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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report of Test
of
Racon Midget Marine Amplifier Reproducer

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 8 Plates - 9

Authorization: BuEng. ltr. S67/49(7-16-Rc6) of 19 July 1938.

Date of Test: 25 July - 24 August 1938.

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bms

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AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter, reference (a).

Reference: (a) BuEng. ltr. S67/49(7-16-Rc6) of 19 July 1938.

OBJECT OF TEST

2. The object of the test was to determine whether the amplifier reproducer under test complies with the specifications embodied in reference (a) and is suitable for Naval use.

ABSTRACT OF TEST

3. The unit was inspected for general construction, wiring, and workmanship. It was tested to determine the following:

(a) Electrical power delivered to the reproducer unit with an a-c input of 1 volt.

(b) The frequency characteristic of the acoustical output between 350-3500 c.p.s. with a constant input voltage.

(c) Whether the unit is capable of continuous and satisfactory operation for a period of 24 hours.

(d) The effect of excessive vibration.

(e) The effect of atmospheric humidity.

(f) The effect of extreme ambient temperatures.

(g) The effect of shock.

Conclusions

(a) This equipment complies with the specifications embodied in reference (a) as to acoustical fidelity, ability to operate continuously for 24 hours, and satisfactory operation under conditions of extreme humidity and temperature.

(b) It does not meet the standard requirements for vibration and shock, nor does it comply with the specification that it must deliver 2 watts of electrical energy to the reproducer unit (reference (a), par. 2a). It delivers approximately 0.30 watt.

(c) With improvements as outlined under Recommendations herein, it is believed that this unit would be satisfactory for Naval use, provided no objection is raised to the use of electrolytic capacitors.

Recommendations

(a) The vacuum tubes should be blocked in or otherwise secured so that they cannot be shaken out of their sockets by excessive vibration and shock.

(b) The electrolytic capacitors should be supported independent of the leads. Flexible leads may be advantageous.

(c) The output transformer should be suitably potted and impregnated to increase protection against humidity.

(d) Lock washers should be used on the screws where applicable.

(e) The strip of insulating material, which secures the woven strap containing the leads joining the 2 compartments of the unit, should be secured by means of nuts on the screws instead of threads in the strip as at present.

DESCRIPTION OF MATERIAL UNDER TEST

4. This Racon midget marine amplifier reproducer consists of a single stage audio frequency amplifier with reproducing unit. A second tube functions as a rectifier for a-c operation; the unit can also be used on a 115 volt d-c supply provided the polarity is correctly chosen.

5. Photographs of the unit are given on Plates 8 and 9 and the wiring diagram on Plate 7. The box beneath the reproducing unit contains the two vacuum tubes (Type 6G6-g, power amplifier pentode), the pilot lamp, the volume control resistor, and a resistor for dropping the line voltage down to a value to permit operation of the heaters of the two tubes in series from the 115 volt supply. On the right side of this box, two threaded holes 7/8" in diameter are provided for conduits containing the power supply and input leads, with a terminal strip inside the box.

6. The disk shown on Plate 9 on which certain circuit elements are mounted, fits inside the metal case which forms a part of the horn and surrounds the lower end of the horn into which the sound pot feeds sound energy. The chamber containing these circuit elements is isolated from the air column of the reproducer and is sealed against humidity by two rubber gaskets. The cover on the tube compartment is also provided with a gasket.

7. A woven strap 7/8" wide contains 12 parallel insulated wires connecting the elements in the tube and amplifier compartments. In the sound pot the reproducer coil is mounted on an extension of a small cone diaphragm and fits into an annular air gap in the field of the permanent magnet so that a change of current through the coil causes a slight movement of it and a consequent excitation of the diaphragm which feeds into the horn. From the wiring diagram, Plate 7, it will be noted that one tube functions as an amplifier and the other as a rectifier or power supply tube. Input and output transformers are supplied. The 16 microfarad capacitors are of the dry electrolytic type, one by-passing the cathode resistor and the other two, together with the 600 ohm resistor connected between them, forming a filter for the output of the rectifier tube.

METHOD OF TEST

8. The methods employed in the several tests are described below:

(a) The power delivered to the reproducer unit when an a-c input of 1 volt was applied was measured by means of an output power meter which was connected in place of the reproducer unit and its impedance adjusted for maximum power. (Measurements made by means of a low range wattmeter indicated approximately the same amount of power, although a considerable error might exist in the latter values in the measurement of such a small amount of power.)

(b) The fidelity, or frequency characteristic, of the equipment was determined by applying a constant a.c. input potential of 1/2 volt or 1 volt, and measuring the sound power at several distances away from the horn by means of a General Radio Sound Level Meter, Type 759-A,. which is provided with a non-directional piezo-electrical crystal microphone. Measurements were made in a room constructed for acoustical work with soundproof walls and all inner surfaces lined with acousticelotex to minimize reflections. A constant a-c potential was applied from a General Radio beat frequency oscillator, Type 713-A, and readings of the sound level meter were taken at 19 frequencies between 250 and 5,000 cycles. These measurements were checked by the measurements made outdoors in the field about 200 feet distant from any buildings.

(c) The equipment was operated for 24 hours with an input voltage of 1/2 volt and a frequency of 1,000 cycles, with a-c supply, and at maximum volume setting to determine its ability to function over extended intervals without failure.

(d) The unit was mounted on a vibration table and subjected to intense vibration for approximately 1 hour and the effects noted. The amplitude of vibration was in excess of 1/16" and the frequency range was from approximately 5 to 25 cycles per second.

(e) The unit was subjected to a relative humidity of 90% at a temperature of 50° C. for 72 hours and then examined for the condition of the parts and the effect on the acoustical output.

(f) The equipment was also chilled to -10° C. to determine if its operation was affected by low temperatures.

(g) The unit was given a shock test consisting of 20 blows of 250 foot pounds each, delivered on the anvil of the Navy standard shock test machine, while the amplifier reproducer was mounted in its normal operating position on the panel of the test machine with its center approximately 18" below the point of impact of the descending hammer. This test is detailed in specifications, SGS(65)-23 of 1 May 1934, Announcing Equipment, Low Powered, under paragraph F4(h).

DATA RECORDED DURING TEST

9. The data recorded during the test are given under "Results of Test" and in graphical form on Plates 1 to 6.

DISCUSSION OF PROBABLE ERROR

10. The error in the measurement of the a-c power delivered to the reproducer unit is less than $\pm$ 10%. The error in the measurement of acoustical energy can only be estimated, but is believed to be less than $\pm$ 3 db in all cases.

RESULTS OF TEST

11. The results of the tests are given below.

(a) Electrical power delivered to the reproducer unit. The electrical power delivered to the reproducer unit was measured to be approximately 0.30 watt. This was determined with an input of 1 volt at frequencies between 350 and 3500 cycles with the volume control set at maximum, as described under "Method of Test." In reference (a), paragraph 2(a), it is stated that the power shall be 2 watts.

(b) Fidelity. The observed frequency characteristic of the acoustical output for a constant input voltage is shown for different conditions on Plates 1 - 4. The varying conditions are location of the equipment, input voltage, distance between the reproducer and the microphone of the sound level meter, and setting of the volume control. These various conditions for Plates 1 - 4 are summarized in the table below:

Plate No.	Location	Volts Input	Distance to Sound Meter	Volume Control Setting
1	Outdoors	0.5	12	100
		"	"	70
		"	"	50
2	In acoustic test room	0.5	6	100
		"	"	70
		"	"	50
3	"	1.0	6	100
		"	"	70
		"	"	50
4	"	1.0	6	70
		"	12	70
		"	18	70

These curves were made from observations at 19 fixed frequencies between 250 and 5000 cycles with 15 of the observations being made between 350 and 3500 cycles, which is the range specified in reference (a), par. 2(b). The sound power is expressed in decibels above the reference level of 10^{-16} watts per square centimeter (which is 7 decibels above the average threshold of hearing as stated by the manufacturer of the sound level meter). In examining these curves it should be remembered that all values of sound energy measured may be at least 2 decibels above or below the values given; also that the measurements were taken at a number of frequencies but

not at all frequencies within the band covered and therefore it is possible that some irregularities in the frequency response may exist which are not represented on the curves. However, in the outdoor measurements no decided irregularities were noted by the ear in varying the frequency source between the points at which observations were made. Measurements taken outdoors are considered to be more representative of the characteristics of the amplifier reproducer than those in the acoustic test room, since some reflections from the surfaces of the room are evident as indicated by the difference between indoor and outdoor curves (Plates 1 and 2) as well as by the indoor curves with the sound level meter at different distances from the horn (Plate 4).

The data given on Plates 1 - 6 may be summarized as follows:

(1) For outdoor conditions, the fidelity is about ±3.5 decibels between 350 and 3500 cycles.

(2) The observed variation of response with frequency was much greater in the acoustic test room than outdoors and varied considerably from one volume control setting to another, increasing on Plates 2 and 3 as the volume control setting (or effective input voltage) was reduced, from ± 7 decibels at maximum volume to ± 12 decibels at a setting of 50 on the volume control.

(3) Frequency response curves outdoors are quite similar at different volume control settings (Plate 1) but those taken in the acoustic test room show a considerable variation particularly below 1,000 cycles (Plates 2-4).

(4) The response curve in the acoustic test room is affected by the distance between the horn and the sound level meter, or the location of the sound level meter with respect to the walls of the room (Plate 4).

(5) An input potential of 1/2 volt produces a condition of saturation when the volume control is set at maximum, as indicated by the uniform acoustical output for 1/2 volt and 1 volt input potentials shown on the upper curves of Plates 2 and 3.

(6) The volume control range obviously depends on the existing noise level, and on the distance of the microphone from the mouth of the horn as indicated on Plates 5 and 6.

(c) 24-hour continuous operation. The unit was operated continuously in excess of 24 hours without any breakdown or failure of any part. During this test the input voltage was 1/2 volt and the frequency 1,000 cycles.

(d) Effect of vibration. After 7 minutes of vibration, the audio output failed, which was found to be due to one of the vacuum tubes having been shaken out of its socket. This was remedied and

in 2 more minutes both tubes had been unseated. To prevent interference with the test on this account, blocks of corrugated paper were placed between the ends of the tubes and the box to prevent movement of the tubes. The test was continued and after a total of 54 minutes of vibration at various frequencies and amplitudes, the quality of the audio output became quite poor or rough, indicating failure of the 60 cycle filter. When the unit was disassembled for examination, two of the electrolytic capacitors fell out and the third was found to be open circuited but held in place by one lead. These capacitors are mounted merely by their terminal leads which are stiff wire, size No. 20. Of the 5 broken capacitor leads, one was broken off at the capacitor and the other four at the soldered junction. These capacitors should be supported independent of the leads. It is believed that flexible leads would also be an advantage over stiff leads if there is any relative motion under intense vibration between the capacitor and the points to which the leads are soldered.

(e) Effect of humidity. After exposure to relative humidity of approximately 90% at a temperature of 50° C. for 72 hours, the unit operated normally. No water was visible in either of the compartments provided with gaskets. It was noticed, however, that the paint on the outer surface of the unit was slightly discolored in spots where drops of water from the top of the humidity chamber had dripped on its surface. During this test the two threaded holes in the tube compartment provided for installation of pipes or conduits carrying input and power leads were plugged up to prevent the entrance of moisture. The unit is considered well protected against humidity effects.

(f) Effect of extreme temperature. The unit was not adversely affected by operation at temperatures between -10 and +50° C.

(g) Effect of shock. The equipment withstood satisfactorily the shock test of 20 blows of 250 foot-pounds each applied to the test machine on the panel of which the unit was mounted, with the following exceptions; on the first blow a filter capacitor lead broke off, and on the third stroke a tube became dislodged from its socket. After the completion of the test it was found that three of the electrolytic capacitor leads were broken off. The effects of the shock test are much the same as those of the vibration test.

(h) Discussion of Various Details.

(1) The unit is 9-1/4" wide, which is the diameter of the horn, 13-1/4" high, and 7" deep. Its weight is 13-1/4 pounds.

(2) Dry electrolytic capacitors are used as previously stated which permits a very large capacity in a small space. These 16 microfarad Solar "minicap" capacitors have a diameter of 11/16" and a length of 1-11/16". The use of electrolytic capacitors is

particularly called to the attention of the Bureau, as well as the fact that paper capacitors, which could be mounted in the available space, would probably have a capacity not greater than about 1 microfarad, which would seriously impair the filtering characteristics of the unit.

(3) Operation on either d.c. or a.c. 115 volt line was satisfactory with practically no change in acoustical output. The hum due to the use of the a-c supply is not objectionable.

(4) The output transformer is not potted for protection against humidity effects but the compartment in which it is located is provided with rubber gaskets at both openings. It is not known whether this transformer could be placed in a metal can and properly impregnated without its becoming too large for the available space in this unit.

(5) No lock washers are used on the screws in this equipment.

(6) The rear surfaces of the 3 mounting lugs provided on this unit do not extend as far back as the heads of the screws by which the sound pot is secured in place. As a result it would be necessary to use spacers behind each mounting lug (1/8 - 1/4") if the unit were mounted on a flat surface, to produce a 3 point mounting without any pressure on the back of the sound pot.

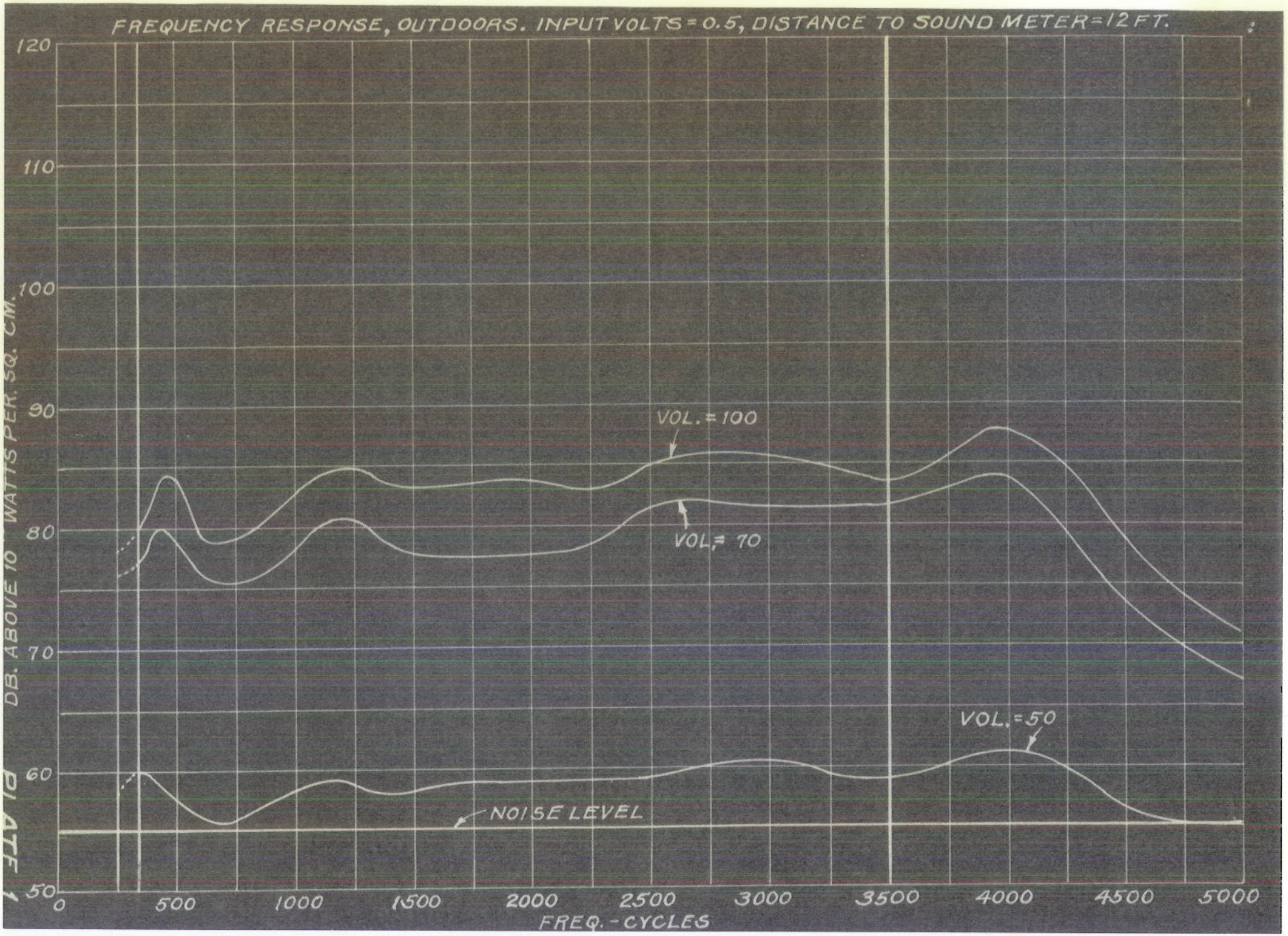
(7) The woven strap which contains the leads from the tube compartment to the panel on which the transformers are mounted is held in place by a small strip of phenolic insulation with two tapped holes for screws. Upon examination previous to any tests it was noted that this strip was split at one end and that one of the securing screws tapped into it was loose. The use of nuts and lock washers instead of tapped holes in this piece is proposed.

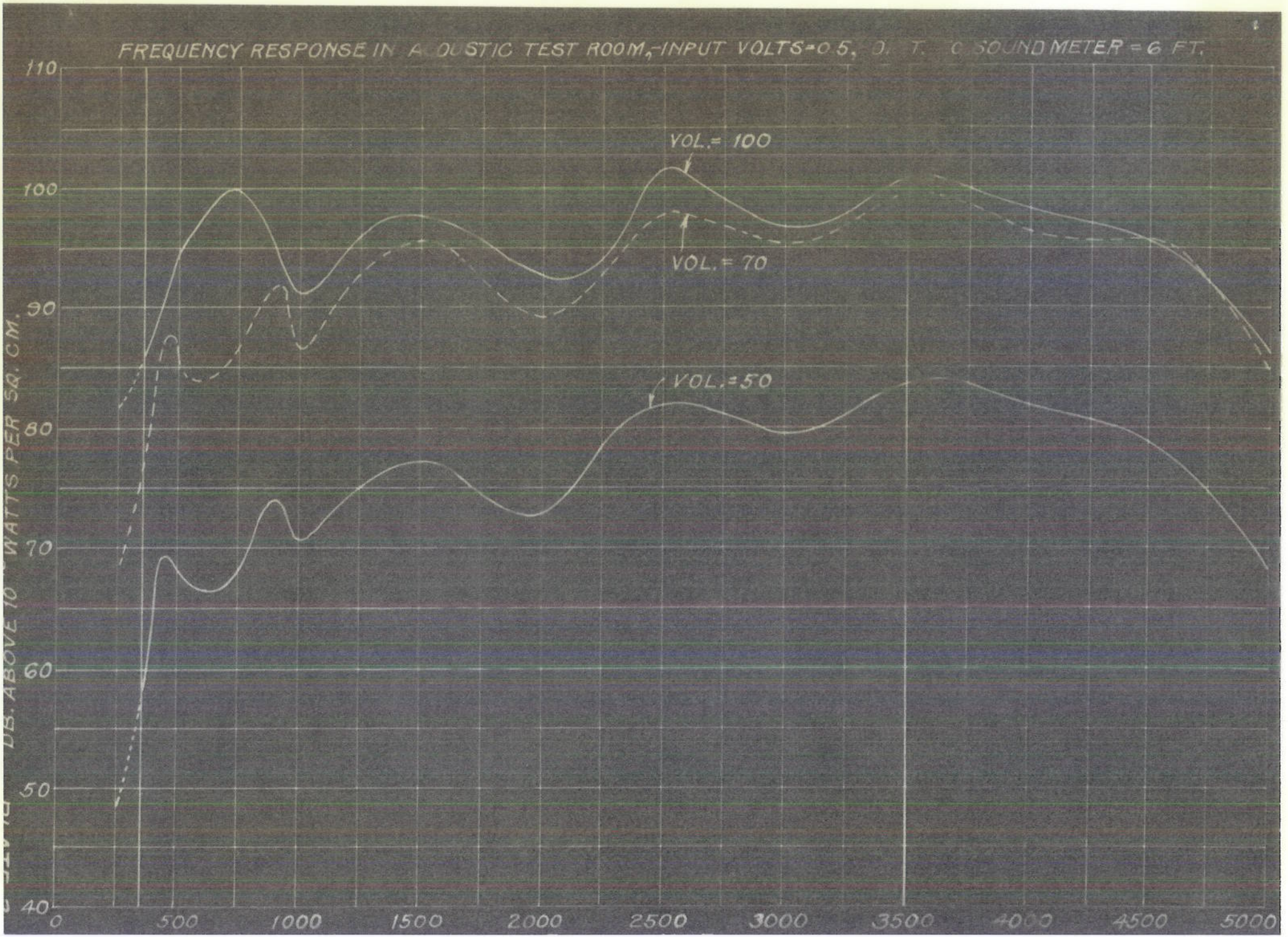
CONCLUSIONS

12. This equipment complies with the specifications embodied in reference (a) as to acoustical fidelity, ability to operate continuously for 24 hours, and satisfactory operation under conditions of extreme humidity and temperature.

13. It does not meet the standard requirements for vibration and shock, nor does it comply with the specification that it must deliver 2 watts of electrical energy to the reproducer unit (reference (a), par. 2a). It delivers approximately 0.30 watt.

14. With improvements as outlined under "Recommendations" herein, it is believed that this unit would be satisfactory for Naval use, provided no objection is raised to the use of electrolytic capacitors.


FREQUENCY RESPONSE, OUTDOORS. INPUT VOLTS = 0.5, DISTANCE TO SOUND METER = 12 FT.
120
110
100
90
80
70
60
50
DB. ABOVE 10⁻¹⁶ WATTS PER SQ. CM.
VOL. = 100
VOL. = 70
VOL. = 50
NOISE LEVEL
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
FREQ. - CYCLES


FREQUENCY RESPONSE IN A OUSTIC TEST ROOM,-INPUT VOLTS=0.5, D. T. C SOUND METER = 6 FT.
VOL.= 100
VOL.= 70
VOL.=50
110
100
90
80
70
60
50
40
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
DB. ABOVE 10 WATTS PER SQ. CM.

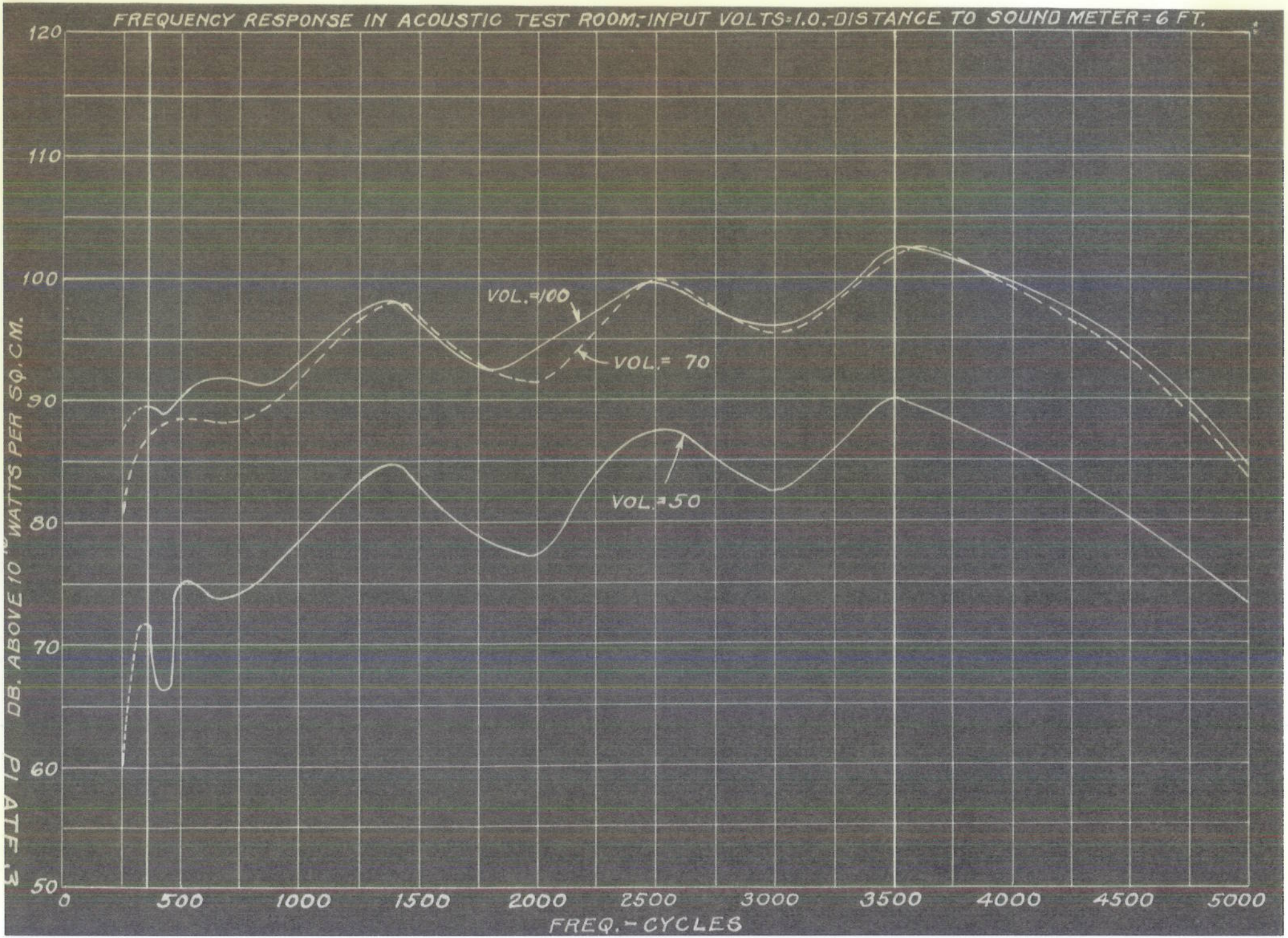
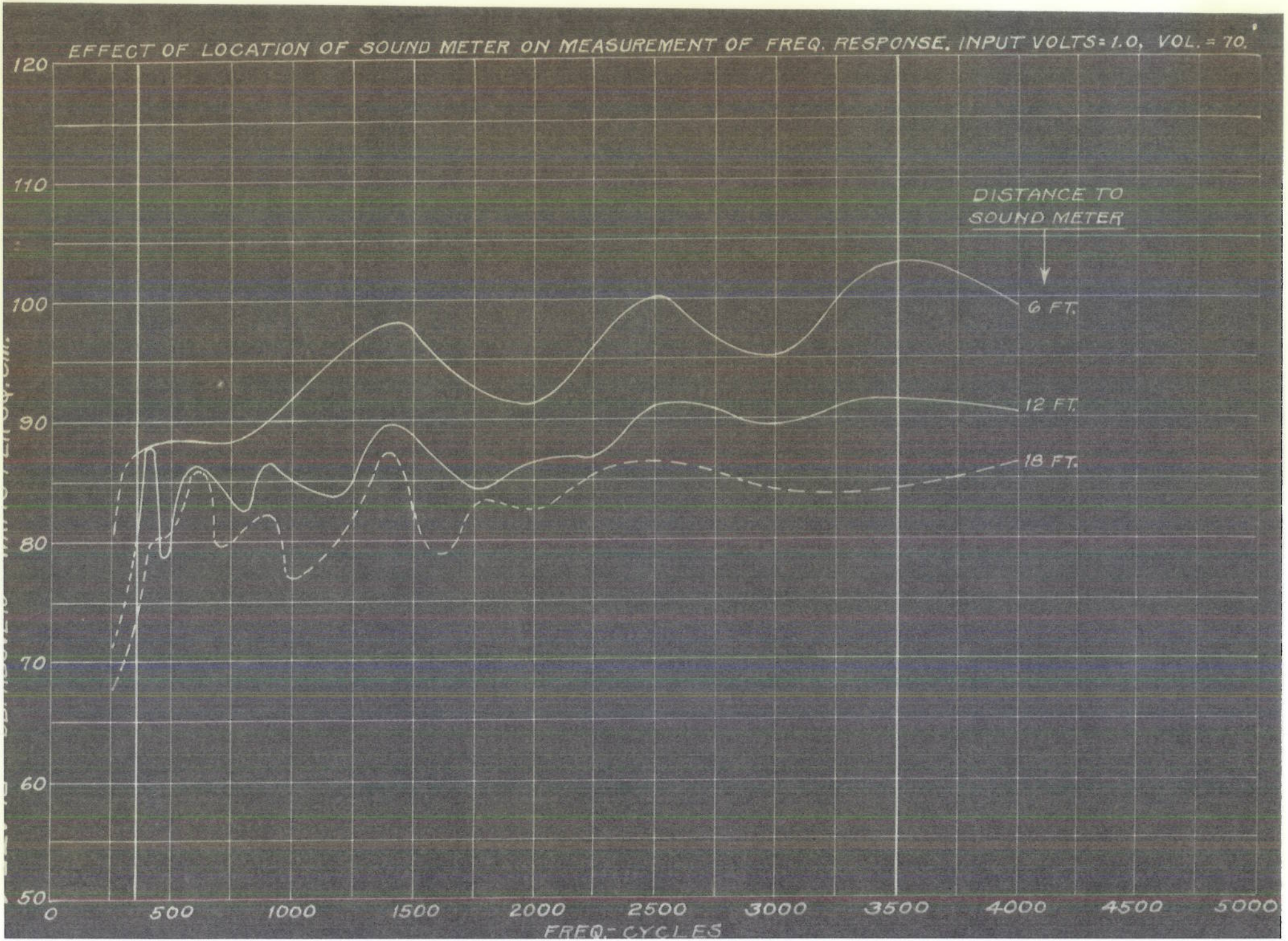
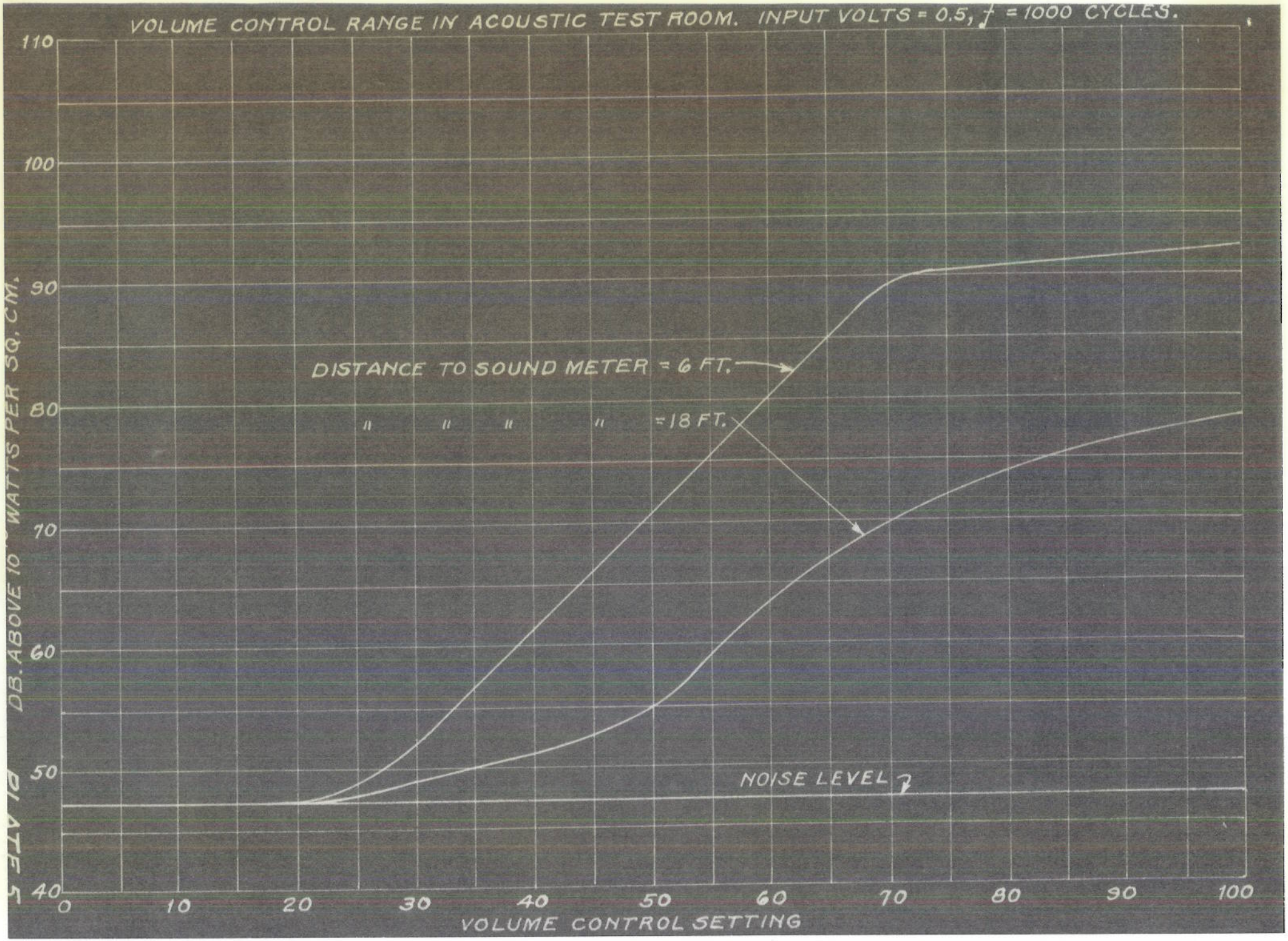
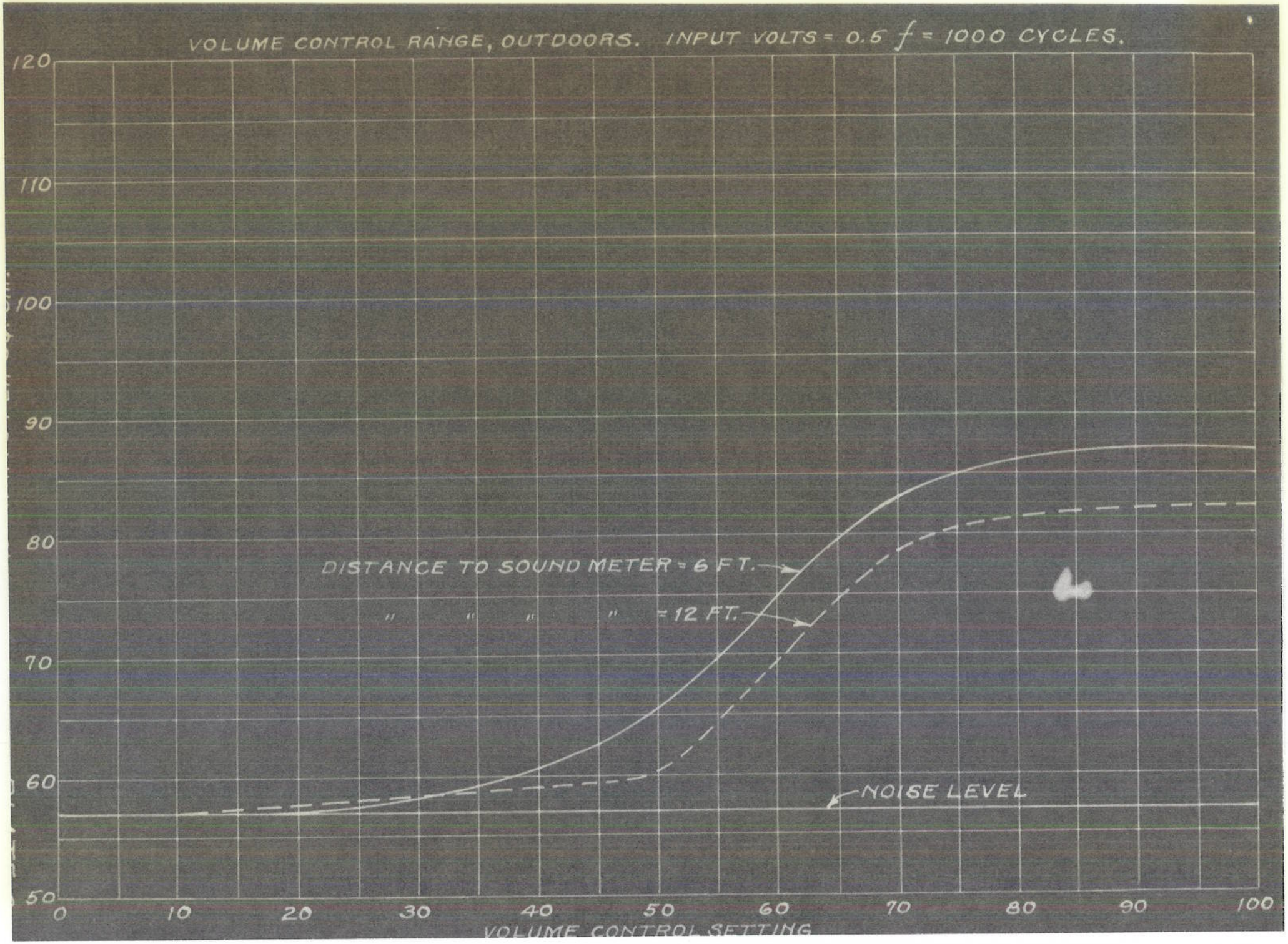

FREQUENCY RESPONSE IN ACOUSTIC TEST ROOM;-INPUT VOLTS=1.0.-DISTANCE TO SOUND METER=6 FT.
120
110
100
90
80
70
60
50
DB. ABOVE 10 WATTS PER SQ. CM.
VOL.=100
VOL.= 70
VOL.=50
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
FREQ.-CYCLES

PLATE 3


EFFECT OF LOCATION OF SOUND METER ON MEASUREMENT OF FREQ. RESPONSE. INPUT VOLTS = 1.0, VOL. = 70.
120
110
100
90
80
70
60
50
DISTANCE TO SOUND METER
6 FT.
12 FT.
18 FT.
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
FREQ.- CYCLES


VOLUME CONTROL RANGE IN ACOUSTIC TEST ROOM. INPUT VOLTS = 0.5, f = 1000 CYCLES.
110
100
90
80
70
60
50
40
DB. ABOVE 10 WATTS PER SQ. CM.
DISTANCE TO SOUND METER = 6 FT.
" " " " = 18 FT.
NOISE LEVEL
0
10
20
30
40
50
60
70
80
90
100
VOLUME CONTROL SETTING


VOLUME CONTROL RANGE, OUTDOORS. INPUT VOLTS = 0.5 f = 1000 CYCLES.
120
110
100
90
80
70
60
50
DISTANCE TO SOUND METER = 6 FT.
" " " " = 12 FT.
NOISE LEVEL
0
10
20
30
40
50
60
70
80
90
100
VOLUME CONTROL SETTING

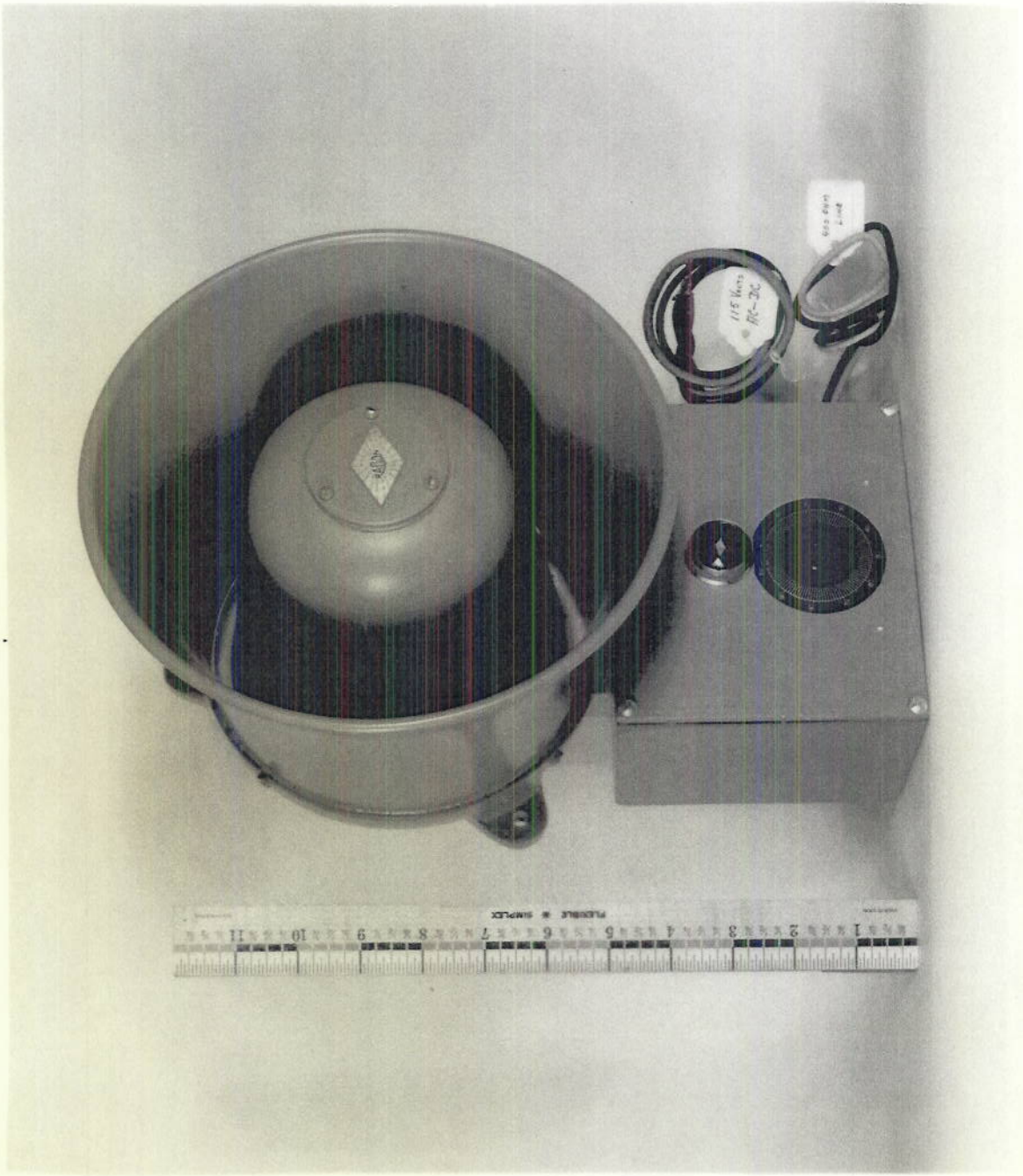


Plate 8

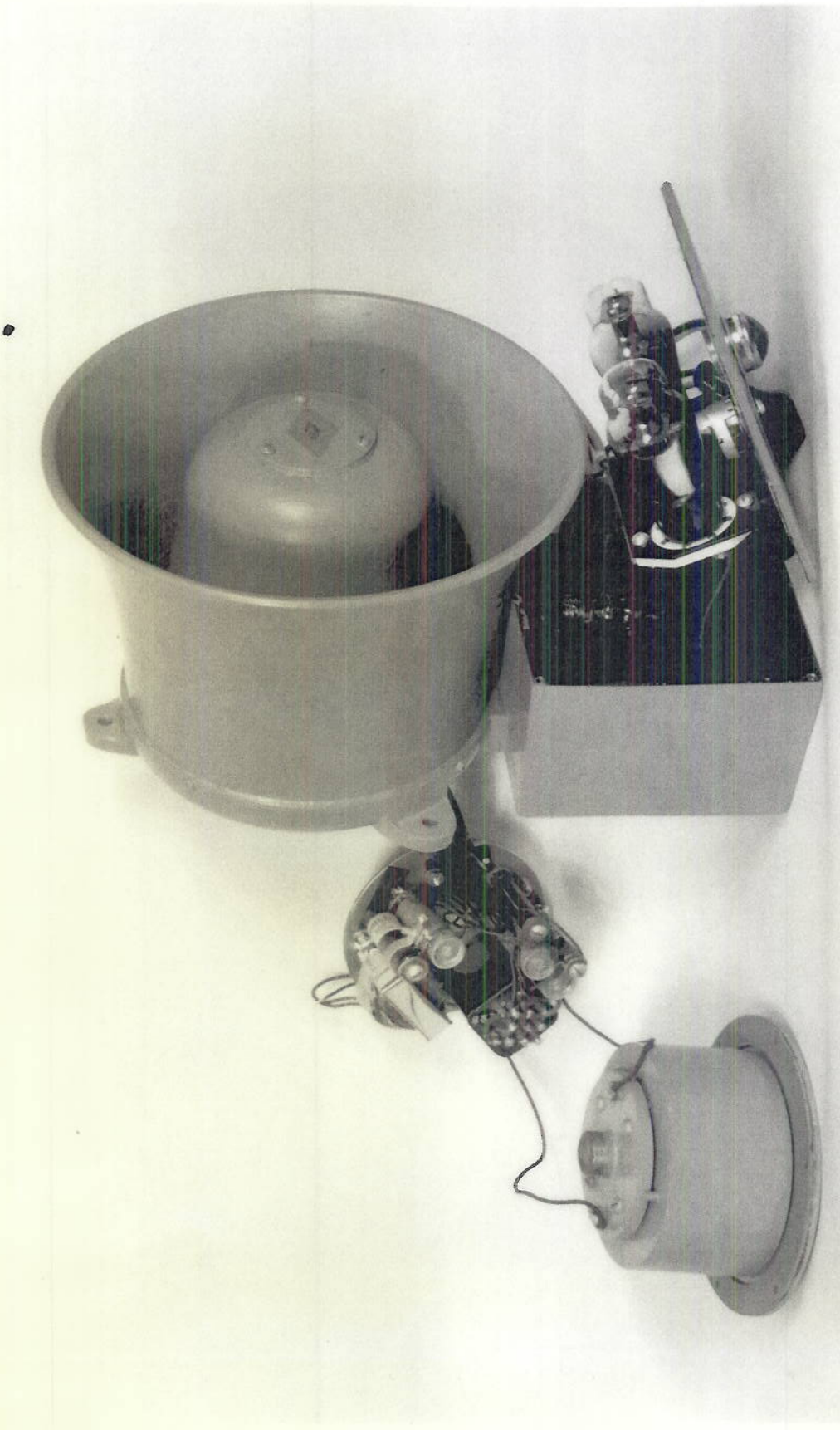


Plate 9