UNCLASSIFIED

AD NUMBER
AD380510
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution: Further dissemination only as directed by the Director, Naval Research Laboratory, Washington, DC 20390, 8 Mar 1967, or higher DoD authority.
AUTHORITY
NRL ltr, 21 Oct 2002; NRL ltr, 21 Oct 2002

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

AD NUMBER
AD380510
CLASSIFICATION CHANGES
TO confidential
FROM secret
AUTHORITY
31 Mar 70, Group-3, per document marking

THIS PAGE IS UNCLASSIFIED

SECRET

NRL Report 6509
Copy No.

AD380510 L

Display for a Forward-Looking Radar

[Unclassified Title]

D. L. DRAKE

High Resolution Branch
Radar Division

STATEMENT #5 CLASSIFIED

In addition to security requirements which apply to this document and must be met, it may be further distributed by the holder only with specific approval of NRL, WASH, DC 20390

March 6, 1967

NAVAL RESEARCH LABORATORY
Washington, D.C.

SEE INSIDE FRONT COVER FOR DISTRIBUTION RESTRICTIONS

SECRET

Downgraded at 12 year intervals.
Not automatically declassified.

SECURITY

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or revelation of its contents in any manner to an unauthorized person is prohibited by law.

In addition to security requirements which apply to this document and must be met, it may be further distributed by the holder *only* with specific prior approval of the Director, Naval Research Laboratory, Washington, D.C. 20390.

SECRET

CONTENTS

ABSTRACT
[Secret]

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of 30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases.

AUTHORIZATION

NRL Problem K03-06A
Project RT 8801-008/6521W3512X

Manuscript submitted November 2, 1966.

DISPLAY FOR A FORWARD-LOOKING RADAR
[Unclassified Title]

INTRODUCTION

A radar indicator disp ıy format was proposed in an internal NRL preliminary report of November 16, 1964, for a proposed ocean surveillance radar of the forward-looking pulse type for use in a manned orbiting vehicle. The display was to present an angular coverage of ±30 degrees dead ahead and a slant range coverage of 130 nautical miles. This represents a ground range coverage of 140 nautical miles. The angular scan period was to be 4 seconds. The resolution cell of the display was the same as the resolution of the radar, 75 feet in range and 2 degrees in azimuth.

DISPLAY FORMAT

The display format was to be a folded range sweep (segments of range side by side) with angle information, and the details concerning the choice of this format are elaborated on in NRL Memo 5316-60:LMW of December 9, 1964. The general reasons for a folded range display are the following:

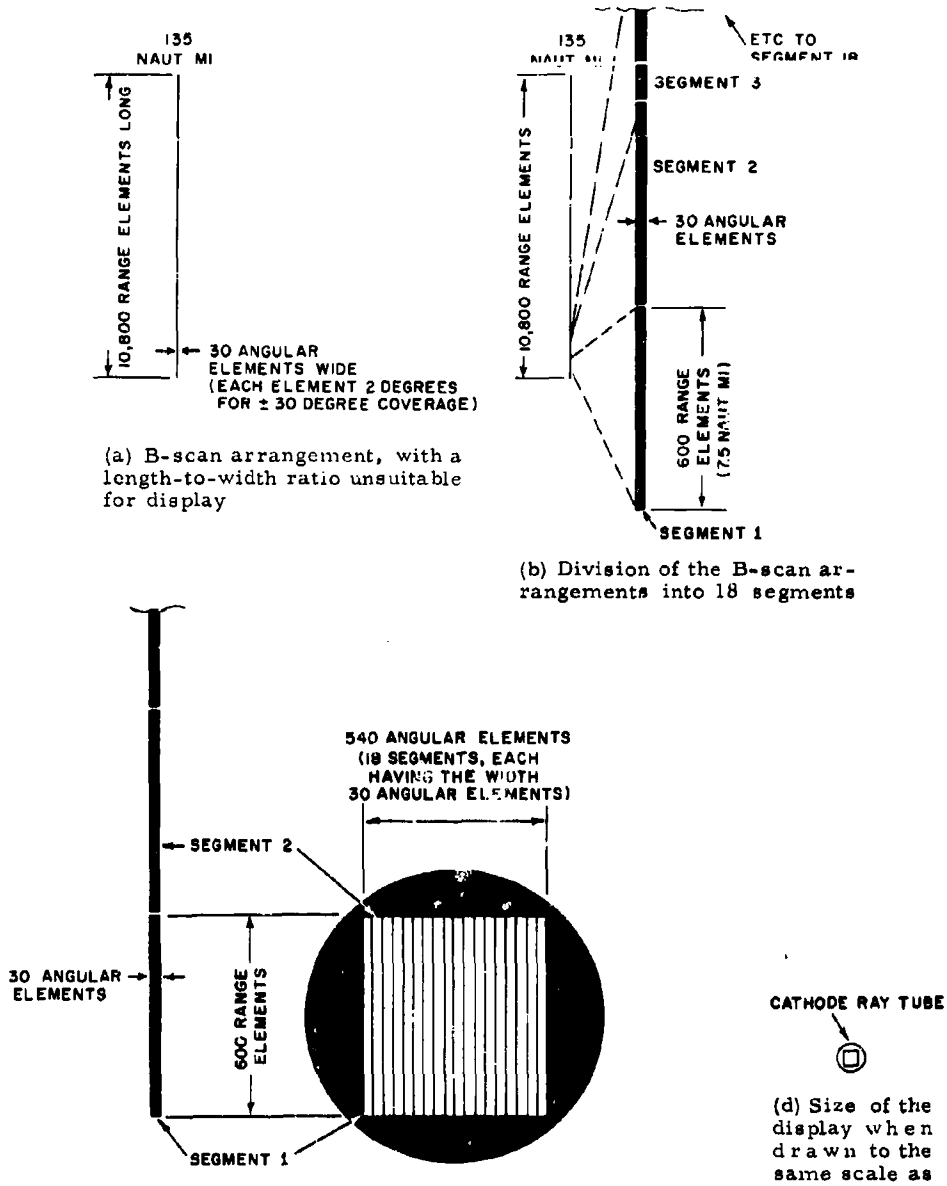
1. The examined area is approximately 30 azimuth elements by 10,800 range elements. By using a folded range display the total display is approximately 600 information bits by 540 information bits, which is fairly easy to handle with a cathode-ray-tube data display.

2. With the chosen format and a target present under a given set of conditions, the target, constantly changing in range relative to the satellite, will be presented with successive scans such that a predetermined pattern will result in the phosphor storage. This aids in the target detection.

Referring to Fig. 1, the range and azimuth information is shown in a scale drawing. The vertical line in Fig. 1a is a normal B-scan display, but because of the large length-to-width ratio such a display would be very difficult to achieve if all range elements were to be retained. The range can be divided into segments (in this case, 18) as shown in Fig. 1b and placed side by side on a display as shown in Figs. 1c and 1d to obtain more manageable proportions. With this format, the information originally in an area 30 by 10,800 units is folded into an area roughly 600 by 600 units.

Figure 2 shows the correspondence between the ground area coverage and the folded display in detail. In the top part, the ground area coverage is broken into range segment areas as shown, 1, 2, 3, ..., 18. These segments are then placed side by side on the display, as shown in the bottom illustration of Fig. 2. Notice that No. 1 area is an individual B-scan (range-versus-angle or azimuth) with a slant range of 0 to 7.5 nautical miles. The second is also an individual B-scan but starts at 7.5 nautical miles and goes to 15 nautical miles. Number 3 area starts at 15 nautical miles, and this process continues to 135 nautical miles, which is slightly greater than the 130 nautical miles mentioned in the Introduction to allow for some variation in the radar parameters.

Figure 3 shows what such a display actually would look like during scanning. Since the antenna is scanning back and forth in azimuth, the display will show eighteen individual



(a) B-scan arrangement, with a length-to-width ratio unsuitable for display

(b) Division of the B-scan arrangements into 18 segments

(c) Display of the 18 segments side by side

(d) Size of the display when drawn to the same scale as (a)

Fig. 1 - Scheme for displaying a range coverage of 135 naut mi and an angular coverage of ± 30 degrees. The range resolution is 75 feet (10,800 range elements), and the angular resolution is 2 degrees (30 angular elements). The range and the angular elements are all normalized to the same dimension to form the B-scan arrangement shown to scale by the line in (a). This arrangement is divided into 18 segments as shown in (b) which are displayed side by side as shown in (c) and (d).

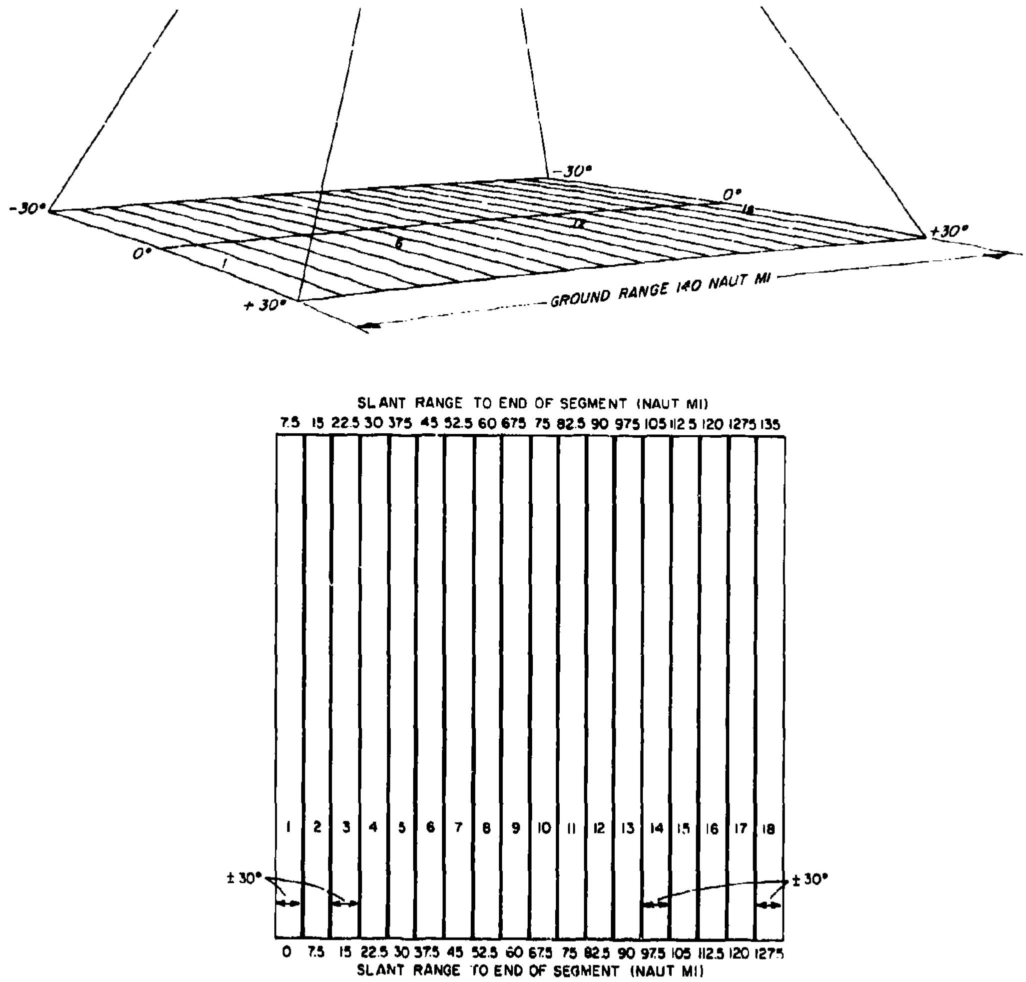


Fig. 2 - Ground coverage broken into 18 segments, with each segment 7.5 naut mi in slant range and ± 30 degrees in azimuth, as viewed (top) and as displayed (bottom)

bright lines, represented by the dark lines, and the phosphor will show a decay from each line to the next caused by the sweeping of these lines in unison (as far as the eye is concerned).

When a target is seen on the display, first being seen in the most distant range segment, a series of 20 dots will appear in a short almost vertical line. Each dot will represent the target return for each radar pulse while the target is illuminated by the antenna during that particular scan. Since the satellite moves with respect to the target

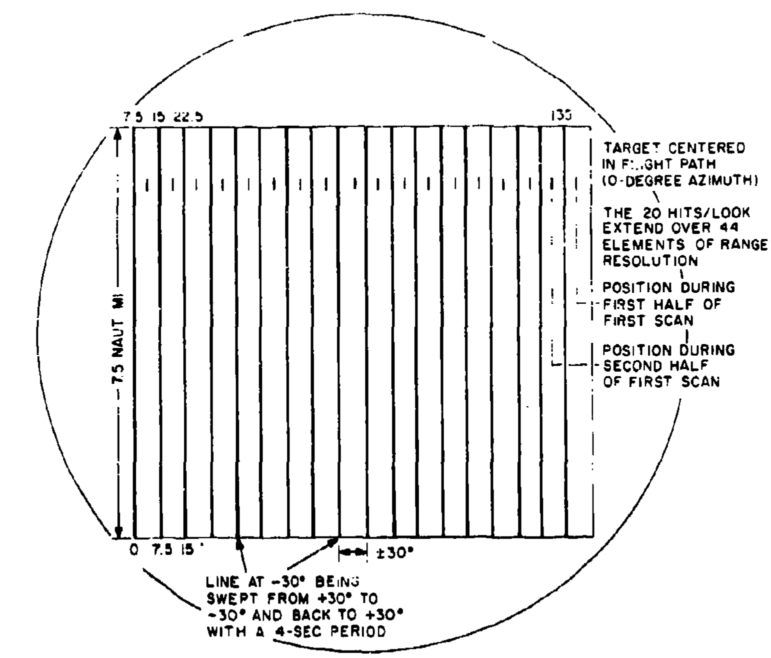


Fig. 3 - Visual appearance of the display when a target is at an angular position of 0 degree. If the target was not at zero degree, the position during the second half of the back and forth scan cycle would not be horizontal to the position in the first half of the scan cycle.

between pulses, the 20 hits or dots are spaced apart such that 2.2 elements of range resolution separate them. This spacing results in a dotted line approximately 44 range resolution elements long. When a target is directly in the flight path at zero degree, then the change in range between the target and the satellite from scan-to-scan is such that each small vertical target line successively falls on a horizontal line as shown in Fig. 3. This, then, is the display format desired.

DISPLAY IMPLEMENTATION

To produce the folded range sweep display described the vertical crt sweep must return to the bottom of the display for each B-scan segment. Thus, it will sweep the first 7.5 nautical miles, return, and be offset horizontally; sweep the second 7.5 nautical miles, return, and be offset, with these cycles repeating to the eighteenth B-scan segment, after which time the horizontal and vertical sweep both return to the start of the first 7.5-mile sweep segment position very close to the same angular position.

The first thought was to use a magnetically deflected crt, since these in general are simpler in construction, have a higher resolution, and are capable of being driven by solid state circuits. However, the retrace of the vertical sweep between each B-scan segment represents a lost-time interval and corresponding range information loss as shown in Table 1, depending on this time of retrace interval. As can be seen, for the 6-microsecond retrace time, which represents a common television flyback or retrace time, a total of 54,000 feet in the 135-nautical-mile slant range would never be seen, which represents a total of approximately 9 nautical miles. It was felt that in a radar designed for target detection any information loss would be deplorable; and in certain cases this range gap between B-scan segments could cause a target to go undetected.

Table 1
Range Losses Due to the Retrace Time Between Segments if Magnetic Deflection were Used in the Cathode-Ray Tube

Ability to Accomplish	Retrace Time (μsec)	Loss/ Sweep (ft)	Loss/Sweep (Elements of Resolution)	Loss Total (ft)	Loss Total (Elements of Resolution)
State of the art	6	3000	40	54,000	720
Difficult but possible	3	1500	20	27,000	360
Very difficult	1	500	6.7	9,040	120

This difficulty of magnetic deflection could be alleviated, however, by using a dual-gun cathode-ray tube, which for the state of the art means electrostatic deflection. The use of a two-gun crt is as follows. The first 7.5-nautical mile sweep is displayed by gun 1. At the end of the sweep the beam is blanked, returned, and shifted horizontally for the third sweep. While gun 1 is sweeping, gun 2 is cut off; but at the end of the first sweep, gun 2 is unblanked and displays the second sweep. At the end of the second sweep, gun 2 is blanked and the beam is returned to the start of the fourth trace, being shifted horizontally during the blanked period. Thus all the range information is presented, and the sweep tops can actually duplicate part of the next sweep if unsymmetrical sweep-retrace times are used.

The basic waveforms and timing for symmetrical operation of the two guns are shown in Fig. 4. Vertical sweep 1 is on when vertical sweep 2 is off, and it is off when vertical sweep 2 is on. The blanking waveforms are shown at the retrace time intervals and would be positive going for cathode input and negative going for grid input. The horizontal sweeps are a step waveform, where the step is accomplished during the blanked period of 94.2 microseconds. The time interval for the vertical retraces and the horizontal stepping can be less than 94.2 microseconds, if desired. The steps are offset in time between horizontal sweep 1 and horizontal sweep 2 by 94.2 microseconds, and the step lengths will be 188.4 microseconds minus the rise time of the step, or will be approximately 188 microseconds if the step is rapid.

This two-gun electrostatic-deflection system then has the following advantages over a magnetic-deflection system:

1. The time intervals of the waveforms are relatively large.

2. No range information would be lost.

3. Range sweeps can even be overlapped.

4. Complete display failure is unlikely because of crt failure, since a failure of one gun still allows display use, although at reduced efficiency.

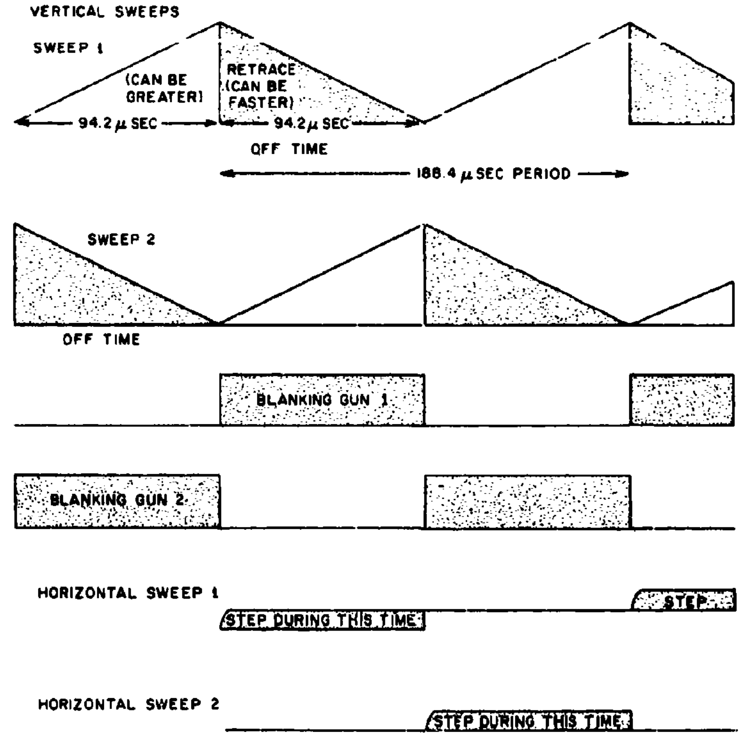


Fig. 4 - Timing and waveforms for two-gun electrostatic deflection in the crt

The system would have the following disadvantages:

1. All-solid-state circuitry would be difficult to use because of high deflection voltages (eight tubes would be required).

2. The crt would take more volume (4.5 cubic feet versus an estimated 3.5 cubic feet).

3. The number of circuits would be increased slightly (19 circuits versus 11 circuits).

4. Power would be increased (standby power of 22.8 watts versus 3.8 watts and an operating power of an estimated 33.6 watts versus an estimated 14.2 watts).

5. The overall weight would probably be slightly more, even though four power transistors would be eliminated.

It is felt that the advantages in favor of the electrostatic-deflection dual-gun crt far outweigh the disadvantages.

CIRCUITS FOR GENERATION, AMPLIFICATION, AND COMBINATION OF WAVEFORMS TO ACCOMPLISH THE PRESENTATION WITH A DUAL-GUN CRT

The block diagram of the circuits necessary for the display is shown in Fig. 5. This can be broken up into the following functions:

1. Timing – generation of time intervals for sweep and blanking.

2. Sweep generation – horizontal and vertical.

3. Combining – the grouping of a set of signals (video and blanking) into a composite signal.

4. Amplifiers.

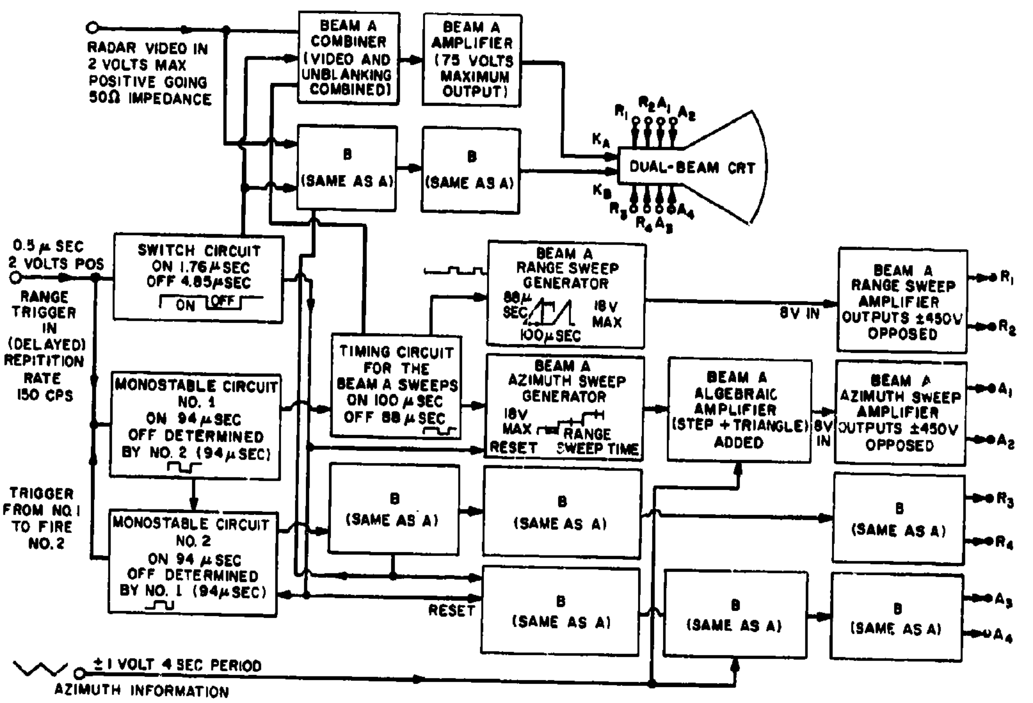


Fig. 5 - Circuits necessary for the display. Values such as 94.2 and 100.2 microseconds have been rounded off to 94 and 100, since the rounded-off values correspond more closely to values obtained in practice.

A trigger into the switch circuit causes a monostable multivibrator in the switch circuit to switch such that a time (on) interval is obtained equal to the total range time displayed, 1.76 milliseconds. It then shuts itself off and stays in that condition until the next trigger.

The same trigger is applied to monostable circuit 1. This is a monostable multivibrator which stays on for a 94.2-microsecond interval and then turns itself off. When it does so it turns on monostable circuit 2. This circuit is also a monostable multivibrator which also stays on for 94.2 microseconds. When it shuts itself off it turns monostable circuit 1 on again, so that a symmetrical (94.2 microseconds on and 94.2 microseconds off) timing waveform results and continues until the end of the total range time. At this time the switch circuit turns off monostable circuit 2 by the simple method of supplying its power and shutting that power off when the total range time is up. Monostable circuit 1 then returns to its stable state waiting for the next range trigger to occur.

The timing circuit for the beam A sweeps receives a trigger from monostable circuit 1, and it also is a monostable multivibrator. It is on for 100.2 microseconds and off for 88.2 microseconds, which provides a nonsymmetrical waveform where the 100.2-microsecond time is used to generate the following sweep. The timing circuit for the beam B sweeps is identical to that for the beam A sweeps except its triggers come from monostable circuit 2, so that its timing intervals are 94.2 microseconds later than those of the timing circuit for the beam B sweeps.

The output of each of these two timing circuits is used to provide blanking pulses and provide timing for the sweep generation. The beam A range sweep generator consists of a constant current source which charges a capacitor switched on for 100.2 microseconds by the waveform from the timing circuit. At the end of 100.2 microseconds the capacitor is discharged by a transistor switch also driven by the timing circuit waveform. The beam B range sweep generator is identical to the beam A range sweep generator except its timing waveform is displaced 94.2 microseconds, which causes its output to be displaced in time the same amount.

The beam A azimuth sweep generator is the same circuit as the range sweep generator except that the circuit constants are changed so that each time a pulse occurs the capacitor changes only a small amount in voltage, so that a stepping circuit results. The polarity of the timing waveform is reversed with respect to the one going into the range generator, so that the stepping circuit charges, or steps, during the retrace time of the range sweep. At the end of the range interval a waveform from the switch circuit turns on a switching transistor to discharge the capacitor and thus reset the stepping circuit for the next range interval. The beam B azimuth sweep generator is identical to the beam A azimuth sweep generator except, again, the waveforms are displaced 94.2 microseconds.

The beam A range sweep is fed to an amplifier and then to the crt. The beam B range sweep is also fed to an amplifier and then to the crt. The beam A azimuth sweep goes to an algebraic amplifier which also has a triangular waveform fed into it from the antenna. This triangular waveform gives the individual range segments their B-scan azimuth sweep. The two waveforms are added together and the combination is amplified and presented to the crt. The beam B azimuth sweep goes through the identical series of steps.

All that remains to be applied to the crt is the video. The radar video in goes to beam A combiners and to beam B combiners. The beam A combiner accepts video unblanking from the switch circuit and unblanking from the timing circuit for the beam A sweeps. These are combined into a single output which is amplified and applied to the crt. The beam B combiner is identical to the beam A combiner, and the inputs are identical except that the short time interval unblanking is obtained from timing circuit for the beam B sweeps. The combined waveform is fed to an amplifier and then to the crt. The information then is all presented to the crt for display. The waveforms and timing are shown in Fig. 6.

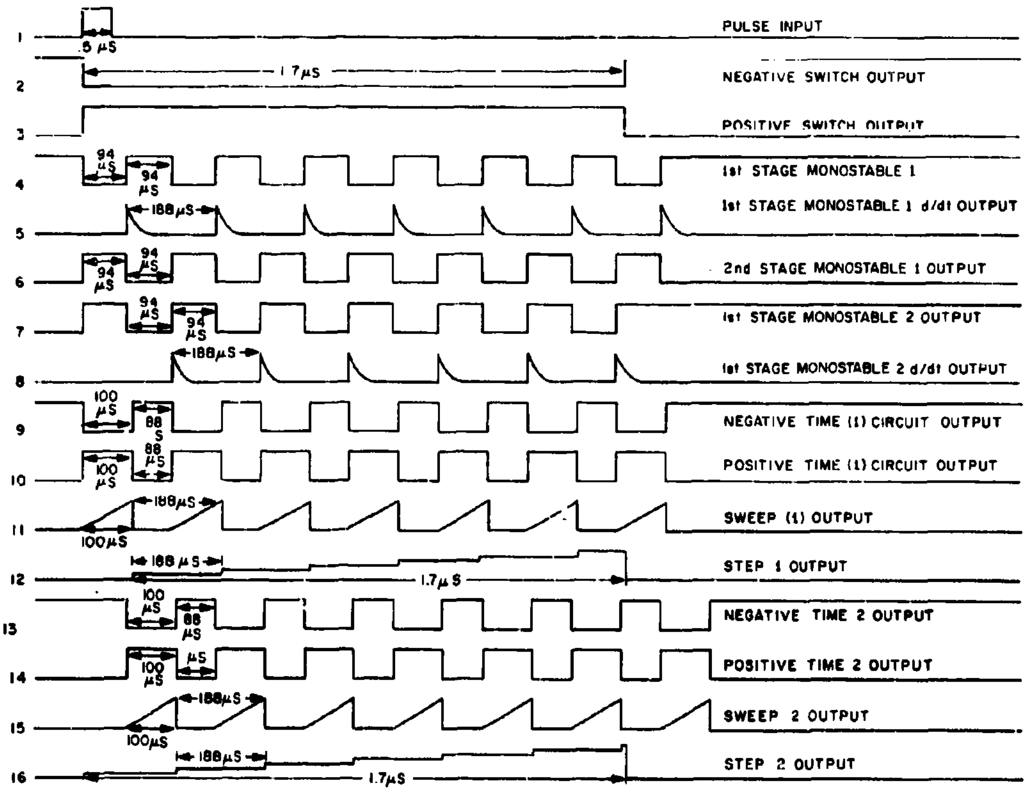


Fig. 6 - Waveforms and timing

THE FOLDED RANGE SWEEP INDICATOR, AS CONSTRUCTED

The indicator, as constructed, is completely self-contained, needing only: (a) a delayed range trigger, (b) radar video, (c) azimuth angle information, and (d) 117-volt-ac, 60-cycle power. The characteristics of the indicator are:

1. Display size = 8-1/2 x 8-1/2 inches.
2. Electroluminescent front panel control lighting.
3. Overall dimension = 16-1/4 x 19-1/2 x 29-3/4 inches.
4. Total weight = 68.55 pounds.
5. Power consumption = 117 watts, approximately.
6. All circuits are solid state except for the crt and the final sweep amplifiers.
7. Phosphor P26.

The first of four photographs of the unit constructed, Fig. 7, shows the display panel and a partial side view of the indicator box. The light panels (including the meter) are electroluminescent lighting for the controls. The upper controls on the right are for one gun and the lower controls are for the second gun.

Figure 8 shows a side of the indicator. In this model, the housing was of Plexiglas and aluminum, such that the interior layout and construction was visible. The long set of circuits in the top rear of the indicator box generate the necessary sweeps and unblanking.

The rear view, Fig. 9, shows the power and three signal inputs. The upper and center boxes on the right side of the photograph are the video chains.

The remaining side of the indicator is shown in Fig. 10. The modular power supplies can be seen (rear of the box), and underneath the crt can be seen the sweep amplifier composed of transistor stages up to the final output which are tubes. The crt lightweight shield, covering only the gun and deflection structures, can also be seen.

Figure 11 shows the segments of the folded B-scan range sweep display. Here the intensity is increased to show the format; no signals are present. The dark traces seen are some burns on the temporary tube used for setting up the indicator (this tube had a P19 phosphor). The even lighting of the electroluminescent panels is also seen here.

Figure 12 shows the appearance of a bright target at an angular position other than 0 degree. Each streak is approximately a 7-microsecond spread of an individual set of target pulses (see Fig. 3). The sets of pulses do not fall on a straight line as shown in Fig. 3 but are curved because of nonlinearity of the delays of the simulator.

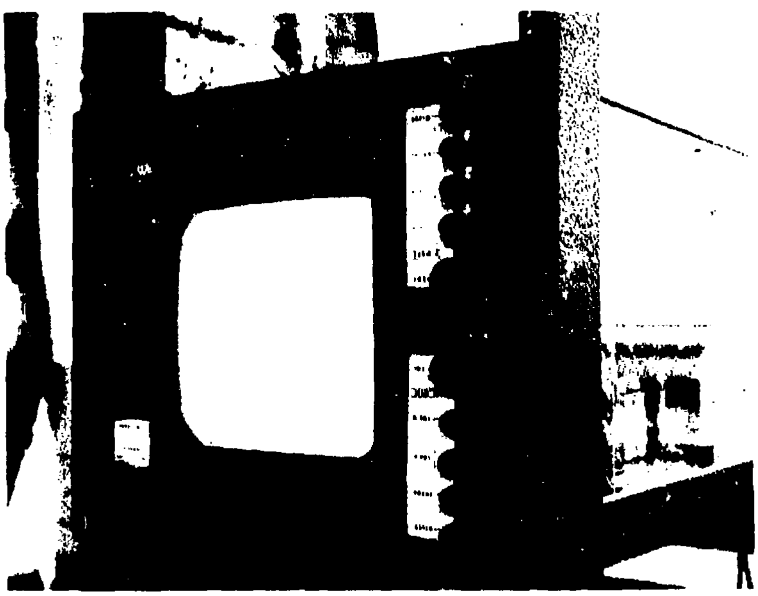


Fig. 7 - Front of the indicator

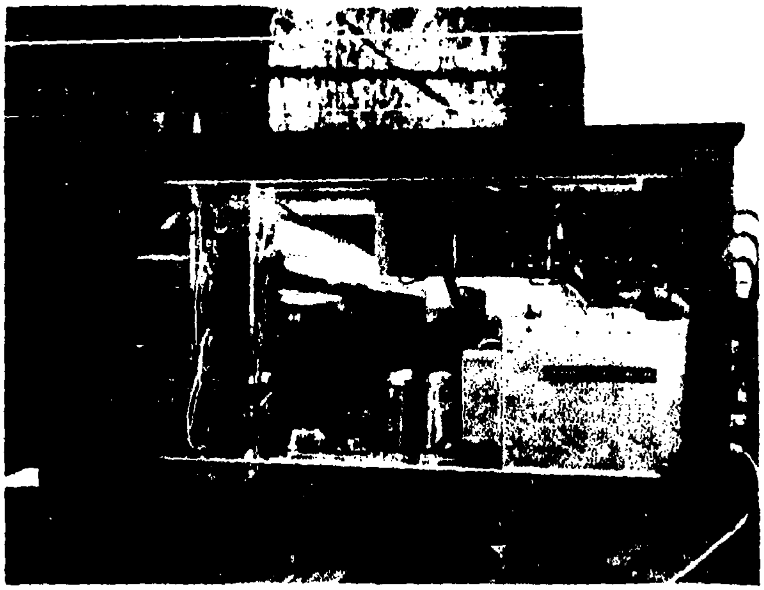


Fig. 8 - Side of the indicator

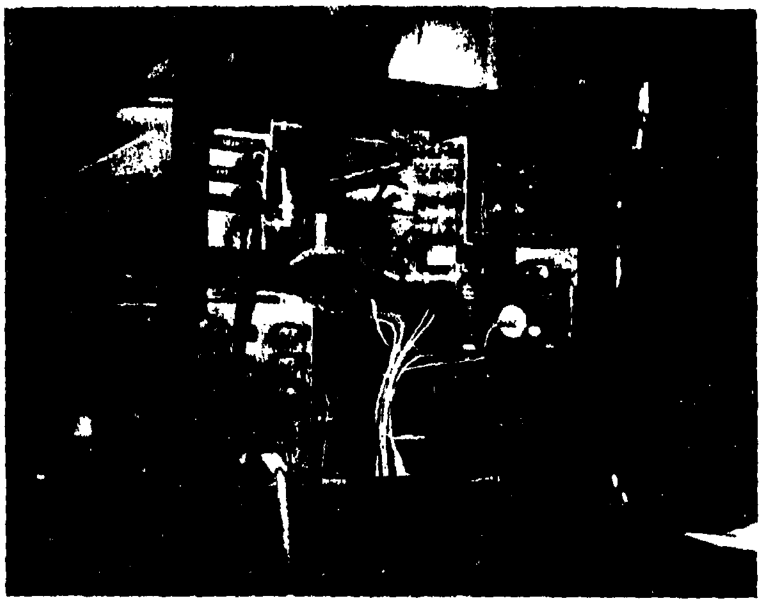


Fig. 9 - Back of the indicator

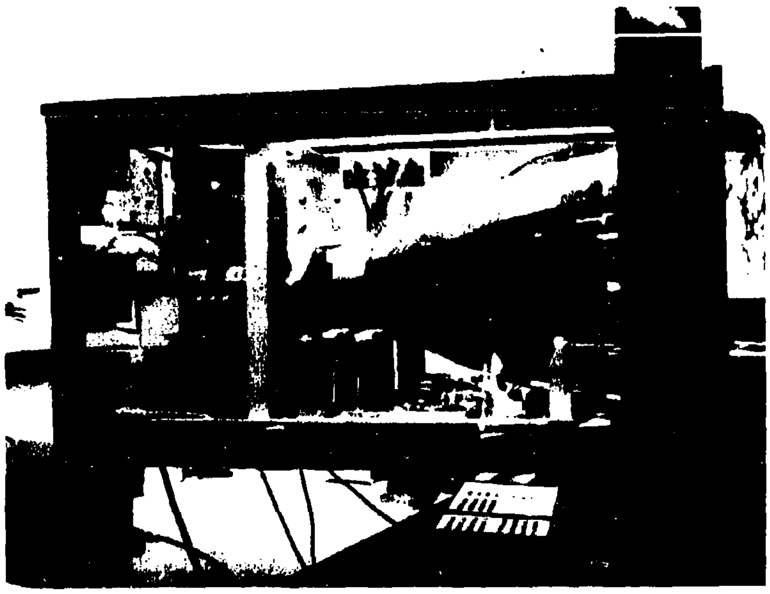


Fig. 10 - Other side of the indicator

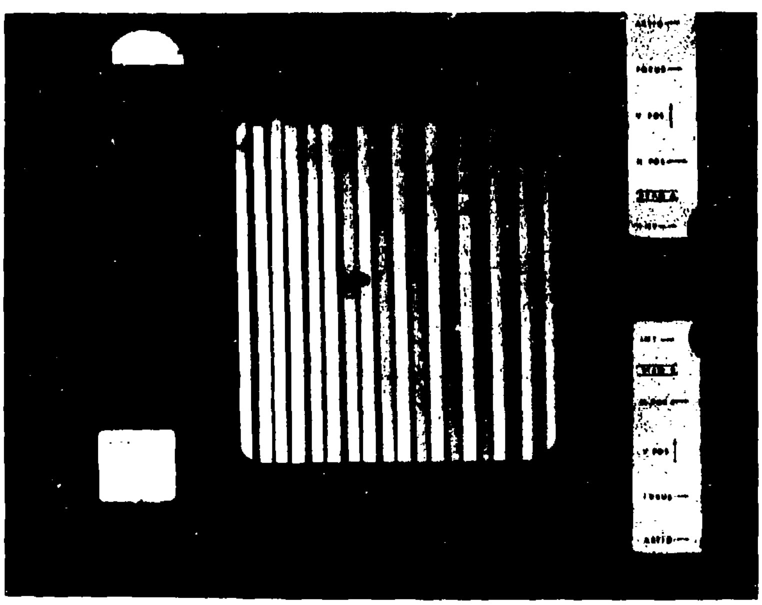


Fig. 11 - Front of the indicator display with the intensity increased and no signals present

Fig. 12 - A bright target on the indicator display when the target is at an angular position other than 0 degree

TEST RESULTS

System for Testing the Indicator Display by Simulation Runs

A block diagram of the equipment used for the simulation runs is shown in Fig. 13. The azimuth generator feeds a triangular signal to the simulator to trigger the gate generator and to the display indicator for the azimuth antenna sweep. The main pulse generator triggers the sweep circuits in the display indicator and also feeds the simulator to provide an output target properly delayed.

A noise source (General Radio Model 1390-A random noise generator having a bandwidth of 30 cps to 5 Mc) and the simulator outputs are added algebraically in an algebraic amplifier to provide target and noise. This output is fed to an amplifier to increase its amplitude (because of the low output of the algebraic amplifier). The output of the amplifier is fed to the indicator as video input and to an oscilloscope for measuring the video characteristics.

Testing Procedure

In making the simulated test runs, initial trials were made to attempt to obtain the brightness level to which the noise background should be adjusted to give the smallest signal-to-noise ratio for signal detection. This level turned out to be with noise just visible, with the signal being detected as the initial flash in a dark room, and was found as follows. The noise level was set and measured. The target pulse amplitude was started large and gradually reduced. A complete cycle was allowed to elapse for each

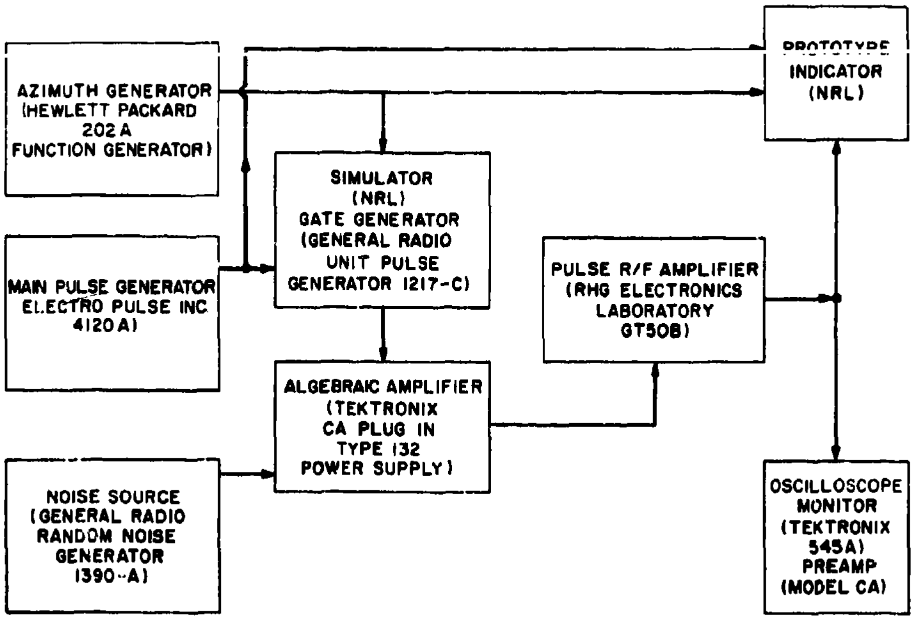


Fig. 13 - Equipment used for the simulation runs

setting change. Since the position of the start of the pulses varies in an unknown manner, if on a recycle the target can still be seen, and further reduction does not allow it to be seen on the next cycle, then a true detection threshold exists.

Testing Results Using the Initial Flash

The results that will be first presented are on the runs using the initial flash for detection. The initial flash of a target could be easily detected when the eye could not detect a difference in the phosphor afterglow. Because of this, the results presented in this subsection are all based on initial flash detection. The threshold of detection is given for two cases:

Room Light	Threshold of Detection
Semidark	Signal-to-noise ratio (postdetection) = 5.1 db
Dark	Signal-to-noise ratio (postdetection) = 4.6 db

The conditions for tests under which the results were obtained were as follows:

PRF = 222 cps.
High voltage for the crt = 7.5 kv.
Number of pulses per look generated by the simulator to represent the theoretical 20 pulses = 16.
Time spread of the 16 pulses = 7 microseconds.

Level of noise (initial flash) set at the threshold of vision (the best level for signal detection).
Target pulse initially 0.23 microsecond wide at the 3-db point.
Target pulse width into the crt at the 3-db point = 0.32 microsecond.
Target pulse width into the crt at the 10-db point = 0.92 microsecond.

The signal-to-noise ratio (postdetection) definition used was

$$\mathrm{SNR} = 10 \log \left[\frac{\text{signal (video) peak voltage}}{\text{noise (noise source) voltage}_{\text{rms}}} \right] .$$

The room light conditions (referenced to the indicator face) were as follows:

Room Light	Reflected Candles/Sq Ft	Incident Ft-Candles
Semidark	0.06	0.04
Dark	0.03	0.02 (extrapolated)

Readings were taken with a General Electric Type PR3, Golden Crown exposure meter.

The following two photographs show the described signal. Figure 14 shows the target pulse presented to the crt. Figure 15 shows the target and noise for the run using the "dark" condition for room light. In this case each time a sync pulse entered the system the target generator was pulsed on (representing 0 delay, or sweep start). This does not, therefore, show the delay spread but does show the true target amplitude and shape.

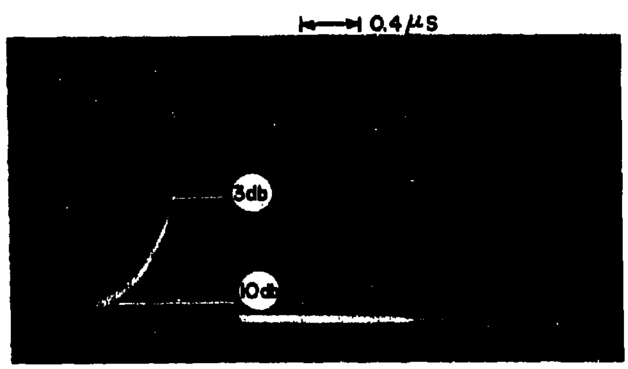


Fig. 14 - Simulated target pulse presented to the crt (0.32 microsecond wide at the 3-db point; 0.92 microsecond wide at the 10-db point). (The initial target pulse into the system was 0.23 microsecond wide at the 3-db point.)

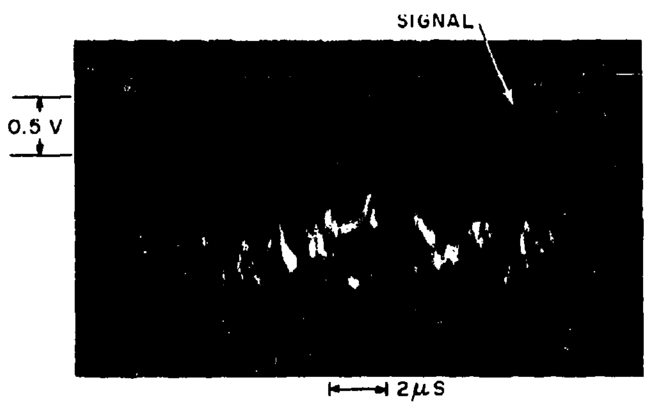


Fig. 15 - Signal and noise using the "dark" condition for the room light

Testing Results for Simulated Storage

The previous results were based on the initial flash of the target and not on the retention in the phosphor afterglow. With storage devices a controlled persistence can be obtained. To simulate such a condition the same equipment was used as before, but this time the indicator was photographed using a 4 x 5 Speed Graphic camera on a tripod with a Polaroid 4 x 5 back. The film used was 4 x 5 Polaroid Land film, Type 57, 3000 speed. The lens opening was f/8, and exposure time in all cases was 36 ± 2 seconds. This, then, would simulate approximately a 36-second, or greater, decay time. Conditions are all the same as before with room lighting under the "dark" condition. Detection here is the ability to distinguish the target in the photograph and is dependent on a pattern as well as contrast differentiation.

Examples of the series run are shown in the following two sets of photographs. The first set is for a signal-to-noise ratio of 11.7 db. Figure 16a shows the signal and noise relative amplitudes. Figure 16b shows the noise background set up fairly bright. Notice it is almost impossible to distinguish the signal. Figure 16c has the intensity of the noise background turned down, and here the target pattern is easily seen.

The second series is for a signal-to-noise ratio of 10 db. This is considered the detection threshold for the controlled persistence case. Figure 17a shows the signal and noise. Figure 17b shows the still visible pattern recorded for the threshold case. One has to look very carefully to see the pattern; it is an arc approximately in the center of the presentation.

OPERATOR CONSIDERATIONS

In the flash detection mode, the operator makes no attempt to scan-search the display as is sometimes done. The procedure found to be the best was to sit approximately 3 feet or more from the display indicator such that the whole display area could be observed and focus on the center of the display, but not intently. The first target flash is

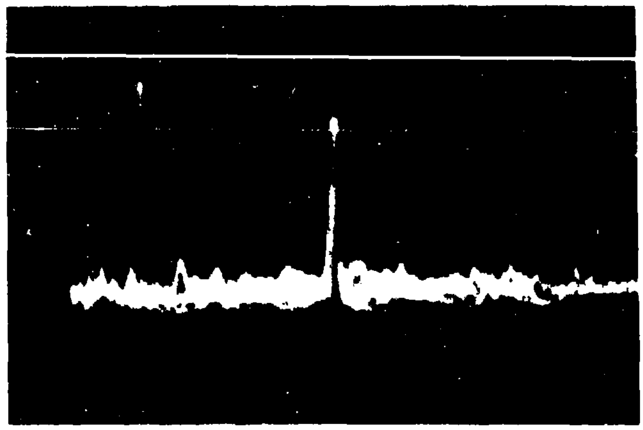


Fig. 16a - Simulated target pulse for a signal-to-noise ratio of 11.7 db (signal, 3 volts peak; noise, 0.2 volt rms)

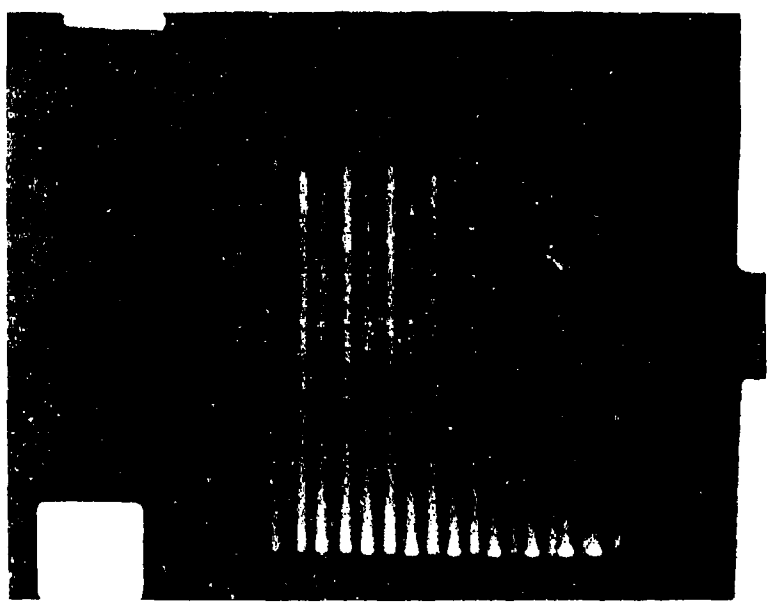


Fig. 16b - Simulated storage presentation (36-second photographic exposure) of the signal shown in Fig. 16a with the intensity of the noise background turned up fairly brightly. For practical purposes the signal is not seen.

Fig. 16c - Same as Fig. 16b except that the noise background intensity is turned down. The signal is now visible.

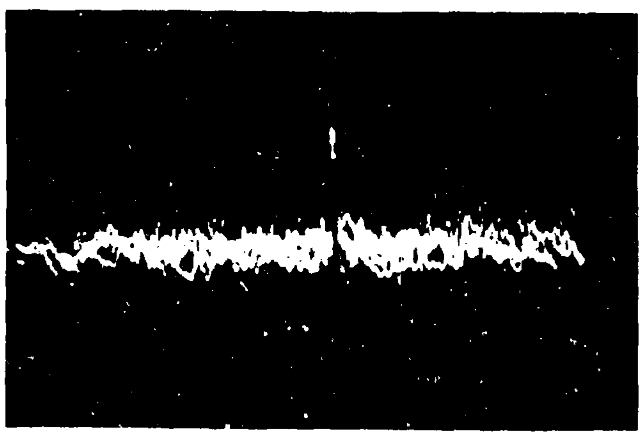


Fig. 17a - Simulated target pulse for a signal-to-noise ratio of 10 db, the detection threshold (signal, 2 volts peak; noise, 0.2 volt rms)

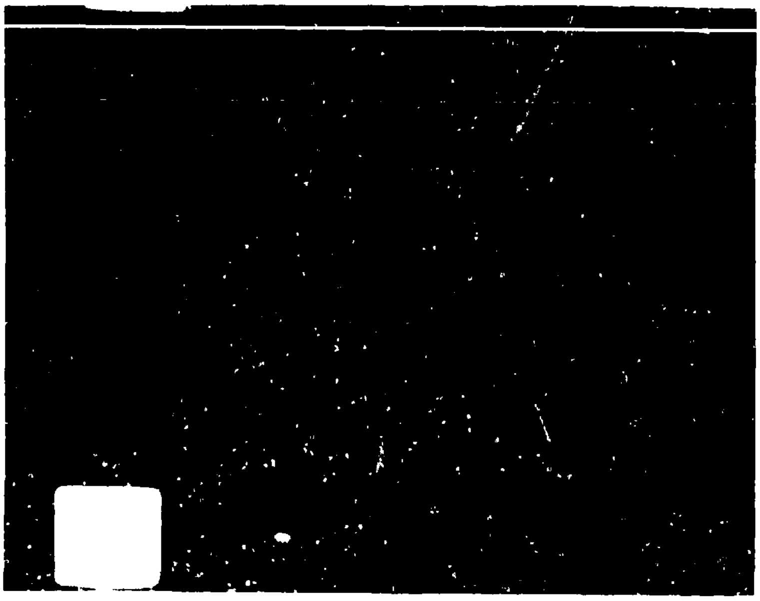


Fig. 17b - Simulated storage presentation (36-second photographic exposure) of the signal shown in Fig. 17a with the background noise barely visible. The target pattern is just barely visible.

then picked up by extrafoveal vision. The focus then is shifted to the expected position of the next appearance if it is a genuine target. This second step is then one of using foveal vision for the expected appearance and extrafoveal vision for appearance on other portions of the B-scan segment under observation. The third pickup definitely establishes the contact as a target or not and its patterns. All of this is done in an automatic manner after a short period (perhaps an hour) of observation.

A target provides 36 seconds from the time of pickup at large range by the display until it is off the display and out of radar vision. Since it was found that three B-scan segment target locations were necessary to establish the actuality of a target, the period of time an operator has to work with this target is 30 seconds. In this time a range and bearing could be read and relayed, but it is felt that a better and more accurate solution would be to use a "pencil" photo pickup to provide a marker pulse to give this information directly or to use a pulse marker with the video movable in range and azimuth which the operator could place at the next expected location. It is expected that with either method the range and bearing information could then be made available in 2 to 4 seconds.

CONCLUSIONS

The threshold of detection of a target, using the folded range sweep display and receiving information from a radar in a satellite, is a signal-to-noise ratio of 4.6 db when the detection is based on the initial flash rather than on the phosphor storage.

It was found that for viewing a target pattern in a background noise a single phosphor layer is detrimental. For this type of detection, a double phosphor with initial flash in one color and afterglow in another would be beneficial with regard to being able to filter the initial flash. Since this type of detection was found to be less sensitive than initial flash detection, the best threshold being a signal-to-noise ratio of 10 db, it would be expected that a double-layer phosphor would not yield significant advantages.

The problem of target detection for a radar moving very rapidly with respect to the targets is more difficult than for slow moving radars, because even pulse-to-pulse target returns are separated on the display, which does not allow target-return phosphor integration. This problem is compounded, in the case of target pattern search in a noise background, because every successive sweep overlays the target area with noise information, whereas the target information for a given area is applied in one sweep only. This provides a building up of background intermediate between the high and low noise components to produce a detrimental effect that might be termed "noise phosphor integration."

In terms of human engineering, this display was found to be fairly easy to interpret and search for long periods of time. In terms of operator data retrieval the operator should have aids such as markers or light pencils for help in retrieval of range azimuth information because of the very short time interval available for working with a target.

SECRET
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Naval Research Laboratory
Washington, D.C. 20390

2a. REPORT SECURITY CLASSIFICATION
Secret

2b. GROUP
3

3. REPORT TITLE
DISPLAY FOR A FORWARD-LOOKING RADAR (Uncl. Title)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
An interim report on one phase of the problem.

5. AUTHOR(S) (First name, middle initial, last name)
David L. Drake

6. REPORT DATE
March 6, 1967

7a. TOTAL NO. OF PAGES
24

7b. NO. OF REFS
0

8a. CONTRACT OR GRANT NO.
NRL Problem K02-06A

b. PROJECT NO
RT 8801-008/6521W3512X

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
NRL Report 6505

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
In addition to security requirements which apply to this document and must be met, each transmittal outside the agencies of the U.S. Government must have prior approval of the Director, Naval Research Laboratory, Washington, D.C. 20390

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Department of the Navy (Office of Naval Research), Washington, D.C. 20360

13. ABSTRACT (Secret)

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of 30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing). (S)

DD FORM 1 NOV 65 1473 (PAGE 1)

SECRET
Security Classification

S/N 0101-807-6801

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Display systems						
Radar						
Search radar						
Radar equipment						
Cathode-ray tubes						
Scanning						
Target acquisition						
Simulation						
Position finding						

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design
I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design
I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design
I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design
I. Drake, D.L.

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design

I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design

I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design

I. Drake, D.L.

SECRET

Naval Research Laboratory. Report 6505 [SECRET-Gp-3]. DISPLAY FOR A FORWARD-LOOKING RADAR [Unclassified Title], by David L. Drake. 24 pp. & 17 figs., March 6, 1967.

A display has been implemented for a proposed forward-looking ocean surveillance radar for a manned orbiting vehicle, and test results were obtained for simulated target signals. The display is a folded range sweep format, which is a B-scan presentation where the 135-nautical-mile range axis with a resolution of 10,800 range elements has been divided into 18 equal range segments with the individual B-scan segments placed adjacent to each other. Each segment retains the full angular coverage of ±30 degrees with a resolution of

Downgraded at 12 year intervals. Not automatically declassified. SECRET (over)

1. Search radar systems – Development
2. Radar display systems – Design

I. Drake, D.L.

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

SECRET

30 angular elements (2 degrees each). This arrangement forms a square pattern and thus provides maximum utilization of the crt resolution elements. It provides a target location prediction technique, since the relative target-to-satellite velocity is such that successive scans of the radar will cause the target to be repeated in successive segments of the display (range decreasing).

SECRET

Naval Research Laboratory
Technical Library
Research Reports Section

DATE: October 21, 2002

FROM: Mary Templeman, Code 5227

TO: **Code 5300 Paul Hughes**

CC: Tina Smallwood, Code 1221.1 ts 8/19/03

SUBJ: Review of NRL Reports

Dear Sir/Madam:

Please review NRL Memo Report 1654 and NRL Report 6505 for:

- ☑ Possible Distribution Statement
- ☑ Possible Change in Classification

Thank you,

Mary Templeman

Mary Templeman
(202)767-3425
maryt@library.nrl.navy.mil

The subject report can be:

- ☒ Changed to Distribution A (Unlimited)
- ☑ Changed to Classification Unclassified
- ☐ Other:

Paul K. Hughes II　　8/18/2003

Signature　　Date

AN (1) AD- 380 510/XAG
FG (2) 170900
CI (3) (U)
CA (5) NAVAL RESEARCH LAB WASHINGTON D C
TI (6) DISPLAY FOR A FORWARD-LOOKING RADAR.
DN (9) Interim rept.
AU (10) Drake,David L.
RD (11) 06 Mar 1967
PG (12) 22 Pages
RS (14) NRL-6505
PJ (16) RT-8801-008/6521W3512X
RC (20) Confidential report
AL (22) Distribution: Controlled: all requests to Director,
Naval Research Lab., Washington, D. C. 20390.
DE (23) (*RADAR EQUIPMENT, *DISPLAY SYSTEMS)
RANGE(DISTANCE), CIRCUITS
DC (24) (U)
DL (33) 05
CC (35) 251950

UNCLASSIFIED

APPROVED FOR PUBLIC
RELEASE - DISTRIBUTION
UNLIMITED