NRL REPORT NO. R-3098

AN AUTOMATIC SCORING DEVICE
FOR GUN FIRE CONTROL SYSTEMS
MARK 57 AND MARK 63

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NAVAL RESEARCH LABORATORY

Washington, D.C.

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AN AUTOMATIC SCORING DEVICE
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MARK 57 AND MARK 63

by

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June 1947

Problem No. 36R05-26

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ABSTRACT

A device is described which is designed for use in evaluating the performance of pointers in tracking by radar with the Gun Fire Control Systems Mark 57 and Mark 63. The device receives information from the pointing-error channels of the radar, and after modifying this information, utilizes it to provide a measure of tracking accuracy through the use of timing clocks. The limitations of other methods of evaluating this kind of tracking, such as by optical checksighting or by use of the kymograph, are discussed in the appendix.

AN AUTOMATIC SCORING DEVICE FOR GUN FIRE CONTROL SYSTEMS MARK 57 AND MARK 63

PURPOSE OF THE SCORER

The device described in this report (pictured in Figure 1) is designed to provide accurate and easily obtainable scores of the performance of pointers when tracking "blind"* with the Gun Fire Control System Mark 57 or Mark 63. Blind tracking is difficult in that it requires the pointer to follow smoothly the center-of-motion of a jittering radar indication. This skill is not obtained without considerable practice on the part of the pointer. The scorer is intended both as an aid in developing "blind" tracking skill and as a means for rating men in this ability for purposes of selection.

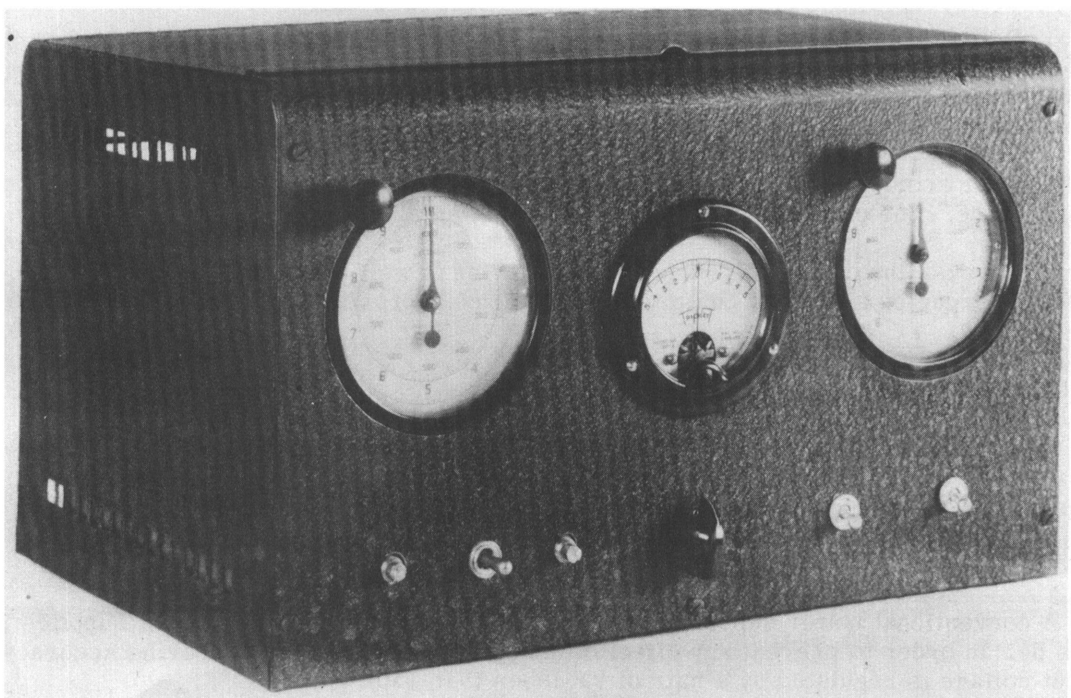

Figure 1. Automatic Scorer

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* The term "blind" refers to the situation where the target is not visible optically, because of weather or darkness, and the tracker is tracking a green cathode-ray-tube spot which indicates the relative position of the target.

IMPORTANT FEATURES OF THE SCORER

The following desirable features of the automatic scorer should be noted:

1. It can be used readily with either Gun Fire Control System Mark 57 or Mark 63 by connecting seven leads to one of the radar junction boxes. Thus, the device may be used with existing equipment either ashore or afloat. Furthermore, it interferes in no way whatsoever with normal operation of the system, and can be easily disconnected if so desired.

2. Scores are taken directly from two clocks. One records total time, and the other shows the length of time that the center-of-motion of the radar image is within a predetermined scoring circle.

3. Both clocks stop whenever the radar image changes from a spot to a circle. Since this change in the image occurs when the tracker loses the target or when the radar operator allows the target pip to slip out of gate, it is proper that no scoring should be done during such periods.

4. Four scoring circles make it possible to evaluate tracking over a wide range of performance. The circles available are 5, 10, 15, and 20 mils in diameter.

5. Because the device is relatively compact, it is well adapted for shipboard use. The prototype occupies about one cubic foot and weighs approximately twenty pounds.

PARTS OF THE SCORER

A prototype of the automatic scorer has been constructed and has been given preliminary tests. The scorer consists of four main parts: (a) a power supply, (b) two error channels, (c) clock circuits (with associated amplifier), and (d) a circle detector.

Power Supply

A conventional power supply in the device, operating from 110 volts ac, supplies 300 volts dc. In order to prevent any effect of changes in line voltage on scoring accuracy, the output voltage is regulated by a pair of VR tubes (VR-150).

Error Channels

Figures 2 and 3 show two error channels, one to handle traverse errors and the other elevation errors. In both cases, signals pass through what is referred to in Figure 2 as isolating impedances. This prevents the scorer from putting more than a negligible load on the spot-scope circuits of the radar. The signals are then fed to cathode-follower circuits which serve as power amplifiers, and also provide for zero adjustment. Such adjustment is important because the deflection-plate voltages in the radar-spot scopes are not necessarily zero when the spot is in the center of the gunsight reticle.

The error voltages are fed from the cathode followers to selector switches. The switches for traverse and elevation are ganged to one shaft, and thus, acting together, determine the size of the scoring circle. The error voltages are then fed to the error amplifiers. The error amplifier in each case is a one-stage, balanced d-c amplifier. Then the voltages go through

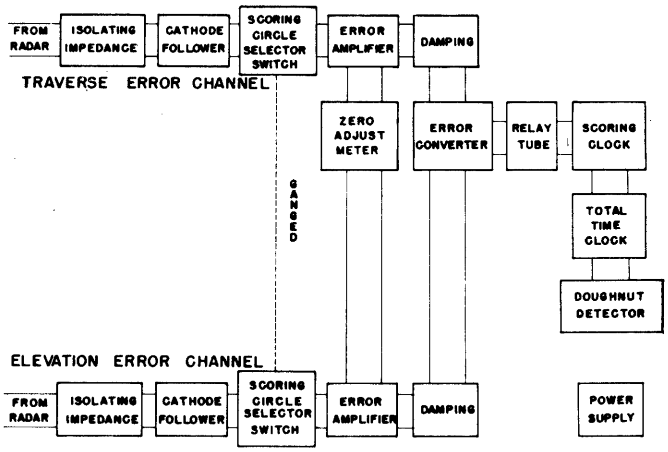

Figure 2. Flow Chart for Automatic Scorer

r-c filters, each having a damping constant of 0.15 seconds. The purpose of these filters is to remove, at this point, as much as possible of the random noise which is picked up from the radar pointing channels along with the error information. After being filtered, the error voltages are fed into 6H6 tubes in such a way that the output of the tube in each case is a measure of error without regard to sign. There is now a d-c voltage in each channel which indicates magnitude of error without regard to the sign of the error.

Clock Circuits

The absolute traverse and elevation errors are added in the error-converter circuit in such a way that a voltage approximating radial error is obtained. (Actually the scoring figure is an octagon.) This voltage controls the current flowing in the plate circuit of a 6SH7 tube, and thus opens and closes a relay in the tube's plate circuit. Whenever this radial error voltage exceeds a certain critical value, the relay is energized and stops the scoring clock. If the voltage later drops below this critical value, the relay is deenergized and the clock starts. The stop and start voltages are very close together because of the sharp cutoff characteristic of the 6SH7 tube.

Circle Detector

In the radar system, whenever either the radar operator or the tracker loses the target, the tracker receives a circular presentation rather than a spot. This circle is formed by suitable 60-cycle a-c voltages injected into the pointing-error circuits. The scorer contains circuits which serve to deenergize both clocks whenever these a-c voltages are present.

OPERATION OF THE SCORER

The first step in placing the scorer in operation is to attach the seven-lead cable to the radar junction box. Then the scoring circle is preset by means of the scoring-circle-selector switch. (Great care must be used in properly adjusting the radar of the fire-control system if the scorer is to perform accurately.)

After the T and E scopes on the radar are adjusted, the switch is left in the adjust position, and the traverse and elevation channels of the scorer are zero adjusted through reference to the meter. The radar adjust switch is returned to OPERATE, a target is acquired by the tracker, and tracking begins.

Measured tracking is initiated by snapping the control switch on the scorer to OPERATE. This actuates the total-time clock, and the scoring clock now operates whenever the mean position of the radar spot is within this preselected scoring circle.

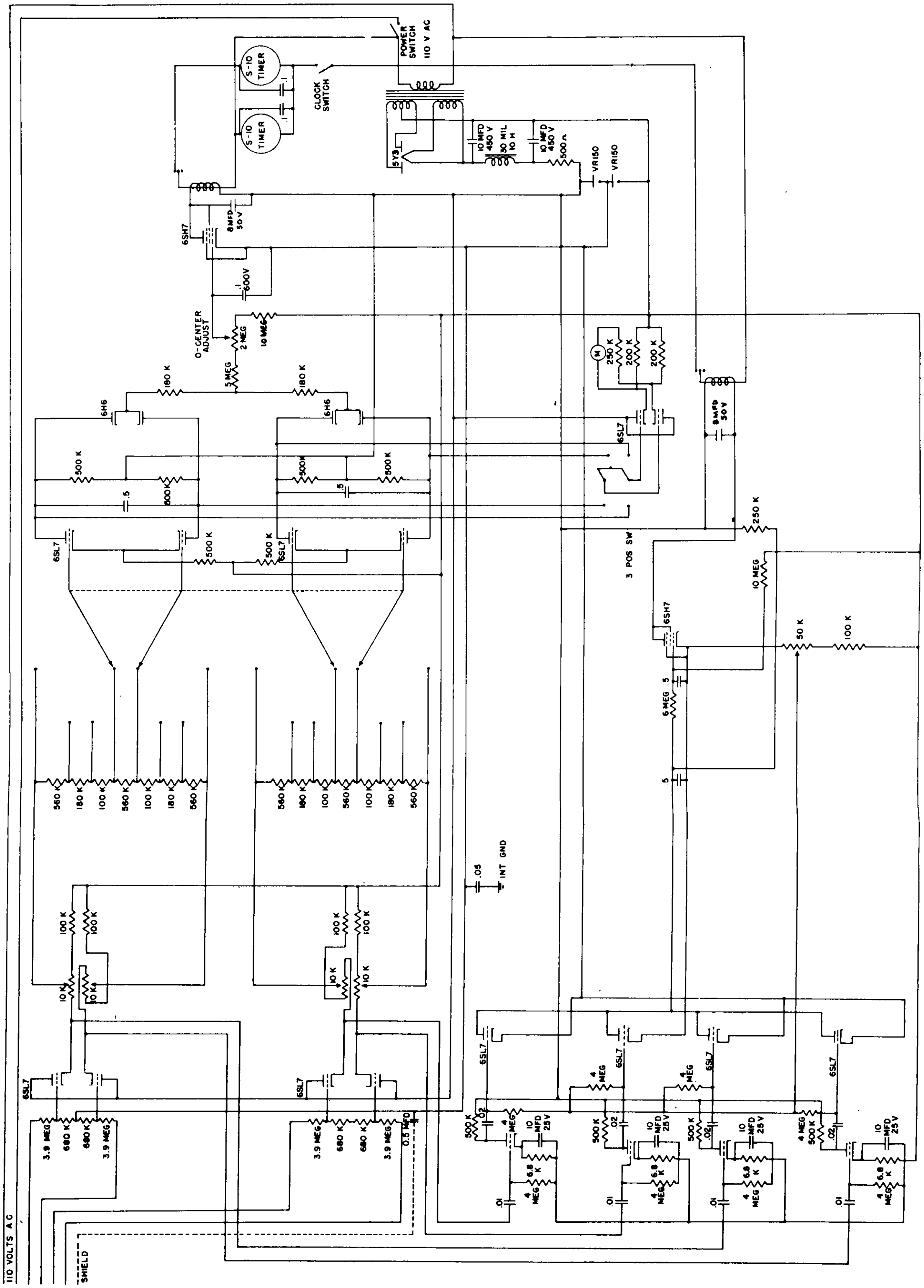

Figure 3. Schematic Diagram for Automatic Scorer

If the tracker loses the target or the radar operator allows the target pip to slip out of gate, the radar spot changes to a circle. At the same time, the device, through the circle detector, stops both clocks. When the tracker gets back on the target or the radar operator correctly gates the pip, the automatic scorer resumes scoring.

At the end of the course, the control switch is snapped to STANDBY and both clocks stop. A score in terms of percentage of time-on-target can then be obtained by dividing the reading on the scoring clock by that of the total-time clock.

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APPENDIX

OTHER METHODS OF SCORING TRACKING

The other methods which have been used in scoring tracking are optical checksighting and kymographic recording of error voltage. As is pointed out below, though these two methods are of value in some instances, they present certain difficulties which are overcome by the use of the automatic scorer.

Optical Checksighting

By means of a checksight, an instructor views the target which is being tracked "blind" by the student. The tracking performance is scored in terms of the time the optical image of the target remains within a fixed distance from the center of the telescope. This method has been recommended for checking optical tracking and, in this connection, has been shown by NDRC Project N-111* to give reliable scores. Furthermore, some tentative results obtained by the Psychology Section indicate that there is a rank order correlation of about +0.90 between optical checksight scores and scores obtained from film records of tracking.

When tracking is done by means of radar, optical checksighting tends to be less reliable, because:

1. With either the Mark 57 or Mark 63 system, inaccurate alignment of the radar will prevent the scoring circles from being concentric with the center of the checksight reticle.

2. In the case of the Mark 63 system, poor follow-up of either gun mount or radar will result in poor correspondence of scoring circle position and reticle position.

3. As a result of the fact that in tracking blind the tracker tends to make oscillatory movements of the director which are of greater amplitude and higher frequency than is the case when he is tracking optically, the checksighter has greater difficulty in determining precisely when the tracker is on target.

Moreover, the use of optical checksighting with the Mark 63 system to score blind tracking requires additional equipment. Optical filters must be used to prevent the tracker= from seeing the real target optically while allowing the checksighter to do so.

Kymographic Recording of Error Voltage

With this method of scoring tracking, the error voltages impressed on the deflection plates of the T and E scope are graphically recorded. Although this provides a permanent record of what the tracker did, considerable time and labor are involved in transcribing the records and tabulating the scores.

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* NDRC Project N-111, Report No.1, OSRD No.4525, of 3 January, 1945.

PRNC-2302-6-18-47-100