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PERFORMANCE TESTS ON FIVE NEW TYPES OF ROPE

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N R L REPORT R-3088

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PERFORMANCE TESTS ON FIVE NEW TYPES OF ROPE

by
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June 1947

Problem No. S1263X-C

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ABSTRACT

Five new kinds of "rope" were tested to determine if an improvement (decrease) in the rate of fall over standard CHR-2 "rope" had been made as well as any improvement as a reflector to electromagnetic waves.

The rate of fall of the several types is essentially the same as that of CHR-2. Type E "rope" represents an improvement in reflection characteristics over the CHR-2 "rope".

REFERENCES

1. Chu, L. J., Harvard University Radio Research Laboratory Report No. 4 of 22 October 1942: Analysis of Window and Related Matters.

2. BuShips ltr. C-A22.1(920-b), C-920-7552; 7 December 1945, to Director NRL (Secretary Radio Problem Priorities Board): Request for Assignment of Problem S1263X-C.

3. COMOPDEVFOR Final Report on Project No. Bu/V12/S67 of 28 October 1946: Effectiveness of Rope Type Window Against Various Types of VT Fuzes.

4. Original data recorded in NRL Log Book 5368.

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PERFORMANCE TESTS
ON
FIVE NEW TYPES OF ROPE

INTRODUCTION

Rope is a form of "window", the latter being defined as a conducting body of appropriate shape which when properly orientated can give radar echoes similar to that of an airplane. Such a reflector is generally flat and its dimensions generally not chosen to resonate at any particular frequency (reference 1). Standard CHR-2 rope is a 400-foot strip of 1/2-inch aluminum foil 0.0008-inches thick in the form of a roll 3 inches in diaameter. Attached to one end of the foil is a rayon leader 16-feet long which in turn is attached to a square piece of cardboard about 2-7/8 inches on a side (figure 1). This assembly is placed in a cardboard container which in turn is wrapped loosely with paper. Three of these rolls are then made up into one package of rope.

Upon release of one package into the slip stream of an airplane the three rolls unwind presenting a reflecting medium for electromagnetic waves. The rope is most effective below about 500 Mc and three rolls are equivalent to a medium bomber of the World War II type.

Two disadvantages of the present form of rope are its fast rate of fall and its reduced response at the higher frequencies. This reduces its overall effectiveness as a decoy or screening medium. Five new types were manufactured by the Standard Rolling Mills of Brooklyn, N. Y. These were tested by the Naval Research Laboratory to determine if any improvements had been effected.

The several "type" designations used for the rope under test are given in Table I with their characteristics.

TABLE I

Physical Characteristics of Rope

Type of Rope	Reflecting Material	Thickness (inches)	Width (inches)	Length (feet)	Weight		Other Description
					1 roll (grams)	5 packages (3 rolls/pkg) (pounds)	
CHR-2	Hard Aluminum Foil	0.0008	0.5	400	123	4	Standard rope used by Navy
A	Soft Aluminum Foil	0.00035	0.5	250	65	--	Skip glued to 12-pound tissue
B	Hard Aluminum Foil	0.00035	0.5	250	67	$2\frac{9}{16}$	Skip glued to 12-pound tissue
C	Soft Aluminum Foil	0.00035	0.5	250	65	--	Spiral glued to 12-pound tissue
D	Hard Aluminum Foil	0.00035	0.5	250	66	--	Spiral glued to 12-pound tissue
E	Hard Aluminum Foil	0.00035	0.5	500	117	$4\frac{1}{4}$	Two equal strips of aluminum, each with dimensions as given. Strips placed face to face and rolled together

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The designations, types A thru E are code keys used by the contractor in development for Navy Contract Nobs-R-29030. The six types are shown in figure 2. The glue lines of paper backed foil, type A, B, C, and D are inked to show clearly in the photograph. Each roll measures 3 inches in diameter.

This work was performed in accordance with BuShips problem S1263X-C (reference 2) and NRL problem number 39R06-26.

DESCRIPTION OF TESTS

Reflection Characteristics

The reflection characteristics of the rope were determined in a series of tests conducted at the Chesapeake Bay Annex of the Laboratory. The rope was dropped as single rolls in containers (figure 1) from a twin-engine Beechcraft (SNB) flying on a radial course from the Bay station at an altitude of 3000 feet. During the tests the following radars were used:

SK - 200 Mc	SG-le - 3050 Mc
Mark 12 - 970 Mc	
SR-3 - 1275 Mc	Mark 35 - 9000 Mc

The models SK, SR-3, and SG-le are search radars and Mark 12 and Mark 35 are fire-control radars. All use horizontally polarized antenna with the exception of the Mk 35 which uses a vertically polarized antenna.

The following two methods were used to obtain data;

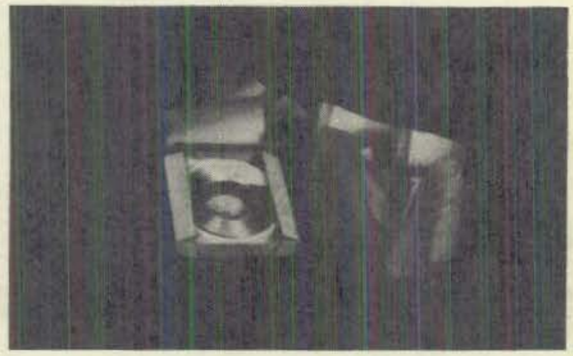
(a) At a range of 10,000 yards from the controlling radar 3 rolls of rope were dropped from the airplane. The radar echo from the airplane and rope then appeared together on the "A" scope. Since the airplane was flying a radial course, the resultant pips were at the same azimuth and were resolved quickly due to better range resolution than azimuth resolution. On some of the radars, calibrated signal generators were available which provided a pip on the "A" scope for comparison purposes. The decibel difference between the airplane pip and the rope could then be measured. When signal generators were not available, information was obtained by observation only.

(b) The second method used was basically the same as the first. In contrast, two drops of 3 rolls each were made on one run, 15 seconds apart. The initial drop was CHR-2 with the second drop being the rolls of rope to be tested. This permitted direct comparison throughout a drop of the rope under test and the CHR-2, and also provided a momentary comparison with the airplane.

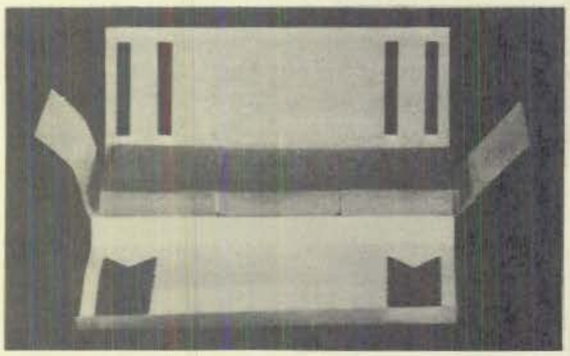
Rate of Fall Tests

These tests were carried out to determine the rates of fall of CHR-2 and the several new types. The procedure consisted simply of a series of drops where three rolls of rope each in an individual container (figure 1), were dispensed simultaneously from an airplane at a signal from a ground observer. The elapsed time from rope release to contact with earth was recorded for each roll as well as the time required for each roll to open.

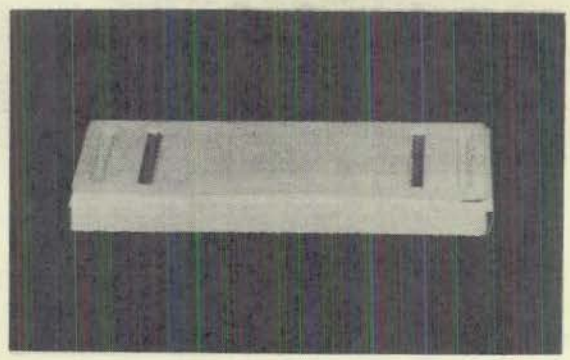
a. 1 Roll of Rope



b. Roll of Rope in Container



c. 3 Containers of Rope Placed in a Package



d. 1 Package of Rope

Fig. 1 Four Steps in the Packaging of Rope

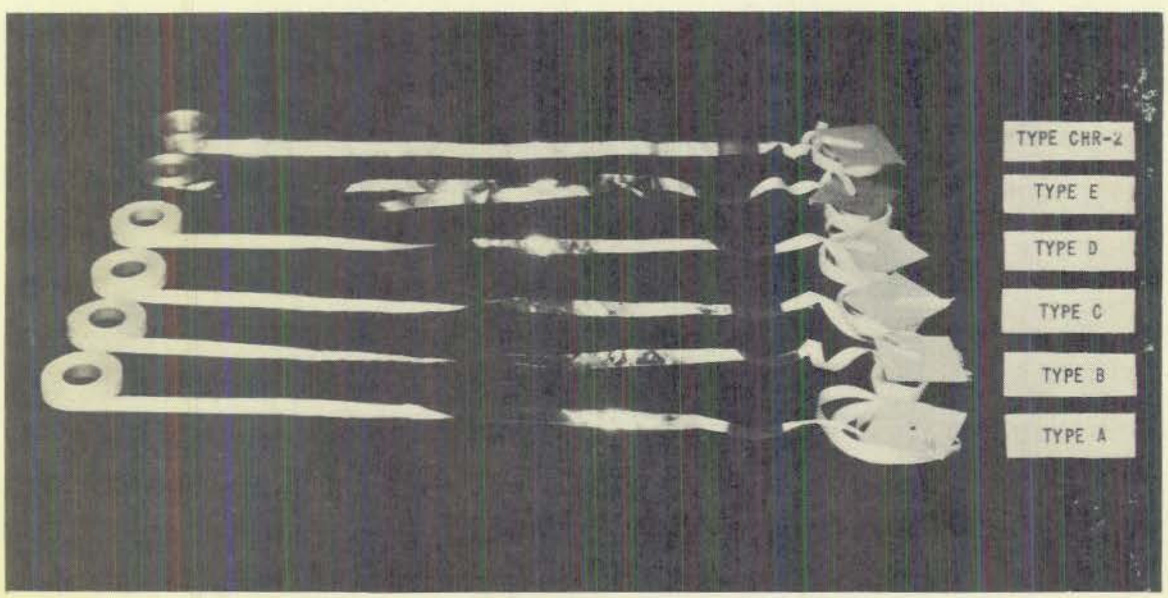


Fig. 2 Six Types of Rope Partially Unrolled

The first series of tests was made at the Chesapeake Bay Annex. Drops were made approximately 500 yards off shore with the airplane flying at an altitude of 1000 feet. One type of rope was dropped on each run. The second series of tests was made at an airfield south of the Patuxent River Naval Air Test Center, Patuxent River, Maryland. In this second group of tests, two drops, 5 seconds apart, were made during each run. The first drop was always 3 rolls of CHR-2 while the second drop consisted of 3 rolls of rope to be tested. Altitudes of 500, 1000, and 3000 feet were used for the second series of drops. All tests were flown at an air speed at 150 knots.

RESULTS

Reflection Characteristics

Reflection characteristics of the various kinds of rope are shown in table II. These values were obtained in the following way: The db differences between CHR-2 rope and the airplane were averaged for the runs of a particular day, corresponding calculations being made for the new types of rope. The differences between corresponding averages then represent the responses of the experimental ropes as compared to the CHR-2 rope. The second method for obtaining these data, as described in the preceding section, yields these differences directly. Results of direct observations, where signal generators were not available, appear in table II and table III as "equal", "larger", and "less."

It was observed that the average of results from test to test were sometimes quite different. Consequently more than one average is shown in table II for a particular type of rope and frequency.

TABLE II

Response in Decibels of Experimental Rope
Compared to Standard Rope

CHR-2 - Standard
A, B, C, D, and E - Experimental

Plus values indicate decibels above CHR-2. Minus values indicate decibels below CHR-2

Type of Rope	2 SK 200 Mc	Mark 12 970 Mc	SR-3 1275 Mc	SG-le 3050 Mc	Mark 35 9000 Mc
A	$+3.5_4$ 0_3 equal$_3$	$+0.8_2$ -9.5_2 --	-- -- --	-3.5_2 -2_2 -2.5_3	All types, including CHR-2, gave reflections too weak for comparison
B	equal$_2$ *less -3_2	-0.5_2 -- --	-- -- --	0 -1_2 --	
C	less$_2$ equal 0	-1.5_2 -- --	-- -- equal$_2$	-- -- 0_3	
D	less$_2$ equal -2_2	-2.4_2 -- --	less$_2$ -- --	-3.5 -- -1_3	
E	larger$_2$ equal$_2$ 0_2	$+4.1_2$ -- --	larger$_2$ -- --	$+3_2$ $+2_4$ --	

Notes: Subscripts indicate number of runs which were averaged to give the value shown
* "less" and "larger" represents approximately 5 db

TABLE III

Spectral Response of Standard Rope
Compared to an SNB Airplane

Plus values indicate decibels above airplane
Minus values indicate decibels below airplane

Type and Frequency of Observing Radars				
SK 200 Mc	Mark 12 970 Mc	SR-3 1275 Mc	SG-le 3050 Mc	Mark 35 9000 Mc
$+5_3$	-2_2	--	-6.5_4	--
-3.5_2	-6.6_2	--	-3.5_2	--
--	-6_2	--	-4.5_2	--
equal	--	--	-2.8_4	1/4 to 1/2 airplane pip** 12 runs
0	--	3/4 airplane pip*	--	1/4 to 1/2 airplane pip** 12 runs

Notes: Subscripts indicate number of runs which were averaged to give the value shown
* -This figure represents approximately minus 5 db
** -This figure represents approximately minus 15 db

As seen in table II the 250-foot paper-backed foil, types A, B, C, and D gave radar echoes less than those from the 400-foot CHR-2. On the other hand the 500-foot type E gave reflections stronger than the CHR-2. On the Mk 35 radar the rope reflections were too weak to be compared with each other.

Table III shows the frequency response of CHR-2 rope as compared to the response of an airplane. In general, at 200 Mc 3 rolls of rope were equivalent to the SNB airplane used for the tests. At 970 Mc, 1275 Mc, and 3050 Mc the response was down approximately 5 db. At 9000 Mc the pip height of the rope was between 1/4 and 1/2 that of the airplane. This is an estimated 15-db difference in power.

Rate of Fall

The results of these tests are shown in Tables IV and V. No attempt has been made to average the falling time for the three rolls of each type of rope dropped on any given run. Generally each roll assumed entirely different attitudes from the others thereby yielding widely scattered falling times. Rates of fall varied between 500 and 3000 feet per minute.

Tables IV and V show little difference between the falling time of CHR-2 and any of the new types tested. Due to adverse winds at upper altitudes no time figures could be obtained on the 3000-foot drops, however observers on the ground with field glasses could detect little difference between the CHR-2 and the new types. The 500-foot drops were too low to yield much data other than a check on opening times for each roll. The interval between the rope release from the airplane and the time it commenced to unroll was consistently 5 seconds.

DISCUSSION

In the evaluation of the effectiveness of rope it is important to consider the resolution of a given radar. Range resolution is dependent upon the pulse length of a radar and is generally greater than azimuth resolution which is dependent upon beam width. Generally as the operating frequency of a radar is materially increased the pulse length is decreased with resultant greater range resolution.

TABLE IV

Falling Time for Six Different Types of Rope

CHR-2 - Standard Type
A, B, C, D and E - Experimental Types

For each test 3 rolls of one rope type were dropped from an airplane flying at 150 knots at a 1000-foot altitude. Wind velocity was 10 knots.

Rope Type	Time Interval from Release to Contact with Water (Seconds)		
	Roll 1	Roll 2	Roll 3
CHR-2	35	110	120
CHR-2	81	98	117
A	55	117	120
B	--	--	140
C	55	120	140
D	89	114	116
E	111	130	180

TABLE V

Falling Time for Six Different Types of Rope

CHR-2 - Standard Type
A, B, C, D, and E - Experimental Types

For each test two drops were made 5 seconds apart, the first being 3 rolls of CHR-2, the second being 3 rolls of one other type. Drops were made from an airplane flying at 150 knots at a 1000-foot altitude. Wind velocity was 3 knots.

Rope Type	Time In Seconds			
	Rope release to start of unwinding (average of the 3 rolls)	Rope Release to Contact with the Ground		
		Roll 1	Roll 2	Roll 3
CHR-2	5	15	--	25
A	5	25	--	--
CHR-2	5	25	80	80
A	5	75	80	95
CHR-2	5	30	75	90
B	5	20	50	70
CHR-2	5-10	45	60	--
B	5-10	60	--	80
CHR-2	5	--	--	100
C	5	30	85	90
CHR-2	5	25	60	60
C	5	40	60	70
CHR-2	5	100	--	110
D	5	40	85	110
CHR-2	5	30	65	70
D	5	80	95	100
CHR-2	5	55	60	60
E	5	20	45	100
CHR-2	5	45	50	--
E	5	40	45	115

Since a finite time is required for rope to completely unroll, an airplane dropping the rope will be some distance away before the latter has unrolled and become effective as a reflector. All radars used for this test except the SK were able to resolve this distance.

With such resolution it becomes necessary to dispense large quantities of rope at a fast rate when screening is desired. This fact has been discussed quite well in reference 3, page 13, where attempts were made to screen against projectiles containing VT fuzes.

Inspection of the new types of rope indicated that some improvement in the rate of fall over that of CHR-2 might be possible. The results of the rate of fall tests did not indicate such an improvement. However the rate of fall may be affected greatly by the 15 feet of rayon leader with attached card and the aluminum (or fiber) ring core which in some cases remains attached to the foil. It was reasoned that if such were the case, foil by itself might display different "fall" characteristics. Accordingly 10-foot strips of CHR-2, type B, and type E were dropped from a height of 30 feet. In each test CHR-2 and one of the new types were dropped together.

Two significant observations were made. First, it was quite evident that CHR-2 had a greater tendency to bunch than the other two types. Second, the type E fell about 25% slower than CHR-2 while type B was comparable to CHR-2. These tests reported above are hardly conclusive. However, they do suggest that the rate of fall of rope may be improved through a change in method of dispensing the foil into the air.

CONCLUSIONS

As a result of the above tests the following conclusions can be made:

(a) The response of type E Rope is greater than CHR-2 rope
(b) The response of type A, B, C, and D rope is less than CHR-2 rope
(c) The response of CHR-2 rope compared to an SNB airplane is down about 5 db at 970 Mc, 1275 Mc, and 3050 Mc while at 9000 Mc with the vertically polarized Mk 35 it is down approximately 15 db (1/4 to 1/2 pip height of the airplane).
(d) The rate of fall of the types A, B, C, D, and E rope is essentially the same as that of CHR-2 rope.

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