RADIO DIRECTION FINDING: A Practical Approach on the BCB with an Algorithm for Manual or Computer Evaluation.

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The BCB presents DXers with numerous opportunities to pinpoint distant transmitters by using loop antennas to take local azimuth bearings of such stations when the signal is placed in the loop pattern null. In general, to uniquely pinpoint a distant station requires observations (bearings taken with a loop antenna) from three distinct points on the Earth's surface not lying on a common great circle path. However, on the BCB, considering propagation conditions and other factors, the number of observations in practice can be reduced to two. For example, if a Midwestern DXer takes a bearing on a station and obtains a reading of 135° (or 315° since the loop is assumed ambiguous and thus symmetrical in pattern response) and an Eastern DXer takes a bearing on the same station and finds the angle to be 175° (or 335°), then the signal is more likely to be coming from the Caribbean area (determined by the bearings of 135° and 175°) for the other location of the station is in the Indian Ocean several hundred miles southwest of Perth, Australia and there appears to be nothing but water in that vicinity. But the deduction is based upon a more significant fact, viz., that one can most likely discount signals from that distance in most (but not all!) cases.

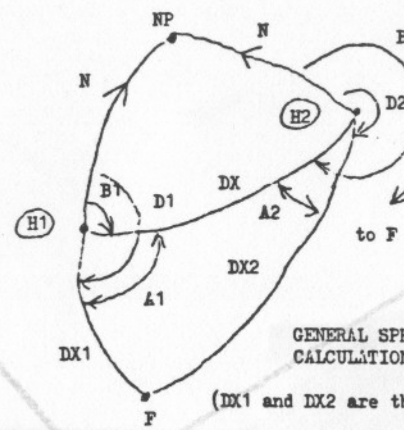
Accuracy of bearing is of the greatest importance and here lies the essential difficulty for the BCB DXer. Bearings taken with most loop antennas are subject to errors and limited in accuracy by null width and the compass used (on the loop) to read the bearing. Accuracy required in the azimuth bearing is most dependent upon the distance between the transmitter and the DXers' receivers and the separation between the DXers' locations. As a rule of thumb, bearings must be accurate to within 1° or less to locate with reasonable accuracy stations more distant than 500 miles. Such accuracy is asking a great deal of a loop antenna! Accuracy to within 1° is the best that can be expected from a given collection of DXers using loop antennas whose patterns are not skewed or rotated--i.e., patterns whose nulls appear at right angles to the loop plane and are symmetrical in their response. However, it is more likely that most loops have some null skewing due to numerous causes (these causes have been and continue to be discussed at length by the DXing fraternity) so that accuracy of bearing is not sufficient, in general, to allow a single pair of DXers to accurately pinpoint a distant station. This difficulty can only be overcome by the efforts of more than two DXers working together and calculating from among all possible pairs of these DXers the distance from each DXer to the distant station. With this concerted effort and the information it gives, an area on the Earth's surface can be isolated in which the station can be correctly assumed therein. The geographical distribution of these DXers is significant (i.e., the distance between any pair of DXers) since the more widely separated they are, the more likely the results with be accurate.

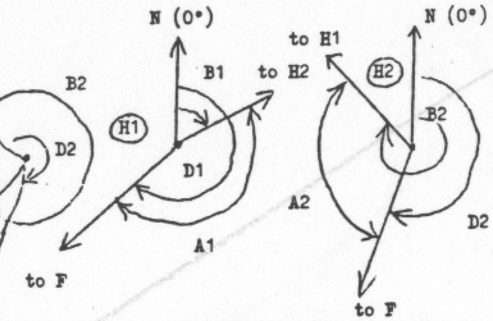
To allow the reading of azimuth bearings with a loop antenna, perhaps the simplest and most convenient way to accomplish this is to add a compass (0 - 360°) at the base of the vertical mast holding the loop. Drilling a hole near the bottom end of the vertical mast just above the compass face will allow a pointer to be inserted in the mast for reading the bearing off the compass. The pointer is most conveniently set in the mast somewhat perpendicular to the loop plane. The compass should be made with great care and should be of sufficient diameter (12" minimum) to allow marks to indicate each degree from 0 thru 359 (clockwise) and the pointer should be very rigid and not "thicker" than the markings used to show degrees on the compass.

A few suggestions on setting up ("calibrating") such a loop: It is not likely that the pointer is exactly perpendicular to the loop plane and even if it were, null skewing will "rotate" the plane again. Also, to use a magnetic compass to line up 0° (on the loop compass) with the North Pole (True North) will not suffice. The only effective way to approach the degree of accuracy desired is to calibrate the azimuth bearings of all your local stations and numerous semi-locals (it is assumed that the correct bearings of these stations are known--See Footnote) by rotating the base compass so that when the null is placed on the known station at the known bearing, the pointer indicates the correct angle on the loop compass. Not all stations will "line up", but by knowing bearings of numerous stations throughout the BCB, re-calibration can be made at various frequencies across the BCB.

Consider now the algorithm that can be used to calculate the distance from each DXer to the distant station. This algorithm is designed to allow only the use of the sine and cosine trignometric functions and is derived from the fundamental identities of the general spherical triangle. (Another approach which offers some advantages but involves additional trignometric functions can easily be derived from Napier's Analogies). Thus, let F be the far or distant station to be located, H1 denotes the location of one DXer and H2 the location of the second DXer. The great circle distance between H1 and H2 will be denoted by DX. The great circle bearing (azimuth angle) of H2 as measured at H1 will be denoted by B1 and, similarly, the great circle bearing (azimuth angle) of H1 as measured at H2 will be denoted by B2. It is assumed that B1, B2, and DX are known quantities-see Footnote). For the record, azimuth bearings are taken with the following conventions: 0° = True North, 90° = East, 180° = South, 270° = West and 360° is equivalent to 0°. Thus, azimuth angles are measured clockwise from True North.

Let D1 denote the bearing (in degrees) of F as measured at H1; D2 denotes the bearing (in degrees) of F as measured at H2; DX1 denotes the distance (to be calculated) between H1 and F and DX2 denotes the distance (to be calculated) between H2 and F.

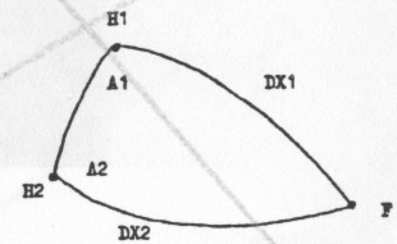




Local Compasses at H1 and H2

GENERAL SPHERICAL TRIANGLES FOR BCB-RDF CALCULATIONS WITH THE ALGORITHM

(DX1 and DX2 are the quantities to be calculated)



ALGORITHM FOR DISTANCE CALCULATION IN BCB DIRECTION FINDING

Angles A1 and A2 of spherical triangle H1,H2,F are calculated from the pairs of bearings (B1, D1) and (B2, D2) respectively. Choose H1 so that A1 is the larger of the vertex angles at H1 and H2.

Location H1=______________________ Location H2=______________________

A1 = ___° A2 = ___° DX = ____ miles D = DX/69.052 = ___° G = 90 - D = ___°

E = 90 - A1 = ___° F = 90 - A2 = ___° sin(A1) = ________ sin(A2) = ________

sin(D) = ________ sin(E) = ________ sin(F) = ________ sin(G) = ________

X = (sin(A1))(sin(A2))(sin(G)) - (sin(E))(sin(F)) = ____________

Y = $\cos^{-1}$(X) = Arccos(X) = ___° T = (sin(D))/(sin(Y)) = ____________

W = (T)(sin(A1)) = ______________ V = (T)(sin(A2)) = ______________

R = $\sin^{-1}$(V) = Arcsin(V) = ___° P = $\sin^{-1}$(W) = Arcsin(W) = ___°

DX1 = (69.052)(R) = _____statute miles DX2 = (69.052)(P) = _____statue miles

(The included FFORTRAN IV program is not being included in this article because of the extremely small number of members in IRCA who would have knowledge of same; anyone interested may drop a pc for photostat of program)

For the reader wishing to "practice" a few calculations, the following table is self-explanatory:

A1	A2	DX	DX1	DX2
67	84	244.0	498.33	461.06
131	41	244.0	1112.48	1285.46
131	45	244.0	2187.11	2353.65
134	45	244.0	4635.36	4806.42
135	45	244.0	6132.75	6132.95