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SPECIAL ELECTRONICS RESEARCH AND DEVELOPMENT DIVISION -
SPECIAL DEVELOPMENT SECTION

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MODIFICATION OF JM-1 SONO BUOY EQUIPMENT FOR USE IN TORPEDO TIMING

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- Report 2551-R

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Preliminary Pages.....a-c
Numbered Pages.....3
Plates.....4
Distribution List.....c

BuShips Problem S303.2R-C

ABSTRACT

A method whereby standard JM-1 type Sono Radio Buoy equipment can be altered for use in automatically timing torpedos over their test run is described in this report. By restricting the acoustic bandwidth of the equipment, using a directional hydrophone, and preventing limiting in the transmitter, the system was improved sufficiently to warrant its installation for use on the Naval Torpedo Testing Range, Piney Point, Maryland.

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TABLE OF CONTENTS

Distribution:

BuShips (10)
R & S Lab, SanDiego (1)
JEIA (1)

INTRODUCTION

1. The Naval Research Laboratory was requested by the Bureau of Ships in their letter No. 2358 (945) of 2 October 1944 to modify a JM-1 type Sono Buoy transmitter and an RBF receiver to aid in automatically charting the progress of a torpedo at the Naval Torpedo Testing Range, Piney Point, Maryland.

2. In the past, torpedo timing has been accomplished by observing the wake of the torpedo as it passes an observation raft and relaying this information back to the firing barge where the travel time is measured with a stop watch. The measured time is then corrected by the amount of time the bubbles take to reach the surface. There are several serious errors in this method and the advent of a wakeless torpedo will make it impractical.

3. The suggested plan was to use a hydrophone to pick up the noise from the torpedo and transmit it back to the firing barge where it would be rectified and recorded on an Esterline Angus Recording Voltmeter. The maximum sound peak would indicate the time at which the torpedo was nearest to the hydrophone. Initial tests were made with a standard JM-1 Sono Radio Buoy and an RBK receiver, but the results were unsatisfactory because the hydrophone was not directional and the recorded sound peak was broad. However, the results of this test were considered promising enough to warrant further work on the problem. BuShips recommended the modification of a JM-1-type transmitter and an RBF receiver to restrict the acoustic bandwidth to the range between 15 and 20 thousand cycles per second in order to improve the hydrophone directivity and reduce background noise. The use of a Brush C-37 5-foot hydrophone was also recommended.

DESCRIPTION OF MODIFICATIONS AND TESTS

4. It was desirable to accomplish the modifications described above by as simple a means as possible to permit modification of further units with the parts and personnel on hand at the Torpedo Testing Range. Simple RC networks were utilized in the first attempts to restrict the audio bandwidth in both the transmitter and receiver. This method provided a rising audio characteristic in the transmitter, but no sharp rise in the 15 to 20 Kc/s band was obtainable. Slight peaking in the band was provided by replacing the cathode bypass condenser in one audio stage with a series resonant circuit resonating at 17,500 cycles per second. The values of audio coupling condensers were reduced to decrease the response at low frequencie A plot of the frequency response of the audio amplifier in the transmitter resulting from the changes described above is shown on Plate (1).

5. The internal resistance of the recording D.C. Voltmeter is approximately 500 ohms which was to be the load on the rectified output of the RBF receiver. For such a low resistance load a selenium rectifier was chosen because it has the advantage of introducing less resistance in the circuit than ordinary vacuum tube rectifiers, although its efficiency falls off rapidly above 5 Kc/s. Fortunately, the RBF receiver incorporates a 17 Kc. beat oscillator and mixer which may be inserted in the audio amplifier.

For use with this problem, the oscillator was retuned to 17.8 Kcs. which, when mixed with the incoming audio signal, gave predominant difference frequencies in a band from 0 to 2500 c.p.s. This is the range over which the selenium rectifier is most efficient.

6. A transmitter and a receiver with the modifications described in Paragraphs (3) and (4) were installed on the end of the NRL pier and the transmitter was connected to a Brush type C-37 hydrophone which was suspended horizontally in the Potomac River with its longitudinal axis parallel to the course of any small craft going by. Observations showed that the sound peak was recorded when the stern of the passing boat was opposite the center of the hydrophone. This preliminary test did not exactly simulate conditions to be encountered with the passage of a torpedo in that the speed of passing boats was about one fifth that of a torpedo and the sound output was much less. The slower speed was made comparable by slowing down the rate of chart feed on the recording voltmeter. In addition to the main peak recorded when the boat was directly opposite the hydrophone, two minor peaks were recorded on each side, apparently representing minor lobes in the directional pattern of the hydrophone. In most cases these minor peaks were well below the amplitude of the center peak.

7. On the basis of the tests described in Paragraph (6), the equipment was taken to the Torpedo Testing Range at Piney Point, on 3 Nov. 1944. The transmitter was installed on station 3 which is 4500 yards down the course from the firing barge, where the receiver and recording voltmeter were installed The equipment was operated during an average day's run and comparisons made between the aurally received bubble mark and the mark taken from the recording voltmeter. There was usually a disagreement of several seconds in no consistent manner. On many of the shots two or three peaks of equal amplitude were recorded two or three seconds apart. Subsequent investigation showed this to be due to limiting in the transmitter audio amplifier. The limiting took place in the stage ahead of the transmitter gain control because turning the control down had no effect on the limiting. An attempt was made to time a torpedo over the course by marking the chart when the torpedo left the tube and letting the recorder run until the torpedo passed the hydrophone. The recording meter chart drum was gear driven from a synchronous motor designed for 60 cycle operation. The power source on the barge was a diesel-driven alternator which delivered a.c. at about 56 cycles. When the torpedo run time was corrected for this slow chart speed it compared with the time obtained from the aural bubble mark within the limits of human error in the aural mark.

8. The equipment was returned to NRL following the tests at Piney Point, where work was undertaken to eliminate the limiting which had been taking place. Information obtained from the Sound Division on the intensity of torpedo sound levels indicated that the signal peak on the first grid was in the order of millivolts when the torpedo passed near the hydrophone. This is many times the voltage the audio stage was designed to handle, consequently, a stepped L-pad was inserted between the secondary of the input transformer and the first grid which reduced the input by approximate multiples of ten.

9. An overall audio response characteristic of the entire system was taken using an altered transmitter as described in Paragraph (3).

This curve is shown on Plate (2). A comparison of the response of the transmitter alone, as shown on Plate (1) with Plate (2) indicates that the response characteristic is due mainly to the action of the 17.8 Kc/s oscillator and mixer; and the frequency characteristic of the rectifier. A transmitter, unmodified except for the removal of 100 mmf. bypass condensor in the grid circuit of the reactance tube, was subjected to an identical response measurement with the complete system. The resulting curve is plotted on Plate 3. It differs from Curve (2) only at the extremities and then by only a small amount. The removal of the bypass condenser had no apparent adverse effect on the transmitter operation and its removal measurably improved the audio response from 15 Kc/s. upward.

10. An unmodified transmitter was equipped with an L-pad in the input circuit and the condenser mentioned in paragraph 8, was removed. A schematic circuit diagram of the transmitter audio input circuit including the modifications made is shown on Plate (4). This transmitter along with the receiver and recording meter was again taken to the Torpedo Testing Range and installed for test on Nov. 1944. An input loss of 100 to 1 was found to give best results. However, it was necessary to compromise on the setting of the attenuator. For torpedos passing within a few feet of the hydrophone, a loss of 100 to 1 or more, could be inserted without limiting action, but on certain shots the torpedo would pass several hundred yards from the raft where, in some instances, insufficient voltage was developed for a good peak. These shots are fired at angles of 60 or 90° off the center line of the range and a switch could be provided to decrease the inserted loss when such a shot is to be fired.

11. Following these last tests, the torpedo testing Station ordered and received eight new unmodified buoys for installation on each station on their lower range. Technical assistance was given by this Laboratory on the modification and installation of one transmitter between 18 and 23 Nov. 1944. A second RBF receiver was supplied with a rectifier. The remainder of the transmitters were to be modified and installed by the personnel at the Torpedo Testing Station and this work is now proceeding. The Naval Ordnance Laboratory has provided the Torpedo Testing Station with two double-penned recording meters and a timing circuit to actuate one of the pens. This will make the accuracy of torpedo timing independent of the chart speed.

CONCLUSIONS

12. The JM-1 Sono Buoy equipment, with slight modifications, used with a Brush type C-37 hydrophone, and RBF receiving equipment feeding a recording voltmeter can be used successfully to chart acoustically the progress of a torpedo along its test course.

RECOMMENDATIONS

13. The Naval Research Laboratory recommends that a type RBF - 1 receiver be installed in place of the RBF. This would provide a separate tuner for each buoy so that the system could be pre-tuned and the audio level could be pre-set for each buoy. It would then be possible to switch the audio amplifier from one tuner to the next after the torpedo passes each buoy. It is planned to use eight buoys on one range and five on the other so that two RBF-1 receivers, which have ten channels each, would adequately serve the purpose.

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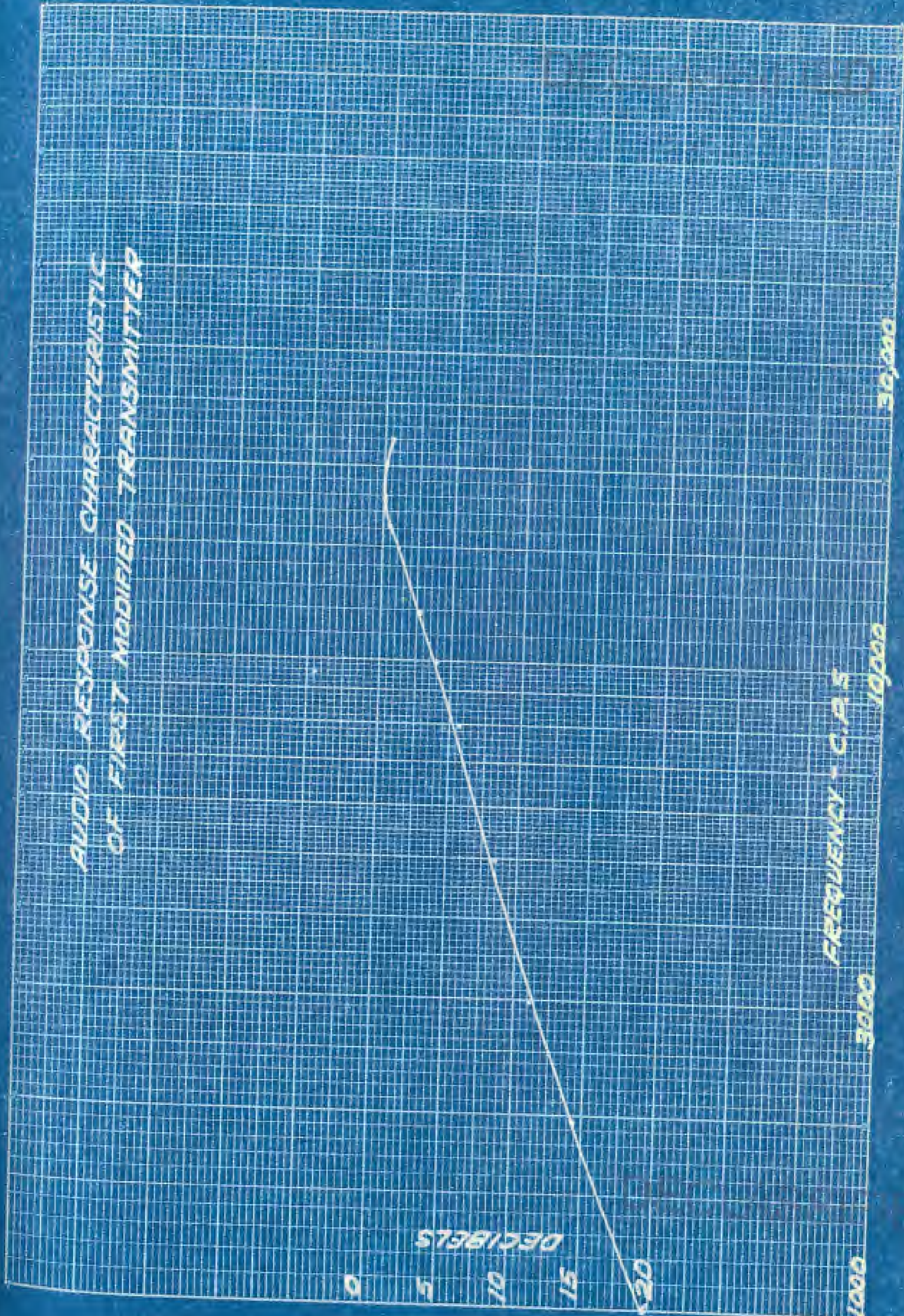


PLATE 1

[redacted]

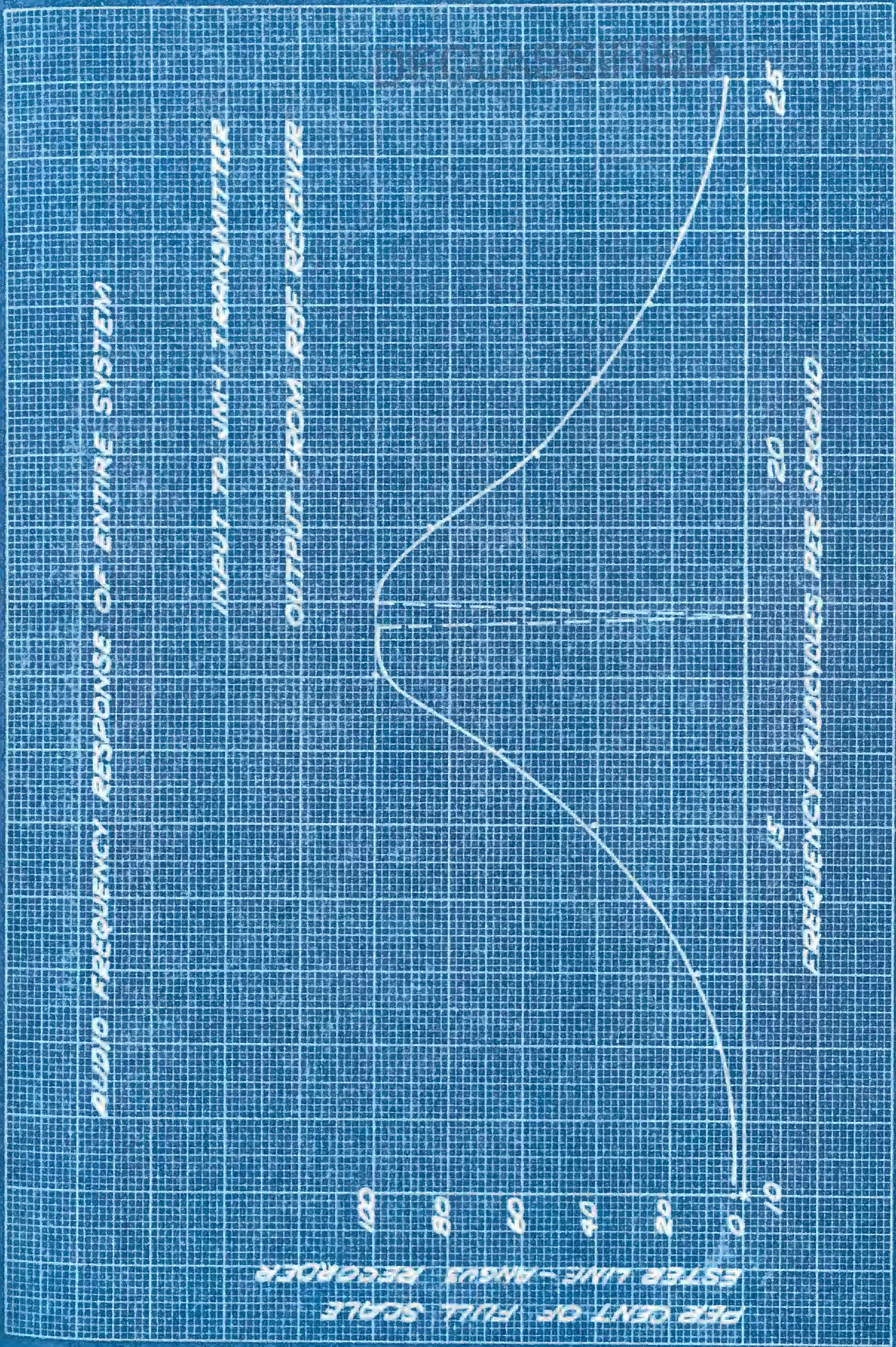


PLATE 2
NRL Report R-2551

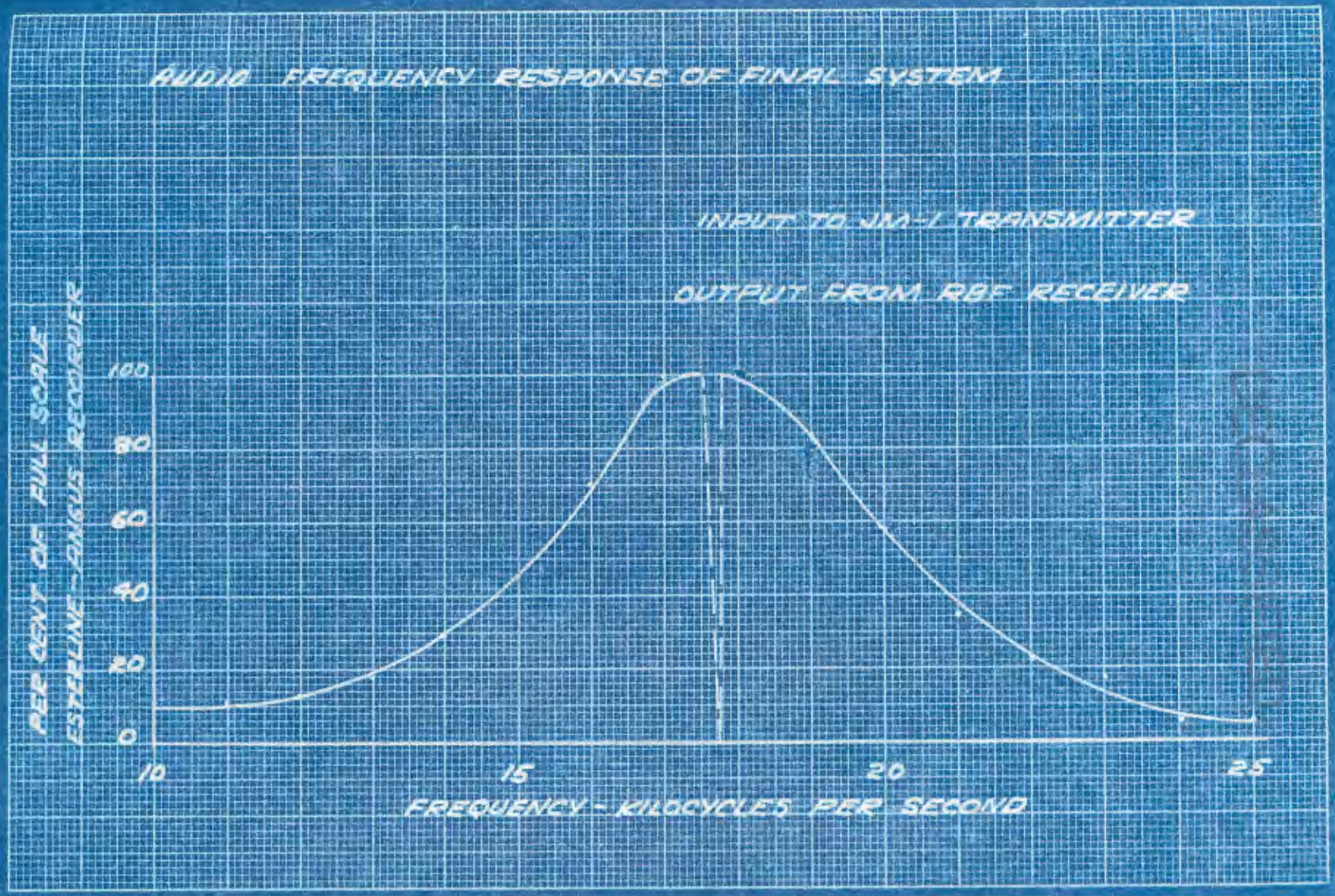
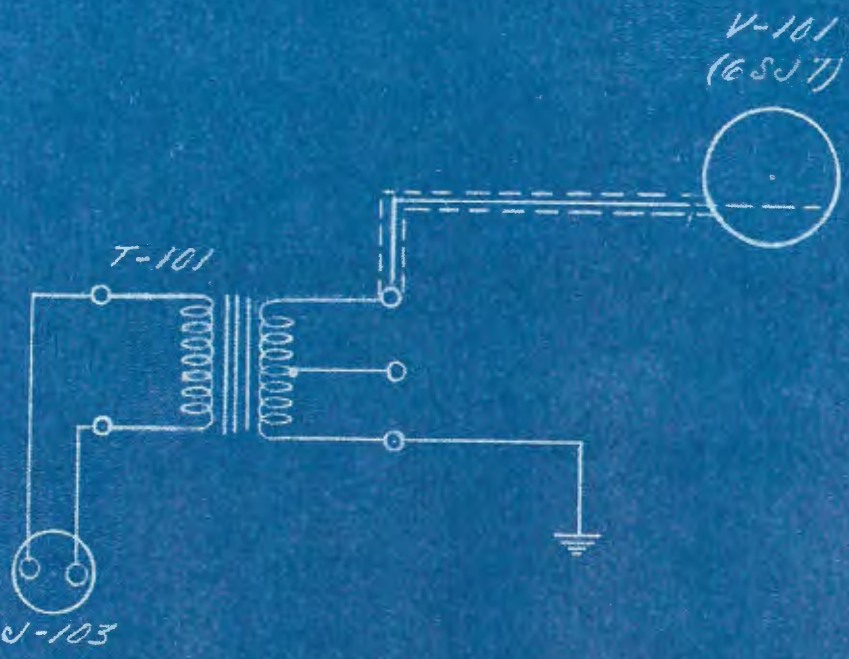


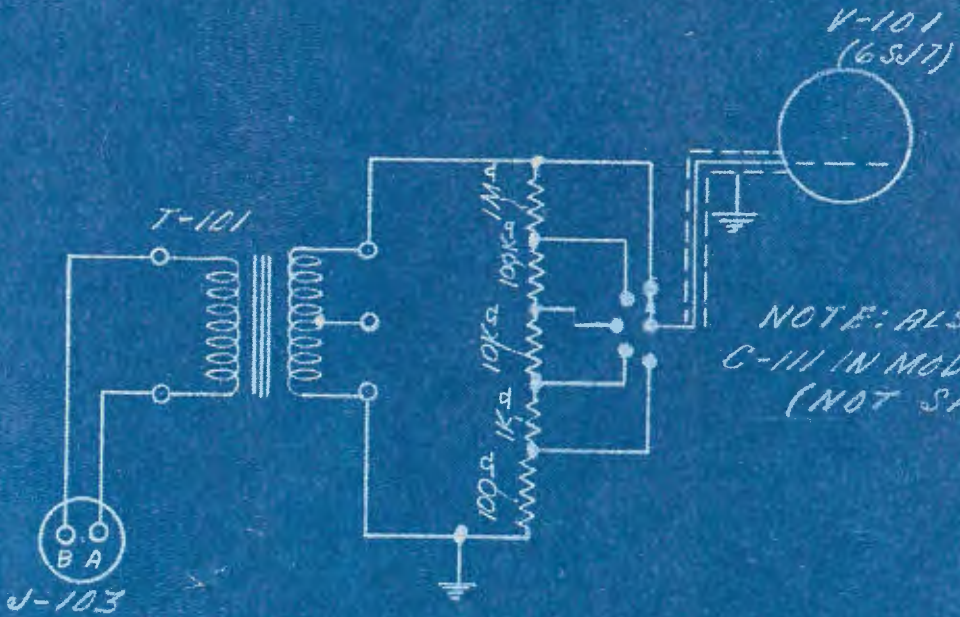
PLATE 3

NRL Report R-2551

ORIGNAL INPUT CIRCUIT
TYPE CIA-5220-A TRANSMITTER (JM-1)



MODIFIED INPUT CIRCUIT



NOTE: ALSO REMOVE
C-111 IN MODIFICATION.
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PLATE 4