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EVALUATION OF BOOK-TYPE SCAN INDICATOR IN RADAR PARAMETER STUDY SYSTEM

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EVALUATION OF BOOK-TYPE SCAN INDICATOR IN RADAR PARAMETER STUDY SYSTEM

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February 21, 1950

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CONTENTS

ABSTRACT

A book-type scan indicator has been compared with the conventional plan position indicator on the Naval Research Laboratory Radar Parameter Study System. Evaluation tests have been made to determine if an improvement in signal detectability could be obtained with this type display. The signal required to yield 50 percent detectability with the book-type scan was one decibel less than that required with the PPI. A fatigue test was included to determine if operator fatigue could be reduced by the book-scan presentations. No positive evidence of any fatigue effect could be found with either PPI or book-type display when operators stood watches up to two and one-half hours.

PROBLEM STATUS

This report concludes work on the problem, and unless otherwise notified by the Bureau it will be closed one month from the date of mailing the report.

AUTHORIZATION

NRL Problem R13-08T (Bureau of Aeronautics Problem NRL-EL-8A-346)

EVALUATION OF BOOK-TYPE SCAN INDICATOR IN RADAR PARAMETER STUDY SYSTEM

INTRODUCTION

The problem "Evaluation of Book-Type Scan Indicator in Radar Parameter Study System" was received 17 February 1949 from the Bureau of Aeronautics. The problem called for "the laboratory evaluation of the 'book scan' indicator in the radar parameter study system for the purpose of comparing performance of operators using this indicator with performance of operators using standard PPI presentation. The securing of comparative signal level data for equal performance and the effect of long period operation upon operator performance should be included.

"(1) Tests should be made under the assumption of search for small targets in regions of considerable clutter.

"(2) Only the detection feature of the indicator should be investigated.

"(3) Sufficient tests should be made on which to base recommendations of the usefulness of the book scan for ASW radar application."

DESCRIPTION OF APPARATUS (Figures 1 and 2)

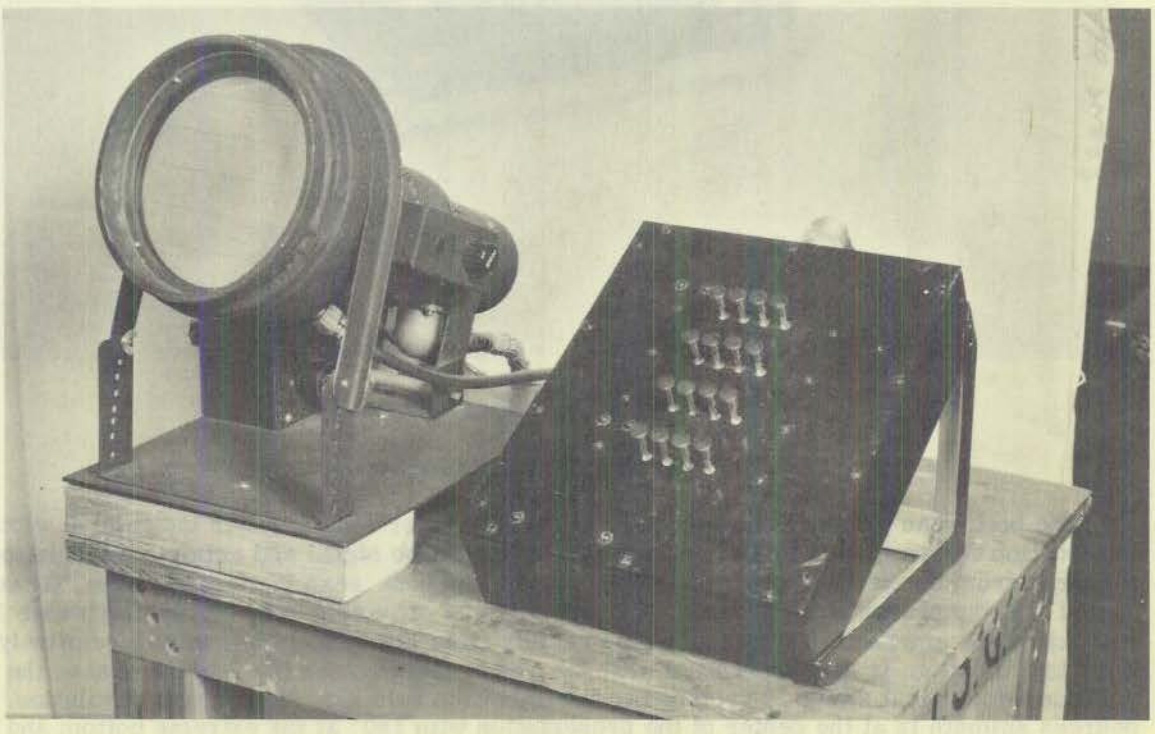

Figure 1. Book-Scan Indicator

Indicator and Observer's Answer Board

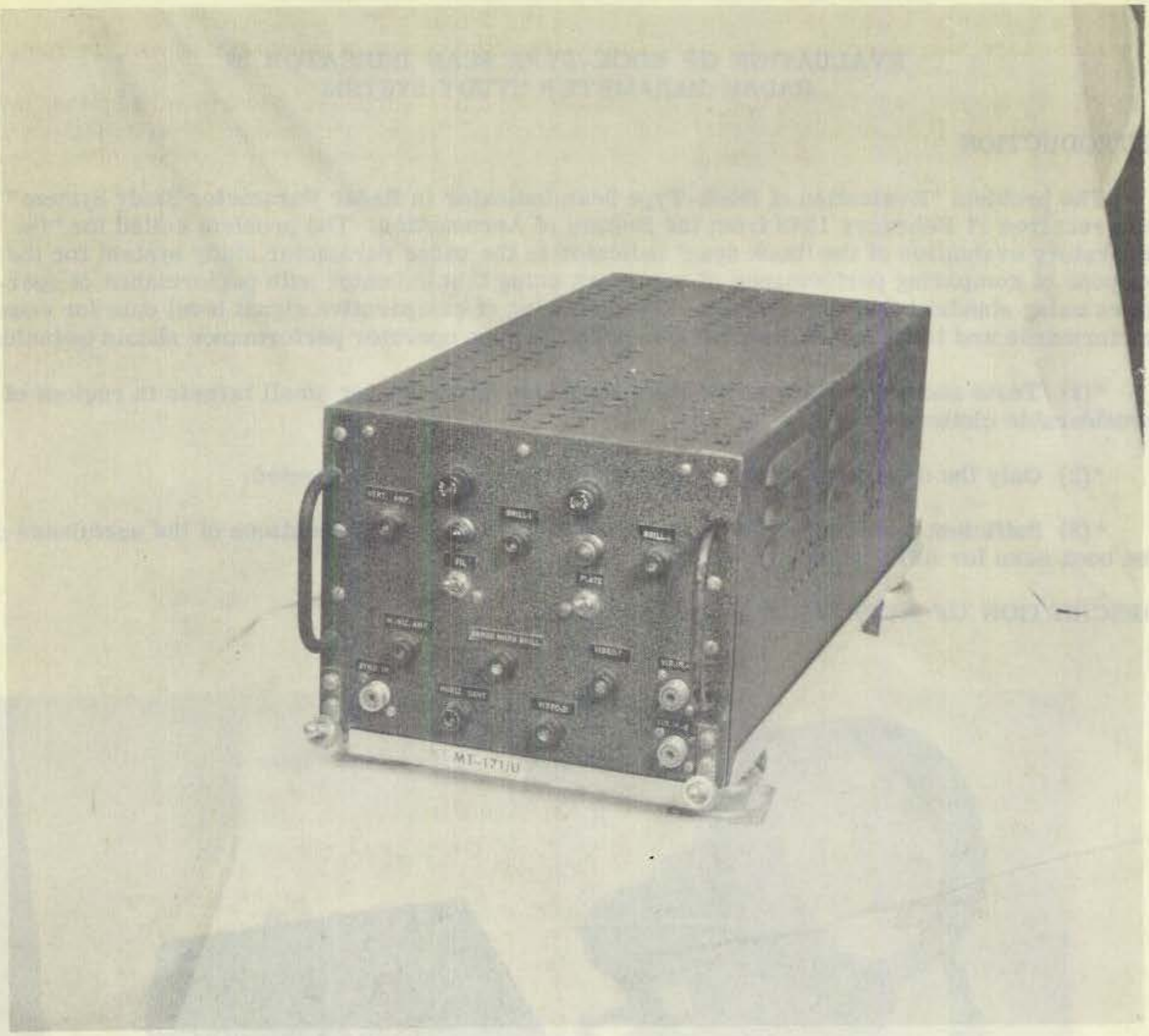

Figure 2. Book-Scan Indicator

Power Supply and Amplifier Unit

The book scan provides a rectangular presentation for search radar indicators, with range information determined from the horizontal position of the signal and azimuth information determined from the vertical position of the signal. The book scan is similar to the "B" scan except that the presentation is turned through 90°, and provision is made for continuous 360° rotation of the antenna. The sweep moves rapidly from left to right and moves relatively slowly from top to bottom in synchronization with the radar antenna. As the antenna passes the 180° position the vertical sweep is returned to the top of the indicator for the next revolution. Zero degrees azimuth is at the center of the presentation with 180° at the extreme bottom and top. This method of presentation was tried because in following it the operator moves his eyes as he would in reading a book.

The plan position indicator provides a circular presentation with range information determined from the distance from the center to the point where the signal appears. Azimuth information is determined from the angular position of the signal. The sweep moves rapidly outward in a radial direction from the center and rotates about the center in synchronism with the antenna.

Two book-type indicators using 7BP7 cathode-ray tubes were designed and built by the Naval Air Development Station at Johnsville, Pennsylvania, and the performance of these indicators has been compared with that of two standard production model VE, remote plan position indicators also using 7BP7 tubes. Small targets were presented in a noise background consisting of simulated receiver noise generated in a 708-A vacuum tube operating as a temperature limited noise diode. Additional clutter in the form of simulated sea return was not added because the present sea clutter simulator had become somewhat erratic during the period of these tests, and more consistent results were obtained using the receiver noise only.

The book-scan indicators were evaluated in the Naval Research Laboratory radar parameter study system[1]. A block diagram of the system as used for these tests is shown in Figure 3. The

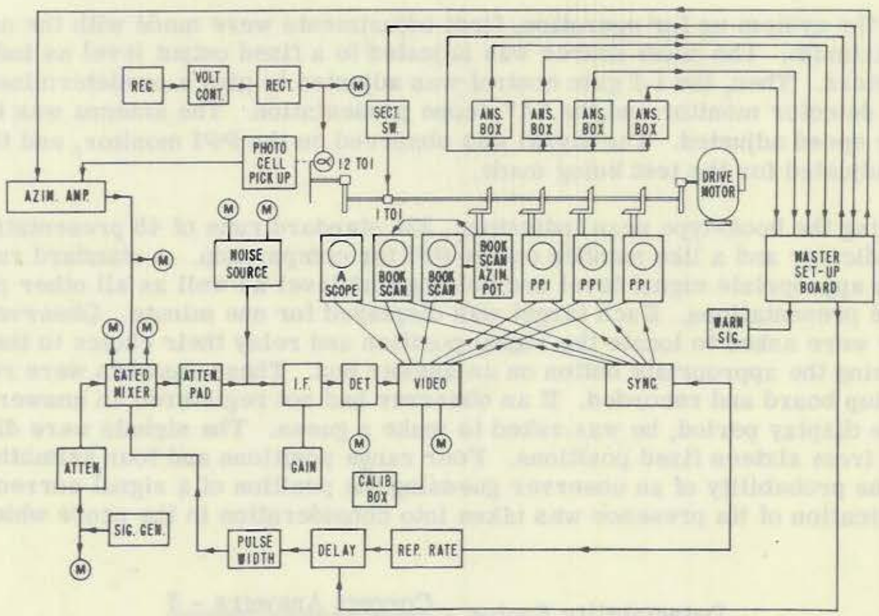

Figure 3. Block Diagram of PPI Parameter Study System
As Used in Book-Scan Evaluation Tests.

test signals were displayed on two book-scan indicators and two plan position indicators simultaneously. A third PPI and an "A" scope were used for monitoring purposes. The antenna rotation simulation was provided by a d-c variable speed motor which was mechanically coupled to each PPI unit, to the saw-tooth potentiometer which developed the vertical sweep for the book-scan indicators, and to a beam simulator device which provided an azimuth gate. A four-degree azimuth gate was used, simulating a four-degree antenna beam.

All the indicators were triggered from a synchronizing unit which supplied an isolated synchronizing pulse to each indicator. The synchronizing unit also supplied a delayed pulse which

[1] Jackson, T. B., "A PPI Parameter Study System," NRL Report No. R-3301, 17 June 1948. (Confidential)

was used as the range gate. The time delay of this pulse could be varied by the operator to change the range position of the simulated target.

A gated mixer unit was fed from three sources: an azimuth gate which determined the bearing of the target, a range gate which determined the range position of the target, and a 30-megacycle variable amplitude signal. The amplitude of this 30-megacycle signal was used to determine the signal strength required for each test. The output of the gated mixer unit is a 30-megacycle signal which represents the output of a conventional mixer in a pulse radar system. The output of the mixer was fed through a fixed attenuator so that the input to the mixer could be relatively high. At this point the 30-megacycle signal was mixed with noise from the diode noise source and then injected into an i-f amplifier. The i-f amplifier was a conventional 30-megacycle amplifier with a 2-megacycle bandwidth. The signal was detected by a diode and fed to a video amplifier, where it was inverted and used to drive six cathode followers, one for each scope unit. Each display indicator had one stage of video amplification, and these were carefully adjusted to provide the same video signal to each cathode-ray tube. The video bandwidth was 1 megacycle.

In setting the system up for operation, first adjustments were made with the antenna stopped on a signal maximum. The noise source was adjusted to a fixed output level as indicated by monitoring meters. Then, the i-f gain control was adjusted to give a predetermined output as indicated by a detector monitor and the "A" scope presentation. The antenna was then put into motion and the speed adjusted. The signal was observed on the PPI monitor, and the signal strength was adjusted for the test being made.

In evaluating the book-type scan indicators, 224 standard runs of 48 presentations were made on this type indicator and a like number on the PPI for comparison. A standard run was made by choosing an appropriate signal level and holding that level as well as all other parameters constant for 48 presentations. Each target was displayed for one minute. Observers placed at each indicator were asked to locate the signal position and relay their choice to the system operator by pushing the appropriate button on an answer box. These answers were registered on the master setup board and recorded. If an observer had not registered an answer at the end of the one-minute display period, he was asked to make a guess. The signals were displayed in random order from sixteen fixed positions. Four range positions and four azimuth positions were used. The probability of an observer guessing the position of a signal correctly and not having any indication of its presence was taken into consideration in the score which was calculated from:

$$\text{Detectability Factor} = \frac{\text{Correct Answers} - 3}{45}.$$

Two standard runs were made for each antenna speed, one with a signal level low enough to obtain a detectability factor somewhat below 50%, the other with a signal level high enough to obtain a detectability factor somewhat above 50%. The signal strength required for 50% detectability was then obtained from interpolation between these two points.

Eight observers were used for the tests, but since one man did not complete the course, his data has been eliminated. The tests covered a range of antenna speeds from 1 to 150 rpm, all other parameters being held constant.

The evaluation tests were made in two parts with the video amplifiers and cathode-ray tubes interchanged between the book-type indicators and the plan position indicators for the second part of the test. The book-type indicator was 1.2 decibels better than the PPI on the first test and 0.8 decibel better on the second test. This difference should be considered as a systematic error produced by slight differences in the band-pass characteristic of the amplifiers rather than as an indication of the spread in the data because the consistency of each run was good. Therefore the improvement should be taken as 1 decibel with a spread of something less than ±0.2 decibel. In all these tests a regular production model PPI was compared with an improvised book-type setup which could undoubtedly be refined. The saw-tooth potentiometer which rotates in synchronism with the antenna to develop the vertical sweep could be improved. This potentiometer became nonlinear, causing irregularities in the vertical sweep. Therefore, the book-type scan was penalized in the tests by a pronounced jitter which was not present with the factory built PPI equipment. However, it is believed that the effect of this on the results is only slight.

RESULTS

The advantages of the book-scan indicator over the PPI are: (1) It is preferred by inexperienced operators. This preference may be caused by reading habits or familiarity with television presentations. (2) The signal appears the same size and brightness regardless of range. (3) The noise background is uniform over the complete raster. (4) At relatively high antenna speeds the individual sweeps may be seen as spokes of a wheel merging at the center on the PPI while on the book scan the sweeps are equidistant at all ranges. (With a repetition rate of 330 pps and an antenna speed of 150 rpm, the individual sweeps on the 7″ PPI tube are separated at the periphery by about 1/8″ while on the book scan the individual sweeps are separated by about 1/32″ at all positions.) (5) As is seen in Figure 4 the change in detectability with range is less on the book scan than on the PPI. This is because of the advantages listed above.

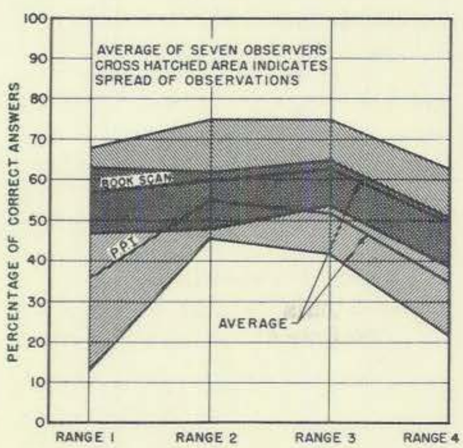

Figure 4. Percentage of Correct Answers vs. Range Position.

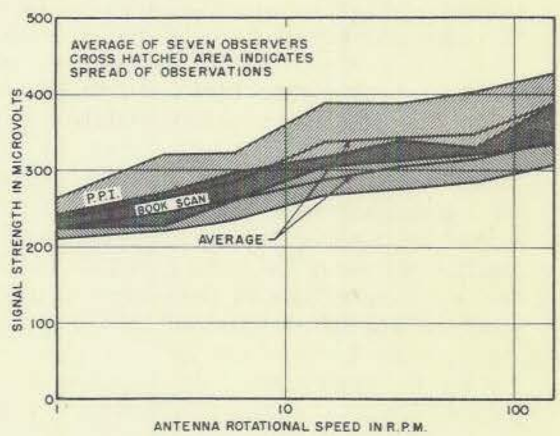

Figure 5. Signal Strength Required for 50% Detectability vs. Antenna Rotational Speed.

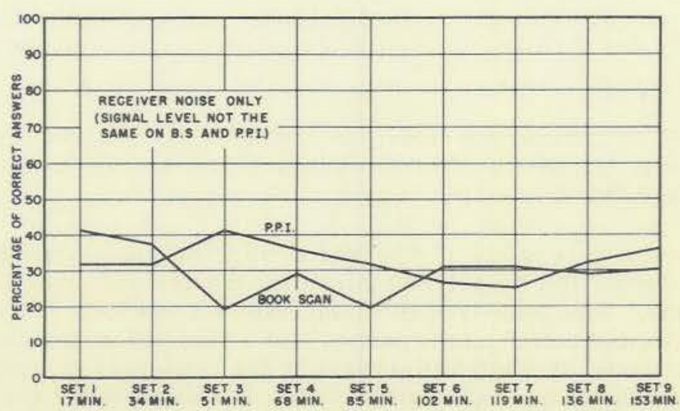

Figure 6. Results of Fatigue Test Covering 2-1/2 Hours of Continuous Operation (July 25, 1949).

The results of these tests, as shown in Figure 5, indicate that the signal required for 50% detection with the book-type indicator is 1.0 ±0.2 decibel less than that for the PPI over the entire range of rotational speeds.

The results of fatigue tests are given in Figure 6. It is apparent that operator fatigue is not a significant factor on either system provided that the watch is less than two and one-half hours. After two and one-half hours of continuous operation, the observers became restless and irritable, but there is no significant change in their ability to detect weak signals in the presence of receiver noise.

Since an improvement of 1 decibel can be realized with the book-type indicator over the conventional PPI, it is recommended that the book-type presentation be used for ASW displays.

* * *

NAVY-DPPO PRNC WASH., D.C.