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Performance Measurements on the Airport and Airway Surveillance Radar (AASR)

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by

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PERFORMANCE MEASUREMENTS ON THE AIRPORT AND AIRWAY SURVEILLANCE RADAR (AASR)

SUMMARY

This report contains performance measurements made on an Airport and Airway Surveillance radar procured by the Department of Transport, Ottawa, Ontario, Canada. These measurements were made to provide advance data on the probable performance of similar equipment, Air Route Surveillance Radar, Model 1, being procured by CAA from the same manufacturer. There are enough differences between the two radars, however, so that no attempt is made in this report to evaluate or interpret these measurements with respect to either the Canadian or the American procurement specifications. Included in the report are measurements of MTI and normal radar performance, the effect of a nearby tower on the magnetron operation and the antenna beam pattern, a short flight check of the radar coverage, and several lesser important characteristics.

INTRODUCTION

The Civil Aeronautics Administration (CAA) is procuring a number of Air Route Surveillance Radar, Model 1 (ARSR-1) radar equipments from the Raytheon Manufacturing Co. These will be installed during 1958 and 1959. The Raytheon Manufacturing Co., working on an earlier contract for the Canadian Department of Transport, also is building another radar similar to the ARSR-1. This equipment, known as the Airport and Airway Surveillance Radar (AASR), was made available to CAA for testing and study to assist in expediting the commissioning of ARSR-1 systems when they become available. The Technical Development Center (TDC) assisted the personnel of the Office of Air Navigation Facilities, Washington, and Region 3 in testing and evaluating the AASR. This report contains data obtained during a brief series of evaluation tests which were performed at Indianapolis during November and December, 1957.

TRANSMITTER

The magnetron stability and spectrum were analyzed by two methods; namely, (1) an echo-box plot of frequency versus output, and (2) a spectrum analyzer. It was found that the upper sidebands were attenuated much more than the lower sidebands. Four magnetrons were used, and the same characteristics were exhibited by each one. A plot of echo-box indicator readings versus frequency is shown in Figs. 1 and 1A. The spectrum as seen on a Vecton spectrum analyzer verified these data

RECEIVERS

Normal Receiver

The sensitivity of the normal receiver had an average value of -109 dbm. This measurement was made with the noise level set at one-third of limit level. The intermediate frequency (i-f) bandwidth was 1.0 Mc with a center frequency of 30 Mc The normal video bandwidth was 375 kc. The video frequency response curve is shown in Fig. 2.

MTI Receiver.

The sensitivity of the MTI receiver had an average value of -108 dbm measured with a noise level of one-third limit level. The i-f bandwidth was measured at both sides of the phase detector. The bandwidth was 1.5 Mc with a center frequency of 29.7 Mc. A phase detector amplitude unbalance of 1.2 to 1 was noted. The moving target indicator (MTI) video bandwidth was 185 kc. The frequency response curve is shown in Fig. 3. The cancellation ratio was measured by two methods, according to Specification CAA-R-1079, Paragraph 3.11.3: (1) the echo-box method, and (2) the fixed-target cancellation ratio method. The cancellation ratios obtained by these methods were 15 db and 20 db, respectively.

The subclutter visibility was measured by three methods, according to Paragraph 3.11.4, of Specification CAA-R-1079: (1) echo-box method, (2) fixed-targets method, and (3) antenna scanning method. The subclutter visibility as measured by these methods was 10 db, 18 db, and 25 db, respectively.

Photographs were taken of the normal presentation at incremental levels of sensitivity from -32 dbm to -107 dbm. For each photograph, the normal i-f gain was set so that a test signal of the level specified was barely visible. Subsequently, photographs were taken of the MTI presentation with an injected cw signal at the same incremental levels but with optimum settings of gain and cancellation controls. Antenna speeds of 3 rpm and 6 rpm were used. The results of these tests are shown in Figs. 4 to 10 inclusive. These photographs also show ground clutter for the different system sensitivities on a 30-mile plan position indicator (PPI), using normal video.

ANTENNA SYSTEM

Horizontal Radiation Pattern.

A check of the relative field strength in the azimuth plane of the antenna was made The beam width at the half-power points was approximately 1.1°. The antenna radiation pattern, in space, is shown in Fig. 11. A similar check with the antenna beam directed through a nearby tower, such as might be used to support microwave remoting antennas, yielded the radiation pattern shown in Fig. 12. The half-power beam width in this direction was approximately 1.0°. The difference in beam width is due, quite possibly, to measurement errors, however, it can be concluded that no serious deformation of the beam can be attributed to the proximity of the tower. The tower did cause a small amount of magnetron frequency pulling; however, the amount of pulling was not significant and in fact was difficult to measure.

Vertical Radiation Pattern and Flight Check.

The results of the flight check are depicted in Fig. 13. A DC-3 airplane was flown in and out on the 322° radial of the Indianapolis VOR. The antenna rotation was set at 6 rpm and the electrical tilt was 2.5° above the horizon.

Photographs of the MTI performance, when the aircraft was flying directly over the site at 1,000 feet, were obtained. These are shown in Figs. 14 and 15.

GENERAL PERFORMANCE

The high-voltage power supply had a high drop-out rate The length of time after the high voltage was turned on until drop-out occurred varied from a few minutes to several hours. The line voltage was recorded, and it was determined that line voltage fluctuation was not causing the drop-out. Some improvement was obtained by optimum adjustment of the carrier oscillator gate, but at the conclusion of the measurement period, the high voltage would occasionally drop out for no apparent reason.

The input to the spectrum analyzer is taken from the coho-mixer The interconnecting lead carried the sweep rate fluctuation of the spectrum analyzer to the coho-mixer, modulating the coho. This resulted in poor MTI performance which was corrected by isolating the two circuits.

Tuning of the Stalo was found to be quite critical. The AASR does not employ automatic frequency control and, therefore, the directional switch on the Stalo tuning motor must be operated manually. The tuning motor, however, has very little friction, and it is very time-consuming to stop it at the optimum adjustment.

Considerable MTI trouble was attributed to a loose fit on the shield of the coho chassis This shield must be tight, otherwise, MTI instability will result.

It was noted that the modulation percentage of the delay-line driver is an important factor in cancellation of the fixed targets. Figures 16 and 17 show this effect The cancellation was good at 20 per cent modulation, but when it was raised to 33 per cent the cancellation was decreased somewhat. The normal modulation percentage is approximately 29 per cent.

The performance monitor was an effective tool for obtaining a rapid check of transmitter and receiver performance, however, the monitor seemed highly susceptible to tube failures in the power supply.

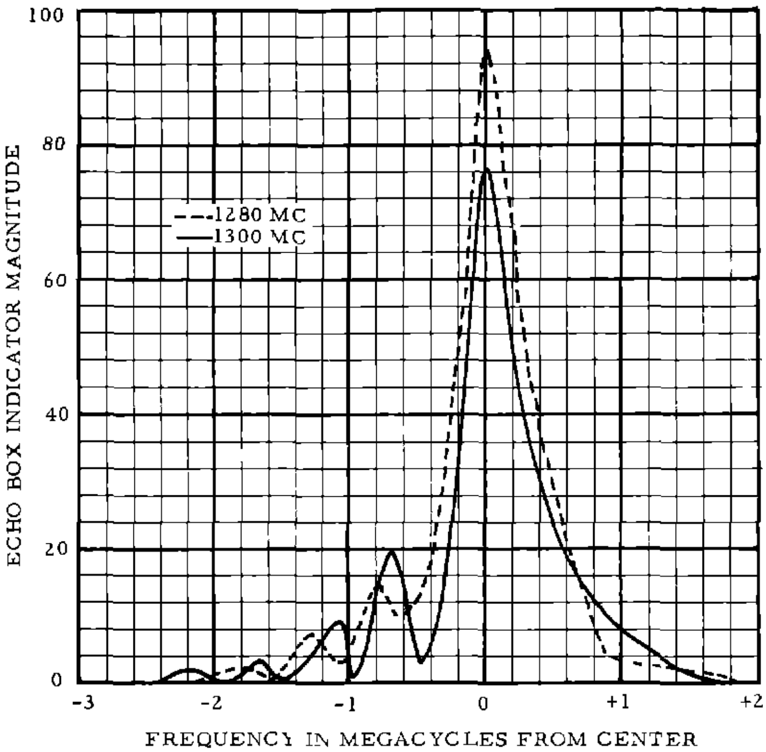


FIG 1 TRANSMITTER OUTPUT SPECTRUM

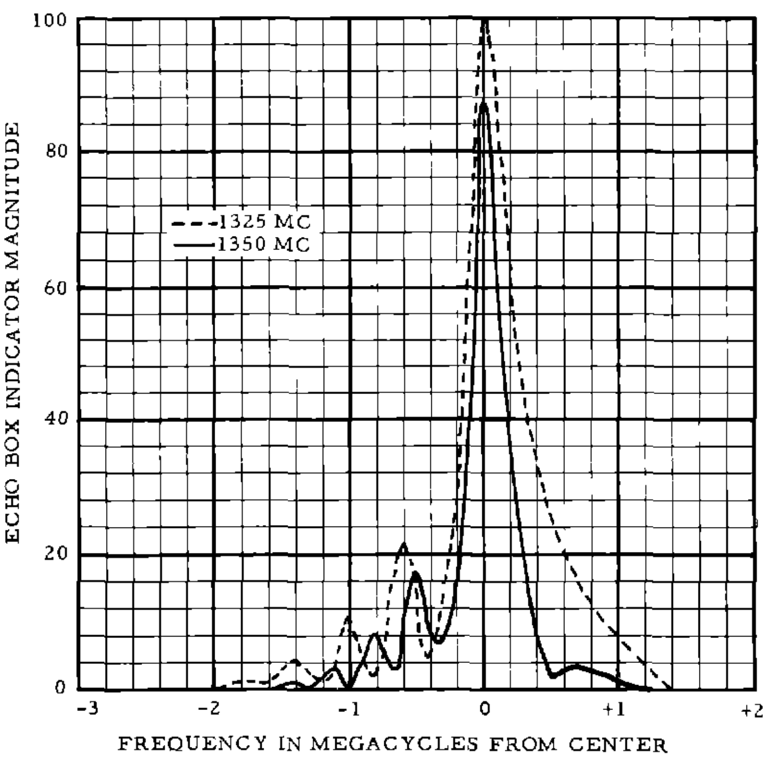


FIG 1A TRANSMITTER OUTPUT SPECTRUM

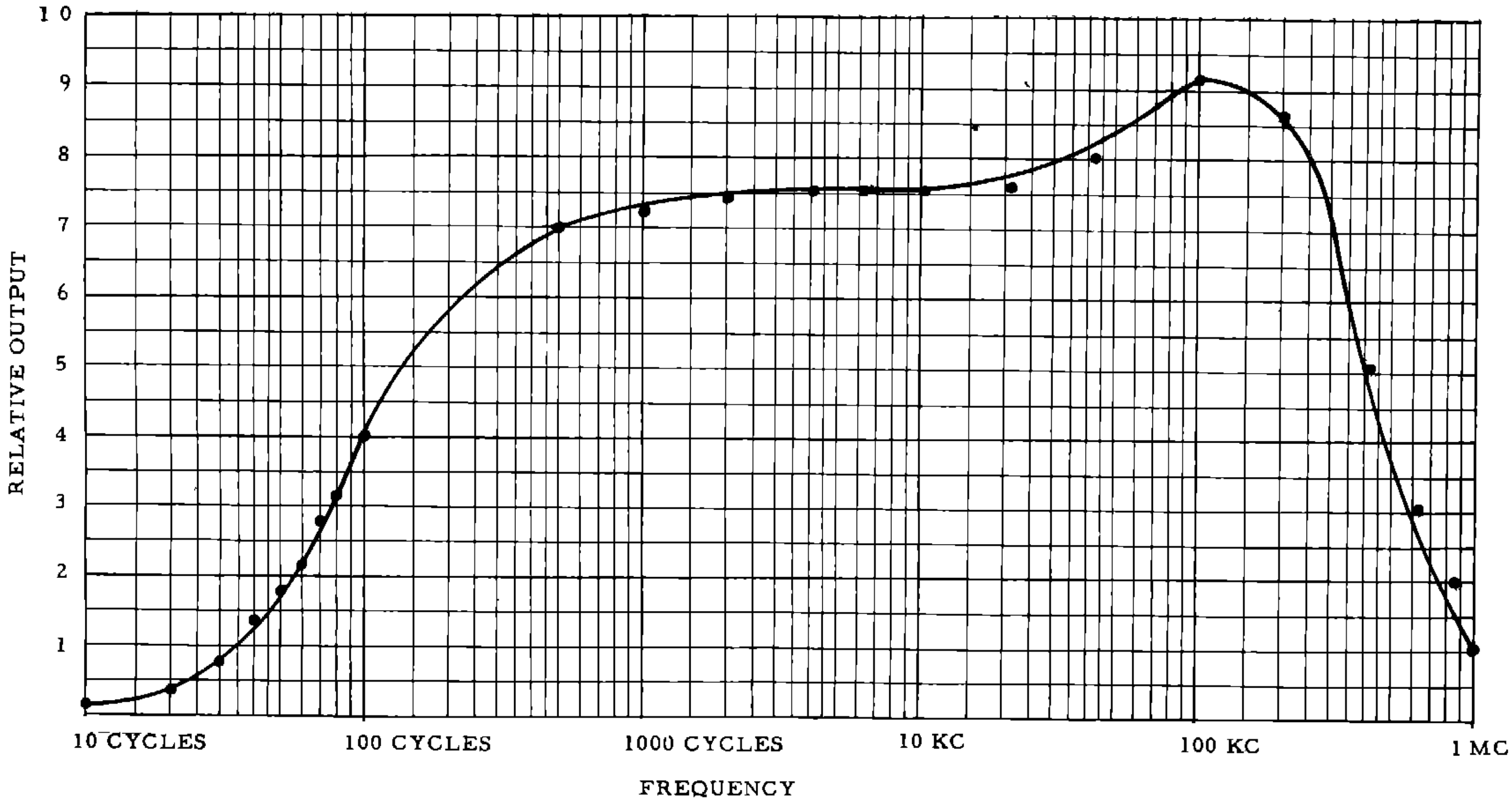


FIG 2 NORMAL VIDEO BAND PASS

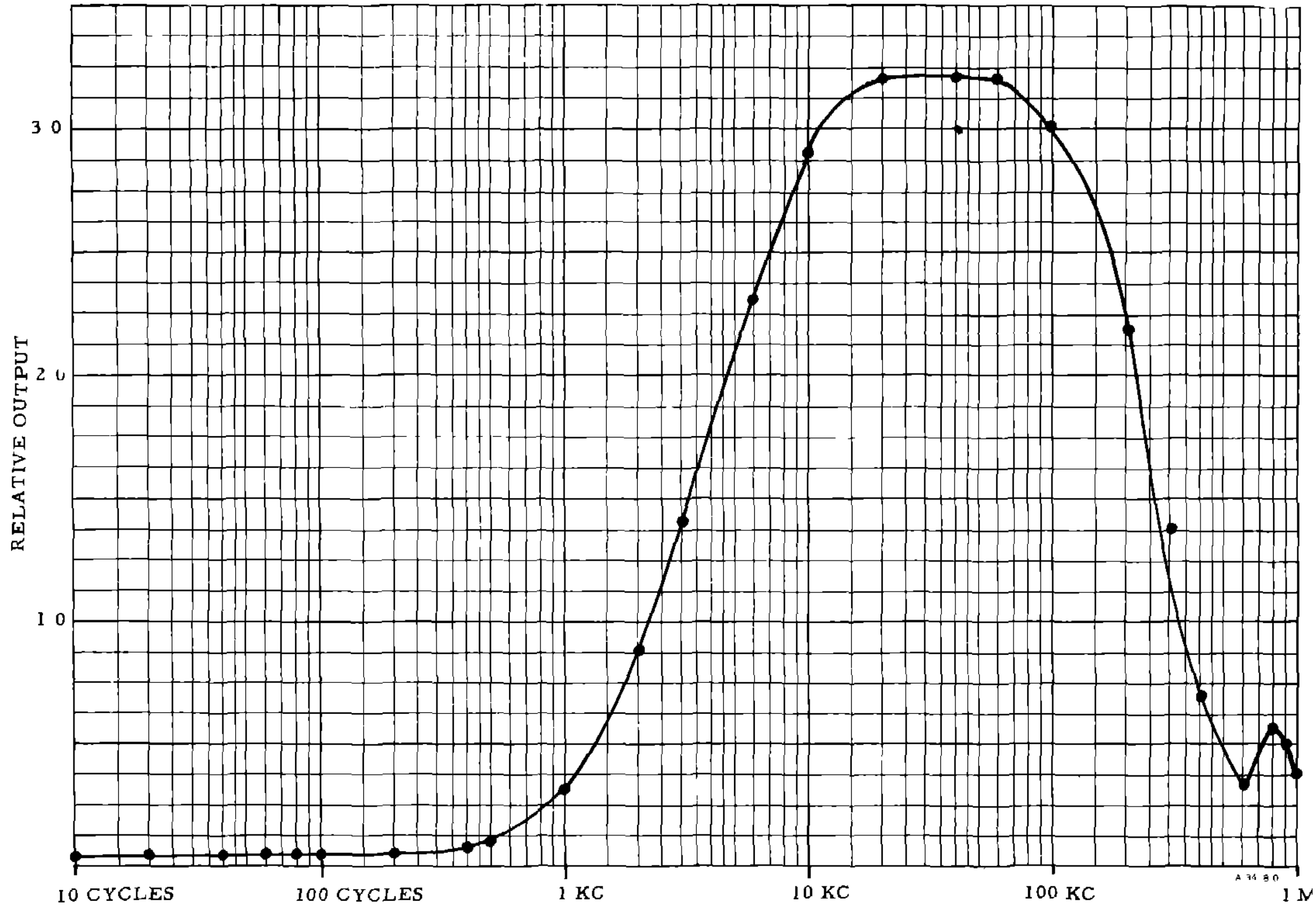
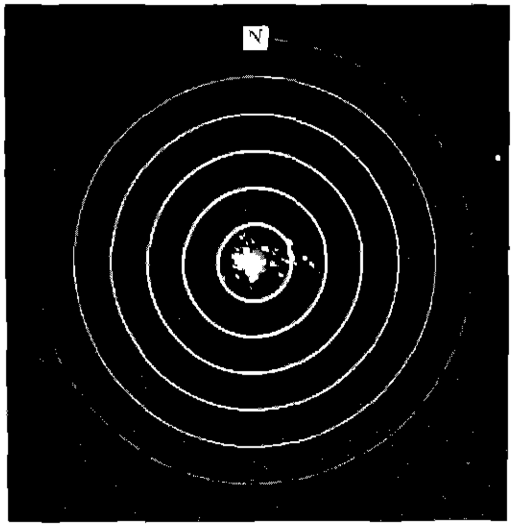
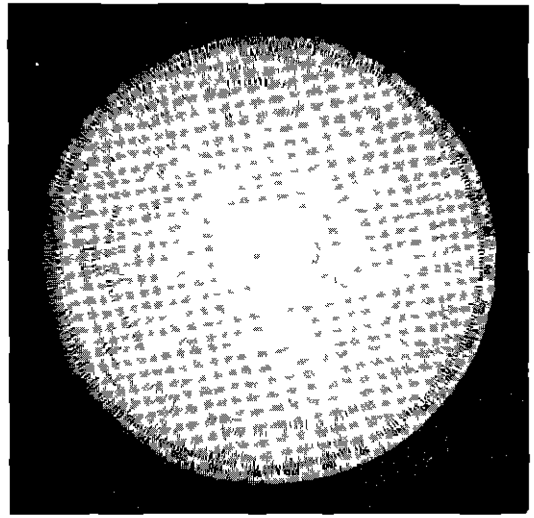


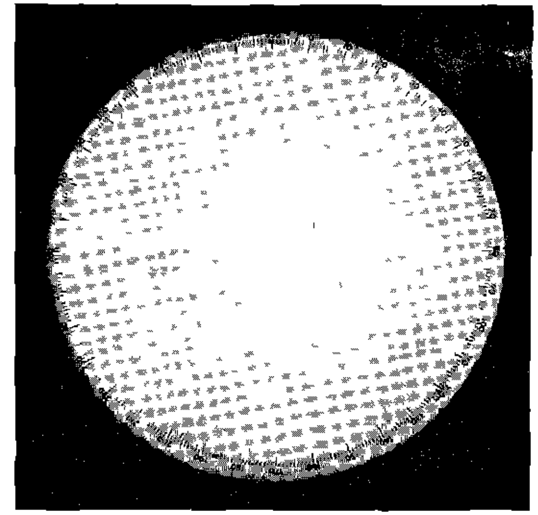
FIG 3 MTI VIDEO BAND PASS



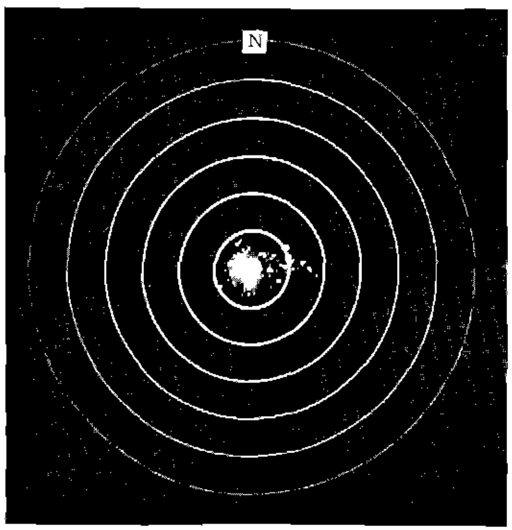
NORMAL VIDEO CLUTTER IN EXCESS OF -32 DBM



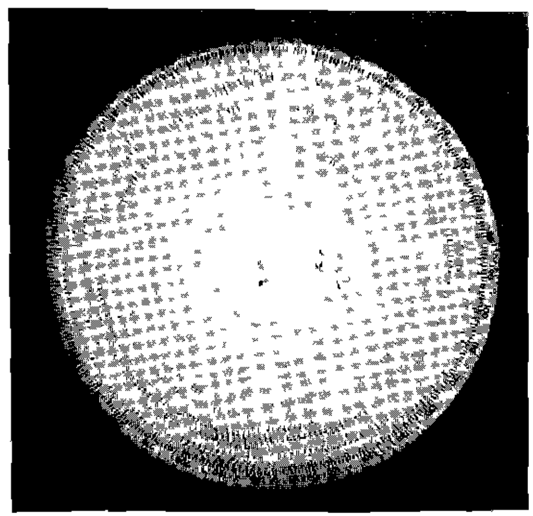
MTI VIDEO -32 DBM CW SIG 6 RPM



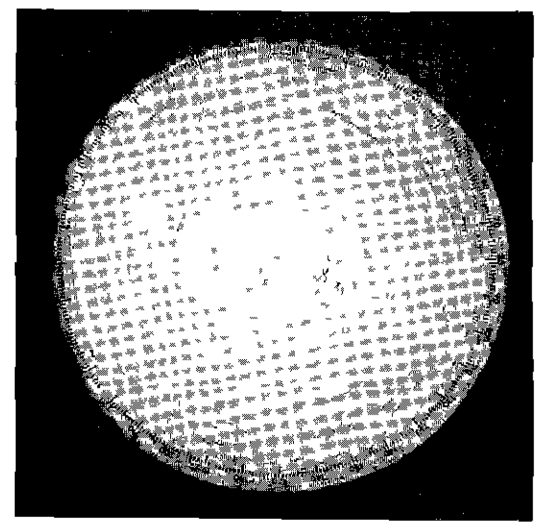
MTI VIDEO -32 DBM SIG 3 RPM



NORMAL VIDEO CLUTTER IN EXCESS OF -37 DBM

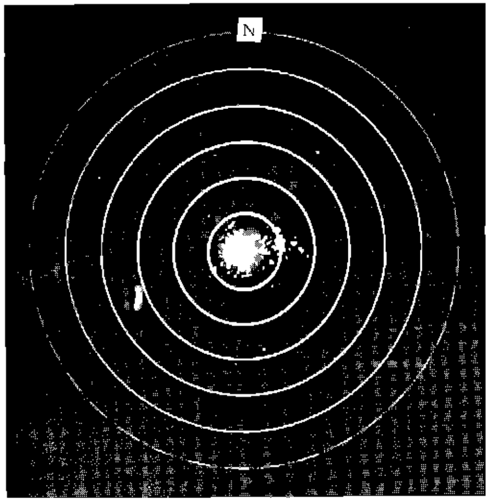


MTI VIDEO -37 DBM CW SIG 6 RPM

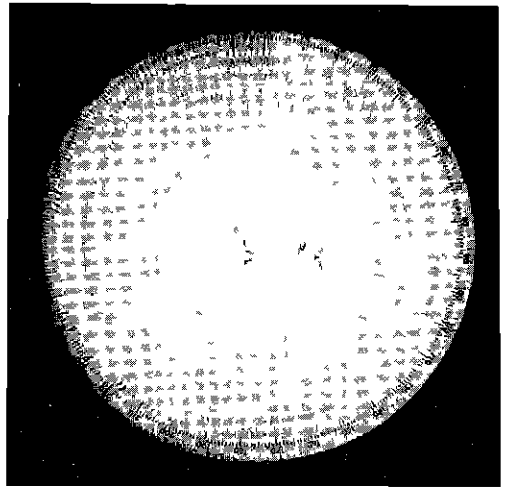


MTI VIDEO - 37 DBM CW SIG 3 RPM

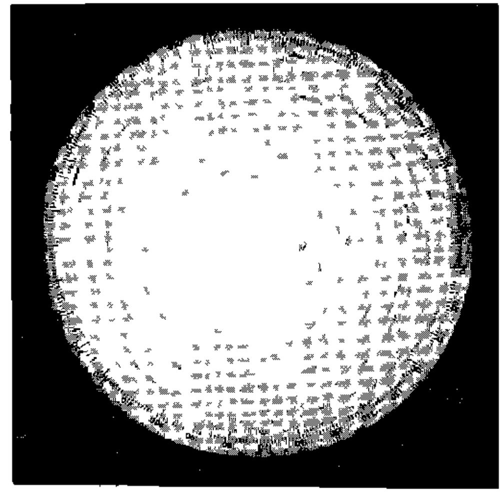
FIG 4 NORMAL AND MTI PPI PRESENTATION



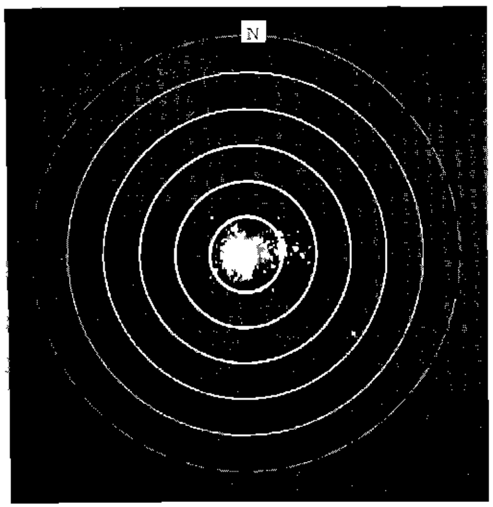
NORMAL VIDEO CLUTTER IN EXCESS
OF -42 DBM



MTI VIDEO -42 DBM CW SIG
6 RPM



MTI VIDEO -42 DBM CW SIG
3 RPM



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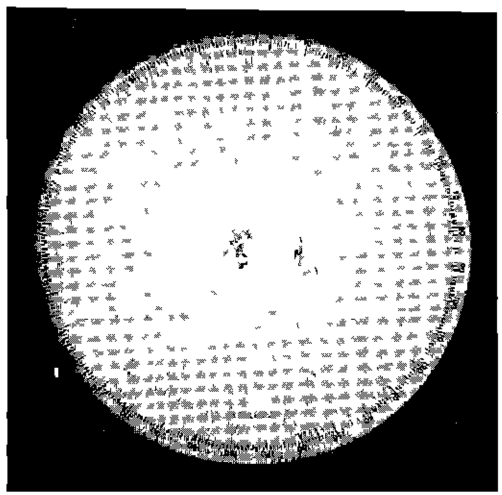
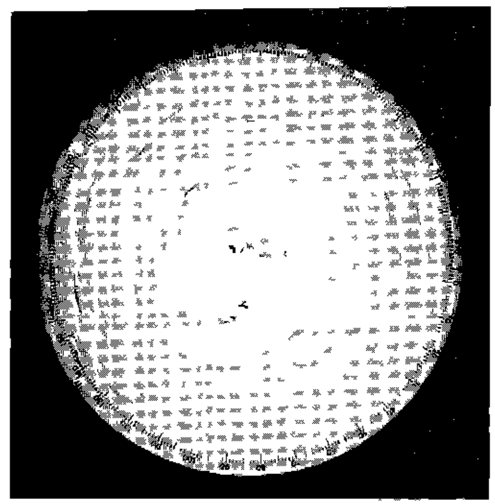
OF -47 DBM

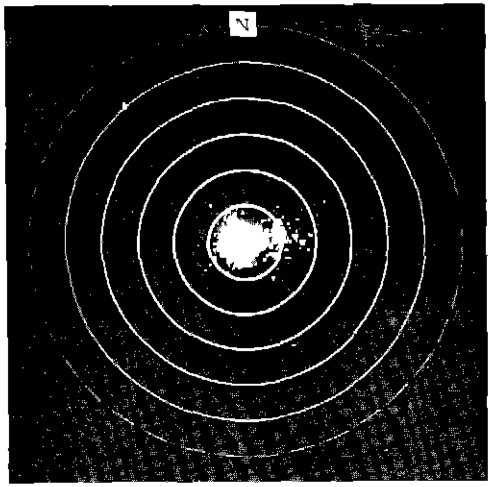


MTI VIDEO -47 DBM CW SIG
6 RPM

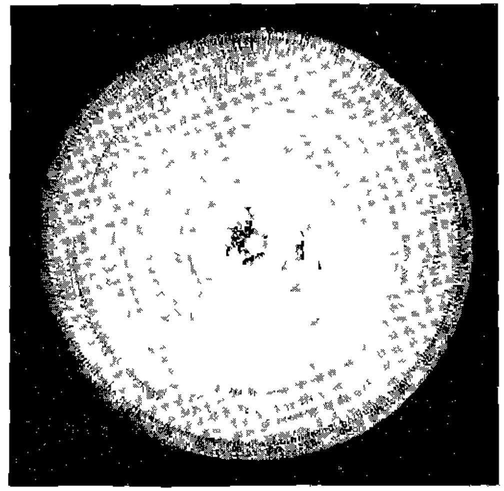


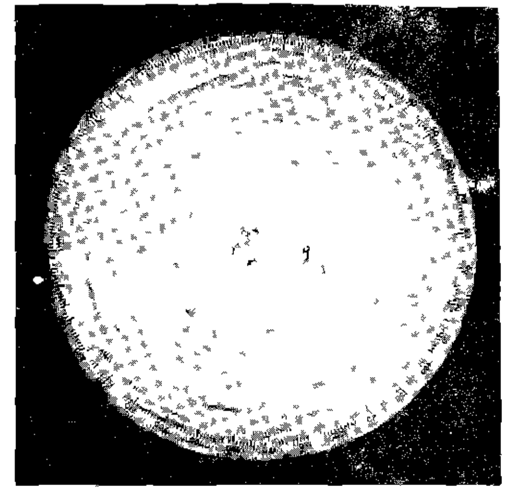
MTI VIDEO -47 DBM CW SIG
3 RPM

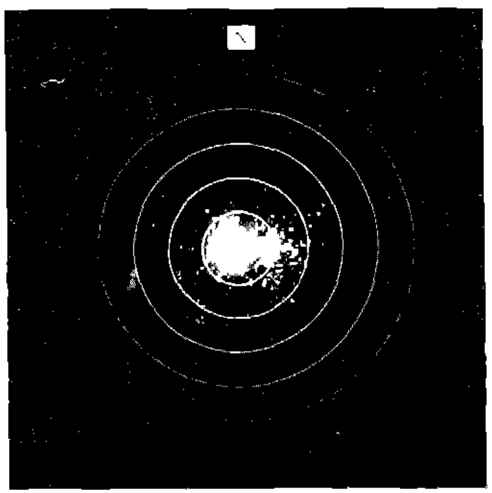
FIG 5 NORMAL AND MTI PPI PRESENTATION



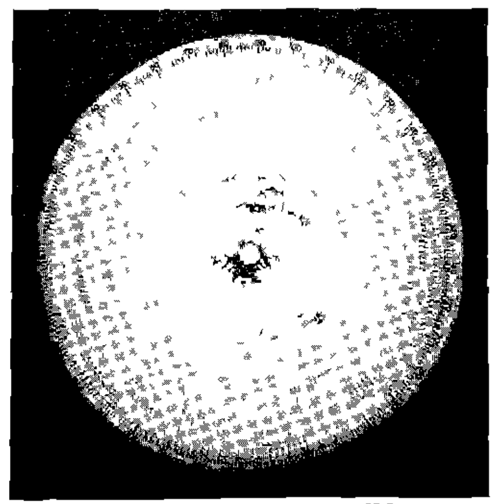
NORMAL VIDEO CLUTTER IN EXCESS OF -52 DBM


MTI VIDEO -52 DBM CW SIG
6 RPM


MTI VIDEO -52 DBM CW SIG
3 RPM



NORMAL VIDEO CLUTTER IN EXCESS OF -57 DBM


MTI VIDEO -57 DBM CW SIG
6 RPM

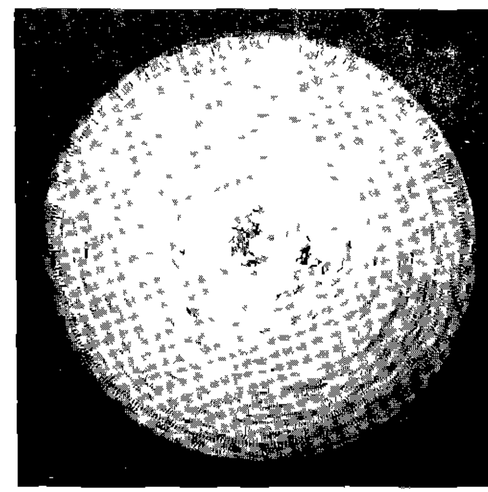
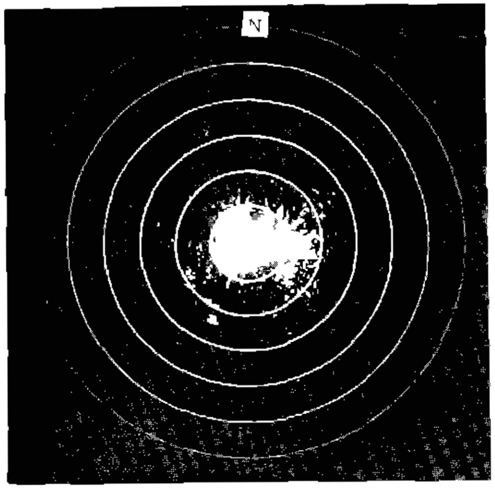
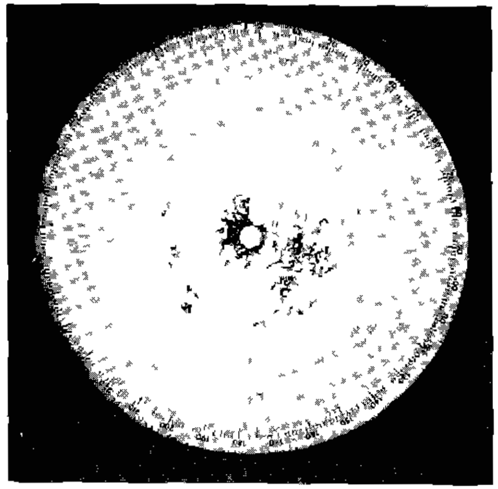

MTI VIDEO -57 DBM CW SIG
3 RPM

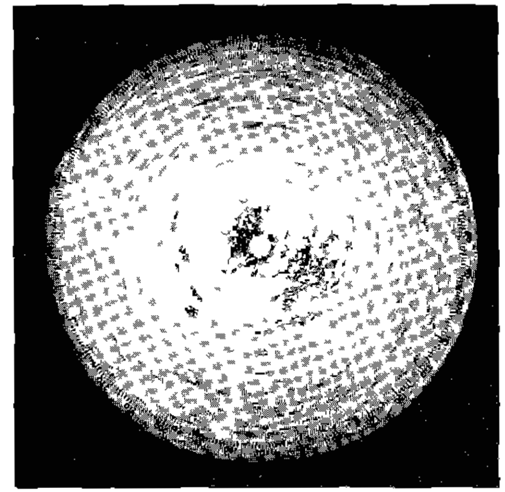
FIG 6 NORMAL AND MTI PPI PRESENTATION



NORMAL VIDEO CLUTTER IN EXCESS
OF -62 DBM



MTI VIDEO -62 DBM CW SIG
6 RPM



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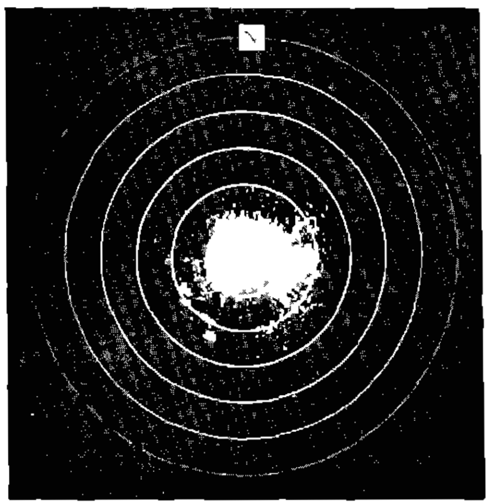
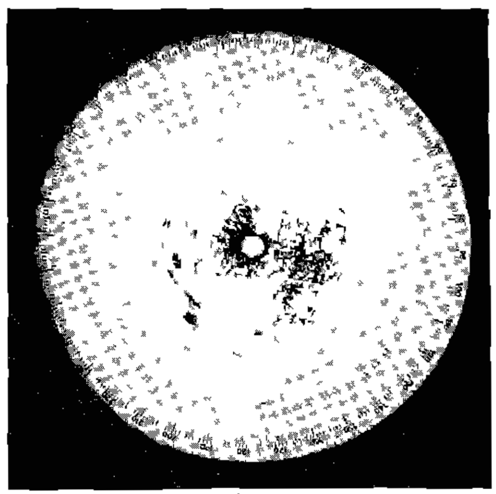
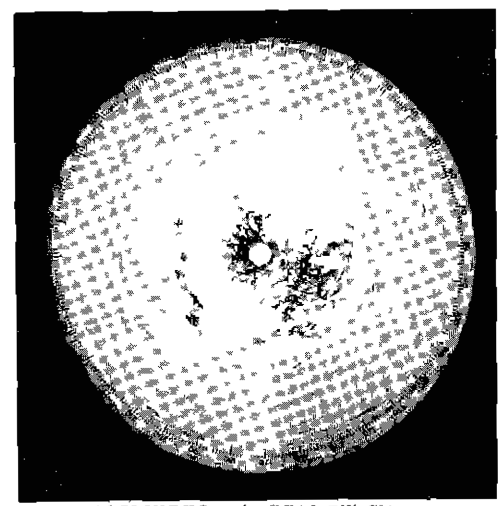


NORMAL VIDEO CLUTTER IN EXCESS
OF -67 DBM

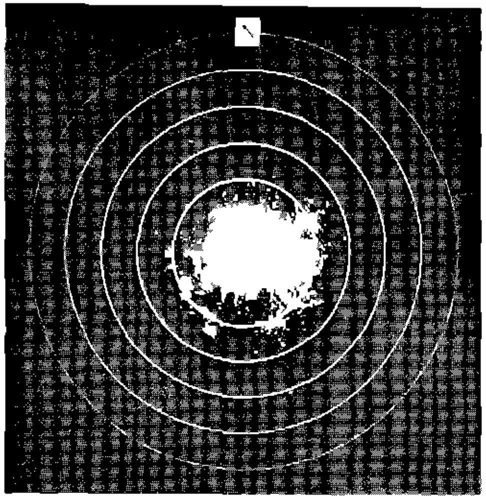


MTI VIDEO -67 DBM CW SIG
6 RPM



MTI VIDEO -67 DBM CW SIG
3 RPM

FIG 7 NORMAL AND MTI PPI PRESENTATION



NORMAL VIDEO CLUTTER IN EXCESS
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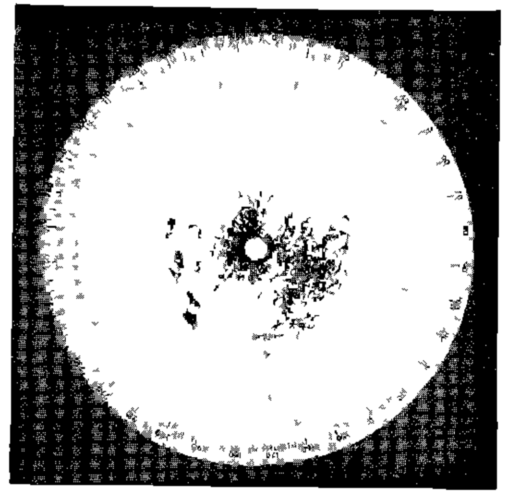

MTI VIDEO -72 DBM CW SIG
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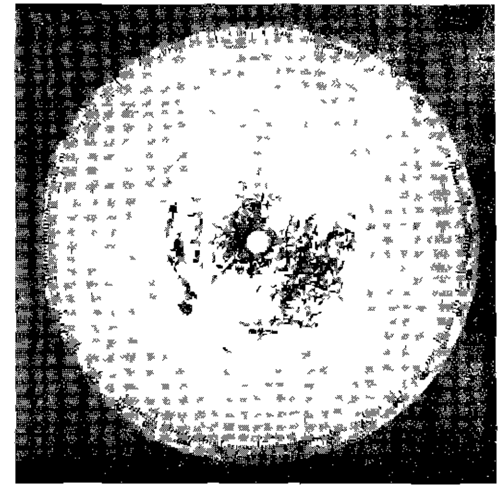

MTI VIDEO -72 DBM CW SIG
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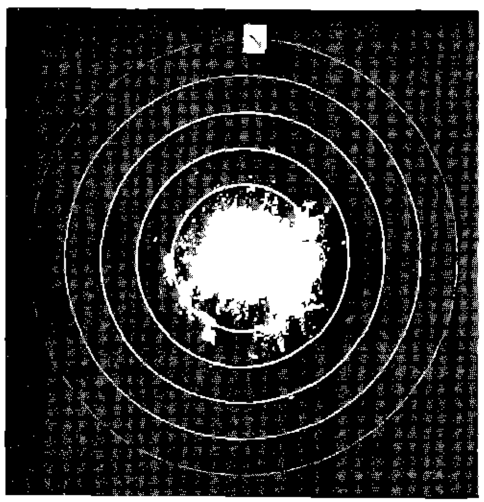

NORMAL VIDEO CLUTTER IN EXCESS
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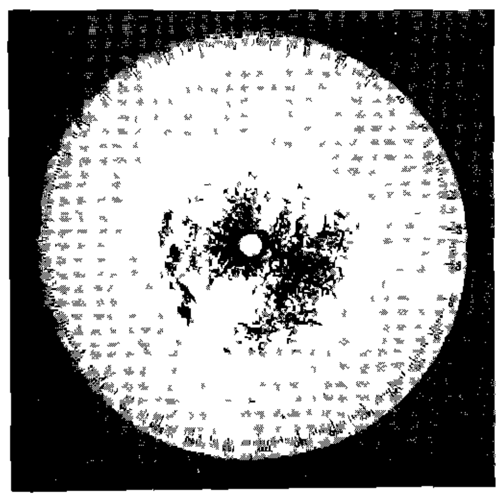
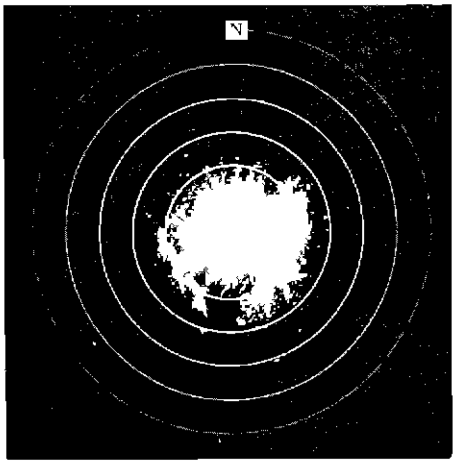
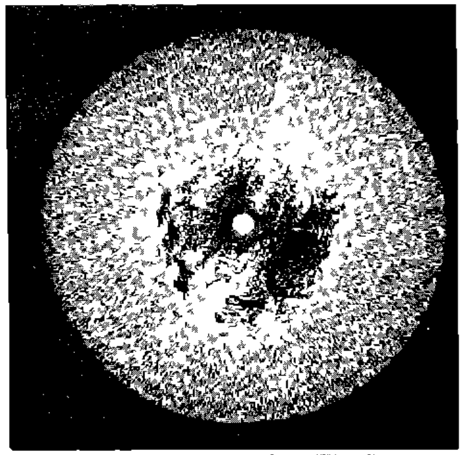


MTI VIDEO -77 DBM CW SIG
6 RPM

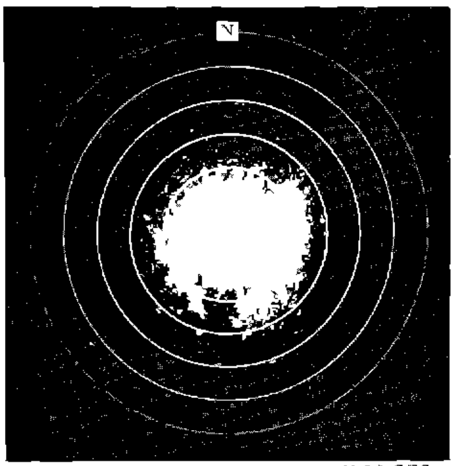
FIG. 8 NORMAL AND MTI PPI PRESENTATION



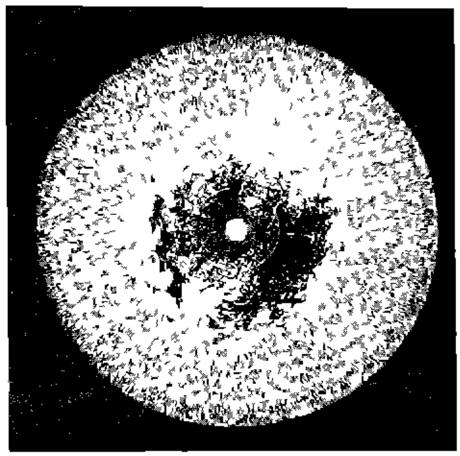
NORMAL VIDEO CLUTTER IN EXCESS
OF -82 DBM



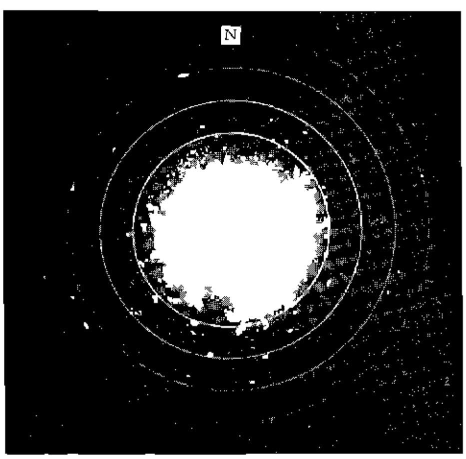
MTI VIDEO -82 DBM CW SIG
6 RPM



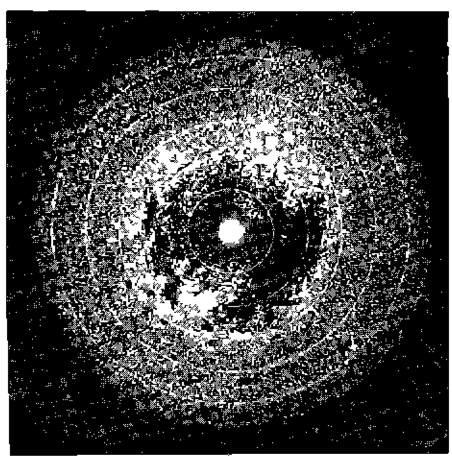
NORMAL VIDEO CLUTTER IN EXCESS
OF -87 DBM



MTI VIDEO -87 DBM CW SIG
6 RPM

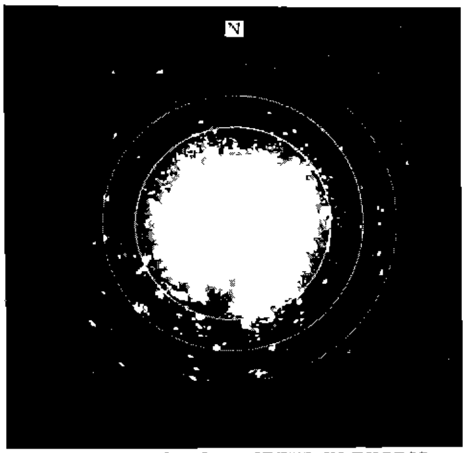


NORMAL VIDEO CLUTTER IN EXCESS
OF -92 DBM



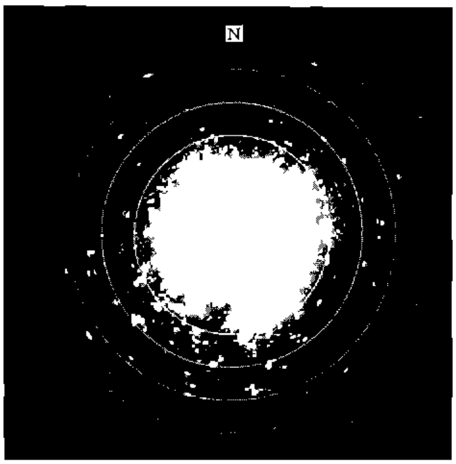
MTI VIDEO -92 DBM CW SIG
6 RPM

FIG 9 NORMAL AND MTI PPI PRESENTATION



NORMAL VIDEO CLUTTER IN EXCESS
OF -97 DBM

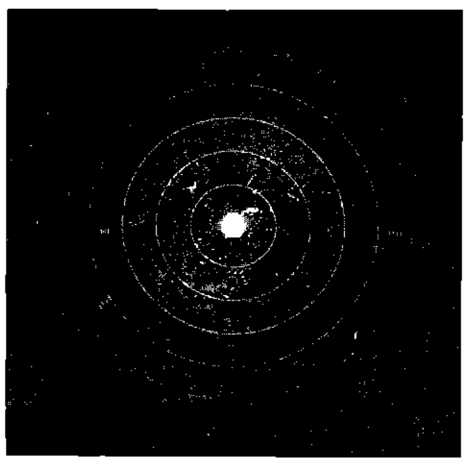
MTI VIDEO -97 DBM CW SIG
6 RPM



NORMAL VIDEO CLUTTER IN EXCESS
OF -102 DBM

MTI VIDEO -102 DBM CW SIG
6 RPM

NORMAL VIDEO CLUTTER IN EXCESS
OF -107 DBM



MTI VIDEO -107 DBM CW SIG
6 RPM

FIG. 10 NORMAL AND MTI PPI PRESENTATION

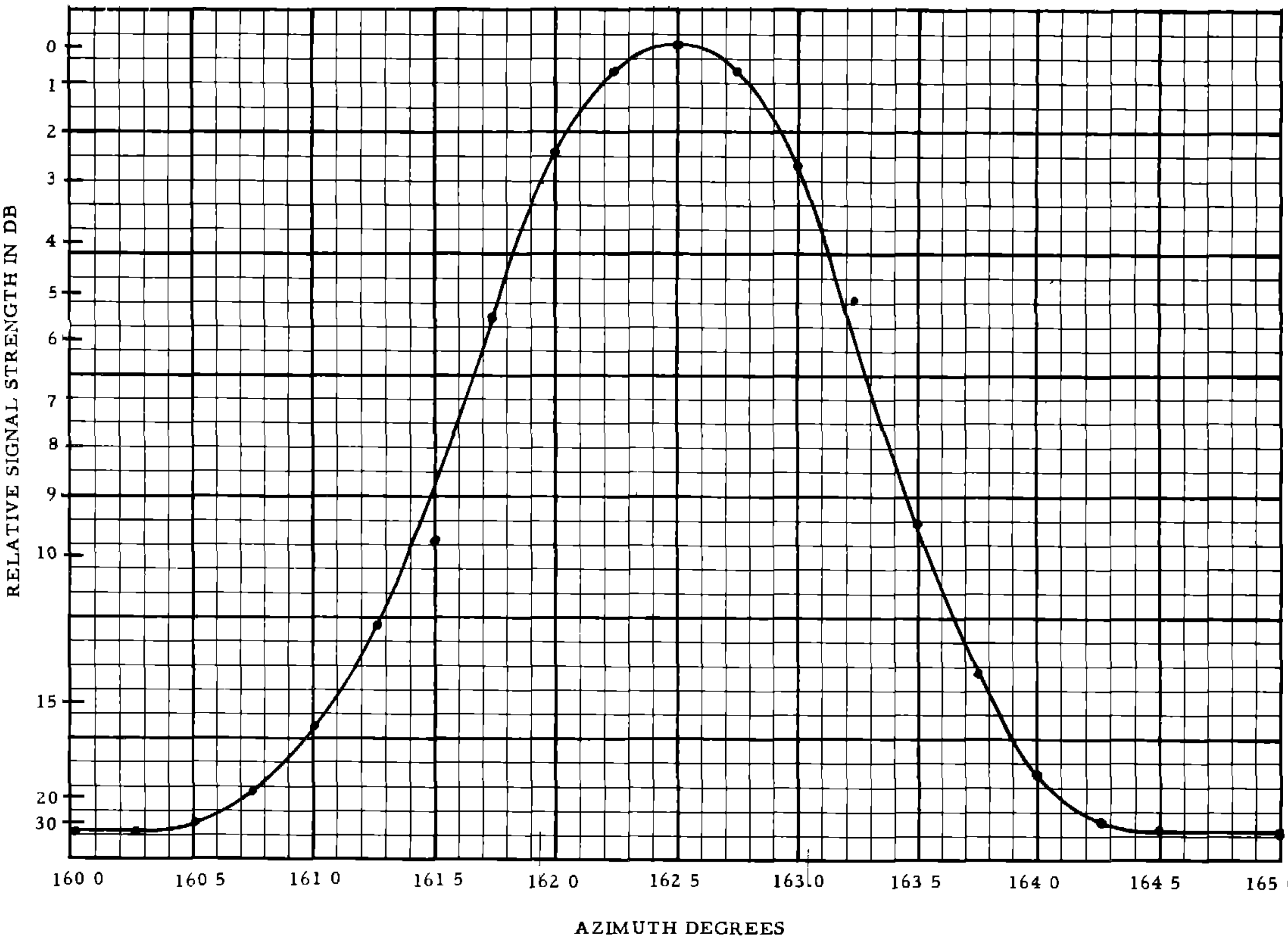


FIG 11 ANTENNA AZIMUTH PATTERN IN SPACE

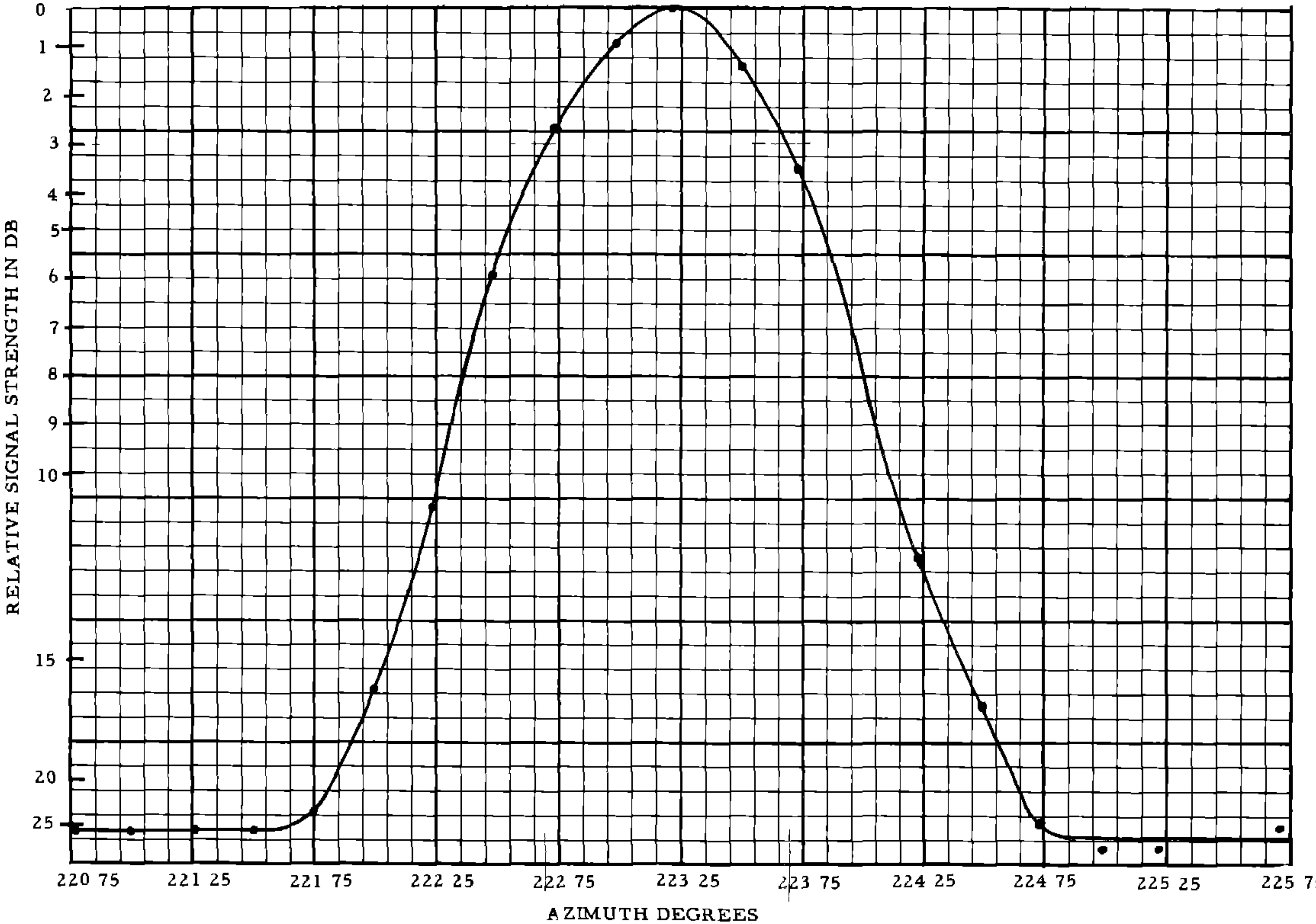


FIG 12 ANTENNA AZIMUTH PATTERN THROUGH MW TOWER

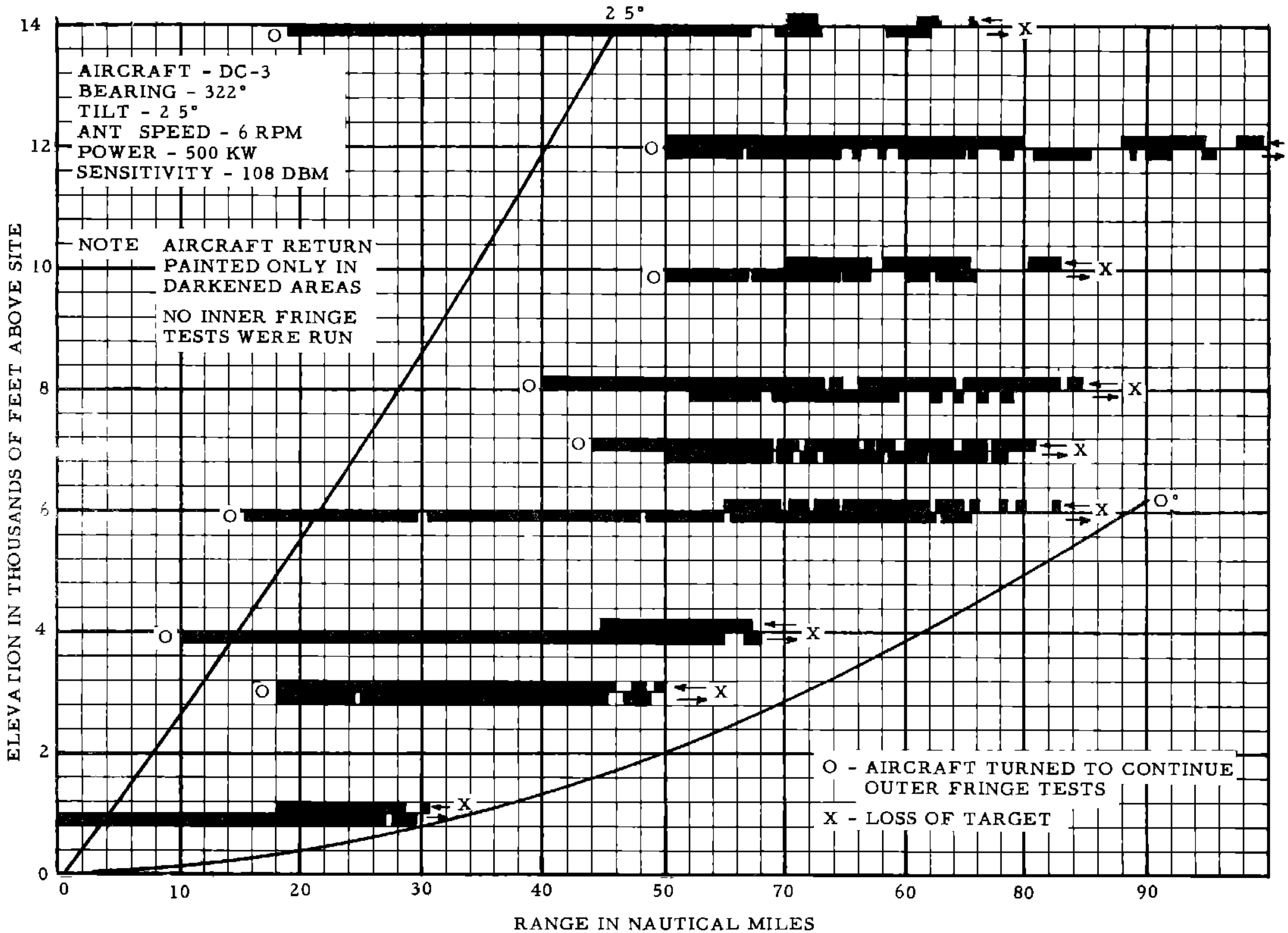
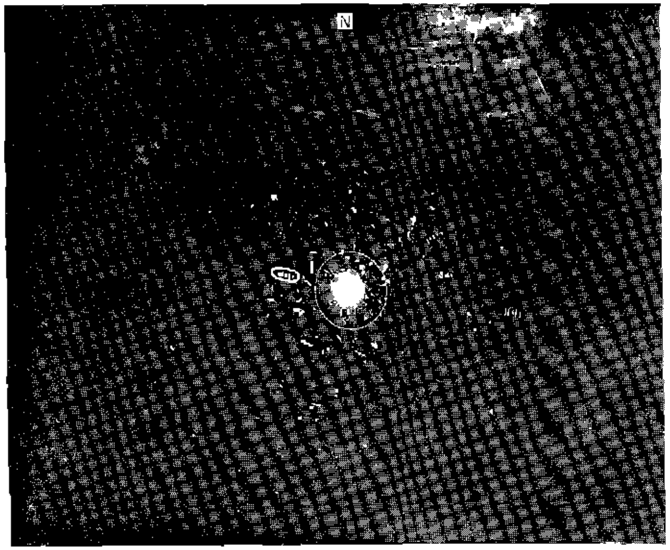
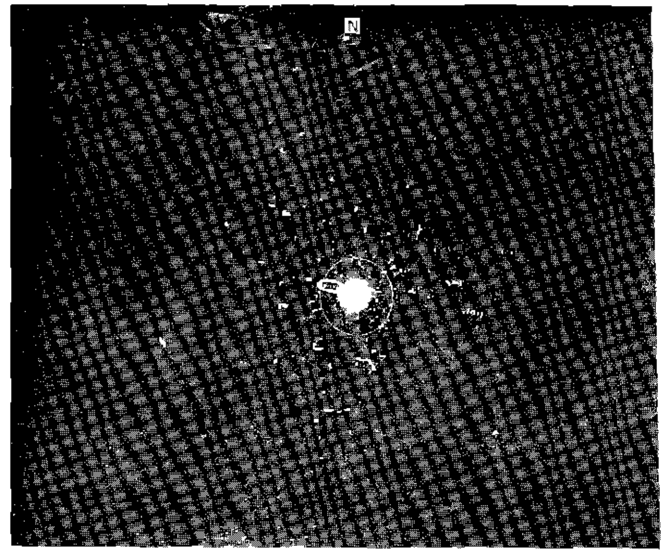


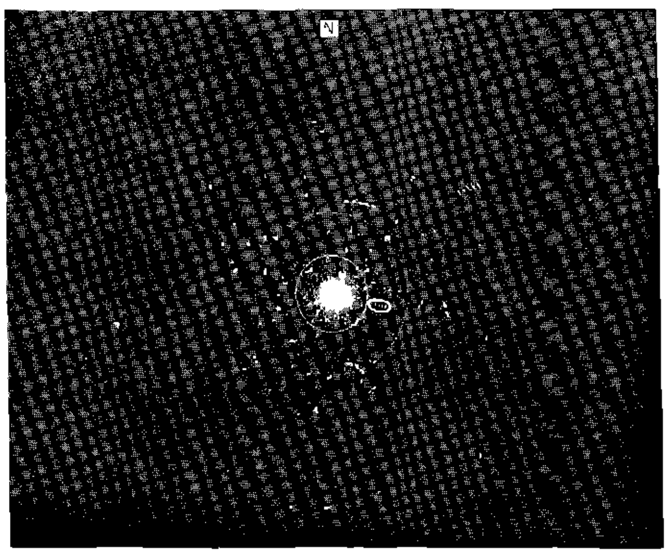
FIG 13 FLIGHT CHECK DATA



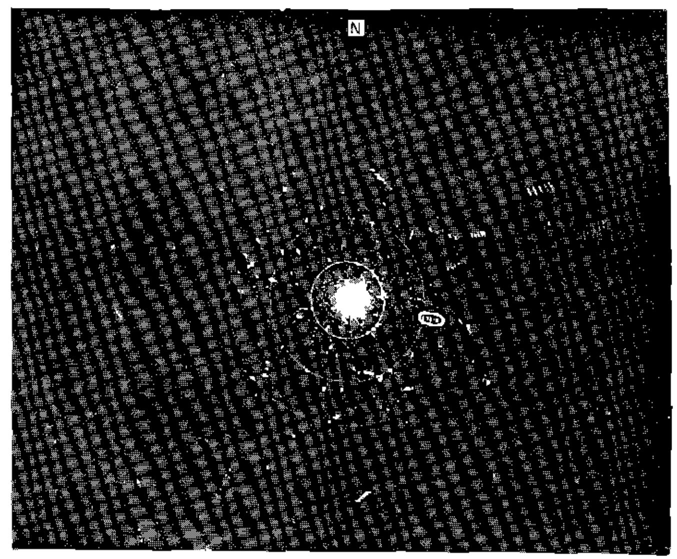
DC-3 RANGE 8-10 BEARING 280 HEADING 100 ALTITUDE 1800 M S L



DC 3, RANGE 3-5 BEARING 280° HEADING 100 ALTITUDE 1800 M S L

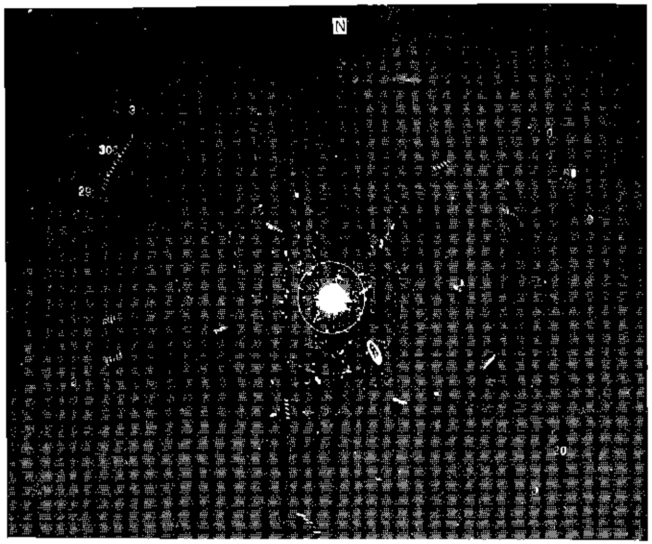


DC-3 RANGE 6-8 BEARING 100° HEADING 100° ALTITUDE 1800 M S L

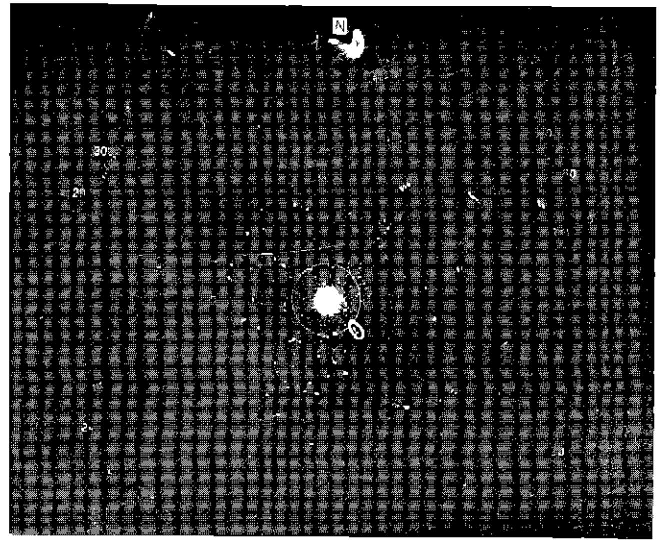


DC 3, RANGE 10 12 BEARING 100 HEADING 100 , ALTITUDE 1800 M S L

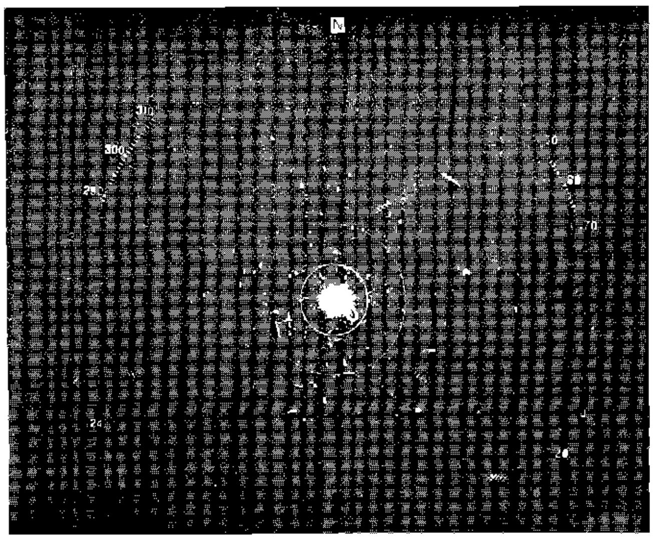
FIG 14 MTI PERFORMANCE—FLIGHT CHECK



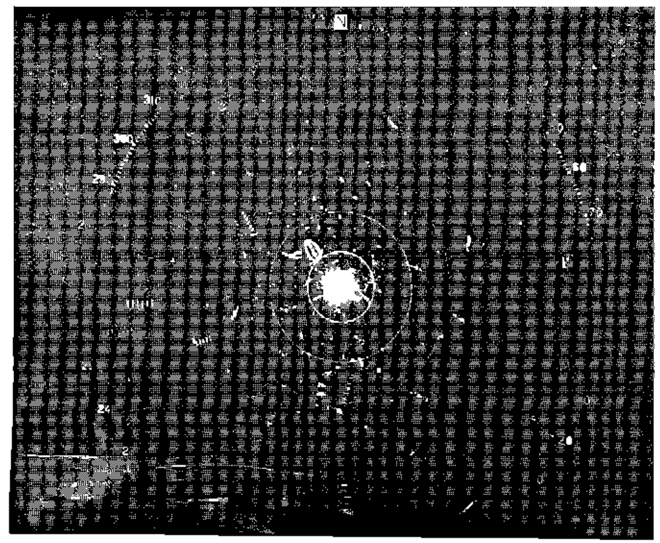
DC-3 RANGE 8 10 BEARING 140° HEADING 320 ALTITUDE 1800 M S L



DC 3 RANGE 5-7 BEARING 40 HEADING 320 ALTITUDE 1800 M S L

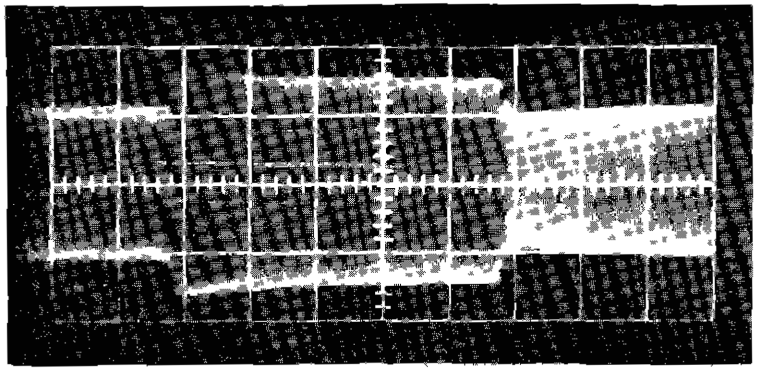


DC-3 RANGE 3 4 BEARING 140 HEADING 320 ALTITUDE 1800 M S L

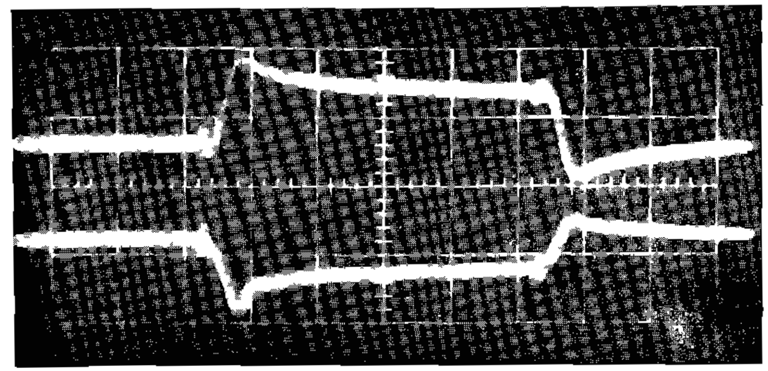


DC 3 RANGE 5 7 BEARING 320 HEADING 320° ALTITUDE 1800 M S L

FIG 15 MTI PERFORMANCE--FLIGHT CHECK

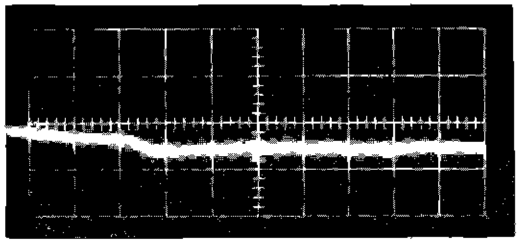


20 PER CENT MODULATION, 10μS PULSE
INPUT TO DELAY LINE

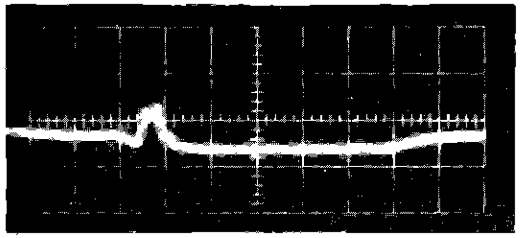


TOP - UNDELAYED OUTPUT
BOTTOM - DELAYED OUTPUT
20 PER CENT MODULATION

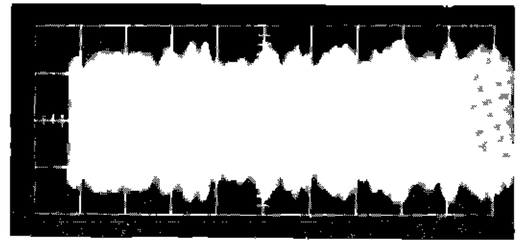
FIG. 16 MTI CANCELLATION VERSUS MODULATION



5 V /CM

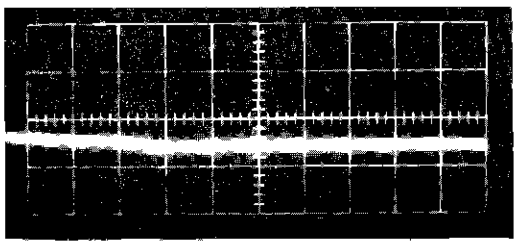


MTI OUTPUT



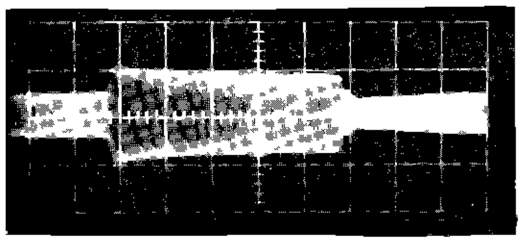
INPUT TO DELAY LINE

NORMAL MODULATION



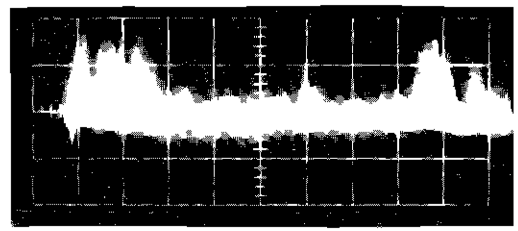
1 V /CM

MTI VIDEO 20 PER CENT MODULATION



INPUT TO DELAY LINE

33 PER CENT MODULATION



MTI OUTPUT

FIG 17 MTI CANCELLATION VERSUS MODULATION