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4 November 1958

SPECIFICATIONS

for

OMNIDIRECTIONAL MICROWAVE TRANSISTORIZED CRYSTAL-VIDEO RADIO RECEIVING SYSTEM

Stub Requisition #54-0718-9

Contract Nonr 2788(00) X

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PURPOSE

1-1. These specifications cover the mechanical design and performance requirements for an omnidirectional "wide open" unattended radio receiving system suitable for mounting in a 20" metallic sphere and capable of receiving both horizontally and vertically polarized pulsed radar signals in the frequency range 2.6 - 3.25 kilomegacycles and rejecting all signals substantially beyond this range. The important features of the equipment are its small size, light weight, low power consumption, extreme sensitivity and its ability to withstand high degrees of vibration and shock.

GENERAL DESCRIPTION

2-1. These are strictly performance specifications and do not describe or predicate any specific design of equipment. Any design that will permit the specified performance to be obtained and meets all other requirements of these specifications will be considered.

2-2. However, in order to assist potential designers, the following description of the basic design of one form of equipment envisioned as meeting the spirit of these specifications is offered. Fundamentally, the equipment desired is an improved and specialized form of a "wide-open" crystal-video receiver in which a relatively wide-band antenna feeds a crystal detector, the output pulses of which are amplified by a high-gain, wide-band amplifier and applied to either headphones or other types of indicating or recording devices.

2-3. The main differences between the equipment that will probably be necessary to meet these specifications and a conventional crystal-video system described in par. 2-2 are the following:

(a) The antenna pattern must be substantially omnidirectional. To accomplish this it is contemplated that it will be necessary to employ a combination of six (6) antennas mounted in the surface of the sphere.

(b) The antennas must be effective for both horizontally and vertically polarized waves. This is anticipated as requiring special antenna design.

(c) Certain specified frequency coverage for the system, with relatively sharp cut-off at and beyond the end frequencies is required. This is contemplated to necessitate the inclusion of high- and low-pass filters between the antennas and the crystals.

(d) The combining must probably be done at the output of the crystals or beyond. It is believed difficult to mix the antenna outputs because of phasing difficulties although the paralleling of antennas on opposite sides of the sphere to reduce the number of filters and crystals required may be possible.

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EQUIPMENT TO BE SUPPLIED

3-1. The equipment to be supplied shall be considered in two categories, namely PROTOTYPE EQUIPMENT and PRODUCTION EQUIPMENT. The material required under each category for one equipment is enumerated below:

(a) PROTOTYPE EQUIPMENT

(1) Six (6) Antennas complete with all mounting hardware, securing screws, etc.

(2) Necessary number of Filter-Crystal units complete with all mounting appurtenances and crystals.

(3) One (1) encapsulated Amplifier Unit.

(4) One (1) "mock-up" sphere.

(5) All necessary interconnecting cables complete with required end fittings.

(b) PRODUCTION EQUIPMENT

(1) Six (6) Antennas complete with all mounting hardware, securing screws, etc.

(2) Necessary number of Filter-Crystal units complete with all mounting appurtenances and crystals.

(3) One (1) unencapsulated Amplifier Unit.

3-2. The purpose of the PROTOTYPE EQUIPMENT is to permit determination by the Navy that the design is fundamentally sound and that the PRODUCTION EQUIPMENTS may be expected to meet all the requirements of these specifications. Accordingly the Prototype System, as mounted in the mock-up sphere, must meet all the electronic performance requirements and all units, with the exception of the sphere, must be capable of being subjected to the vibration and temperature tests covered by the ENVIRONMENTAL CONDITIONS section of these specifications without evidence of

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mechanical damage or measurable degradation in performance. It need not, however, incorporate all mechanical refinements and other details and niceties expected in the Production Equipments.

3-3. The sphere is required only to permit the determination of the omni-directional and sensitivity characteristics of the System and accordingly, aside from possessing a relatively smooth and spherically true exterior, with an outside diameter of 20 inches and being sufficiently strong to support the antennas and to be handled without distortion, need meet no other specifications.

3-4. The interconnecting cables required with the PROTOTYPE EQUIPMENT are for test purposes only. All rf and video cables shall be 18 inches in length and provided with necessary end fittings. The power cable may be of any length in excess of 18 inches and need not be terminated.

3-5. No cables or cable fittings will be required with the PRODUCTION EQUIPMENTS except the cables permanently secured to the Amplifier.

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PARAMOUNT REQUIREMENTS

4-1. While it is highly desirable that in the design and fabrication of these equipments every effort be made to produce equipments possessing performance and electrical and mechanical features superior to the limits specified, in case of required compromises, the following paramount features are listed in their order of importance.

(a) Resistance to Environmental Conditions, (detailed in Section 9).

(b) Maximum usable Sensitivity (see par. 8-1(a)).

(c) Omnidirectionality (see par. 8-1(h)).

(d) Small size (detailed in Section 5).

(e) Low Weight (not in excess of 60 ounces total, excluding detachable cables).

(f) Low power consumption (not in excess of 60 milliwatts total).

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MECHANICAL DESIGN DETAILS

5-1. The Antenna System.

(a) The antenna system shall consist of six (6) antennas suitable for mounting on and in the surface of a metallic sphere having a skin thickness of 0.020 inches. It will be permissible to require the cutting of suitable holes in the sphere to permit their mounting.

(b) Each antenna shall be of such design as to permit the reception of either horizontally or vertically polarized waves with equal effectiveness.

(c) Each antenna shall be of such design, as to beam width, that the outputs of the six as mounted in the sphere and as combined in the system, will result in substantially omnidirection response characteristics within the limits specified in Section 8-1(h).

(d) Each antenna shall be capable of withstanding cyclic exposure to sphere temperatures in accordance with the "Flash Temperature" requirement of Section 9.

(e) Each antenna shall be entirely self-supporting on the skin of the sphere, shall not require any stiffening of the skin or other additions and shall be supplied with all necessary hardware.

(f) No particular design of antenna is required or predicated by these specifications, provided all mechanical and electrical performance requirements for the entire system are met and further provided that:

(1) The total surface area of the sphere (either inside or outside) occupied by the six antennas does not exceed 3% of the total surface area. For purposes of computation, the surface area of one antenna, either inside or outside the sphere, shall be considered as the area covered by a cylinder that will just pass over all parts of the antenna either inside or outside the sphere or should the antenna be flush with the outside, will just cover the mounting fitting in its entirety.

(2) No part of any antenna extends more than 3 inches beyond the inside or outside of the shell of the sphere. This shall include all parts of the antennas except the actual coaxial cables.

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5-2. The Filter-Crystal System: This shall consist of the proper number of individual Filter-Crystal units, as predicated by the design, to connect between the respective antennas and the Amplifier. Not more than twelve units for each system will be acceptable and fewer would be desirable. Each unit shall consist of a bandpass filter with a crystal mount fabricated as an integral part thereof or attached thereto. The filter input and crystal output shall be by means of coaxial receptacles of the miniature screw type similar to the "Microdot" "S" Series female connectors. In view of the importance of obtaining the maximum Sensitivity in the system, the type of crystal mount and crystal is left to the discretion of the designer excepting that the crystals shall be readily removable for replacement. Physically each unit shall not exceed eight (8) inches in length over-all (excluding coaxial cables) nor one (1) inch in diameter over all protuberances, as indicated by its being possible to pass them through a 1" ID tube. The group of units will be mounted around a 5 1/2" cylinder when installed within the sphere. Mounting lugs, clamps or other securing devices shall be included as a part of each filter-crystal unit and the securing means shall be such as to assure that the units will withstand the maximum vibration specified under ENVIRONMENTAL CONDITIONS (Section 9) without damage or change in characteristics. Such mounts or clamps shall be excludable from the 1" diameter dimension but must not extend the height from the mounting cylinder to more than 1 1/4" or prevent them from being mounted around the 5 1/2" cylinder.

Inasmuch as the characteristics of the antennas may affect the acceptance and rejection band characteristics of the over-all system as covered in Section 8, no electrical characteristics for the filters and crystal mounts alone will be specified.

5-3. The Amplifier Unit: The Amplifier shall be suitable for amplifying the pulse output from the crystals to the specified output level, when powered by a single positive source of dc potential with grounded negative. Should the design require the employment of a number of preamplifiers, such items shall be considered as part of the Amplifier unit and be included as an integral part thereof.

(a) All amplifier components shall be mounted on a circular phenolic card meeting the detailed requirements of NRL drawing 5430B-153/58 included as part of these specifications.

(b) The amplifier shall be completely transistorized and printed circuit techniques shall be employed for the wiring.

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(c) All inputs, output and power shall be carried into the unit through miniature coaxial cables. These cables shall enter the unit through tight-fitting rubber grommets mounted in the copper plate shown on NRL drawing 5430B-153/58 provided for this purpose. Inasmuch as the number of such leads cannot be known until the design is crystallized, the location of the leads is not detailed. All leads shall be firmly clamped to the mounting card close to the exit point to preclude movement and subsequent damage under severe vibration. All leads supplied with the PROTOTYPE unit shall be 18" in length (excepting the power lead which may be longer). The exact lead lengths for the PRODUCTION units will be furnished upon approval of the PROTOTYPE but will not exceed 18".

(d) The PROTOTYPE unit shall be furnished completely encapsulated with a suitable light-weight compound similar to "Eccofoam" mixed to produce a final density of approximately 12 lbs./cu. ft. The top and bottom of the encapsulation shall be smooth up to the level of the "Kel-F" risers. This encapsulation requirement is to protect the components from damage resulting from severe vibration, to permit the unit to be clamped between plates for vibration testing and to establish the electrical performance of the unit in an encapsulated condition. The PRODUCTION units shall be furnished unencapsulated, to be encapsulated by the Navy. This is necessary because in mounting the unit with other items the outside diameter of the encapsulation must be held to a very close tolerance for which the Navy has the molds.

(e) To assist in the design and fabrication of the Amplifier units the following description of the method in which these units will be mounted and employed is given. There will be items of equipment other than the system covered by these specifications to be mounted with it. These will be encapsulated with exactly the same outside dimensions. All the items will be stacked one on top of the other with clamping rods passing through the two 0.261" holes and secured to a base. Between each unit is sandwiched a thin beryllium copper disc with spring fingers around its periphery. After all units are stacked and wired a tight-fitting cylindrical case is pressed down over the stack which completes the shielding and firmly supports all units against the effects of vibration. The slots on the edge of the units form a wiring trough.

ELECTRICAL DESIGN CHARACTERISTICS

6-1. Power Source: The entire equipment shall operate on a single source of positive dc potential with grounded negative, of 12.0 volts.

6-2. Power Consumption: The total power consumption with the equipment operating on specified voltage and with a signal being received producing a peak OUTPUT pulse of 1 volt, shall not exceed 60 milliwatts.

6-3. Output Circuit: The output circuit of the Amplifier shall contain no dc component and shall be suitable for operating into a 270-ohm resistive load.

6-4. Pulse Polarity: The polarity of both the crystal and amplifier output pulses shall be negative.

6-5. Amplifier Gain Adjustment: Means shall be provided for reducing the gain of the Amplifier by any amount up to approximately 20 db in a permanent manner, such as by soldering a suitable resistor across terminals provided for the purpose. The electrical method shall be one that will effectively protect against final stage overload, will not reduce the maximum obtainable output and will not reduce the SENSITIVITY of the system (for constant INPUT).

6-6. Pulse Repetition Frequency: The equipment shall be capable of operating in accordance with these specifications with any signal PRF between the limits of 30 and 2500 pps.

6-7. The equipment shall be capable of operating in accordance with these specifications with any signal pulse length between the limits of 0.5 and 12 microseconds.

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DEFINITIONS

7-1. In order to preclude misunderstandings and lengthy and repetitive definitions, the following definitions shall be applicable to the Performance Specifications of Section 8.

(a) THE SYSTEM: All components mounted on or in the sphere from and including the antennas to the output of the AMPLIFIER.

(b) THE AMPLIFIER: This includes all gain devices fed by the crystals and ending in a common output, whether a single unit, a multiplicity of units or a combination of both.

(c) TANGENT SIGNAL OUTPUT: The output pulse, as viewed on a cathode ray oscilloscope, that will raise the NOISE LEVEL by its own height, i.e., the condition when, with a rising pulse, the bottom of the noise image centered on the top of the pulse is just tangent to the top of the noise level image on either side of the pulse.

(d) SENSITIVITY: The field density of a signal existing at the surface of the sphere nearest the signal source, expressed in terms of watts/cm^2, that will produce TANGENT SIGNAL OUTPUT from the AMPLIFIER.

(e) NOISE LEVEL: The output of the AMPLIFIER, in the absence of any signals and shall include all noise contributed by any part of the SYSTEM.

(f) PEAK VALUES: The voltages indicated by a cathode ray oscilloscope image as measured from the position of the horizontal trace to the extreme observable point(s) of the vertically deflected image, (either positive or negative). Not to be confused with peak-to-peak values.

(g) TEST CONDITIONS: Wherever not otherwise specified these conditions are predicated:

(1) BATTERY VOLTAGE - Nominal design voltage.

(2) AMPLIFIER TERMINATION - 270 ohms (resistive).

(3) AMBIENT TEMPERATURE - 22° C.

(4) SPHERE LOCATION - In free space.

(5) SPHERE POSITION - The position, with respect to the signal source, in which the lowest SENSITIVITY (greatest number of watts/cm^2) is indicated.

(6) POLARIZATION - The polarization of the signal that results in the lowest SENSITIVITY.

(7) FREQUENCY - The frequency between 2.6 and 3.25 kMc at which the lowest SENSITIVITY is obtained.

(8) PULSE LENGTH - The pulse length between 0.5 and 12 microseconds at which the lowest SENSITIVITY is obtained.

(9) PULSE REPETITION FREQUENCY - The PRF between 30 and 2500 pps at which the lowest SENSITIVITY is obtained.

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PERFORMANCE

8-1. The complete equipment, under TEST CONDITIONS (Par. 7-1(g)) shall meet all the following performance requirements, without hiatus, after subjection to the ENVIRONMENTAL CONDITIONS covered by Section 9.

(a) Sensitivity: The INPUT necessary to produce TANGENT SIGNAL OUTPUT shall not be greater than 2.5×10^{-10} watts/cm^2.

(b) Gain: With the Amplifier adjusted for full gain, the observable peak noise OUTPUT shall not be less than 0.1 volts.

(c) Dynamic Range: With the Amplifier gain adjusted for a peak NOISE OUTPUT (with no signal) of 0.05 volts and thereafter a signal applied just sufficient to produce TANGENT SIGNAL OUTPUT, a peak pulse output of 1 volt shall be obtained with an increase in INPUT not in excess of 20 db.

(d) Overload Recovery: With the Amplifier gain adjusted for a peak NOISE OUTPUT (with no signal) of 0.05 volts and thereafter a signal 30 db above that just sufficient to produce TANGENT SIGNAL OUTPUT applied, the Amplifier shall have completely recovered in less than 100 microseconds after removal of the signal.

(e) Fidelity: The Amplifier band width and other pertinent design features shall be such that, with a square wave input pulse, the rise time shall not exceed 0.4 microseconds, nor shall the sag be more than 10% in 12 microseconds.

(f) Acceptance Band: The INPUT necessary to produce TANGENT SIGNAL OUTPUT shall not vary more than a total of 2 db over the frequency range of 2.60 - 3.25 kilomegacycles.

(g) Rejection Bands: All frequencies below 10% and above 10% of the actual low and high limits of the Acceptance Band respectively shall be attenuated at least 50 db. 12 kMc may be considered as infinity. The actual Acceptance Band limits are those frequencies where the SENSITIVITY has dropped 2 db below the maximum attainable.

(h) Omnidirectionality: The maximum variation in SENSITIVITY of the system for any position of the sphere with respect to the signal source shall not exceed 6 db.

(i) Polarization Effects: For any position of the sphere, the difference in SENSITIVITY of the system for vertically and horizontally polarized waves shall not exceed 3 db.

(j) Temperature Effects: A variation in temperature between the limits of 0° C and 60° C shall not result in a variation in OUTPUT NOISE level in excess of 1 db total.

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ENVIRONMENTAL CONDITIONS

9-1. All individual units comprising the complete PROTOTYPE equipment (with the exception of the "mock-up" sphere) shall be capable of withstanding the environmental conditions specified herein. These conditions fall in two categories, namely VIBRATION and TEMPERATURE.

9-2. None of the units will be expected or required to operate while under vibration conditions but shall be capable of withstanding the vibration tests without evidence of mechanical damage or impairment of their electrical characteristics as measured prior thereto.

9-3. All of the units must be capable of operating in accordance with the PERFORMANCE requirements of these specifications (Section 8) while undergoing the temperature tests with the exception of the high temperature "flash" tests on the antennas which must be withstood only without mechanical damage or permanent impairment of their electrical characteristics.

VIBRATION TESTS

9-4. Preparation of units: The various units shall be prepared for securing to the vibration table in the following manners:

(a) The Antennas. Each antenna shall be secured to the center of a heavy plate by the normal securing means provided for the purpose, this plate to be secured to the vibration table. The plate shall be sufficiently heavy as not to distort while being vibrated.

(b) The Filter-Crystal Units. Each Filter-Crystal unit shall be secured to a heavy plate as for the Antennas by means of the normal securing means provided for the purpose.

(c) The Amplifier Unit. The Amplifier shall be firmly clamped between two heavy plates in such manner that all the forces, while under vibration, will be transmitted to the unit; the plates to be secured to the vibration table.

9-5. Direction of Vibration. The vibration shall be applied to each unit in three distinct mutually perpendicular directions, designated arbitrarily as I, II and III. With respect to the direction of the applied force, direction I shall be as follows for the three types of units:

(a) The Antenna: Perpendicular to the aperature.

(b) The Filter-Crystal Units: In line with the long axis.

(c) The Amplifier: Perpendicular to the diameter.

9-6. Nature of Vibration. In all cases the applied vibration shall be of the "random" type, involving all frequencies between 25 and 2000 cycles.

9-7. Details of Tests. Starting with Direction I, and with an rms acceleration of 10g, each unit shall be vibrated for four (4) minutes, thereafter being examined and/or tested for any evidence of electrical or mechanical damage. If none is found, the acceleration shall be increased to 15g and again vibrated for four minutes. This procedure shall be repeated with 5g increments in acceleration up to and including an acceleration of 30g. Thereafter this process shall be repeated with the units vibrated in Directions II and III. However, in these two directions the tests shall be terminated after 25g with the exception of the antenna which shall be tested through 30g in all three directions.

TEMPERATURE TESTS

9-8. Preparation of Units. The units shall be placed in an unmounted condition in a suitable temperature controlled cabinet in as near free space as possible and connected so as to permit monitoring the performance.

9-9. Test Procedure. Starting at the ambient temperature for reference performance, the temperature shall be reduced to 0° C and then increased in 15° C increments up to and including 60° C, holding the temperature at each value for a period of two (2) hours. After the 60° C test the units shall be permitted to return to ambient. Performance shall be observed at each temperature and should the results obtained indicate any marked variation in any performance characteristic between two temperature increments, additional tests shall be conducted at suitable intermediate temperatures.

9-10. Antenna "Flash" Temperature Tests: In view of the fact that the antennas may be subjected to higher temperatures for brief periods of time, an antenna shall be given an additional test conducted as follows:

(a) The antenna shall be secured to the center of a bright aluminum plate, one foot square and 0.020" in thickness and temperature cycled three times between the limits of ambient (not greater than 25° C) and 150° C as

measured on the plate. The temperature shall be increased as rapidly as possible but in not less than one minute and held at the 150° C temperature for five (5) minutes. At the termination of the three cycles there shall be no evidence of any mechanical damage or derangement or permanent degradation in the electrical characteristics within the limits of measurement accuracy.

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ADDENDUM
to
Specifications for

OMNIDIRECTIONAL MICROWAVE TRANSISTORIZED CRYSTAL-VIDEO RADIO RECEIVING SYSTEM

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The following clarifications to the basic specifications shall apply:

Par. 3-3. Add "Spherically true shall predicate no variation in diameter in excess of plus or minus 1/16 inch."

Par. 4-1(e). Add after the word cables "and encapsulating material."

Par. 5-1(e). Add "All antenna flanges and clamping rings (if used) shall not be less than 1/2 inch in width nor less than 1/32 inch minimum thickness with their bearing surfaces shaped to the contour of the sphere. Flanges designed for securing to the sphere by means of screws shall be left undrilled in the Production units and no screws will be required as part of the antenna hardware."

Par. 5-2. Delete remainder of sentence after "(excluding coaxial cables)." Delete last sentence. Add "The design of the Filter-Crystal units shall be such as to permit mounting the required number around the exterior of a 5-1/2 inch cylinder with no parts extending more than one inch beyond the surface of the cylinder."

Par. 6-1. Add "plus and minus 10%."

Par. 6-5. Add "The gain adjusting resistor and its terminals shall not be encapsulated."

Par. 8-1(a): Add: "A tolerance of -6 db will be permitted."

Par. 8-1(f): Add: "This excludes variations due to the natural variations of any antenna with frequency, for which an additional 2 db will be permitted."

Par. 8-1(j): Add: "This shall exclude variations resulting from the natural characteristics of crystals."

Drawing 5430B-153/58. Add to the .558 and .745 dimensions, +.005, -.000.

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