FC

STUDY OF COMMUNICATION IN HIGH-LEVEL AMBIENT NOISE FIELDS

Report No. 6
1 December 1955 – 15 February 1956

Coles Signal Laboratory
Fort Monmouth, N.J.

Surface Communications Engineering
Defense Electronic Products
Radio Corporation of America, Camden, N.J.

Contract DA-36-039-sc-64469
SIGEL-CWB-Projects 132B, 843D
Order No. 94-PH-55-91 (4307)

STUDY OF COMMUNICATION IN HIGH-LEVEL AMBIENT NOISE FIELDS

Report No. 6

December 1, 1955 - February 15, 1956

Object: To obtain design information that will lead to significant improvement in Signal Corps voice communication system used in the high-level noise encountered in many armored vehicles and helicopters.

Contract No. DA-36-039-sc-64469
Specification No. SCL-1502, 15 February 1954
SIGEL-CWB Projects 132B, 843D
File No. 94-PH-91 (4307)

Report Prepared by:
Surface Communications Engineering
Defense Electronics Products
Radio Corporation of America
Camden, New Jersey

TABLE OF CONTENTS

SECTION I

PURPOSE

The purpose of this contract is to perform the research necessary to provide design information that will lead to significant improvement in Signal Corps voice communication systems used in the high-level noise environments encountered in many armored vehicles and helicopters. The emphasis is on integrated system design. The program consists of six parts.

1.0 Review of the literature and the preparation of a bibliography on the subject.

2.0 Field tests.

- 2.1 Analysis of noise spectra in approximately eight types of armored vehicles and three types of helicopters.
- 2.2 Evaluation of the communications efficiency of the present signal corps interphone when installed in the vehicles.

3.0 Systems analysis and block design.

4.0 Detailed determination of system and component parameters.

- 4.1 System parameters.
- 4.2 Microphones.
- 4.3 Amplifiers.
- 4.4 Headsets.

5.0 Construction and evaluation of research models.

6.0 Preparation of the final report.

The results of the program will be stated in such a manner that equipment development, design and production work can follow smoothly from this information.

SECTION II

ABSTRACT

Articulation tests were conducted with the improved system, using components similar to the H-101 headset and AIC-12 amplifier, in a noise environment which essentially duplicated the Armored Vehicle Noise (AVN) spectrum above 200 cps. No significant variation of the test scores were obtained with changes of the clipping level in the amplifier. The tests showed that the hand-held dynamic noise cancelling microphone with the noise shield is substantially equivalent to the boom mounted microphone (M-55/AIC) with noise shield. The performance of the M55/AIC without the noise shield did not meet the agreed upon 80% articulation score criterion, but it is believed that it would be adequate for most environments on most occasions. The noise shield would be necessary under the maximum conditions anticipated.

The performance of the improved system was markedly superior to that of the VRC-7 system in the test noise used. Articulations scores of the order of 20% were obtained with the VRC-7 as opposed to scores of about 80% with the improved system.

Severe temporary hearing losses were sustained by members of the crew while using the VRC-7 system. It is considered that the noise levels encountered in the vehicles measured will produce permanent hearing losses in members of crews continuously exposed without adequate ear protection in the form of proper headsets or ear defenders.

SECTION III

MEETINGS, REPORTS, CONFERENCES

During the period of this report, the following meeting was held:

Date:	December 1, 1955
Place:	Coles Signal Laboratory
RCA Personnel:	W. F. Meeker, A. J. May
SCEL Personnel:	F. J. Petschauer, C. E. Tepper
Purpose:	Discussion of project status and determination of minimum word articulation criterion.

SECTION IV

FACTUAL DATA

1.0 INTRODUCTION

In the previous report, the result of articulation index calculations were presented. These calculations indicated that an interphone system having components and characteristics similar to those of the AN/AIC-10 system would provide the required performance under conditions representative of the worst likely to be encountered in armored vehicles. These calculations were carried out using an assumed noise spectrum compounded of the worst conditions found in the earlier field survey of noise in armored vehicles. This synthetic spectrum was called the Armored Vehicle Noise spectrum, or the AVN spectrum.

The substance of the work covered in this report is concerned with articulation tests evaluating various noise cancelling dynamic microphones and amplifier gain control settings. The general nature of the problem which this contract is attempting to solve is similar to the one which led to the development of the AN/AIC-10 system by RCA for the Air Force.

RCA recognizes that the Signal Corps requirements differ in some respects from those in other areas. To meet these requirements, RCA has, on other contracts, produced the H-101 headset-microphone assembly, and is developing the AN/AIC-12 (XC-1) amplifier, specifically for the Signal Corps.

In the tests reported herein, an AIC-10 system was used as a matter of convenience. The components used for the present articulations tests include a small boom microphone, the M-55/AIC, a hand-held microphone, the M-34/AIC, and earphones having higher sensitivity than those incorporated in the H-101.

1.1 General Considerations

RCA has as part of its facilities a room equipped with polycylindrical diffusers which is used for articulation testing. High level noise fields can be generated in this room by a set of theater loudspeakers driven by amplifiers having a total rated capability of 180 watts. The noise signals are produced by a white noise generator, whose output is modified by suitable

filters. In order to generate the AVN spectrum at an overall level of 127 db it was necessary to orient the speakers so as to block off a corner of the room, making a semi-enclosed area large enough for five men to sit in. Even with these measures, an overall level of 124 db was the highest that could be achieved. The difference between the desired spectrum and the one actually produced lies principally in the region below 100 cps, as shown in Figure 1. In the region above 200 cps, which is considered to be the range important in speech masking, the actual test spectrum very closely matches that of the AVN spectrum used in the calculations.

The test crew consisted of five engineers, some of whom have had previous articulation testing experience. Two members of the crew served alternately as talker and listener. Approximately twelve hours of practice time was accumulated before the final tests were performed.

1.2 Hearing Loss Considerations

It was the contractor's consideration that it could not justify exposing the crew to sound levels which incurred any appreciable risk of long term hearing damage. Although there is no extensive data on the effects of moderate exposure to noise in the 120-130 db region, it was decided that 120 db was the highest level which would be used. Since the AVN spectrum is very strong below 200 cps and neither the H-101 earcushion or the H-63 earcushion afford any protection in this region, it was decided to sharply reduce the spectrum level below 200 cps, as is also shown in Figure 1. This reduction was just sufficient to lower the overall level to 120 db. It left unaffected the noise spectrum in the speech masking range, which is substantially identical with that of the originally synthesized AVN spectrum.

It is the contractor's belief that this forms a reasonable basis for articulation tests. There is a region of uncertainty as to the effect of the very strong low frequency components upon the hearing at higher frequencies in the masking range. The customary calculations are based upon the assumption that the frequencies below 200 cps do not produce masking in the speech range. This may not be true at high intensities. There is little data available in the literature concerning this type of masking phenomena.

There is no certain way of assessing these effects short of running articulation tests with and without the low frequency components. The contractor feels that it has no right to ask its test crewmen to expose themselves to sound levels which entail any appreciable risk of permanent hearing loss (however slight that risk may be) it is not strictly "in the line of duty" for them.

It should be noted that the wearing of an ear defender under headsets is perfectly feasible from a communication standpoint and would be expected to actually improve intelligibility. The consideration here has been that if ear defenders are not worn by personnel, the system should still be capable of supplying adequate communication performance.

The contractor believes that it should point out that there is considerable evidence that persons exposed to noise similar to the AVN spectrum on a continuous basis will certainly develop a permanent hearing loss unless fitted with adequate ear protection devices. This has in the past been considered as an occupational hazard which the personnel simply accept. However, there is increasing precedence being established in industry and the military services for permanent hearing loss entitling one to compensation payments, whether this is a normal "occupational hazard" or not. Such compensation payments can in the long run be extremely costly and far outweigh the additional cost of equipment which gives adequate protection against such hearing loss.

In the January 1956 issue of Noise Control, H. E. Von Gierke presents a damage risk criterion based on the concept that "when people work in certain noise levels day after day, eight hours a day for several months or years, they certainly develop some hearing loss." This criterion is presented in Figure 2.

The noise levels encountered in the survey (with the exception of the T-97) exceeded this criterion for all conditions of operation except with the vehicle stationary and the engine idling.

There is little information on the long term effects of short or moderate term exposure to intense noise. It is the contractor's belief that it would be in the interest of the Signal Corps for the Signal Corps to undertake an investigation of this.

1.3 VRC-7 in Comparison with the AIC-10

Although the primary purpose of the present contract is to determine the performance characteristics necessary in interphone equipment to give adequate intelligibility in armored vehicles, it would be useful to compare the performance of a system such as the AIC-10 against the VRC-7. This was done on a preliminary basis during the practice sessions. In the AVN spectrum the difference between the VRC-7 and the AIC-10 was so striking that it was considered pointless to make a formal set of tests comparing these two systems. The articulation scores for the VRC-7 ranged around 20 points as compared with about 80 percent for the AIC-10 system.

Further, after the first set of tests, three of the test crew experienced severe temporary hearing losses (up to 45 db at 2500 cps) accompanied by loud ringing of the ears. About a week was required for recovery of substantially normal hearing. On the second test, another member of the crew suffered similar effects.

The AIC-10 amplifiers are designed so the output stage clips at a 200 mw level, so that the peak sound intensity developed will not exceed about 120 db with an earphone sensitivity of 97 db/milliwatt. In the tests using the AIC-10 system with various degrees of clipping, small temporary hearing losses were encountered, clearing within 24 hours.

Where noise similar to the full AVN spectrum at 127 db level is encountered, something of the order of ear defenders or the David Clark ear protector is required in order to provide somewhere near adequate protection against hearing loss. RCA has under development a headset having attenuation properties similar to the David Clark ear protector.

2.0 Formal Articulation Test

There were two formal tests made using the AIC-10 system. The first of these was designed to explore the effect of peak clipping in the amplifier upon the articulation score. Two talkers with three levels of clipping were used with three word lists read for each condition of tests.

The result of the test when analyzed showed no significant relation between the degree of clipping and the articulation score under the present test conditions. This is at variance with the calculations, which indicated an increase in percent word articulation when 15 db of peak clipping was used.

This disagreement with the prediction may be due to a number of factors. One of these is the uncertainties in the articulation index calculation technique. This technique was developed for moderate noise levels rather than extremely high noise levels. This correlation of articulation index and percent word articulation has not been well established in the high noise region.

There is data which indicates that word articulation decreases at high sound pressures, even in the absence of masking noise (see K. D. Kryter,

Journal of the Acoustical Society of America 18, 413-417 (1946). Other tests under RCA sponsorship show similar results.

It may be here that the sound pressures under the earcushions without clipping are near the point of diminishing returns and that the increase of average level effected by the clipping process does not yield a corresponding increase in word articulation because of the effect noted by Kryter. The use of ear defenders under the headset may result in an increase of intelligibility under this circumstance.

That the use of clipping in the present case has apparently little effect on word articulation does not say that clipping is not desirable; it performs a definite and useful function in protecting the ears of the listener from excessive sound pressures with the corresponding risk of hearing damage, as noted above.

The original intention was to use the optimum clipping level as established by the first series of tests as the clipping level in the second series. There being no preferred level indicated by the first series, a level of 7.5 db was arbitrarily chosen for the second series.

2.1 Microphone Comparisons

The second series of tests was designed to compare three microphone combinations:

Table I	% Word Articulation
1. M-34/AIC with noise shield	85
2. M-55/AIC with noise shield	84
3. M-55/AIC less noise shield	72

The M-34/AIC was included as a reference point for comparison with the previous series of tests. The M-55/AIC was compared with the M-34/AIC to test its equivalence in performance to the M-34/AIC. The M-55/AIC would be a preferred unit as it is boom mounted.

The M-55/AIC was also tested with a noise shield, which in this case was a modified M-34/AIC noise shield. Although this is bulky and not readily mounted on the head, a useful, demountable hand free noise shield

could be designed for the M-55/AIC. The test scores shown above show that the M-55/AIC with a noise shield is equivalent to the M-34/AIC in performance.

A statistical analysis of the data in this second series of tests shows that the M-55/AIC performance with the noise shield is significantly superior to the performance without it.

Without the noise shield, the percent word articulation of the M-55/AIC is below the desired criterion agreed upon. The calculations and tests were deliberately constructed for extreme conditions. In many operating situations, the M-55/AIC without the noise shield will be quite intelligible.

Most listeners prefer a microphone with a noise shield as less high frequency noise, which is an irritant, is transmitted. Over long periods of time, the high frequency noise may bring about listening fatigue.

There is a 95% certainty that the true median word articulation score for the M-34/AIC or the M-55/AIC, both with noise shields, is above 80%.

SECTION V

CONCLUSIONS

1.0 On the basis of the test conducted, it is concluded that:

1. The required word articulation score (80%) can be obtained in a noise environment such as 127 db Armored Vehicle Noise in the speech masking range (above 200 cps).

2. The recommended system for accomplishing this would have characteristics similar to the Signal Corps equipment as follows: Amplifier, AIC-12; Headsets, H-101 (less microphone) with a high sensitivity earphone. The recommended microphone would be a moving coil first order gradient boom mounted unit similar to the M-55/AIC but provided with an optional hand free noise shield.

3. A system such as outlined in (2) above is greatly superior to the presently used VRC-7.

4. A noise shield for the recommended microphone will not be necessary in many situations, but it will be required to obtain the minimum proposed performance under the most severe conditions.

SECTION VI

PROGRAM FOR NEXT QUARTER

The articulation tests herein show that the required intelligibility can be obtained. Recognizing that it may not be expedient for the Signal Corps to attempt a switchover to an entirely new system, the contractor will conduct additional tests using the dynamic earphones and microphones in combination with the VRC-7 amplifier, using transistor adaptors already available.

On the basis of these further tests, it will be possible to make detailed recommendations for systems for communication in Armored Vehicle Noise.

The next quarterly report will also contain information on the Active Ear Defender phase of the project, which is now beginning.

SECTION VII

IDENTIFICATION OF KEY PERSONNEL

This report originates in Surface Communications Engineering, Defense Electronic Products Division, Radio Corporation of America, Camden, New Jersey. Mr. S. W. Cochran is Manager and Mr. O. B. Cunningham is the Chief Engineer of the department.

The following men are directly responsible for the work reported herein:

Willard F. Meeker, Class AA Engineer, B. S. has fifteen years of experience in acoustics and speech communications systems.

A. J. May, Class AA Engineer, B. S. has twelve years experience in acoustics and sound equipment.

R. M. Carrell, Class A Engineer, B. S. has six years of experience in microphone development and acoustical measuring techniques.

The articulation test crew, in addition to A. J. May and R. M. Carrell, consisted of the following:

C. E. Farr

R. A. Backus

A. M. Heisman

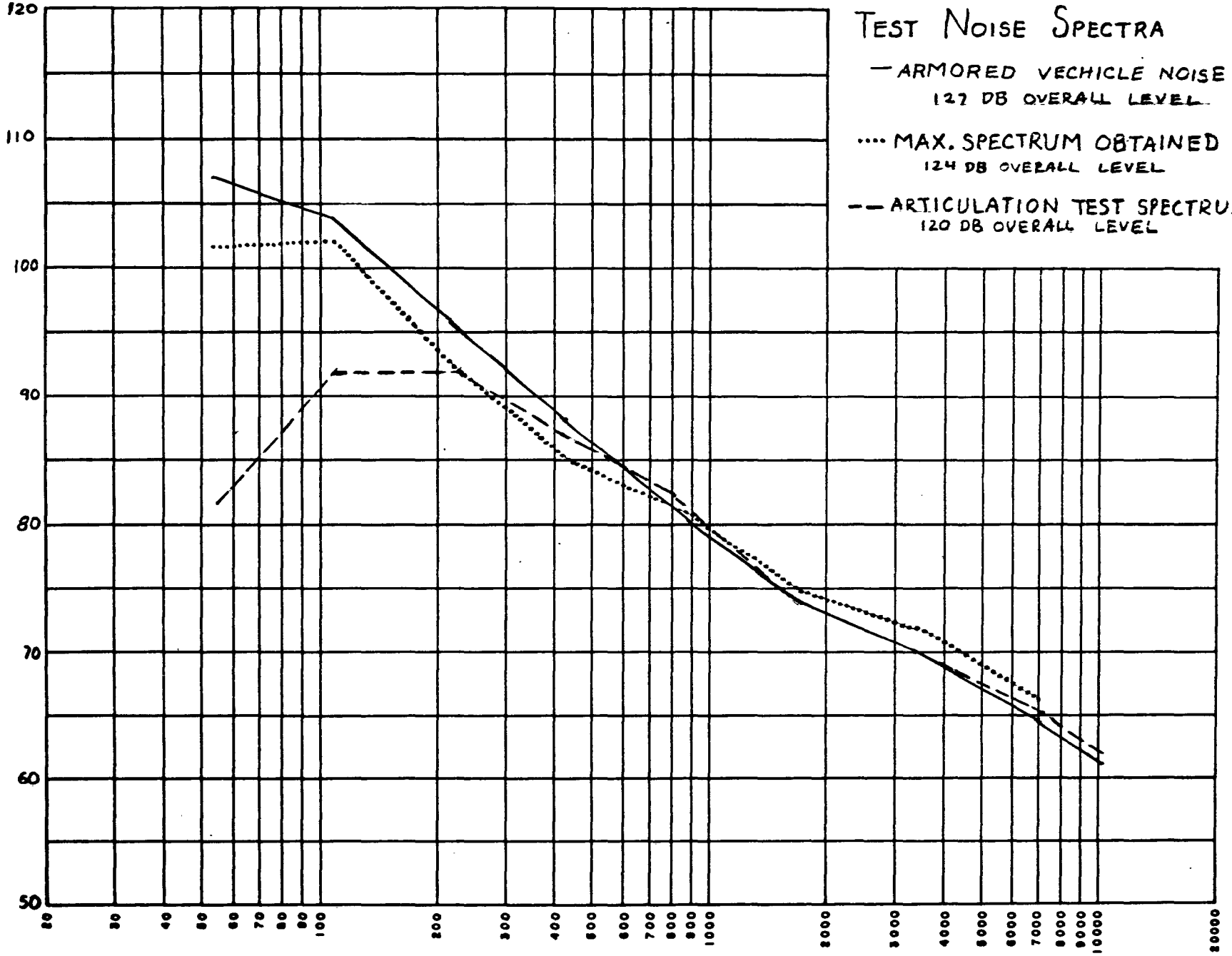
TEST NOISE SPECTRA
— ARMORED VECHICLE NOISE
127 DB OVERALL LEVEL
···· MAX. SPECTRUM OBTAINED
124 DB OVERALL LEVEL
– – ARTICULATION TEST SPECTRUM
120 DB OVERALL LEVEL
SPECTRUM LEVEL (DB PER CYCLE RE. 0.0002 DYNES PER CM²)
120
110
100
90
80
70
60
50
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
20000
FREQUENCY IN CYCLES PER SECOND

FIGURE 1

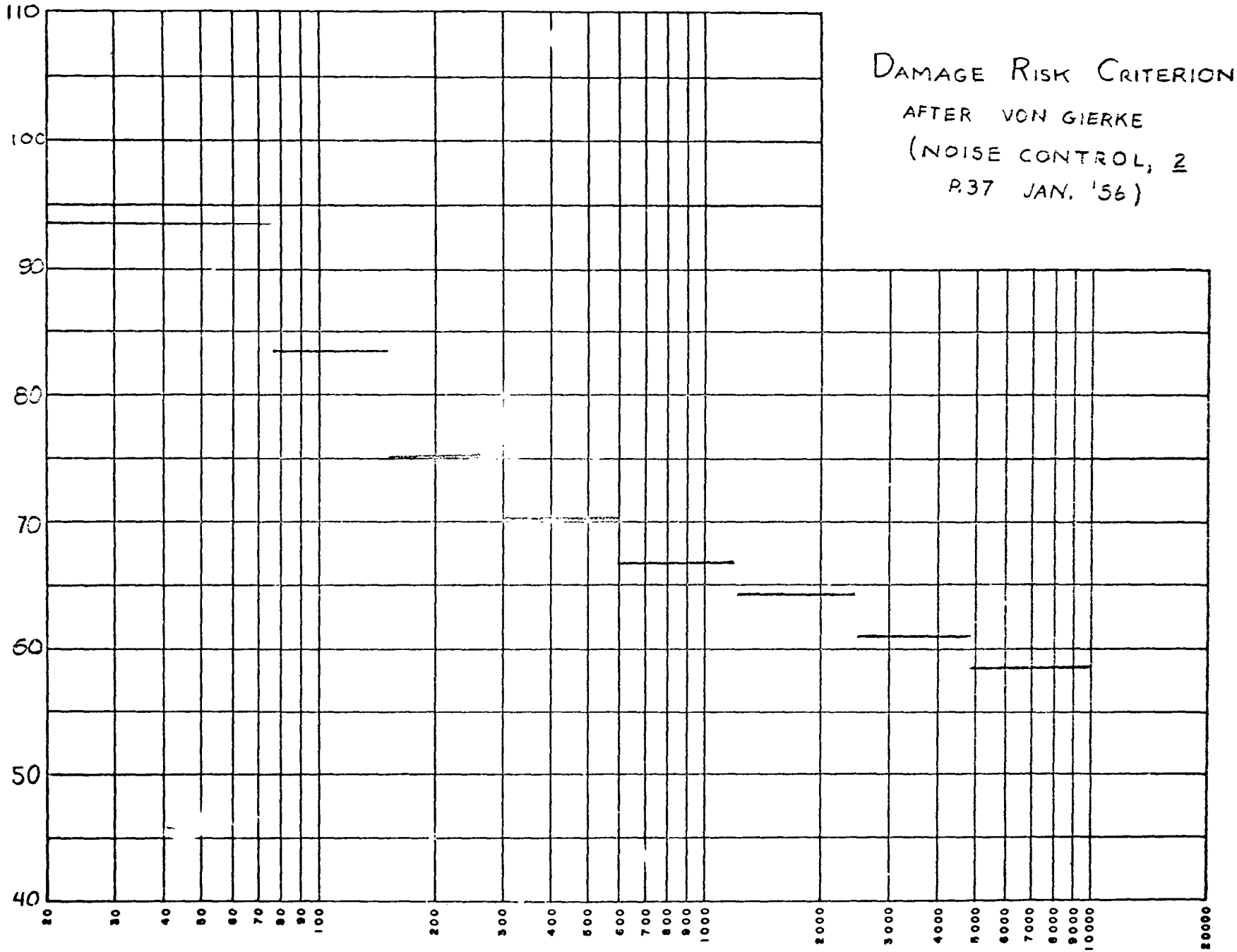
DAMAGE RISK CRITERION
AFTER VON GIERKE
(NOISE CONTROL, 2
P.37 JAN. '56)
SPECTRUM LEVEL IDB PER CYCLE RE. 0.0002 DYNES PER CM²)
110
100
90
80
70
60
50
40
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
20000
FREQUENCY IN CYCLES PER SECOND

FIGURE 2