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FIRST REPORT ON THE DEVELOPMENT
OF THE INFRARED ANNUNCIATOR SYSTEM

By
M. A. Gilleo

Report H-3019

[redacted]

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OPTICS DIVISION - ENGINEERING DEVELOPMENT SECTION

26 November 1946

FIRST REPORT ON THE DEVELOPMENT OF THE INFRARED ANNUNCIATOR SYSTEM

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* * *

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ABSTRACT

In response to the request of the fleet for an equipment which would permit a ship to maintain a watch for signals of near infrared radiation without requiring that a lookout with an image forming receiver be kept on duty all night, the Infrared Annunciator System has been developed at the Naval Research Laboratory. This device has also become known as the type K equipment. The system consists of a directional transmitter and receiver that is omnidirectional in azimuth and which will distinguish between signals arriving from port and starboard directions. The transmitter is arranged to utilize the twelve inch signaling searchlights installed on all ships as the source of radiation by the addition of a modulating and filtering hood. The total weight of the equipment is only 179 pounds. In preliminary operation tests results were obtained which indicate the equipment will be useful at distances of at least three nautical miles in usual weather (atmospheric transmission 50 percent per nautical mile or better) and would have a useful range of about 7.5 miles in a perfectly transmitting atmosphere. There is promise of better performance with some refinements of design which are being investigated.

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CHAPTER 1

INTRODUCTION

Authorization. BuShips Secret ltr to Director NRL dated 30 July 1945 Serial 003296, File S-S67-(12) (660E-9)

The need for a Nancy Annunciator System in the fleet for use in conjunction with hand operated infrared signaling equipment was outlined in a letter from Commander Destroyer Pacific to the Chief of the Bureau of Ships on 12 July 1945. The infrared signaling methods used require that ships guard laborious time schedules and that traffic held during non-schedule periods be initiated by the code word "Nancy Hanks". This use of radio causes security to suffer.

It was desired that an infrared annunciator system which would meet the following requirements be designed:

(a) The system should respond to a type of signal peculiar to the annunciator system.

(b) Response should be certain at a minimum distance of 500 yards.

(c) Weight should not exceed fifty pounds.

(d) The system shall discriminate between signals from port and starboard.

The signals to be obtained from this system were to be of a warning nature only since it would not be used for communication. It was proposed by the Commander Destroyer Pacific that the standard twelve inch searchlight with filter hood be equipped with a modulating vane to provide a signal source for use with an infrared annunciator system in the interest of simplicity.

Work on equipment which would meet these requirements was started early in August of 1945. This equipment was to consist of a transmitter based on the use of a type H filter hood equipped with a modulating vane rotating about a vertical axis at a speed to give a modulation frequency of about twenty-five cycles per second; a two channel receiving equipment employing thalofide cells without optics to be mounted for port and starboard coverage; and an indicator unit using two signal triggered oscillators of distinctive pitch for port and starboard discrimination.

Two complete systems were completed and tested in the laboratory in May of 1946. Operational tests were conducted between the Bureau of Ships Test Station on the shore of the Atlantic Ocean at Cape Henlopen, Delaware and the test ship U.S.S. Callao, IX205 on 12 and 13 August 1946.

The test results indicated that the equipment would meet the performance specifications. The "vacuum" range of the equipment was calculated to be about 7.5 miles from test results which showed satisfactory operation of the Annunciator System at a range of 7,000 yards (3.5 nautical

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miles) for atmospheric transmission of about 65 percent per nautical mile. During these tests the transmitter was located on the shore and a nearly full moon was present.

A twenty four inch searchlight that had been equipped with a modulating shutter which had been constructed by Bureau of Ships Test Station personnel was available as a transmitter. Using this searchlight increased the "vacuum" range to nearly 20 miles. Satisfactory operation of the system was experienced at a range of 13,600 yards.

During these tests a Brelco-McGaffin Ships Call Alarm Unit was connected to the receiver output. This Call Alarm rings a bell only when a predetermined dot dash sequence is received. It was possible to use this unit satisfactorily at ranges only slightly less than those effective for simple "call up".

CHAPTER 2

Design: The Receiving System

(a) The Photocell and Input Circuit

The receiving system for the infrared annunciator equipment is required to distinguish the direction, port or starboard, from which signals arrive; it must permit a considerable amount of roll and pitch of the ship without interfering with reception; it must not respond to stray electric and magnetic fields; it must give reasonably uniform response to signals arriving over an arc of 180 degrees in azimuth and little response to signals outside this region; it must be as sensitive as possible to infrared radiation in the region 0.85 to 1.5 or more microns and still be able to withstand exposure to filtered sunlight. These requirements are determined by the performance requirements for the system and by its exposed mounting aboard ship. Fortunately these requirements almost force a simple solution.

One of the most important receiving element requirements is sensitivity since receiver sensitivity is in general far easier to control than transmitter output. Since the receiver is required to respond to signals arriving over an arc of 180 degrees in azimuth and perhaps 40 degrees in elevation to allow for roll and pitch, an optical system of any appreciable gain would not be readily devised. Without optics the receiving element may be considered to be operating in a field of uniform illumination. Under these conditions it can be shown that the signal to noise power ratio at the output of semiconductor type photocells and photoemissive cells will vary directly with the area. There is, therefore, considerable advantage from the standpoint of sensitivity in the use of cells of large area.

There are two types of cells well suited to detection of infrared radiation in the wave length region 0.85 to 1.5 microns. They as the C - Ag - O photoemissive type and the thalofide semiconductor type. The caesium surface type is almost immediately ruled out by the higher load impedance required for maximum signal to noise ratio and by the unavailability of a type with a suitable cathode configuration. In addition the long wave length cutoff for a caesium surface comes at about 1.2 microns while the thalofide cell response extends to nearly 1.4 microns before cutoff. The additional long wave length response of the thalofide cell is helpful since infrared filters which limit the visible range of a tungsten source to 400 yards do not begin to transmit radiation well until a wavelength of 0.9 micron is reached.

Two types of thalofide cells have been in production. The type A cell has a sensitive area of 3/4 by 3/4 inch (0.56 square inch) and the type B or 1P38 cell has a sensitive area of 1 1/4 by 2 1/8 inches (2.6 square inches). These cells are shown in Plate 1. Since the type B cell has an area about 4.5 times greater than that of the type A cell it is a logical choice for the receiving element.

The resistances of a number of type B cells were measured. Most of the better cells had resistances between 1 and 5 megohms. These cells will generate noise which is about 15 decibels above thermal noise in a load impedance of 1.5 megohms when a potential of 90 volts is applied to them

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through a resistance of 5 megohms. This noise level is sufficiently high to permit the use of high quality composition resistors for cell load resistors. Allen-Bradly type EB resistors have been found to be particularly free of current noise and have been used successfully as cell load resistors. It is possible to pass sufficient current through the thalofide cells to produce semi-conductor noise well above thermal, tube, and resistor noise within reasonable limits without deterioration of signal to noise ratio since the signal output as well as the noise level of the thalofide cell is proportional to the direct current flowing through the cell. The input impedance required can be readily obtained with sharp cutoff pentode type amplifier tubes such as the 6SJ7 and 9001. High gain is desirable in the first stage to minimize the noise contribution of succeeding stages.

At the time this equipment was designed it was feared that exposure of the thalofide cells to the suns radiation during the day would render it useless for night use. It has been shown by test of a number of type B cells that this signal to noise ratio is almost unaffected by direct exposure to sunlight without flow of current. A housing for one of the cells is shown in Plate 2. This photograph also shows the double electrostatic shield of 3/8 inch mesh screen which has been placed over the exposed portion of the cell. The rear half of the shield is solid to prevent response to signals arriving over the undesired 180 degrees arc of azimuth.

(b) The Amplifier and Indicator

The amplifier and indicator design for the infrared annunciator system was determined from the following considerations:

(1) The signal to noise ratio of the system should be determined by the characteristics of the photocell and the band width of the amplifier.

(2) Infrared signals from sources other than the annunciator system transmitter should produce a minimum of interference.

(3) Signals arriving from port and starboard must be easily reported.

(4) Indication of reception should be positive when a certain signal to noise ratio is reached to avoid the disturbing effect of a constant background of noise.

The first of these requirements is probably not too difficult to achieve and maintain. The requirements that the signal to noise ratio of the equipment be determined by the photocell is tantamount to requiring that an amplifier having an input impedance greater than or equal to the impedance of the photocell have a noise level not much greater than thermal agitation noise in the input impedance. The thermal agitation power for a 5 c.p.s. band width at a temperature of 300 degrees Kelvin is about 2.10^{-20} watts, a very small power. If an input impedance of 1.5 megohms and a perfect amplifier are assured, a noise figure of 6.4 decibels is obtained. With a cell of five megohms resistance and with a two megohm cell a noise figure of 3.7 decibels results. These noise figures are sufficiently low to insure a predominance of cell noise in the circuit provided that the amplifier is almost noise free. It is usually possible to construct an amplifier with an input impedance of one or two megohms and a noise level not more than twice thermal agitation noise level. The excess noise is contributed by tube noise in the first stage. Practical consideration of circuit insulation leakage and the input tube grid current limit the input impedance to the range of values considered.

The second requirement, prevention of interference by other infrared signaling systems might be solved by choice of an unused wave length band in the infrared region or by selecting a source modulation frequency which is not in the band of frequencies occupied by other infrared equipments. These include the following:

(a) 90 c.p.s. - type US/D

(b) 120 c.p.s. - Infrared beacons such as type X-2A, X-3A, X-9B, X-12, and other lamps supplied with alternating current at 60 c.p.s.

(c) 400 to 4000 c.p.s. - type US/E

The use of a selected portion of the infrared region did not appear to be practical with the available sources, photocells, and filter. It therefore remained to choose a suitable modulation frequency. An examination of the available frequency bands reveals only two that are suitable. The region between 120 and 400 c.p.s. and the region below 90 c.p.s. are available. The desire that the transmitter be simple and light practically eliminates the use of frequencies between 120 and 400 c.p.s. because of the high speeds and relatively high power required to drive suitable shutters. The region near 60 c.p.s. is unsatisfactory in many ways because of the difficulty in completely eliminating the introduction of unwanted power line frequency voltages into the amplifier system. To be sure a high gain amplifier can be constructed which will give satisfactory performance even though tuned to 60 c.p.s. and operated from a 60 c.p.s. power supply frequency. However it would seem to be unwise to expect that such an amplifier could be used aboard ship without developing serious trouble.

Twenty five cycles per second was finally chosen as a nominal operating frequency. Since a 25 c.p.s. sound is scarcely audible and not particularly agreeable to the ear some method employing this frequency to operate an alarm of more distinctive and piercing tone was sought. Since the equipment will have a certain noise output at all times and since it is undesirable that this noise be in evidence when no signals are present because of its distracting nature, a circuit which would give constant warning signal output when the signal level exceeded a predetermined amount and none for signals and noise of lesser amplitude was sought. Such a circuit was found to be already available in the type US/D-1 receiver. This circuit employs a thyraton input tube which will fire only on signals above a fixed level. This thyratron controls an audio oscillator. In order to provide distinctive port and starboard signals two oscillators operating about an octave apart were provided. The amplified oscillators signals are used to operate loud speakers which will be mounted on the signal bridges and in the signalman's hutch.

The band width of the receiving amplifier has, of course, considerable influence on the speed of response of the system to incoming signals and at the same time upon the sensitivity of the system to these signals. In general a narrow band width gives improved sensitivity and increased response time. It was stated that the system would not be used for signaling; it could, therefore, have a considerably longer time of response than would otherwise

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be possible; even one second would not be too long perhaps. This response time would correspond to a band width of about 0.25 c.p.s. at 25 c.p.s. Such a narrow band width could be obtained, but not without difficulty. Adjustment of an amplifier with this narrow pass band would not be a simple matter and would require accurate low frequency standards. In addition the source modulation frequency would have to be controlled from a standard independent of the ship's power supply which may vary ± 3 per cent in frequency. A band width of 3 or 4 c.p.s. was finally selected as a reasonable compromise for the first model. This band width is measured at the one half power point on the response curve and permits an output signal of one half maximum amplitude in about one cycle at twenty-five c.p.s.

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CHAPTER 3

Design: The Transmitting System

The principal requirements for the transmitter for the annunciator system were that as little additional equipment be placed aboard ship as possible and that it be directional to permit calling a particular ship. Since all naval vessels carry a twelve inch signal searchlight and since it is this light which, in conjunction with a filter hood, will be used to carry on communication after it has been initiated with the annunciator system it was logical to consider this searchlight as a possible source for the transmitter.

Several methods of modulating the light from this searchlight are available. Three of the more practical arrangements are given below.

(a) A cylindrical shutter for the lamp.

(b) Two sectored discs rotating in opposite directions about the optical axis of the searchlight.

(c) A vane or shutter rotating about an axis perpendicular to the optical axis of the searchlight.

The first of these methods, (a), would be satisfactory from the respect of modulation efficiency as it would give an average modulated flux only about one half the unmodulated value. It would also be simple to construct. However it would have to be installed in the field in a number of different searchlights. This was considered to be an unsatisfactory condition.

Finally the scheme described in (c) was considered. The rotating vane could readily be installed in a type H hood. A vane of width equal to one half the diameter of the beam would intercept the major portion of the useful flux and not require much room or excessive power. Such a modulating vane would give performance equivalent to that of (b) with considerable simplification. It would work well only if a spread lens were used but the type H filter hood is regularly supplied with filter type spread lens designed to give a beam spread of 10.5 by 6.5 degrees. The greater angle is employed in the vertical direction.

The infrared filter used in the type H hood is a polaroid dyed cellophane type cemented to the plane surface of the spread lens. The dye is of Polaroid XR7X type.

The modulation frequency is entirely dependent upon the speed of rotation of the shutter. Hence it is desirable that shutter speed be accurately maintained. This can be accomplished by using a synchronous drive motor. The modulation frequency is then as accurate as the line frequency which is not likely to deviate more than two cycles in sixty.

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CHAPTER 4

Description of Equipment Constructed

(a) The Receiving Equipment

Three units of the receiving equipment will regularly be mounted outside: the cell housing, the preamplifier, and the junction box. The junction box is used to avoid running an extra armored cable to the receiver control unit. These three units are shown in Plate 4. The cell housing is a modified infrared beacon housing Navy type X-9B; the preamplifier and junction boxes are standard 20 wire connection boxes. These units were selected for water tightness and have been provided with terminal tubes.

The cell housing is shown with the filter removed in Plate 2. The cell is surrounded by a combined light and electrostatic shield. The electrostatic shield consists of two concentric cylinders spaced three eighths of an inch apart. The inner cylinder is made of one half inch mesh screen; the outer cylinder is made of one half inch mesh screen over half of its circumference and three hundredths inch brass sheet over the other half to confine response of the receiver to signals arriving over a bearing arc of 180 degrees. The type 1P38 photocell can be seen behind the electrostatic shields. The housing is designed to mount on a one inch pipe.

The construction of preamplifier Model 1 and Model 2 is clearly shown in Plates 2, 5, 6, and 7. Preamplifier Model 1 has a chassis of one sixteenth inch thick cadmium plated steel. The mounting system has been designed to hold these preamplifiers rigidly in the water tight enclosure. The preamplifiers are held in place by the two truncated cones shown on the underside brackets in Plates 5 and 7 and the flat angle brackets shown clearly in Plate 2. They extend from the preamplifier chassis toward the terminal block. Since the latter brackets seat on a surface inclined toward the preamplifier, the covers are firmly forced into tapered holes in two steel blocks welded to the wall of the housing. This mounting scheme provides ease of replacement and a reasonably shakeproof assembly.

It should be noted that preamplifier Model 2 has been constructed to provide unusual rigidity. The chassis and brackets were made from one eighth inch steel. The first two tubes are clamped in an eighth inch of rubber by housings turned out of one and one eighth inch diameter brass rod. The input circuit wiring was done with number ten tinned copper wire and the remainder of the wiring was securely laced. These precautions were taken in an effort to improve performance under mechanical vibration. The results of vibration of the cell housing and preamplifier are discussed in Chapter 7.

The control panel for the annunciator system is shown in Plates 8, 9, and 10. All the controls required in normal operations are available on the front panel and their labels can be clearly seen in Plate 8. The port and starboard gain and cell voltage controls have been grouped for convenience of identification. The cell voltage controls are slotted shaft types for screwdriver adjustment. They have been covered to discourage frequent and inadvertent adjustment.

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Plate 9 shows the top view of the control panel chassis. The starboard and port channels of the main amplifier have been grouped in such a way that the successive tubes and capacitors proceed about in the order of their appearance in the circuit from the front panel to the rear of the chassis. The starboard channel is on the extreme right of the chassis; the port channel is immediately to the left. All power supply components and wiring have been confined to the left rear corner of the chassis to avoid trouble from hum pickup in the rather low level input circuits at the right front of the chassis. Test points to facilitate location of open tube heaters, and jack pairs to facilitate tuning the relative stages can be seen among the tubes and capacitors mounted on the right half of the chassis.

The layout of wiring and components beneath the chassis shown in Plate 10 follows the scheme used in laying out the component arrangement on the top of the chassis.

Connections to the control panel are made at a terminal block fastened to the inside of the rear wall of the cabinet.

(b) The Transmitting Equipment

The searchlight modulator was designed and constructed to utilize as much as possible of the structure of a type H hood. The unit constructed is shown in place on a twelve inch searchlight in Plate 3; details of its assembly are given by Plate 11. The motor is a small four shaded pole type with an integral gear box. The lower vane shaft bearing is grease packed; the upper bearing is a self aligning ball bearing. A knob with two flat surfaces has been provided on the upper end of the vane drive shaft to permit the operator to set the vane parallel to the emergent light when signaling to avoid occlusion of a portion of the beam; the flat surfaces of the knob are parallel to the plane of the vane. The motor housing has been placed as near the searchlight as is practical without further reducing the width of the modulating vane or providing additional vane drive complications.

(c) Weight, Size, and Quantities of the Units Required

The weights, quantities and overall dimensions of the units of the annunciator system are given in Table I. It should be noted that the complete system weighs only 179 pounds of which only 52 pounds need be placed above signal bridge level.

CHAPTER 5

Circuits and Laboratory Performance

(d) The Preamplifier

Two preamplifiers were constructed for use with the annunciator system. The first design used the circuit of Plate 12; it was designated Model 1. Component values are given in Table 2. The preamplifier is a three stage resistance capacitance coupled amplifier using type 9001 miniature tubes. The first two stages are pentode connected as an aid in attaining a small noise figure. The last stage is triode connected since it is desirable that the preamplifier have a fairly low output impedance to reduce sensitivity to electrostatic power frequency fields. It would furthermore be difficult to avoid overloading a high gain pentode stage at this point. The output impedance and gain have been modified suitably by the introduction of a negative feedback loop between the output tube plate and the input tube screen. With this arrangement maximum gain is about 8.5×10^3 at 25 c.p.s.; output impedance is about 3500 ohms. The peak at 25 c.p.s. in the gain versus frequency characteristic is the result of using sufficient negative feedback to accentuate the decrease in the feedback factor caused by rapid decrease in gain and increase in phase shift in the preamplifier in the region of incipient low frequency cutoff. Screen feedback was used in preference to feedback to the grid of the first stage because of the difficulty of maintaining a constant feedback factor while using a cell circuit which has one grounded terminal and which will be required to accommodate cells of varying resistance. The shunting capacitor, C114 of Plate 12, has been introduced to eliminate a peak in amplifier response similar to the desired one at 25 c.p.s. which would otherwise be present at some high frequency. It accomplishes this purpose by reducing amplifier gain at frequencies below those at which the phase shift in the remainder of the amplifier would be sufficient to begin a reversal in the sign of the feedback factor.

It should be noted that the heaters of the preamplifier tubes have been series connected and are supplied from a source of direct current having a low percentage of ripple. This has been found quite necessary if the noise level at the input grid is to be kept below one microvolt. The grounding method for the system is also of importance in amplifiers which are expected to have a low input noise level. In particular, impedances in the grid circuits of the first two tubes which might carry circulating ground currents from the return of the heater supply line for example are to be avoided. This is accomplished insofar as possible in the preamplifier by returning all ground circuits to the chassis at the point of the input grid return. The shield on the signal cable which carries the signal from the preamplifier to the main amplifier is grounded only at the preamplifier. This precaution is not always necessary but is often helpful.

The cell housing and its electrostatic shields should be grounded at this point also. However the construction of the housing required connection of the shields to the body casting which in turn will be grounded to the hull of the ship when installed. A two conductor coaxial cable has been used to connect the housing to the preamplifier; the cable shield is connected to the housing and to the common ground return in the preamplifier while the cell is connected to the cable conductor. This expedient avoids insofar as possible, trouble from circulating ground currents in the input circuit. This is not the only reason for using a two conductor cable as will be explained in Chapter 7.

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The gain versus frequency characteristic of preamplifier Model 1 is given by Plate 16.

The input impedance of these preamplifiers was measured by the method of varying signal generator impedance and found to fall between 1.4 and 1.6 megohms after the value of the input tube cathode bias resistor was experimentally chosen for greatest input impedance. The signal voltage at the grid was held below one millivolt during these measurements.

Preamplifier Model 2 is approximately the electrical equivalent of Model 1; its construction and circuit are somewhat different. The circuit is given by Plate 13 and component values are given by Table 5. Its mechanical design is such that it is more rigid than Model 1 as pointed out in Chapter 4. The tubes employed in the first two stages are Sylvania type SD-834, the development model of the type 6K4. This tube is a subminiature size triode patterned after Variable Time Fuse Tubes. It has a 6.3 volt 150 milliampere heater type cathode and triode element structure. The heaters of the tubes in this preamplifier are series connected and supplied with direct current as in Model 1. Selectivity in this Model 2 preamplifier is obtained by choosing the size of coupling capacitor, C 107, Plate 13, to resonate with the primary leakage inductance of transformer, T 1. The response versus frequency characteristic of this preamplifier is shown on Plate 17.

The input impedance of the Model 2 preamplifier was again adjusted to the optimum value by experimental variation of the input tube cathode resistor. Input impedance was measured by the variable signal generator impedance method with signal levels of less than one millivolt and was found to be very nearly equal to the impedance of the resistance of the parallel combination of the cell load and grid resistor. Some trouble was encountered with high input circuit noise levels until the plate current of the first tube was reduced by using a higher value of plate load resistance. The last stage is a 9002 type triode, it was used only because another SD-834 was not available at the time of construction. The overall gain of the unit is about 1.2×10^{14}. Ground return wiring in this preamplifier adheres to the principles followed in wiring Model 1.

The output signal level of either preamplifier is always in excess of four millivolts and the impedance level is less than 50,000 ohms. At 25 c.p.s. little trouble from attenuation or noise is encountered even when using long signal cable runs.

(b) The Main Amplifier and Indicator

The portion of the control unit handling the 25 c.p.s. signals will be designated the main amplifier and the portion connected with the higher frequency indicating signals will be called the indicator. The main amplifier and indicator are divided into two similar sections, one for port signals and the other for starboard signals. The signals from these sections join at the input to the final amplifier tube. The circuits for these units are given by Plate 14; the component values are available in Table 2.

The main amplifier for each channel consists of a two stage amplifier the second stage of which is tuned to 25 c.p.s. by a parallel T feedback network. At least eight volts of signal at 25 c.p.s. is required at the grid of V213 to operate the indicator circuits. Since the preamplifier output may be as low as four millivolts, a gain of at least 2×10^3 times must be provided. Actually a gain of 6×10^3 times is available. The gain control is located at the input of the amplifier. A reserve of gain has been provided to allow for cable attenuation, loss of gain with deterioration of components, and to ensure that it will be possible to drive the second stage to saturation even with weak signals.

The frequency selectivity of the second stage is a result of using a null type feedback network, the parallel T. This network requires only resistance and capacitance and it is possible to obtain a variety of transmission characteristics from it by small adjustments of the value of three components. It is possible to obtain infinite attenuation at a particular frequency or to obtain a finite attenuation with phase shift passing through either zero or one hundred and eighty degrees.

When the network is used in a feedback loop over one stage it is possible to adjust the amplifier to be highly selective, broadly selective, or oscillatory depending on the adjustment of the network. In this equipment the resistor R 211 and R 212 of the starboard channel, Plate 14, have the greatest effect upon selectivity. If their resistance is lower than the value for zero network transmission, network attenuation will be finite and phase shift will pass through 180°. Under this condition selectivity and gain will be high and the amplifier may oscillate. If these resistors are somewhat larger than the value for zero transmission network attenuation will be finite and phase shift will pass through 0°. The amplifier will be broadly selective and gain will be low. Normally the network will be adjusted for a transmission null at the frequency to which the system is to be tuned, in this case, 25 c.p.s.

As a consequence of using a selective amplifier a certain amount of time is required for the signal level to change in amplitude (Chapter 2). If a signal of much greater amplitude than is required to operate the indicator circuits is applied to the system an appreciable time will elapse after it is removed before the indicator will cease to operate. This effect can greatly lengthen a signal and reduce its readability. Dr. P. H. Geiger of the University of Michigan proposed a simple solution for this difficulty some time ago. His method requires that the tuned stage be operated in such a way that it begins to saturate at signal levels slightly higher than are required to operate the indicator circuit. When this is done the signals will all require about the same time to decay below the indicator operation level since they will all decay from the same level, i.e., the level at which the stage saturates. This principle has been employed in the annunciator system by operating the tuned stage at a reduced plate voltage and overdriving it. The overload point and the operating point of the indicator circuit are stabilized by regulating the plate supply voltage for two amplifier stages in the main amplifier and the grid bias voltage on the first tube in the indicator. The saturation curve for the main amplifier is shown by Plate 21. Since the output voltage at which saturation begins to take place is greater than the voltage required to operate the indicator circuit a divider composed of R 218 and R 217 has been used in the grid circuit of V 213. Adjustment of this divider determines the position of the indicator operating point on the saturation curve.

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As a convenience for adjustment of the tuning of the selective stage two test jack pairs have been provided. One pair (TP-210, TP-212) is connected between grid and ground of the selective stage and the other pair (TP-211, TP-213) is connected between plate and ground. Initial adjustment of the stage is accomplished with the power removed or with the tube in the selective stage removed. A signal at 25 c.p.s. is then fed into one pair of terminals and the network adjusted for a null reading on a vacuum tube voltmeter or oscilloscope connected to the other pair. The voltage at the null should be at least 40 decibels below input voltage level. When this adjustment is completed the tube is replaced and the equipment tuned on. With a signal fed into the input of the main amplifier the response should drop about 6db three cycles either side of the peak. If the stage does not give maximum response at the correct frequency or if the curve should happen to be highly asymmetrical it is possible to readjust the network controls to attain the desired response. It is essential that the voltmeter or oscilloscope used in measuring response have an input impedance of at least one half megohm.

The indicator circuit for this unit consists of three tubes - a thyratron trigger tube, a triode bias control tube, and pentode phase shift oscillator. In operation a positive signal somewhat in excess of ten volts peak applied to the grid of the 2050 type thyratron will cause it to conduct thereby discharging capacitor C 214. When this happens the grid potential of V 214 is so reduced that its plate current is cut off. Since the grid of the oscillator tube V 215 returns to the cathode of V 215 through the plate load of V 214, cut off of plate current to V 214 will allow the grid potential of V 215 to rise above cut off at which time oscillation may commence. The oscillator employed is a phase shift type with a network having an attenuation less than the amplifier circuit gain at a frequency at which the phase shift through the network is 180 degrees is used in a feed-back loop connected between the grid and plate of the tube to permit sustained oscillation. The particular network employed is a five section resistance capacitance high pass filter consisting of C 217 through C 221, R 225, and R 227 through R 230. The starboard channel oscillator operates at a frequency of about 1100 c.p.s. and the port channel oscillator about an octave lower or 550 c.p.s. The output of the oscillator is amplified somewhat and applied to the grid of the power amplifier tube through a volume control. The equipment will deliver about two and one quarter watts to a six hundred ohm load.

The oscillator tubes and the first succeeding amplifier tubes are twelve volt heater types but are operated from a 6.3 volt supply with satisfactory results.

(c) Power Supply

The complete power requirements for the receiver are handled by a single power supply which furnishes 225 volts at 225 milliamperes for the plates and screens of all tubes in the system and the heater of all tubes except V 202, V 207, V 209, V 210, V 213, V 215, and V 216. These tubes are supplied with 6.3 volts from a winding on the power transformer. The remaining tubes, heated with direct current, are all 150 milliampere types and are series connected. The tubes operated at the lower signal levels are near the ground end of the series. No tube handling high frequency indicator

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voltages is in this group. Current for the series connected tubes is controlled by an adjustable resistor, R 291 and is taken from the power supply after the second filter section. A third filter section is provided for current supplied to the remainder of the equipment. It should be noted that decoupling sections have been liberally applied and that the equipment is quite free of power line frequency and harmonics of it in the signal channels and shows no tendency toward instability. Line current varies from 1.2 to 1.7 amperes at line voltages of 104.5 and 124.5 volts single phase sixty cycles per second.

(d) Interunit Cabling.

The method of connecting the several units of the annunciator system together when it is installed aboard ship is given by the Interunit Wiring Diagram, Plate 15. Armored cables have been specified by their Navy type number for all wiring except that to the searchlight modulator which is a flexible cable, and the cell housing cable which was not available with armor. Spare conductors have been provided in most cables. The junction box shown is not entirely necessary but will simplify wiring in many cases by reducing the number of cables required by one.

If the equipment is to operate properly while the ship's structure is vibrating at the point where the preamplifier and cell housings are mounted, it is essential that the cell housing cables NA-1 and NA-2 be firmly clamped to a rigid support every few inches of their length and that this support extend the whole length of the cable.

Any of the cable runs with the cables shown may be as long as two hundred feet except the cell housing cables which must be less than two and one half feet.

(e) The Transmitter.

The searchlight modulator operates at a speed of 750 RPM and produces a fundamental modulation frequency of 25 c.p.s. The root-mean-square fundamental component candlepower distribution of the beam in a horizontal plane was measured at a distance of 123 feet with and without a clear spread lens by comparison with a source of known rms fundamental component candlepower. The root-mean-square fundamental component is rms value of the lowest frequency alternating component obtained in a fourier analysis of the modulated output of the searchlight and is the component to which a selective receiver responds.

Plate 22 shows the type of beam distribution obtained from the searchlight with modulator but without a spread lens and Plate 23 shows the beam distribution with a clear spread lens in place. The spread lens was a Holophane number 706. Plate 22 reveals several severe variations in candlepower even in the center of the beam as a result of the filament structure of the lamp, a 1000 watt monoplane filament type. The maximum rms fundamental component candlepower without the spread lens is about 190,000 and with the spread lens about 60,000. However there are no significant irregularities over the beam when a spread lens is used.

(f) Sensitivity and Vacuum Range

Receiver sensitivity in the annunciator system is of foremost importance since it is far more practical to realize improvement in system vacuum range (distance over which equipment will operate if there is only geometrical attenuation) by improving the receiver than by increasing transmitter wattage.

The overall performance of the amplifier system was judged by determining how much the noise level referred to the input grid exceeded the theoretical value for thermal agitation noise in the input impedance. The input impedance of the preamplifier was measured as described previously. The effective band width for noise for the combination of the main amplifier with either of the two preamplifier models was determined by graphical integration of the voltage gain squared (power gain) versus frequency curves, Plates 24 and 25. The noise bandwith for preamplfier Model 1 plus the main amplifier was found to be 5.2 c.p.s. and for preamplifier Model 2 plus the main amplifier noise band width was 5.6 c.p.s. If a cell of two megohms resistance is used the thermal agitation noise at the input grid would be about 3×10^{-7} volts for either combination at a temperature of 300 degrees Kelvin.

Measurement of the noise at the input grid was carried out by a comparison method. The noise level at the output of the low frequency amplifier (TP-211 for example) was noted on a Ballantine Model 300 Electronic Voltmeter which had been highly damped by the addition of a 1000 microfarad capacitor to the meter circuit. A signal was then injected into the system input circuit by inserting a General Radio Microvolter Model 546B in the ground return of a resistor which had previously been substituted for the photocell. A resistance of about two megohms was used for this purpose. The signal from the microvolter was set to give an output voltage about ten times the noise level. From knowledge of the preamplifier input impedance, it is possible to compute the signal at the grid and thereby determine the noise level. Model 1 preamplifier had noise levels between 0.4 and 0.6 microvolt; Model 2 preamplifier had a noise level of about 1.1 microvolts. Model 1 preamplifier was considered to be quite satisfactory in the respect of noise level while Model 2 preamplifier was not wholly acceptable. Either of the preamplifiers will permit realization of full sensitivity of a type 1P38 thalofide cell.

The signal to noise ratio required to give reliable operation of the indicator is of almost as much interest as the noise level of the system. The indicator employed in the annunciator system is such that any signal exceeding a certain amplitude will give an indication of a given amplitude but the duration of indication is a function of the duration of the signal. This type of indicator does not permit much aural discrimination between signal and noise and consequently requires a larger minimum signal to noise ratio for usable operation but it does eliminate fatigue which results from listening to a persistent noise background. Laboratory tests with signals from a low intensity modulated source or microbeacon indicate that a signal to noise ratio of not less than fifteen decibels is necessary. Field experience indicates that an additional five decibels is required to counteract the effect of moonlight and fluctuations in atmospheric transmission (twinkle effect).

The type 1P38 thalofide cells used in the equipment will usually give a signal to noise ratio of 60 decibels when a signal of one microlumen of white light at 2848 degrees Kelvin color temperature interrupted 90 times per second is used and the cell output is measured at 90 c.p.s. with a noise band width of 7.4 c.p.s. The cells will give somewhat better response at 25 c.p.s. These cells have a projected area of 2.4 square inches. There are a number of sources of loss of signal level between the unfiltered modulated searchlight beam. In the system constructed these are about as tabulated below:

(a) Infrared filter loss 18.5 decibels.

This loss is the total loss introduced by the two layers of Polaroid XR7X25 filter material on the spread lens and the X9B filter jar used on the cell housing.

(b) Electrostatic shield attentuation 3 db

(c) Loss resulting from use of thalofide cells in beam of parallel light instead of focused beam used in test set, 6 db.

The total loss from the above factors is about 27.5 decibels. Under these conditions a signal of 230 nautical mile candles is required for satisfactory operation. With a transmitter of 6×10^4 effective candle power a vacuum range of about 16 miles should be available. If the equipment is operated under atmospheric conditions such that fifty percent of the signal strength would be lost for every mile of path traversed a useful range of 4 miles could be expected provided no interference from reflected moonlight or other sources of radiation having modulated components were experienced.

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CHAPTER 6

Performance of the Annunciator System on Operational Test

(a) Test Installation

Two complete annunciator systems consisting of the units listed in Table 1 were constructed at the Naval Research Laboratory. One system was installed aboard the U.S.S. Callao, IX-205 and the other aboard the E-PCE(R)-852. These ships are from the Operational Development Force.

The units of the annunciator system installed on the U.S.S. Callao were distributed as follows:

Unit	Location
Control Panel	Chart Room
Preamplifier and Cell Housings	Mounted on port and starboard legs of the tripod mast about 45 feet above the water line
Searchlight Modulator	Mounted on searchlights located on Navigating bridge about 28 feet above the water line
Speaker	Chart room.

No photographs of this installation are available at this time. The locations selected worked out quite well during receiving tests with the equipment.

The Annunciator System installed on the E-PCE(R)-852 was similar to the installation on the U.S.S. Callao. The control panel and speaker were located in the chart room as shown by Plate 26. In this installation there was little convenience in the use of a junction box which is shown just above the upper left hand corner of the control panel. The speaker is just below the center of the control panel. The cell housings were mounted on brackets welded to the type US/D-1 receiver platform. These platforms are welded to port and starboard bulk heads surrounding the open bridge deck and are about 34 feet above the water line. Only the cell housings are visible in Plate 26; the open bridge splinter shield obscures the preamplifier and type US/D-1 receiver.

The cell housing and preamplifier mounting details are shown more clearly in Plate 27. The preamplifier is in the shadows under the receiver mounting platform. It should be noted that the signal cable between the cell housing and the preamplifier has not yet been securely fastened to a rigid support throughout most of its length as it must be if vibration noise problems are to be avoided. Plate 27 also shows a searchlight modulator installed on the port searchlight located just above the open bridge level behind the Nancy Room and about 37 feet above the water line.

(b) Test Results

Operational tests of the Annunciator System were ultimately conducted on the night of 12 and 13 August. Unfortunately the EPCE(R)-852 was not available for test purposes at that time and it was necessary to employ the fifty foot tower at the Bureau of Ships Test Station as the transmitting location. The U.S.S. Callao, IX205, was used only for receiving signals. The shore was unavoidably studded with many rather powerful lights. These lights have been observed to introduce a masking background for shore signals because of their fluctuations in intensity resulting from rapid variations in atmospheric transmission. This difficulty was quite pronounced when using signaling sources of lesser candle power than that of the annunciator.

In addition to the modulated twelve inch searchlight there was available a twenty four inch carbon arc searchlight which had been equipped with an infrared filter of Corning glass and a sector disc modulator. This modulator for this searchlight was constructed by Test Station personnel under the direction of Lt. (j.g.) R. W. Mitchell at the suggestion of Mr. L. Dunkelman of the Bureau of Ships. The modulator operated at a frequency of about 28 cycles per second which is somewhat removed from the frequency of maximum response of the receiver.

Prior to tests to be conducted on the evening of 12 August the receiving equipment was checked and found to be almost completely inoperative. Examination disclosed that the starboard cell housing had not been tightly closed and held about a quarter of an inch of water; the port cell housing was quite dry. In addition the preamplifier for the starboard channel suffered from the effects of water and was inoperative. The port channel which appeared to be in good condition was checked for noise level and found to have about ten times the normal noise level. It would still be able to receive strong signals. This equipment had been exposed to the weather since its installation in June.

No signals were received on the night of 12 August. It was later discovered that the port and starboard cell voltage connections were crossed and as a result no polarizing potential had been applied to the port cell that night.

During the following day the starboard receiving channel of the annunciator system installed on the U.S.S. Callao was reconditioned. The noise level in this channel was found to be about 0.4 microvolt, a very satisfactory figure. The port channel was not touched for lack of time and was not used in the test.

The night of 13 August was well suited to test of the equipment. The sea was reasonably calm, the sky was partly cloudy, and the atmosphere quite clear. In addition a nearly full moon was in the sky and on occasion was unobscured by the clouds. The moon in general was in a direction opposite to that of the transmitter for reception. Tests were begun at 8:15 PM EST; using a twelve inch searchlight; first reception occurred at 8:24 PM. The signals were received well and agreed exactly with the signals observed in a type C-3 image forming receiver. At 8:36 PM the U.S.S. Callao

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was 4920 yards from the Test Station on bearing 100 degrees true from the station.

During the period 9:06 PM to 9:13 PM the ships heading was changed from 192 degrees to 96 degrees true and measurements were made of signal level to determine receiver response versus relative transmitter bearing for the installation. For ship's heading of 190 degrees true the shore bearing was 282 degrees true; the shore would, therefore, be exactly off the starboard beam at 192 degrees true. The results of this test are given in Plate 28. This response is not satisfactory because of the great loss of response between 150 and 180 degrees relative bearing. The distance to the shore station was about 550 yards during these measurements.

At the conclusion of the azimuthal response measurements which were made with a signal which was on five seconds and off five seconds the signal was changed to "AA". Reception of the latter signal was good at 7000 yards and the signal was often readable at 8000 yards. At a range of 9000 yards the signal was still recognizable on occasion but its usefulness was small. The signal to noise ratio was measured several times as the range was opened; the data is tabulated in Table 7. At 9:39 PM, range 9,140 yards the X9B type filter jar was removed from the cell housing. As expected the signal level increased 4 or 5 decibels.

During these tests all of the ship's running lights were in use and many portholes in lighted compartments were open. These lights are run from 60 c.p.s. alternating current. No appreciable improvement in signal to noise ratio was observed when the ship was completely darkened and the filter was on the cell housing.

A Brelco McGaffin Ships Call Alarm Unit had been installed for possible test with the annunciator. This alarm is arranged to ring a bell when a certain sequence of dots and dashes is received and of course may be arranged to respond to certain words or letter combinations in any telegraph code. This unit was connected to the annunciator and the letter combination AA, ABK, and ABKZY were received between 12:03 and 12:17 AM 14 August at ranges from 5240 to 5880 yards and signal to nose ratios between 20 and 22 decibels. Code speed was about 7 words per minute and the code was sent by hand.

At 12:40 AM transmissions on the twelve inch searchlight were discontinued and the twenty four inch searchlight was turned on. A signal to noise ratio of 34 decibels was observed at a range of 8400 yards. Since the twenty four inch searchlight has a torque motor driven shutter it was connected to an automatic keyer which was sending JH nine times per minute. The call alarm was set to respond to a sequence of JH- JH - JH. This is a rather severe test because of the large number of dots which must be perfectly received. The system worked well at a range of 10,000 yards. At 11,800 yards it was necessary to set the alarm to respond to only one JH as it was no longer possible to receive three perfect JH combinations. At 13,260 yards and 1:15 AM the signal to noise ratio was about 24 decibels but wide variations in signal level were observed. Signal readability was poor and the run was discontinued at a range of 13,980 yards.

The U.S.S. Callao returned to a range of 5,200 yards to conduct a test using the modulated twenty four inch searchlight which had been equipped

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with a ninety degree reflecting cone to produce omnidirectional signals in azimuth. Equipment failure at the shore station prevented completion of this test.

During the course of these tests data was taken in such a form that it would be possible to make a rough determination of atmospheric transmission on the assumption that attenuation for the atmosphere can be expressed as a certain percent per unit distance. On this basis it is only necessary to have data for variation of signal level with distance. Such data are given in Table 7. Some figures in the signal level column are listed as signal to noise ratio but the noise level was constant in these instances and the signal to noise ratio may therefore be considered equivalent to signal level. Since the signal level is a function of the bearing of the transmitter from the ship only data which includes this information may be used to determine system vacuum range.

It can be shown that if the plot of the logarithms of the product of the signal level and range squared as ordinates versus the ranges as abcissas is a straight line the atmospheric transmission is then one hundred times the antilog of the slope of the line in units of percent per unit distance. Such a plot is presented in Plate 29.

During the period 11:00 PM to midnight 13 August observations of the strength of the 90 c.p.s. signals from a Crouse Hinds Co. type D beacon were made on an output meter connected to an RCA type US/D-1 receiver. These measurements are included in Table 7 and have been plotted on Plate 29. Only measurements made as a consistent set have been included on Plate 29. Point number 5 has been ignored because it falls much too far from the suggested position.

The data from measurements with the annunciator system indicate that atmospheric transmission was of the order of 70 percent per nautical mile while the measurements made with the type US/D system would indicate a value of about 65 percent per nautical mile. The method is not highly accurate but provides a means of estimating the performance of the equipments with a minimum of special apparatus.

If the annunciator system was considered to be at the limit of its useful range at 7000 yards when using a twelve inch searchlight and the transmission were 65 percent per nautical mile its vacuum range is about 7.5 nautical miles and it will have a maximum range of 2.8 nautical miles for atmospheric transmission of 50 percent per nautical mile. It is felt that the initial requirements for the system have been met. However it is also certain that the equipment is capable of considerable improvement. It is believed that the conditions under which the tests were made insofar as interfering illumination is concerned are more severe than those under which the equipment will be expected to operate.

The vacuum range of the annunciator system with a twenty four inch searchlight for a 20 decibel signal to noise ratio may be deduced from the signal to noise ratio of 24 decibels obtained at 13,600 yards; it is about 20 miles.

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CHAPTER 7

Performance of Preamplifier While Subject to Vibration

It is well known that the structure of a naval vessel is subject to vibration while the ship is in motion. This vibration frequency is usually related to propeller shaft speed and the number of blades employed as well as hull and engine design. The principal frequencies of vibration likely to be encountered fall in the range of five to twenty three c.p.s. Amplitudes of vibration are likely to be less than 0.050 inch displacement.

It is also only too well known that high gain amplifier noise levels rise when the amplifiers are subjected to vibrations. For this reason the preamplifier and cell housing of the annunciator system were tested for noise level rise while subject to vibration of frequencies between 10 and 33 c.p.s. The range below 10 c.p.s. generally causes little trouble and has been neglected for lack of equipment suited to production of such low frequencies. The range above 23 c.p.s. is of less importance since it is unlikely that such fundamental vibration frequencies will be encountered but it is of considerable experimental interest.

The Model 1 preamplifier and cell housing together with the cable between the cell housing and preamplifier were securely fastenedto the horizontal plates of a light weight vibration machine. The cell housing was mounted vertically eight inches above the table top on a one inch pipe. No shock or vibration mounts of any kind have been employed in the equipment or in mounting the equipment on the table. The table produced vibration in a horizontal plane. The preamplifier was mounted with bottom side (opposite the removable cover) horizontal and against the top of the vibration table.

The preamplifier was completely connected to the main amplifier as it would be in actual operation. Output noise level was measured at the test jack pair TP-211 after the tuned stage with a Ballantine Type 300 Electronic Voltmeter. The system gain was adjusted to give one volt output for ten microvolts at the input grid. The vibration table was set for 0.015 inch displacement, The table was operated for a time sufficient to permit reading the output meter at vibration frequencies one c.p.s. apart from 10 to 33 c.p.s. in most cases. Plate 30 shows typical behavior of noise level with variation in vibration frequency. In this run frequencies above 28 c.p.s. were not used. The gain of the amplifier system is plotted on the same sheet in relative units. This was done to show the close correlation between the slope of the gain and noise level curves. It seems apparent that most of the noise in the system is generated at the fundamental frequency of vibration. The curve shows that the noise level is fourteen times the rest noise level at 23 c.p.s. and rises to 32.5 times rest noise level at 26 c.p.s.

This particular run was made without polarizing potential applied. Another run made with polarizing voltage applied indicates that twenty five percent more noise may be expected. Removal of the cell housing cable from the preamplifier input caused a general rise in noise level at frequencies between 18 and 28 c.p.s. while shorting the input caused a general decrease in the noise level at all frequencies.

The cable connecting the cell housing to the preamplifier was twinax, RG-22/U, type high frequency cable. This cable was found by test to produce less noise while flexing than the single conductor type when one of the two central conductors is used for signal from the cell and the other for ground returns; the shield is also grounded. Even RG-22/U cable introduced a considerable amount of noise when it was clamped to the table or cell housing support about every four inches of its length.

Since preamplifier Model 1 was not too satisfactory when operated under vibration and since it was observed that the choice of the input tube from a number of 9001 type tubes could remarkably increase the noise generated under vibration a new tube type and preamplifier design were sought. The Sylvania SD 834 later known as the 6K4 was finally selected for trial. This tube features Variable Time Fuse Tube style of construction but has a cathode with a 150 milliampere 6.3 volt heater and is a triode. A preamplifier, Model 2, was designed to use this tube. As previously described the construction was intended to minimize vibration of components employed in the unit. Only two type SD 834 tubes were available at that time.

The preamplifier Model 2 was ultimately subjected to the same test used for Model 1. Its behavior was little different than that of Model 1 except that the noise output was about six times higher than that of Model 1 at 0.015 inch displacement and over twenty times higher at 0.050 inch displacement. When the input to Model 2 preamplifier was shorted a general increase in noise level was observed at all vibration frequencies contrary to experience with Model 1. Curves of noise level versus vibration frequency at 0.015 inch and 0.050 inch amplitude are given in Plate 31. The relative system gain versus frequency curve has again been included as a clue to the reason for the observed variation of output noise level with vibration frequency. The rest noise level of this preamplifier is excessively high also. Since no additional type 6K 4 tubes could be obtained at the time of the tests it was not determined whether the tubes used were representative of the type. The performance of Model 2 preamplifer was not encouraging or acceptable.

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CHAPTER 8

The Course of Future Work

The first model of the annunciator system has been quite thoroughly tested in the laboratory and in the field. Certain shortcomings have become evident during these tests. However the equipment has been able to satisfy all of the original requirements set forth in Chapter 1 except the weight limit.

The original range requirement, five thousand yards dependably, it appears was set at the lower limit of usefulness; certainly additional usuable range is to be desired. During field tests the equipment gave performance equivalent to a vacuum range of about 7.5 miles whereas laboratory tests predicted a vacuum range of about 16 miles. Even then it is recognized that several of the losses in the system may well be reduced. Among the possibilities for loss reduction are elimination of the infrared cell housing filter, reduction of the electrostatic shield loss by redesign, alleviation of losses caused by the curved cell surface, use of a more efficient filter on the searchlight and possibly eliminating the spread lens by changing from a monoplane filament lamp to a biplane type filament. It is anticipated that a thorough exploitation of this loss reduction program would result in increasing the laboratory vacuum range to nearly thirty miles with a corresponding increase in useful field range.

The present searchlight modulator unit is not satisfactory as the drive motor is not a synchronous motor nor is it of adequate power to drive the modulating vane at the proper speed with varying ambient temperature and minor maladjustment of the bearings. A synchronous type motor must be substituted.

Vibration tests of the equipment have shown that serious difficulty is to be expected with any of this equipment which might be installed on a ship at points where the ship's structure vibrated much over 0.015 inch displacement at frequencies higher than 15 or 20 c.p.s. It appears that the best solution to this problem is the use of a higher frequency such as 90 or 200 c.p.s. at which only harmonics of the fundamental vibration frequency could cause trouble and then only a rather limited amount. However it is difficult to predict performance of equipment of this type under vibration and it is expected that a large amount of experimentation will be required before a suitable design is evolved. The achievement of a design satisfactory for use under vibration is essential if this equipment is to be placed aboard naval vessels.

The failure of the supposedly watertight preamplifier housing requires that housing be designed specifically for the problem at hand. At the same time it is highly desirable that the cell housing and preamplifier housing become one unit in order that the troublesome signal cable between the present two units may be eliminated.

The field tests have demonstrated that the azimuthal variation of sensitivity of the receiving units is excessive and must be reduced. It is believed that a simple arrangement of plane mirrors can be devised to reduce this irregular response.

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The thalofide cell in the existing equipment is in a housing directly exposed to the weather. The temperature of the cell is expected to follow ambient temperature. In cold weather the resistance of the cell will rise to quite high values and it may be necessary to provide heat to maintain an adequate signal to noise ratio.

Further development of the annunciator system will probably require a general refinement of design and concurrent construction of new units of the equipment of more satisfactory characteristics.

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CHAPTER 9

Admiralty Development

Two reports, numbers 8308 and 8309, by the General Electric Company Ltd. on the development of an Infrared Signaling System under admiralty contract have recently been discovered. These reports describe results obtained with two systems developed after the original ZAX system which it is recalled employed a direct current amplifier and failed to give a range much in excess of two cables (0.2 mile approx.).

The next system tried operated at 30 c.p.s. It used a searchlight with a ten inch mirror and a 1500 watt tungsten lamp as a source and caesium photocell receiver. A useful range of 1.1 nautical miles with an atmospheric transmission of about 75 percent per sea mile was realized in the light of a full moon.

A similar system operating at 800 to 1000 c.p.s. was subsequently developed. This system performed satisfactorily at 2.2 nautical miles with an atmospheric transmission of about 60 percent per nautical mile. A full moon was present during these tests also.

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7. Holland, L. M., Operating Instructions for Photocell Test Set, N.D.R.C. Contracts NDC rc - 185 dated 25 April 1944.

8. Hole, W. L., Operating Instructions for Microflux Source Model 3, N.D.R.C. Contract NDC rc - 185 dated 9 June 1944.

9. A Summary of Vibration Measurements on New Vessels of the U.S.N., D.T.M.B. Report No. 314.

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TABLE 1

Weights, Quantities, and Overall
Dimension of Annunciator System Units

Unit	Quantity per System	Weight in Pounds	Overall Dimension in Inches
Cell Housing	2	11	7 in diameter by 8½ high
Preamplifier	2	15	5 x. 10 x 10
Junction Box	1	11	5 x 10 x 10
Control Unit	1	76	14 ½ deep by 12 high by 21½ wide
Searchlight Modulator	2	14.5	10 long by 20½ high by 13 wide
Loudspeaker	1	11	

Total weight of installation less cable - - - 179 pounds

TABLE 2

Electrical Components List

Pre Amplifier

Nancy Annunciator System

Symbol		Description		
C-101A	Capacitor	Mica	0.01 MFD	300V
C-101B	"	Mica	0.01 MFD	300V
C-101C	"	Mica	0.01 MFD	300V
C-102A	"	Paper	2.0 MFD	600V
C-102B	"	Paper	2.0 MFD	600V
C-103	"	Elec.	15 MFD	450V
C-104	"	Paper	0.1 MFD	600V
C-105	"	Elec.	20 MFD	450V
C-106	"	Paper	0.1 MFD	600V
C-107	"	Elec.	15 MFD	450V
C-108	"	Paper	0.1 MFD	600V
C-109	"	Elec.	20 MFD	450V
C-110	"	Paper	0.1 MFD	600V
C-111	"	Paper	0.25 MFD	600V
C-112	"	Elec.	20 MFD	450V
C-113	"	Elec.	40 MFD	25V
C-114	"	Mica	0.01 MFD	300V
J-101	Coaxial Jack	Navy	CPH - 49194	
P-101	Coaxial Plug	Navy	CPH - 49190	
R-101	Resistor	Composition	5.6 MEG	½ Watt
R-102	"	"	2.2 MEG	½ Watt
R-103	"	"	3,900 OHM	½ Watt
R-104	"	"	1.5 MEG	½ Watt
R-105	"	"	1.5 MEG	½ Watt
R-106	"	Wirewound	0.2 MEG	½ Watt
R-107	"	Composition	56,000 OHM	½ Watt
R-108	"	"	1.0 MEG	½ Watt
R-109	"	"	2,200 OHM	½ Watt
R-110	"	"	1.5 MEG	½ Watt
R-111	"		0.27MEG	½ Watt
R-112	"		56,000OHM	½ Watt
R-113	"		1.0 MEG	½ Watt
R-114	"		3,900 OHM	½ Watt
R-115	"		0.1 MEG	½ Watt
R-116	"		56,000 OHM	½ Watt
R-117	"		6,800 OHM	½ Watt
R-118	"		10.0 OHM	½ Watt
V-101	Tube	Jan - 9001		
V-102	Tube	Jan - 9001		
V-103	Tube	Jan - 9001		

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TABLE 2 (CONTINUED)

Electrical Components List

Control Unit

Nancy Annunciator System

Symbol	Description			
C-201	capacitor	Elec.	40 MFD	25V
C-202	"	Paper	0.1 MFD	500V
C-203	"	Elec.	15 MFD	450V
C-204	"	Paper	0.1 MFD	500V
C-205	"	Elec.	40 MFD	25V
C-206	"	Paper	0.5 MFD	500V
C-207	"	Elec.	15 MFD	450V
C-208	"	Paper	0.5 MFD	500V
C-209	"	Paper	0.01 MFD	500V
C-210	"	Paper	0.01 MFD	500V
C-211	"	Paper	0.01 MFD	500V
C-212	"	Paper	0.01 MFD	500V
C-213	"	Paper	0.1 MFD	500V
C-214	"	Paper	0.1 MFD	500V
C-215	"	Elec.	4.0 MFD	350V
C-216	"	Mica	0.004 MFD	300V
C-217	"	"	400MMFD	300V
C-218	"	"	"	"
C-219	"	"	"	"
C-220	"	"	"	"
C-221	"	"	"	"
C-222	"	Mica	0.01 MFD	500V
C-223	"	Elec.	15 MFD	450V
C-224	"	Paper	0.02 MFD	600V
C-225	"	Elec.	30 MFD	450V
C-226	"	Elec.	40 MFD	25V
C-227	"	Paper	0.1 MFD	500V
C-228	"	Elec.	15 MFD	450V
C-229	"	Paper	0.1 MFD	500V
C-230	"	Elec.	40 MFD	25V
C-231	"	Paper	0.5 MFD	500V
C-232	"	Elec.	15 MFD	450V
C-233	"	Paper	0.5 MFD	500V
C-234	"	Paper	0.01 MFD	500V
C-235	"	Paper	0.01 MFD	500V
C-236	"	Paper	0.01 MFD	500V
C-237	"	Paper	0.01 MFD	500V
C-238	"	Paper	0.1 MFD	500V
C-239	"	Paper	0.1 MFD	500V
C-240	"	Elec.	4 MFD	350V
C-241	"	Mica	0.004 MFD	300V
C-242	"	Mica	800MMFD	300V
C-243	"	Mica	800MMFD	300V
C-244	"	Mica	800MMFD	300V
C-245	"	Mica	800MMFD	300V
C-246	"	Mica	800MMFD	300V

TABLE 2 (CONTINUED)

Symbol	Description				
C-247	capacitor	Mica	0.01 MFD	500V	
C-248	"	Elec.	15 MFD	450V	
C-249	"	Paper	0.02 MFD	600V	
C-250	"	Elec.	30 MFD	450V	
C-251	"	"	40 MFD	450V	
C-242	"	"	40 MFD	450V	
C-253	"	"	40 MFD	450V	
C-254	"	"	20 MFD	450V	
F-201	fuse	2 ampere	3 AG size		
F-202	fuse	2 ampere	3 AG size		
I-201	Lamp, Pilot	6 - 8V	Bayonet Base	G-E No. 44	
J-201	Coaxial Jack	Navy	CPH - 44194		
J-202	" "	"	" "		
J-203	Phone Jack	2 wire			
L-201	Choke	10 H	250 MA.		
L-202	Choke	20 H	250 MA.		
L-203	Choke	20 H	100 MA.		
P-201	Coaxial Plug	Navy	CPH - 49190		
P-202	" "	"	" "		
R-201	Potentiometer		Composition	0.5 MEG	
R-202	Resistor		"	1000 OHM	½ Watt
R-203	"		"	1.0 MEG	½ Watt
R-204	"		"	0.22 MEG	½ Watt
R-205	"		"	39,000 OHM	½ Watt
R-206	"		"	1.0 MEG	½ Watt
R-207	Potentiometer		"	50,000 OHM	
R-208	Resistor		"	0.56 MEG	½ Watt
R-209	Resistor		"	0.56 MEG	½ Watt
R-210	Potentiometer		"	50,000 OHM	
R-211	Potentiometer		"	50,000 OHM	
R-212	Resistor		"	0.37 MEG	½ Watt
R-213	Resistor		"	1000 OHM	½ Watt
R-214	"		"	1.0 MEG	½ Watt
R-215	"		"	0.27 MEG	½ Watt
R-216	"		"	39,000 OHM	½ Watt
R-217	"		"	0.22 MEG	½ Watt
R-218	"		"	0.22 MEG	½ Watt
R-219	"		"	5,600 OHM	½ Watt
R-220	"		"	56,000 OHM	2 Watt
R-221	"		"	8,200 OHM	2 Watt
R-222	"		"	120 OHM	½ Watt
R-223	"		"	0.22 MEG	½ Watt
R-224	"		"	3,300 OHM	2 Watt
R-225	"		"	0.22 MEG	½ Watt

[redacted]

TABLE 2 (CONTINUED)

Symbol		Description		
R-226	Resistor	Composition	0.56 MEG	½ Watt
R-227	"	"	0.56 MEG	½ Watt
R-228	"	"	0.56 MEG	½ Watt
R-229	"	"	0.56 MEG	½ Watt
R-230	"	"	0.56 MEG	½ Watt
R-231	"	"	1000 OHM	½ Watt
R-232	"	"	0.82 MEG	½ Watt
R-233	"	Wirewound	10,000 OHM	10 Watt
R-234	"	Composition	0.22 MEG	½ Watt
R-235	"	"	1.5 MEG	½ Watt
R-236	"	"	0.47 MEG	½ Watt
R-237	"	"	2,700 OHM	½ Watt
R-238	"	"	0.10 MEG	½ Watt
R-239	"	"	10,000 OHM	½ Watt
R-240	"	"	22,000 OHM	½ Watt
R-241	Potentiometer	"	0.50 MEG	
R-242	Resistor	"	0.27 MEG	½ Watt
R-243	Potentiometer	"	0.10 MEG	½ Watt
R-244	Resistor	"	270 MEG	1 Watt
R-245	Potentiometer	"	0.5 MEG	
R-246	Resistor	"	1000 OHM	½ Watt
R-247	Resistor	"	1.0 MEG	½ Watt
R-248	Resistor	"	0.22 MEG	½Watt
R-249	Resistor	"	39,000 OHM	½ Watt
R-250	Resistor	"	1.0 MEG	½ Watt
R-251	Potentiometer	"	50,000 OHM	
R-252	Resistor	"	0.56 MEG	½ Watt
R-253	"	"	0.56 MEG	½ Watt
R-254	Potentiometer	"	50,000 OHM	
R-255	"	"	50,000 OHM	½ Watt
R-256	Resistor	"	0.37 MEG	½ Watt
R-257	"	"	1000 OHM	½ Watt
R-258	"	"	1.0 MEG	½ Watt
R-259	"	"	0.27 MEG	½ Watt
R-260	"	"	39,000 OHM	½ Watt
R-261	"	"	0.22 MEG	½ Watt
R-262	"	"	0.22 MEG	½ Watt
R-263	"	"	5,600 OHM	½ Watt
R-264	"	"	56,000 OHM	½ Watt
R-265	"	"	8,200 OHM	½ Watt
R-266	"	"	120 OHM	½ Watt
R-267	"	"	0.22 MEG	½ Watt
R-268	"	"	3,300 OHM	½ Watt
R-269	"	"	0.22 MEG	½ Watt
R-270	"	"	0.56 MEG	½ Watt
R-271	"	"	0.56 MEG	½ Watt
R-272	"	"	0.56 MEG	½ Watt
R-273	"	"	0.56 MEG	½ Watt
R-274	"	"	0.56 MEG	½ Watt
R-275	"	"	1000 OHM	½ Watt

[redacted]

TABLE 2 (CONTINUED)

Symbol		Description		
R-276	Resistor	Composition	0.82 MEG	½ Watt
R-277	"	Wirewound	10,000 OHM	10 Watt
R-278	"	Composition	0.22 MEG	½ Watt
R-279	"	"	1.5 MEG	½ Watt
R-280	"	"	0.47 MEG	½ Watt
R-281	"	"	2,700 OHM	½ Watt
R-282	"	"	0.10 MEG	½ Watt
R-283	"	"	10,000 OHM	½ Watt
R-284	"	"	22,000 OHM	½ Watt
R-285	Potentiometer	"	0.50 MEG	
R-286	Resistor	"	0.27 MEG	½ Watt
R-289	"	Wirewound Adjustable	6,000 OHM	50 Watt
R-290	"	Wirewound	50,000 OHM	10 Watt
R-291	"	Wirewound Adjustable	1000 OHM	50 Watt
R-292	"	Wirewound Adjustable	6,000 OHM	50 Watt
T-201	Transformer	Power	Thordarson Pri. 115V 60 cps Sec. 800V @ 200 Ma., C.T. 6.3V @ 5.14 A., C.T. 5.0V @ 4.0 A., C.T.	
T-202	Transformer	Output	Thordarson T-61S25 5,000 OHM Plate to 500 OHM Line	
V-201	Tube	Type 5U4G		
V-202	"	Type 6V6		
V-203	"	Type OD3		
V-204	"	Type OD3		
V-205	"	Type 12SJ7		
V-206	"	Type 12SJ7		
V-207	"	Type 2050		
V-208	"	Type 12SJ7		
V-209	"	Type 12SJ7		
V-210	"	Type 12SJ7		
V-211	"	Type 12SJ7		
V-212	"	Type 12SJ7		
V-213	"	Type 2050		
V-214	"	Type 12SJ7		
V-215	"	Type 12SJ7		
V-216	"	Type 12SJ7		

[redacted]

TABLE 2 (CONTINUED)

MISCELLANEOUS ELECTRICAL COMPONENTS LIST

Nancy Annunciator System

Symbol		Description
V-301	Photocell	Type 1P38, G-E Type B
LS-401	Loud Speaker	Navy Type CUL-49546 10 Watts 15 OHMS, 200-5000 c.p.s. with matching transformer and "T" Pad.

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[redacted]

TABLE 2 (CONTINUED)

SPARE PARTS LIST

Nancy Annunciator System

Name	Description			Circuit Symbol	Quantity
Capacitor	Mica	0.01 MFD	300V	C-101A, B, C, 114 C-209,10, 11 C-212, 22, 34, 35, 36, 37, 47	8
Capacitor	Paper	2.0 MFD	600V	C-102A, B	2
Capacitor	Elec.	2 sec. 15 MFD 1 sec. 40 MFD	450V 25V	C-103, 07, 13, 201, 03, 05, 07,23 26, 28, 30, 32	3
Capacitor	Elec.	20-20-20MFD	450V	C-105, 09, 12	2
Capacitor	Paper	0.25 MFD	600V	C-11	1
Capacitor	Paper	0.1 MFD	600V	C-104, 06, 08, 10	2
Capacitor	Paper	0.1 MFD	1000V	C-202, 04, 13, 14, 27, 29, 38, 39	4
Capacitor	Paper	0.5 MFD	1000V	C-206, 08, 31, 33	2
Capacitor	Elec.	4.0 MFD	350V	C-215, 40	1
Capacitor	Mica	0.004MFD	300V	C-216, 41	1
Capacitor	Mica	0.0004 MFD	300V	C-217, 18, 19, 20, 21	5
Capacitor	Paper	0.02 MFD	600V	C-224, 49	1
Capacitor	Elec.	4 sec. 20-20-20-20-MFD(each sec.)	450V	C-251, 52, 53, 54, (each two 20 MFD, Sec. in parallel)	2
Capacitor	Elec.	15-15 MFD	450V	C-225, 50 (each two 15 MFD sec. in parallel)	1
Fuse	3 AG size	2 ampere		F-201, 02	10
Pilot Lamp	6-8V Bayonet Base G.E. No. 44			I-201	2
Coaxial Jack	Navy	CPH-49194		J-101 J-201, 02	1
Phone Jack	2 wire			J-203	1
Choke	10 H	250 MA		L-201	1
Choke	20 H	250 MA		L-202	1
Choke	20 H	100 MA		L-203	1

[redacted]

TABLE 2 (CONTINUED)

Name	Description			Circuit Symbol	Quantity
Coaxial Plug	Navy	CPH - 49190		P-101 P-201, 02	1
Resistor	Composition	5.6 MEG	½ Watt	R-101	2
Resistor	Composition	2.2 MEG	½ Watt	R-102	2
Resistor	Composition	3,900 OHM	½ Watt	R-103, 14	2
Resistor	Composition	1.5 MEG	½ Watt	R-104,05,10,235,97	3
Resistor	Wirewound	0.2 MEG	1 Watt	R-106	2
Resistor	Composition	0.22 MEG	1 Watt	R-204,17,18,23,25,34 48,61,62,67,69,78	6
Resistor	Composition	56 K	½ Watt	R-107,12,16 R-220,64	3
Resistor	Composition	1.0 MEG	½ Watt	R-108,13 R-203,06,14,47,50,58	4
Resistor	Composition	2,200	½ Watt	R-109	2
Resistor	Composition	0.27 MEG	½ Watt	R-111 R-215,42,59,86	2
Resistor	Composition	0.1 MEG	½ Watt	R-115 R-238,82	3
Resistor	Composition	6,800OHM	½ Watt	R-117	2
Resistor	Composition	10.0 OHM	½ Watt	R-118	2
Resistor	Potentiometer	Composition 0.5 MEG	½ Watt	R-201,41,45,85	2
Resistor	Composition	1000 OHM	½ Watt	R-202,13,31,46,57,75	3
Resistor	Composition	39 K	½ Watt	R-205,16,49,60	2
Resistor	Potentiometer	Composition 50 K	½ Watt	R-207,10,11,51,54,55	3
Resistor	Composition	0.56 MEG	½ Watt	R-208,09,26,27,28,29, 30,52,53,70,71,72,73, 74	
Resistor	Composition	0.33 MEG	½ Watt	R-212,46	
Resistor	Composition	5,600 OHM	½ Watt	R-219, 63	

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TABLE 2 (CONTINUED)

Name	Description	Circuit Symbol	Quantity
Resistor	Composition 8,200 OHM 2 Watt	R-221,65	1
Resistor	Composition 120 OHM ½ Watt	R-222,66	1
Resistor	Composition 3,300 OHM 2 Watt	R-224,68	1
Resistor	Composition 0.82 MEG ½ Watt	R-232,76	1
Resistor	Wirewound 10 K 10 Watt	R-233,77	1
Resistor	Composition 0.47 MEG ½ Watt	R-236,80	1
Resistor	Composition 2.7 K ½ Watt	R-237,81	1
Resistor	Composition 10.0 K ½ Watt	R-239,83	1
Resistor	Composition 20.0 K ½ Watt	R-240,84	1
Resistor	Potentiometer Composition 100 K ½ Watt	R-243	1
Resistor	Composition 270 OHM 1 Watt	R-244	1
Resistor	Wirewound Adjustable 6,000 OHM 50Watt	R-289	1
Resistor	Wirewound 50 K 10 Watt	R-290	1
Resistor	Wirewound 1,250 OHM 50 Watt	R-291	1
Tran.	Power PRI. 115V-Sec. 800V @ 200 M.A.C.T. 6.3V @ 5.14 A.C.T.- 5.0V @ 4.0 A.C.T.	T-201	1
Tran.	Output 5000 OHM Plate to 500 OHM Line	T-202	1
Tube	Jan. - 9001	V-101,02,03	3
Tube	12SJ7 - Metal	V-205,06,08,09, 10,11,12,14,15,16	6
Tube	5U4G	V-201	1
Tube	6V6 Metal	V-202	1
Tube	OD3	V-203,04	1

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TABLE 2 (CONTINUED)

Name	Description	Circuit Symbol	Quantity
Tube	2050	V-207,13	1
Tube	Type 1P38 - GE Type B	V-301	3

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[redacted]

TABLE 3

Components List

Annunciator System Preamplifier

Model 2

Symbol					
C 101	Capacitor	0.10 MFD.	1000V	Pyranol - GE 23F183	
C 102	"	4.0 MFD.	600V	Paper Bath, C-D Dye - 6200 2 in parallel	
C 103	"	50.0 MFD.	25V	Elec. Bath.	
C 104	"	0.50 MFD.	600V	Paper Bath.	
C 105	"	2x20.0 MFD.	450V	Elec. (Can) One Sect.	
C 106	"	50.0 MFD.	25V	Elec. Bath.	
C 107	"	0.25 MFD.	600V	Paper Bath.	
C 108	"	20.0 MFD.	450V	Elec. (One Section C- 105)	
C 109	"	50.0 MFD.	25V	Elec. Bath.	
C 110	"	0.50 MFD.	600V	Paper Bath.	
C 111	"				
J 101	Jack, Coaxial				
R 101	Resistor	5.6 MEG.	½ Watt	Composition	A-B
R 102	"	2.2 MEG.	"	"	
R 103	"	8,200OHM.	"	"	
E 104	"	0.27 MEG.	"	"	A-B
R 105	"	0.27 MEG.	"	"	
R 106	"	1,500OHM	"	"	
R 107	"	0.10 MEG.	"	"	A-B
R 108	"	2700 OHM	"	"	
R 109	"	56,000 OHM	"	"	
R 110	"	1,8 MEG.	"	"	A-B
R 111	"	0.27 MEG.	"	"	
R 112	"	2,700 OHM	"	"	
T 101	Transformer	15,000 OHM Plate to 60,000 OHM Grid UTC Type O-4			
V 101	Electron Tube	Type 6K4			
V 102	" "	Type 6K4			
V 103	" "	Type 9002			

[redacted]

TABLE 4

Operational Test Data of

13 August 1946

Point Number	Signal Level or Signal to Noise Ratio - Decibels Signal Level	Range Yards	Relative Bearing of Shore Station	Time	Equipment
1	7	8000		2300	Crouse-HindsCo.
2	9.5	7600			Type "D" Beacon,
3	11	7200		to	RCA Type US/D-1
4	12	6800			Receiver
5	14	5600		0000	
	Signal to Noise Ratio				
6	29	4920	143°	2036	Annunciator System
7	24	5100		2050	with Twelve inch
8	22	6180		2119	Searchlight
9	14	9140	090°	2139	
10	11	9400	125°	2206	
11	10	10440	090°	2240	
12	22	5240	035°	0003	
13	34	8400		0050	Annunciator
14	24	13600		0115	System with 24 in. Searchlight
15	26	5660	125°	0311	Returned to 12 in. Searchlight

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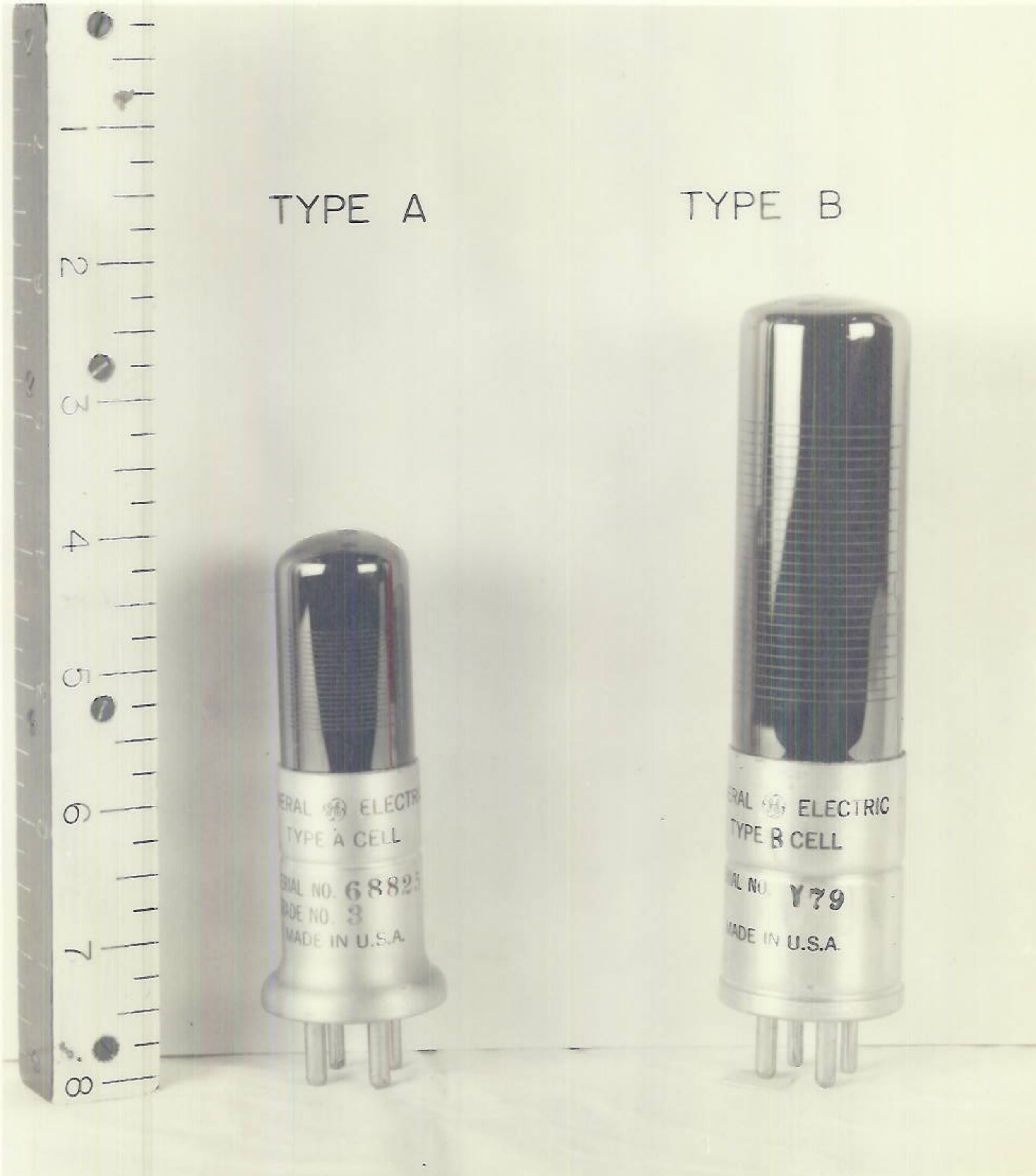
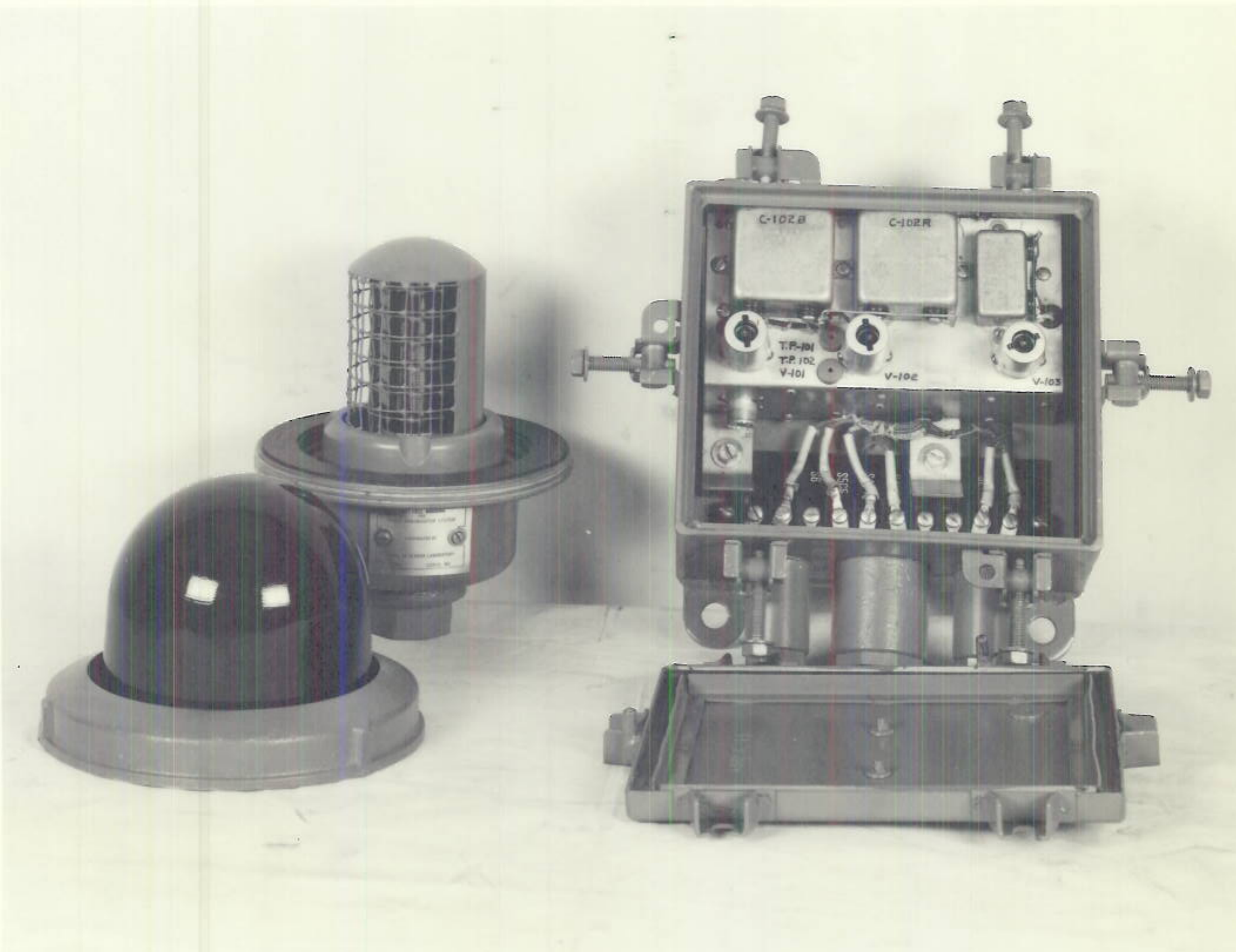
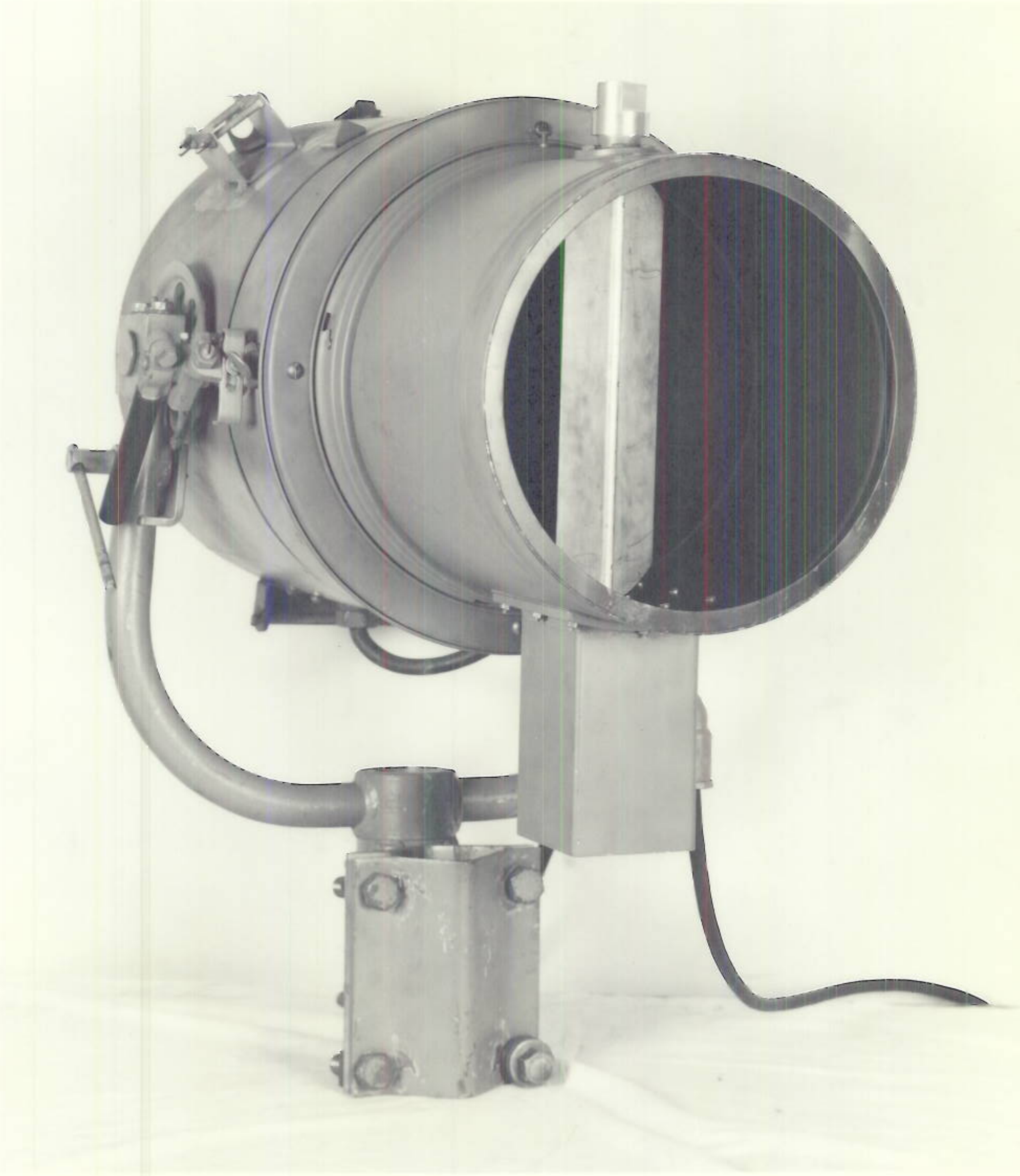


THALOFIDE CELLS

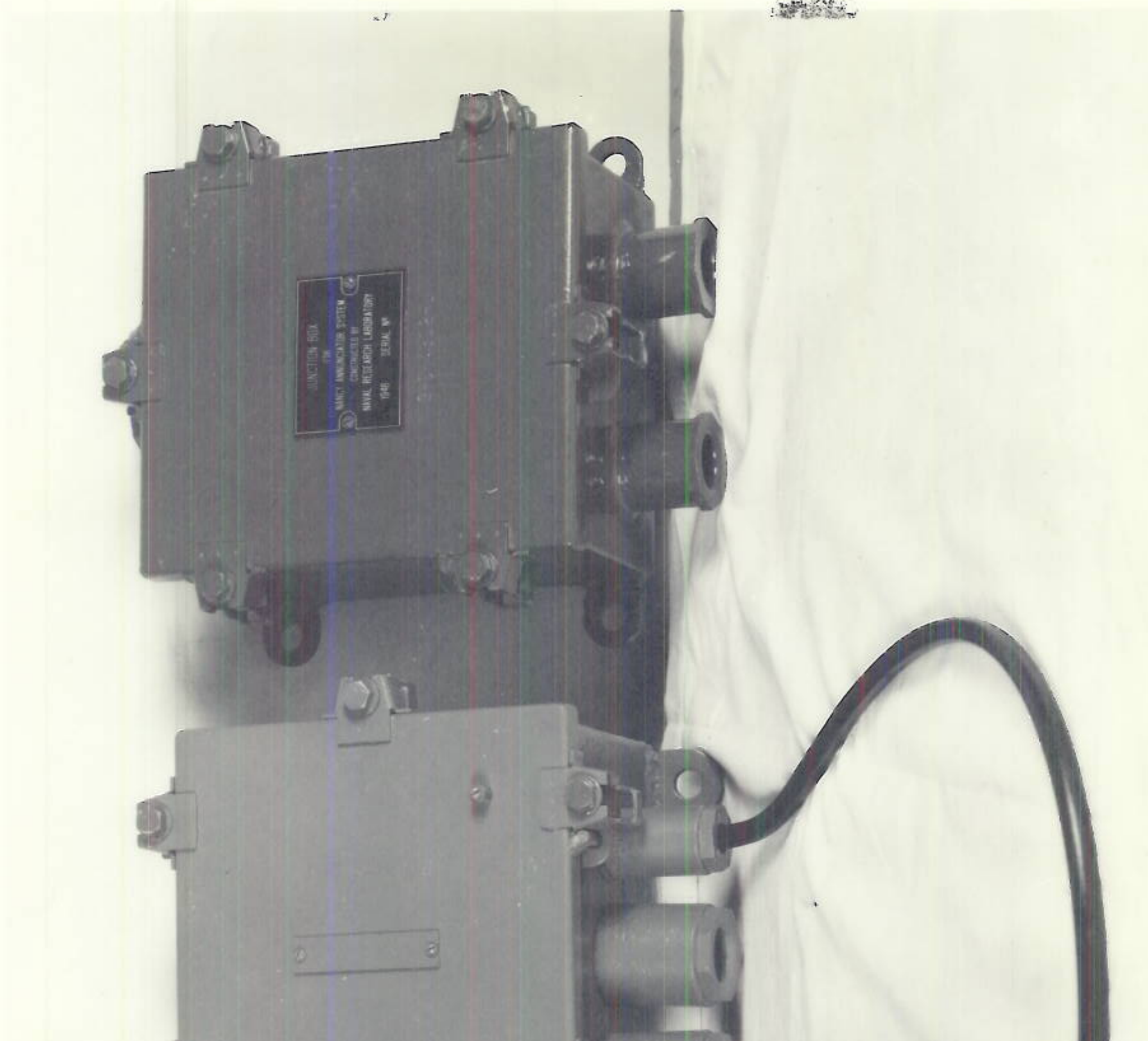


CELL HOUSING WITH FILTER REMOVED AND PREAMPLIFIER WITH COVER REMOVED

PLATE 2

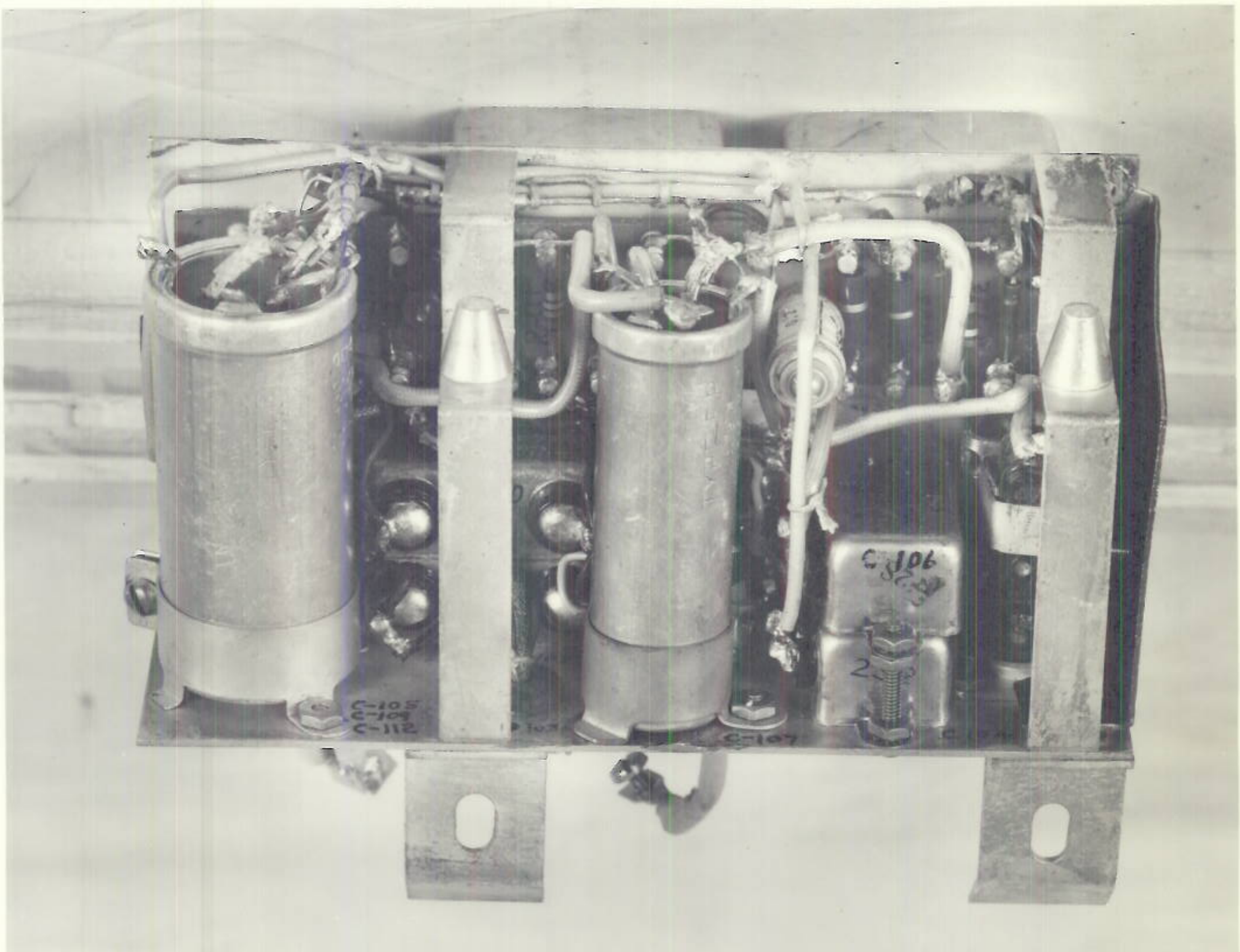


TWELVE INCH SEARCHLIGHT WITH MODULATOR



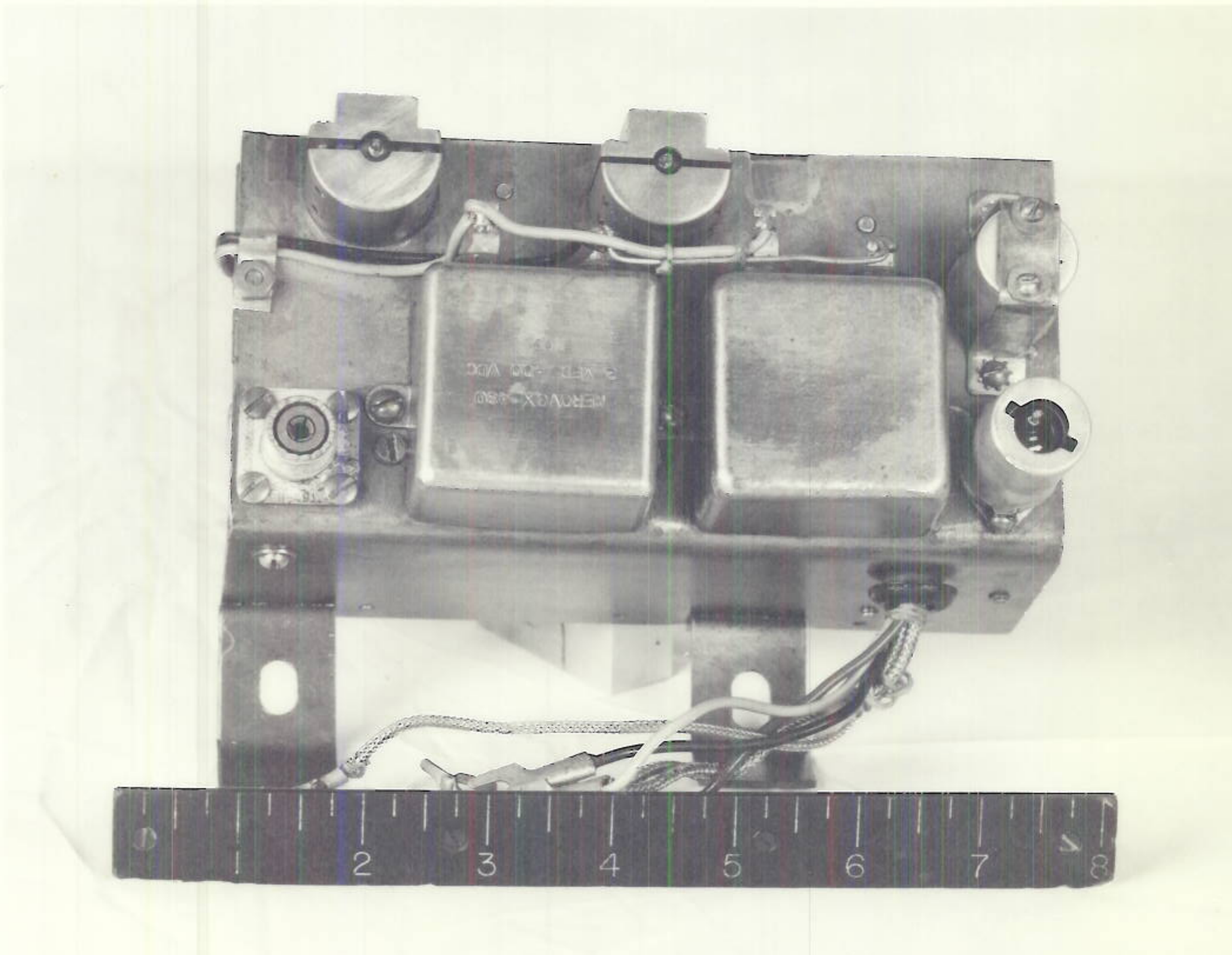
CONTROL PANEL: FRONT VIEW

PLATE 4

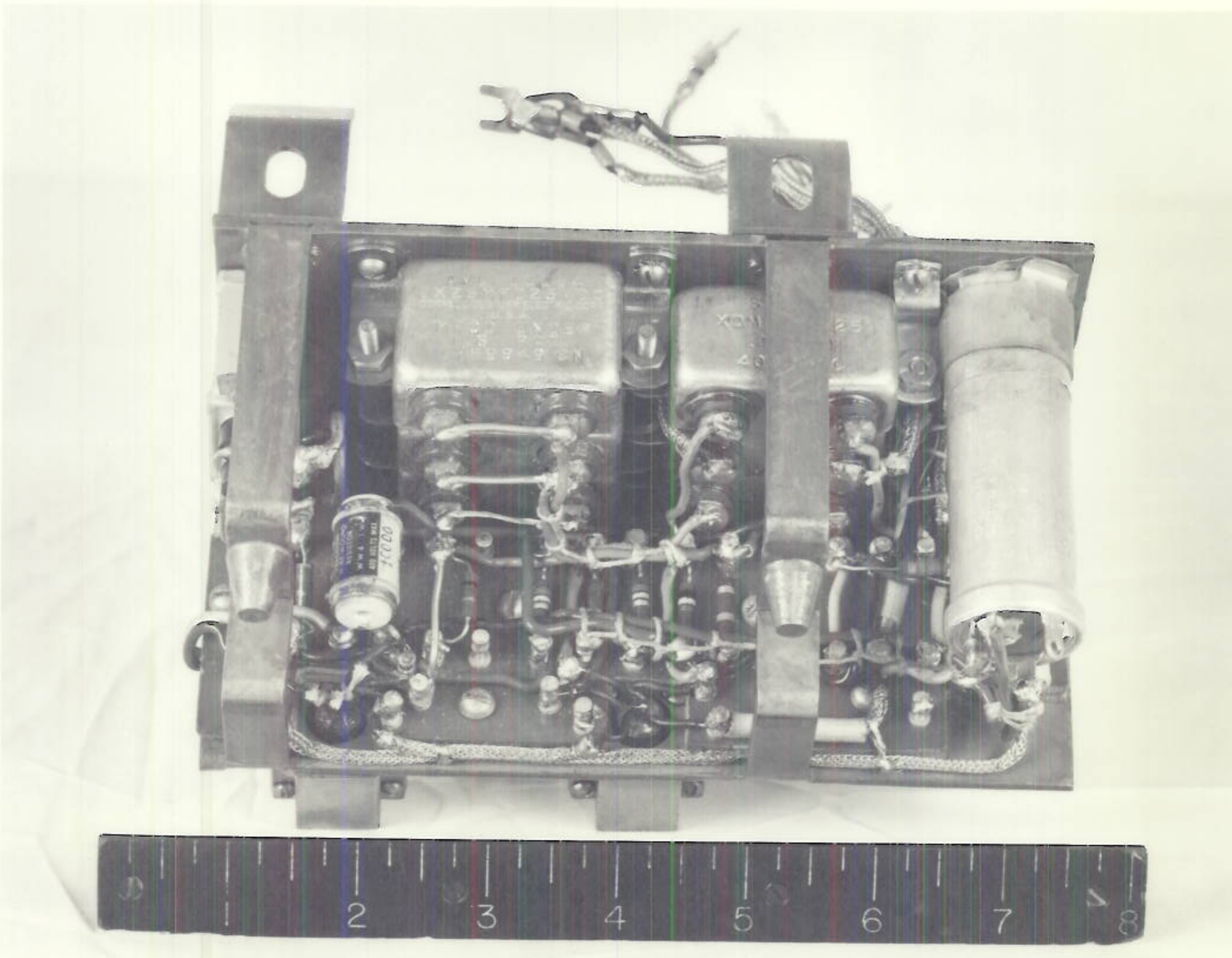


PREAMPLIFIER MODEL I: BOTTOM VIEW

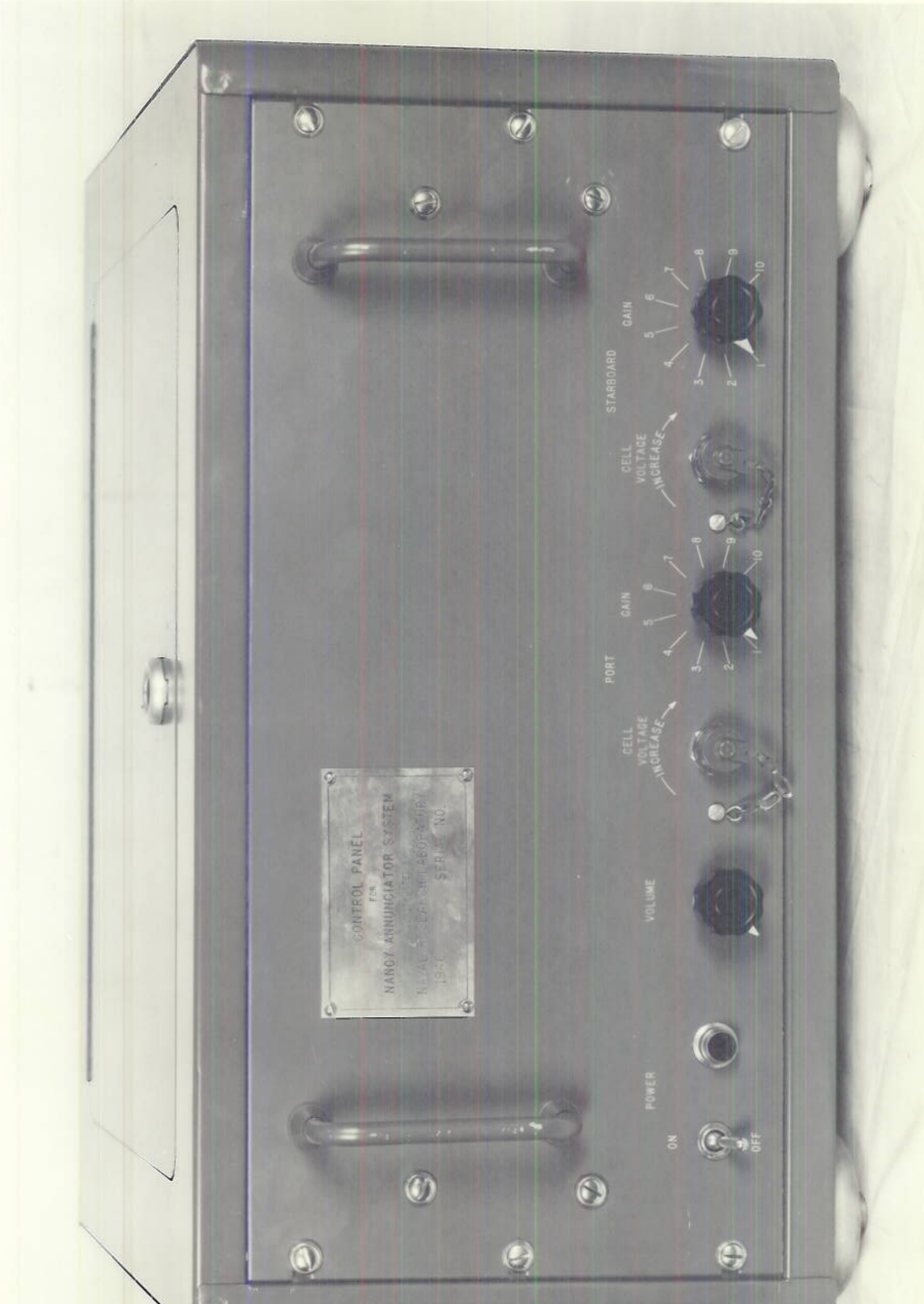
DECLASSIFIED



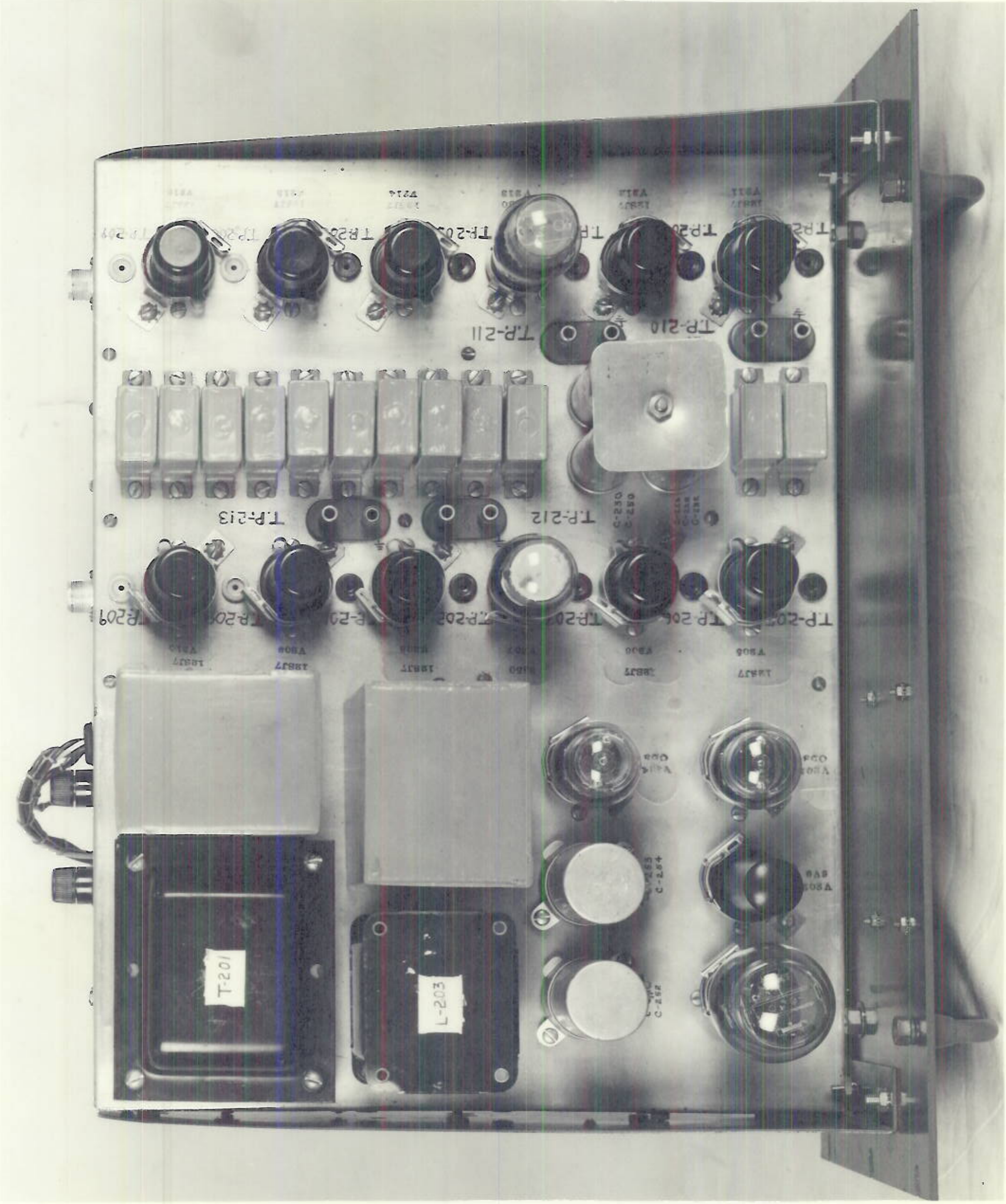
PREAMPLIFIER MODEL 2: TOP VIEW



PREAMPLIFIER MODEL 2: BOTTOM VIEW



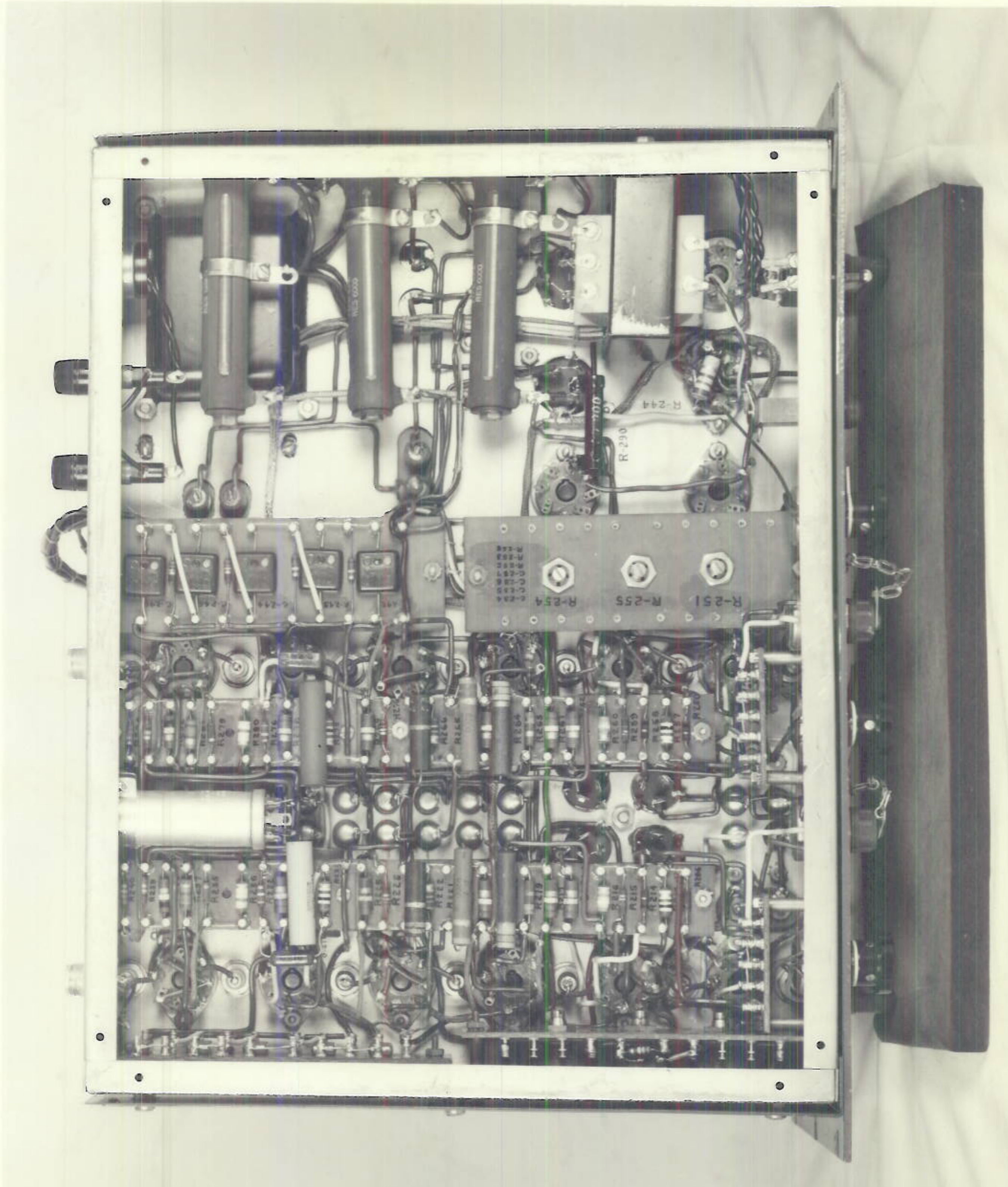
LEFT TO RIGHT: CELL HOUSING, PREAMPLIFIER, AND JUNCTION BOX



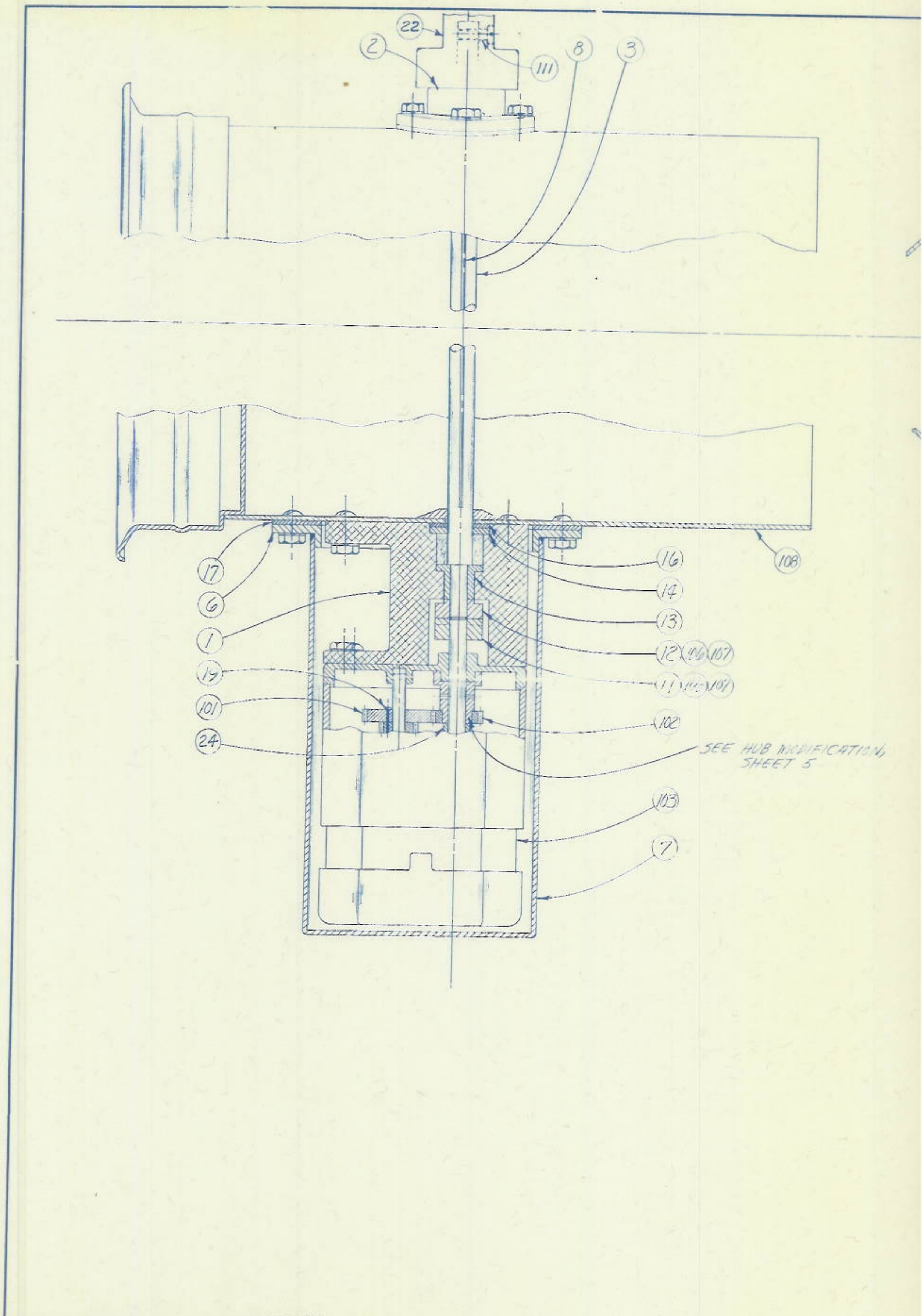
CONTROL PANEL CHASSIS: TOP VIEW

DECLASSIFIED

PLATE 9



CONTROL PANEL CHASSIS: BOTTOM VIEW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12
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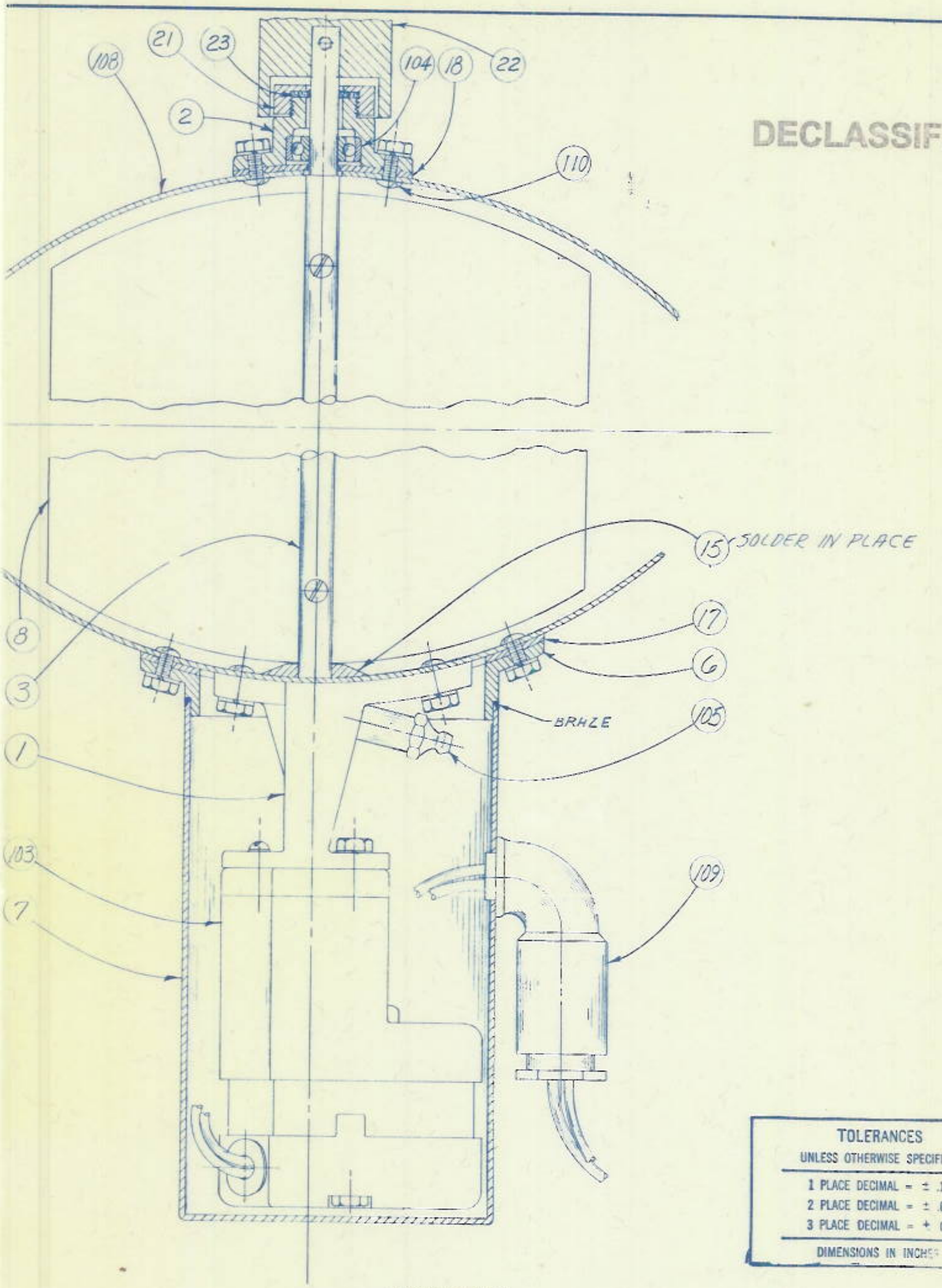
101
24
SEE HUB MODIFICATION,
SHEET 5
103
7

DECLASSIFIED



TOLERANCES
UNLESS OTHERWISE SPECIFIED
1 PLACE DECIMAL = ± .1
2 PLACE DECIMAL = ± .01
3 PLACE DECIMAL = ± .005
DIMENSIONS IN INCHES

ALTERATION TABLE

REFERENCE DRAWINGS

DRAWN	RHB	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED		CPS	[signature] FOR DIRECTOR
CHECKED	GP-1?		
APPR'V'D	[illegible]		COMDR. U.S.N.

NAVAL RESEARCH LABORATORY
WASHINGTON 20. D. C.

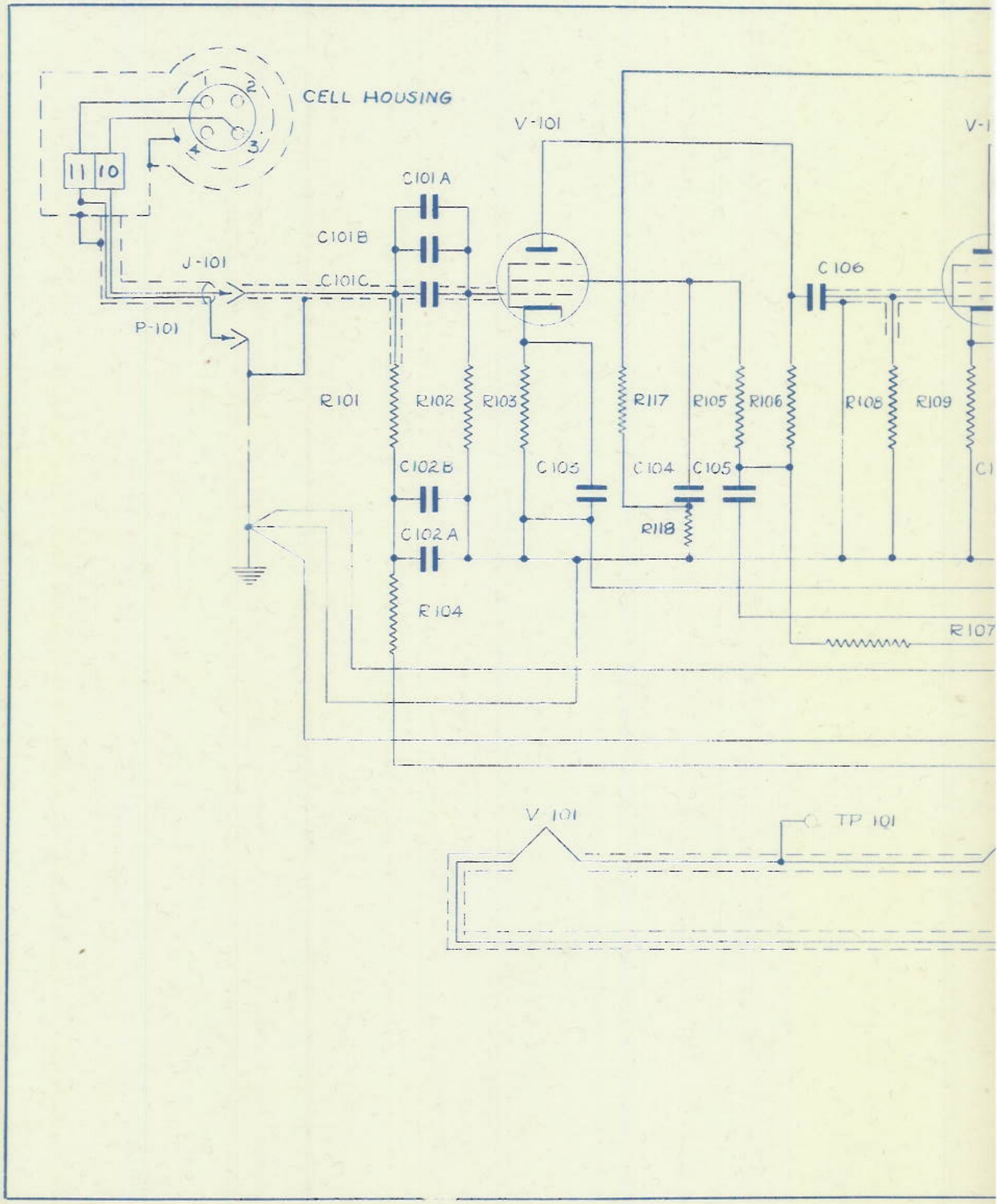
SEARCHLIGHT MODULATOR
ASSEMBLY

SCALE: FULL SIZE DATE OCT. 3, 1945

F 917A

NAVEXOS-2142

H-3019 6 SHEETS SHEET 1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2
4
3
11
10
J-101
P-101
C101A
C101B
C101C
V-101
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C102B
C102A
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R109
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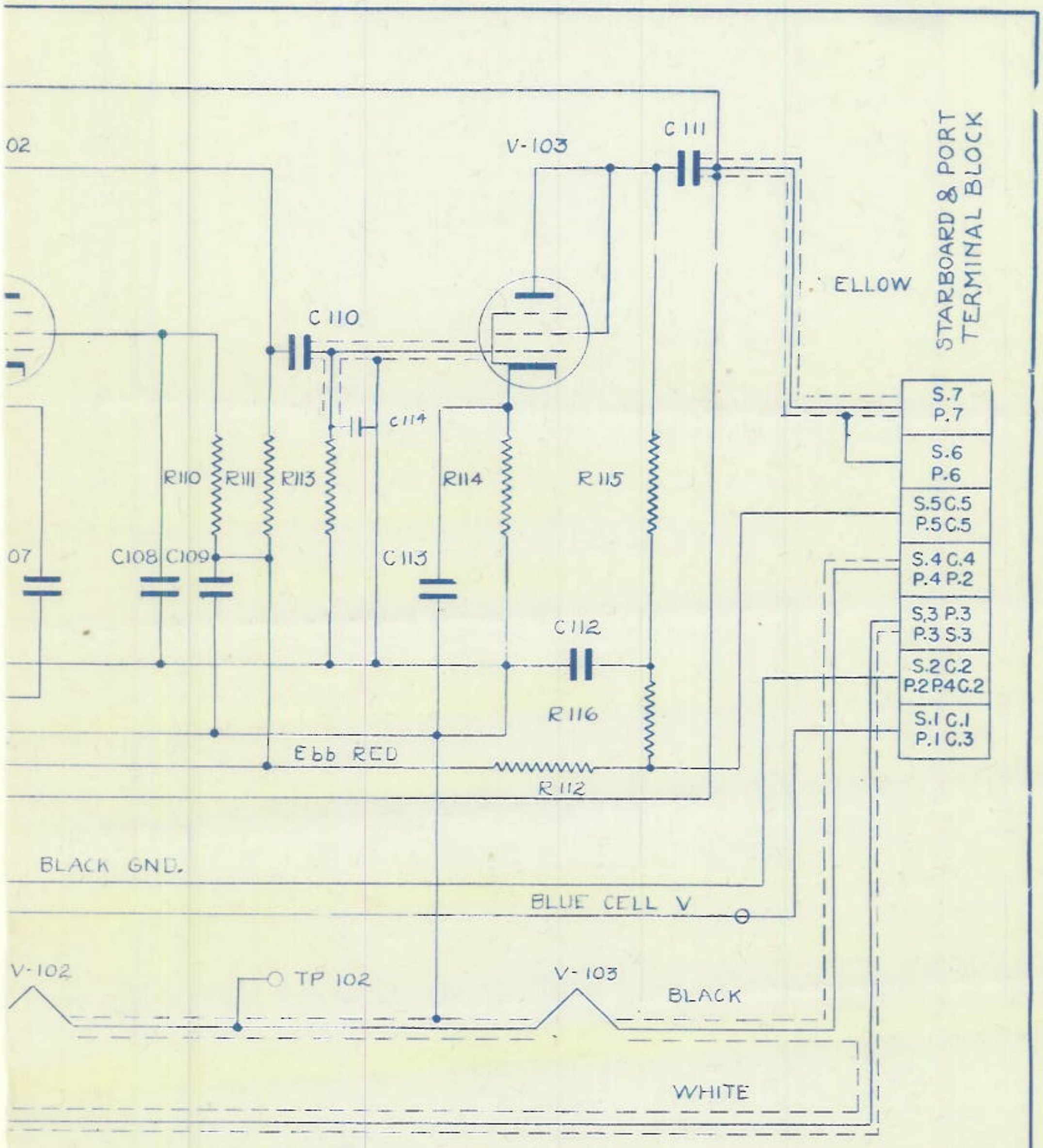
V-101
TP 101

DECLASSIFIED



ALTERATION TABLE

DRAWN	
TRACED	
CHECKED	
APPROVED	
IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIV.
FOR DIRECTOR	
COMDR. U.S.N.	

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

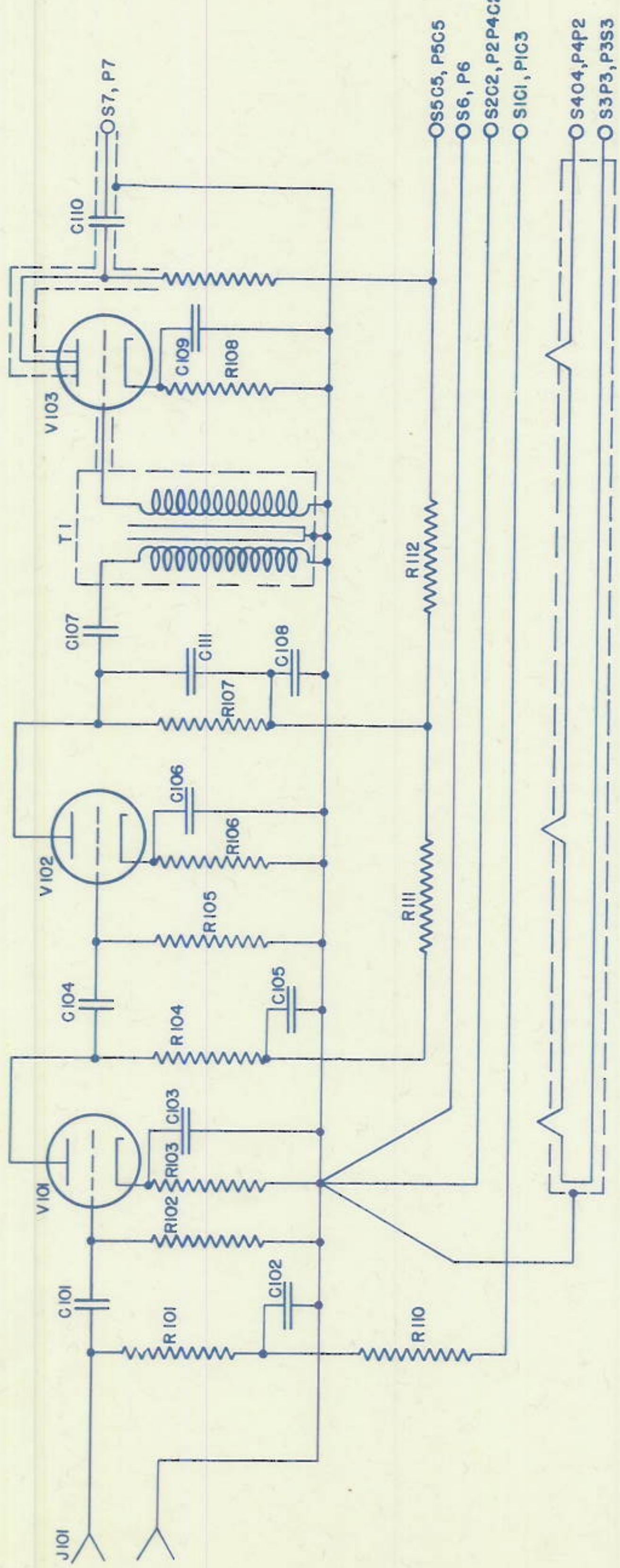
NANCY ANNUNCIATOR SYSTEM
CELL HOUSING AND
PREAMPLIFIER WIRING

SCALE

DATE MAR. 13, 1946

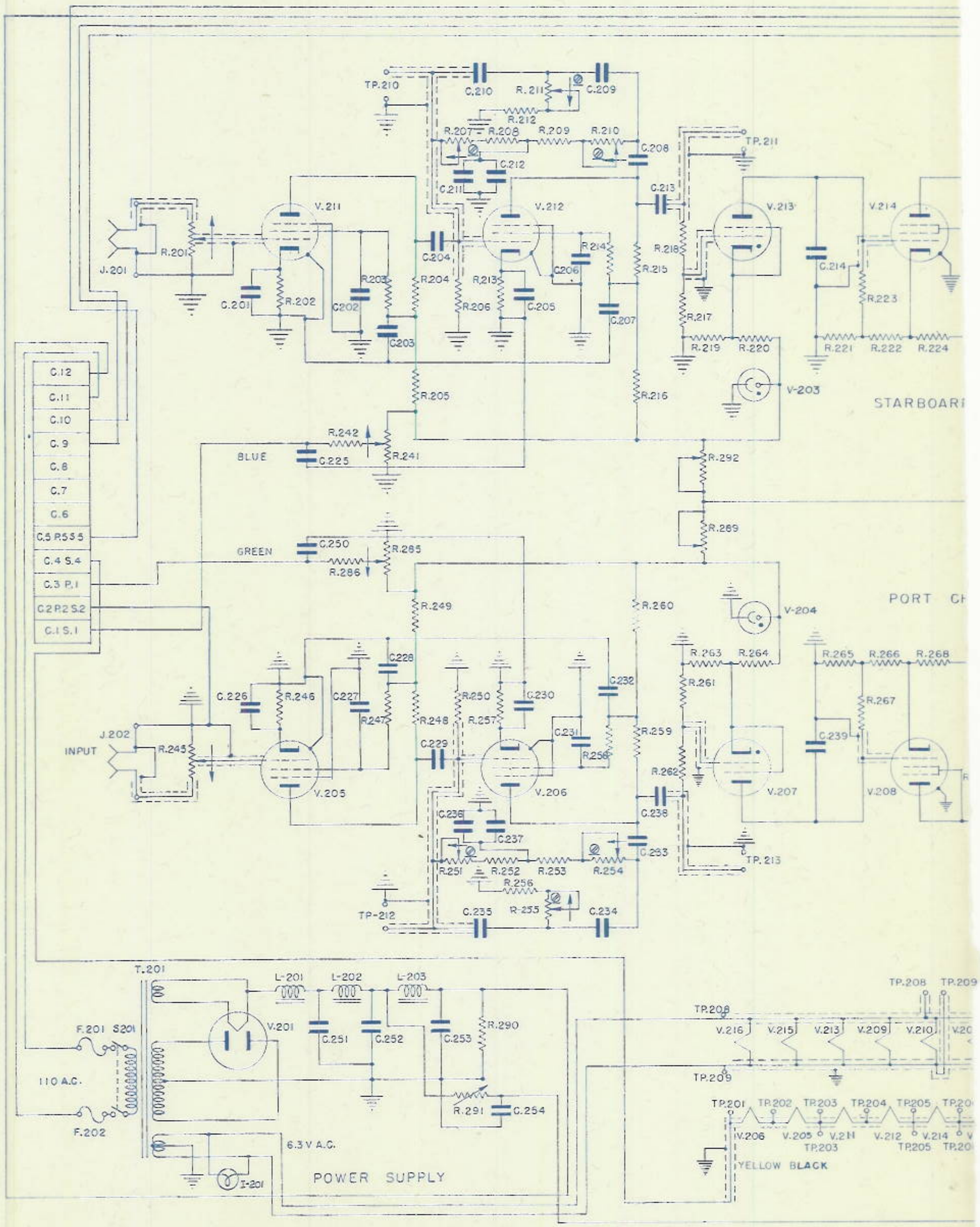
H-3019

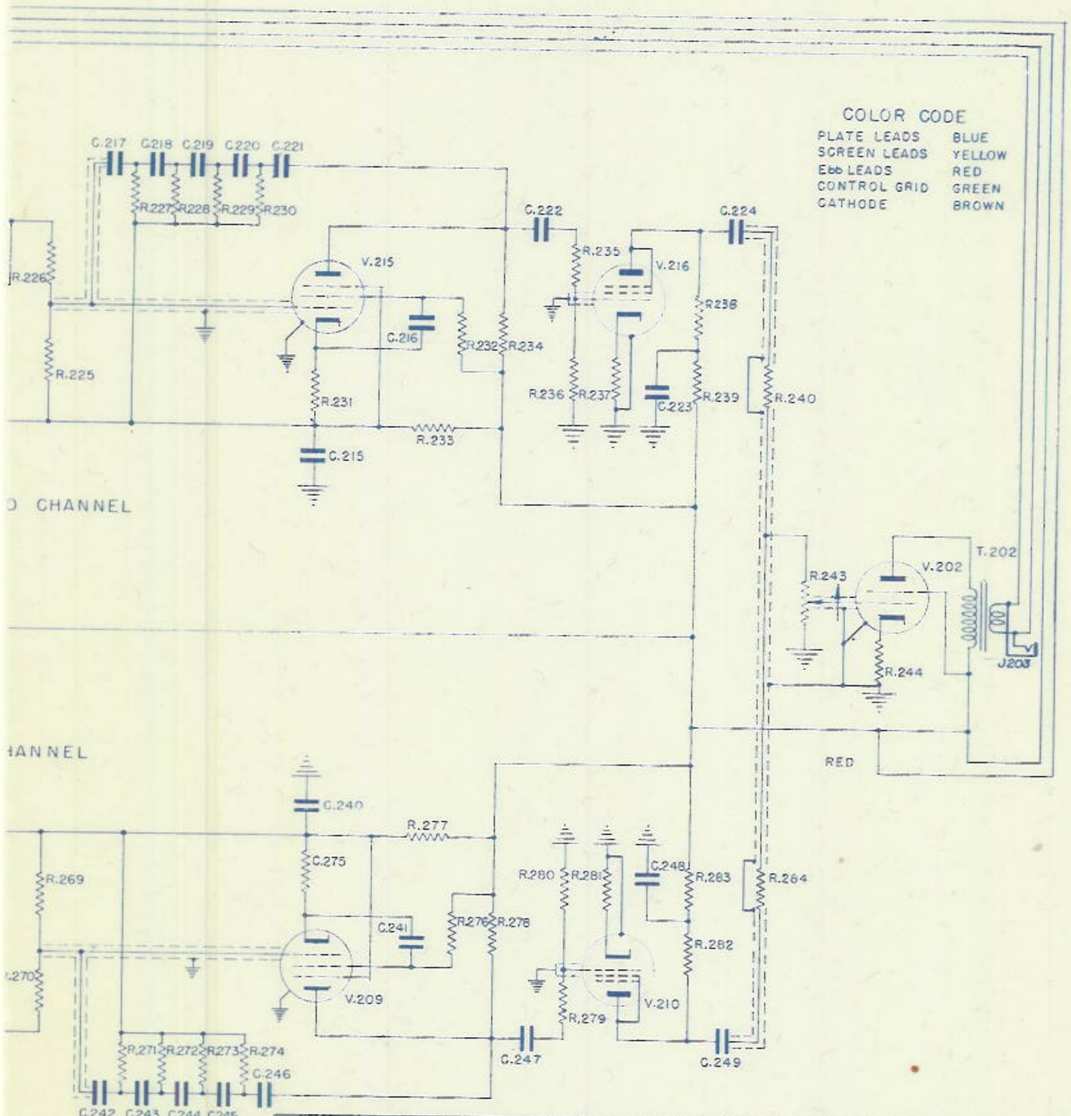
AA 9835A PLATE 12



PREAMPLIFIER MODEL 2 WIRING

PLATE 13


TP.210
C.210
R.211
C.209
R.212
R.207
R.208
R.209
R.210
C.208
TP.211
C.212
C.211
C.213
V.211
V.212
V.213
V.214
J.201
R.201
C.204
R.214
R.218
R.215
C.214
C.206
R.203
R.204
R.213
R.223
C.201
R.202
C.202
R.206
C.205
C.207
R.217
C.203
R.219
R.220
R.221
R.222
R.224
C.12
C.11
C.10
C.9
C.8
C.7
C.6
C.5 P.5 S.5
C.4 S.4
C.3 P.1
C.2 P.2 S.2
C.1 S.1
R.205
R.216
V-203
STARBOARD
R.242
BLUE
C.225
R.241
R.292
R.269
GREEN
C.250
R.285
R.286
PORT
R.249
R.260
V-204
R.263
R.264
R.265
R.266
R.268
C.226
R.246
C.227
C.228
R.250
R.257
C.230
C.232
R.261
R.267
R.247
R.248
J.202
INPUT
R.245
C.229
C.231
R.258
R.259
C.239
R.262
V.205
V.206
V.207
V.208
C.236
C.237
C.238
C.233
R.251
R.252
R.253
R.254
TP.213
R.256
R-255
TP-212
C.235
C.234
T.201
L-201
L-202
L-203
V.201
F.201
S201
C.251
C.252
C.253
R.290
110 A.C.
R.291
C.254
F.202
6.3 V A.C.
I-201
POWER SUPPLY
TP.208
TP.209
V.216
V.215
V.213
V.209
V.210
TP.201
TP.202
TP.203
TP.204
TP.205
V.206
V.205
V.211
V.212
V.214
YELLOW
BLACK



ALTERATION TABLE

DELINEATOR	WT DE GROOT	IN CHARGE OF RADIO DRAFTING	CHIEF DRAFTSMAN
TRACER			
CHECKER			

APPROVAL

RADIO ENGINEER	SUPT. OF RADIO DIVISION

FOR DIRECTOR

COMDR. U. S. N.

BUREAU OF SHIPS	REFERENCE

SYMBOLS AND THEIR EQUIV. TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1	±.0005
SYMBOL 2	±.0010
SYMBOL 2½	±.0030
SYMBOL 3	±.0050
SYMBOL 3½	±.0100
SYMBOL 4	±.0250
SYMBOL 5	

U. S. NAVAL RESEARCH LABORATORY
"BELLEVUE," ANACOSTIA, D. C.

NANCY ANNUNCIATOR SYSTEM

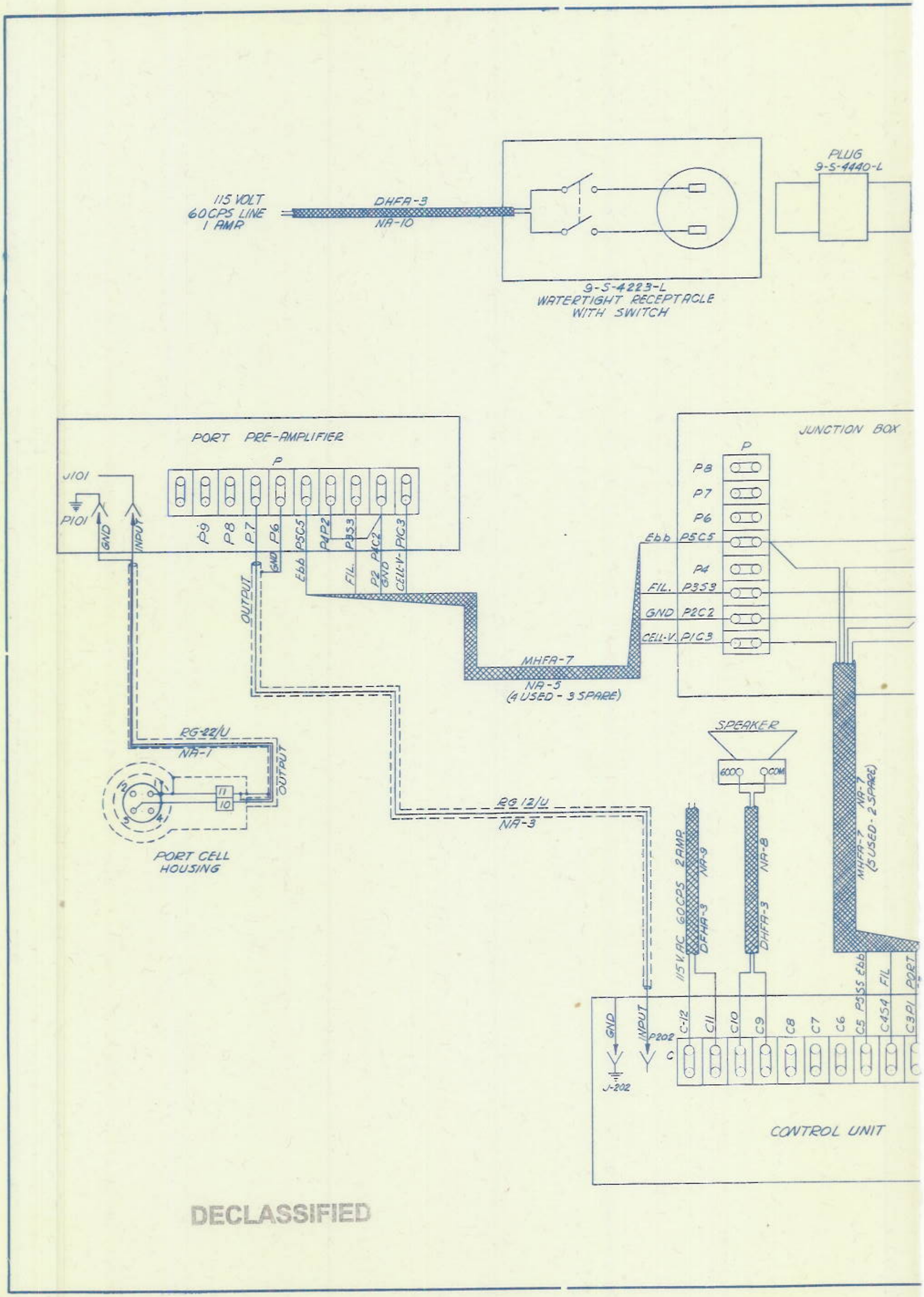
CONTROL UNIT WIRING

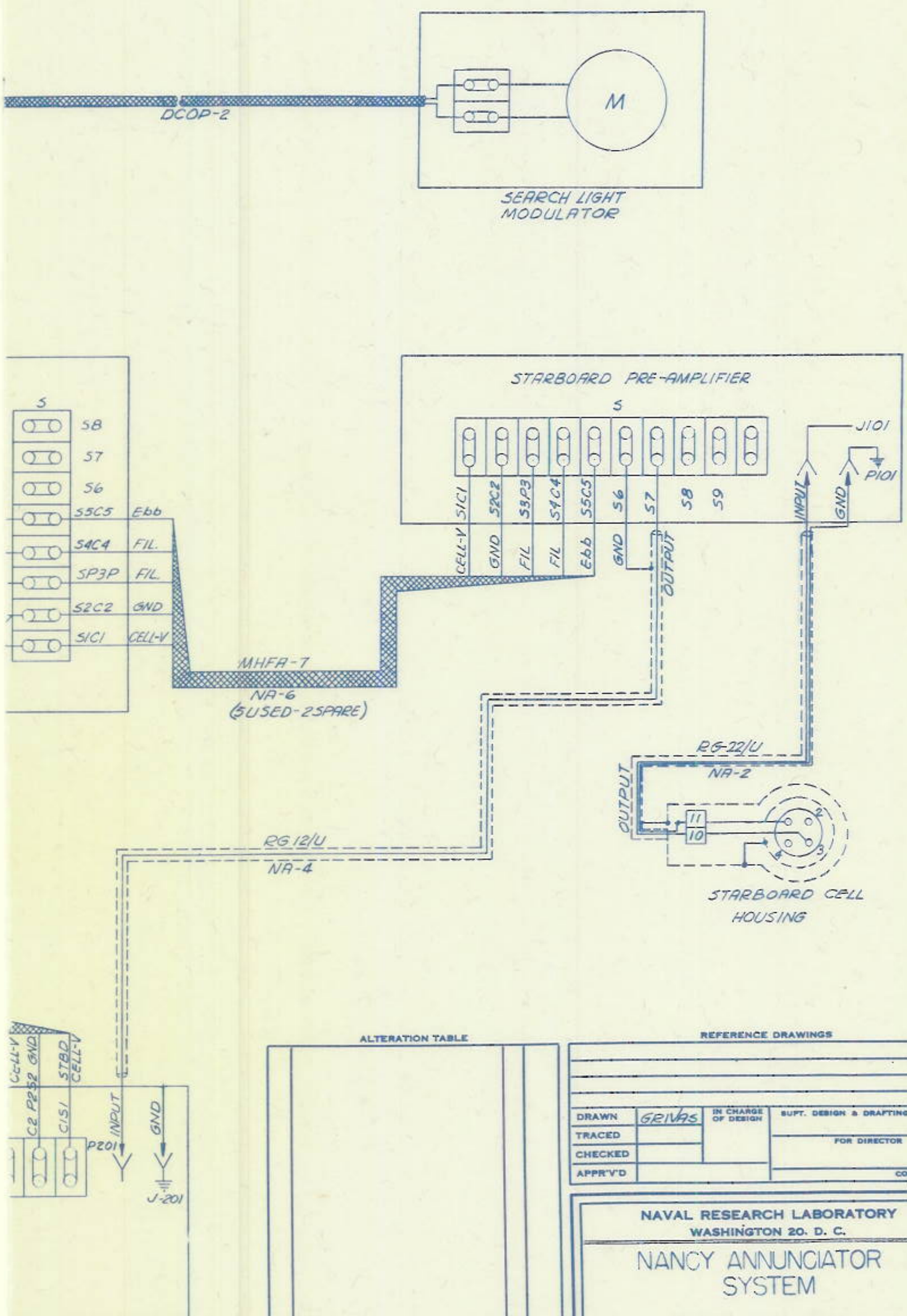
SCALE

DATE 3/8/46

F 964A

H-3019


115 VOLT
60CPS LINE
1 AMP
DHFA-3
NA-10
PLUG
9-S-4440-L
9-S-4223-L
WATERTIGHT RECEPTACLE
WITH SWITCH
PORT PRE-AMPLIFIER
J101
P101
GND
INPUT
P
P9 P8 P7 P6 P5C5 P4P2 P3S3 P2 P4C2 P1C3
OUTPUT
GND
Ebb
FIL.
P2 GND
CELL-V.
JUNCTION BOX
P8
P7
P6
Ebb P5C5
P4
FIL. P3S3
GND P2C2
CELL-V. P1C3
MHFA-7
NA-5
(4 USED - 3 SPARE)
RG-22/U
NA-1
OUTPUT
11
10
PORT CELL
HOUSING
RG 12/U
NA-3
SPEAKER
600
COM
115V. AC 60CPS 2AMP
DHFA-3
NA-9
DHFA-3
NA-8
MHFA-7 NA-7
(5 USED - 2 SPARE)
GND
INPUT
P202
C
J-202
C-12 C11 C10 C9 C8 C7 C6 C5 P3S5 Ebb C4S4 FIL C3P1 PORT
CONTROL UNIT



ALTERATION TABLE

REFERENCE DRAWINGS

DRAWN	GRIVAS	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED			FOR DIRECTOR
CHECKED			
APPR'V'D			CONDR. U.S.N.

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1........ ± .0005 SYMBOL 3........ ± .0050
SYMBOL 2........ ± .0010 SYMBOL 3½...... ± .0100
SYMBOL 2½...... ± .0030 SYMBOL 4........ ± .0250
SYMBOL 5..........

NAVAL RESEARCH LABORATORY
WASHINGTON 20. D. C.

NANCY ANNUNCIATOR SYSTEM

INTERUNIT WIRING DIAGRAM

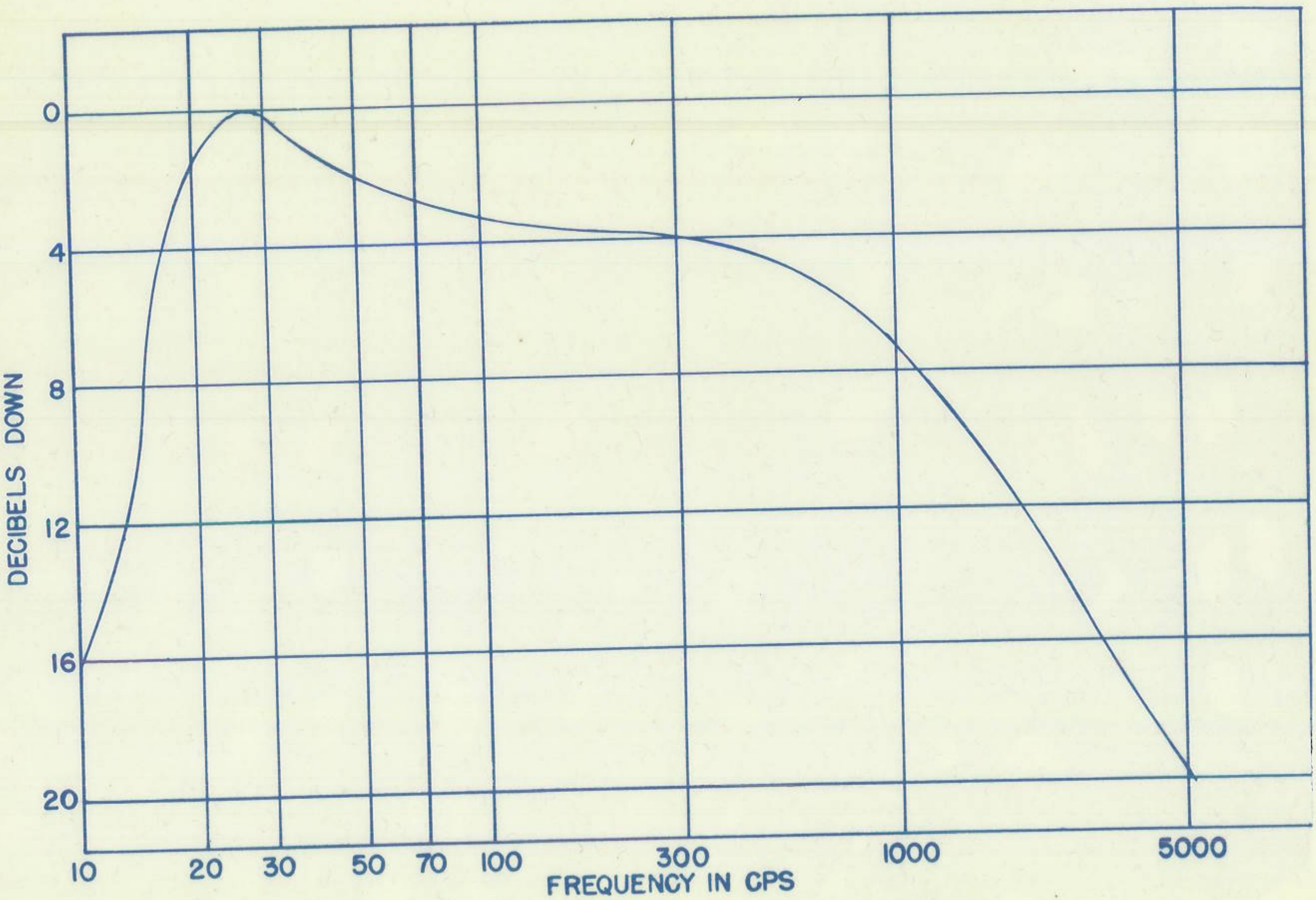
SCALE DATE MAR. 13, 1946

F 963A

NAVEXOS-2142

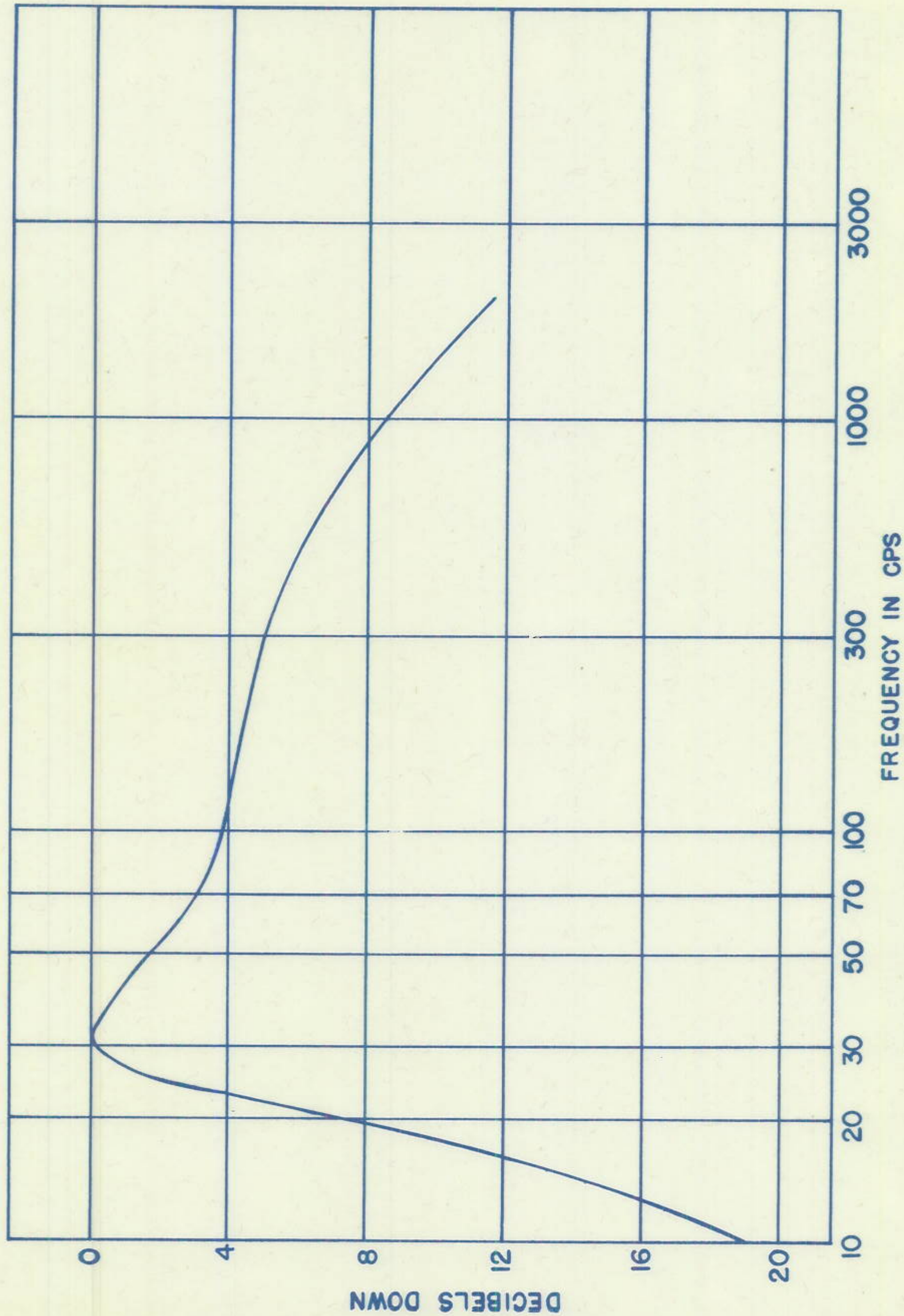
H-3019

SHEET 1 PLATE 15

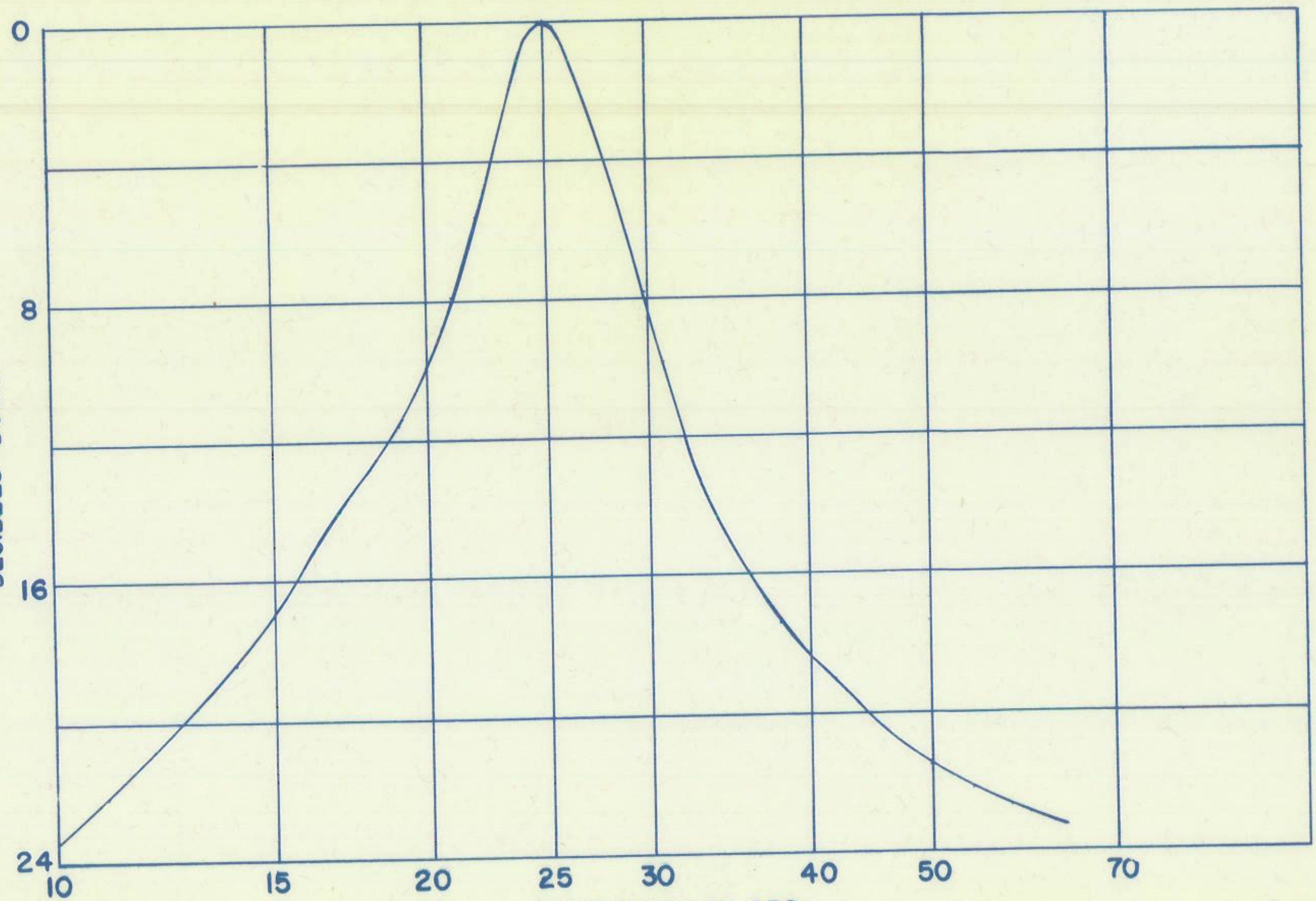


RESPONSE VERSUS FREQUENCY: PREAMPLIFIER MODEL I

DECLASSIFIED

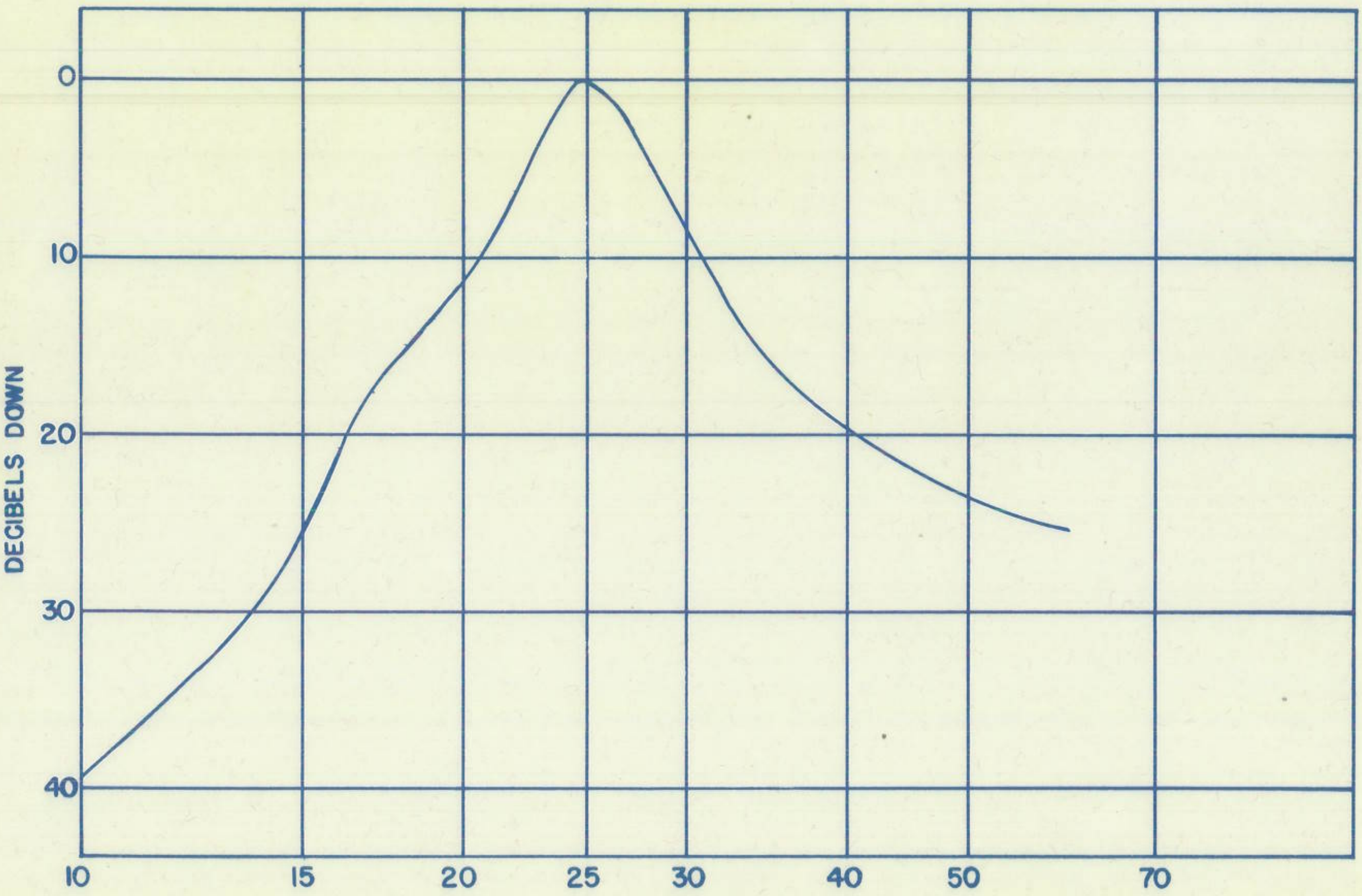


RESPONSE VERSUS FREQUENCY PREAMPLIFIER MODEL 2

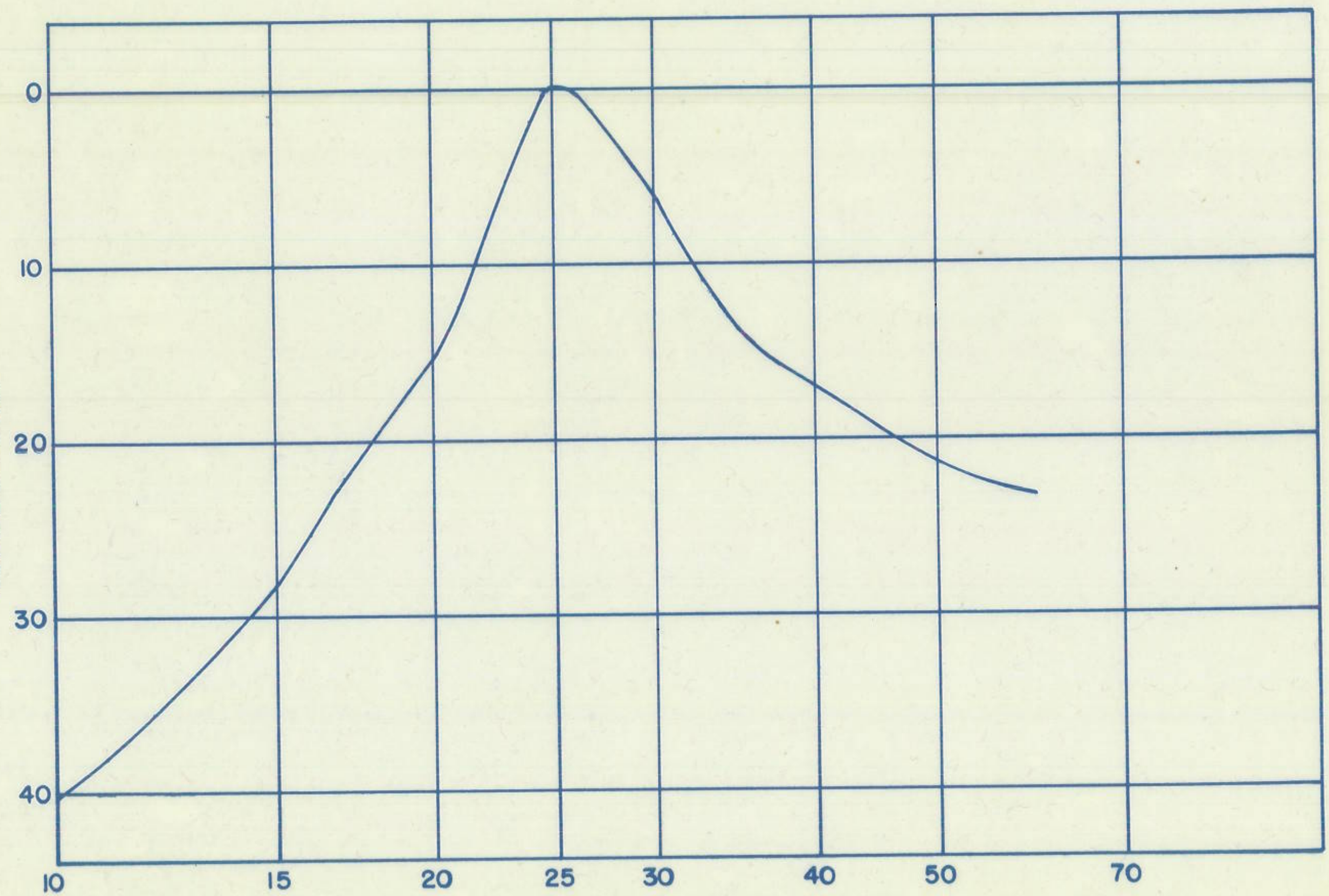


RESPONSE VERSUS FREQUENCY: MAIN AMPLIFIER

DECLASSIFIED



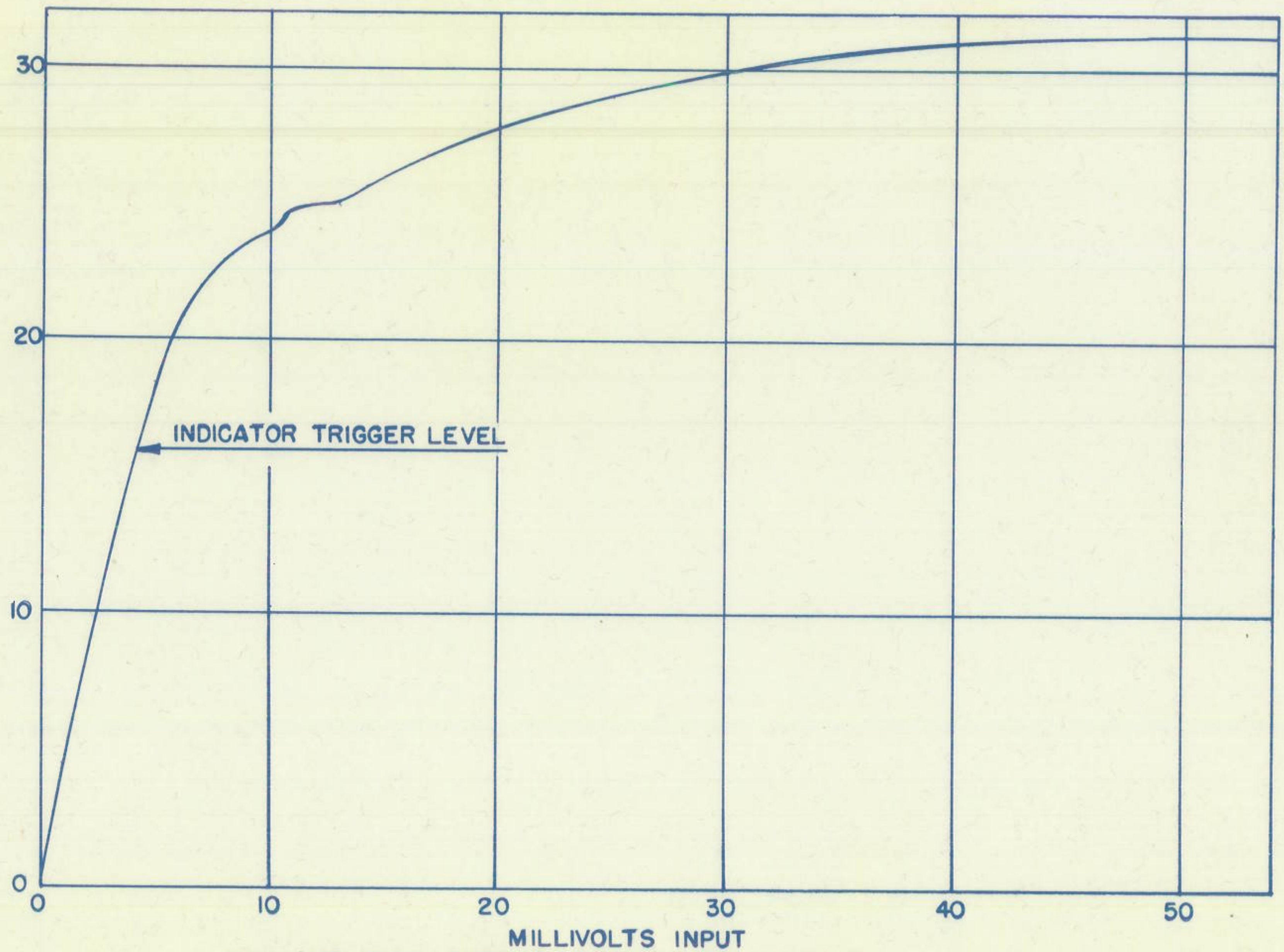
RESPONSE VERSUS FREQUENCY: MAIN AMPLIFIER PLUS PREAMPLIFIER MODEL I



RESPONSE VERSUS FREQUENCY : MAIN AMPLIFIER PLUS PREAMPLIFIER MODEL 2

H-3019

PLATE 20

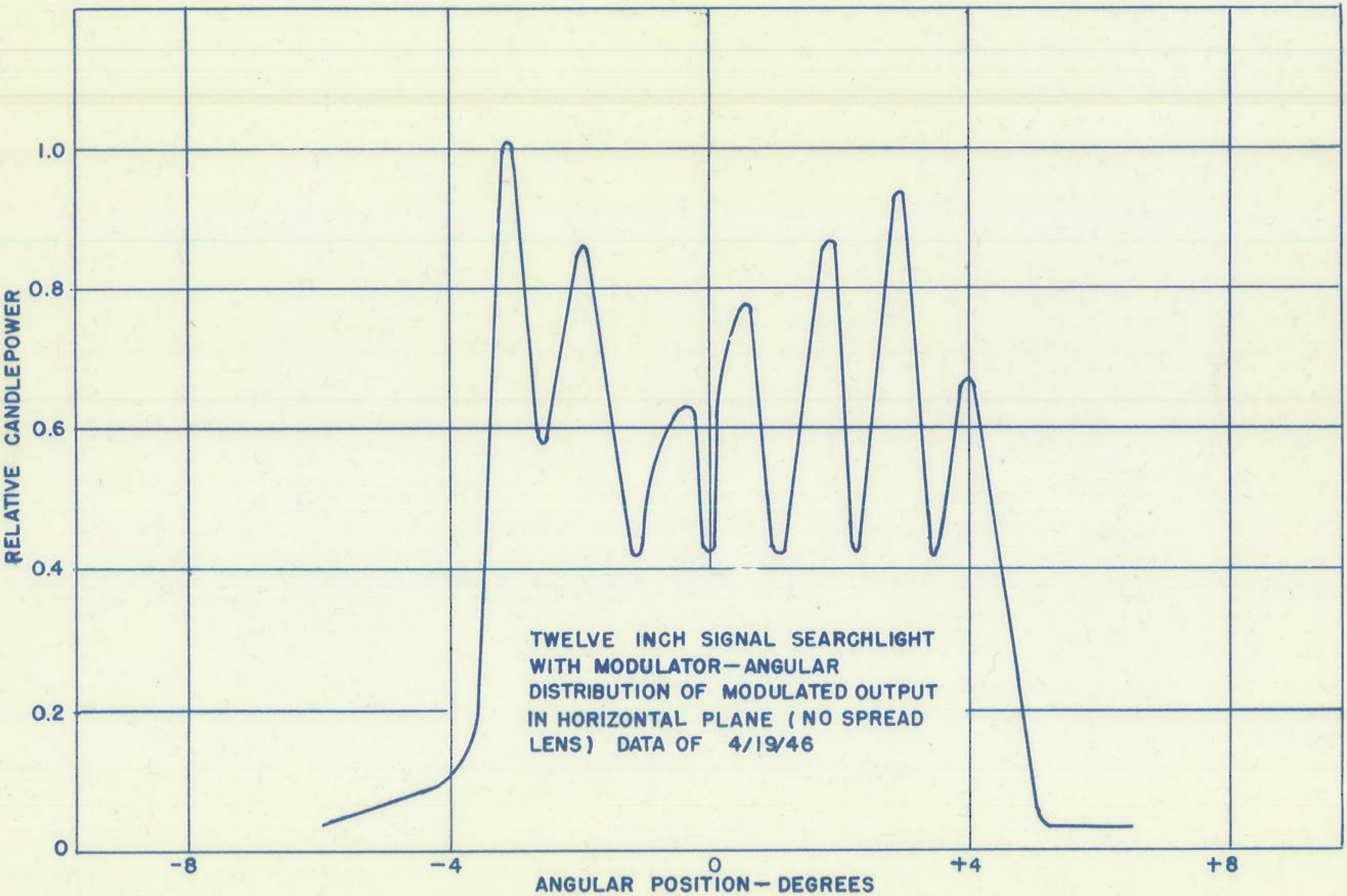


MAIN AMPLIFIER : OUTPUT VERSUS INPUT VOLTAGE

H-3019

PLATE 21

DECLASSIFIED



TRANSMITTER BEAM DISTRIBUTION — HORIZONTAL PLANE, NO SPREAD LENS

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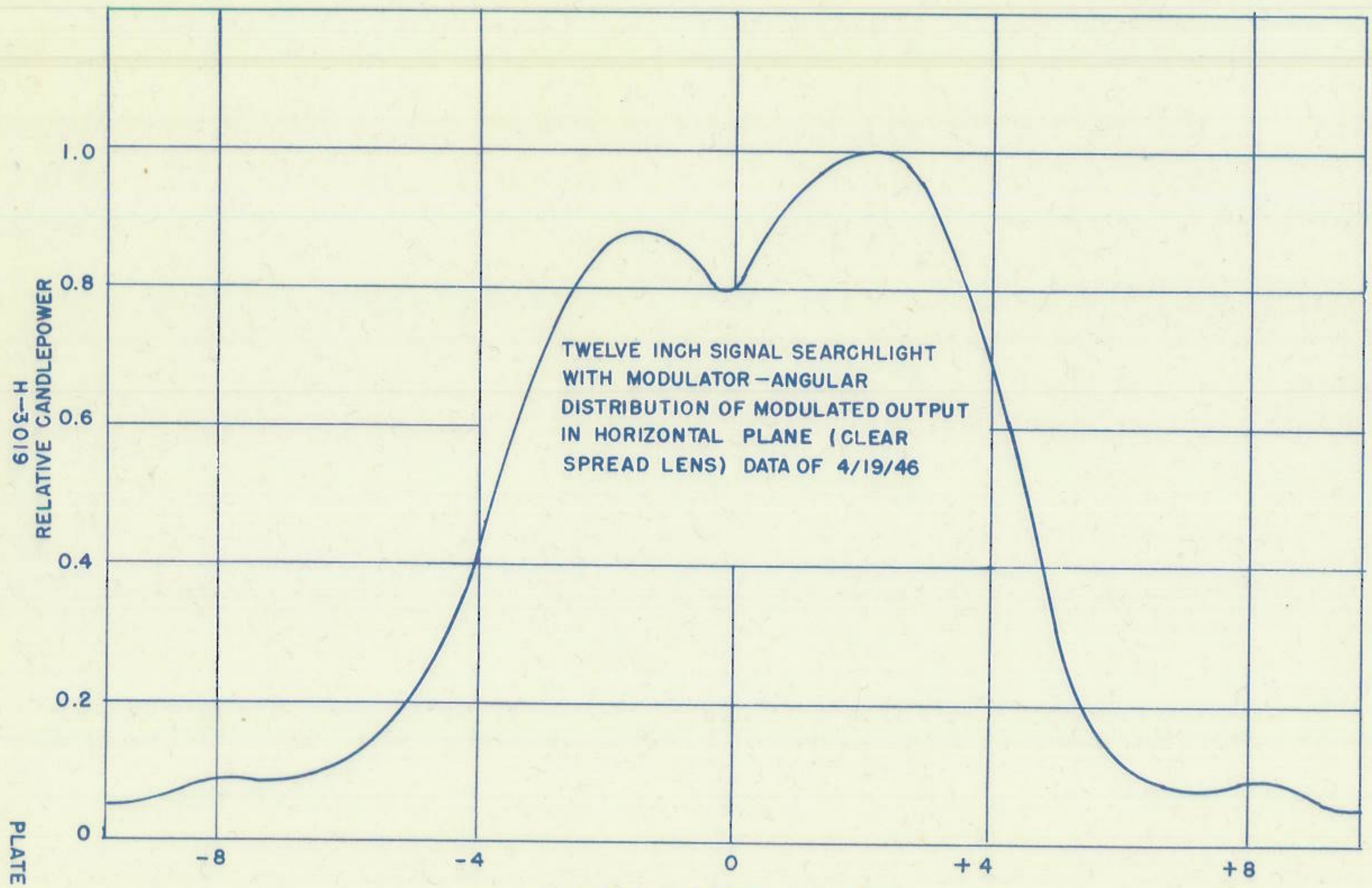
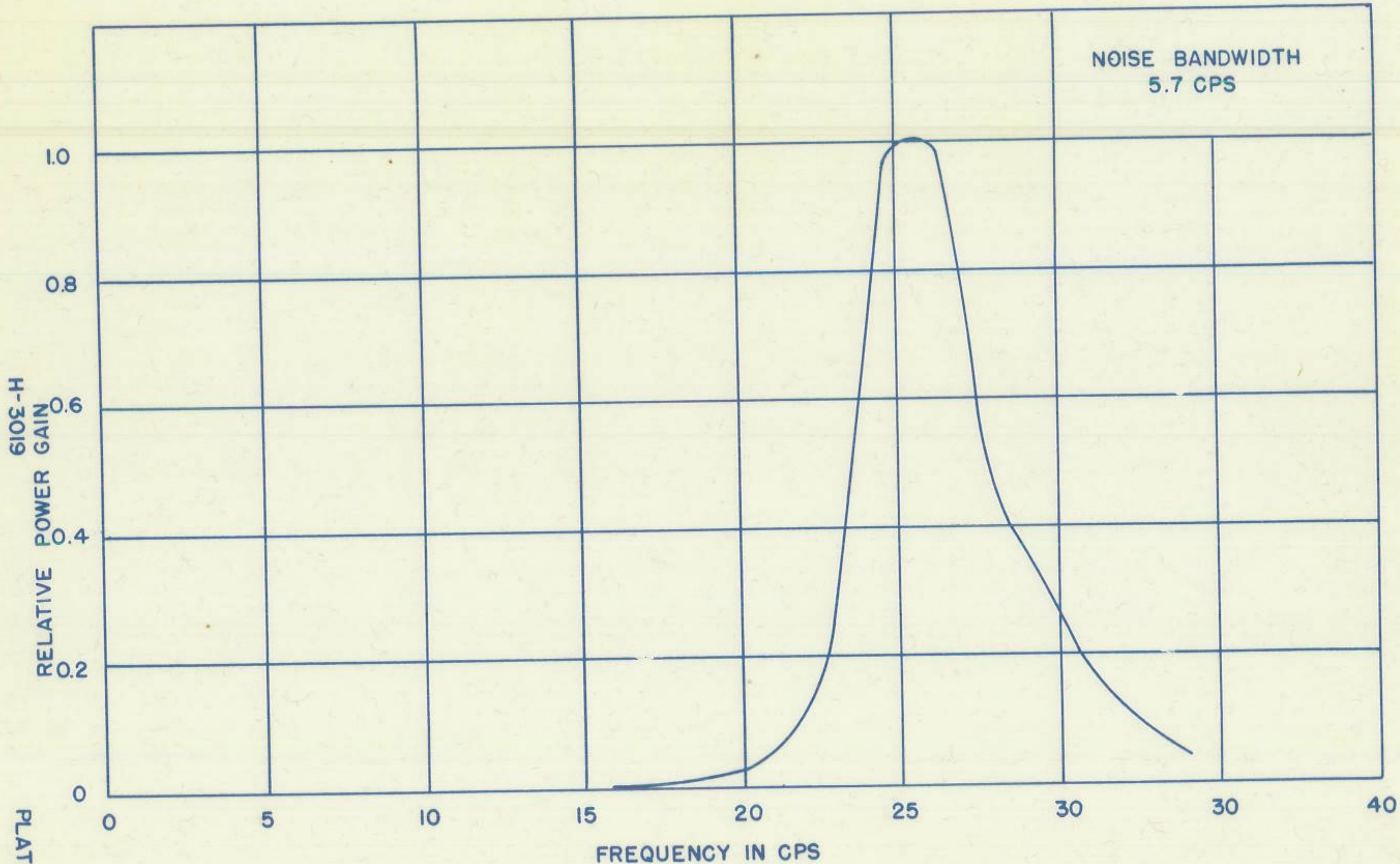
PLATE 22



TRANSMITTER BEAM DISTRIBUTION — HORIZONTAL PLANE, CLEAR SPREAD LENS

PLATE 23



RELATIVE POWER GAIN VS. FREQUENCY—MAIN AMPLIFIER PLUS PREAMPLIFIER MODEL 2

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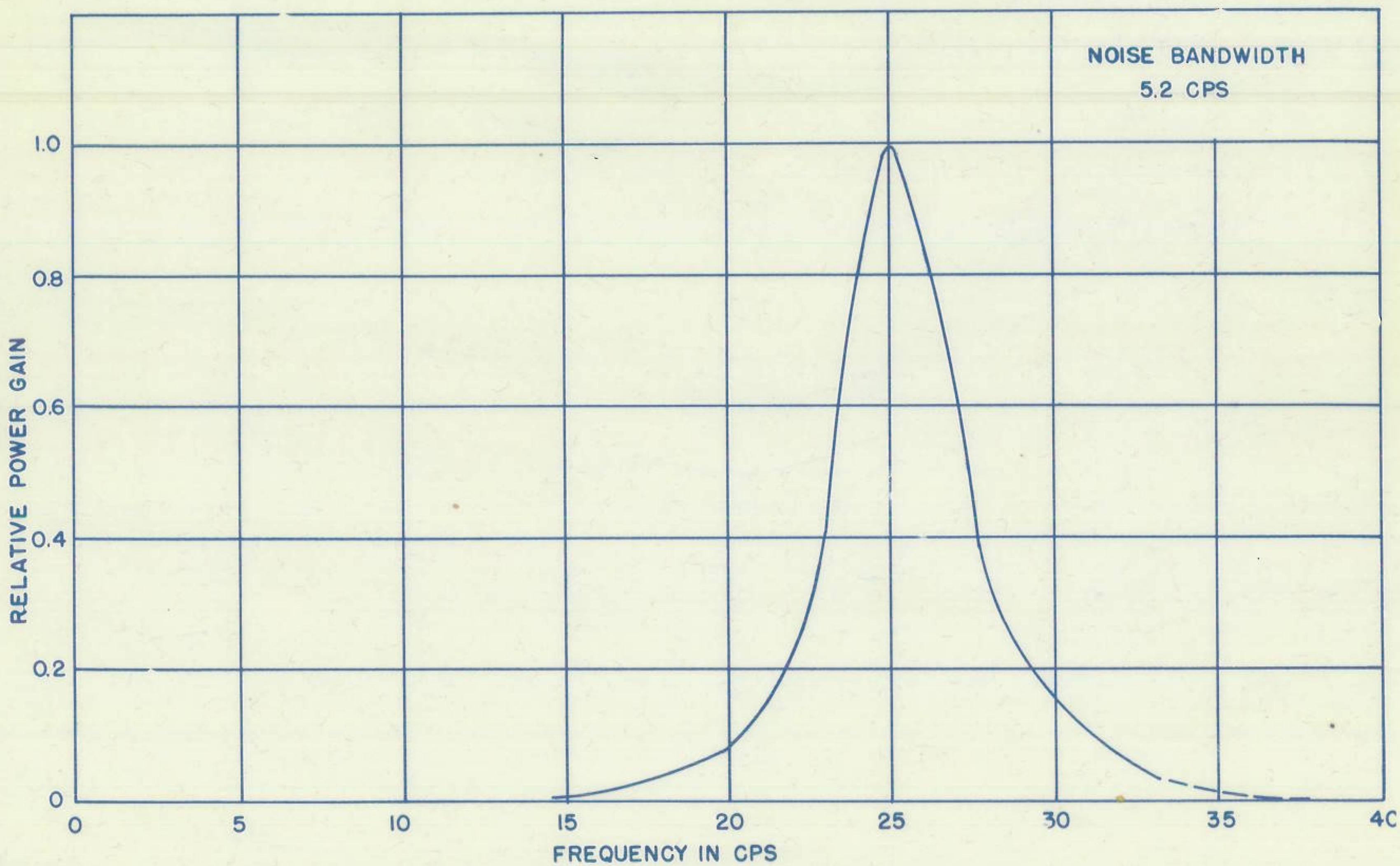
PLATE 24

DECLASSIFIED



RELATIVE POWER GAIN VS. FREQUENCY — MAIN AMPLIFIER PLUS PREAMPLIFIER MODEL I

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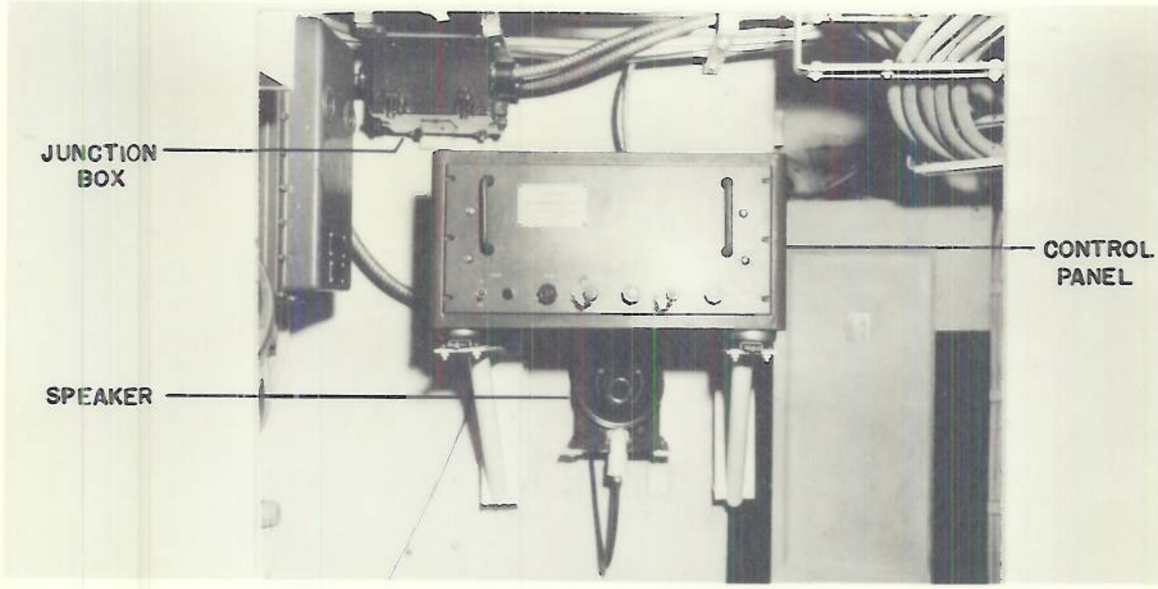
PLATE 25

DECLASSIFIED

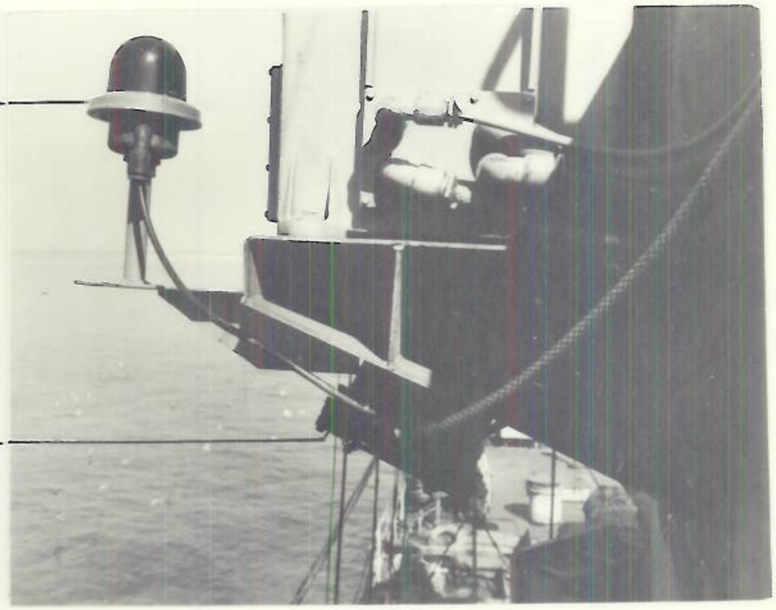


CONTROL PANEL AND SPEAKER
INSTALLATION CHART ROOM

CELL HOUSING INSTALLATION

ANNUNCIATOR SYSTEM INSTALLIATION
ON EPCE (R) 852

DECLASSIFIED

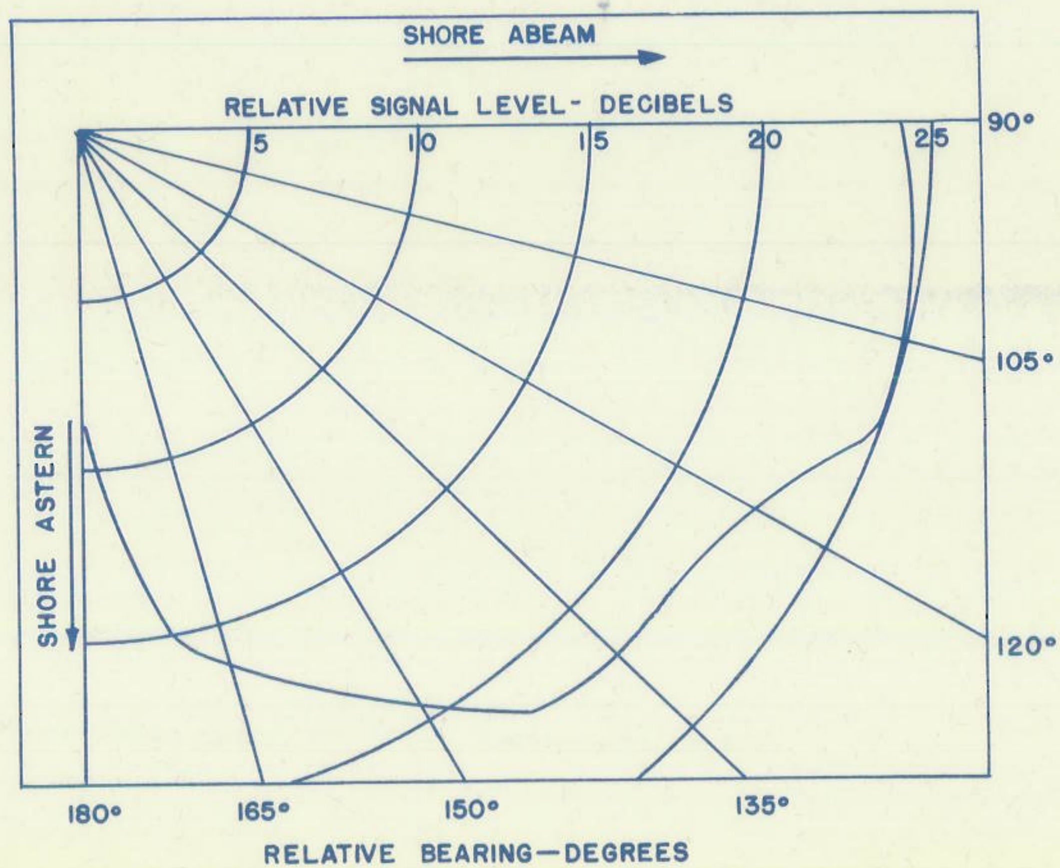


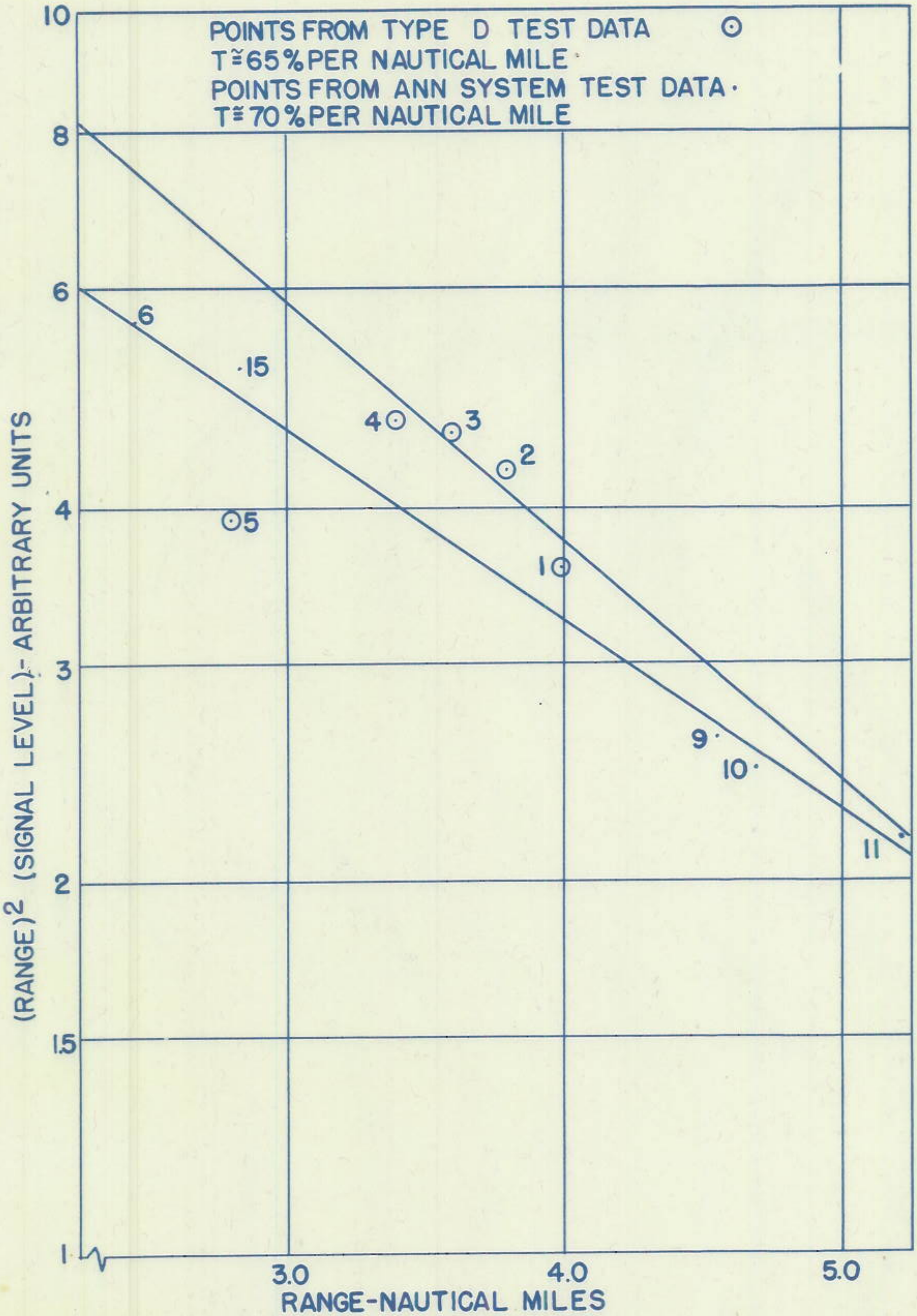
STARBOARD CELL HOUSING AND
PRE AMPLIFIER MOUNTING

SEARCHLIGHT MODULATOR ON
PORT SEARCHLIGHT

ANNUNCIATOR SYSTEM INSTALLATION
ON EPCE(R) 852

RESPONSE VS. RELATIVE BEARING OF SIGNAL FOR STARBOARD RECEIVER, USS CALLAO, IX 205

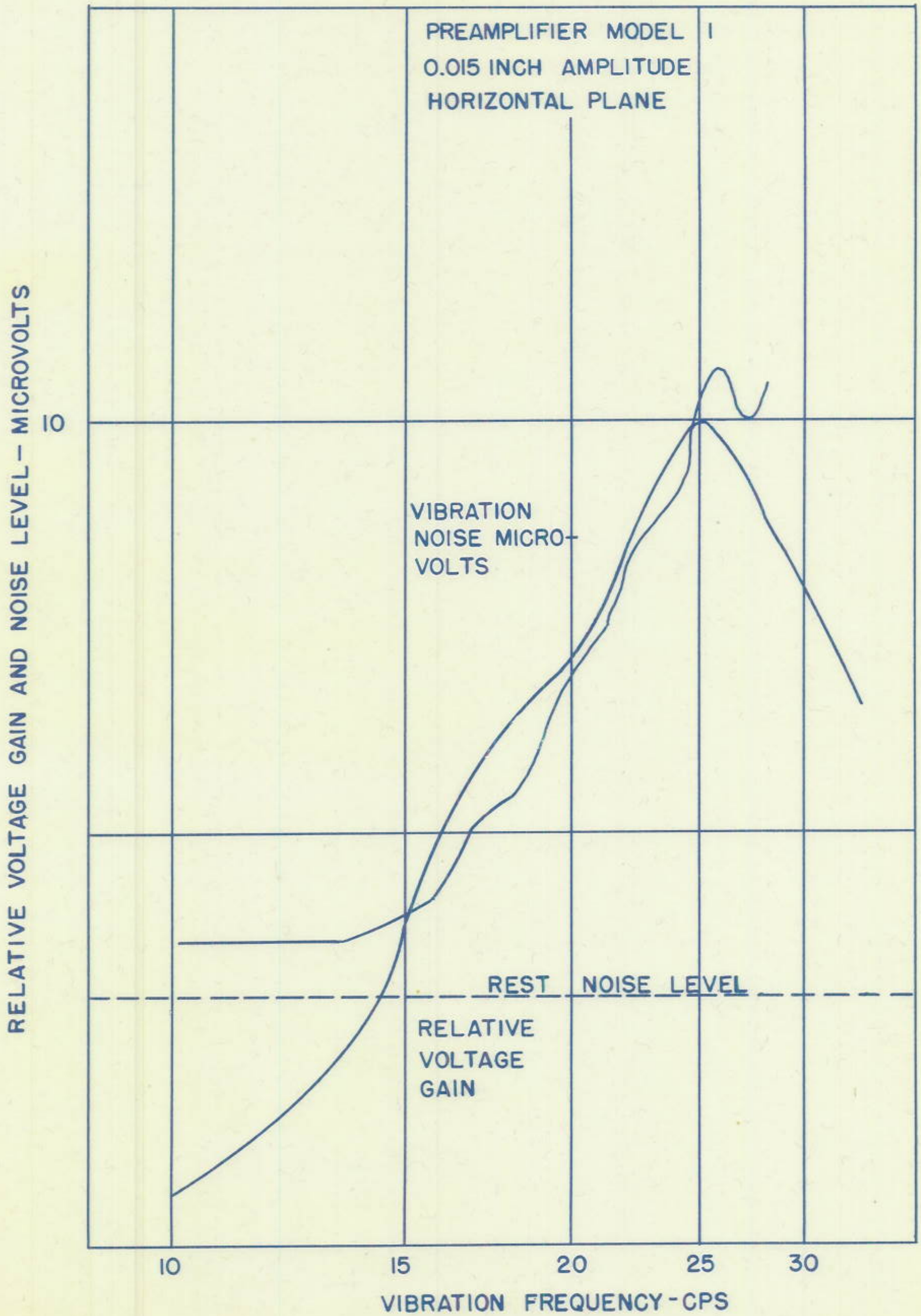




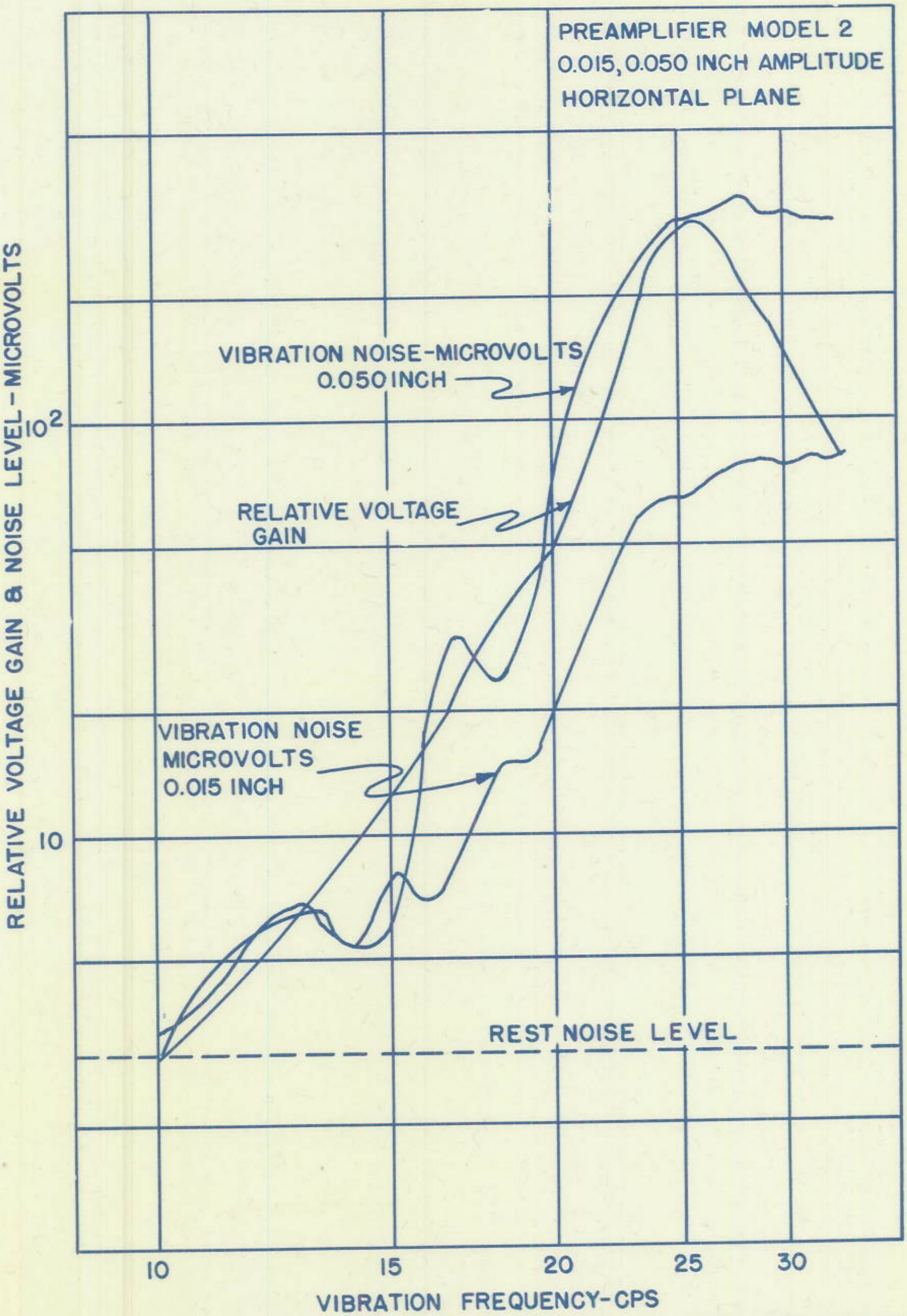
DATA PLOT ATMOSPHERIC TRANSMISSION ESTIMATION

H-3019

PLATE 29



PREAMPLIFIER MODEL I: NOISE LEVEL VS. VIBRATION FREQUENCY



PREAMPLIFIER MODEL 2: NOISE LEVEL VS. VIBRATION FREQUENCY

H-3019 PLATE 31

Distribution:

BuShips Code 921	5
Officer-in-Charge, BuShips Test Station, Fort Miles, Lewes, Delaware.	1
Commanding Officer, U.S.S. Callao, IX-205, c/o Fleet Post Office, New York, New York.	1
Commanding Officer, EPCER-852, c/o Fleet Post Office, New York, New York.	1
ONR	1