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EVALUATION OF A HIGH-SPEED PPI SCAN

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EVALUATION OF A HIGH-SPEED PPI SCAN

INTRODUCTION

The detection of snorkel and other small targets in the presence of sea clutter is dependent on the performance of the radar operators as well as the physical properties of the system. The NRL Radar Parameter Study System¹ has been adapted to permit scanning speeds up to 3000 rpm for checking the operator's ability to pick out small targets at speeds so high that the individual sweeps cannot be discerned. A test has been made of detectability as a function of antenna speed (from 6 to 3000 rpm) to determine whether or not a high-speed PPI scan would increase the detectability of weak signals in the presence of simulated sea clutter.

DESCRIPTION OF APPARATUS

The high-speed scan tests were run on the NRL Radar Parameter Study System. A block diagram of the system as used for these tests is shown in Figure 1. To obtain the extremely high scanning speeds employed in this test, the mechanically rotated indicators were replaced with electronically rotated PPI units and a new azimuth gating unit was designed. Figure 2, representing one of the observer positions, shows the indicator and the answer box. Simulated antenna rotation was provided by a dc variable-speed motor directly coupled to the azimuth gating unit (Figure 3) and to a two-phase generator, which supplied the quadrature voltages for the electronically rotated PPI scan. A scanning disc with a single aperture rotates in synchronism with the PPI sweep. Four photocells, each of which has its own exciter lamp, are fixed close to the disc and 90 degrees apart. A selector switch on the master control board enables the operator to place a positive voltage on the desired photocell; the azimuth position of a simulated echo is determined in this manner. The aperture in the scanning disc together with narrow slits in a fixed plate mounted between the photocells and the disc were designed to provide an output that simulates the beam pattern of a radar antenna (Figure 4).

A synchronizing unit supplies isolated trigger pulses to the PPI sweep generator and the "A" scope monitor and also provides a delayed pulse which is used as the range gate. The time delay of this pulse can be varied by the operator to change the range position of a simulated echo.

A gated mixer unit is fed from three sources: an azimuth gate which determines the bearing of the echo, a range gate which determines the range of the echo, and a 30-Mc variable-amplitude signal. The amplitude of this 30-Mc signal was used to determine

¹ Jackson, T. B., "A PPI Parameter Study System," NRL Report R-3301 (Confidential), June 17, 1948

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the signal strength required for each test. The output of the gated mixer unit, a pulsed 30-Mc signal representing the output of a conventional mixer in a pulse radar system, is fed through a fixed attenuator so that the input to the mixer can be relatively high. At this point, the 30-Mc signal is mixed with noise from the diode receiver-noise source and injected into a conventional i-f amplifier which has a 2-Mc bandwidth. The signal is detected by a diode, fed to a two-stage video amplifier, and then fed to five cathode followers, one of which is used for each scope unit. Each display indicator had an additional stage of video amplification which was carefully adjusted to provide the same video signal to each cathode-ray tube. The video bandwidth was 1.4 Mc.

The simulated sea-clutter noise was generated by a diode noise source with a low-Q tuned circuit for the load impedance. The output is a band 50 kc wide at the half-power points centered at 30 kc (Figure 5); this noise was amplified and then injected into the video amplifier. Before this simulation of sea clutter was selected, it was determined from measurements of the frequency spectrum of actual sea clutter that broad peaks at frequencies below 100 kc were responsible for typical sea-clutter echoes. Photographs of actual sea clutter on an APS-20 radar indicator were then compared with photographs of simulated clutter. The spectrum used for these tests was chosen as the one which best simulated actual sea clutter.

TESTING PROCEDURE

In setting up the system for operation, the noise sources were 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. By observing the signal on the PPI monitor, the signal was adjusted for the test being made. Five observers were used for the tests, which covered a range of antenna speeds from 6 to 3000 rpm; all other parameters were held constant. The constant parameters were a repetition rate of 7000 pps, a pulse width of 2.2 microseconds, an antenna beam width of 4 degrees, a sweep length of 6 miles, and a background of simulated sea clutter with receiver noise.

In evaluating the high-speed scan, 80 standard runs of 48 presentations each were made; 40 of these runs were on P-7 long-persistence cathode-ray tubes and 40 on P-11 short-persistence tubes. Each target was displayed for one minute. Observers at each indicator were asked to locate the signal position and relay this information to the system operator by pushing the appropriate button on an answer box. These replies were registered on the master set-up board and recorded. If an observer did not register an answer by the end of the one-minute display period, he was asked to make a guess. The probability of an observer guessing the position of a signal correctly without any indication of its presence was taken into consideration in the score which was calculated from:

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

The signals were displayed in random order at 16 fixed positions, including four range and four azimuth positions. Two standard runs were made for each antenna speed with each type display; one run was completed with a signal level low enough to obtain a detectability factor somewhat below 50 percent and the other with a signal level high enough to obtain a detectability factor somewhat above 50 percent. The signal strength required for 50-percent detectability was then obtained from interpolation between these two points.

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RESULTS

Figure 6 shows the results of the high-speed-scan evaluation test. At all antenna speeds, the long-persistence P-7 phosphor is superior to the short-persistence P-11 phosphor. On the long-persistence screen, the signal strength required for 50-percent detectability increases slowly as the antenna speed increases to 1200 rpm. Above this point, the required signal falls slightly; this drop probably results from integration by the eye between scans. At 1200 rpm, the time between scans is 1/20 second, and this is about the length of time that the eye can retain an image. On the short-persistence screen, the signal required for 50-percent detectability is about the same regardless of antenna speed and from 2.5 to 4.8 db greater than that required for the long-persistence presentation. Figure 7 is a photograph of the PPI showing one revolution at 6 rpm on a P-11 screen, and Figure 8 is a 10-second exposure on the same PPI with the sweep rotating at 2000 rpm.

The results of this test indicate that the lowest tolerable antenna speed and a long-persistence screen should be used for the detection of weak signals in the presence of sea clutter. No improvement was found at high scanning speeds with either type presentation. It must be realized, however, that the simulated sea-clutter signal used in these tests has no sweep-to-sweep coherence. Signals with such coherence could conceivably show a difference between the high and low scanning speeds. No suitable simulation for coherent signals has been devised by this Laboratory; thus, direct measurement using actual sea clutter would seem to be the only way to investigate this condition.

* * *

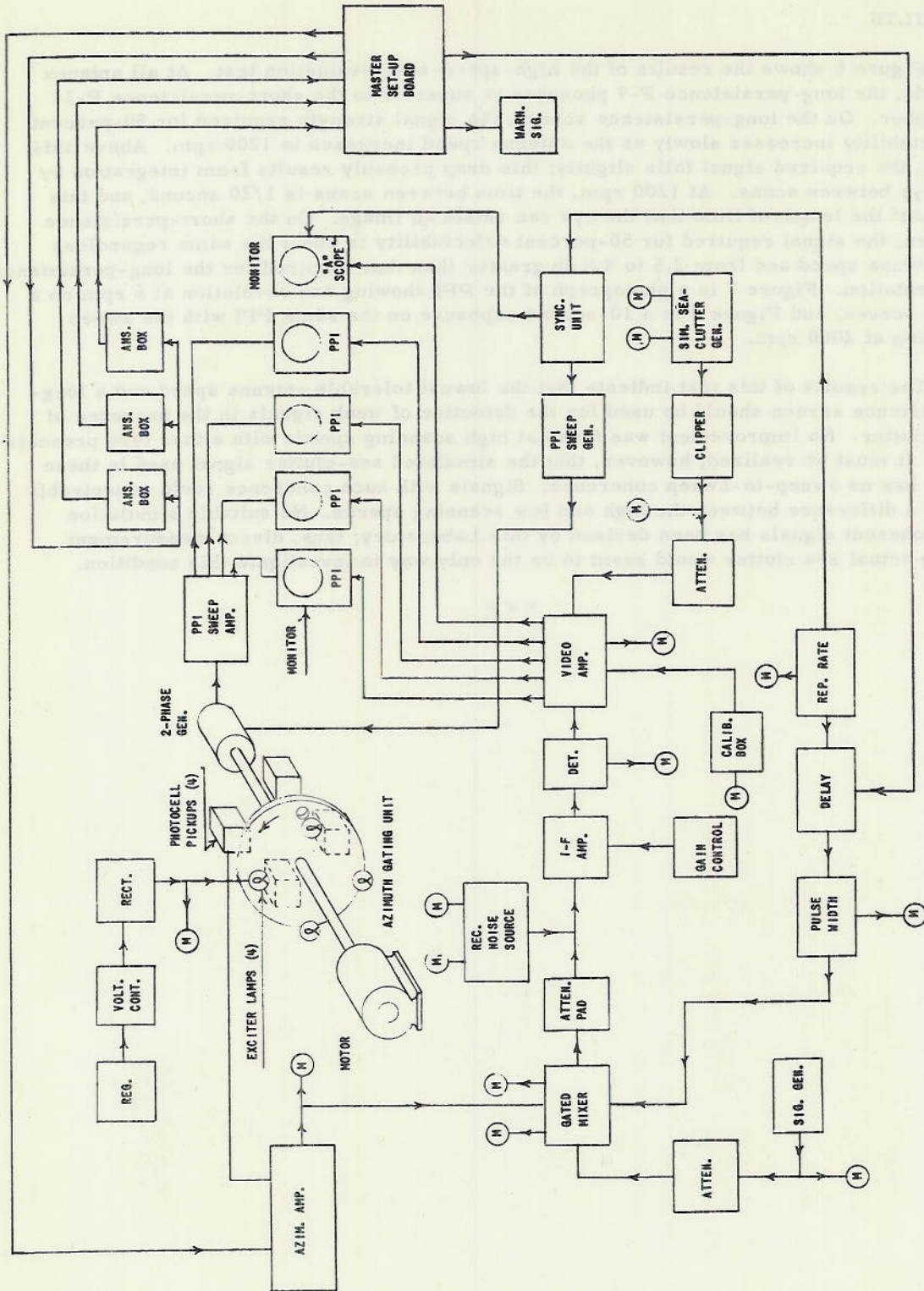


Figure 1 - Block diagram of Modified Radar Parameter Study System

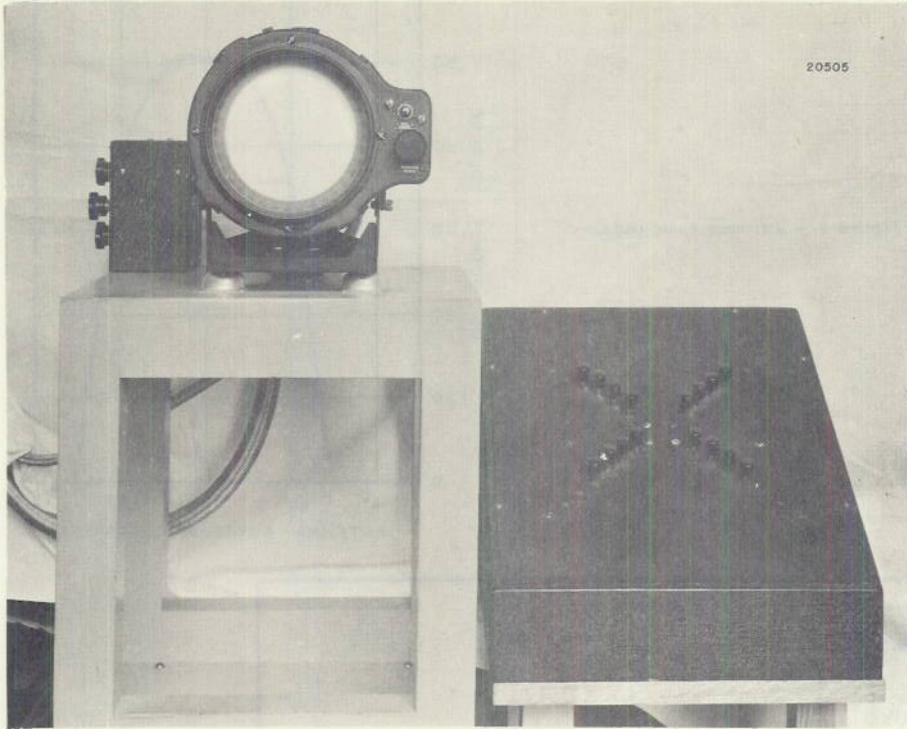


Figure 2 - Observer's indicator and answer box

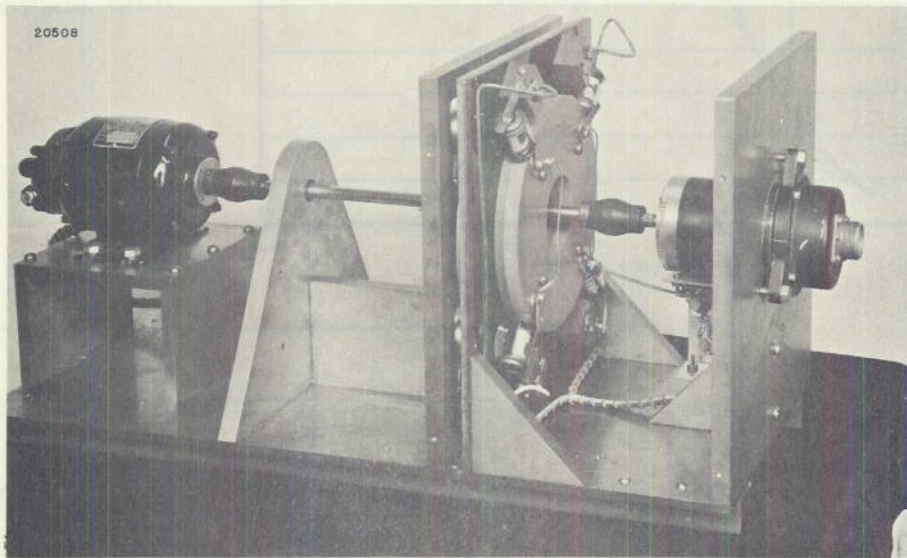


Figure 3 - Azimuth gating unit

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Figure 4 - Antenna beam pattern

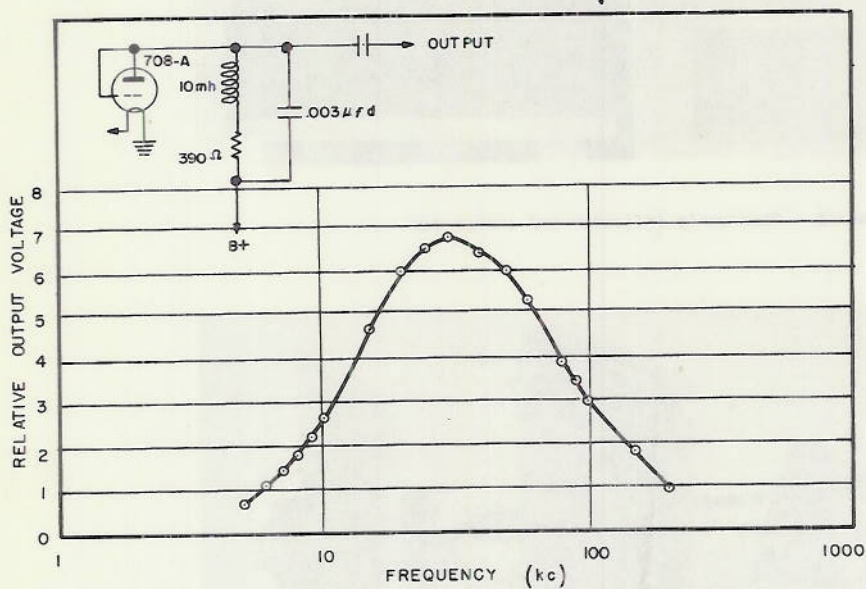
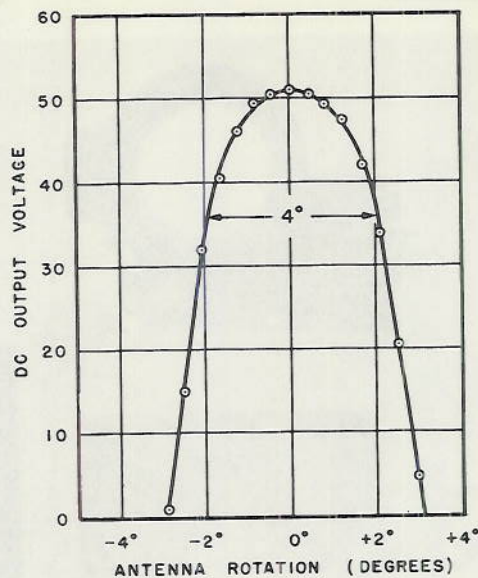
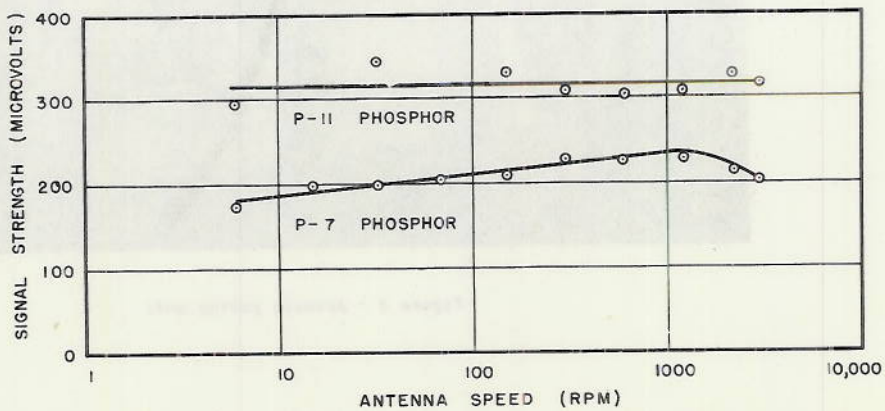


Figure 5 - Simulated sea-clutter noise spectrum

Figure 6 - Signal required for 50-percent detectability vs. antenna speed



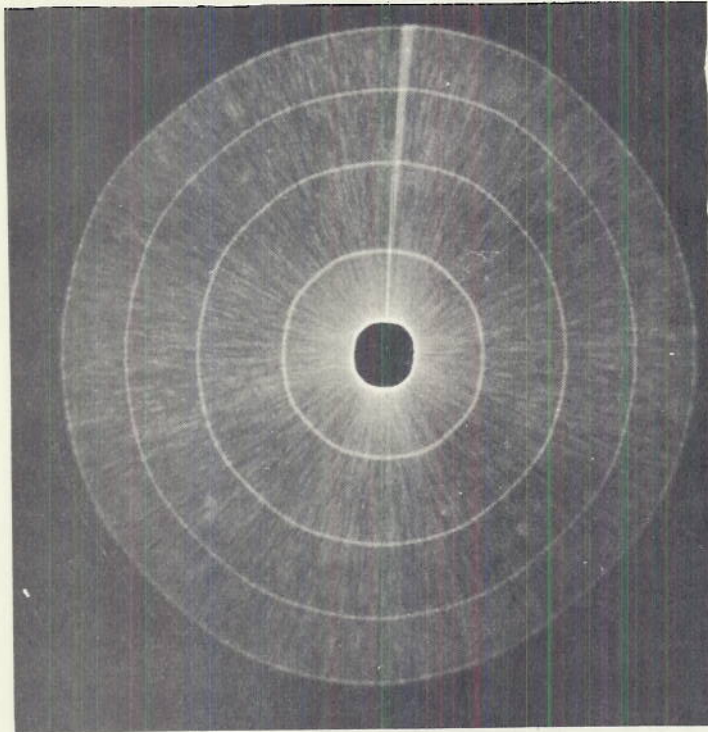


Figure 7 - Slow-speed scan on PPI

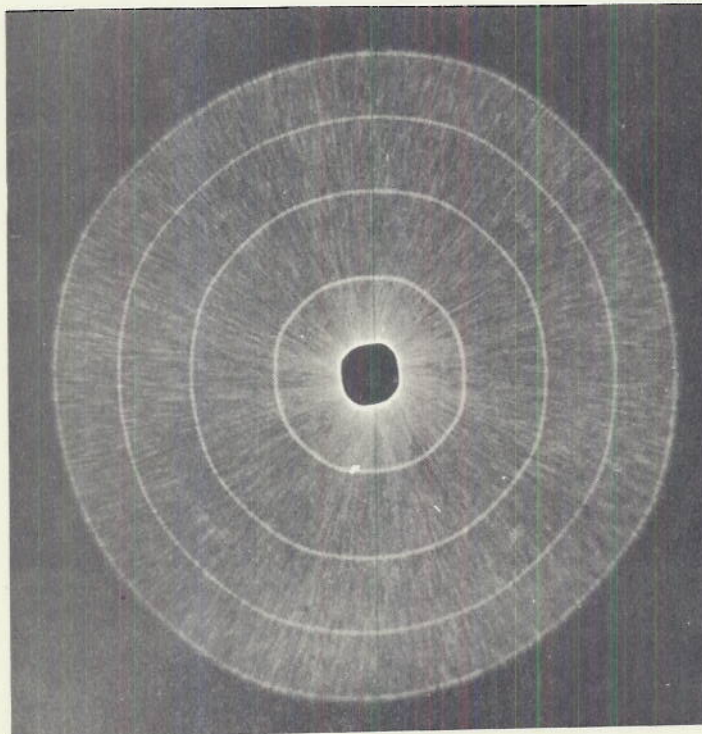
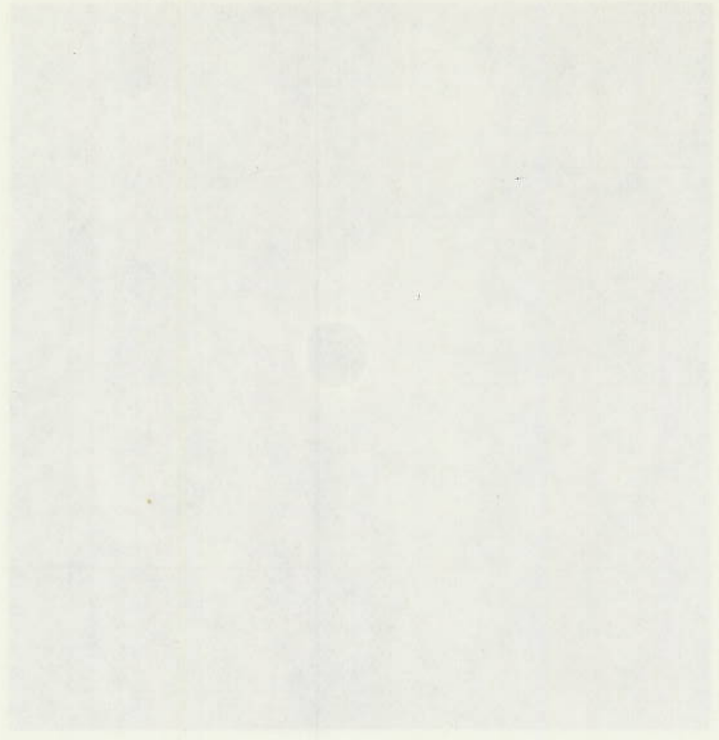
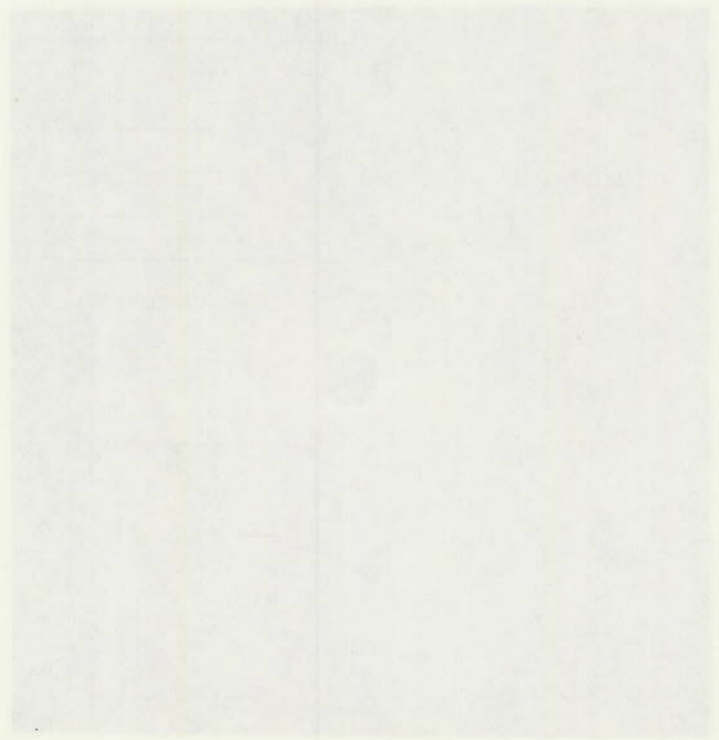


Figure 8 - High-speed scan on PPI

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