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NOTE NO. 8

COMPARISON OF DIRECTION FINDER BEARINGS

TAKEN ON

TRANSMITTING STATIONS EMPLOYING LOOP AND VERTICAL ANTENNAS

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COMPARISON OF DIRECTION FINDER BEARINGS TAKEN ON TRANSMITTING STATIONS EMPLOYING LOOP AND VERTICAL ANTENNAS

This report describes an investigation made at the request of the Airways Engineering Division for the purpose of accumulating sufficient information to permit the above comparison to be drawn. Bearing observations were confined to the frequencies in the 200-400 kilocycle band using radio range stations operated by the Civil Aeronautics Authority. The receiving equipment comprised a loop antenna and receiver mounted in an automobile which was taken to various locations between Richmond, Va., and Harrisburg, Pa. Bearings were taken on the radio ranges at Richmond, Va. (260 kc), Washington, D. C. (332 kc), Harrisburg, Pa. (242 kc), and Gordonsville, Va. (347 kc). Richmond and Washington had loop antennas and the other stations had vertical antennas. The procedure followed in these tests consisted in observing the changes in the bearing on a signal from the ranges over a period of about 15 minutes at each of the several points named below. As the bearing shifted, the loop antenna was manually realigned and the angular difference noted. An effort was made to supplement these observations with others made utilizing automatic bearing recording equipment built by the Signal Corps Aircraft Radio Laboratory at Wright Field. A trip was made to Wright Field where it was discovered that the equipment had not been used for about two years. It had been partially dismantled and would require the work of

two men for about one week to recommission it. Furthermore, the equipment was designed to use a tuned radio frequency radio compass which was thought to be inadequate for the tests contemplated. In order to incorporate a new type superheterodyne compass, additional time and work would have been required. Because of the fact that this apparatus was constructed on an experimental basis and not designed for mobility, tests made with it would have been of doubtful value. Rather than spend time with this equipment, it was felt that a greater advantage would be attained by making additional observations with the manually operated loop equipment. Nevertheless, if it is believed that bearing observations should be made utilizing an automatically operated loop antenna, it is recommended that more suitable commercially-available equipment be employed. The Sperry-RCA automatic direction finder recently demonstrated would be admirably suited for this work. It could be used either on the ground or in an airplane. Bearing shift could be read on the azimuth scale or a continuous recorder could be fitted to the apparatus, and a printed record of the bearing swing obtained.

The observations recorded below were made at nighttime since bearings taken during the day were quite steady. The amplitude of the bearing shift observed at various locations and the distance to the transmitting station are tabulated below.

Extent of bearing swing	Distance to transmitting station	Transmitting station	Signal strength uv/meter	Remarks
	Observation point — 1 mile south Dumfries, Va.			
7°	55	Gordonsville	37	
11	27	Washington	254	
27	69	Richmond	20	
—	120	Harrisburg	14.0	Unable obtain bearing indication
		1/2 mile south Fredericksburg, Va.		
11°	138	Harrisburg	10	
2	41	Gordonsville	78	
15	46	Washington	114	
17	52	Richmond	43	
		6 miles south Cooksville, Md.		
4°	101	Gordonsville	3	
9	28	Washington	256	
16	130	Richmond	2	
14	67	Harrisburg	35	
		1 mile south Hampstead, Md.		
0	43	Harrisburg	75.0	
24	52	Washington	34	
9	126	Gordonsville	14	
—	145	Richmond	less than 1 uv/m	unable obtain bearing indication
		Ladysmith, Va.		
2.5°	37	Gordonsville	67.0	
11.0	63	Washington	85.0	
12.0	35	Richmond	171.0	
—	157	Harrisburg	less than 1 uv/m	unable obtain bearing indication
		6 miles north Richmond, Va.		
—	181.5	Harrisburg	—	
0	50.0	Gordonsville	51.0	
0	10.0	Richmond	385.0	
15.0	86.0	Washington	17.0	

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Extent of bearing swing	Distance to transmitting station	Transmitting station	Signal strength uv/meter	Remarks
Observation point — 4 miles north Abbottstown, Md.				
0	20	Harrisburg	338.0	
19	76	Washington	40.0	
10	144.5	Gordonsville	1.0	
—	138.0	Richmond		unreadable

Gordonsville and Harrisburg have vertical radiators, and loop antennas are used at Richmond and Washington.

From this data, the curves of Fig. 1 were plotted showing the relation between the bearing shift and the distance from the observation point to the transmitting station. One curve represents observations on transmitting stations employing vertical antennas and the other comprises observations on stations using loop antennas. It is evident that, under nighttime conditions, much more satisfactory results will be obtained if stations having vertical antennas are selected. Two factors are responsible for this situation: at any given distance, the extent of the bearing swing is less, and the radius of the area in which no bearing error or instability will be noted is twice that surrounding loop antenna stations.

A discussion of the limitations applying to the above conclusions follows. The observations were made over a comparatively short period. Since the conditions in the ionosphere are continually changing, it might be argued that results, in order to be conclusive, should be based on observations taken over a much longer period. However, the bearing shifts observed were made on signals traveling

various transmission paths and the results thus obtained on different days were sufficiently consistent to permit smooth curves to be plotted. Furthermore, the important consideration in this investigation was that of comparing the characteristics of direction finder bearings taken on the two types of transmitting antennas employed at radio ranges, and it is reasonable to assume that changes in the ionosphere would not influence this comparison. If observations over a longer period were contemplated, no limit could be set since observations on the effects of the ionosphere resulting in fading of radio signals are a continuing project of certain research agencies. There is, however, likely to be a difference in the distances shown on the curves for a given bearing shift in other sections of the country. The radius of the area of zero bearing shift would be particularly subject to modification when the transmission takes place over terrain having different radio signal attenuation characteristics from that involved in these tests. A reduction in attenuation would result in an increase in the radius of the area mentioned above. Based on field intensity surveys, it can be stated that although the terrain over which these tests were conducted has relatively high attenuation, it is representative of the United States, with the exception of the middle west plains where the attenuation is materially lower than that encountered here.

APPENDIX

Fig. 2 illustrates the manner in which the several parameters combine to cause unstable bearings. The set of conditions shown could obtain at any point where both the ground wave and sky wave are present. The example takes no account of the fact that the phase angle between the sky and ground wave will change, it being possible for the two components to become momentarily antiphased. This would result in an indefinite or broad null.

In the figure, it has been assumed that the plane of polarization of the skywave has been rotated 90° and is now horizontal. The angle V which the downcoming sky wave makes with the horizontal is assumed to be 45°, and the amplitude of the sky wave has been taken as half that of the ground wave. With these assumed values, it is shown on the figure that the bearing error would be 19.5°. It will be recalled that errors of this magnitude were encountered frequently in the tests already described.