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REPORT NO. R-2081

DATE 29 April 1943

SUBJECT

Operational Tests of Special "Chaff"

Developed by Radio Research Laboratory

Harvard University

FR-2081

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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Navy Department

Report on

Operational Tests of Special "Chaff"

RESTRICTED

Developed by Radio Research Laboratory,

Harvard University

[redacted]

(Supplementary Information for RRL Engineers

Harvard University, Cambridge, Mass.)

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Naval Research Laboratory

Anacostia Station

RESTRICTED

Washington, D.C.

Tests conducted at N.R.L. Chesapeake Bay Annex

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Date of Tests: 7 and 9 April, 1943.

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1. ABSTRACT.

1-1. Tests of "Chaff" as a radar countermeasure were made at the Naval Research Laboratory Chesapeake Bay Station on 7 and 9 April 1943. The material ("Chaff") was prepared at Radio Research Laboratories, Harvard University, Cambridge, Mass., and tests were made using the radar and other facilities of the NRL Chesapeake Bay Station, under the general direction of personnel from Radio Research Laboratories. Strong echo signals were observed from quantities of "Chaff" varying from 500 to 2,000 strips, of length resonant at the radar operating frequency. A record was made of the radar operators' observations, and motion pictures were taken of the echo signals.

2. INTRODUCTION.

2-1. The tests were requested in a letter of April 1, 1943, S-67, Serial RRL-00173, from RRL-BuShips Liaison Officer to Director, NRL, asking that the tests be carried out at the NRL Chesapeake Bay Annex. The tests were authorized under BuShips letter S-S67-5(920-2) Serial #3437 of December 26, 1942.

2-2. The Radio Research Laboratories representatives present during the tests, and the Naval Research Laboratory personnel in charge of the various phases of the tests were as follows:

Dr. F.L. Whipple	RRL
Mr. W.W. Farley	
Ens. R.E. Lyon, USNR	
Major A.O. Dodge	
Mr. M. Katzin	NRL
Mr. L.V. Blake	
Mr. J.H. Green	
Mr. L.H. Smaus	

2-3. The object of the tests was to determine the strength of echo obtainable from various quantities of "Chaff", at radar frequencies near the resonant frequency of the strips and also at radar frequencies considerably above and below this resonant frequency. It was also desired to study various methods of packaging the strips for ejection from the plane.

2-4. Motion pictures (16 mm.) were taken of the echo signals on the radar indicator screens, and a copy of the film has been sent to Radio Research Laboratories for the use of their engineers. This report is intended to serve as information supplementary to that contained in the film, and includes notes taken by the Naval Research Laboratory radar operators.

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3. METHODS.

3-1. The "Chaff" was cut in strips resonant at about the FD radar frequency (700 mc.). Observations of the echo signals resulting from quantities of the "Chaff" ejected from an airplane (Navy PBY) were made on the FD, and also on the Mark X (3,000 mc.) and XAR (200 mc.).

3-2. The material used in the tests on April 7 was aluminum foil cut in strips of four different lengths resonant at or near the FD frequency (700 mc.). The strips were assembled in packages of 500, 1,000, and 2,000 and the packages were of three different types. A code was used to instruct the plane as to the size and type of package to be ejected for each test.

3-3. For the tests of April 9, the packages all contained 2,000 strips each, and only the strips quite close to resonant length at the FD frequency were used. The only variable was the type of package. The three types were designated "Apple", "Pear", and "Orange". Further, a special test was arranged in which 6 or more packages were to be ejected from the plane at 5 second intervals; the code words for this test were "Shoot the works".

3-4. Motion picture cameras (16 mm.) were mounted to take pictures of the radar indicator screens. Table 1 gives the starting time for each burst of pictures made (the cameras were capable of taking only about 25 second bursts of pictures at a single winding of the spring). All cameras were started and stopped together.

4. DATA OBTAINED.

4-1. It was desired to take the pictures at times when the plane and reflecting material echoes were both present on the screen, so that the relative height of the echoes could be compared. However, it was found that the "cloud" of reflecting material could not be seen from the plane, so it was impossible for the plane to deliberately fly close to the cloud. It was possible to take camera shots at times when the plane passed close enough to the reflecting material for both echoes to be seen, although it was not always known that the plane was fully within the radar antenna beam. Unfortunately the pictures taken of the FD indicator screen appear to have been under-exposed, so that they do not provide a good record of the echoes. The reason for this under-exposure has not been determined. The intensity of the cathode ray tube was at maximum, and results of previous motion picture photography of this indicator were satisfactory.

4-2. A partial transcription of notes taken by the radar operators during the tests is attached. Since the plane, as mentioned above, could not deliberately fly past the cloud of reflecting material, a record of the reflector echo-to-noise ratio

was kept as well as a record of the plane-to-reflector echo ratio during the second day's tests (April 9). The notes taken on April 7 are not transcribed here as they were not very complete and it is believed that the second day's tests were considered of greater interest and importance to the Radio Research Laboratories representatives.

TABLE 1

Tabulation of Tests for Radio Research Laboratory at

Naval Research Laboratory Chesapeake Bay Station

Test #		Package Code	Distance From Station (Mi.)	Bearing	Altitude (ft.)	Starting Time of Camera Runs 4/7/43
1	A	Cast 5 Apple	4	045°	5,000	14:19
	B					14:27
2	A	Cast 10 Apple	4	045°	5,000	14:46½
3	A	Cast 20 Apple	4	045°	5,000	15:12
	B					15:13
4	A	Cast 10 Apple	3	135°	5,000	15:55
	B					15:56
	C					16:00
5	A	Baker 10 Apple	3	135°	5,000	16:17
	B					16:18
	C					16:20
						4/9/43
6	A	Apple	5	030°	7,000	11:15
	B					11:18
	C					11:24
	D					11:26
7	A	Orange	6	030°	10,000	12:06
	B					12:07½
	C					12:10½
8	A	Pear	6	030°	10,000	13:16
	B					13:18
	C					13:18½
	D					13:21½
9	A	Orange	5	030°	8,000	13:51
	B					13:53
	C					13:55
	D					13:58
10	A	Apple	5	030°	8,000	14:19
	B					14:22
	C					14:24
	D					14:27
11	A	Shoot the works	5	030°	8,000	14:54½
	B					14:55
	C					14:56
	D					15:00
	E					15:06
	F					15:08

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TABLE 1
(Cont'd)

Notes: (a) Due to equipment failure, the Mark X was not used after Test 4.

(b) The camera bursts are separated on the reels by a few frames of unexposed film. In a few cases the cameras jammed or otherwise failed so that not all the above recorded camera shots were taken of all the radar scopes.

(c) The "package code" (column 2 above) has the following meanings:

Apple - Cylindrical card-board container with string release.

Orange - Heavy paper wrapping with string release.

Pear - Paper wrapped package ejected by hand; no special release mechanism.

The numbers (5, 10, 20) used on April 7 referred to the number (hundreds) of strips in the package. On the second day (April 9), all packages contained 1,000 strips each.

The terms "Albert, Baker, Cast, and Dog" referred to the different lengths of strips employed on the first day.

TABLE 2

FD Operator's Notes

Tests of 9 April 1943

Time	Test #	"Plane to "X" Ratio	"X" to Noise
11:15	6 A	1:1	"X" Saturation, no noise.
11:18	6 B	1:2	"
11:24	6 C	1:1	5:1
11:26	6 D	1:1 Plane and "X" indistinguishable from each other.	
11:30		"X" still at saturation; elevation 0°. Spread of "X" about 2500 yds. at this time.	
12:06	7 A	AGC left on accidentally, but both signals saturated.	
12:07½	7 B	1:1	5:1
12:10½	7 C	1:1 Echo was lost just after this observation.	5:1
13:16	8 A	1:1	Saturation, no noise
13:18	8 B	1:2	"
13:18½	8 C	1:1	"
13:21½	8 D	1:1	"
13:25		"X" drifted into landscape interference, but was still of high amplitude (saturation signal).	
13:51	9 A	1:1	Saturation, no noise
13:53	9 B	2:1	"X" fading, ave. ½ saturation.
13:55	9 C	1:1	"
13:58	9 D	Echo fuzzy from "X", still ½ saturation.	
14:03		"X" became too tenuous for observation.	
14:19	10 A	1:1	Saturation, no noise.
14:22	10 B	Plane echo very weak.	"
14:24	10 C	1:1	"
14:27	10 D	1:2	Approx. 20:1
14:35			About 1:1.
14:54½	11 A	1:1	Saturation, no noise.
14:55	11 B	1:4	"X" Saturation, no noise; "X" spread out over about 3,000 yds; ragged echo, fluttering between base line and saturation.
14:56	11 C	1:1	Same as 11 B.
15:00	11 D	1:2	"

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TABLE 2

(Cont'd)

Time	Test #	*Plane to "X" Ratio	"X" to Noise
15:06	11 E	3:2	"X" about 2/3 sat.; no noise. "X" still spread about 3,000 yds., but fading more rapidly than in 11 B; echo more "tenuous".
15:08	11 F	2:1	"X" about ½ saturation; no noise. Spread still about 3,000 yds. Rapid fading.

*Note: The symbol "X" is used to refer to the echo from the reflecting material ejected from the plane. The operators attempted to record the relative strength of echo from plane and "X" and also the ratio of "X" to noise. It should be remembered that the relative strength of the plane and "X" echoes could not always be taken when both targets were well within the antenna beam, as it was not possible to see the reflecting strips either from the plane or with the FD optical system.

The test numbers of the second column refer to the successive "camera shots" taken during each test; the time given in the first column when followed by a test number in the second column, refers to the time the cameras were started.

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TABLE 3

XAR Operator's Notes

Tests of 9 April, 1943

The complete notes of the XAR operator are not given here, as in the majority of the tests no echo from the reflecting material was observed on the XAR.

Only those tests (on this date) where some echo from the reflecting material was observed are here recorded.

Time	Test #	Remarks
13:51	9 A	"X" to noise about 2:1; plane echo saturated.
13:53	9 B	"X" to noise about 3:2.
13:55	9 C	"X" to noise about 3:2.
13:58	9 D	"X" to noise momentarily about 3:1. Plane to "X" about 5:1.
14:54½	11 A	Plane to "X" was between 5:1 and 10:1.
14:55	11 B	"X" barely visible.
14:56	11 C	"X" visible occasionally.
15:00	11 D	Plane to "X" from 3:1 to 8:1.
15:06	11 E	"X" not observed.
15:08	11 F	"X" not observed.

Mark X Operator's Notes

Tests of 7 April 1943

Trouble developed in the Mark X equipment during test #4, so that it could not be used during the remainder of the tests. On tests #1 and #2, the Mark X operator reported no echoes from the reflecting material were observed. On the third test, the "X" echo was observed during test #3B; the plane to "X" signal strength ratio was about 2:1.

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