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SUBJECT

Report on Models DBC and DBC-1, Direction Finding Equipment

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NRL Report R-2268
Problem S637T-S.

Navy Department

Report on

Models DBC and DBC-1 Direction Finding Equipment

Naval Research Laboratory

Anacostia Station

Washington, D. C.

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1. ABSTRACT.

The models DBC and DBC-1 direction finders were designed to cover the frequency range 100-600 megacycles per second. Each model consists of a collector system and a model AN/APR-1 receiver. The collector for the DBC is for horizontal polarization and the collector for the DBC-1 is for vertical polarization.

The two units were installed aboard the U.S.S. Navajo and tested against several radars at the Chesapeake Bay Annex. Measurements of bearing accuracy were taken at various ranges. The accompanying plates and data show the method of installation and the performance under typical operating conditions.

At ranges at which a good signal was being received the bearing accuracy on various radar equipments from 100 mcs to 700 mcs was less than one degree.

2. INTRODUCTION.

The two direction finders were submitted to the Naval Research Laboratory for tests as requested by BuShips letter S-S67/69(925D). Because of the short time allowed for these tests, it was decided to merely determine the operational performance aboard a small Naval vessel.

The equipment was installed aboard the U.S.S. Navajo (YP-564), the method of mounting and the position relative to the ship's structure being clearly shown in the accompanying plates.

The equipment consisted of two antenna systems, one for vertical polarization and one for horizontal polarization; two search antennas, one for each polarization; and a Model AN/APR-1 receiver with head-phones. This equipment is mounted on a tripod having an azimuth scale for obtaining bearings.

The principles of operation of the system are described in the instruction book. It is seen that each antenna system has two sets of dipoles connected in phase opposition so that the field pattern consists of two lobes with a null in a direction perpendicular to the plane of the reflector. When a signal is received, the antenna is rotated until a signal minimum is obtained. The direction of the transmitter is indicated by the azimuth scale of the equipment.

3. DESCRIPTION OF TESTS.

Several radars at the Chesapeake Bay Annex were directed toward the ship whose position was known to the radar operators at all times. At each position the ship was made to lie to but its heading was varied to obtain readings at various azimuth angles. In this way it was possible to D-F on the radars with the reflecting surfaces of the ship in different azimuth positions relative to the antenna. Readings were taken with the ship's cabin and structure between the antenna and the radar station. This occurred when bearings in the region of 180° were obtained, the antenna pointing due aft for a 180° reading.

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The bearings obtained on the D-F equipment were compared with those of the polaris at 10,000 and 20,000 yards and those of the ship's compass at 30,000 and 40,000 yards.

When the minimum signal was not sharp enough to obtain a definite bearing the antenna was rotated in each direction until an equally audible signal was obtained on each side of the null. The bearing was then obtained by averaging these two readings.

Both horizontally and vertically polarized d-f antennas were used against each radar set, regardless of the radar polarization. The signal strength was much greater when both the radar and d-f antennas were of the same polarization, but it was possible in most cases to obtain a bearing when the antennas were not of the same polarization.

Tests were also performed with the radar antennas rotating. It was found that with a little practice it was possible to obtain fairly accurate bearings with the radar antenna rotating, provided a reasonably strong signal was present and the ship was not rolling or changing heading appreciably. In any event it was always possible to obtain an approximate bearing, even under very adverse conditions.

4. DISCUSSION OF RESULTS.

It is seen from the enclosed performance data that for an installation of this type the equipment gives very good bearing accuracy.

The maximum bearing error was six degrees which was obtained when the polarization of the D-F antenna was not the same as that of the radar antenna. When both antennas were of the same polarization the maximum error was four degrees, the average error being approximately one degree.

Signals were obtained at 40,000 yards on two of the radar units while these same two radars have a maximum range of only 15,000 yards on the ship. Therefore, it was possible to intercept and locate the radar installation within $\pm 1.5^{\circ}$ at approximately three times the radar detection range of the U.S.S. Navajo.

Some difficulty was encountered due to reflection from the ship's structure. This was obtained when the antenna was rotated away from the radar station and toward the ship's structure. This reflection did not seem to affect the bearing accuracy and in some cases it was possible to locate a second null 180° from the main null, the second being obtained from the reflections.

These tests were made under very favorable conditions. The U.S.S. Navajo is a wooden boat and consequently the amount of metal in the superstructure which would cause reflections is much less than in an all metal vessel. The bay was very calm during the tests - reduced accuracy is to be expected in a heavy sea and many repeated readings will be required for a good average reading.

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5. GENERAL COMMENTS AND RECOMMENDATIONS.

Several difficulties were encountered during operation of the equipment. Harmonics and sub-harmonics as well as images were obtained, but it was possible in all cases to determine which was the fundamental. This was a peculiarity of the receiver and did not affect the bearing accuracy. One of the receivers had a tendency to block near 700 mcs, but this did not interfere with the test.

Some difficulty was also experienced from the interference due to ignition and engine noise.

The equipment is satisfactory electrically, but needs improvement mechanically. The mounting is not rigid, having too small a bearing. It would certainly not stand much vibration or shock. The bearing should also be made tighter or an inertia damper should be used to prevent the equipment from swinging so freely when the ship rolls and shifts. In a rough sea the whole apparatus whips around and swings back and forth making it very difficult for the operator to manipulate the system. To facilitate ease of operation, longer handles should be supplied so that the operator is not required to constantly have his arms above his head.

Best performance will be obtained if the equipment is mounted high above the water level and removed from reflecting surfaces.

It is recommended that a future production model of this equipment to be known as the DBB and to have 45° collectors for both polarizations be sent to this laboratory for examination and tests.

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Table I

Performance Data

Type Radar	Radar Freq.	Radar Polar.	Radar Ant.	Approx. Range	DF Ant.	DF Bearing	Actual Bearing	Bearing Error	Null Width	Remarks
Jap	100	H	Fixed	10,000	H	None	---	---	--	Strong search signal, no D.F. signal.
SD	115	V	Fixed	10,000	H	2	1	1	8	Fair Signal.
					V	349	349	0	5	Fair Signal.
SK	200	H	Fixed	10,000	H	321	320	1	2°	Several minor lobes but very
						311	312	1	2°	weak. D.F. signal very
						235	236	1	2°	strong and quite easy to
						205	203	2	2°	obtain bearing. Some (very
						213	215	2	2°	little) reflection off Navajo
						359	357	2	2°	when D.F. antenna near 180° bearing.
			Turning	10,000	H	123	127	4		Difficult to get accurate
						191	190	1		bearing with rotating radar
						221	220	1		antenna, but practice makes
						358	360	2		bearing easier to obtain.
			Fixed	10,000	V	356	355	1	10°	Fair signal. Some reflection from ship.
Mk V	400	H	Fixed	10,000	H	355	355	0	3°	Sharp null.
						290	289	1	3°	Strong signal.
						194	195	1	3°	
						354	354	0	3°	
			Fixed	10,000	V	0	354	6	50°	Very weak signal and broad null.
			Rotating	10,000	H	164	166	2		Not too difficult to obtain
						251	250	1		bearings after a little
						331	330	1		practice.
						84	86	2		
						95	95	0		
CXAZ	400	V	Fixed	10,000	H	350	350	0	10°	
					V	356	356	0	2°	Very strong signal with appreciable reflection.

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Table I (Cont'd)

Type Radar	Radar Freq.	Radar Polar.	Radar Ant.	Approx. Range	DF Ant.	DF Bearing	Actual Bearing	Bearing Error	Width	
"Hot Dog"	560	V	Fixed	10,000	H	136	138	2	10°	Extreme[illegible] s
						8	40	4	10°	
					V	0	358	2	8°	Very little back
						357	355	2	8°	Strong signal.
FD	700	H	Fixed	10,000	H	324	322	2	3°	Strong signal.
						290	288	2	3°	
						196	195	1	3°	
		V			V	3	0	3	5°	Strong signal. Appreciable reflections.
					H	358	356	2	4°	Strong signal. Minor lobes strong.
Jap	100	H	Fixed	20,000	H	---	---	-	-	No response.
SD	115	V	Fixed	20,000	V	12.5	7	4	25°	Signal weak, no back radiation much ignition noise.
						10	9	1	25°	
					H	---	---	-	-	No response.
SK	200	H	Fixed	20,000	H	355	355	0	10°	Fair signal. Appreciable reflection.
					V	3	0	3	6°	
Mk V	400	H	Fixed	20,000	H	355	356	1	4°	
						95	95	0	10°	
						118	118	0	7°	
CXAZ	400	V	Fixed	20,000	V	4	4	0	4°	Strong signal.
						358	356	2		Small reflections.
			Turning	20,000		0	357	3		Hard to get bearing.
"Hot Dog"	560	V	Fixed	20,000	V	---	---	-	-	No response.
FD	700	H	Fixed	20,000	H	0	0	0	40°	Very weak signal.
		V	Fixed	20,000	V	9	5	4	25°	Weak signal, slight reflection

Table I (Cont'd)

Type Radar	Radar Freq.	Radar Polar.	Radar Ant.	Approx. Range	DF Ant.	DF Bearing	Actual Bearing	Bearing Error	Null Width	Remarks
Jap	100	H	Fixed	30,000	H	---	---	---	--	No response.
SD	115	V	Fixed	30,000	V	---	---	---	--	No response.
SK	200	H	Fixed	30,000	H	355	358	3	25°	Weak signal.
Mk V	400	H	Fixed	30,000	H	354	354	0	6°	No reflection.
CXAZ	400	V	Fixed	30,000	V	0	0	0	20°	No reflection.
"Hot Dog"	560	V	Fixed	30,000	V	---	---	---	--	No response.
FD	700	H	Fixed	30,000	H	7	6	1	25°	Very weak signal.
					V	---	---	---	--	No response.
Jap	100	H	Fixed	40,000	H	---	---	---	--	No response.
SD	115	V	Fixed	40,000	V	---	---	---	--	No response.
SK	200	H	Fixed	40,000	H	0	0	0	30°	Very weak.
Mk V	400	H	Fixed	40,000	H	3	0	3	15°	Fair signal, no reflection.
			Turning	40,000						Can't take bearing with radar antenna slewing.
CXAZ	400	V	Fixed	40,000	V	---	---	---	--	No response.
FD	700	H	Fixed	40,000	H	---	---	---	--	No response.
		V	Fixed	40,000	V	---	---	---	--	No response.

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Table II

Approximate Ranges of CBA Radars

Against U.S.S. Navajo

Radar Set	Frequency in mc/s	Antenna Polarization	Approximate Max. Range (Yds.)
"Snake"	100	Horizontal	(Cannot be seen at any range)
SD	115	Vertical	"
SK	200	Horizontal	15,000
CXAZ	400	Vertical	15,000
Mark V	400	Horizontal	15,000
"Hot Dog"	560	Vertical	8,000
FD	700	Horizontal	15,000
FD	700	Vertical	15,000

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Table III

AN/APR-1 Receiver Sensitivity

Receiver No.	Freq. Mc/s.	Input for Audible Output	Type of Modulation
133	100	33.6 microvolts	5 usec pulse at 1000 cycles
	200	17.8 "	" " " " " "
	400	4.0 "	50% mcw at 1000 cycles
	560	9.3 "	5 usec pulse at 1000 cycles
	700	23.2 "	" " " " " "
103	100	28.8 "	5 usec pulse at 1000 cycles
	200	15.1 "	" " " " " "
	400	5.0 "	50% mcw at 1000 cycles
	560	10.5 "	5 usec pulse at 1000 cycles
	700	14.7 "	" " " " " "

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PLATE I

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PLATE 2

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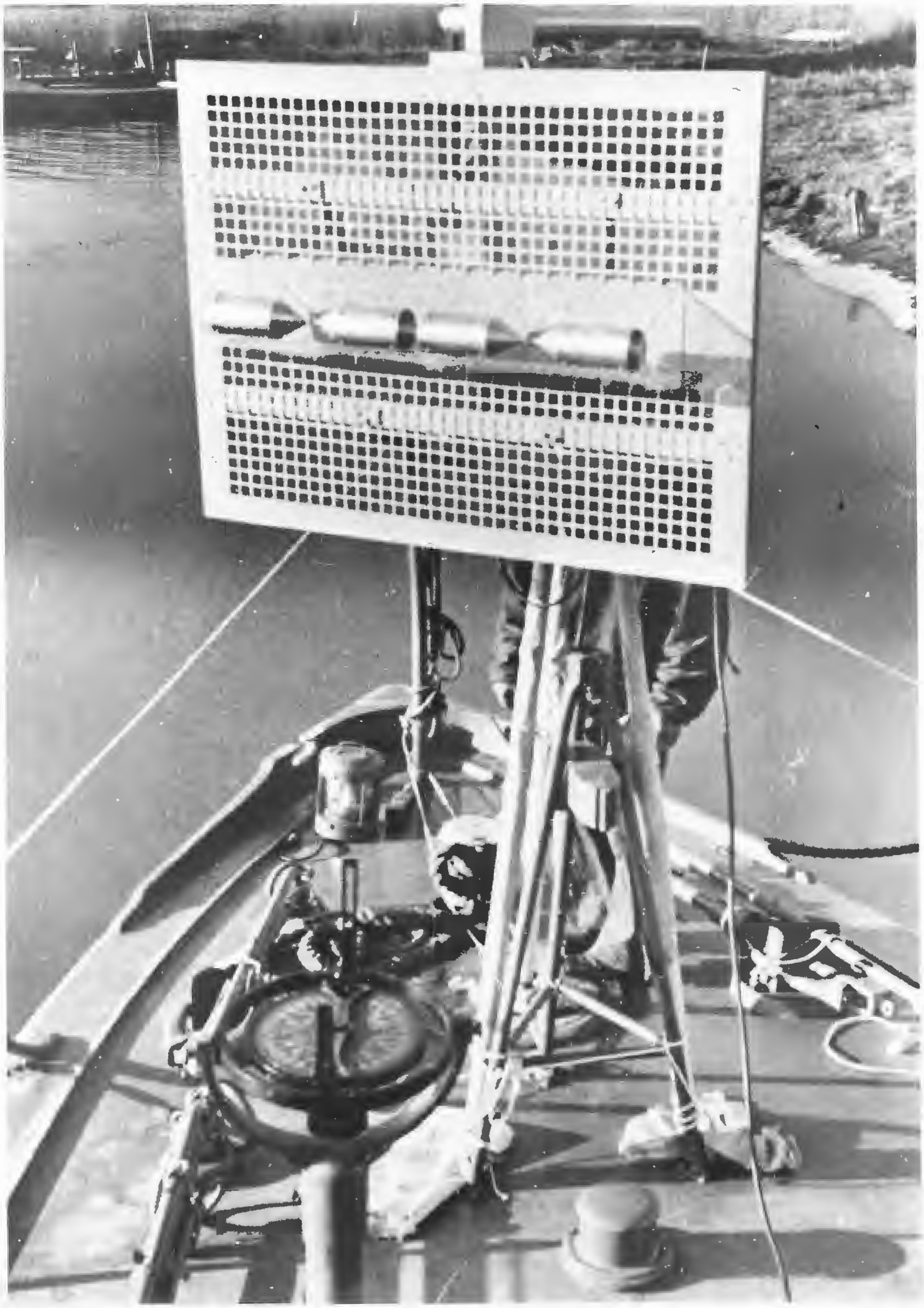

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PLATE 3

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PLATE 4