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SERIAL NO. 56

Navy Department - Office of Research and Inventions

NAVAL RESEARCH LABORATORY
Washington, D.C.

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ELECTRONICS DIVISIONS

20 June 1945

NRL RADIO COUNTERMEASURES PROBLEMS

Compiled by
L. W. Boothby

Report R-2612 \ FR-2612

[redacted]

* * *

Approved by:

W. L. Emery, Technical Aide for Radio Countermeasures

L. A. Gebhard, Coordinator
For Radio Countermeasures

Rear Adm. A. H. Van Keuren, USN (Ret.)
Director, Naval Research Laboratory

Preliminary Pages-- a-c
Numbered Pages----- 85
Distribution List-- d

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FOREWORD

This report is a summary of the Radio Countermeasures work at the Naval Research Laboratory. All problems which were active on 20 March 1945 or which have been assigned since then are included. The status given on each problem is as of 20 June 1945 except in a few specified cases. A supplementary report to be issued at a later date will summarize the essential data on projects which were closed during the period 16 August 1943 to 20 March 1945.

Discussion of each project is necessarily limited; nevertheless, references to correspondence, interim reports, and final reports are included whenever possible. The problem titles used are those which appeared on the original Navy Department problem request sheets. Priority designations, however, are those of current issue and are not necessarily in accord with the initial priority assignments.

Source material for this compilation was obtained from the Laboratory files and from data sheets submitted by the various divisions engaged in the work.

The problems have been grouped in accordance with the primary function of the equipment involved. Since a given equipment may be used in several different ways, cross references have been provided at the beginning of each subsection. In addition, indicies arranged according to problem numbers, equipment type numbers, and code words have been included.

Dimensions, weights, and performance specifications are quoted for Laboratory models except where type designations show that production equipments are specifically indicated.

It is hoped that "NRL Radio Countermeasures Problems" will prove sufficiently useful to warrant the publication of revised editions on a regular schedule. Advantage might then be taken of the many suggestions for improvement which will doubtless occur in the employment of this issue.

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CONTENTS

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GENERAL

TITLE:		
	PROVIDE OR INSTALL SIMULATED OR CAPTURED ENEMY EQUIPMENT	N6R-C A

DESCRIPTION: Problem N6R-C requests that the Naval Research Laboratory provide or install simulated enemy equipment or reconstruct captured enemy equipment as necessary to carry out RCM problems and other related activities.

STATUS: Problem N6R-C is inactive at present because work on specific equipments has been covered by special problem assignments. Occasionally, cases arise which do not warrant a separate problem assignment. Problem S148R-C formerly satisfied this need but has recently been closed; therefore, N6R-C should be kept open.

TITLE:		
	DESIGN BROAD BAND ANTENNA AND DETERMINE LOCATIONS ON SHIPBOARD FOR GUIDED MISSILE COUNTERMEASURES	N9R-S A-1

DESCRIPTION: Suitable designs and locations for broad band antennas for GMCM are to be determined by means of measurements on ship models. The research is first to be focused on mine sweepers and then to be extended to other classes as the need arises.

STATUS: The work of this problem is being carried out under other problems which have been assigned to cover particular antenna developments or particular installations. For example, see problem S482.3R-S. As a result this problem is inactive and should be closed.

TITLE:		
	COUNTERMEASURES AGAINST GUIDED MISSILES	S16R-S B

DESCRIPTION: This is the original problem set up for the purpose of developing countermeasures against guided missiles. It involves the design of special equipment for intercepting and then jamming radio control signals. A broad range panoramic receiver is used to spot the approximate frequency of the control signal. The frequency is located more exactly by a manually-tuned receiver, which is equipped with a narrow band panoramic adapter. The incoming signal is then analyzed to determine the nature of the control modulation

(supersonic or pulse) and to determine its characteristics, frequency, pulse length, number of pulses, etc. A jammer is then set on the control frequency and is modulated with noise or the output from a modulation synthesizer. The synthesizer produces sine waves of various frequencies or pulses of various widths, spacings, and numbers. It simulates the normal control modulation characteristics and attempts to "deceptively" control the enemy missile.

STATUS: Long-term work on this problem has been temporarily suspended. The development of the countermeasures equipment which was started under this problem is being continued under higher priority. A report is being prepared on jamming tests made on the receiver from enemy HS-293 and FX-1400 missiles.

Reference S16.2R-S, S482R-S, and S560R-S.

TITLE:	DETERMINATION OF RADAR REFLECTION CHARACTERISTICS OF SHIPS AND AIRCRAFT	S411R-S A-3

DESCRIPTION: The equivalent reflection areas of various sections of ships and aircraft are to be measured for all aspects. The procedure used in this determination is to compare the echo from the ship or aircraft with that returned from a standard target. This method allows elimination of propagation anomalies.

STATUS: NRL Report RA 3A 213A "Special Report on Radar Cross Section of Ship Targets" of 24 January 1944, gives an analysis of the magnitude of the signal reflected from ship targets. It was found that the variations of received signal with range can be divided into two regions--the near and far zones. In the far zone the received field intensity varies as the inverse fourth power of the range and as the square of the radar antenna height. In the near zone the field intensity varies as the inverse square of the range, but is independent of antenna height.

NRL Report R-2232 "Report on Radar Cross Section of Ship Targets, II" of 18 February 1944 gives numerical data on the cross section of combat ships of various types over the frequency range of 200 to 3000 Mc. The data are compared with the theoretical analysis of RA 3A 213A and found to give satisfactory agreement.

NRL Report R-2295 "Radar Cross Section of Ship Targets, III" of 27 June 1944 gives numerical values of the cross sections on several additional types of combat ships. In the far zone, it was found that radar cross sections increased roughly as the fourth or

[redacted]

fifth power of frequency. The reflections from a shipborne air search radar antenna in its broad side aspect, predominate when the ship is partially below the horizon.

NRL Report R-2332 "Radar Cross Section of Ship Targets, IV" of 21 July 1944 gives the cross section of a DD and an AGC for the frequency range 200 to 3060 Mc and compares this data with previous results. An analysis of the near zone radar cross section as a function of frequency is made on the basis of the limited data available from previous reports. Simultaneous low level meteorological soundings have been made during the cross section tests to determine the type of radar propagation conditions in existence during tests. Correlations between these soundings and the measurement of the ship's reflection are being made. Tests are planned on measurements of aircraft cross section areas. When these tests are completed, a comparison is planned of the experimental data obtained and model reflection measurements.

NRL Report R-2466 "Radar Cross Section of Ship Targets, V" of 12 March 1945 gives the results of measurements on an SS, a BB, a CVE and two DD's. The correlation between radar results with meterorological conditions is discussed. Measurements showed the echo from the SK-2 antenna aboard a BB could not be distinguished above that of the ship itself.

NRL Report R-2467 "Radar Cross Section of Ship Targets, VI" of 10 April 1945 gives the results of measurements on a DD, a CV, a CL, a CA, and two APA's. Anomalous propagation was found to increase the echo by 35 db above the level received during standard conditions. An analysis of the values of far zone radar cross sections as a function of frequency is made.

NRL Report R-2524 "Radar Cross Section of Ship Targets, VII" of 1 May 1945 gives the results of measurements which were made on an LST, and AG, and a CV. Low level meteorological soundings were made during these tests.

TITLE: CARIBBEAN WAVE PROPAGATION EXPERIMENT — S411.2R-C A-1

DESCRIPTION: The possibility of low level atmospheric duct radio wave propagation over open sea is to be determined.

STATUS: NRL Report R-2493 "Preliminary Report on S- and X-Band Propagation in Low Ducts Formed in Oceanic Air" of 24 March 1945 has been forwarded. One way propagation measurements in the Atlantic

[redacted]

trade wind area show that low level ducts formed in air of long ocean trajectory produce extended ranges on S and X bands. The improvement in transmission is greater for X band.

An interim report, NRL letter C-S67/56(307) serial C-301-85/45 dated 19 May 1945 has been issued and the final report is nearing completion.

TITLE:	TESTS OF PRESSURE AND END SEALS FOR RG17/U AND RG8/U CABLE	S794T-C A-3

DESCRIPTION: It is desired that the Laboratory test a number of samples of RG17/U amd RG8/U cable with molded vinylite pressure seals for use in 9-6-5100-L, Type XLVI-II stuffing tubes. In order to determine the suitability of these seals, it is requested that the Laboratory mold seals for five samples of RG17/U and RG8/U cable from each manufacturer now supplying such cable to the Navy and test these samples under conditions of 300 lbs./sq. in. static pressure plus a minimum of 300 lbs./sq. in. dynamic pressure.

It is requested that comparative tests be made on samples of the Water-tight Cable Entrance Fitting described in Report D50/730-NX238 from the Columbia University Division of War Research at the U. S. Navy Underwater Sound Laboratory, New London, Connecticut. Tests of this fitting should be made on both RG17/U and RG8/U cable and on a sufficient number of samples under the conditions specified above to permit the Laboratory to make definite recommendations as to its suitability.

It is further requested that the Laboratory test the RG-17/U end seal such as was employed in the USS HAKE installation or any improved end seal since developed by the Laboratory to determine its suitability for its intended use under the conditions specified above.

STATUS: This problem has been completed as reported in C-S67/62 (370d), C370-36/45 dated 13 February 1945.

TITLE:	RECEIVER AND TRANSMITTER (RCM) INTERFERENCE TESTS	S819R-C A-5

DESCRIPTION: An evaluation of the interference in RCM receivers caused by neighboring radars and of the interference in communications receivers caused by RCM jammers is desired.

[redacted]

STATUS: Tests aboard ships working off the NRL Chesapeake Bay Annex and studies of the interference in the AN/APR-5AX and AN/SPR-1 by shipborne radars available at CBA have been undertaken. Measurements were made using standard receiving antennas mounted in several typical positions relative to the radars. It was concluded that interference in the AN/SPR-1 is serious when operating in the vicinity of 100- to 1000- Mc. Interference from S-Band radars is less serious in the SPR-1, but very serious in the 5AX. Radar interference below 1000 Mc is also objectionable in the 5AX. It is recommended that a 1000- Mc low-pass filter be used with the SPR-1 and RDO receivers, while a 1000- Mc high-pass filter should be used with the 5AX and SPR-2 receivers. A final report on this investigation is in preparation.

Some measurements of the amount of interference caused in communications receivers by RCM jammers have been made. NRL letters to BuShips S-S67/46(356) Serial 3273-S-350-325 of 22 June 1944, and C-S67-6/RCM(356:JWK) C-350-20/45 of 27 January 1945 describe this work.

TITLE: FACTORS AFFECTING SHIPBOARD ANTENNAS — S884-R A-2

DESCRIPTION: A report is to be prepared summarizing information on factors affecting the performance of various shipboard antennas. It is to be written in simple language for the information of Fleet Communications RCM personnel and to assist these personnel in evaluating factors affecting the range of communications.

STATUS: The report is now in preparation and is about 60% complete.

TITLE: MEASUREMENTS FOR BROAD BAND ANTENNAS — S940R-C A-2

DESCRIPTION: Measurements are to be made on various kinds of broad band antennas using reflectors to determine standing wave ratios and field patterns in a horizontal and vertical plane. The feasibility of adopting balanced feed to permit operation with standard unbalanced feed is to be investigated. Recommendations are to be made concerning design features for providing suitable mechanical strength for Naval service.

STATUS: Experimental work on this project is continuing. No reports are available to date.

TITLE: RADIATION PATTERNS OF BLANKET ANTENNAS	S942T-C A-5

DESCRIPTION: Radiations patterns of shipboard antennas which will be used for blanket installations are to be determined.

STATUS: Work was completed in Boston on 3 December 1944. The preliminary results were given to BuShips. The final report is dated 28 December 1944, S67/66(341B:HEP) serial 341-341. The problem was closed 24 May 1945.

TITLE: RCM PHOTOGRAPHIC WORK, REQUEST FOR	S1086R-C A-2

DESCRIPTION: This problem requests the preparation of detailed photographs covering typical (simulated) RCM and GMCM prototype installations aboard ship. These photographs are needed to assist installation and repair activities.

STATUS: Approximately half the work of this problem has been completed. The photographs of the TEA and associated equipment have been made and submitted in the form of slides as enclosures to NRL letter to BuShips C-F42-1/84/RCM(325) serial C-320-400/45 dated 7 June 1945.

I N T E R C E P T

RADAR

See also (a) General - S819R-C and S1086R-C

TITLE:	RCM - INVESTIGATE THE PRACTICABILITY OF SIMULTANEOUS PRESENTATION OF DIRECTION AND FREQUENCY IN PANORAMIC INTERCEPT RECEIVER SYSTEM	N28R-S A-1

DESCRIPTION: Investigation of the feasibility of simultaneous presentation of direction and frequency for a panoramic-intercept-receiver system is required. Existing components are to be utilized wherever possible.

STATUS: Work on this problem is incomplete. Tests made with the RDH panoramic receiver connected to the CXGA direction finder were discouraging. The uncertainty of being on tune during a given pulse adds to the uncertainty of simultaneous illumination of intercept direction-finder antennas. This results in unreliable operation, particularly at low pulse-repetition rates. Restriction of the frequency scan and an increase in bandwidth over that of the RDH will be required in a more workable system which may eventually be devised.

TITLE:	DEVELOP 1000-20000 MC RECEIVER TECHNIQUES	N30R-S A-2

DESCRIPTION: The objectives of this problem are twofold:

A. Build a receiver having the following specifications:
   1. Frequency range 2000-4000 Mc
   2. Discrimination and reradiation comparable to low frequency standards
   3. Intermediate frequency approximately 800 Mc
   4. Shipboard construction
   5. Panoramic presentation

B. Outline of Receiver Techniques covering RCM in the range 1-20 kMc:
   1. Type of receiver
   2. Numbers of receivers and tactical application

[redacted]

3. Specifications

STATUS: A design of the 2000 - 4000 Mc receiver that appears to be practical has been completed and two stages of the 800 Mc i-f strip have been constructed. Experimental results so far indicate that the i-f stage gain will be 15 to 17 decibels with a bandwidth per stage of 12.0 Mc. Six stages will produce a unit having an overall gain of 90 decibels and a bandwidth of 4 Mc. The video will be entirely conventional. The Air Communications Company of Kansas City is constructing six experimental i-f units.

Work on the overall research program is continuing.

TITLE: HOMING ON JAMMING SIGNALS — S62R-S, A-3

DESCRIPTION: The ASA, ASB, and ASE are to be modified to permit homing on jamming signals. Essentially, the modification consists in the incorporation of a volume control in the receiver.

STATUS: Work on the ASB and ASE has been completed and was reported in NRL letter C-F42-1/36(314) dated 8 January 1943. Nothing has been done for the ASA since it is not being used extensively. The development of equipment for aural homing indication is in progress.

TITLE: CONSULTANT SERVICE ON RDJ PULSE ANALYZER — S138.1R-R, A-5

DESCRIPTION: NRL is to furnish consultant service for the RDJ pulse analyzer which is under development at the Radio Receptor Company.

STATUS: Tests on the preliminary model X-RDJ have been completed under problem S787T-R. The consultative services of the Laboratory are still being utilized to discuss production test procedures and specification revisions as well as future modification plans on this equipment.

TITLE: CONSULTANT SERVICES TO THE MANUFACTURER OF THE CLS - 66AJO SUBMARINE ANTENNA SYSTEM — S180.4R-C, A-4

DESCRIPTION: NRL is to act as consultant to the manufacturer of

[redacted]

the CLS-66AJO antenna system during the period of manufacture. Tests and research necessary to refine the system are to be made. The development of this antenna (XCV) was done under Problem S180.1.

STATUS: The original contract $NX_{sr}73852$ is completed. The 25 units ordered have been shipped and are now in the process of being installed. The contractor, Brach Mfg. Corp., Newark, N. J., is now working on two other contracts $NX_{sr}85042$ & $NX_{sr}81465$, calling for the production of 185 additional equipments. Estimated delivery date of the first group of these units is July. The Navy designation assigned to the production equipment is "Model DBU Radar Direction Finder Equipment"; but this designation has been modified to DXA when referring to the entire system which is assembled in the field. Assistance is being furnished to the manufacturer and the Bureau as required. Life tests are being conducted on improved type SA56/SPR-1 switches submitted for approval. Electrical and mechanical tests are being conducted on a factory model equipment. An NRL representative has been sent to Pearl Harbor to aid in the work on submarine direction finders. Engineering information is also being given the contractor for the construction of the collector elements and in the preparation of an instruction book.

TITLE: DESIGN A SEARCH ANTENNA FOR AN/SPR-2 SEARCH RECEIVERS TO BE USED ON SUBMARINES	S180.5R-S A-1

DESCRIPTION: An omnidirectional search antenna for submarine use is required which covers the frequency band 1000- to 3000 Mc and is equally receptive to horizontal and vertical polarization.

STATUS: An antenna has been developed consisting of a type AS-125 cone mounted against a 120° sector of a circular ground plane. (The cone is tilted 60° from the vertical, toward 90° relative bearing of the antenna, the center element of the ground-plane sector being considered zero bearing.) The whole assembly is mounted so that the ground plane is at a vertical angle of 45°.

For pressurizing the antenna a glass seal consisting of a glass bushing between the neck of the cone and the outer conductor of the coaxial line, at the point where the ground plane is attached, is proposed. Without the glass seal the antenna covers the frequency range of 800 to 3600 Mc, with a standing wave ratio of better than 2 to 1. When the glass seal is inserted, the standing wave ratio increases to slightly more than 4 to 1 at the worst points.

[redacted]

The omnidirectional characteristics of the antenna are promising. However, at some frequencies in the band there are narrow dips in coverage which sometimes drop to as low as 10% of the maximum of the pattern.

Relative sensitivity to horizontally and vertically polarized waves is approximately the same, although as a whole the vertical coverage patterns are more uniform than the horizontal. If this antenna is mounted against the submarine periscope shears as has been proposed, there will be a null caused by shielding due to the shears. Therefore, it is recommended that two antenna assemblies be oriented roughly at 180° from each other on opposite sides of the ship in order to give more complete coverage.

The absolute sensitivity of the antenna and relative sensitivities at the high and low ends of the band have not yet been determined.

Preproduction models of the antenna are now in the process of manufacture by the Air Track Company, Washington, D. C.

TITLE: DESIGN OF WAVE GUIDE FOR AN/SPR-2 SEARCH RECEIVERS TO BE USED ON SUBMARINES	S180.6R-S A-5

DESCRIPTION: An antenna for submarines covering the frequency range 3000 - 10000 Mc is urgently needed for use with the AN/SPR-2 search receiver. It is requested that a broad band wave guide antenna be designed for this application. Consideration must be given to the details of installation through a pressurized submarine hull.

STATUS: Two experimental designs for this antenna are being drawn.

TITLE: DEVELOPMENT OF MICROWAVE D/F ANTENNA FOR SUBMARINES	S180.7R-S A-1

DESCRIPTION: A microwave antenna similar to the XCV is to be developed for use with the AN/SPR-2 (AN/APR-5AX) on submarines. The frequency range is to be 2000 to 3500 Mc or 1000 to 3500 Mc if possible. Bearing of intercepted signals will be determined by swinging ship. A mechanical switching mechanism is to be provided so that signal amplitude from the two antennas may readily be compared or connected in parallel for intercept operations.

[redacted]

STATUS: NRL ltr. S-S67/69(342C) serial 4744 of 21 March 1945 is a report on the performance tests of the direction finding system XCY for S-band which was designed after the XCV direction finder collector. The production XCY is known as the DBV. DXB is the name of the system assembled in the field which includes the DBV antenna. Novices obtained bearing accuracies of 7° and more experienced operators averaged 3° accuracy. An ASG at 5000 ft. was detected out to a range of 100 miles. NRL ltr. S-S67/69(342C) serial 4847 of 2 July 1945 is a second interim report on this problem and discusses installations on the USS DENTUDA (SS335) and USS SKATE (SS305). Bids are to be submitted by various manufacturers for the manufacture of 166 equipments. Delivery time is estimated to be about 1 September 1945.

TITLE: TEST OF XCV INSTALLATIONS	S180.8R-C A-1

DESCRIPTION: Antenna patterns, calibration curves, bearing and range data on an XCV (DBU) Direction Finder installation aboard the submarine USS SKATE are required. Final report is to include details and recommendations for future installations.

STATUS: The installation and tests were completed about 1 April 1945 at Hunter's Point, California. Results were satisfactory, being similar to those experienced with the experimental models. NRL ltr. C-S67/69(342:JRA) serial C342-51/45 of 30 May 1945 is the final report on this problem. Antenna patterns are also given in Navy Radio and Sound Laboratory ND11/NP22/S67(B19-CD) serial C-RS-1673 of 8 May 1945. Problem was closed 9 June 1945.

TITLE: TEST OF AN/APR-1 PULSE STRETCHER CIRCUIT	S378.2R-R A-4

DESCRIPTION: Modification of an AN/APR-1 receiver is requested according to RRL Report TMR15D of 25 November 1944. Investigation of the pulse-stretcher circuit is desired with emphasis on determining whether its value is sufficient to warrant the conversion of receivers now in service with the Fleet.

STATUS: An AN/APR-1 receiver was modified by removal of the 6AC7 tone oscillator and insertion of a 6SN7 as a pulse-stretcher audio amplifier as specified in RRL report TMR15D. Minimum detectable signal measurements were made before the alteration and then after the alteration, both with and without the pulse-stretcher, but using the

additional audio gain provided by one half of the 6SN7. Comparisons were made using pulse widths of 2, 5, and 25 microseconds and pulse repetition frequencies of 50, 100, 200, 300, 500, 1000, and 2000 cycles per second. It was found that the pulse stretcher improved apparent sensitivity as the pulses became shorter and/or as the repetition rate became lower. The improvement for 2 microsecond pulses was 4 db at 2000 cycles and 6.75 db at 50 cycles. For 25 microsecond pulses, the improvement was 2 db at 2000 cycles and 5.75 db at 50 cycles.

The system has the following drawbacks: (1) there may be an introduction of 60-cycle hum which appears on the pulse analyzer, (2) the addition of an audio gain control may be required because presentation of a good pulse on the pulse analyzer requires an unpleasantly loud signal in the phones, and (3) elimination of the 6AC7 tone oscillator interferes with the reception of c-w signals. However, the pulse-stretcher circuit is likely to prove more valuable than the tone-oscillator feature in the AN/APR-1 series receivers. Field conversion whenever practicable is therefore recommended. A report , NRL ltr R-F42-5(375) R-370-199/45 will be available in July 1945.

TITLE: UHF PRESELECTOR — S499R-C A-1

DESCRIPTION: Improved preselectors for replacement of the TN type tuning units are to be developed for the frequency range of 40 to 3500 Mc. The range 40 to 750 Mc is to have higher priority than the 600 to 3500 Mc range. The units are to be mechanically interchangeable with the TN series AN/APR-1 tuning units. They are to have a motor driven tuning control and provision for sector sweep. At least two tuned circuits are to be used ahead of the first detector for minimizing spurious responses and to provide protection against cross-modulation. A cathode-follower connection for panoramic applications is required.

STATUS: Two units, 85 to 175 Mc and 175 to 350 Mc are well underway. Sample condensers, being manufactured by the Radio Condenser Company, for these units have been received at the Laboratory. If these preliminary condensers are satisfactory in capacity range and frequency characteristics, similar condensers for each of the units will be purchased. Preliminary tests with hand-made condensers indicate that satisfactory performance can be secured. The experimental model for 350 to 700 Mc is out of the shop and tests are being conducted to determine optimum condenser plate shape and performance characteristics of the unit.

[redacted]

TITLE:	SHIPBORNE TESTS OF GALVIN MANUFACTURING CORPORATION MODEL AN/SPR-1 RADAR RECEIVING EQUIPMENT WITH AN/APR-6 PULSE ANALYZER AND CXFE PANORAMIC ADAPTOR AS ASSOCIATED UNITS	S547R-C A-2

DESCRIPTION: Make temporary installation of AN/SPR-1 radar receiving equipment aboard a ship at NRL Chesapeake Bay Annex and obtain data on installation problems, operating pecularities, and maximum ranges against various radars.

STATUS: This problem is inactive. The information sought on the original problem request has already been transmitted to the Bureau of Ships in conjunction with work on other problems. It is recommended that this problem be closed.

TITLE:	USE OF SD ANTENNA WITH SEARCH RECEIVERS	S547.3R-C A-1

DESCRIPTION: An evaluation of the performance of the SD radar antenna as an intercept antenna is desired. The frequency range over which this antenna will function satisfactorily with the AN/SPR-1 type receivers is to be determined. Range tests within the useful frequency band and antenna pattern measurements are also to be made. Particular emphasis is placed upon the 100-320 Mc frequency range. It is intended that the SD antenna will be used for intercept while the submarine remains submerged.

STATUS: Tests of the SD antenna for intercept use with the APR-1 (or SPR-1) receiver have been made using a connection to the diplexer similar to that used for connecting the TBL communication transmitter to the SD antenna. The pattern obtained is not omnidirectional. It has nulls in the fore and aft directions. Appreciable response to vertically polarized signals is obtained by virtue of the "unbalanced" connection. The "sensitivity" characteristics of the antenna are useful over the range 100 to 500 Mc, with "spotty" response between 230 and 500 Mc. Flight tests with a Japanese Air Mark 6 (150 Mc) radar (elevation 5000 feet) gave detection ranges of about 60 miles with the submarine surfaced, and 35 miles when submerged to "SD radar depth". This test was run by Naval Research Laboratory engineers on temporary duty at ComSubPac., Pearl Harbor. Some of the preliminary work on this problem was also done at the U. S. Submarine Base, New London, Connecticut. The investigation of performance of the SD antenna is about 90% completed. It is presumed that the minor adaptations required for this use of the SD antenna are currently being made

on will soon be made on Fleet submarines.

TITLE: USE OF SJ RADAR AS AN INTERCEPT SYSTEM	S547.4R-S A-1

DESCRIPTION: Determination of the maximum reliable range at which an SJ radar can detect radiation on neighboring wave lengths is desired.

STATUS: NRL Chesapeake Bay Annex letter to NRL S-S67-5(539:EMK) serial 530:0041/45 of 17 April 1945 is an interim report on problem S547.4R-S. Radar signals on frequencies adjacent to the S-band may be intercepted up to ranges of 10 to 20 miles according to this report. The shortest wave length limit is determined by the receiver local oscillator and the longest wave length limit by the dimensions of the wave guide system. A tuning range from 9.56 to 10.44 cm proved feasible during preliminary tests at the NRL Chesapeake Bay Annex.

TITLE: WAVE TRAPS - DEVELOPMENT OF	S660.2R-R A-1

DESCRIPTION: The development of a wave trap for the frequency range of the SPR-2 receiver is desired. It is also requested that investigation be made of the possibility of ganging two modified butterfly circuits to provide a wave trap without sliding contacts for the AN/APR-1 and RDO type receivers.

STATUS: F-26/UPR is the designation assigned the wave trap designed for the SPR-2 receiver. An experimental laboratory model has been completed and tested. National Electric Company of Washington, D. C. is beginning production on this equipment. The NRL drawing for the F-26/UPR is RA62F356D.

F-52/UPR is the designation assigned the experimental butterfly circuit wave trap. Work on a dual circuit to cover the range 80-1000 Mc is just getting underway according to the recommendations of NRL ltr to BuShips C-S67-5/RCM(375:LWB) R-370-134/45 of 27 April about the modified butterfly circuit (coaxial condenser) developed at NRL. It is intended that this single unit may eventually replace the F-19/UPR and F-20/UPR wave traps which are already in production.

Reference NRL report R-2380 of 18 November 1944 for additional information on the development of wave traps for the AN/APR-1, SPR-1,

[redacted]

and RDO type receivers. This report covers the work under the original wave trap problem. A101R-R.

The NRL drawings (revised to date) listed below describe wave trap units already in production:

Wave Trap Type Designation	NRL Drawing Number	Frequency Range Megacycles
F-19/UPR	RA 62F 352B	80 - 320
F-20/UPR	RA 62F 336D	300 - 3400
F-22/UPR	RA 62F 340B	180 - 3400
F-26/UPR	RA 62F 356C	1000 - 6000
F-27/UPR	RA 62F 358D	170 - 3400

The F-22/UPR and F-27/UPR cover the same frequency range. However, the F-27 is a straight stub similar to the F-20/UPR while the F-22 is a circular stub. The F-27 is in quantity production. Only 25 experimental F-22/UPR wave traps are being made. The original NRL F-22/UPR is installed on the USS BOARFISH.

TITLE: IMPROVEMENT OF PANORAMIC ADAPTORS FOR PROTOTYPE USE	S668R A-2

DESCRIPTION: Representative Navy models RBV, RBW, and RCX panoramic adaptors are to be modified and improved by the Laboratory for use as manufacturing prototypes. The changes which are to be made are to provide greater reliability of operation and performance as well as greater ease of alignment, servicing, and maintenance.

STATUS: Investigation revealed that no minor electrical improvements were apparent which would notably improve the performance of the present adaptors. Hence, a complete redesign has been attempted which incorporates basically new circuits.

On 11 April 1945 a conference was held at NRL to acquaint the Bureau of Ships and interested commercial companies with the proposed new adaptor system. A working electrical demonstration was held at the conference. Numerous electrical defects, both new and old, were discussed during this conference. Progress on this problem and a description of the new system have been reported in NRL ltr C-S67-5(356:EEH) C350-117/45 of 11 April 1945.

Since the conference some of the major defects have been eliminated, and electrical development may be considered 80% complete. Considerable work will be required before a prototype equipment can be begun. The remaining difficulties require time

for further investigation.

Thus a fundamentally new prototype panoramic adaptor (radio spectrum analyzer) is in the process of development. This prototype is intended to serve as a basic unit from which other analyzers or adaptors may be developed for a wide range of frequencies and bandwidths. Existing specifications on the new equipment are still tentative. Final proportions may be as small as the RCX with weight as low as 50 lbs. The adaptors will operate with receivers having an i.f.. of 450 to 460 kc and will provide a 200-kc sweep. Reference NRL ltr. S67-5(356:EEH) serial R-350-204/45.

TITLE:	DEVELOPMENT OF PANORAMIC ADAPTOR FOR PROTOTYPE USE	S668.1R A-4

DESCRIPTION: A line of panoramic adaptor equipments are to be developed which are the Navy counterparts for existing commercial types. The equipments are to be designed with subassembly type of construction, with separate units for power supply, i-f amplifiers, etc.

STATUS: This problem is inactive pending the completion of Problem S668R. Reference NRL ltr. S67/5(356:EEH) serial R-350-204/45.

TITLE:	TEST OF CXGA SHIPBORNE RADAR DIRECTION FINDING EQUIPMENT	S707T-C A-1

DESCRIPTION: Complete electrical tests are requested including the following items:

(a) Determine frequency range.
(b) Determine sensitivity against horizontal and vertically polarized signals.
(c) Determine instrumental bearing accuracy.

STATUS: The CXGA shipborne radar direction finding equipment has been subjected to electrical and mechanical tests preliminary to acceptance for general shipboard use. This includes mechanical inspection of each unit and operational tests which were conducted aboard YP-354 at CBA. Additional field measurements were also made to determine bearing accuracy and sensitivity. The CXGA equipment has been accepted and approved according to the recommendations detailed in the following references:

[redacted]

NRL Report R-2386 Problem S707T-C
NRL ltr. to BuShips C-S67-5/RCM(375:PRC) 7/1/44

This problem should be closed.

TITLE: TEST OF BLINKER MARK II	S710.2T-C A-5

DESCRIPTION: Complete electrical and mechanical tests are to be conducted on the Blinker, Mark II. This receiver is a version of the RDL-1 Blinker that has been modified for shipboard use. It is essentially a panoramic receiver covering the frequency range from 70 Mc to 430 Mc. Panoramic indication is provided by means of a neon lamp mounted on the motor-driven dial. The neon bulb flashes when the receiver is tuned through a signal. This indicates the frequency on a calibrated dial. Means for an approximate indication of p.r.f. is also included. The Blinker is approximately 11" x 15½" x 19 3/4". Weight is nearly 70 pounds.

STATUS: The Laboratory received this unit on 9 May 1945, and electrical tests have been proceeding since that time. A panel inspection was held on 18 May 1945 which was attended by various members of the Radio Division. The results of the inspection and subsequent tests will be covered in a final report.

TITLE: TEST OF NEW MODEL (D-1500) TN-4 FOR AN/APR-1	S748.1T-R A-1

DESCRIPTION: Limited mechanical and electrical tests are to be made of the D1500 before production models are submitted. Complete tests are then to be made on the production run models. This unit has a cavity-type oscillator, and covers a 1000-3000 Mc frequency range.

STATUS: Test results on the first Sickles Company TN-4A model employing a Type 703A oscillator tube are given in NRL ltr. R-S67-5 (351:EOL) of 19 July 1944 to BuShips. The sensitivity (using a 30% sine wave modulated carrier with a 6 mw output in a 600 ohm audio output load with a 10 db modulation-on vs. modulation-off ratio) varied from 45 to 300 microvolts in an AN/APR-1 receiver. The local oscillator tunes from 500 to 1000 Mc. Harmonics are used for the higher frequencies. Performance under shock and vibration tests was fair. Conclusions on the basis of limited mechanical and electrical tests on the Galvin Manufacturing Corp. Laboratory Model TN-4(D-1500) tuning unit in an AN/APR-1 receiver are given in NRL ltr. F42-5(356: EOL) R350-542 of 16 January 1945 to BuShips. This unit employs a

Type 446 oscillator tube, covering a range of 1000 to 3100 Mc. Sensitivity averaged about 300 microvolts in the AN/APR-1 receiver and about 30 microvolts in the Model RDO receiver; the difference being due to lack of AN/APR-1 gain (mainly audio). Operation under varying temperature, humidity, shock, and vibration was satisfactory. Some mechanical improvements were recommended.

On March 16-17, 1945 an improved preproduction model of the Galvin Manufacturing Corp. TN-4 tuning head was given preliminary tests under an extension of this problem. It employed a 2C40 oscillator tube. A 1000 Mc high pass filter had been added in the antenna lead. Sensitivity proved erratic due to an indefinite ground at one end of the cavity. A range in sensitivity from 8 to 80 microvolts was measured using an RDO receiver. Improvements recommended are listed in BuShips ltr. R-A22.1(920-Dz) R920-3149 March 1945 to Galvin Mfg. Corp.

Final tests are to be made on a production model.

TITLE:	ELIMINATION OF RADAR INTERFERENCE AND SPURIOUS RESPONSES FROM RADAR SEARCH INTERCEPT RECEIVERS BY USE OF "IRIS" RECEIVER	S749.3R-C A-1

DESCRIPTION: An attachment is desired which can be used in conjunction with existing intercept receivers to reduce interference caused by strong local radar signals. A level control is to be incorporated which will allow the operator to reject all signals above a chosen amplitude. Automatic blanking of strong signals picked up by the intercept receiver is accomplished by the "Iris" receiver. This system will allow concentration on the reception of weak enemy radar signals without interference from neighboring friendly radars. Since the blanking is done on a "time" basis, no frequency discrimination is introduced.

STATUS: An experimental receiver called the Iris has been developed at NRL which will minimize interference from strong local radars when used as an adjunct to a standard intercept receiver. The Iris may also be used alone as an untuned, broad-band, early-warning equipment. The production version of the Iris has been designated CXKA. Five units are being built by the Warwick Manufacturing Company of Chicago, Illinois.

The intercept receiver used with the Iris is unaltered. Its r-f input and video output are merely coupled to the Iris. However, the final audio and video outputs are taken from the Iris instead of

from the intercept receiver. Four important circuit functions are incorporated in the Iris. The sections of the receiver which perform these functions are: (1) a crystal detector and video amplifier with variable gain; (2) a clipper and pulse-stretcher circuit; (3) a mixer circuit in which the intercept-receiver output is combined in a special manner with output from the Iris clipper and pulse-stretcher circuit. (Strong signals from the intercept receiver are "blanked" by strong signals picked up on the Iris in this stage, and only relatively weak signals from the intercept receiver are passed by this "mixer" circuit); and (4) a conventional video and audio output combination with optional pulse-stretcher circuit in the audio output stage.

The maximum sensitivity of the Iris blanking channel is on the order of five millivolts. No loss in frequency coverage is introduced by this method of interference elimination. The loss in intercept receiver sensitivity appears to be negligible.

Preliminary tests indicate that the Iris will minimize interference in the Model DBM d-f equipment caused by radars on the same ship. Signals from neighboring ships which are strong enough to cause serious interference are also blanked. This operational experience has been supplemented by subsequent tests aboard a DE in which interference from the ship's own radars in the SPR-1 and SPR-2 intercept receivers was effectively eliminated.

Research is continuing in order to make the Iris circuits more flexible and to simplify the operating techniques as much as possible.

TITLE: TYPE TEST OF XRDJ PULSE ANALYZER	S787T-R A-1

DESCRIPTION: Typical performance tests are to be made on the video amplifier, keyer, multivibrator sweep, p.r.f. meter and oscillator. The degree of interaction between controls is to be determined. Heat, humidity, vibration, shock, and salt spray tests are also to be made.

STATUS: The preliminary model X-RDJ submitted on 6 April 1945 has been modified and given complete electrical tests and a mechanical inspection. The modified equipment is satisfactory for Naval service. Prior to receipt of the above-mentioned model, an earlier model was given shock, vibration, and temperature tests. This model was not suitable electrically in many respects. One of its units failed during the temperature tests. The shock and

vibration tests did not reveal any serious mechanical weaknesses of the design. The results of these mechanical tests are reported in NRL ltr. S67-5(354:EEH) of 13 January 1945.

The model which arrived at the Laboratory on 6 April 1945 was returned to the contractor at the end of the tests and inspection. The first 25 units to be manufactured are expected to be comparable to the model returned to the contractor. A production model is expected at the Laboratory for complete type tests in the near future. The X-RDJ equipments are being manufactured under Navy contract NXsr-51517.

TITLE: DEVELOPMENTAL WORK ON THE X-RDJ PULSE ANALYZER	S787.1R-R A-5

DESCRIPTION: The Model X-RDJ is a pulse analyzer intended to be used with the Model RDO Receiver. A delay line, a built-in calibration oscillator to determine the pulse length, and a pulse repetition meter are incorporated in the X-RDJ analyzer, which has the following specifications:

Pulse Length Range: 1/2 to 100 microseconds
Repetition Rate Range: 20 to 10000 pps
Power Input: 130 watts at 115 v 60 cycle ac
Size: Cabinet size (less projections)
9-3/16"x 18-1/8"x 22"

STATUS: Development work has been completed. Production is being handled by the Radio Receptor Company of New York. The first manufacturer's model has been received by the Laboratory. This shows that further developmental work is necessary. Defects encountered in the preliminary model submitted to this Laboratory were reported in NRL ltr. S67-5(354:EEH) of 13 January 1945.

On March 20, 1945, another Model X-RDJ was submitted for preliminary inspection. This model incorporated many of the suggestions made by the Laboratory on the prior model. Results of the inspection of this model were discussed with the contractor and a representative of BuShips on 21 March 1945.

As a result of the above findings, still another model was submitted on 6 April 1945 for inspection and type tests, if suitable. Inspection revealed several new defects, as well as several previously noted defects. Investigation by the Laboratory of the above defects resulted in recalling a representative of the contractor to see the results of modifications of the equipment by the Laboratory . A

summary of the final modifications proposed by NRL will be submitted in the near future.

It is believed that no further development work will be required on this problem unless unexpected production difficulties are encountered.

TITLE: OPERATIONAL TESTS OF AN/APR-7 (SPUD) RECEIVER ABOARD SHIP	S898T-R A-3

DESCRIPTION: Range tests are requested for an APR-7 receiver installed on shipboard and using an AS-44/APR-5 antenna. The likelihood of spurious responses is also to be investigated.

STATUS: NRL ltr. to BuShips C-S67-5/RCM(375) serial C370-424 of 20 December 1944 describes the measurements made on this receiver. Problem S898T-R should be closed.

TITLE: LOOK-THROUGH RECEIVER 50-1000 MC	S924R-C A-2

DESCRIPTION: The design of a look-through receiver system similar to that used in the Leopard equipment is to be investigated for the frequency range 50 to 1000 Mc. The possibility of using two AN/SPR-1 receivers with adaptors is to be studied. Possible application of such a system for use with the Model TDY-1 jamming transmitter is understood to be a special reason for the setting up of this problem.

STATUS: Three approaches to the problem of providing satisfactory look-through equipment are being investigated. These are (1) cancellation of jamming noise, but not the enemy signal in the receiver r-f, i-f, or video stages; (2) placement of the receiving antenna in a relatively shielded area with respect to the jamming antenna; and (3) the use of a single antenna with a directional coupler which differentiates between the transmitted and received signals in the transmitting antenna cable. (This method has proven unsatisfactory.)

Experiments with r-f cancellation have resulted in a 15- to 20-db increase in the signal to noise ratio. It is desirable to cancel as nearly "cycle for cycle" as possible. Circuit limitations curtail the advantage that can be achieved by reading a portion of the transmitted signal directly into the receiver 180 degrees out of phase with, and equal in amplitude to, the transmitted signal picked up by the receiving antenna. Similar investigations at NRL have yielded

a 30- to 60-db gain by this method under certain conditions.

I-f cancellation has not been fully studied to date. Some experimentation has been undertaken using the jamming signal picked up by an auxiliary crystal detector to provide a voltage for application to the grid(s) of one or more i-f stages in an APR-1 receiver. The receiver gain is thus varied inversely with the amplitude of the modulation of the jamming signal. This system has to be non-linear and consequently can only cancel completely at one amplitude. A maximum of 12 db improvement in signal to noise ratio has been reached, but generally little gain can be realized by this scheme. Video cancellation has also been attempted. The most successful method has been to use two "parallel" receivers (one connected to the usual receiving antenna, and the other fed with an r-f signal direct from the jamming transmitter; this is the scheme used in the "Leopard" system; Problem S877R-S) and to feed the video outputs of these receivers into opposite ends of the "push-pull" primary of a broad-band (video) transformer, the secondary of which is connected so that cancellation of the two receiver outputs results. An improvement of 12 to 15 db may quite readily be obtained.

Another method involving a single receiver and a crystal to supply the cancellation signal by feeding a modulation voltage into the receiver has not been successful. It appears that the two carefully balanced receiving channels used in the Leopard system are better matched than two APR-1 type receivers because about a 25 db gain has been achieved in the Leopard system.

Approximately 100 db isolation is required between jamming and receiving antennas in order to perceive a 100 micro-volt signal if no other means of interference elimination is provided. Preliminary tests to date indicate that isolation of at least 80 db may be obtained in typical installations without excessive difficulty.

TITLE: MECHANICAL AND ELECTRICAL TEST OF SECTOR SWEEP TUNING UNITS FOR AN/SPR-1 EQUIPMENT	S937T-C A-1

DESCRIPTION: The performance of the tuning motor added to the AN/SPR-1 r-f units is to be determined. Ability to withstand operation under gun fire and temperatures ranging between +70°C and -40°C is also to be determined. Observations are to be made on the noise level caused by the motor in the tuning units. The mechanical performance of the motor drive is also to be checked.

[redacted]

STATUS: The tests on the sector sweep mechanism have been completed on a Galvin TN-3 tuning head. Results are given in NRL report C-S67-5/RCM(356:EOL) C350-531 of 27 December 1944 to BuShips. The angle of sweep can be varied by setting two stops. A toggle switch on the front panel turns the sweep motor on and off, and the speed of sweep is also varied with a front panel control. The motor does not introduce any appreciable electrical noise into the AN/SPR-1 receiver, but does generate considerable acoustic noise. It will run satisfactorily at very low temperatures, but with its speed somewhat reduced. The speed control range is from 9 to 15 seconds for a 90 degree sector at room temperature. Improvements in the provision of protection against the effects of fungus and high humidity are necessary.

TITLE: TEST OF NBS PULSE REPEATER — S946R-C A-3

DESCRIPTION: An operational test of the NBS pulse repeater is to be made. It is a balloon-borne system with an intercept receiver set to cover a band of selected enemy radar frequencies and a triggered transmitter on 250 Mc. Separate receiving and transmitting antennas are employed. The receiving antenna is equipped with "cups" which are revolved by wind action in order to insure 360 degree coverage. If successful, this system should relay the presence of enemy radar signals, thereby presenting our own ships with warning of enemy radar activities considerably in excess of the normal range of a search receiver.

STATUS: Inactive - Equipment has not been received.

TITLE: TEST AN/SPR-2 INTERCEPT RECEIVER — S952T-R A-1

DESCRIPTION: Tests on the first preproduction model are to be made. These should include a mechanical inspection and sensitivity curves throughout the 1000 to 3000 Mc range. The problem has recently been extended to include complete type tests of the low-frequency tuning units up to 5000 Mc, using the second harmonic of the local oscillator.

STATUS: Preliminary tests have been completed as reported in NRL ltr. S67-5/RCM(356:EOL) serial R350-521 of 19 December 1944. The receiver is similar to the AN/APR-5AX except that the oscillator mixer circuits are incorporated in plug-in units so that they can be quickly changed. The sensitivity averages about 35 microvolts from 1000-3000 Mc using

[redacted]

an equivalent 30% 1000 cps modulated carrier, with a 10 db modulation-on vs. modulation-off ratio and 6 mw output in a 600 ohm audio load. At 3200 Mc, the sensitivity is 0.024 volts/ meter at the wave guide input, using a "Free Field" box and signal generator technique. Selectivity is 10 Mc at 6 db down. Image and harmonic rejection are poor. There is an objectionable peak in the video response at 500 kc. The i.f. and audio gain control ranges are inadequate. The resonant overload characteristics are very poor. A pulse stretcher circuit is quite effective in rendering short pulses at low repetition rates more audible. Complete type tests on a later preproduction model AN/SPR-2 receiver have been completed as reported in NRL ltr. R-S67-5/RCM (356: CEY) R350-103/45 of 17 April 1945 to BuShips. This receiver tunes from 1000 to 3100 Mc with the local oscillator operating on its fundamental and from 3030 to 6230 Mc by utilizing the oscillator second harmonic.

The sensitivity varies from 34 to 100 microvolts from 1000 to 3000 Mc with oscillator fundamental operation, and from 37 to 148 microvolts from 3000 to 4000 Mc with second harmonic operation. No tests of the wave guide unit have been made. No signal generator equipment was available for measurements from 4000 to 5000 Mc, but second harmonic operation of the coaxial line unit above 4000 Mc does not appear desirable. The bandwidth is 13.48 Mc at 6 db down with an excellent shape factor. Resonant overload and blocking characteristics are very poor. There is insufficient overall receiver gain. The pulse stretcher gives up to a 25 db audio improvement on some types of pulses. Excessive tuning dial backlash could be removed by greater care in construction. The blower motor creates excessive mechanical noise. The aircraft type shock mounting cannot withstand shipboard standard shock tests.

TITLE: AN/SPR-2A RADAR INTERCEPT RECEIVERS - TESTS OF	S952.1T-R A-1

DESCTIPTION: Type test is to be made of the AN/SPR-2A receiver. This receiver is built by Stromberg Carlson and is similar to the Galvin AN/SPR-2 except that the SPR-2A chassis is made of sheet metal instead of a cast base.

STATUS: Final test results are reported in NRL ltr. S67-5/RCM(356: CEV) R-350-236/45 of 19 July 1945. The performance of the SPR-2A is similar to that of the SPR-2 including the same limitations. Reference S952T-R.

[redacted]

TITLE:	PERFORMANCE OF AN/SPR-2 RECEIVER AT "X" BAND WITH COAX AND WAVE GUIDE MIXERS	S952.2R-C A-1

DESCRIPTION: The performance of the AN/SPR-2 receiver complete with wave guide antenna connected (a) to coaxial mixer through transformer section and (b) to wave-guide mixer is to be determined at X-band only.

STATUS: Work has been completed. Final report will show that on the basis of tests made at NRL Chesapeake Bay Annex, X-band reception on S-band gear seemed promising. The relative merits of various combinations of antennas and mixers will be indicated in the report.

TITLE:	TEST OF COMBINED TUNER FOR AN/SPR-2 SEARCH RECEIVER	S952.3T-R A-1

DESCRIPTION: The performance of the combined tuner is to be compared with the TN-56/SPR-2 and TN-57/SPR-2. Sensitivity, frequency coverage, effectiveness of switching arrangement, and any other points which would have a bearing on the decision concerning the use of this tuner instead of the TN-56 and TN-57 is to be determined.

STATUS: Tests have been completed. Approval of the unit is recommended. Report will be ready shortly.

TITLE:	ELECTRICAL TEST OF TWO AN/SPR-2 SEARCH RECEIVERS EQUIPPED WITH REACTANCE PLUNGERS	S952.4T-S A-1

DESCRIPTION: The performance of the subject sets is to be compared with sets using conventional plungers. Sensitivity, frequency coverage, stability, noise, uniformity of output, ruggedness of construction, and other features are to be investigated.

STATUS: Tests have been completed. The reactance-plunger change appears to be desirable. A report is in preparation.

TITLE:	DEVELOPMENT AND TESTS OF S-BAND EARLY WARNING RECEIVER SYSTEM	S983R-S A-1

DESCRIPTION: A preliminary model of the S-band early warning receiver

[redacted]

has been developed at the Naval Research Laboratory. Problem S983R-S requests the completion of this receiver, the provision of consultant service for the manufacturer, and the testing of prodution models. The S-band early-warning receiver is a crystal-video system covering the range from 2500-3500 Mc. An associated wavemeter provides a means of measuring the frequency of intercepted signals.

Problem S983R-S has been modified to include the development of a non-directional antenna system with a frequency range of approximately 2000-4000 Mc. This antenna must be suitable for submarine use.

STATUS: The first model of the REF (Christopher) early warning receiver was inspected on 9 April 1945 by NRL personnel at the Air-Track Mfg. Co., College Park, Md. The sensitivity, frequency calibration, and calibration of the associated wavemeter were checked at four points and found to meet the specifications drawn up by the Bureau of Ships.

TITLE: VHF SHORE DF SYSTEM (XCZ) S989R-C
A-1

DESCRIPTION: Development of suitable antenna collector systems, coupling networks, and controls for shore type direction finders covering the frequency range 30-145 Mc with equipment suitable for taking accurate bearing on minimum field intensities (resulting from anomalous ionospheric and tropospheric propagations over long distances) is requested.

The equipment will consist of two separate systems. System (1) (XDD) will cover 30 to 65 Mc and will employ a fixed elevated crossed H antenna system using a variable speed inductive goniometer and a cathode ray indicator. The goniometer speed will be variable from 0 to 1800 rpm making it possible to obtain either an aural or visual indication. System (2) (XDE) will cover the range 65 to 145 Mc using a 30-foot parabolic reflector rotated by a Model SK radar pedestal and control system. A model SK PPI indicator will be modified for presentation which will be of the pattern tracing type. Model RBK and RDC receivers will be modified for use with the equipments, and a Model REM panoramic adaptor will be provided for use with these receivers.

STATUS: Models of a crossed H antenna system for the 30-65 Mc equipment and an inductive goniometer have been developed and are under test. Design work on the indicator is partially complete. An antenna system (parabolic reflector) for the 65-140 Mc equipment

is in the design and development stage based on results from scale model experiments. Modification of an SK radar equipment is in the final stage of completion and will be assembled soon.

For basis of goniometer design see JEIA Report #6908.

For complete description of systems see NRL Interim Report on "VHF Shore Type 20-100 Mc (Model XCZ) Direction Finder" NRL ltr. C-S67/69(342j) C342-169 of 3 January 1945. See also NRL ltr. C-S67/69(340) C340-91/45 of 18 April 1945.

TITLE: PERFORMANCE TEST OF AN/APA-11 PULSE ANALYZER	S1000T-R A-5

DESCRIPTION: Electrical and mechanical tests are requested for the AN/APA-11 analyzer to determine the modifications required for shipboard use. The AN/APA-11 would be desirable on submarines because of its small size. Suggestions concerning the substitution of the APA-11 for the AN/SPA-1 or RDJ are desired.

STATUS: Inspection of the APA-11 chassis revealed some crowding of parts with the standard 400 cycle power supply. Modification to provide a 60 cycle power supply would probably require an increase in the overall dimensions of the present APA-11.

The APA-11 is better than the SPA-1 in that determination of the repetition rates of interfering signals is possible. However, the measurement of the repetition rates of weak signals is difficult, because it is hard to know whether noise or the desired signal is keying the pulse rate meter. Presentation of the actual pulse being measured as in the SPA-1 and RDJ equipment is a definite advantage in this respect. Errors up to 40% in pulse width are also possible on the APA-11. Work on this problem is still in progress.

The AN/APA-11 pulse analyzers are manufactured by R. Wurlitzer Company, North Tonawanda, New York.

Reference NRL ltr. S67-5/RCM(354:RGH) R-350-76/45, of 22 February 1945.

TITLE: TEST OF UHF DIRECTION FINDERS	S1051T-C A-3

DESCRIPTION: General performance tests are to be made on the VHF direction finder systems developed by NDRC and comparison tests are to be made on Navy type VHF and UHF direction finders which have

been independently developed and consigned to the Laboratory for test. An effort is to be made to appraise the suitability of the various general kinds of equipment without resorting to detailed type tests. Tests are to be conducted according to the NDRC (Standard F-F Measurements) specifications where applicable.

STATUS: The RCA VHF direction finder, developed under NDRC contract DEM_{sx} 1009, has been installed at Blue Plains. Necessary construction work on test facilities prevents immediate testing. The Federal UHF direction finder, developed under NDRC contract OEM_{sr} 961 is at the Laboratory, but has not been installed at Blue Plains. Testing this equipment will follow that of the RCA direction finder.

TITLE: TEST OF DBM-1 DIRECTION FINDER — S1063T-C, A-1

DESCRIPTION: Shock, vibration, temperature, and humidity tests are to be made on the DBM-1 direction finder to determine compliance with standard specifications and general suitability for Naval service. A mechanical inspection is to be made, and the performance of the equipment is to be observed under conditions of variable input voltage and frequency.

STATUS: This equipment arrived 5 June 1945, and the above mentioned tests are well underway.

TITLE: D-F INDICATOR REQUIREMENTS — S1071R-C, A-5

DESCRIPTION: An analysis is to be made of the requirements for VHF, UHF, and SHF direction finder indicators. The correct rotational speed ranges for d-f collectors is also to be determined. Existing information on the characteristics of friendly and enemy pulse communication and beacon transmissions is to be correlated with various properties of automatic direction finders.

STATUS: The report on this problem is being written.

TITLE: SHOCK AND VIBRATION TEST OF RCM — S1110T, A-2

DESCRIPTION:: A mounting rack for shipboard use is to be tested under

standard shock and vibration conditions with the RDJ equipment in the top position, the RDP in the center position, and the RDO in the bottom position.

STATUS: BuShips is procuring the necessary rack and mounting table for these tests. Tests will start when these and one unit of each of the Model RDJ and RDP equipment become available.

RADIO CONTROL

See also (a) General - N9R-S, S16R-S, and S1086R-C
(b) Test and Training - Radio Control - S473.1R-S
(c) Enemy Equipment and Signal Analysis - Radio Control - S596R-S

TITLE: DEVELOPMENT OF PANORAMIC RECEIVERS — S16.2R-S A-2

DESCRIPTION: The problem is divided into two parts: (1) the modification of the commercial receivers for broad band panoramic operation, and (2) the development of receivers specially designed for panoramic operation. The two commercial receivers which were modified are: The National HRO which was converted to the RDG, and the Hallicrafters RBK which was converted to the RDC. The specifications on these receivers are as follows:

RDG - (National HRO)
Frequency: .5 to 30 Mc in approximately 2 to 1 bands
Scanning speed: 15 scans per second
Display: external cathode ray
Size: 19 x 12 x 17 inches
Weight: 90 lbs

RDC - (Hallicrafters RBK)
Frequency: 28 - 143 Mc in 3 bands
Scanning speed: 15 scans per second
Display: external cathode ray
Size: 19 x 10 x 17 inches
Weight: 70 lbs

The specially designed panoramic receivers are the RDH and two other receivers which are to replace the RDC and the

RDG and their associated manually tuned receivers.

The RDH is a broad band, mechanically-scanned receiver. Sweep voltage is generated by light falling on a photo-electric cell which varies according to the amount intercepted by a shutter on the main tuning condenser shaft. The receiver may be tuned manually or motor driven and still give panoramic presentation. The specifications on this receiver are as follows:

RDH
Frequency: 130 to 600 Mc in 2 bands
Scanning speed: 15 scans per second
Display: external cathode ray
Size: 19 x 21 x 19 inches
Weight: 100 lbs (approximate)

One of the receivers to replace the RAO and RBK will be manually tuned with external electronic scanning over a one megacycle band. The other receiver will be a broad-band panoramic which is mechanically scanned over the entire band. The two receivers will be used together. The mechanically-scanned receiver will sweep over a wide band and will locate any signals within its range. The manually-tuned receiver will then be adjusted to the narrow band indicated for a more exact determination of carrier frequency. These receivers have the following specifications:

Manually-tuned Receiver
Frequency range: 14 to 140 Mc in 4 bands
Display: external panoramic adaptor and cathode ray
Size: 19 x 22 x 8 inches
Weight: 100 lbs (approximate)

Broad-band Panoramic
Frequency range: 14 - 140 Mc in 4 bands
Scanning speed: 900 rpm
Display: external cathode ray
Size: 19 x 22 x 8 inches
Weight: 100 lbs (approximate)

STATUS: The laboratory model and the manufacturer's pre-production model of the RDG have been tested. Production is proceeding at the National Company. A number of RDC receivers have been produced by the Halstead Traffic Communications Company, and production has started at Hallicrafters. Experimental work on the RDH has been completed, and the development of a manufacturer's model at Hallicrafters is progressing satisfactorily. An experimental model of the manually-tuned receiver is approximately 75% complete. The development of the broad-band panoramic is in its early stages.

[redacted]

TITLE: CATHODE RAY DUAL PRESENTATION UNIT (XCW OR REM)	S16.3R-S A-1

DESCRIPTION: This problem covers the development of a dual presentation unit for panoramic display of receivers. One cathode-ray tube shows signals from a broad-band (two-to-one frequency range) panoramic receiver while the other tube displays the signal from a panoramic adaptor attached to a companion manually-tuned receiver. Extra marker pips show on the broad-band display the frequency to which the manual receiver is tuned and indicate the region which is shown as an expanded scale on the other cathode-ray tube. This greatly facilitates the identification of any particular signals seen on the broad-band display.

The unit contains panoramic adaptor circuits which can be used with receivers having either 5.25 or 0.456 Mc intermediate frequencies. Single-tuned staggered circuits are used to facilitate lining up of this apparatus with its companion receiver. Other major components are the marker pip circuits and a sweep generating circuit for the broad-band panoramic receiver.

Size: 19 x 16 x 22 inches
Weight: 100 lbs (approximate)
Input: 115 v 60 cycle

STATUS: Laboratory model is complete, and the first manufactured model has been tested in the TEA mockup. NRL ltr. to BuShips, C-F42-1/84/RCM(320:RP) serial C-320-401/45 dated 1 June 1945 recommends specific changes for this unit. After some modification, these equipments will be manufactured by Midwest Radio Company.

TITLE: OBH ANALYZER TYPE TESTS	S779T-C A-3

DESCRIPTION: Make test on OBH equipment for compliance with the specification RE-9176-B and the specification for Radio Test Equipment, RE-13A-700A.

STATUS: Final report C-F42-1/84/RCM(369:LDH) serial 361-179 dated 14 September 1944. Problem was closed 24 May 1945.

[redacted]

TITLE: TEST OF RDG	S836T-R A-1

DESCRIPTION: Type tests of the RDG are to be made to determine compliance with Navy specifications. This receiver is described under problem S16.2R-S.

STATUS: A portion of the type tests have been completed as reported in NRL ltr. R-F42-1/84/RCM(320:EFZ) serial R320-998 of 13 November 1944. It was found that there was excessive reradiation from the RDG. This condition has been corrected. A panel inspection of the RDG is reported in NRL ltr. R-F42-1/84/RCM(327) serial R322-914 of 1 October 1944. Production is now proceeding on the basis of the improved model RDG.

TITLE: TYPE TEST OF RDC RECEIVER	S870T-R A-1

DESCRIPTION: Type tests are to be made on the RDC receiver to determine its suitability for Naval service. These include sensitivity, variation in sensitivity, variation of frequency with humidity, line filter characteristics, bandwidth of i-f amplifier, and salt spray tests.

STATUS: Tests have been completed, as reported in NRL ltr. S67/43 (356:BIG) serial R350-85/45 of 5 April 1945 to BuShips and NRL ltr. S67/45(356:BIG) serial R350-85/45 of 20 April 1945. It was found that the RDC met design specifications, but did not conform with good Navy practice and failed to pass the humidity test. Problem was closed 24 May 1945.

TITLE: RADIO-RECORDING-TIME INDICATING DEVICE	S1035R-R A-1

DESCRIPTION: A method of recording time on voice recordings is to be developed. Four timing pulse generators and one receiving clock suitable for shipboard installation are to be built.

STATUS: Equipment has been designed and tested, and plans submitted to the Bureau of Ships. Negotiations are proceeding for the manufacture of several units.

This equipment generates a pulse code at one-half minute

[redacted]

intervals to indicate the number of time units elapsed since the apparatus was started. These pulses are superimposed on voice or signal recordings so that upon later analysis, correlations can be made between events recorded on several machines. It is intended to apply the pulses to recorders making records of GM signals and others recording descriptions of conditions prevailing at the same time.

JAMMERS

RADAR

See also (a) General - S819R-C and S1086R-C
(b) Test and Training - Radar - S550R-S

TITLE: INVESTIGATE LEOPARD — N19R-S A-1

DESCRIPTION: This problem covered the early developmental work on the Leopard type of jammer. Under it the principles involved were developed and some circuits were devised.

STATUS: Work on the production model of Leopard, MBE, is being carried on under problem S877.1R-S. Reference S877R-S for specifications on the Leopard equipment. This problem is inactive.

TITLE: DEVELOP BARRAGE-TYPE JAMMERS — S135R-S A-5

DESCRIPTION: A series of expendable bomb-type jammers are to be developed for communication frequencies and radar frequencies. The radar Chick consists of a pulsed oscillator built into a Mark 4 flare case. Pulses from the oscillator are prevented from locking in with the radar by a transmission line used in the place of the usual grid condenser of the self-pulsing oscillator. The antenna is of the turnstile type consisting of four elements which are brought into position by springs. Specifications on this unit are as follows:

Frequency range: 92-108 Mc
Power output: 10 w
Weight: 12 lbs
Life: 3 hours

The communications Chick is also built into a standard flare case and has the following specifications:

Frequency: 2 to 9 Mc
Size: 6½" diameter and 4' long
Weight: 20 lbs

[redacted]

Power Output: 2 to 4 w
Time of Operation: 2 hours

STATUS: Models of both the radar and the communication Chicks have been built and reported. The final NRL report number on the radar Chick is R-2313. A report on the construction and drop tests of the communication Chick is given in NRL ltr. S-S67-5/RCM(365) serial 2705 of 21 March 1944. An interim report on the operational test of the radar Chick against the Japanese Guadalcanal radar is given in NRL ltr. S-S67-5/RCM(361) serial 2785 of 31 March 1944. The radar was jammed to saturation up to distances of four miles when the antenna was 15 inches above water. A report on comparative field strength tests of the communication Chick is given in NRL ltr. S-S67-5/RCM(366-2) serial 2605 of 28 February 1944. Curves of qualitative results of NRL, BTL, and Camp Coles Chicks are given. This problem is now inactive.

TITLE: RADAR JAMMING PERFORMANCE - DETERMINATION OF	S411.1R-S A-2

DESCRIPTION: The performance of radar-jamming equipment under various tactical situations is to be computed and tested. The self-screening and mass screening of small and large vessels against fire-control and search radar are to be investigated.

STATUS: Tabulations of minimum jamming results of various jamming equipments for the protection of surface vessels against enemy radar have been compiled. NRL Report R-2381 "Preliminary Tests of Model AN/SPT-6 Jamming Transmitter" of 1 November 1944 states that the operational tests against the Mark 12 (960 Mc) and the Wurzburg (560 Mc) showed that the SPT-6 (crash-production model) is capable of self-screening combat ships to a sufficiently close range to justify its use. The rotating dipole of the Wurzburg constituted an a-j feature which improved performance against even noise (polarized) jamming by as much as 10 to 20 db.

Report R-2502 titled "Comparison of Jamming Effectiveness at 200 Mc of Types AN/APT-1 and AN/APQ-2 Airborne Radar Jammers" was released 25 April 1945. Results are given which show that the AN/APT-1 ("Dina") is superior to the AN/APQ-2 ("Rug") for "spot jamming" at 200 Mc due to the wider spread of its jamming energy and due to the non-critical nature of its adjustment.

[redacted]

ing receiver bandwidth are all important in determining the best setting-on-frequency technique.

A report (R-2498) is in preparation on studies of radar jamming "screening ratio". Tests show that J/S power ratios as high as 100 to 1 result when the noise jamming signal is highly "clipped", if the radar receiver bandwidth is as great or greater than the bandwidth of the jamming signal. Knowledge of this variation in "screening ratio" for various conditions is a prerequisite for making jamming calculations.

Nomograms have been prepared to facilitate the calculation of the minimum jamming range for self-screening of ships from enemy radars. The nomograms are based on theoretical formulas, using parameters which have been found from experimental results. NRL Report R-2495 "Nomograms for Calculating Minimum Jamming Range for Ships" dated 1 May 1945 has been written about this work.

TITLE: INVESTIGATION OF LOW POWER OSCILLATOR AND MODULATORS FOR X AND S_W BANDS	S550.1R-S A-5

DESCRIPTION: It is requested that investigation be made of suitable low-power, high-frequency oscillators and associated modulator circuits with the objective of developing a trainer for X and S_W bands. The incorporation of a-j features in the majority of new radars increases the need for training equipment in these bands.

STATUS: Available tubes for X-band have been investigated. Circuits for the modulator and r-f mounting have been designed.

TITLE: TYPE TEST ON CAPR-10AFJ, CAPR-23AGN, AND TDY-1 ANTENNAS (CAKZ SERIES)	S684.2T-C A-1

DESCRIPTION: Shock and vibration tests and electrical tests, including antenna pattern and standing wave measurements, are required.

STATUS: Tests have been completed on all but the CAKZ-66AJY and CAKZ-66AJR antennas which have not been available for test. A report is in preparation.

[redacted]

TITLE: OPERATIONAL TEST OF THE TDY-1 SYSTEM	S684.3T-C A-2

DESCRIPTION: Operational tests are to be made on the TDY-1 system to determine (a) the effectiveness of jamming; (b) a procedure for setting on frequency, and (c) the extent of interference between the TDY- 1 and associated equipment.

STATUS: Laboratory tests are nearly complete. Laboratory measurements of power output and spectral distribution for this equipment indicate a jamming effectiveness at least equal to that of the TDY over its entire range. Operational tests have been conducted at NRL Chesapeake Bay Annex. Data are now being analyzed.

TITLE: JAMMING TRANSMITTER AND ASSOCIATED ANTENNA FOR S-BAND OPERATION	S740.1R-S AA-15

DESCRIPTION: An S-band jamming transmitter and antenna centering at 3000 Mc is required with as much coverage above and below this frequency as practicable. The highest possible power output should be sought in order to permit the use of omni-directional antennas; however, it is recognized that directional antennas may be necessary. Noise modulation with a transmitted bandwidth of approximately 5 Mc is desired.

STATUS: The MBR jamming system has been developed under this problem. The system includes a setting on receiver display unit and antenna system as well as the transmitter and modulator. The preliminary specifications on the system are as follows:

Frequency range: 2500 - 3750 Mc
Power output: 300 - 500 watts
Modulation: 8 Mc A-M noise
Input: 2 kw 110 volts 60 cycles
Antennas: Circularly polarized dishes fed by waveguide
Weight installed: 1500 lbs

Preproduction models of the basic components are being built by Raytheon Mfg. Co., following designs recommended by NRL.

[redacted]

TITLE: MBE (LEOPARD) JAMMING SYSTEM	S877R-C A-1

DESCRIPTION: The Laboratory is requested to complete the development of the MBE system for manufacture. The MBE is a system of jamming whereby pulses of jamming signal are synchronized with the radar echo pulse so that a small portion of the enemy range scope in the area of the target is obscured. In this manner tubes of relatively low rating are capable of developing sufficient jamming power to obscure sizeable targets. The equipment consists of a transmitter, receiver, and two antennas that are automatically controlled. The receiver provides a continuous look-through system. It has a balanced input which enables the operator to balance the noise picked up from the jammer by the receiver antenna against the modulation noise which is taken directly from the transmitter. This permits the operator to receive enemy signals during the jamming period. The specifications on this equipment are as follows;

Frequency range: 2500 to 3500 Mc
Peak power output: 100 to 150 w
Power input: 1500 w at 110 v 60 cycle ac
Size: 20" x 32" x 56"
Weight: Approximately 1000 lbs
Modulation: Amplitude noise 2 Mc wide (3 db down)

STATUS: The laboratory model of the equipment has been completed and circuits drawn up for the production model. These drawings have been submitted to the Hewlett Packard Co. for production. Production unit scheduled for delivery by June 25. Problem has been superseded by S877.1T-C.

TITLE: TYPE AND SYSTEM TEST - MBE EQUIPMENT	S877.1T-C A-1

DESCRIPTION: A panel inspection of the equipment is to be made and this is to be followed by a type and operating test of system to determine suitability for use aboard Naval vessels.

STATUS: First production model now being completed and installed on shipboard at San Diego for Fleet tests. Three NRL and one BuShips representatives are at San Diego during these tests.

[redacted]

TITLE: TYPE TEST AN/SPT-6 JAMMING TRANSMITTER	S890T-C A-4

DESCRIPTION: The AN/SPT-6 is a jamming transmitter using 3C22 tubes and operating in the frequency range 350 to 1400 Mc with an output of 20 to 40 w. Type test of the subject equipment is to be made in accordance with BuShips specifications.

STATUS: An inspection report on the AN/SPT-6 was given in NRL ltr. C-S67/52(380:MFH) of 19 December 1944. A report covering power output and spectral distribution of the transmitter was submitted 24 February 1945 under File No. C-S67/52(380:MFH) C380-70/45. Results agree reasonably well with those obtained with the previously tested crash model. The performance of the equipment under shock and vibration, as well as under temperature and humidity variations, was reported in NRL ltr. C-S67/52(380:MFH) C380-152/45 of 28 March 1945. Modifications were necessary in the power supply and mounting of the transmitter as a result of mechanical weaknesses discovered during shock and vibration. The performance of the equipment during temperature and humidity variations is satisfactory. On 23 April 1945 report C-S67/52(380:MFH) C380-219/45 containing corrected spectral distribution curves for the transmitter was forwarded to the BuShips. This report supersedes Plates 5 to 20 of NRL ltr. C-S67/52(380:MFH) C380-70/45 of 24 February 1945. The final report on this problem, NRL ltr. C-S67/52(380:RDE) C380-393/45, is being reviewed in the Laboratory and should be forwarded the first part of July.

TITLE: OPERATIONAL TEST AN/SPT-6 JAMMING TRANSMITTER	S890.1T-C A-5

DESCRIPTION: Operational tests are to be run on the SPT-6 to observe the effect on performance of changes made in this model as compared with an earlier one tested under problem S890. The operational procedure developed by NRL for setting the jammer on frequency by use of a panoramic receiver adaptor and wave trap combination is to be described and included in the instruction book for the SPT-6 jamming transmitter.

STATUS: Operational tests made at CBA during the week of 18 December 1944 showed the SPT-6 production model to be at least as effective as the "crash production" model at all frequencies tested. Further work, both at the NRL Chesapeake Bay Annex and at the Naval Research Laboratory, remains to be done, however, especially in the comparison of effectiveness of the SPT-6 with

that of other radar jammers.

NRL ltr. to BuShips C-S67-5/RCM(373) of 6 February 1945 forwards a paper on "Use of AN/SPT-6 for Spot-Frequency Jamming". A detailed explanation of the process of setting the AN/SPT-6 on frequency is set forth in this paper, which was written to furnish basic material for use in the instruction book for the SPT-6 equipment. Two other references on this are NRL Report R-2381 of 1 November 1944, "Preliminary Tests of Model AN/SPT-6 Jamming Transmitter" and Preliminary Instruction Book NavShips 312 for Radar Set AN/SPT-6 of October 1944.

TITLE: EXTENSION OF TYPE TEST AN/SPT-6 — S890.2T-C
A-4

DESCRIPTION: The present modulator strip on the AN/SPT-6 using a 931A "noise" tube is to be replaced with a strip using a 6D4 tube. The 829B tubes are also to be replaced with 807 tubes. A type test is to be made on the modified equipment. A modified feedback ring for increasing the power output at the low end of the band is also to be tested under this problem.

STATUS: Work on S890.2T-C is complete. Data showed improved noise output and spectrum dispersion with the 6D4 noise tube as compared with the phototube source. Power output with the modified feedback ring was not materially changed. Operation, however, was more critical than with the original feedback ring. The final report on this problem, NRL ltr. C-S67/52(380:RDE) C380-393/45 is being reviewed in the Laboratory and should be forwarded early in July.

RADIO CONTROL

See also (a) General - N9R-S, S16R-S, and S1086R-C

TITLE: DEVELOP TEA JAMMER — S482R-S
A-3

DESCRIPTION: A shipboard jamming transmitter suitable for use against GM is required. Two types of transmitters have been produced. The earlier of these is called the TEA equipment. It

[redacted]

consists of two transmitters, low and high frequency power oscillators, and a common power supply. The resonant circuit of the low unit is a variable condenser in conjunction with plug-in coils. The circuit of the high frequency oscillator is a condenser loaded transmission line. Keying circuits in the transmitter allow alternate transmission and monitoring of the enemy signal on panoramic receivers. The specifications on the complete unit are as follows:

Frequency range: Low 15 to 55 Mc in three ranges
High 40 to 130 Mc
Power output: 1 kw nominal
Type of modulation: Square-wave keying tone (10-200 kc) and noise
Size: Overall 6' x 4' x 6'
Weight: 1500 lbs approx.

The later transmitter is called the XCL. It is tuned by means of a condenser loaded transmission line and incorporates the same look-through, tone, and noise modulation features as the TEA. The specifications are as follows:

Frequency range: 20 to 120 Mc continuously
Power output: 2 kw nominal
Size: 2' x 2' x 6', exclusive of power supply

STATUS: Development work on the TEA transmitter has been completed. Final Report R-2330 of 22 September 1944 has been written covering this work. The production of the TEA is being handled by Temco. The XCL has not been placed in production due to the advanced status of the TEA and the anticipated production difficulties. Shock tests have been made on several sleeve antennas which are to be used with the TEA. Problem closed 24 May 1945.

TITLE: TEST PREPRODUCTION MODEL TEA RADIO EQUIPMENT	S482.2T-C A-1

DESCRIPTION: The TEA transmitter contains three essential units a power supply, a low frequency unit covering 15 to 55 Mc, and a high frequency unit covering approximately 40 to 130 Mc. This combination is a further development of the NRL design XCJ and XCK transmitters. The problem requires complete performance tests and recommendations for improvement.

STATUS: The power supply and low frequency unit have been received and subjected to test. After recommended revisions were made, a subsequent model was tested and found satisfactory.

[redacted]

The high-frequency unit is being worked on under an extension to the problem to improve its performance. Work is going on both at Naval Research Laboratory and with Naval Research Laboratory help at Temco. Present indications are that a satisfactory unit will be available very shortly. Tests of this unit such as shock, vibration, rock and roll, temperature change, and humidity change have not been performed.

TITLE: IMPROVEMENT OF ANTENNAS DEVELOPED FOR "TEA" SYSTEM	S482.3R-C A-3

DESCRIPTION: The transmitting sleeve antennas for the TEA are to be modified in the following ways: broader frequency coverage is to be provided; the effect of location is to be studied; installation materials are to be improved; and a better seal for breathe--proofing is to be developed. The use of the DAQ mast (aft) on the DE is also to be investigated as a possible mount for three antennas.

STATUS: A mounting for the DAQ antenna mast has been constructed. These three antennas cover the frequency range (17 to 120 Mc) with better than 2:1 standing wave ratio except within limited regions. This has been accomplished by erecting suitable ground structures on the mast. A balanced fan antenna using a balun unit has been built and tested with promising results. The present half-scale model covers a 2-½ to 1 band with 2 to 1 standing wave ratio and covers approximately a 4 to 1 band with 5 to 1 standing ratio. A matching transformer using wound coils has been developed to replace the balun unit for receiving only within the range 25-140 Mc. Some further improvement is believed likely. Consideration is given to the possibility of using the fan-type antenna to replace the present sleeve antenna. Ceramic manufacturing concerns have been contacted concerning proposals for improving the insulators used on the sleeve antennas. Reference NRL ltr. to BuShips C-F42-1/84/RCM(320:DW), serial C320-336/45, dated approximately 20 June 1945 for information on the mounting of three sleeve antennas on the DAQ mast. This report also covers the design of a matching transformer for broad-band receiving antennas.

TITLE: MODEL TEA - SYSTEM TEST OF	S482.4T-C A-1

DESCRIPTION: A test of the complete TEA GMCM system is requested to determine its suitability for operational use. Experience with XCJ and CXGE indicates that numerous problems arise when separate parts are combined into a new system.

[redacted]

STATUS: The TEA system has been built into a mockup with all associated receivers, indicators, antennas, and switching gear. Tests have been made on the interactions of various components. The accuracy of jamming is adequate. Further tests will be made to check the radiated jamming power. Minor changes in the power supply and output coupling are already indicated.

TITLE: CXGE GMCM TRANSMITTER, MODIFICATION OF	S574.1R-C A-4

DESCRIPTION: Modifications were required to improve the serviceability of the CXGE transmitter. One unit was to be modified and plans prepared for the modification of the other units. An improved output indicator was installed, the rectifier tubes shock mounted, and the power transformer more securely mounted.

STATUS: This problem is inactive since it parallels work now being done on the TEA.

TITLE: MODIFIED MODEL MAS, TEST OF	S705.1T-C A-3

DESCRIPTION: It is required to test the modified Model MAS equipment to determine its suitability for shipboard operation before modification of the remainder of approximately forty (40) units to cover a 20-70 Mc range. These equipments are designed to permit jamming guided missiles having control signals in the 20-70 Mc range. A receiver, transmitter, and a dummy antenna for the latter are provided. The transmitter is designed to provide 250 watts average r-f power output, square wave keyed at audio frequencies of 1,000, 1,500, 8,000, and 12,000 cps. An external audio frequency signal generator is also provided as part of the equipment.

STATUS: Preliminary tests indicate that the equipment is not operating properly and that modifications are necessary. Reference NRL ltr. to BuShips C-S67/5/RCM(380:TWH) serial C380-303/45, dated 1 June 1945 for an interim report on this problem.

TITLE: GM JAMMING EQUIPMENT, 135 TO 400 MC RANGE INVESTIGATIONS TOWARD	S773R-S A-5

DESCRIPTION: A study is to be made to determine the best means for

providing a transmitter-receiver jamming combination for 135 to 200 Mc and for 200 to 400 Mc. The investigation is to survey all existing jammers whether actually in production or in the development stage.

STATUS: A report on the experimental investigation of the TDY for use against GMCM was made in NRL ltr. C-F42-1/84/RCM(320:WF) serial 3977 of 14 October 1944. It was found that the TDY would be satisfactory for the spot jamming of guided missiles within the frequency range 350 to 800 Mc if modified for square wave modulation and look-through operation. A tone modulator for the TDY has been designed and is now being constructed. Preliminary work is going on to check the feasibility of a development using the L600N tube.

TITLE:	GM JAMMING EQUIPMENT - MEDIUM POWER AT HIGH FREQUENCIES	S774R-S A-5

DESCRIPTION: The basic design and bread-board model for a GMCM system is to be developed. The system must have more than 200 w output and operate up to 140 Mc.

STATUS: Tests on the L600N tubes have shown that they will give the desired 200 w output, but receiver noise is excessive for the MAS type of operation. Oscillators using the 127A tubes will only give sufficient power up to 100 Mc. An equipment has been built using the MAS zero-beat principle which covers the range 70 to 100 Mc with 200 w output. Problem was closed 24 May 1945.

TITLE:	AN/ARQ-11, GMCM TRANSMITTER - RECEIVER - SHIPBOARD TEST OF	S1018T-C A-3

DESCRIPTION: Complete tests are to be made of the AN/ARQ-11 transmitter to determine its suitability as a shipborne GMCM jammer for 20-70 Mc. The AN/ARQ-11 has a power output of about 1 kw. The optimum antenna location and the extent of interference with other gear are to be determined. Power output under modulated and unmodulated conditions is to be measured. The required antenna isolation is to be measured, and receiver sensitivity and accuracy of frequency setting are to be determined. The problem has now been amended to include laboratory type tests.

STATUS: Work on this problem is just beginning.

COMMUNICATION

See also (a) General - S819R-C, S942T-C, and S1086R-C
(b) Jammers - Radar - S135R-S

TITLE: AN/ARA-13 FLIGHT TEST	A145T-C B

DESCRIPTION: A flight test is to be made using the AN/ARA-13 500 watt class B r-f amplifier to determine jamming effectiveness under operational conditions. Maximum jamming ranges are to be measured for various aspects of the plane working against a land-to-land communication link. General operating characteristics are also to be evaluated.

STATUS: A special installation has been prepared on a Navy R4D aircraft. Two NEA-7 generators powered by auxiliary gasoline engines and a motor-driven trailing-wire antenna have been provided. However, three FT&R engineers have not been able to make the ARA-13 perform well enough to warrant a flight test to date. This problem was closed on 19 June 1945.

TITLE: AUTOMATIC RF SWEEP FOR NAVY JAMMER TRANSMITTERS	S669R-C A-3

DESCRIPTION: A device is required which will automatically sweep the carrier frequency of standard Navy transmitters at a random rate over a band controllable from 100 to 500 cycles, either side of the frequency to be jammed. The intervals between the excursions of the frequency must sound like random keying on the victim signal. This device is intended for Navy transmitters in the frequency range of 2 to 18 Mc.

STATUS: A Laboratory experimental model which demonstrates the required operation has been constructed. An NRL report on this work, R-2368, was forwarded to BuShips on 27 October 1944. Two factory prototype models have been constructed by the Hammarlund Manufacturing Company, one of which was delivered to the Naval Research Laboratory for type tests. The equipment is known as the CHC 50192. Problem was closed 24 May 1945.

TITLE: TYPE TEST CHC 50192 - AUTOMATIC RF SWEEP UNIT	S669.2T-C A-2

DESCRIPTION: The following details are to be covered: (a) A complete type test with the exception of salt water spray. (b) All electrical and operational tests are to be completed and a preliminary report written before shock and vibration studies are conducted.

STATUS: Electrical and operational tests have been completed, and a report is in progress.

TITLE: TYPE TEST AND FLIGHT TEST OF AN/ARQ-10	S676T-C A-1

DESCRIPTION: AN/ARQ-10 equipment is to be tested to determine compliance with Naval specifications. A flight with measurements on at least three frequencies is also to be made to determine the maximum possible distance for complete jamming.

The AN/ARQ-10 is an airborne look-through type spot jammer developed by Federal Telephone & Radio Laboratories. It operates over the frequency range of 0.165 to 80 Mc with a power output of 50 w. Three units designated type L, M, and N are required to cover this range.

STATUS: The M and N units have been tested and returned to FT&R for further development work. Unit M has since been returned to the Naval Research Laboratory. Laboratory checks and a flight test showed this unit still to be deficient in frequency stability and power output. Therefore, unit M has again been returned to the company for further improvement. Return to the Naval Research Laboratory of the type M, N, & L units is awaited.

TITLE: AN/ART-2 ENGINEERING TEST	S854T-C. A-1

DESCRIPTION: A complete engineering test is requested on the AN/ART-2 jamming transmitter to determine its compliance with production specifications. The AN/ART-2 is designed for installation on fighter aircraft to jam Japanese walkie-talkies. Two frequency bands, 21-36 and 36-50 Mc are provided with a power output rating of 35-50 watts.

STATUS: Type testing has been completed. A noise spectrum of

approximately 385 kc bandwidth at the 3 db points was found. Output dropped to 20 watts at the high frequency and of the unit tested. Frequency stability is relatively poor with drift under extreme service conditions likely to approach the value of band - width quoted above.

TITLE: MONITOR AND TRACKING SYSTEM "STOPWATCH"	S987R-S A-3

DESCRIPTION: This problem requests type testing "STOPWATCH" and solving the problem of matching and coupling to TBK, TBL, and TCK transmitters. The "STOPWATCH" equipment is designed to automatic- ally track a signal which is to be jammed once the operator has tuned the receiver frequency control to within approximately 2 kc of the enemy frequency. The accuracy of tracking is stated as 10 to 20 cycles. The equipment originally was to have a power output of 10 watts which was to serve as the excitation power for Navy shipboard transmitters operating in the range from 2 to 18 Mc. A self-track - ing jamming signal of output power equal to that of the transmitter used would thereby be provided.

STATUS: A coupling unit has been devised by means of which the equipment may be coupled to the required transmitters through 250 feet of RG-10/U or 500 feet of RG-18/U cable without the use of a terminating amplifier, providing that the output of "STOPWATCH" is increased (from the original requirement of 10 w) to 17 w. The type test portion of the problem awaits the arrival of the equip- ment.

TITLE: DIRECTIVE ANTENNA FOR SHIPBOARD COMMUNICATIONS	S1058R-C A-3

DESCRIPTION: It is required to explore the possibilities of developing a directive antenna in the band 6 to 18 Mc for use on battleships of the Iowa class, heavy cruisers and large type sub- marines, and on carriers of the Essex class; and also to make preliminary tests and obtain radiation patterns.

STATUS: Equipment has been constructed which will permit coupling the output of a Model TBK transmitter to a two element collinear antenna. Dimensions and factors regarding installation of the antenna on a carrier of the Essex class were forwarded to BuShips on 15 May 1945 in NRL ltr. C-S67/66(380:LGR) serial C380-269/45. Field strength pattern measurements have been made with this antenna.

mounted upon an aircraft carrier of the Essex class. These measurements indicated that the radiation from the antenna was practically only horizontally polarized, and the pattern was suitable for the intended application.

TITLE: 500 WATT R-F AMPLIFIER - FLIGHT TEST OF	S1113T-C A-1

DESCRIPTION: The jamming effectiveness, operational feasibility, and general operating characteristics of the RP-200, 500 watt, r-f amplifier for the AN/ARQ-10 communication jammer is to be determined.

STATUS: The problem is approximately 80% completed. Additional flights are in preparation.

A N T I - J A M

RADAR

See also (a) Test and Training - Radar - S473R-S
(b) Intercept - Radar - S749.3R-C

TITLE: (APQ) TEST POSSIBILITY OF READING THROUGH WINDOW WITH MODULATION INDICATORS	A92T-S A-5

DESCRIPTION: A range unit for tracking airplanes through Window was requested under this problem. A unit was developed for use with the Radar Mark 4 which was capable of detecting an airplane echo through Window giving competing echoes twice as high as the plane echo. However, this equipment proved to be of limited potentiality because multiple adjustments are required when tracking targets. Reed type "Sambo" frequency indicators covering the range 16-84 cps were used to detect propeller modulation.

STATUS: It was found that "Sambo" indicators were relatively unsatisfactory because of too long time constants. Doppler modulation has proven to be a more reliable means of tracking aircraft through window than propeller modulation. Therefore, work on "Sambo" indicators and propeller modulation has ceased. Reference O-106.1R-S. The following reports have been issued: (a) NRL ltr. S-S67-5/25(399:AEH) serial 4228 to BuAer., "Radar - Fire Control - Test of Possibility of Reading through Window with Sambo Indicator. Fire Control Section Interim Report on Problems A-92T-S(APQ) and N24R-S. Tests of Propeller Modulation and Doppler Modulation versus Window", dated 11 November 1944. (b) NRL ltr. S-67-5/25 (399) serial 3426 to BuAer., "Radar - Fire Control - Test of Possibility of Reading through Window with Sambo Indicator. Interim Report of Problem A-92T-S First Test of Propeller Modulation versus Window" dated 13 July 1944.

TITLE: CONDUCT OPERATIONAL TESTS OF SAMBO	N8R-S A-3

DESCRIPTION: This problem deals with the possibility of using the Sambo IFF technique with fire control radars, One or more blades of an airplane propeller are coated with non-reflecting Sambo material. The echo then contains subharmonics of the "tip frequency".

[redacted]

STATUS: The work actually consisted in using representative fire-control radars to investigate the presence of frequencies which might be confused with the Sambo sub-harmonics. In general, it was found that the frequencies of lobing and its harmonics, line frequency, and the cross-products of these frequencies with the tip frequency and its harmonics, generate a confusing multitude of frequencies likely to obscure or give false sub-harmonic indication. Moreover, tests on standard planes and models showed that sub-harmonics can be generated by untreated planes. It was concluded that the confusion due to the large number of frequencies displayed and the uncertainty due to spurious indications with untreated planes are serious disadvantages in applying Sambo to fire-control radars.

The following reports have been issued: (a) NRL ltr. S-S67-5/25(399:JBS) serial 3730 to BuAer. "Radar Fire Control. Fire Control Section Interim Report on Problem N8R-S. Pulse Lengthener with Automatic Gain Control" dated 29 August 1944. (b) NRL ltr. S-S67-5/25(399) serial 3561 to BuAer. "Radar Fire Control - Project Sambo. Fire Control Section Interim Report on Problem N8R-S. Analysis of Propeller Modulation Data from Ohio State University Research Foundation (OSURF)" dated 19 August 1944. (c) NRL ltr. S-S67-5/25(399) serial 3364 to BuAer. "Radar Fire Control - Project Sambo. Fire Control Section Interim Report on Problem N8R-S. Evaluation of Sambo for Possible Service Applications", dated 5 July 1944. (d) NRL ltr. S-S67-5/25(399) serial 3274 to BuAer., "Radar Fire Control - Project Sambo. Fire Control Section Interim Report on Problem N8R-S. Investigation of Propeller Modulation with Radar Mark 19", dated 23 July 1944. (e) NRL ltr. S-S67-5/25 (399) serial 2891 to BuAer., "Radar Fire Control - Project Sambo. Interim report on Problem N8R-S - Spurious Low-Frequency Modulation Components Generated by Radar Mark 4", dated 15 April 1944. (f) NRL ltr. S-S67-5/25(399) serial 2858 to BuAer., "Radar Fire Control - Project Sambo. Interim Report on Problem N8R-S. Performance Tests of Reed Frequency Meters", dated 10 April 1944. (g) NRL ltr. S-S67-5/25(399) serial 2594 to BuAer., "Radar Fire Control - Project Sambo. Interim Report on Problem N8R-S - First Tests on Target Planes", dated 24 February 1944. (h) NRL ltr. S-S67-7(399) serial 2364 to BuAer., "Radar Fire Control - Project Sambo. First Interim Report on Problem N8R-S - Development of Apparatus and Preliminary Tests", dated 18 January 1944.

TITLE: INVESTIGATE JITTERBUG — N21R-S, A-2

DESCRIPTION: An investigation was made of whether or not a random

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variation of repetition rate would be an effective method of rendering radar immune to the effects of jammers designed on the Leopard principle. (See Problem 877R-S). A pulse generator has been developed which can be added to any radar with "aperiodic" components (components whose performance is not deteriorated by transient or steady state variations in repetition rate below a specified maximum) such as the High-Speed Lobing System, an X-Band fire control radar developed under problem O-20R-S. This pulse generator causes the radar to produce pulses at randomly spaced intervals. The specifications on the unit are as follows:

Repetition rate:	Average:	1250 pps
	Instantaneous Max:	2000 pps
	Instantaneous Min:	500 pps
	Jitterbug ratio: =	4.1 =
	(These values are adjustable over a wide range)	
	Size:	7 x 19 x 15 inches
	Weight:	40 lbs

In addition, an extended mathematical treatment of Jitterbug has been made, and the results presented in the form of charts by which the effect on Leopard can be found. The theoretical treatment, certain practical considerations, and laboratory tests indicate that a Jitterbug ratio of approximately 4:1 is the optimum adjustment. Tests were made on the High-Speed Lobing System, O-20R-S. A simulated Leopard jammer was used because no X-Band Leopard was available.

STATUS: The Laboratory model of the Jitterbug pulse generator has been completed and tested to the extent indicated. More complete tests against Leopard, and the determination of Jitterbug's anti-homing properties are in order. It is also desirable to measure the deterioration in performance which occurs when the maximum repetition rate is above the value given by maximum range considerations. It appears from preliminary calculations that simple circuit changes would allow an aperiodic radar to operate very satisfactorily under these conditions.

The following report has been issued: (a) NRL report RA 3A 224A to BuOrd., "A 'Jitterbug' Pulse Generator", dated 7 December 1944.

TITLE:	STUDY CHARACTERISTICS OF LOW FREQUENCY MODULATION OF RADAR ECHOES	N24R-S A-1

DESCRIPTION: A study was to be made of low frequency propeller modulation to determine the feasibility of using this effect to track targets flying through Window. Methods were to be developed for the detection and identification of these modulations.

STATUS: Most of the work done under this problem has been reported under A92T-S, N8R-S, O-105R-S, and O-106.1R-S. Some general studies, the construction of indicators, and improved pulse lengtheners, have been described in the following reports: (a) NRL Report RA 3A 225A to Bu Ord., "Electronic Indicator for Low Audio Frequencies", dated 26 December 1944. (b) NRL ltr. report S-S67-5/25(399) serial 4187 to BuAer., "Radar - Fire Control - Analysis of Propeller Modulation Data (Problem N24R-S)", dated 18 December 1944. (c) NRL ltr. S-S67-7(399) serial 4643 to BuOrd., "Radar - Fire Control. Fire Control Section Interim Report on Problem N24R-S - Modulation Test on Japanese Airplane Tony 1," dated 24 March 1945. (d) NRL Report RA 3A 216A "An R-C Parallel-T Network with Applications", dated 15 December 1944.

TITLE:	DEVELOP IMPROVED METHODS OF APPLICATION OF RADAR TO FIRE CONTROL	O-20R-S A-1

DESCRIPTION: This problem calls for the improvement of fire-control radar in regard to the quality of radar data, size of equipment, ease of servicing, and other important operational objectives.

Work has centered on the development of two fire control radar systems: (1) The TAB simultaneous lobing system, and (2) a high-speed lobing system. The simultaneous lobing system makes an amplitude comparison between the two opposed angle lobes of an angle channel, with one lobe shifted in r-f phase by 180°. The output from the angle mixer is, therefore, zero for the on-target angle, and progressively increases for greater angle errors. With respect to the range channel, the angle signal on either side of the null point alters in phase by 180°; on one side there is an in-phase condition, on the opposite side phase opposition. This fact is used to obtain sense; i.e., left or right bearing, from the angle signals. The high-speed lobing system employs electronic lobing so that a lobing rate of one-quarter the repetition rate, or 500 cps can be achieved. The receiving channel only is lobed;

and pulse-skipping circuits are incorporated which have been proven to be a useful countermeasure against angle jamming. In connection with both systems, "aperiodic" components (components which tolerate either transient or steady-state changes in repetition rate, below a specified maximum without deterioration of performance) have been designed for Jitterbug operation. Jitterbug has proven, with the high-speed lobing system, to be an effective countermeasure to Leopard (see N-21R-S).

STATUS: The high-speed lobing system is virtually complete except for the development of lobe-switching tubes which are unsatisfactory from a life standpoint. It appears likely that this obstacle will be overcome by improved design of the tubes. The components of the simultaneous lobing system are in an advanced state of construction.

The following reports have been prepared: (a) NRL report RA 3A 221A to BuOrd., "An Aperiodic Range Delay Circuit", dated 4 December 1944. (b) NRL report RA 3A 222A to BuOrd., "Accurate Angle Tracking by Radar", dated 28 December 1944. (c) NRL report RA 3A 218A to BuOrd., "Development of Automatic Angle Circuits for X-Band Automatic Radar", dated 1 December 1944. (d) NRL ltr. S-S67-7(399:JJM) serial 3731 to BuOrd., "Radar - Fire Control - Improved Methods of Application of Radar to Fire Control. Fire Control Section Interim Report on Problem O-20R-S. Testing Equipment for Automatic Angle Circuit", dated 4 September 1944. (e) NRL ltr. S-S67-7(399) serial 3570 to BuOrd., "Radar - Fire Control -Improved Methods of Application of Radar to Fire Control - Fire Control Section Interim Report on Problem O-20R-S. Development of Automatic Ranging Circuit for X-Band Automatic Radar", dated 19 August 1944. (f) NRL memo S-S67-7(399:RWB) to Dr. R. M. Page, "Technique for Measuring Attenuation of Lobe Switching Tubes", dated 2 June 1944. (g) NRL ltr. S-S67-7(399:RL) serial 4128 to BuOrd., "Radar - Fire Control. Fire Control Section Interim Report on Problem O-20R-S. Simultaneous Lobe Comparison System Antenna", dated 5 February 1945. (h) NRL ltr. S-S67-7(399:JJM) serial 4556 to BuOrd., "Radar - Fire Control - Improved Methods of Application of Radar to Fire Control. Fire Control Section Interim Report on Problem O-20R-S. Testing Equipment for Raytheon Type QK38 Switching Tubes", dated 6 April 1945.

TITLE: ANTI-WINDOW INVESTIGATIONS ON FIRE CONTROL RADAR	O-106.1R-S AA-11

DESCRIPTION: Problem O-106.1 covers vulnerability investigations of Radars Mark 4 and Mark 12 to L-band dipole Window and Rope which have been conducted at CBA. This study has lead to the formulation

of anti-window operational techniques using the Mark 4-Mark 22 combination and the Mark 12 and Mark 22 systems. The success of these techniques depends largely upon the radar operator's ability to distinguish differences in Window and aircraft echoes, to operate the gain controls in a prescribed manner, and to utilize the Radar Mark 22 in the acquisition and tracking of the target. The Radar Mark 22 Model 1 affords a convenient means for operation against L-band Window as used against the Radars Mark 4 and Mark 12.

An extension of work under this problem calls for the development of a non-coherent Doppler system for tracking targets through Window. Also included under this problem are anti-Window investigations for Radars Mark 8, Mark 13, Mark 22, Mark 28, and others as specified by the Bureau of Ordnance.

STATUS: The development of an Aural Doppler Ranging Aid for the Radars Mark 4 and Mark 12 is essentially complete. Production of the Doppler aid for the Radar Mark 4 is not contemplated because of the obsolete status of this radar. Production of the Laboratory model for the Radar Mark 12 is under consideration. This equipment allows range tracking of airplanes through Window with an effective radar area up to twenty times that of the plane. Attempts to develope specific equipment for angle tracking by Doppler means have not proven successful.

A report covering the anti-window operational techniques for the Radars Mark 4 and Mark 12 utilizing the Radar Mark 22 Model 1 is to be issued soon. Much of this information is to be included in Bureau of Ordnance Operational Pamphlet Ord #1407. Preliminary observations have been made to determine the vulnerability of the Radars Mark 8, Mark 22, and Mark 28 to Window. The following reports have been issued: (a) NRL Report RA 3A 219A to BuOrd., Radar -Fire Control Section Report on Problems O-106R-S, A-92T-S, N-24R-S, dated 1 November 1944 "Tentative Evaluation of Propeller Modulation and Doppler Modulation as Aids to Tracking through Window with the Radars Mark 4 and Mark 12". (b) NRL ltr. S-S67-5/RCM(398A) serial 4589, to BuOrd., "Radar - Fire Control - Fire Control Section Interim Report on Problems O-106.1R-S Anti-Window Investigation of Fire Control Radar. Radars Mark 8, Mark 22, and Mark 28 - Vulnerability to Window." (c) NRL ltr. S-S67-7(399) serial 4876 to BuOrd., " "Radar - Fire Control - Problem O-106.1R-S Anti-Window Investigation of Fire Control Radar. Conference on Doppler Anti-Window Device held at NRL 5 April 1945." (d) NRL ltr. S-S67-7(399:WWM) serial 4824 to BuOrd., "Radar - Fire Control - Problem O-106.1R-S. Report on Conference on Doppler Range Tracking Aid." (e) NRL Report RA 3A 228A dated 21 April 1945, "Accuracy of Range Tracking Aided by Modulation with the Radar Mark 4". (f) NRL ltr. S-S67-5/RCM(398:LWS/HLF) serial 4350 to BuOrd., Code Re4f. "Radar - Fire Control - Report

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on conferences on Anti-Window and Anti-Jamming Circuits and Techniques held at Radiation Laboratory, Radio Research Laboratory, and MIT Radar Schools, 11 through 13 December 1944. Problems S-578R-S and O-106.1R-S", dated 17 February 1945. (g) NRL ltr. S-S67-5/RCM (398A) serial 4843, "Report of Conference on Radar Amplifier (Doppler) Mark 17 Mod 0 held at NRL 3 April 1945," dated 7 May 1945.

TITLE: ANTI-CLUTTER INVESTIGATION ON FIRE CONTROL RADAR	O-129R-S A-4

DESCRIPTION: This problem deals with the study of anti-clutter methods which might be applied to fire-control radar.

STATUS: The proposals listed below have been set up for theoretical study. Only a minimum of experimental work has been done. In case any of these proposals appear useful, further work may be initiated under this problem or under another more specific problem. The titles of the following reports indicate the scope of investigations to date: (a) NRL ltr. S-S67-7(399A:JBS) serial 4983 to BuOrd., "Radar - Fire Control - Moving Target Indication. Fire Control Section Interim Report on Problem O-129R-S. Report of conference on Magnetic Recording", dated 24 May 1945. (b) NRL ltr. S-S67-7 (399A:JBS) serial 4904 to BuOrd., "Radar - Fire Control, Problem O-129R-S. Report of conference on Magnetic Recording", dated 16 May 1945. (c) NRL ltr. S-S67-7(399) serial 4845 to BuOrd., "Radar - Fire Control, Fire Control Section Interim Report on Problem S-129R-S. The 'Porthole' type of Moving Target Indicator", dated 2 May 1945. (d) NRL ltr. S-S67-7(399) serial 4550 to BuOrd., "Radar - Fire Control. Fire Control Interim Report on Problem O-129R-S. Use of Doppler Frequencies to Track Ships in Land Clutter", dated 21 February 1945. (e) NRL ltr. S-S67-5/RCM(399) serial 4917 to BuOrd., "Radar - Fire Control. Fire Control Section Interim Report on Problem O-129R-S. Methods for Increasing Effectiveness of Window as a Countermeasure to Radar Mark 4 and Mark 12 and other Radars", dated 16 May 1945.

TITLE: ANTI-WINDOW SURVEY	S15.2R-S A-2

DESCRIPTION: An investigation and review of all anti-clutter devices for radar use has been completed. The primary concern of this work has been the detection of aircraft targets through various types of clutter. It is recommended that the MTI system developed at Radiation Laboratory be used as a basis for development of a system to be used

with the SC-SK series air search radars.

STATUS: This problem is completed and reported in NRL Report R-2480. As a result of this survey Problem S-1055 was initiated to develop MTI for the SC-SK series radar systems.

TITLE: DEVELOP A-J RECEIVER (RADAR) S45R-S B

DESCRIPTION: Since the last report work has been conducted along three specific lines. These are (1) the extension of anti-jamming work to cover the performance of a radar system with a PPI, (2) the adaptation of a-j circuits to fire-control radar systems, and (3) the development of a standard test procedure for a-j radar receivers.

STATUS: (1) The cause of and means of eliminating the loss in performance of the PPI (over that of "A" scope) when jamming is present have been investigated. It was found that receiver gain must remain substantially constant regardless of jam level, the video amplifier must have sufficient bandwidth, there must be no interaction between circuits, and video limiter action must be sharp and set at the correct levels. NRL Report R-2392 of 1 November 1944, titled "Investigation of AJ Receivers for Search Radar," discusses this investigation in some detail.

(2) The a-j requirements of a fire-control system were studied thoroughly, and circuits were developed to satisfy these requirements. It was found essential that pulse gain remain constant regardless of jam level. The other receiver requirements are similar to the requirements for a search system except that they are more rigorous. Back-biased i-f circuits have been developed to give the required constancy of gain. Filters have been developed for the video system and ringing cancellation has been investigated for application to the filters. A filter by-pass circuit has been developed to correct defects inherent in the use of filters. NRL Reports R-2507 and R-2508 describe this work in detail.

(3) The requirements of a-j receivers for both search and fire-control radars were investigated, and a test procedure to check these receivers was developed. The test procedure aims to determine receiver characteristics on a test bench and under actual field conditions using simulated jamming. NRL report R-2456 describes this test in detail.

TITLE: STUDY OF THE VULNERABILITY OF THE MARK 8 RADAR TO ENEMY COUNTERMEASURES	S542R-S A-2

DESCRIPTION: The vulnerability of the Radar Mark 8 to enemy countermeasure devices is to be studied by a laboratory investigation of the system and by actual field tests. The Mark 8 is to be modified as required to combat such devices.

STATUS: A training jammer has been developed, and some field tests run at CBA. A few preliminary observations have been made of the effect of electronic jamming on the Radar Mark 8 Mod. 1. Photographs have been taken of the Indicator screens and a report is in preparation. NRL ltr. S-S67-5/RCM(C398A:IEB) serial 4961, "Fire Control Section Interim Report on Problem S542R-S Vulnerability Studies of Radar Mark 8 to Enemy Countermeasures" will soon be available.

Further work to determine the extent of loss information and errors in fire-control radars under conditions of electronic jamming and/or Window are contemplated pending installation of a Radar Mark 8 Mod. 2 at the Laboratory.

TITLE: STUDY OF THE VULNERABILITY OF THE RADAR MARK 12 TO ENEMY COUNTERMEASURES	S578R-S A-1

DESCRIPTION: A laboratory investigation of the vulnerability of the Radar Mark 12 is requested with field tests against RCM devices including Window and electronic jamming. Modifications are to be made in the Radar Mark 12 receiver to minimize the possibility of trouble from enemy countermeasure activities. Training methods are also to be developed to assist operators in working through jamming interference.

STATUS: Partial results of the laboratory investigation of the vulnerability of the Radar Mark 12 are covered in NRL report RA 3A 220A dated 1 December 1944. The accuracy of the Radar Mark 12 may be seriously impared by relatively small amounts of jamming power according to NRL interim ltr. S-67-5/RCM(374) serial 2711 of 16 March 1944.

It was found necessary to use a 1-5 Mc high pass video filter following a diode (6AL5) detector. Three video stages with a bandwidth of 5 Mc and a third detector were also required to provide the same protection to cw jamming as afforded the Radar Mark 4 by the type CAOS-50-AEY converter. A report on this work is in progress.

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A conference to consider the feasibility of adapting the CAOS-50-AEY converter to the Radar Mark 12 as an a-j measure is reported in NRL ltr. to BuShips S-67-5/RCM(395:HLF) serial 3690 of 12 August 1944. Design of a modified adaptor unit was actually begun, but later abandoned because of the unwarranted complexity required. It was determined that if the type 'K' split-echo type of presentation is replaced by type 'K' side-by-side presentation (as in the Mark 4 radar) an a-j protection of 8 db, J/S ratio, is obtained for pip matching.

Revisions have been recommended for the indicator units and other associated circuits. Investigations have also been made of circuits using Doppler frequencies to track moving targets through clutter interference. This work is now being continued under problem O-106.1R-S.

The following reports have been issued to date on problem S578R-S: (a) NRL report RA 3A 220A, dated 1 December 1944, "A Study of the System Vulnerability of the Radar Mark 12 to Electronic Jamming." (b) NRL ltr. S-S67-5/RCM(398:HLF) serial 3699, to BuShips, Code 920, "Prob. S-578R-S, Radar Mark 12 Vulnerability Studies - Fire Control Section Proposal for the Adaptation of the CAOS-50-AEY IF to Video Converter to Radar Mark 12 - Forwarding of Conference Report On", dated 12 August 1944. (c) NRL ltr. S-S67-5/RCM(398:JAW) serial 3743, to BuShips, Code 920, "Radar - Fire Control - Radar Mark 12, Fire Control Section Interim Report on Problem S-578R-S, Radar Mark 12 Vulnerability Studies. Adaptation of the Type CAOS-50-AEY IF to Video Converter to the Radar Mark 12", dated 30 August 1944. (d) NRL ltr. S-S67-5/RCM(398:HLF) serial 4165, to BuShips, Code 938, for Code 917, "Conference Report of 8 November 1944, on Prob. S-578R-S, to acquaint BTL with A-J Adapter Design Requirements for the Radar Mark 12 and to Familiarize BTL with Proposed Change in Presentation", dated 7 December 1944. (e) NRL ltr. S-S67-5/RCM(398:HLF) serial 4021, to BuShips, Code 938, "NRL Conference Report Problem S-578R-S - Radar Mark 12 RCM - Vulnerability Studies, Discussion of System Vulnerability and Proposed A-J", dated 18 October 1944.

TITLE: INCORPORATION OF MTI IN NAVY RADAR — S1055R-C, AAA-4

DESCRIPTION: An MTI system for detection of moving targets is being developed for the SC-SK series search radar equipments. This system uses supersonic-delay-line cancellation in which a stationary-target echo is canceled by output from the delay line; it is similar in principle to the MTI system developed at Radiation Laboratory for S-band radars. The advantage of MTI on the 200-Mc radars compared with

S-band radars is that no "velocity holes" will be present in the velocity range of aircraft targets and no compensation for ship movement will be required. Land clutter, sea clutter, and "Window" clutter will be heavily suppressed even with ship velocities up to 40 knots. Normal radar indications as well as MTI indications will be available simultaneously.

STATUS: All units of the MTI system have been constructed and are undergoing laboratory test. It is expected that a preliminary laboratory system will be assembled and ready for initial tests about 1 July 1945.

D E C E P T I O N

RADAR

TITLE: INVESTIGATE VULCAN — N22R-S A-1

DESCRIPTION: Vulcan is a method of radar operation in which searching is accomplished by presenting single pulses or a very small number of randomly spaced pulses on a long persistence screen. Whether this method offers a notable improvement in security without undue sacrifice in the overall performance of the radar system is the question investigated in the tests described below.

STATUS: A series of tests have been made on the application of Vulcan to the SD radar. The results of these tests were reported in NRL ltrs. S-S67-5/RCM(374:JHC), serial 3532, of 31 July 1944; S-S67-5/RCM(370:THC), serial 2749, of 2 February 1944; and S-S78-5/RCM(370:THC), serial 3769, of 28 August 1944, and NRL report R-2419 of 9 January 1945. As a result of this work a "pulse timer", type CUZ-50AGD, has been produced for application to all SD radars in service in the Fleet. This pulse timer supplies two different kinds of keying. The first is intermittent random, which consists of trains of 8 random-repetition- rate pulses with random spacing of the trains. The second is continuous-random in which keying is continuous but with a random repetition rate. The intermittent keying is for use in general search, and the continuous keying for use in tune-up.

With either type of keying the intercept range is reduced between 5 and 10 per cent for an operator trained to receive this type of signal, and between 30 and 70 per cent for an operator skilled in intercept work but unfamiliar with this type of keying. Aural direction finding is extremely difficult when operating with intermittent keying, but continuous keying offers no protection against direction finding once the signals have been located by intercept means.

With Vulcan keying, the SD radar range is actually increased about 10 per cent. This increase, however, would not necessarily be obtained in the application of Vulcan to other radar systems.

Vulcan has also been tried on the SJ as reported in NRL ltr. S-S67-5/RCM(375) of 24 November 1944. Practical limitations

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were found in applying the Vulcan principle to the SJ. No further work in this direction is contemplated.

TITLE: RADAR COUNTERMEASURES - REFLECTOR TESTS	S15R-S A-1

DESCRIPTION: This problem requires development and test of reflecting devices designed to effect jamming of radar transmissions. Development of suitable techniques for ejection from aircraft and surface craft is also desired.

STATUS: Preliminary tests in the summer and fall of 1943 resulted in the origination of BuShips Specifications "NavShips RE13A 836A" of 1 November 1943. The tests conducted prior to the existence of the above specifications are reported in NRL ltr. S-S67-5/RCM(379) serial 2096, of 22 November 1943. The Window materials subject to these specifications are the subject of NRL report R-2289 "Features of Design, Preparation, and Use of Naval Window", of 22 May 1944.

The desirability of adapting the Army/Radio Research Laboratory type of Window for Navy use is discussed in BuShips ltr. S-S67-5 (920-Dn), serial S-920-09022, to CNO (Op-20-S), dated 12 June 1944. Subsequent NRL studies led to two new specifications - NavShips 16F2(RE) of 11 October 1944, and NavAer M622 of 13 November 1944. The tests and materials covered by these specifications are the subject of NRL reports R-2351 "Investigation of Window Types for S-Band Use" dated 15 March 1945, and R-2443 "Window Types for Naval Use in the Frequency Range 90 - 3000 Mc," dated 20 March 1945. The latter of these two reports includes test results on Rope.

Window chutes for the TBF and SNB have been designed and tested. Radio Test at Patuxent River Naval Air Station has designed chutes for PBJ (B25) and PB4Y2 aircraft. A bomb-bay dispenser designed at NRL has been built by "Designers for Industry" and awaits test. For projection from surface vessels, the Bureau of Ships has designed several rocket and 5-inch/38-caliber-shell Window loads. Some of these have been tested at the NRL Chesapeake Bay Annex: NRL ltrs. S-S67-5/RCM(379), serial 4642, dated 8 March 1945; C-S67-5/RCM(379) serial C370-53/45 dated 26 February 1945; S-S67-5/RCM(379) serial 4397 dated 16 January 1945.

Future tests will be made for the purpose of improving the design of existent materials; e.g., Rope is too heavy, uses to much aluminum, and is relatively inefficient against horizontally polarized radars. The present S-band Window is heavy and bulky. Proposed X-band Window is also bulky and difficult to manufacture.

There is no practical X-band Window available for both polarizations. Off-resonance response at 200 Mc is being measured for 1/4-wavelength Window. Harmonic response of S-band Window in X-band is also to be tested

TITLE:	RADAR DECEPTION - ASSIGNMENT OF PROBLEM ON. WORD DESIGNATING PROJECT IS "CHICKEN"	S22R-S A-2

DESCRIPTION: This problem concerns tests on balloon-borne reflectors for use in deception of radars ranging in frequency from 100 to 3000 Mc.

STATUS: A letter discussing the general problem of decoys for use against airborne radars is in preparation. (Reference: Problem S22.2R-S.) The recommendations of NRL ltr. S-S67-5/RCM(378) serial 1490, of 8 July 1943 have been incorporated in the Navy Type 10-AEV balloon-borne decoy. The ZKM miniature barrage balloon has been developed by the BuAer. Lighter-Than-Air Design Section in an effort to support larger (corner) reflectors. This work is discussed under problem S22.2R-S. Plans are in progress to improve or replace the 10-AEV by a more convenient decoy device satisfying the requirements of ComSubPac.

TITLE:	SIMULATION OF LARGE SHIPS BY A TOWED REFLECTOR	S22.2R-S A-2

DESCRIPTION: Development and test of corner reflectors for radar deception from 100 to 3000 Mc has been the object of this problem.

STATUS: Tests on two-foot, four-foot, and seven-foot corner reflectors have been made. The four-foot corner reflector performs satisfactorily from 100 to 2000 Mc. Type 10-AEY is the production designation of the four-foot reflector. Its half-diagonal length is also four feet; the weight is eight to ten pounds.

A suitable balloon to replace the unstable ZKM and ZKM2M is not yet available.

NRL report R-2522 "Simulation of Surface Targets" contains test data and instructions for the use of the corner reflector. NRL ltrs. C-S67-5/RCM(379), C370-396, of 8 November 1944, and S-S67-5/RCM(370:OJM), serial 4923, discuss balloon tests on the ZKM.

The work on S22.2R-S is essentially complete. Any further general studies will be done under S22R-S.

TITLE: GERMAN SUBMARINE-BORNE RECEIVERS	S26R-S B

DESCRIPTION: Possible countermeasures to be used against submarine early warning receivers are to be investigated. Three approaches are recommended: (1) equipment is to be developed for reducing the signal strength of airborne radars as the aircraft homes on the target; (2) expendable ASV simulators are to be developed; (3) it is hoped that keying the radar for a brief period of five pulses at a time might make aural interception more difficult.

STATUS: The success of the anti-submarine campaign has eliminated the urgency for developing the equipment proposed under this problem. A breadboard model decoy device to simulate the repetition rate of the ASE has been built, but has never been developed to the point where flight tests could be made. Some work was done on the development of Vixen for the ASE and ASB radars; however, no model has been completed. This problem has remained inactive for nearly a year and it should be closed.

TITLE: DESIGN, DEVELOPMENT, AND TEST OF "MOONSHINE" IN CONJUNCTION WITH MANUFACTURER'S ENGINEERS	S28R-S A-2

DESCRIPTION: An equipment to simulate a mass raid of aircraft by producing modulation on a returning signal like that of echoes from a large fleet of aircraft is desired.

STATUS: A simplified Moonshine mass-raid deception equipment known as the CXFG has been developed. Modulation is accomplished by a train of gears which drive variable condensers in a series of shock excited circuits. The following specifications apply:

Frequency range: 88 to 118 Mc
Size: 2ATR Racks
Weight: 75 lbs
Power Input: 200 w at 25 v

The CXFG has an attenuator which enables the operator to regulate the apparent signal strength of the simulated echoes. An automatic power control maintains signal strength at the correct level as a

radar is approached.

Several models of the CXFG have been constructed and flown against the Japanese Attu radar at CBA. Motion pictures of the results were taken in July and August of 1944, but those have not been finished in form for instructional use. A final report on this problem is in preparation.

TITLE:	RESEARCH AND DEVELOPMENT OF RADAR BLACK BODY	S82R-S B

DESCRIPTION: This is a cooperative project between Naval Research Laboratory and the Radiation Laboratory. It consists of testing non-reflecting coatings developed by duPont for the Bureau of Aeronautics.

STATUS: Test equipment has been set up in the Measurements Section so that qualification samples and inspection samples of coatings fabricated by duPont can be checked. These coatings are being manufactured for application in night fighter radomes, and Vee absorbers used in tuning aircraft X-band radars aboard ship. Preliminary tests on samples of German Black Body reveal that the permeability obtained in the German samples was on the order of 100% greater than the permeability obtained on the corresponding U. S. samples in S-band.

TITLE:	FLIGHT TESTING OF "MOONSHINE" EQUIPMENTS	S448T-S A-3

DESCRIPTION: Problem S448T-S requests flight tests of the several Moonshine equipments; CXFG (NRL design), CXET (F.T. & R.L. design), and CXFD (NBS design).

STATUS: Final report on CXFG tests has been made under development, S28R-S, NRL ltr. S-S67-5/RCM(320:MLK) serial 3886 of 12 October 1944. A set gain of 31 db is required for the R4D and 34 db for the TBM aircraft. CXET (AN/APQ-15) tests indicate that a gain of the same order of magnitude is required for the PB4Y2. PB4Y2 tests are complete and will be reported when bench tests are finished. Practical use of CXET is not as difficult as theoretical considerations indicate. The test program now in effect includes tests for installations on surface craft, and tests of operation of multiple Moonshine equipments against several radars. (See BuShips ltr. S-S67-5, S-A22.1 (920-Daa), S-920-001089 of 22 February 1945.)

TITLE: RCM PHANTOM	S609R-S A-2

DESCRIPTION: A system for producing radar echoes by means of chemical smokes, ionization, charged particles, or by means other than Window or corner reflectors is desired.

STATUS: Preliminary tests with charged droplets of freon and sesame oil gave indefinite results. Tests with charged "Santocel" also led to indefinite results because of the failure of the dispensing chute to perform its intended function. "Santocel " is composed of finely divided silica, globular in form. The particles are about 1 micron in diarmeter. Santocel will assume a charge of 60 microcoulombs per gram. FS smoke (chlorosulpheric acid, $ClSO_3H$) produced short-lived echoes that persisted longest on lower frequencies. Results of preliminary tests are given in NRL interim ltr. report S-S67-5/RCM (379:OJM), serial 4578.

Further tests are planned using Santocel and smokes. An attempt will also be made to determine how reflection occurs; i.e., whether by ionization, charged particles, or Rayleigh scattering.

TITLE: TESTS OF PETER EQUIPMENT AGAINST WURZBURG	S624.1T-S A-5

DESCRIPTION: Operational tests of Peter aboard ships are to be made against the German Wurzburg radar.

STATUS: Preliminary tests on Peter under other problems showed that it had inherent operational limitations which would prevent its extensive use. Consequently, the tests planned under this problem were deemed inadvisable and were not undertaken. This problem should be closed.

COMMUNICATION

See General - S942T-C.

TEST AND TRAINING

RADAR

TITLE: DEFENSIVE CM TRAINING FILMS	S473R-S A-5

DESCRIPTION: Confidential training films on defensive countermeasures are the subject of this project. Naval Research Laboratory is to serve as technical advisor and aid in providing operational conditions and equipment for the films.

STATUS: Two films have been released, MN2867A "Window" and MN2867C "Radex Fire Control Radar Mark 3 & 4". Both films include pictures of SC, SG, and Mark 4 indicators under varying conditions of jamming. Problem was closed 24 May 1945.

TITLE: DEVELOPMENT OF SIGNAL GENERATOR	S519R-C A-5

DESCRIPTION: A standard signal generator is to be developed for the frequency range 4000 to 10000 Mc. Its performance characteristics are to be similar to those of the LAG, LAE, and LAF.

STATUS: An oscillator has been built around the 1289 CT tubes which gives satisfactory operation over the entire frequency range without holes. The alignment monitoring bolometer, the wave meter, and attenuator are now in progress. An oscillator design has also been completed around the 1429 CT tubes. The construction of this oscillator is now underway. This problem has become inactive.

TITLE: LOW POWER JAMMER FOR PRACTICE AND TRAINING PURPOSES	S550R-S A-2

DESCRIPTION: A low-power jammer for use against Navy S-band radars is required to facilitate vulnerability studies on the Mark 8 and SG radars. This equipment is also needed for practice training purposes. The design should be such that the jamming oscillator may be used under the following conditions:

1. At a distance, ship-to-ship or ship-to-shore for practice

jamming.

2. At close range, as aboard ship or training schools.

STATUS: The training jammer developed under this problem has been completed and is known as the AN/UPT-T3. It has the following specifications:

Frequency range: 2700 - 3350 Mc
Power output: 50 - 150 mw
Power input: 110 v 60 cycle ac
Modulation: Noise 1 Mc wide or 60 cps, 10, 50, 200, or 350 kc sine-wave AM at 50%, 100% or 500% modulation. The 60 cps modulation can be superimposed on all the others except the overmodulation.
Size: 12" x 12" x 18"
Approximate overall weight (Including carrying case cables, and antenna) 130 lbs

First production model has been tested, and appears satisfactory. A report on this project is under way.

TITLE: ABSORPTION TYPE WAVEMETER FOR THE FREQUENCY RANGE 1250-4000 MC - DESIGN AND TYPE TESTING — S583.2R-S A-3

DESCRIPTION: This problem requires the design of an absorption wavemeter to be used in setting jamming transmitters on frequency. Construction of a model and providing drawings, testing, and calibration of frequency versus dial setting, and consultant service to the manufacturer are also requested.

Frequency range: 1200-4000 Mc
Accuracy: Better than 0.01%
Sensitivity: Better than 5 mw
Power Supply: None

It is recommended that the antenna, cable, connectors, and meter used on the AN/UPM-2 wavemeter be employed if possible. Reference problem S-583R-S.

STATUS: Preliminary work on several models of the wavemeter has begun.

TITLE: TEST ON LAG SIGNAL GENERATOR	S585T-C A-1

DESCRIPTION: Manufacturer's models of the LAG signal generator are to be type tested.

STATUS: Report in progress on preliminary tests of XLAG Serials 1, 2, & 3 should be available by 15 August 1945.

A present production model is to be received about 1 August 1945 and will be given a complete type test.

TITLE: DEVELOPMENTAL WORK ON LAG SIGNAL GENERATOR	S585.1R-C A-1

DESCRIPTION: This problem covers development work on the type LAG Signal Generator. Checking of instruction books and manuscripts for correctness and adequacy of technical material is also requested.

The LAG has the following specifications:

Frequency range: 1200 - 4000 Mc
Modulation: 60-2500 pulses per second, pulse length variable from 1 to 30 microseconds. Built in delay circuit allowing delay from 3 to 300 microseconds with respect to synchronizing pulse
Output voltage: 1 microvolt to 100 millivolts
Power input: 115 v 60 cycle ac
Size: 15" x 16½" x 18"
Weight: 125 lbs.

STATUS: A Laboratory model has been built. Production is being handled by General Communication Company, Boston, Mass. It has been established that the r-f monitor maximum level can be made relatively flat with respect to frequency by the insertion of a polyiron slug around the r-f pickup loop.

Six feet of RG-21/U cable have been sent to the General Communication Company to be used in an experimental model. This should correct the output voltage variation with ambient temperature.

An interim report on the calibration of Serial A has been written: R-S67/74(341C-1), R-341-460/45 of 2 May 1945. This problem will be completed when production of the LAG Signal Generator is com-

pleted. The final report will then be written. Approximate completion date of present production contract is September 1945.

Bad leakage and faulty attenuator action has been discovered in the equipment. Production was stopped. A new model was constructed. This model was found to be satisfactory and production will be started when necessary components are procured.

The following NRL letters reference this work:

R-S67/74(341C-1), R-341-460/45 of 2 May 1945.
C-S67/74(341C-JPL), serial 341-372 of 5 February 1945.
C-S67/74(341C:JPL), serial C341-276 of 1 December 1944.

TITLE: TEST OF PRODUCTION MODEL LAG — S585.3T-C A-2

DESCRIPTION: This problem requests (1) a calibration check with respect to frequency and output and (2) determination of whether the new attenuator meets specifications.

STATUS: Production LAG equipment is being tested. The new attenuator has been found satisfactory. Work is continuing. It is estimated that a final report will be available approximately 20 September 1945.

TITLE: DEVELOPMENTAL WORK ON LAE SIGNAL GENERATORS — S635.1R-R A-2

DESCRIPTION: A pulsed signal generator is to be developed and tested for countermeasures receivers in the frequency range of 510 to 1300 Mc. The LAE signal generator has been constructed for this purpose. It has the following specifications:

Frequency range: 510-1300Mc
Modulation: 60-2500 pulses per second, pulse length variable from 1 to 30 microseconds. Built in delay circuit allowing delay from 3 to 300 microseconds with respect to synchronizing pulse
Output voltage: 1 microvolt to 100 millivolts
Power input: 115 v 60 cycle ac
Weight: 55 lbs

STATUS: A laboratory model of this signal generator has been completed.

Production is being handled by Airadio Incorporated.

The Airadio models contained bad third-harmonic output. NRL revised the coupling stub to eliminate this trouble and Airadio Corporation will use the revision in future production.

TITLE: LAE-2 TEMPERATURE COMPENSATION TEST	S635.2T-R A-1

DESCRIPTION: Investigate automatic temperature compensation method to determine adequacy for use in production.

STATUS: Equipment received on 9 April 1945. Final report NRL ltr. R-S67/74(341C-1) serial R-341-746/45 of 28 June 1945.

TITLE: DEVELOPMENT WORK ON LAF SIGNAL GENERATORS	S673.2R-R A-2

DESCRIPTION: This problem covers developmental work to improve the operation, either mechanical or electrical of the LAF signal generator. Production testing and the checking of instruction book manuscripts for correctness and adequacy of technical material are also required.

STATUS: A counter-clockwise tapered 1.0 megohm potentiometer (Allen Bradley, Taper B) has been tested and is recommended for the pulse rate control circuit in the LAF.

The temperature compensation and saturation effect caused by changing the bolometer meter shunt from 1000 to 2000 ohms revealed no harm in the operation of the equipment and very little improvement.

TITLE: TYPE TEST OF LAF-1 SIGNAL GENERATOR	S673.4T-R A-1

DESCRIPTION: Electrical and mechanical tests of LAF-1 are required.

STATUS: Electrical tests, and shock, vibration, and salt-spray tests have been completed. A report is in progress and production has begun.

TITLE: TEST OF X-LAF-1 SIGNAL GENERATOR	S786T A-2

DESCRIPTION: Electrical tests, a mechanical inspection, and the editing of technical material for instruction books are required.

STATUS: An interim report R-S67/74(344C-1) serial 341-291/45 of 11 April has been written on equipment serial 1-7 inclusive. Final report on equipment serials 8, 9, 10, NRL letter R-S67/74(341C-1:LCH) serial R-341-775/45 of 20 June 1945.

TITLE: TESTS OF TS-47/APR TEST OSCILLATOR	S933T-R A-5

DESCRIPTION: The TS-47 oscillator is to have its calibration accuracy checked as well as the frequency drift between minus 10 and plus 50 degrees C. The order of magnitude of harmonics is to be measured, and general usefulness with respect to accuracy and voltage is to be determined.

STATUS: This problem is inactive.

TITLE: TEST PREPRODUCTION MODEL OF TS-189/U TEST OSCILLATOR	S973T-R A-2

DESCRIPTION: Complete electrical and mechanical tests are to be made on the TS-189/U oscillator to determine its suitability for use as field test equipment for the AN/APA-17 direction finder. This oscillator was developed by RRL under project M3010.

STATUS: The TS-189/U equipment manufactured by the Technical Radio Company of San Francisco was tested to determine its acceptability for Naval service. In order to save time these tests were run concurrently with the manufacturer's own type tests at the manufacturer's plant. The equipment was tested for effects of temperature, humidity, vibration, and salt spray without failure or significant injury. Details of these tests may be found in NRL ltr. to the Bureau of Ships, R-S67/22(375:PRC), R370-97/45, dated 5 April 1945. It was recommended that the TS-189/U equipment be accepted for Naval service. This problem should be closed.

TITLE: TYPE TESTS OF TS-202/U HARMONIC GENERATOR	S1057T-C A-2

DESCRIPTION: The performance of a preliminary model TS-202/U harmonic generator manufactured by Lavoic Laboratories is to be checked. The frequency at which the output of the harmonic drops below useable values is to be determined. The possibility of using the equipment at S-band with a spectrum analyzer is to be investigated.

STATUS: Tests have been delayed pending the completion of higher priority problems.

RADIO CONTROL

TITLE: GMCM TRAINING RECORDS	S473.1R-S A-4

DESCRIPTION: This problem involves script writing and cooperation in the production of a set of training records on GMCM. These records are desired to train operators to recognize the characteristic modulation of German guided missiles. The problem has recently been extended to include the making of recordings of other signals which may be encountered in other theatres of operation and also to enable operators to distinguish guided missile signals from other types.

STATUS: A record for recognition of GMCM signals has been produced together with the training record for the MAS equipment. A general GMCM script has been prepared. It includes numerous samples of signals which are to be used as illustrations and tries to point out the features of signals which might identify them as control signals. There has been no activity in making the final records pending receipt of further instructions. Problem was closed 24 May 1945.

ENEMY EQUIPMENT AND SIGNAL ANALYSIS

RADAR

See also (a) General - N6R-C.

TITLE: INVESTIGATE "WANZ-G2" AND "NAXOS" — N23R-S, A-1

DESCRIPTION: Complete operational information on the German "Wanz", panoramic receiving system, and "Naxos" early warning system is desired. Details concerning the methods of operation, electrical characteristics, and antenna systems are requested. It is anticipated that "field" tests will follow the laboratory investigation on these receivers.

STATUS: Work on the"Wanz" receiver has been completed as reported in NRL report R-2390 of 22 November 1944. The frequency range of this receiver is 146-250 Mc.

Tests on the Naxos have been completed and were reported in NRL ltr. S-S67/RCM(390:RVH) serial 4025 dated 15 November 1944 and NRL ltr. S-S67-5/EF 74(390-PAC) serial 4059 dated 9 December 1944. With a Naxos antenna height of 15 feet, the intercept range against shipboard S-band radar was 10 miles and the intercept range against an ASG at 1000 feet was 40 miles.

TITLE: MARK IV - MODEL 3, JAPANESE RADAR - RECEIVER AND INDICATOR — S148.13T-C, A-2

DESCRIPTION: Work on this problem will include complete electrical tests of the receiver, indicator, power supplies, transmitter, and antenna system. Tracking, jamming and other operational system tests will be performed at CBA. Information obtained to date is itemized below:

Receiver:
Tuning range: 185-215 Mc
RF/IF bandwidth: 2 Mc at 3 db down points
Noise factor: 15 db

AJ features: None

Transmitter
Pulse power: 15 kw
Pulse length: 2 microseconds
Repetition rate: 2000 cycles
RF tuning range: 185-210 Mc
Frequency shifting as an AJ measure is considered impractical

STATUS: A summary of the important electrical characteristics of the Mark 4 receiver has been forwarded to the Fleet. The equipment will be sent to NRL Chesapeake Bay Annex for operational tests. Reference NRL report R-2545 entitled "Laboratory Tests of the Japanese Mark 4 Model 3 Radar Transmitter and Power Supply".

TITLE: INVESTIGATE CAPTURED JAPANESE INTERCEPT RECEIVER	S148.14R-C A-3

DESCRIPTION: Analysis of a Japanese intercept receiver is requested. Sensitivity, image rejection, i-f bandwidth, audio characteristics, and the likelihood of spurious responses are particularly to be investigated. Operational tests are also desired in order to determine the capabilities of this receiver in intercepting U. S. radar signals.

STATUS: Laboratory tests on a type E-27 Japanese Radar-Intercept Receiver which tunes from 70 to 400 Mc have been made. This receiver is a conventional superheterodyne with a regenerative first detector. The r-f units are of plug-in construction. Switching between them is accomplished by an r-f switch, but a separate operation is required to plug the antenna input cable into the appropriate tuning head. The oscillator and mixer tuning controls are not ganged. Intercept ranges comparable to those obtained using an APR-1 are possible. However, a proficient operator is required, and rapid searching becomes excessively laborious.

Two directional and one non-directional radar-intercept antennas of Japanese origin were tested with the E-27 receiver. The "directional" antennas displayed poor directional qualities when used with the Japanese receiver. This has been attributed to unbalance in the receiver input circuit because patterns obtained with the same antennas and an APR-1 receiver are fairly good.

Other models of the E-27 type receiver have recently been received. These are all similar to the receiver described above

[redacted]

except for modifications in the design of the r-f tuning units. The most recently manufactured receiver is dated October 1944. It uses five r-f units to cover the range from 70 to 420 Mc. Unlike the model described above, ganged tuning of mixer and oscillator controls is featured with a trimmer control provided for the mixer circuit.

Operational tests of the Japanese radar intercept receiver are projected at NRL Chesapeake Bay Annex. A technical report on the laboratory phase of this work is in progress.

TITLE: MARK IV MODEL I JAPANESE RADAR — S148.15T-C A-1

DESCRIPTION: Complete electrical tests of the Mark 4 Model 1 Japanese radar system are requested under this problem. Operational tests of jamming susceptibility, range, and bearing accuracy will also be performed at the NRL Chesapeake Bay Annex. The following information on electrical characteristics has been secured:

Receiver
Tuning range: 105-215 Mc
RF/IF bandwidth: 2 Mc at 3-db-down points
Noise factor: 12 db
No a-j features

Transmitter
Power output: 18 kw
Pulse length: 3 microseconds
Repetition rate: 2000 cps
Oscillator circuit: 4-tube ring, grid-keyed

STATUS: Preliminary measurement and adjustment of receivers and indicators has been completed. Copies of the Japanese transmitting-oscillator tubes were made by an American manufacturer, Eitel McCullough, Inc. The transmitter has been operated in the laboratory, and its electrical characteristics determined. Measurements of the antenna characteristics have been made at the Chesapeake Bay Annex, and the complete system is now being set up there for operational test. A summary of the information found to date has been forwarded to the Fleet. The data accumulated so far tends to indicate that this set may be the Mark 4 Model 2 rather than the Mark 4 Model 1 as originally supposed.

TITLE: JAPANESE AI RADAR INTERCEPT RECEIVER - INVESTIGATION OF	S148.17R-C A-1

DESCRIPTION: An investigation of the susceptibility of a Japanese AI receiver to jamming is requested.

STATUS: Performance tests on the Japanese AI receiver have been completed. Jamming tests are in progress. This receiver has relatively low i-f. and overall gain. Report is to follow.

TITLE: GERMAN AIRBORNE RADAR INTERCEPT RECEIVER FUG 350 - INVESTIGATION OF	S148.18T-C A-1

DESCRIPTION: The FUG 350 receiver is a new kind of captured German airborne radar intercept receiver. It is deemed highly desirable to evaluate the performance and operating characteristics of this receiver since it is likely that equipments of similar design may appear in the Japanese theatre.

Tests against typical U. S. shipborne and airborne radars are requested in order to determine the useful ranges and ease of homing provided by the receiver. Laboratory measurements are then to follow on lower priority.

STATUS: The equipment has been installed in an airplane, and some range checks have been made against radars at the NRL Chesapeake Bay Annex.

RADIO CONTROL

See also (a) General - N6R-C

TITLE: ANALYSIS OF GM SIGNALS	S596R-S A-5

DESCRIPTION: Studies are to be made of recordings of enemy guided missile radio signals. Modulators are to be developed to reproduce the modulation of these signals.

[redacted]

STATUS: A report on the analysis of recordings received up to 1 September 1944 was given in NRL ltr. S-F42-1/84/RCM(321) serial 3818 of 16 September 1944. All recent records have furnished statistical confirmation of the conclusion that the HS-293 missiles should be jammed with 1500 cycle modulation. The up-down control is obtained by varying the relative duration of alternately recurring 1000 cycle and 1500 cycle tones. The rate of alternation between these tones is 10 cps. NRL ltr. S-F42-1/84/RCM(321) serial 3944 of 3 November 1944 gives an analysis of the records made during a guided missile attack at the time of the invasion of Southern France. These records give the first evidence that 8 to 12 kc control signals are used. The keying rate of these frequencies is identical with that of the 1 and 1.5 kc frequency. NRL ltr. S-F42-1/84/RCM(321) serial 3943 of 14 November 1944 is a report on the 8 and 12 kc directive components of the HS-293 guided missile as recorded in Southern France. Problem was closed 24 May 1945.

COMMUNICATION

See also (a) General - N6R-C

TITLE: COMMUNICATIONS COUNTERMEASURES CIRCUITS — S148.12R-C A-2

DESCRIPTION: This problem requests the installation of captured enemy transmitters and receivers at the NRL Chesapeake Bay Annex for use in testing U. S. countermeasure circuits and study of operating characteristics under normal "field" conditions. The following equipment should be set up as soon as available:

CEE 5150	Type 95 Short-wave Transmitter, 1 kw, 3.7-8Mc
CEE 5149	Type 92 Long-wave Transmitter, Revision 1, 1 kw, 100-1000 kc
CEE 5152	Type TE-MU Short-wave Transmitter, Revision 3, 200 w, 1.5-18Mc
CEE 5157	Type 92 Radio Receiver, Revision 4, 20 kc - 20 Mc
CEE 5115	Type 94 Mark 3A Receiver Model 53C, 400 kc - 5.75 Mc
CEE 5040	Type 92 Short-wave Monitor, Revision 2, 1.3 - 3.1 Mc
CEE 5457	Type 3 Mark 1 Aircraft Transmitter and Receiver, 75 w, 5 - 10 Mc

STATUS: The communications equipment listed above has been installed at the NRL Chesapeake Bay Annex. Antenna towers have been erected, but the antennas and ground systems are not yet complete. This problem is currently inactive.

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