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ORTHOGONAL DETECTION OF RADAR TARGETS IN RAIN 'AT KU-BAND

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THE SCIENTIFIC COMPANY AIRPLANE DIVISION RENTON, WASHINGTON

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ORTHOGONAL DETECTION OF RADAR TARGETS IN K_u-BAND

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ELECTRODYNAMICS STAFF

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THE **BOEING** COMPANY
AIRPLANE DIVISION
RENTON, WASHINGTON

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ORTHOGONAL DETECTION OF RADAR TARGETS IN RAIN AT K_u-BAND

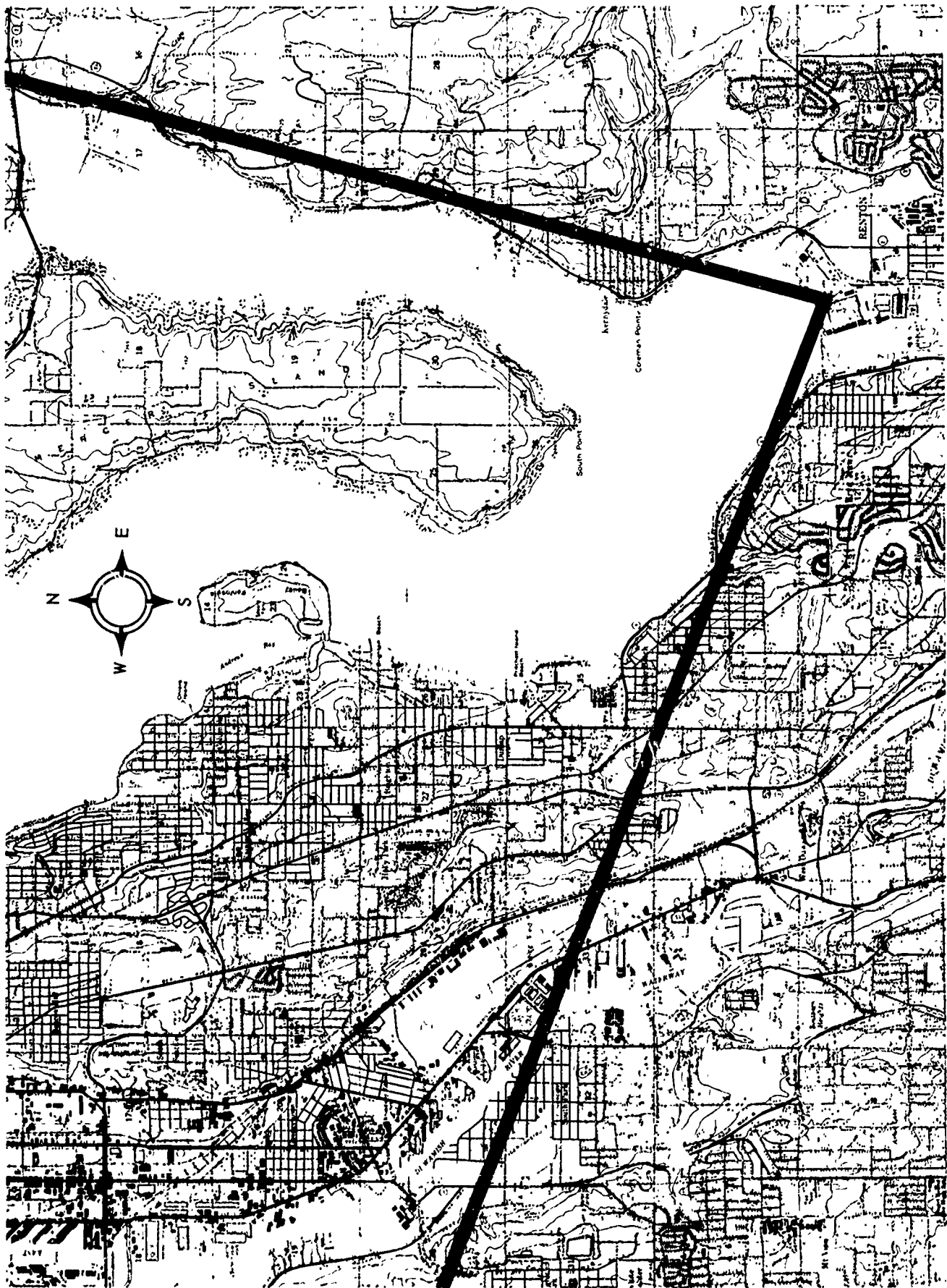
The performance of conventional, linearly polarized airborne radars, using the higher frequencies (X-band and above), can be severely degraded by even moderate rainfall. However, the difference in the polarization properties between precipitation and desired targets can be used as a basis for discrimination. Because raindrops are nearly spherical, the backscattered energy from a linearly polarized incident wave is not depolarized. The backscattered energy from man-made and natural objects, on the other hand, are depolarized significantly. These polarization differences form the basis for the most practical discrimination schemes. Normal radar practice in the past has been to use circularly polarized transmission as a basis for discrimination. However, a linearly polarized radar capable of receiving and displaying the orthogonal component of the backscattered energy as well as the co-polarized component should be able to discriminate targets from precipitation. Other potential advantages inherent in dual polarization are being investigated.

The Boeing K_u-band radar system was modified to permit either horizontally- or vertically-polarized linear transmission, and simultaneous reception of both the co-polarized and cross-polarized signal return.

The parameters of the K_u-band radar are as follows:

- Frequency = 16.1 kmc
 - Pulse length = 0.33 μ sec
 - PRF = 2100 per sec
 - Radiated power = 72KW, peak
 - Antenna beam width = 2.0 degrees (pencil)
 - Antenna gain = 40 db
 - Antenna scan angle = \pm 40 degrees
 - Isolation between channels: at least 30 db
- The test site is on the south shore of Lake Washington.

The test data obtained is shown in a series of photographs on the following pages. The basic information in the photographs is a comparison of the co-polarized and cross-polarized radar return from terrain and various waterborne and airborne targets under the rain conditions noted. The rainfall rates noted are subjective because no adequate means of measuring the rainfall, in the area being scanned by the radar, were available. From the photographs it is clear that clutter due to weather is greatly reduced in the cross-polarized channel, and the detection of targets in that channel is greatly enhanced. Measurements made indicate clutter return in the cross-channel is down approximately 20 db from that in the co-channel. Changing the transmitted polarization from horizontal to vertical makes no apparent difference in the effect.



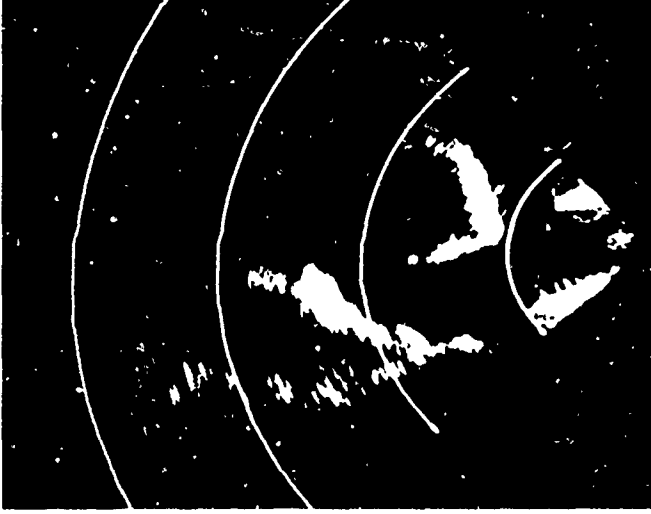
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1/2 1 Mile

CLEAR WEATHER



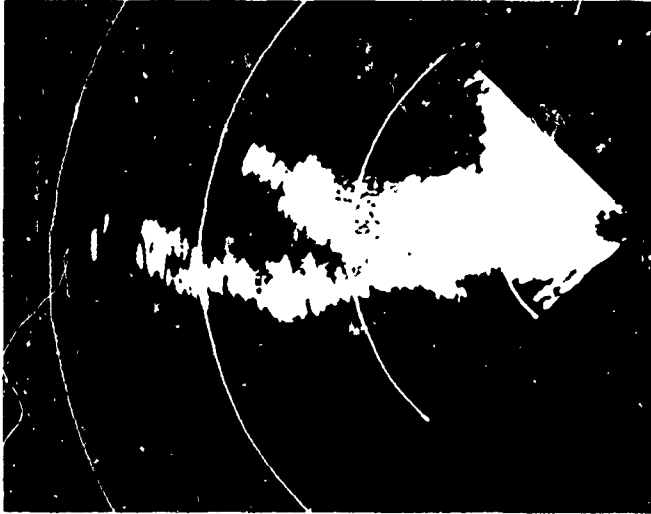
CO-POLARIZED RETURN



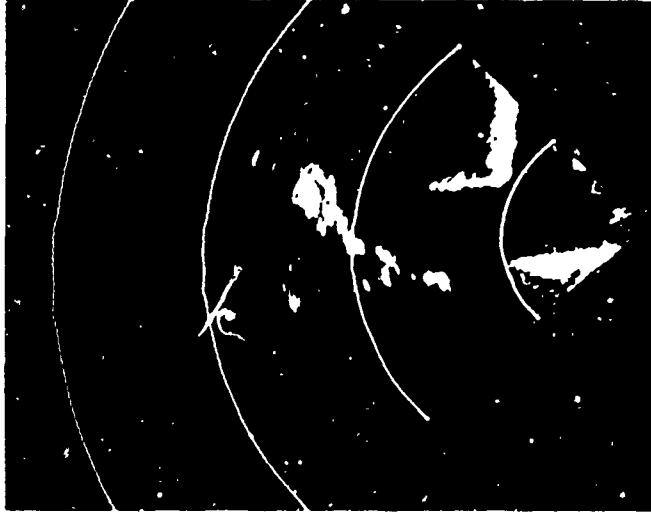
CROSS-POLARIZED RETURN

- TRANSMISSION POLARIZATION: HORIZONTAL
- RANGE MARKS: 1.7 MILES

HEAVY RAIN



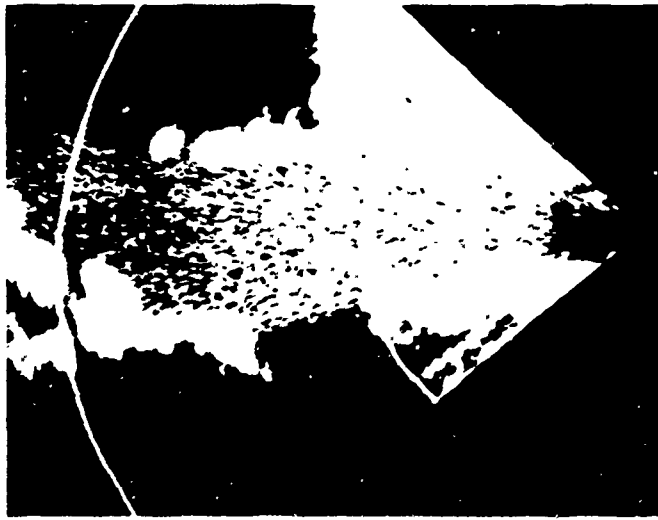
CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

- TRANSMISSION POLARIZATION: HORIZONTAL
- RANGE MARKS: 1.7 MILES

HEAVY RAIN



CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

● TRANSMISSION POLARIZATION: HORIZONTAL

● RANGE MARKS: 1.7 MILES

HEAVY RAIN

"A" SCOPE DISPLAY SHOWING RAIN AND LAND RETURNS IN THE TWO CHANNELS.



TOP TRACE: CO-POLARIZED RETURN

BOTTOM TRACE: CROSS-POLARIZED RETURN

SWEEP SPEED: 10 μ SEC/CM

SWEEP LENGTH: 10 MILES



TOP TRACE: CO-POLARIZED RETURN

BOTTOM TRACE: CROSS-POLARIZED RETURN

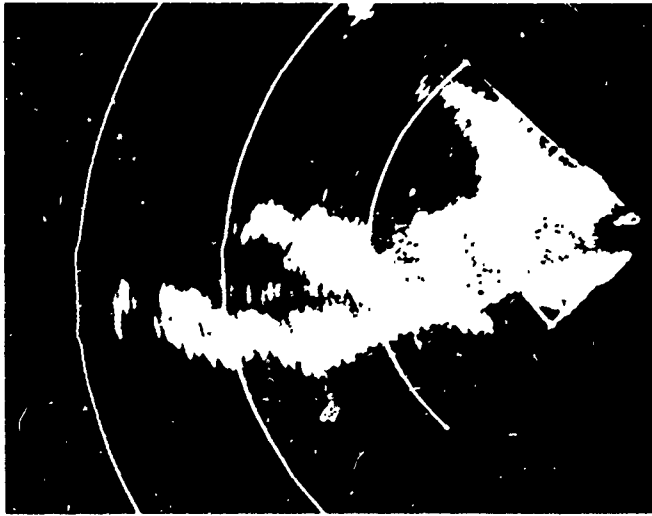
SWEEP SPEED: 5 μ SEC/CM

SWEEP LENGTH: 5 MILES

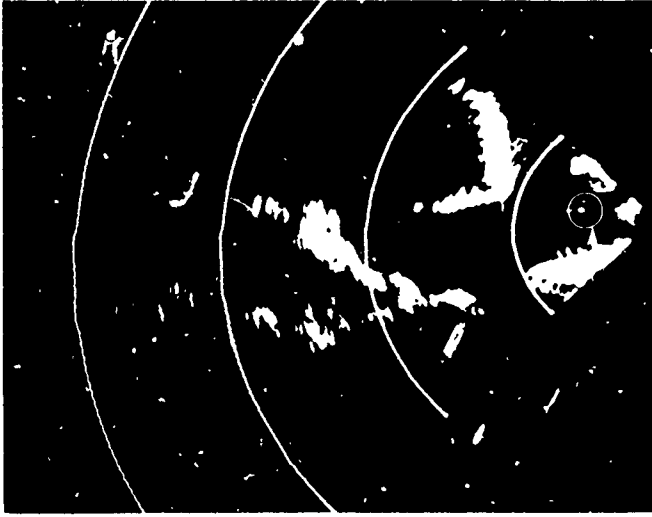
● TRANSMISSION POLARIZATION: HORIZONTAL

MEDIUM RAIN

BARGE ON LAKE WASHINGTON AT APPROXIMATELY ONE MILE IN RANGE



CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

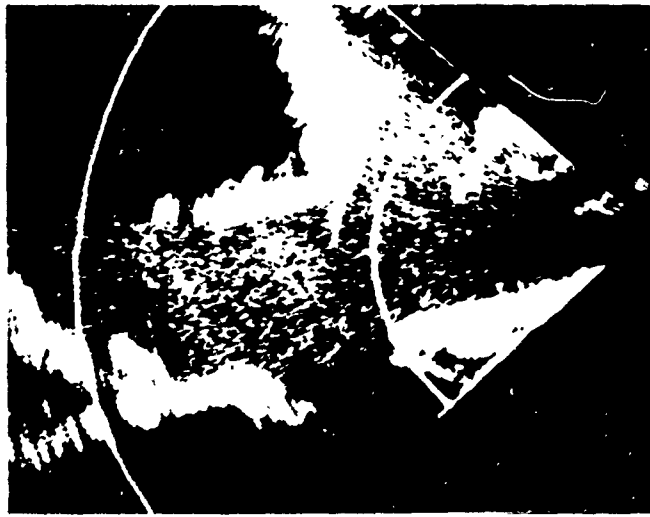
BARGE

● TRANSMISSION POLARIZATION: HORIZONTAL

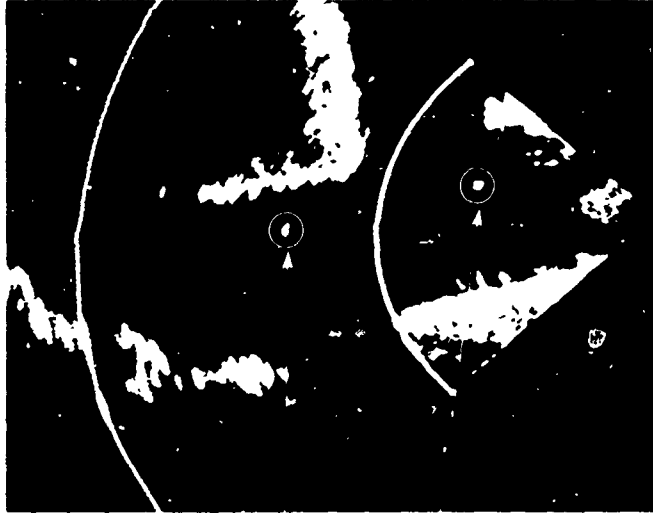
● RANGE MARKS: 1.7 MILES

MEDIUM RAIN

BARGE ON LAKE WASHINGTON AT APPROXIMATELY 1.5 MILES
FISHING BOAT ON LAKE AT APPROXIMATELY 2.5 MILES



CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

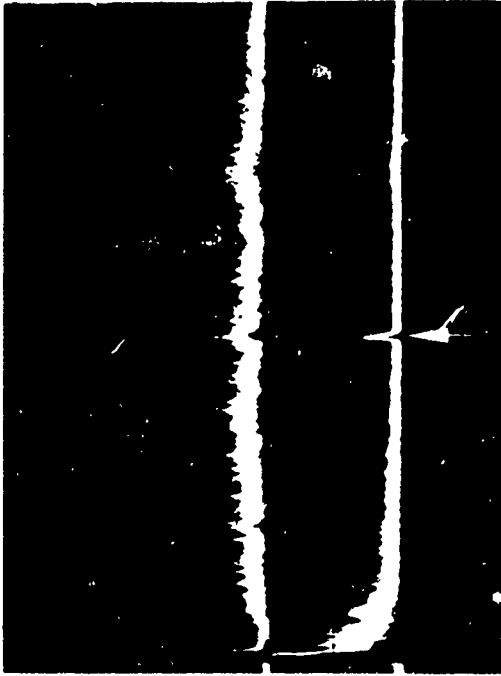
FISHING BOAT

BARGE

- TRANSMISSION POLARIZATION: HORIZONTAL
- RANGE MARKS: 1.7 MILES

LIGHT RAIN

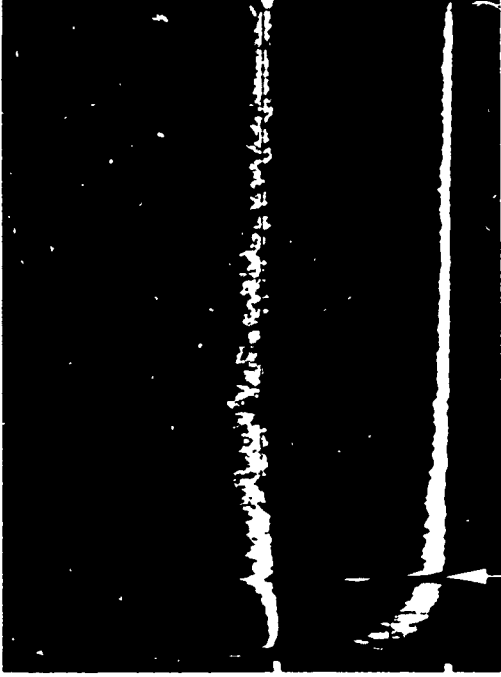
"A" SCOPE DISPLAY SHOWING AIRBORNE TARGET IN RAIN



TOP TRACE: CO-POLARIZED RETURN

BOTTOM TRACE: CROSS-POLARIZED RETURN

TARGET: 727 AIRCRAFT AT 5 MILES



TOP TRACE: CO-POLARIZED RETURN

BOTTOM TRACE: CROSS-POLARIZED RETURN

TARGET: SMALL AIRCRAFT AT 1.5 miles

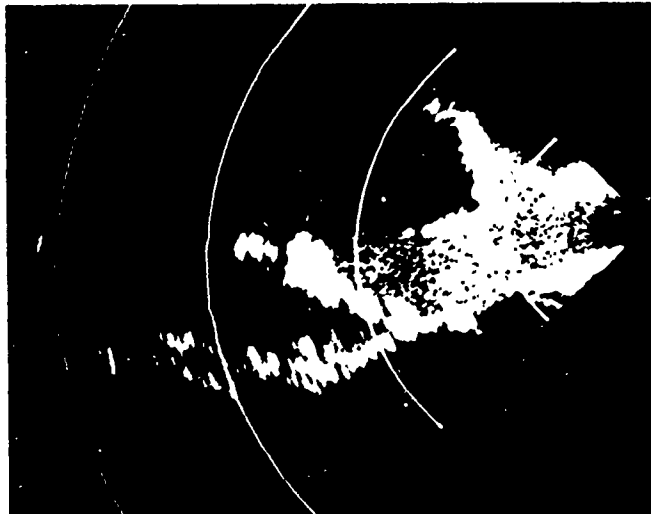
NOTE: THE CAUSE OF THE INCREASE OF THE RAIN RETURN AT VERY NEAR RANGES IN THE CROSS-CHANNEL, AND THE DECREASE IN THE CO-CHANNEL, IS NOT FULLY UNDERSTOOD AT THIS TIME.

● TRANSMISSION POLARIZATION: HORIZONTAL

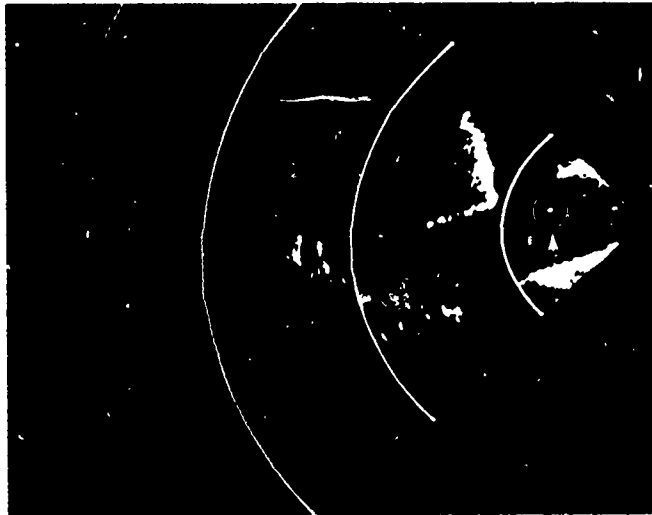
● SWEEP SPEED: 10 μ S/CM

MEDIUM RAIN

BARGE ON LAKE WASHINGTON AT APPROXIMATELY 1.5 MILES



CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

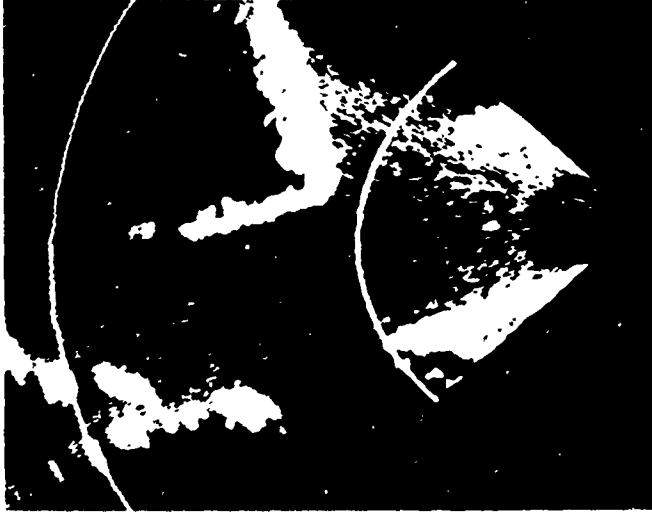
BARGE

● TRANSMISSION POLARIZATION: VERTICAL

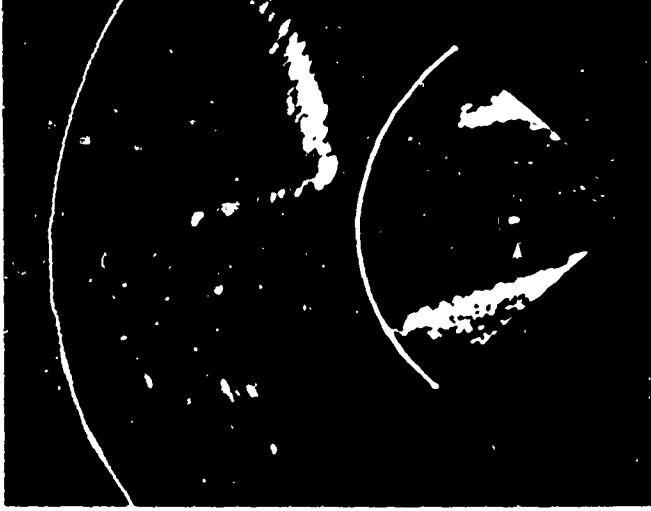
● RANGE MARKS: 1.7 MILES

MEDIUM RAIN

BARGE ON LAKE WASHINGTON AT APPROXIMATELY ONE MILE



CO-POLARIZED RETURN



CROSS-POLARIZED RETURN

BARGE

- TRANSMISSION POLARIZATION: VERTICAL
- RANGE MARKS: 1.7 MILES