NO. 22

WESTERN REGION TECHNICAL MEMORANDUM

Derivation of Radar Horizons In Mountainous Terrain

by

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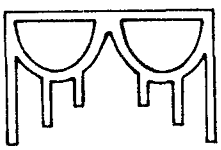

A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

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DERIVATION OF RADAR HORIZONS IN MOUNTAINOUS TERRAIN

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Roger G. Pappas

Introduction by Herbert P. Benner

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(1) $R_{hmax} = 1.23\ (\sqrt{h_r} + \sqrt{h_t})$ nautical miles where R_{max} is the range to the target, h_r is the height of the radar antenna in feet, and h_t is the height of the target in feet.

By solving for h_t it is possible to determine the minimum target height for interception of the radar beam at a given range:

(2) $h_t = (R_{max} / 1.23 - \sqrt{h_r})^2$

The computation of the minimum target height is complicated by the introduction of a mountain barrier or "block" in the radar beam. This is illustrated in Figure 1. In Figure 1 the location of the radar is at Point R. Point H is where the radar beam is tangential to the earth, i.e., the horizon of the radar. A mountain or blocking barrier is introduced at Point E, with a Height CE. It is desired to determine the height of the beam's base, C'E', over Point E' after partial beam blocking by the mountain at E. It can be seen that B is the point at which the base of the beam is intercepted by the mountain and BB' represents the extension of the beam's base if no blocking had occurred. Further, the stippled area represents the region below the radar horizon, and the hatched area the additional region blocked by the mountain at E. HBB' is the locus of h_t.

Since RCB and RC'B' are triangles which are approximately similar,

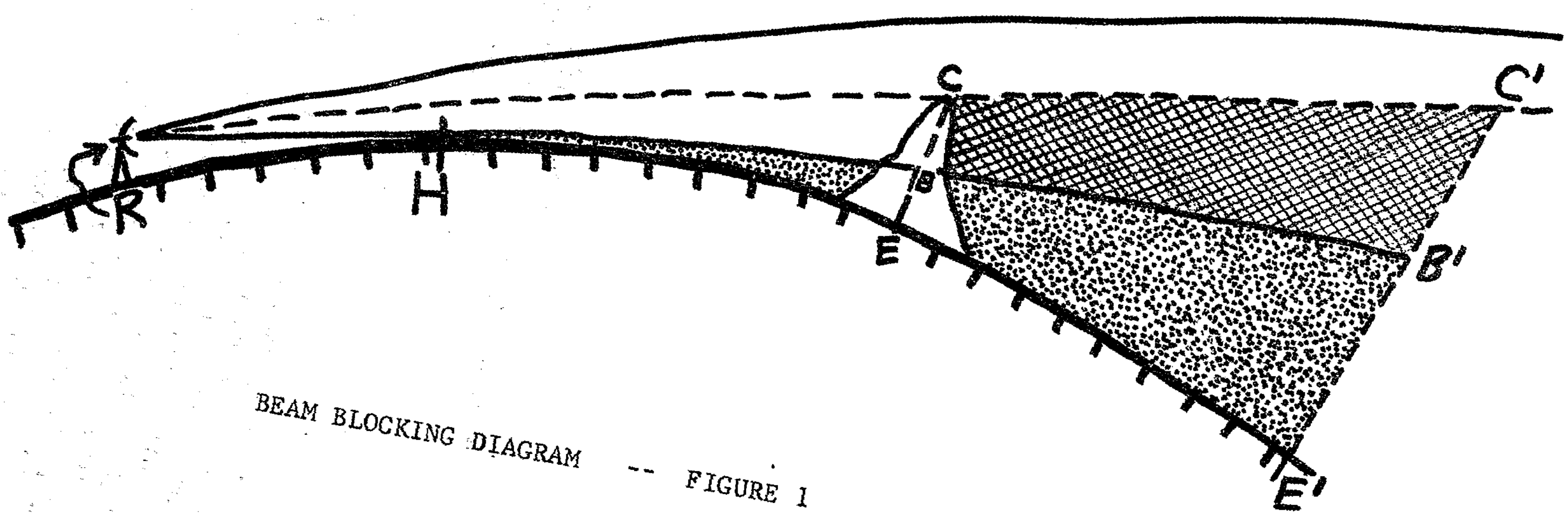
$\frac{CB}{RHB} \approx \frac{C'B'}{RHBB'}$, where CB = CE - BE, or the difference between the elevation of the mountain and h_t computed for range to E. RHB is essentially the range to E, and RHBB' is the given range to E'. Hence, C'B' is easily evaluated, and when added to B'E' (the value of h_t at Point E') gives the value of C'B'E', the minimum target height for penetration of the radar beam.

In cases where higher terrain is down range from the blocking mountain at, say, Point E', it is necessary to test whether or not it is higher than C'B'E'. If it is higher, a new proportionality must be set up based on the amount of further blocking caused by the peak at Point E'. If not, the computations continue down range at intervals of 10 to 20 nautical miles.

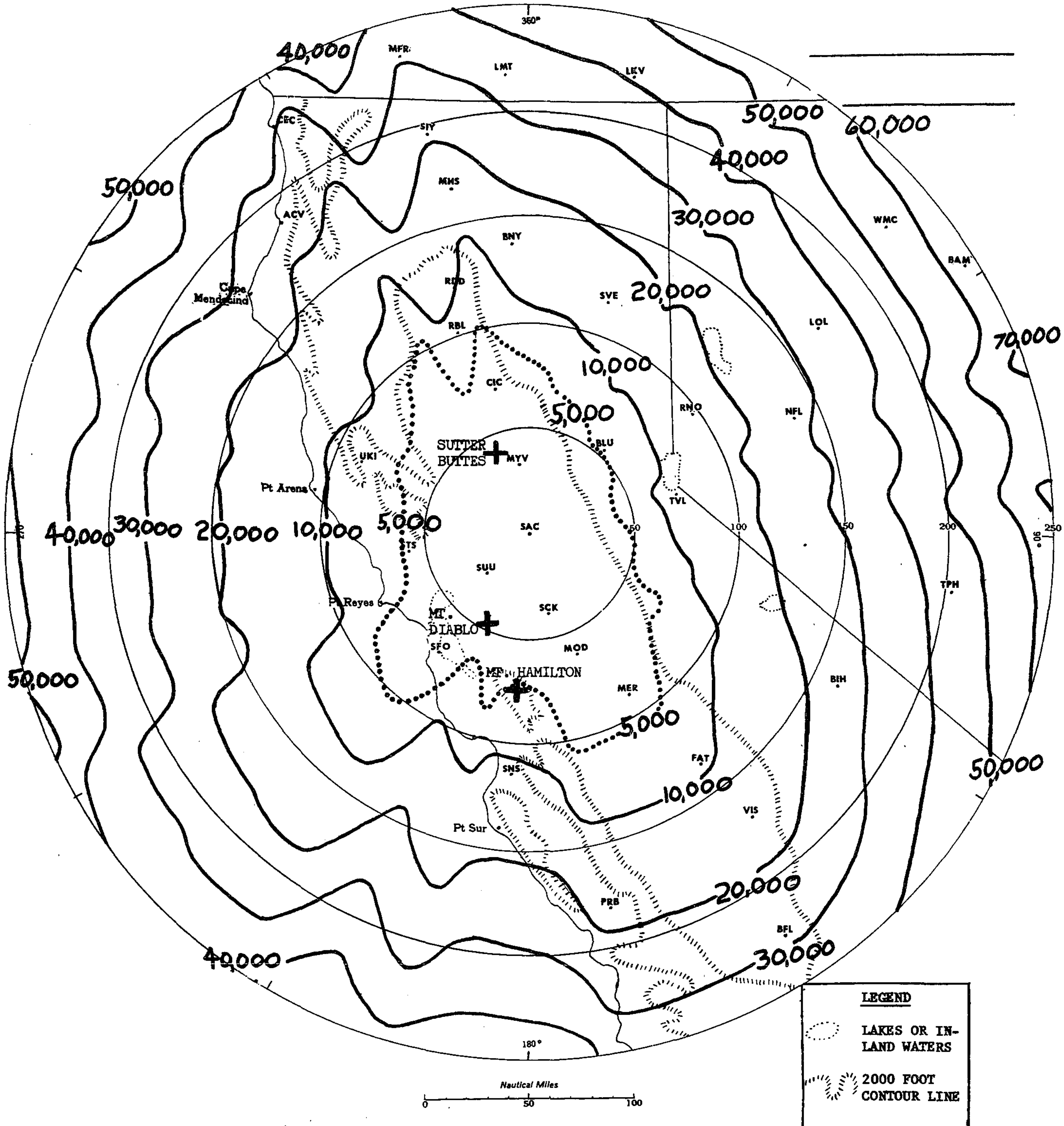
The construction of the blocking charts, Figures 2 and 3, was accomplished by tabulating terrain height data along azimuth radials from the radar at five-degree increments. Using an aeronautical chart showing 1000-foot contours, the crossing of each contour on the radials is noted with regard to its range. In the case of mountain peaks, the exact elevation is recorded. Starting with the first contour of elevation that is higher than the h_t value at that range, the "blocking" computation is begun and carried down range as explained above (with, of course, testing for additional down range blocking by higher terrain and setting up new proportionalities if necessary). Values for CBE, C'B'E', C"B"E", etc., (or h_t if there is no terrain blocking) along each five degrees of azimuth are then plotted and isopleths drawn to obtain the final chart. The procedure is rather time consuming and tedious, but certainly worth the effort. Once the computations get beyond about 100 nautical miles they become fewer since blocking from terrain rarely occurs at those extended ranges. It should be pointed out that this technique could easily be programmed for a computer.

III. Reference

Hiser and Freseman, RADAR METEOROLOGY, The Marine Laboratory, University of Miami, Coral Gables, Florida, 1959, page 83.



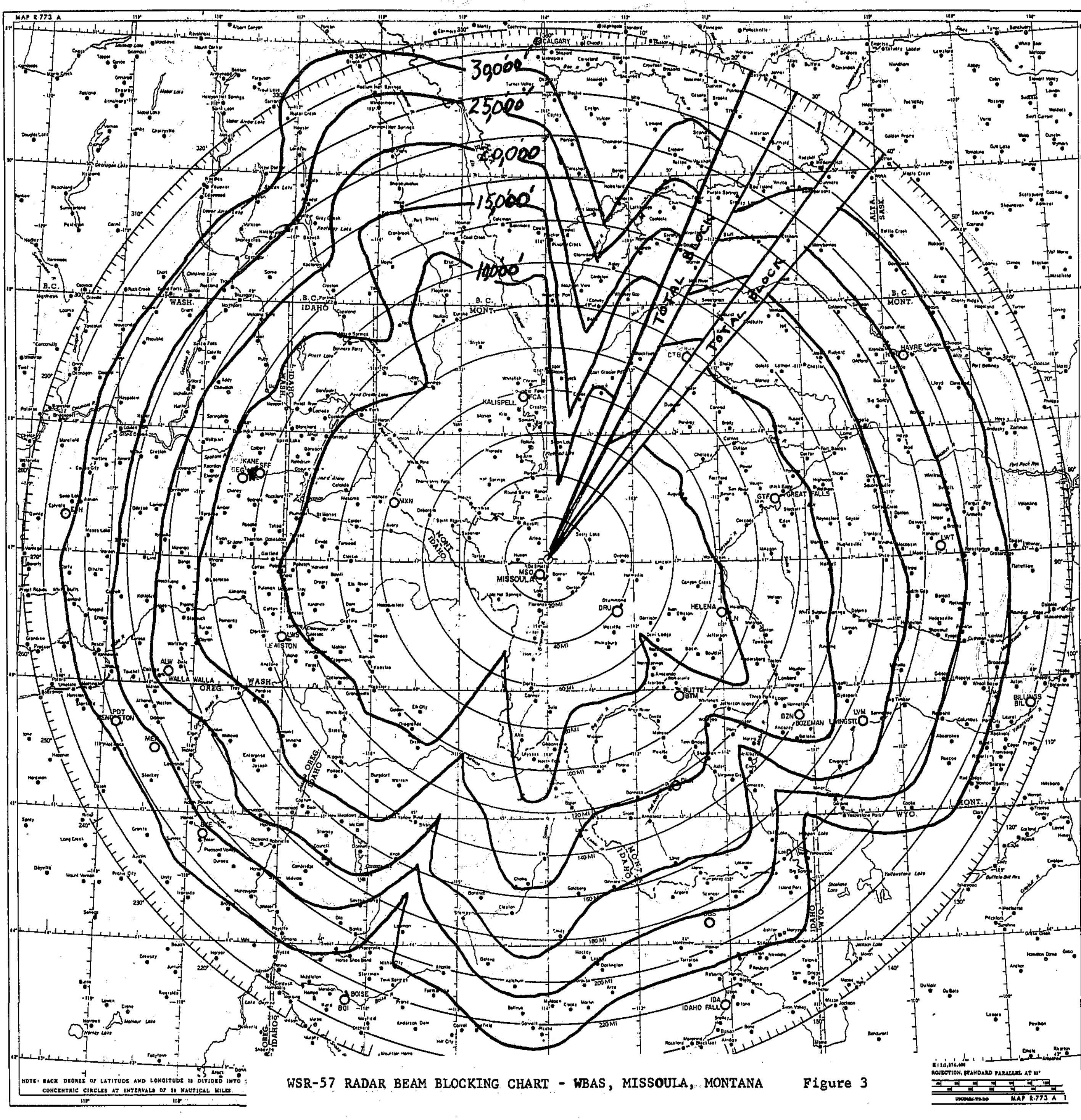
BEAM BLOCKING DIAGRAM -- FIGURE 1



MINIMUM HEIGHT TO WHICH PRECIPITATION MUST EXTEND TO PENETRATE THE RADAR BEAM (IN FEET ABOVE MSL)*

*Based on earth's curvature and blocking due to terrain, assuming standard propagation and that the rain is intense enough to be detected.

WSR-57 RADAR BEAM BLOCKING CHART - WBO, SACRAMENTO, CALIFORNIA Figure 2



WSR-57 RADAR BEAM BLOCKING CHART - WBAS, MISSOULA, MONTANA Figure 3