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THE NSMC SONAR OPERATOR ALERTNESS RESEARCH APPARATUS: DESCRIPTION AND INSTRUCTIONS FOR USE

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SUMMARY PAGE

THE PROBLEM

To devise a simple portable system with which to perform research on sonar operator vigilance, in the laboratory and especially while under-way in submarines.

FINDINGS

An inexpensive automatic system was derived to present signals and background noise to a listener, and to record his responses (together with strengths of signals and noise) so that over extended vigilance testing sessions the detection performance of the operator may be specified at selected intervals.

APPLICATIONS

The system is useful as a research tool in specifying differences among listeners in detection ability, in resistance to monotony, in effect of signal density, time on watch, drugs, group interactions, etc.

THE NSMC SONAR OPERATOR ALERTNESS RESEARCH APPARATUS: DESCRIPTION AND INSTRUCTIONS FOR USE

1. PURPOSE

It was desired to provide a portable apparatus which could be put aboard submarines at an early date in order to examine the variables which lead to alertness on the part of sonar watchstanders. It was hoped that this apparatus could be handled and significant research performed by the medical officer attached to the ship, as an appropriate experimenter already in liaison with the Auditory Division, NSMC.

The apparatus was to be self-contained, with its own earphone, and to be used with subjects off watch, purely on a research basis. It was definitely not to be rigged to the sonar stack, nor be coupled to the sonar earphones, nor be used with subjects actually standing sonar watch to check on their detection ability and vigilance. Specifications for such an apparatus have indeed been written by the Chief, Auditory Division, following a general conference on auditory vigilance held at NSMC on 25 January 1965, attended by representatives from NavTraDevCen, ComDevGruTwo, S/M School, and NSMC. These specifications are included here as Appendix A for the convenience of those interested in the overall problem.

2. BACKGROUND

An array of 20 matched earphones, to which may be led any taped signal and background noise, together with response buttons operating the pens of a 20-channel recorder, has been put into operation in the workspaces of NSMC, and has formed the basis for a series of studies on auditory surveillance. These studies have concerned themselves with signal density, the effects of negative motivation for 'false alarm' detection reports, learning over many trials, and other variables (see NSMC Report No. 455 "Signal Rate Intersignal Interval Variability and Auditory Vigilance" in preparation).

Of course it is not possible in the laboratory to simulate actual S/M sonar listening conditions very truly, nor to commandeer the really appropriate subjects, namely, sonar operators of greater as well as of minimum experience.

In January, 1965, LT Bruce Geer, MC, USN, reviewed the problem and concluded that a forward step could be taken by working with S/M sonar operators during their off-watch time while actually under way on a mission. A general notion of a stripped-down version of the Auditory Division's signal surveillance apparatus, applicable for one

listener at a time, was worked out between Dr. Geer and the Chief, Auditory Division.

3. ACTION

A block diagram of the apparatus and a photograph, are shown as Figures 1 and 2. A home-type type recorder/playback, playing at 1 7/8 inches/sec, is split and led to transformer networks; one branch goes through Attenuator No. 1 in 1-db steps to the earphone. Also to the earphone is led the output of Noise Generator No. 1.

The output of Noise Generator No. 1 is to be set to 0.15 volts with the aid of the vacuum tube voltmeter (VTVM) built into the back; this voltage will result in a noise of 75 db sound pressure level in the octave around 1000 cycles/sec.

The other branch from the tape playback goes through a second Attenuator No. 2 and to a paper tape recorder fitted with a 50-db potentiometer. Also to this recorder is led the output of Noise Generator No. 2. Specific instructions for the use of this apparatus (see Appendix B) ensure that the pen records a baseline voltage from Noise Generator No. 2 which, when interrupted by the subject's response button, produces a drop to zero db of the pen. Superimposed upon this baseline voltage is the output of the tone-bursts from the tape playback. The actual level of each tone burst can be read in db on the paper tape; the playback level is adjusted so that the weakest tone burst just rises 2 db over the baseline voltage.

It was necessary to utilize a potentiometric recording in db of signal (tone-burst) strength because of the inexpensive tape/recorder/playback and because of the slow tape speed necessary to provide a continuous long listening session. Although each succeeding tone-burst of a series of eleven bursts was exactly 2 db more intense, there were variations from this pattern by the time the tape was played back through the same inexpensive low-speed system. However, the paper recorder is a faithful index of what goes to the subject's earphone on any burst, and the experimenter is enabled to make some allowance for loudness irregularities in interpreting the data.

Four tapes were prepared, with signal densities of 3, 6, 9, and 12 per hour. Each signal consists of a series of 1000 cycles/sec tone-bursts, 1/3 sec long, with 1.5 sec silent interval, 10 msec rise-fall time, for a total of 18.6 sec, the first burst recorded at VU= -20, the next at VU= -18, ... the last a VU= 0. The 1/3 sec-duration was designed to allow full loudness to develop, the fairly long silent interval was designed to allow plenty of response time before the next burst.

An initial 60-sec continuous tone at 1000 cycles/sec at VU= 0 was impressed upon the tape, so that the experimenter can quickly set the overall level with the aid of the VTVM. Next is 60 sec of tone-bursts at VU= -20. This is for two purposes:

(a) to allow the subject to listen to these bursts in 0.15 volt noise and adjust Attenuator No. 1 until he can just hear them (this defines his "Alerted Signal/Noise Ratio"); and

(b) to allow the experimenter to adjust Attenuator No. 2 so that the weakest signal causes the pen to rise about 2 db over the baseline voltage.

Following these preparatory signals, the 1-hour vigilance session begins. At each signal density, however, a regular temporal pattern was avoided by varying the presentation time in a gaussian fashion around the regular interval. Thus, at the 6/hr signal density (every 10 min), the actual intervals varied between 8-12 minutes.

4. RECOMMENDATIONS

This apparatus was shipped 9-17-65 to LT Bruce Geen, MC, USN, for use aboard a POLARIS submarine during an actual mission. The Commanding Officer has directed that subjects be made available to him for basic research. It is expected that Dr. Geer can contribute data on the effects of signal density on extended auditory surveillance (the tape can be re-wound in a few seconds to obtain sessions of 2 or more hours), and of the effects of a variety of personality and environmental parameters contributing to alertness. This will materially advance our present laboratory data based as the latter are on less appropriate subjects and under general conditions having less face validity for the sonar problem.

An evaluation of the apparatus itself by Dr. Geer will determine what its future usefulness may be, or what modifications in apparatus or method will yield a body of more meaningful material.

APPENDIX A

SPECIFICATIONS FOR A PASSIVE SONAR OPERATOR ALERTNESS TESTER

1. It is desired to provide a passive sonar operator with a system whereby he can check his own alertness, and thereby yield data useful

(1) for assessing the general vigilance of a whole watch bill,
(2) for analyzing the day-by-day performance of individuals, and
(3) for determing those stimulus parameters (rate of signal presentation, information feedback, S/N ratio, frequency uncertainty, etc).) which are known to contribute to target detection in the human.

2. A taped library of at least one dozen targets should be available from endless loops, so that with a target randomizer could be presented one target at a time to a BQS sonar stack. Each target should be of approximately the same loudness, and all targets should be selected from among those most likely to be encountered on the particular mission of the submarine to be fitted with this gear.

3. The target selected should be led by a bearing randomizer to the sonar stack in such a way that it appears at random at any of 24 bearings, the 15° steps around the horizon.

4. The target should be caused to appear, with a timing randomizer, over a 1-hour watch, at a rate preset by the experimenter from 2-8 times per hour.

5. The target should be adjustable by hand, with machine set in a "Manual Mode", and the bearing randomizer out of action, so that the operator at the initial phase of his watch can set the target strength such that, in the particular background noise in the sonar stack at that time, he can just barely make out the target. At that point, the operator should be able to push a button labelled "Automatic Mode", and the target randomizer, the bearing randomizer, the timing randomizer, and the recording system should be simultaneously thrown into operation for one hour.

6. After the "Automatic Mode" is on, and the watch proper begun, the target should appear after some time at some bearing at the S/N initially set by the operator as in (5) above. The target should remain constant for one minute, during which time the operator will have, by current practice, explored the horizon once. If the target is detected, the operator presses a button called "Artificial Target"; the response recorded, to which the operator should not have access until the end

of the watch, should clearly show that, for example, at 7 min 30 sec after the start of the watch the operator detected Target No. 5 at Bearing 45° at S/N-0. Also, if the target is detected, during the time the operator depresses the "Artificial Target" button the target should be interrupted. This is a signal to the operator that he is not on a real target, and that he has made a correct response to an artificial target. The only time-out from his regular job is to take a couple of seconds to hear if the target disappears. Any real target at the same bearing will not however disappear and should be reported to the conning station. The "Artificial Target" button, when depressed when the sonar is trained to any bearing ± 3° of the artificial target bearing, will cause the artificial target to disappear and reappear when the button is let up, and at the end of the minute during which the artificial target is at the particular intensity, the increasing-intensity programmer is set to 0 S/N and waits for the timing randomizer to select the next target time. If the "Artificial Target" button is depressed at any other bearing than ± 3° of the artificial target bearing, as it will be with a real target, the operations of this system are unaffected and the timers proceed as usual.

7. If, on the other hand, the operator fails to detect the artificial target during the first minute of its presentation, an increasing-intensity programmer raises the target by 2 db for the next minute at the same bearing, by 2 db more for the third minute, and so on until the target is in fact detected. The response recorder would then state that at 9 min 25 sec after the start of the watch the operator detected Target No. 3 at Bearing 195° at S/N= 4 db (where 0 db = fully alerted response) that at 25 min 5 sec of the watch Target No. 7 was detected at Bearing 15° at S/N= 8 db, and so on.

8. A print-out record which would be immediately interpretable by the operator, and from which the experimenter could quickly reconstruct cycles of alertness over the watch, would be preferable to a complicated voltage tracing of signal strength and of on-off event recordings on a long constantly-running paper tape, which would take inordinately long to decode. The record should resemble the following, with time, bearing target number, and S/N always in order:

10' 14"
165
11
6
17' 45"
30
4
8
etc.

APPENDIX B

Instructions for Using the "NSMC Apparatus for Sonar Operator Alertness Research"

Adjusting Listening Levels of Tones and Noise

1. Plug from "Monitor" of tape playback into transformer network on panel.

2. Set tape playback "Loudness" to maximum.

3. Set top listening noise generator gain to read 0.15 volts.

4. Set tape playback listening attenuator to 35 db. At this S/N, few if any of our lab subjects hear all the program bursts, and a range of about 14-16 db is available for documenting loss of alertness. If your subjects are better or worse than this, you should change the attenuator down or up respectively in accordance with your findings. Arrange it so that no one gets all eleven bursts at any signal presentation. The sonar operator should listen to the calibrating bursts in noise and adjust the attenuator dials following the tape recorder until he can just barely pick up the tones. This is designated as his "alerted S/N". Any calibrating tone bursts from any tape can serve for all tapes.

Adjusting the Pen recording

1. Set gain knob of pen recorder to 12 o'clock.

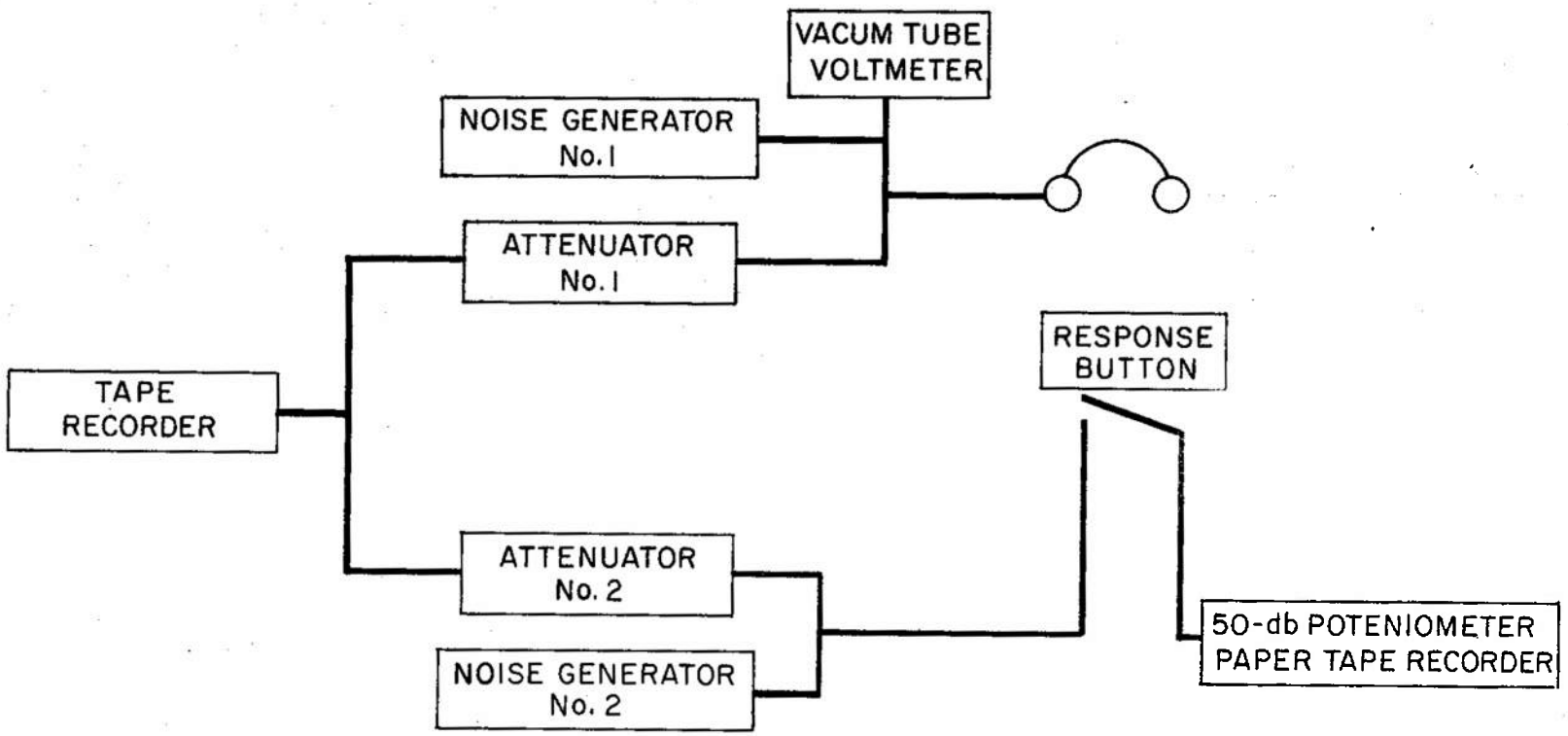
2. Set gain of bottom recording noise generator so that pan registers 10 db above zero on pen scale.

3. Play a section of the calibrating tone bursts and set the tape playback recording attenuator so that the pen rises at least 4-5 db over the noise.

Each signal will now be clear on the paper and when the subject responds, his button will cause an immediate drop in the pen level. He should be instructed to respond so far as possible between tone bursts. The actual vigilance session, pre-recorded on the tape, is now ready to run. When the first signal comes on, it should appear as an increase in the pen level of the noise background but be inaudible to the operator. 1.5 sec later, a second burst will come on at a level 2 db louder, driving the pen a bit higher over the noise; then the third burst at a level 2 db louder still, etc., until a total of 11 bursts has come on for a total of 18.3 sec. The first time that the operator presses his

response button defines his alertness S/N at that moment, provided he responds to all higher levels as well. There will be occasions when the subject's response, which momentarily interrupts all voltage to the paper recorder, will obscure the signal response; but the constant speed of the paper tape and the fact that the weakest signals will not be responded to but will certainly appear on the paper, allows the experimenter to reconstruct with ease the momentary S/N.

Due to the slow speed (1 7/8 ips) of the recording and the "wow" and other instabilities of this cheap home-type tape recorder, the amplitude of each tone burst may not be exactly what was sent into the tape recorder in the original recording session. But the fact that, for instance, the 4th tone burst of a signal, which was sent in to the recorder at a level 6 db louder than the 1st burst, plays back at a level only 3 db louder, or perhaps 8 db louder, can be seen from the pen recording of the bursts, and allowances can be made for this sort of variability.



BLOCK DIAGRAM OF APPARATUS

FIGURE 1

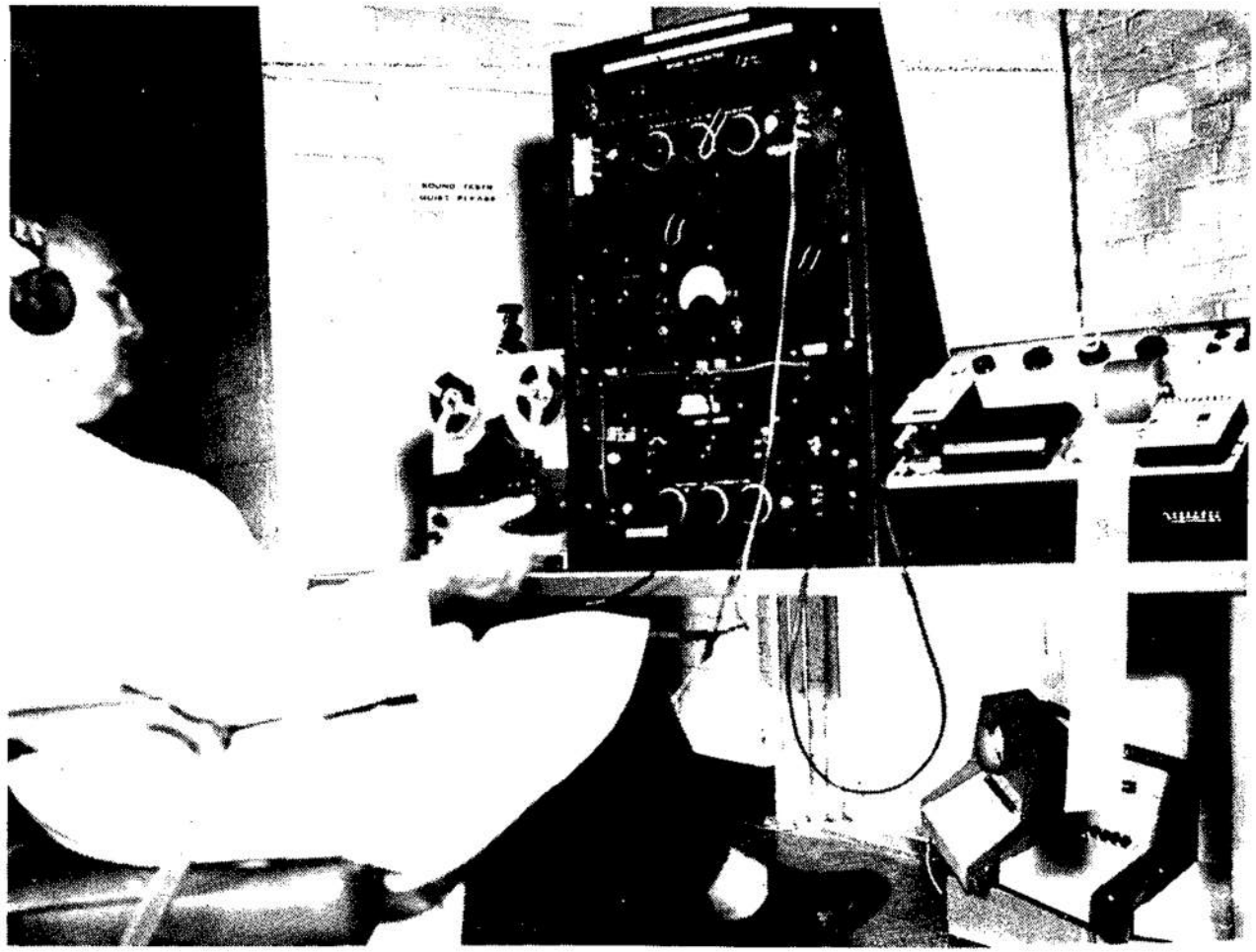


Figure 2 - Photograph of signal surveillance apparatus