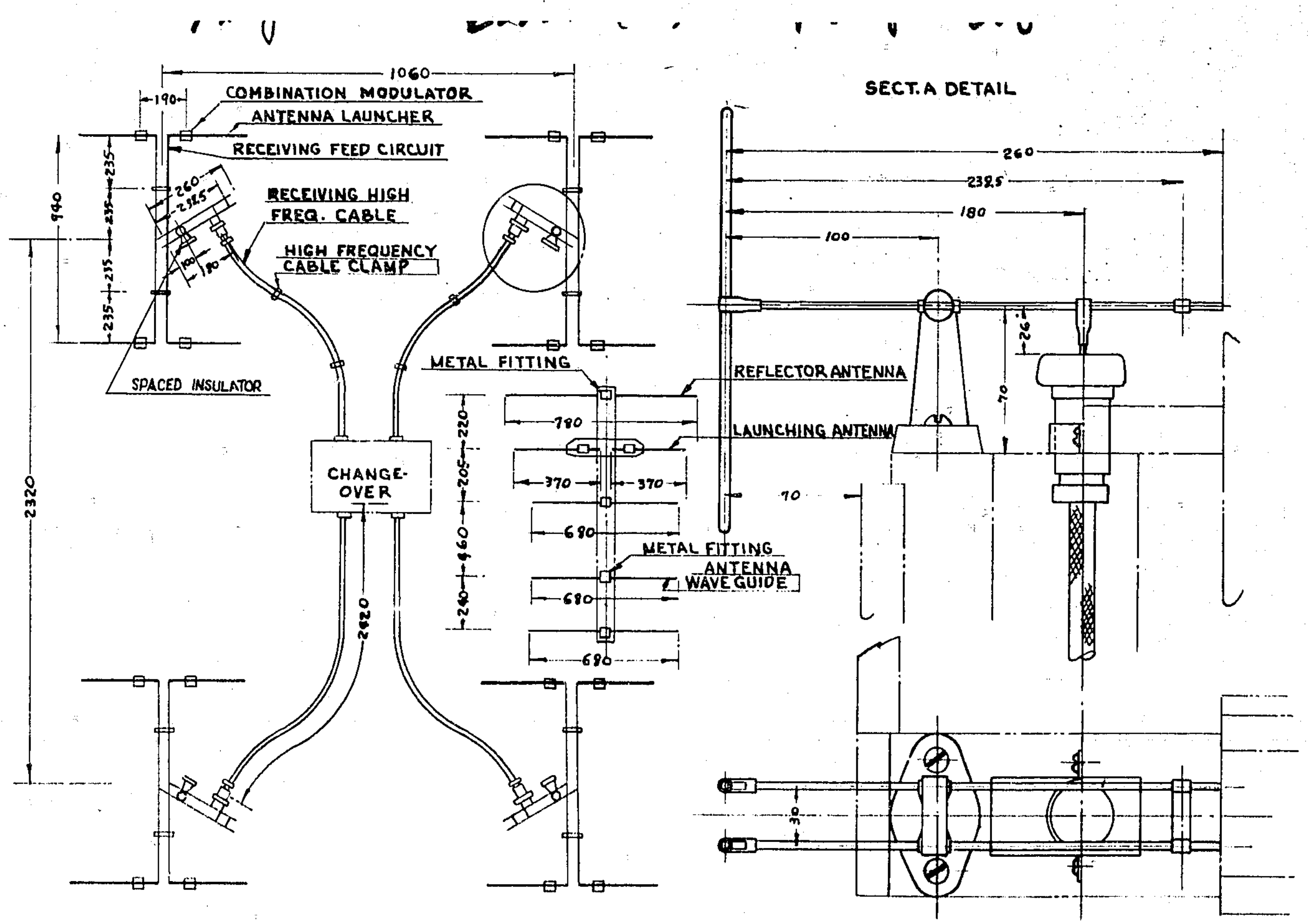


SCHEMATIC DIAGRAM OF TEMPORARILY DESIGNATED TYPE 3, MARK 1, MODEL 3 (13) RADAR ANTENNA

ENCLOSURE (F)

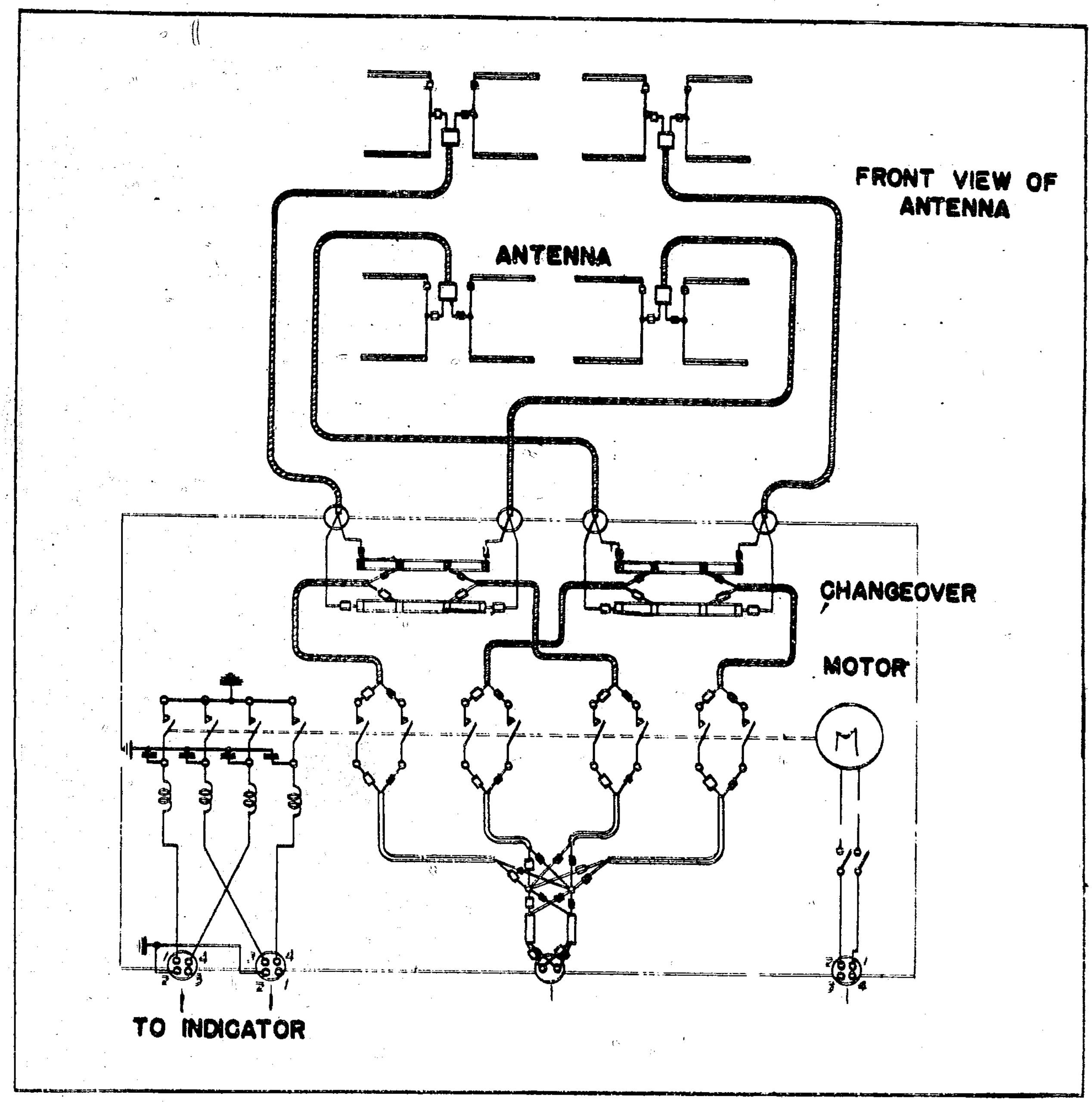

CONSTRUCTION & INSTALLATION LAND RADAR & RADAR INTERCEPT RECEIVER
DIAG. NO. ATTACHED DIAG. NO. 40
DIAG. PROV. NO. 4 RADAR TYPE 2 MOD. 2
NAME TRANSMITTING ANTENNA WIRING DIAG.
DIMENSIONS MAY BE CHANGED 10 MM DEPENDING ON THE TRANSMITTER
TRANSMITTER
TRANSMITTING "TRAP" (2)
UPPER PART OF REVOLVING BASE (TOP OF BASE ATTACHED TO TRANSMITTER)
TRANSMITTING FEED CIRCUIT
LATERAL TYPE INTERVAL INSULATORS ATTACHED TO BASE
TRANSMITTING FEED CIRCUIT (4)
TRANSMITTING "TRAP"
TRANSMITTING FEED CIRCUIT (3)
METAL FITTINGS
LAUNCHING ANTENNA
ANTENNA REFLECTOR
ANTENNA WAVE GUIDE
TRANSMITTING FEED CIRCUIT (1)
TRANSMITTING FEED CIRCUIT (2)
BASE ATTACHED LENGTHWISE TYPE INTERVAL INSULATORS
COMBINATION INSULATORS
1860
2.210
2.320
940
1.630

ENCLOSURE (G)



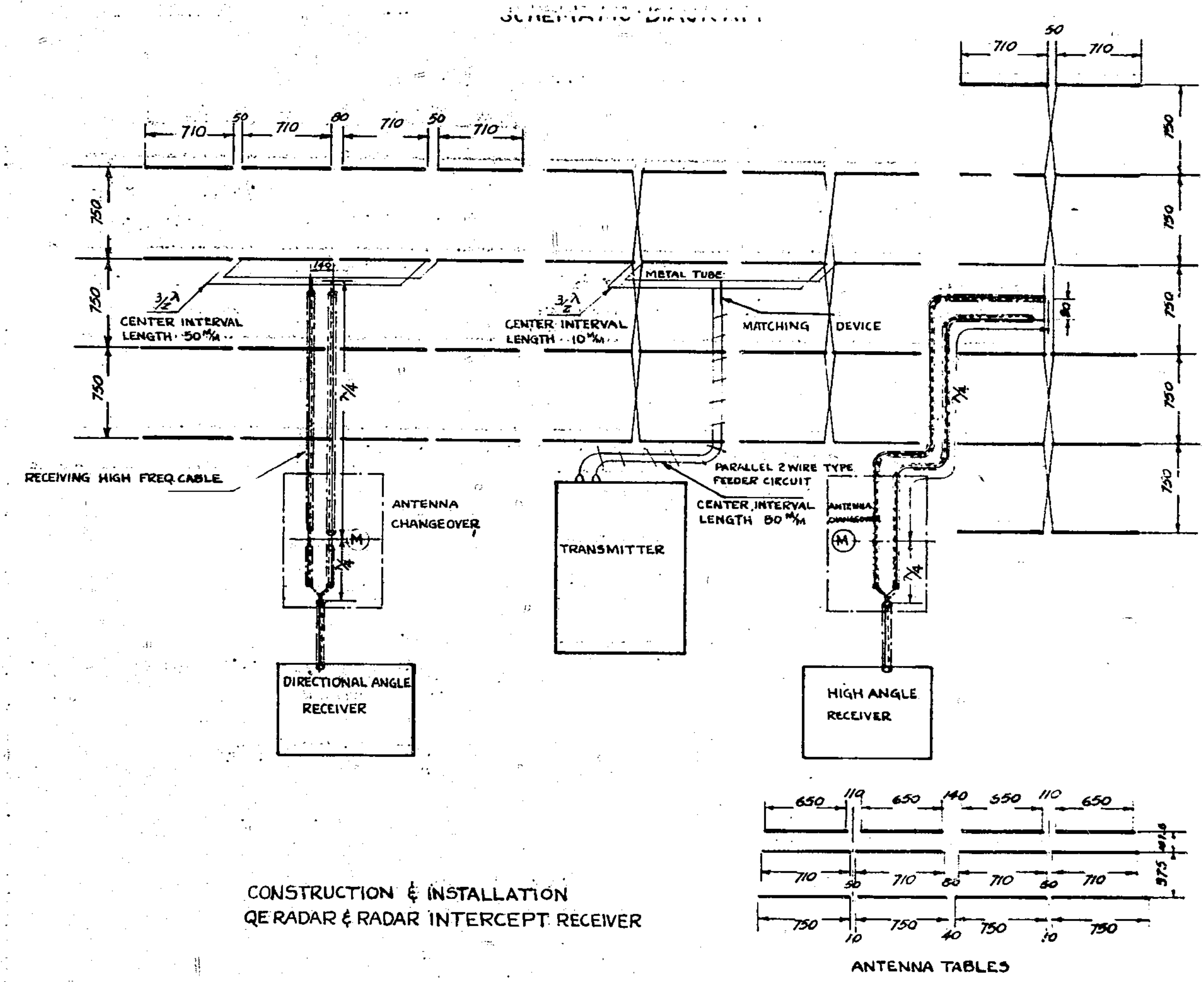
SCHEMATIC DIAGRAM OF RECEIVING ANTENNA
MARK 4, MODEL 2, MODIFICATION 2 (S24) RADAR (PART 1)

ENCLOSURE (H)



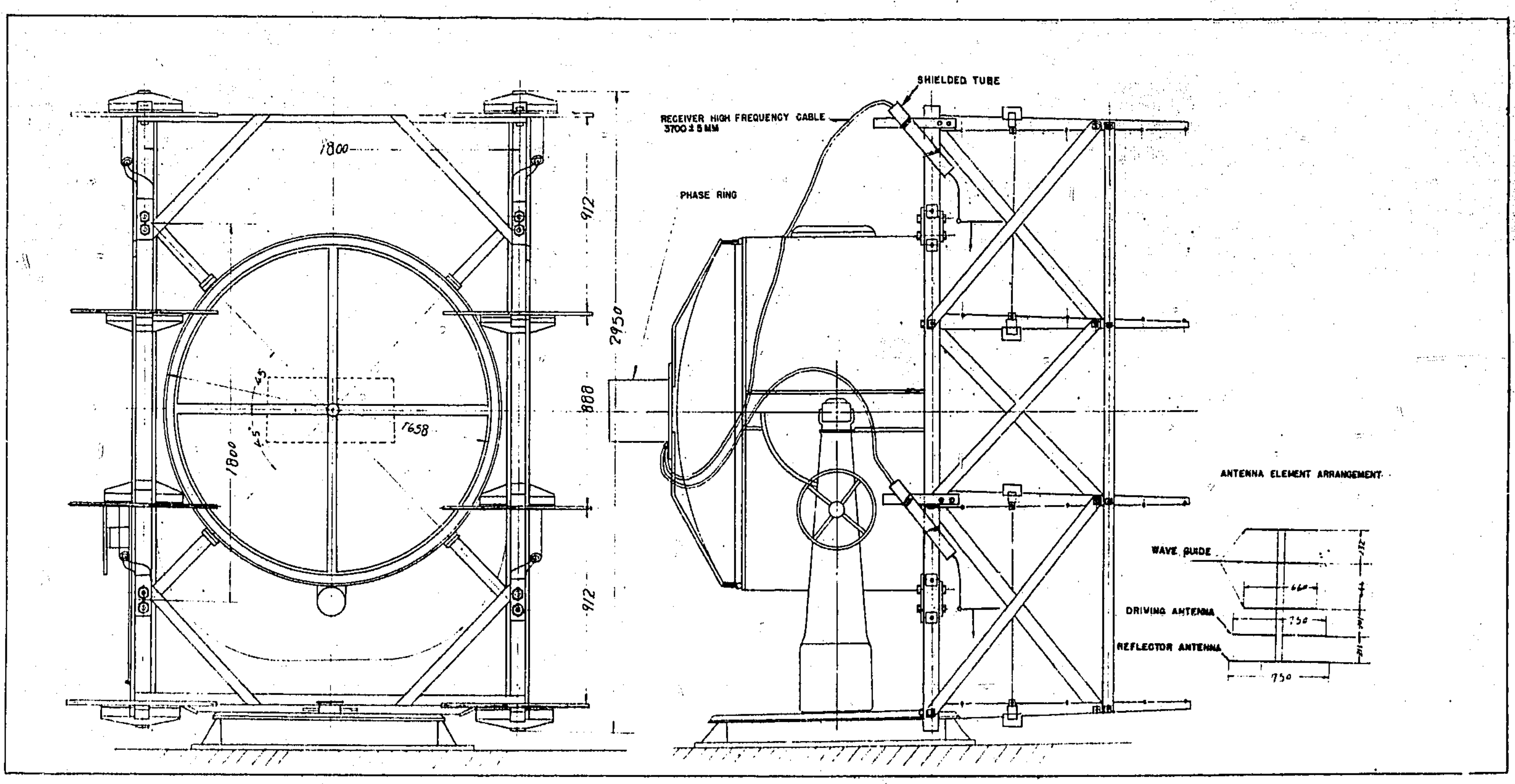
SCHEMATIC DIAGRAM OF RECEIVING ANTENNA
MARK 4, MODEL 3, MODIFICATION 2 (SCA) [illegible]

ENCLOSURE (I)



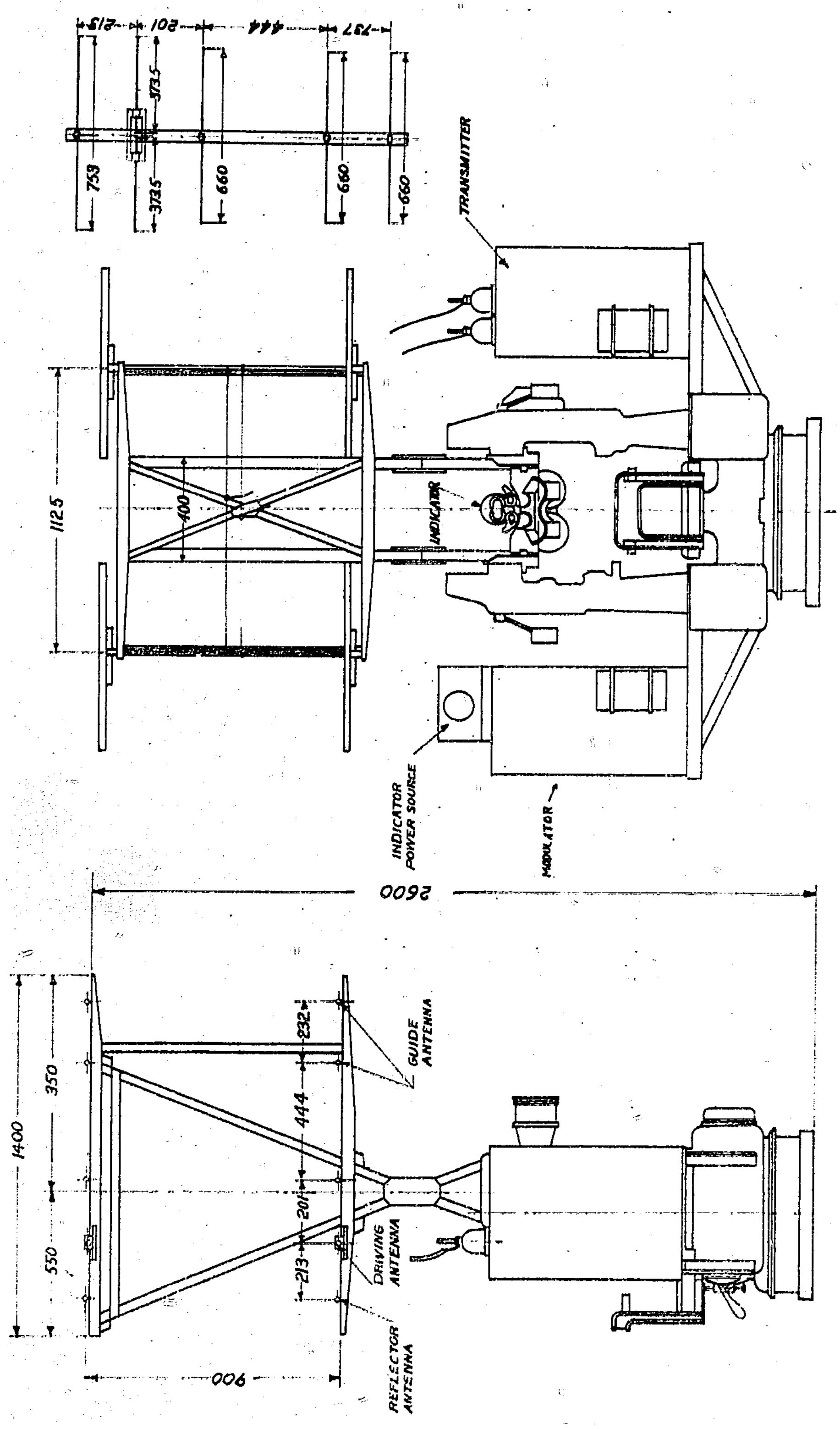
SCHEMATIC DIAGRAM ANTENNA
MARK 4, MODEL 1 (S5) RADAR

ENCLOSURE (J)



INSTALLATION DIAGRAM OF TRANSMITTING ANTENNA
TYPE 4, MODEL 3, MODIFICATION 1 (12) RADAR

ENCLOSURE (K)

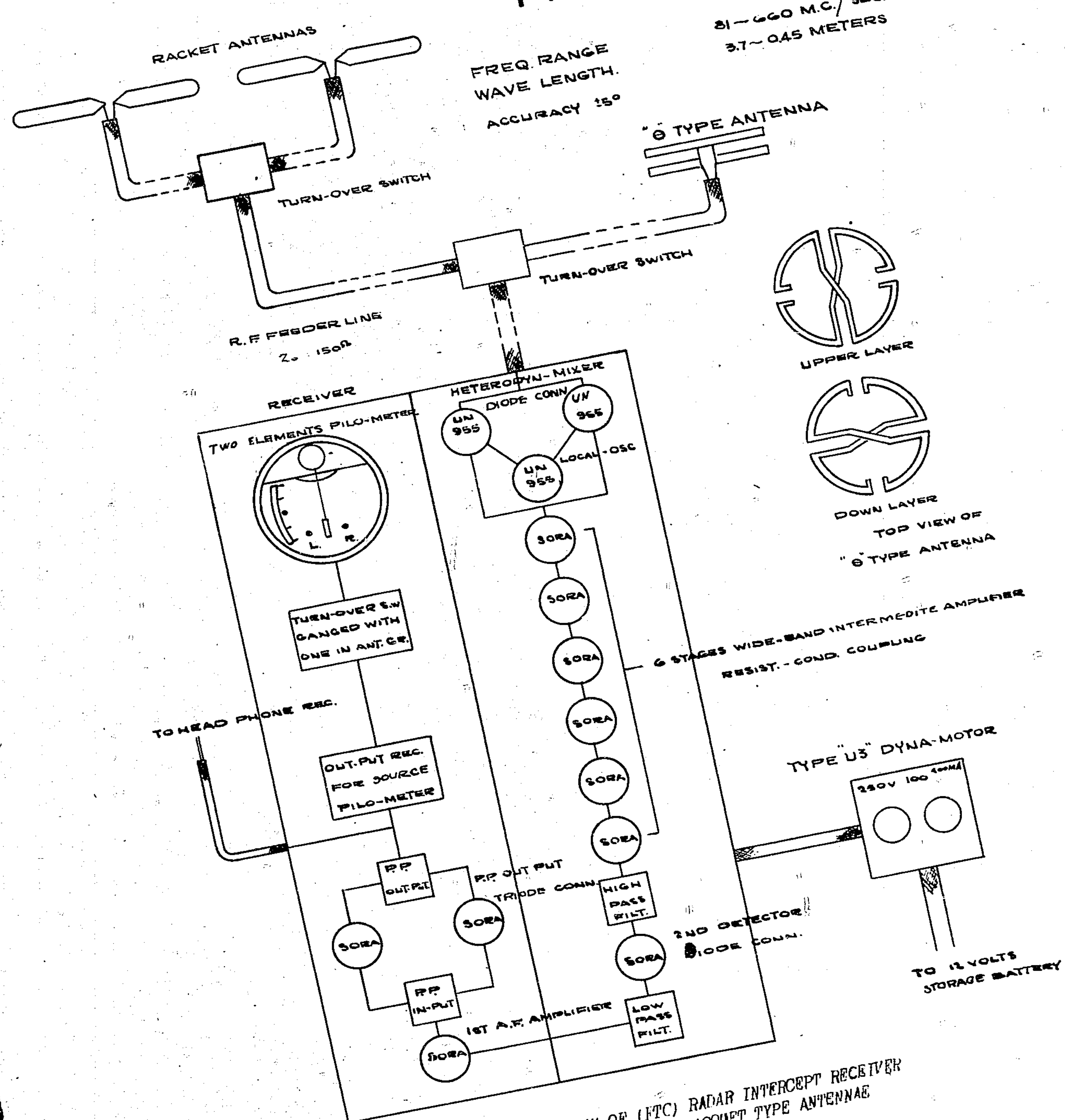


TRANSMITTER
INDICATOR
INDICATOR POWER SOURCE
MODULATOR
GUIDE ANTENNA
DRIVING ANTENNA
REFLECTOR ANTENNA
2600
1125
400
1400
350
550
900
232
444
201
213
753
373.5
660
737

RESTRICTED

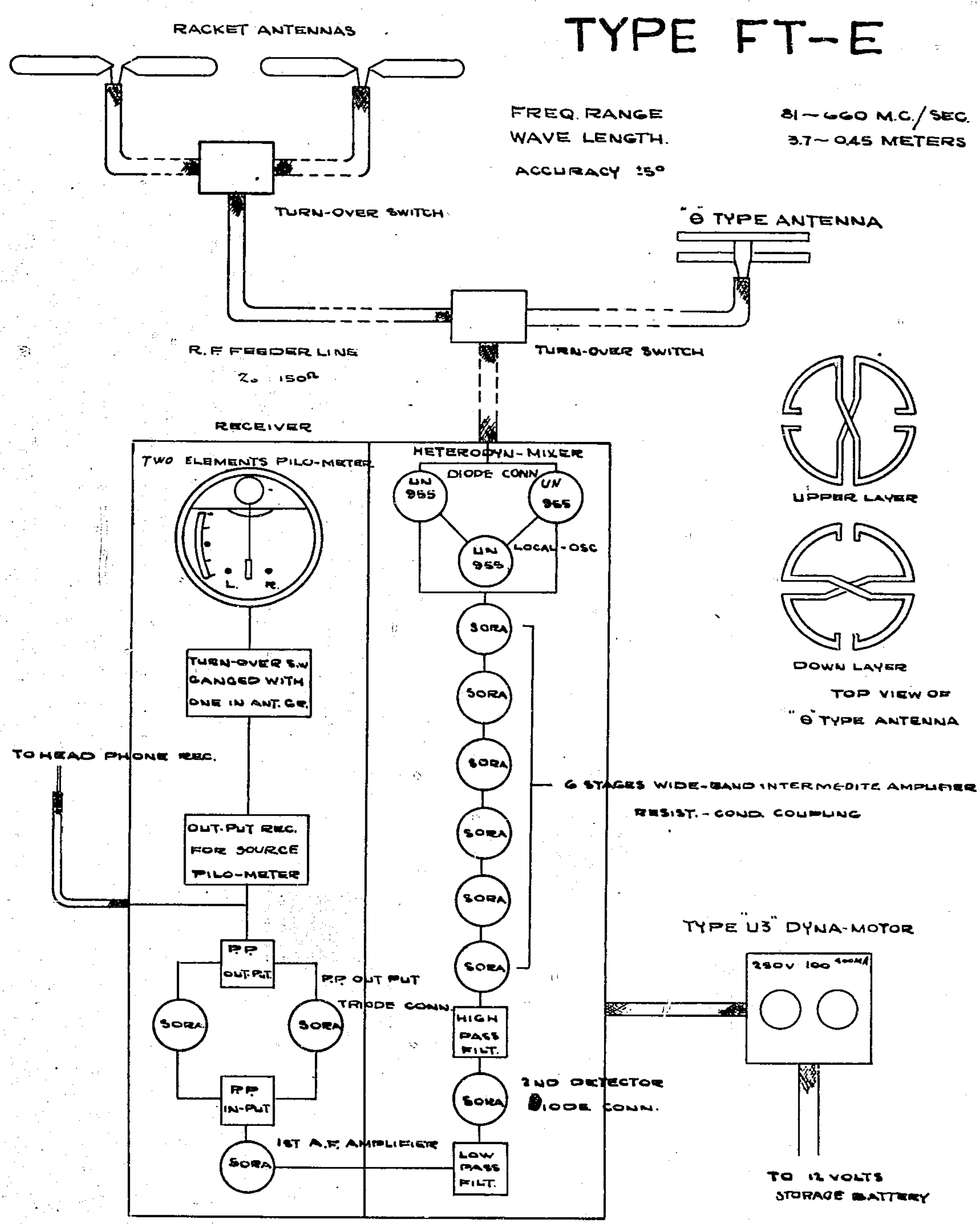
ENCLOSURE (L)

TYPE FT-E



NOOR DIAGRAM OF (FTC) RADAR INTERCEPT RECEIVER SHOWING TEETA AND RACQUET TYPE ANTENNAE

ENCLOSURE (L)



NOOR DIAGRAM OF (FTC) RADAR INTERCEPT RECEIVER SHOWING TEETA AND RACQUET TYPE ANTENNAE

ENCLOSURE (M)

A. LAND BASED RADARS.

No.	Name	Designation	Object	Research Started	Research Finished	Remarks	Installations	Frequency Wave length	Power Output (peak) (KW)	Pulse Length (μs)	Repetition Frequency (c/s)	Oscillation Circuit	Oscillator Valve	Receiver: Intermediate Frequency	Receiver: Detector	Receiver: Local Oscillator
1	Mark-1 Model-4	14	Long range anti-air warning	1945-1	1945-5	in use	Important points	50MC (6m)	100	20	250	Back-coupled Oscillation(Parallel Wire)	TR-594A x 2	8.5MC	UN-954	UN-955
2	Mark-3	RD	Anti-air warning	1941-11	1942-10	installed but not used	Important points Inland	5m	500W	Continuous		Crystal Controlled Oscillator and Ampl.	P-220 x 2	3.5MC 200KC	UN-954	UN-955
3	Type-2 Mark-1 Model-1	11	Anti-air warning	1941-4	1942-3	out of use	Sea Shore	100MC(3m)	5	20	1,000	Resonator-tanc	TR-593A x 2	21.5MC 3.5MC	UN-954	UN-955
4	Type-2 Mark-1 Model-1-1	11-1	Anti-air warning	1941-11	1942-5	out of use	Sea Shore	100MC(3m)	5	20	1,000	LC-Circuit	TR-593A x 2	21.5MC 3.5MC	UN-954	UN-955
5	Type-2 Mark-1 Model-1-2	11-2	Anti-air warning	1942-5	1943-5	in use	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
6	Type-2 Mark-1 Model-1-3	11-3	Anti-air warning	1943-5	1943-7	in use	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
7	Prototype Air warning Radar	11-3-Kai	Anti-air warning	1945-1	1945-5	not yet used	Sea Shore	100MC(3m)	40	20	500	LC-Circuit	TR-1501 x 2	21.5MC 3.5MC	UN-954	UN-955
8	Type-3 Mark-1 Model-3 Land Based	13	Small size Anti-air warning	1943-4	1943-8	in use	Sea Shore	150MC(2m)	10	10	500	LC-Circuit	T-311 x 2	14.5MC	UN-954	UN-955
9	Type-3 Mark-1 Model-1	11-k	Medium size Anti-air warning	1943-5	1943-10	in use	Sea Shore	150MC(2m)	10	20	500	LC-Circuit	T-311 x 2	21.5MC 3.5MC	UN-954	UN-955
10	Type-2 Mark-1 Model-2	12	Portable Anti-air warning	1942-4	1942-12	in use	Sea Shore	200MC(1.5m)	5	10	1,000	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
11	Type-2 Mark-1 Model-2-2	12-Kai-2	Portable Anti-air warning	1943-8	1943-12	in use	Sea Shore	150MC(2m)	5	10	1,000	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
12	Type-2 Mark-1 Model-2-3	12-Kai-3	Portable Anti-air warning	1943-12	1944-4	in use	Sea Shore	150MC(2m)	5	10	500	LC-Circuit	T-310 x 2	21.5MC 3.5MC	UN-954	UN-955
13	Prototype Mark-4 Model-3	L_1	Searchlight control	1943-1	1943-4	out of use	Battery	1.5m	7	4	1,000	LC-Circuit	T-311 x 2	14.5MC	UN-954	UN-955
14	Prototype Mark-4 Model-3-1	L_2	Searchlight control	1943-1	1944-4	in use	Battery	1.5m	10	3	1,000	LC-Circuit	TA-1504 x 2	15MC	UN-954	UN-955
15	Prototype Mark-4 Model-3-2	L_3	Searchlight control	1944-4	1945-7	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955
16	Prototype Mark-4 Model-1	S_3	Anti-aircraft fire control	1942-8	1943-8	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955
17	Prototype Mark-4 Model-2	S_{2A}	Anti-aircraft fire control	1943-1	1944-10	in use	Battery	1.5m	13	3	1,000	LC-Circuit	TA-1504 x 4	14.5MC	UN-954	UN-955
18	Prototype Radar for A.A. Control	S_{8A}	Anti-aircraft fire control	1944-9	1944-12	not yet used	Battery	58cm	6	2.5	3,750	Shielded type Push-pull Oscillator	T-321 x 2	21.5MC 8.75MC	2400	UN-955B
19	Prototype Mark-6 Model-1	61(S_{8B})	Altitude measurement	1944-12	1945-4	in development	Airfields	60cm	10	2.5	1,875(No.1) 1,000	Shielded Type Single tube Oscillator	RT-326	21.5MC 8.75MC	2400	UN-955B
20	Prototype Mark-6 Model-2	62	Friendly aircraft locator	1945-1	1945-6	not yet used	Airfields	2m	10	10	500	Back-Coupled Oscillator (Parallel Wire)	T-311 x 2	14.5MC	UN-954 RH-2	UN-955
21	Prototype Mark-6 Model-3	63	Foe aircraft locator	1945-1		in development	Airfields	3m	40	20	416.7	LC-Circuit	T-311 x 2	21.5MC 3.5MC	UN-954	UN-955
22	Radar to guide boats	TH	To guide friendly boats	1944-12	1945-7	in development	Sea Shore	1.5m	13	6	1,000	LC-Circuit	TA-1504 x 4	15MC	UN-954	UN-955

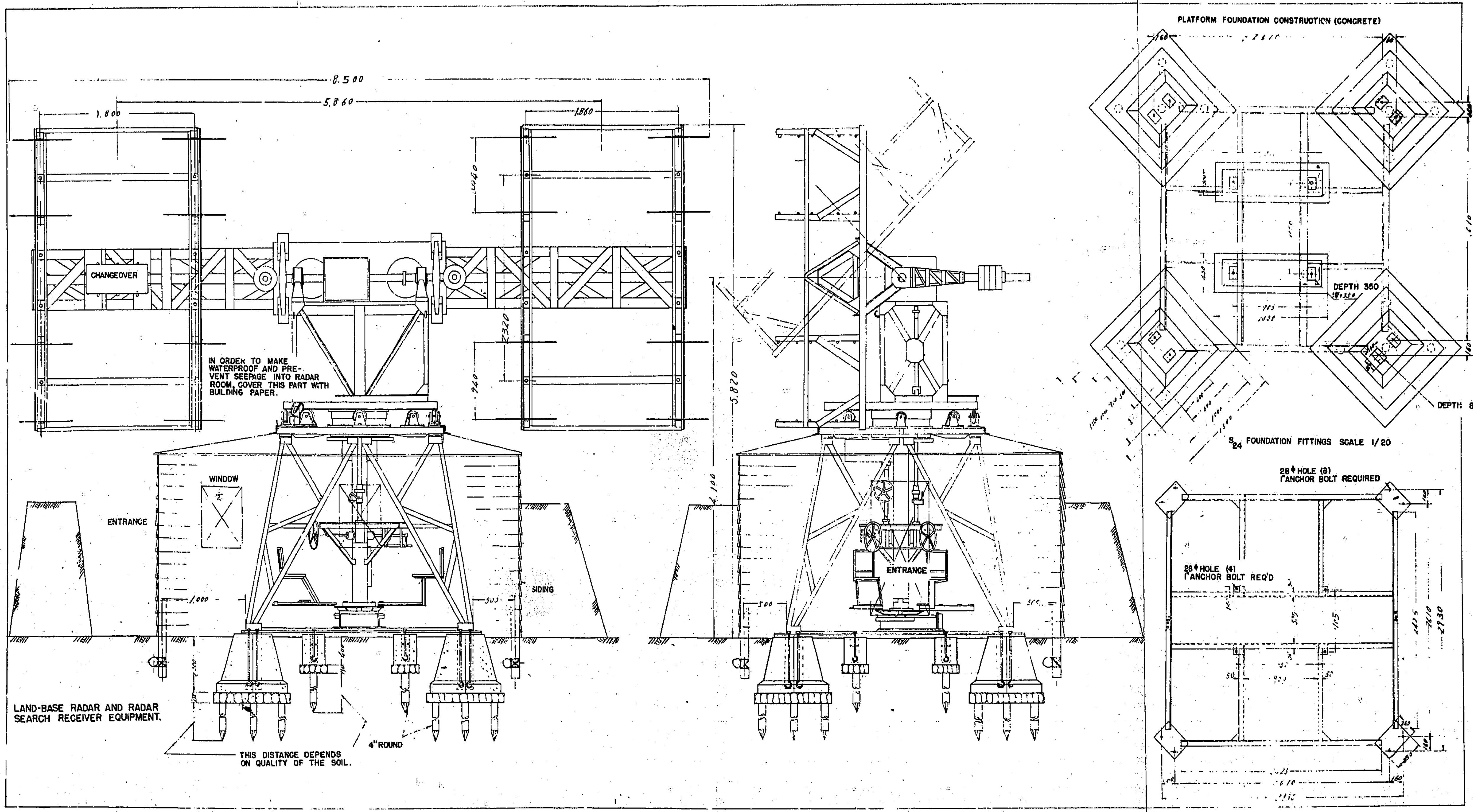
No.	Scope Representation: Dia. (mm)	Scanning Axis	Scale	Antenna: Type	Gain (db)	Beam Angle Horizontal	Beam Angle Vertical	Max. Range Max. Effective Scale (km)	Min. Distance	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	
1	120	Semi linear	Electric	Multiple Yagi-Ant Horizontal	4	±15°	±15°	550 450		±5km	≦5km	±3~4°	≦30°		3	None	Almost no trouble
2	75	Linear		Horizontal Doublet with Reflector	3	60°		200	0km						2	None	Ordinary
3	120	Linear	Electric	Tr: Ant: 5 x 2 Hor. Rec.Ant: 5 x 2 Hor.	2.5 2.5	±14°	±40°	150 150	5km	±1~2km	≦3km	±2~3°	≦30°		2	Slight	Trouble- Frequently broke down
4	120	Linear	Electric	Tr: Ant: 5 x 2 Hor. Rec.Ant: 5 x 2 Hor.	2.5 2.5	±14°	±40°	150 150	5km	±1~2km	≦3km	±2~3°	≦30°		2	None	
5	120	Linear	Electric	Tr. Ant: 2 x 4 Hor. Rec.Ant: 3 x 4 Hor.	2 4	±32° ±32°	±17°	300 200	5km	±1~2km	≦5km	±3~4°	≦40°		2	None	
6	75	Linear	Optical	Tr. Ant: 2 x 4 Hor. Rec.Ant: 3 x 4 Hor.	2 4	±32° ±22°	±17°	300 200	5km	±1~2km	≦3km	±3~4°	≦40°		2	None	Ordinary (at first trouble. Freq. broke down)
7	75	Warning: Linear Range Bearing: Sinusoidal		Common for Tr. and Rec. 6 x 4 Hor.	6.5	±11°	±17°	300 200	5km	±1~2km	≦3km	±1°	≦20°		3	None	
8	75	Linear	Mechanical	Common for Tr. and Rec. 2 x 4 Hor.	2	±32°	±17°	150 100	5km	±2~3km	≦3km	± 10°	≦60°		2	None	
9	75	Linear	Optical	Common for Tr. and Rec. 4 x 5 Hor.	6	±17°	±14°	300 150	5km	±2~3km	≦3km	± 5°	≦30°	Number of Vacuum Tubes in use x 3	2	None	Ordinary(Trouble in parts. Frequently broke down.)
10	120	Linear	Electric	Tr. Ant: 2 x 4 Hor. Rec.Ant: 6 x 2 Hor.	4 4	±11°	±40°	150 100	5km	±1~2km	≦2km	± 5°	≦20°		2	None	
11	120	Linear	Electric	Common for Tr. and Rec. 5 x 3 Hor.	4.5	±14°	±35°	150 100	5km	±1~2km	≦2km	± 7°	≦30°	Number of Resistances in use x 3	2	None	
12	75	Linear	Mechanical	Tr. Ant: 2 x 4 Hor. Rec.Ant: 2 x 4 Hor.	2	±32°	±17°	300 150	5km	±2~3km	≦2km	± 10°	≦60°		2	None	
13	Selection Range measurement: 120 and Indicator: 75	Logarithmic		Yagi Tr. Ant: Single Rec. Ant: 1-2-1 Hor.	5 8	A=50° B=20°	A=50° B=20°	150 10(20)	1500m	200m	1000m	± 3°	≦40°	Number of Condensers in use x 3	2	None	
14	75	Logarithmic	Electric	Multiple Yagi Hor. Tr: 1 x 2 Rec: 2 x 4	5 5	A=28° B=12° c/d<30°	A=26° B=12° c/d<30°	70 15(30)	1000m	150m	500m	±1.5°	≦30°		3	None	
15	75	Logarithmic	Electric	Multiple Yagi Hor. Tr: 1 x 2 Rec: 2 x 4	8 5	ditto	ditto	150 20(40)	600m	160m	500m	±1.5°	≦30°		3	None	
16	Selection Range measurement: 120 and Indicator: 75	Logarithmic		Tr.Ant: 4 x 4 Rec. Ant: 4 x 4 2 x 6 Hor.	5 5.14	ditto	ditto	150 20(40)	1500m	100m	1000m	± 1°	≦20°		4	None	Trouble with parts
17	75	Logarithmic	Electric	Multiple Yagi Tr. and Rec: 2 x 4 Hor.	18	A=32° B=11° c/d<30°	A=30° B=11° c/d<30°	150 20(50)	600m	50m	500m	±0.4°	≦20°		4	None	
18	75	Warning linear Range Bearing: Sinusoidal		Paraboloid 2.9m Dia. Rotating	19	±10°	±10°	33 ≒25(-)	600m	50m	Research Incomplete	±0.3°	Research Incompleted		4	None	
19	75	Warning: Linear Range Bearing: Sinusoidal		Paraboloid 7m Dia. Rotating	16	±4°	±4°	130 ≒50(120)	600m	200m	Research Incomplete	±0.3°	Research Incompleted		4	None	
20	Selection:120 75	Logarithmic	Electric	4 x 4 Vertical	Equi echo System 15	±17°	±17°	150 130	2km	±0.8km		±0.4°			4	First Adjustment Difficult	Many troubles at first Broke down
21	75	Linear	Electric	Common for Tr. and Rec: 6 x 4 Hor.	6.5	±17°	±17°	300 200	Research Incomplete	Estimated 500m	Research Incomplete	Research Incomplete	Research Incompleted		3	Research Incompleted	Not yet Tested
22				Common for Tr. and Rec: 6 x 4 Vert.	16.5	±11°	±17°	40 20	1000m	300m	1000m	±0.5°	≦20°		4	Ordinary	Ordinary

B. SHIPBORNE RADARS.

No.	Name	Designation	Object	Research Started	Research Finished	Remarks	Installation	Freq. Wave	Pulse Length μs	Power Output (Peak) kw	Rep. Freq. cs	Transmitter: Oscillation Circuit	Transmitter: Oscillator Value	Receiver: Inter. Freq. (mc)	Receiver: Detector	Receiver: Local Oscillator
1	Type-3 Mark-1 Model-3 for ships	13 for ship	Anti-air warning	1943-9	1944-2	in use	Both sides of Mizzen Mast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
2		13 for Submarine Anti-Air	Anti-air warning	1943-9	1944-5	in use	Communication Mast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
3		13 for Submarine Anti-Air	Anti-air warning	1943-9	1944-7	in use	On Conning Tower	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
4		13 for small vessels	Anti-air warning	1943-9	1944-7	in use	Foremast	2 m	10	10	500	LC-Circuit	T-311x2	14.5	UN-954	UN-955
5	Type-2 Mark-2 Model-1	21	Anti-air warning	1942-1	1942-4	in use	Bridge (Converted Merchant Ship)	1.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
6		21-Kai-1	Anti-air warning	1942-8	1942-12	out of use	Fore-top	11.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
7		21-Kai-2	Anti-air warning	1943-5	1943-8	in use	Fore-top	1.5m	10	5	1000	LC-Circuit	T-310x2	21.5 3.5	UN-954	UN-955
8		21-Kai-3	Anti-air and Anti-surface warning	1943-8	1944-2	out of use	Fore-top	1.5m	6-10	30	500	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-955
9		21-Kai-4	Anti-air and Anti-surface warning	1944-2	1944-5	research stopped	Fore-top	1.5m	10	30	1000	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-955
10		21-Kai-5	Anti-air warning and surface fire control	1944-5	1944-9	not yet used	Fore-top	1.5m	6	30	1000	LC-Circuit	T-311x4	21.5 3.5	UN-954	UN-955
11		F8	Anti-surface warning	1943-3	1943-10	research stopped		58 cm	5	2	500	Resonator-tanc	SN-7 x2	21.5 8.75	2400	UN-955B
12	Type-3 Mark-2 Model-3	23(S_8)	Anti-surface fire control	1943-10	1944-3	not yet used	Fore-top	58 cm	2.5	5	3750	Resonator-tanc	T-321	21.5 8.75	2400	UN-955B
13	Prototype Mark-2 Model-4	24	Anti-surface fire control	1943-11	1945-4 stopped	research stopped		28 cm	2	1	1000	Parallel wire (standing wave)	LD-212-Cx2	15	Crystal	LD-1
14	Prototype Mark-2 Model-2	22-Kai-1	Anti-surface warning	1941-10	1942-6	out of use	Fore-or Mizzen Mast	10 cm	10	500w	2500	Magnetron	M-311	Super regenerative	M-60	
15		22-Kai-2	Anti-surface warning	1942-6	1942-12	out of use	Fore-or Mizzen Mast	10 cm	10	2	2500	Magnetron	M-312	Autodyne	M-60-A	
16		22-Kai-3	Anti-surface warning	1942-10	1943-6	in use	Conning Tower of Submarine	10 cm	10	2	600	Magnetron	M-312-B	14±1	Crystal	M-60-S
17		22-Kai-4	Anti-surface warning	1942-12 1943-12	1943-12 1944-9	in use	Fore-or Mizzen Mast	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
18	Prototype Mark-3 Model-1	220	Anti-surface fire control	1944-2	1945-3	not yet used	Fore Mast and Sea Shore	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
19	Prototype Mark-3 Model-3	105 S_1	Anti-surface fire control	1944-5	1945-1 stopped	research stopped		10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S
20	Prototype Mark-3 Model-2	105 S_2	Anti-surface fire control	1944-2	1944-9	not yet used	Fore-Mast of Battleship or Sea Shore	10 cm	10	2	2500	Magnetron	M-312-A	14±1	Crystal	M-60-S

No.	Scope Representation: Dia. in mm	Scanning axis	Scale	Antenna: Type	Gain (db)	Beam Hor.	Angle Vert.	Maximum Range, Scale Effective (km)	Minimum Distance (km)	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance
1	75	Linear	Mechanical	2 x 4 Horizontal	12	±34°	±17.5°	150(300) 100	5	± 2~3km	3km	±10°	≦60°		2	None	Few troubles
2	75	Linear	Mechanical	Single Vertical	≃ 3	360°		150(300) 30	5	± 2~3km	3km				2	None	Antenna System gave trouble
3	75	Linear	Mechanical	Yagi Hor.	7	±30°	± 25°	150(300) 15	5	± 2~3km	3km	± 5°	≦60°	Number of Vacuum Tubes in use x 3	2	None	Antenna System gave trouble
4	75	Linear	Mechanical	2 x 4 Hor.	12	±34°	±17.5°	150(300) 100	5	± 2~3km	3km	± 5°	≦60°		2	None	Antenna System gave trouble
5	120	Linear	Electric	6 x 2 6 x 2 Hor.	14 14	±11°	± 40°	150 100	5	± 1~2km	≃ 2km	± 5°	≦20°	Number of Resistances in use x 1/3	2	None	At first trouble Frequently broke down
6	120	Linear	Electric	4 x 2 3 x 2 Hor.	12 11	±17° ±23°	± 40°	150 70	5	± 1~2km	≦2km	± 8°	≦40°		2	Slight	Antenna System gave trouble
7	120	Linear	Electric	4 x 3 Hor.	14	±17°	± 30°	150 100	5	± 1~2km	≦2km	± 5°	≦20°	Number of Condensers in Use x 1/3	2	None	No troubles
8	75	Linear	Optical Electric	4 x 3 Hor.	14	±17°	± 30°	270, 14 against a battleship	4	± 0.5km	1km	± 1°	8°		4	Difficult	Liable to break down
9	120	Linear	Electric	4 x 4 Hor. Interchangeable	15	±17°	± 17.5°	150, 15 against a battleship	5	± 1.0km	1.5km	± 1°	8°		3	Difficult	Liable to break down
10	120	Linear	Electric	4 x 4 Hor. Interchangeable	15	±17°	± 17.5°	150, 20 against a battleship	4	± 0.5km	1km	± 1°	8°		3	Difficult	Ordinary
11	120	Curve	Mechanical	Tr: Paraboloid 1.7m dia. Rec. 1.7m Vertical	11	±25°	± 25°	150, 15 against a cruiser	1.3	± 2km	Research Incompleted	± 3°	Research Incompleted		1	None	Not yet tested
12	75	Warning: Linear Range and Bearing: Sinusoidal		Tr: Paraboloid 1.7m dia. Rec. 1.7m Rotating	11 11	±25°	± 25°	33, 22 against a battleship	1	± 50m	150km	±0.5°	14°		3	None	Liable to break down
13	75	Logarithmic	Electric	Tr: Paraboloid 2m dia. Rec. 2mDouble Ant.(switch)	19 19	± 9°	± 9°	40, 11 against a battleship	1	± 50m	150 m	±0.5°	14°		3	None	Gave some trouble
14	120	Linear	Electric	Paraboloid 0.8 x 1.7m	15	±15°	± 15°	60, 30 against a battleship	1.5	± 500m	1.5km	± 3°	≦±30°		3	Difficult	Gave some trouble
15	120	Linear	Electric	Horn 400mm	13	±19°	± 19°	60, 22 against a battleship	1.5	± 500m	1.5km	± 3°	≦±40°		3	Slight	Gave some trouble
16	75	Linear		Horn 400mm	13	±19°	± 19°	60, 10 against a battleship	1.5	± 500m	1.5km	± 3°	≦±40°	Number of Resistances in use x 1/10	3	None	No trouble
17	75	Linear	Electric	Horn 400mm	13	±19°	± 19°	60, 25 against a battleship	1.5	±100~250m	1.5km	± 3°	≦±40°	Number of Vacuum Tubes in use x 4	3	None	No trouble
18	75	Warning: Linear, Range and Bearing: Sinusoidal		Paraboloid	25	± 7°	± 7°	60, 35 against a battleship	1.5	±100~250m	1.5km	±40°	≦±15°	Number of Magnetron in use x 5	3~4	Slight	No trouble
19	75	Warning: Linear, Range and Bearing: Sinusoidal		Horn, Tr: 1 Rec: 2	15	±15°	± 15°	60, 28 against a battleship	1.5	±100~250m	1.5km	±30°	≦±30°		4	None	No trouble
20	75	Warning: Linear, Range and Bearing: Sinusoidal		Horn, Tr: 1 Rec: 2	20 15	±15° ±20°	± 13° ± 10°	60, 30 against a battleship	1.5	±100~250m	1.5km	±30°	≦±30°			None	No trouble

ENCLOSURE (N)



ASSEMBLY AND FOUNDATION DIAGRAM OF RADAR ANTENNA
MARK 4 MODEL 2 MODIFICATION 2 (S24)