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Instrumentation for Propagation and Direction-Finding Measurements[1, 2]

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Limitations imposed on radio direction-finding systems are discussed in terms of a generalized representation of such systems in the form of a block diagram. Factors affecting these limitations include: (1) considerations of signal-to-noise ratio in the early part of the system, (2) receiver bandwidth requirements for adequate selectivity, (3) width of spectrum generated by prereceiver encoding and computing processes, (4) restriction to linear processes in multisignal portions of the system, and (5) availability of operational devices suitable for use in low-signal-level portions of the system.

A generalized representation of a radio direction-finding system can be given in the form of a block diagram or flow chart (fig. 1) showing the operations or functions which are necessary in translating the basic measurements on the incident signal field into the values of the desired incident field parameters. Limitations are imposed on the system at each stage in the process. Factors leading to these limitations include: (1) Considerations of signal-to-noise ratio in the early part of the system, (2) receiver bandwidth requirements for adequate selectivity, (3) width of spectrum generated by prereceiver encoding and computing processes, (4) restriction to linear processes in multisignal portions of the system, and (5) availability of operational devices suitable for use in low-signal-level portions of the system.

The development of the detailed configuration of any direction-finding system is based on some concept of the character of the incident signal field. This character is described in terms of a mathematical model, the parameters of which are the quantities to be evaluated by the system. To this point, the incident signal field models which have been used as bases for direction-finding system development have been rather simple, far too simple in fact to satisfactorily describe the actual signal fields. One of the frontiers in direction-finding system development lies, at the moment, in the area of improving the incident field model and of developing more sophisticated systems based on the improved signal field models.

Another frontier lies in the area of applying modern computing techniques to direction-finding system design. One of the major functions of a direction-finding system is, after all, the performance of a computational operation. To this point all systems in use are based on some simple-minded analog computation scheme. This is an unnecessarily restrictive limitation, especially considering the tremendous strides which have been made in recent years in the field of electronic computation.

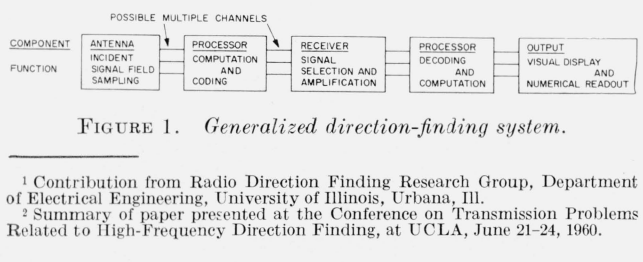

FIGURE 1. *Generalized direction-finding system.*

Two specific direction-finding systems are proposed, both intended primarily for use with antenna arrays of wide aperture. In one system, intended principally for circular arrays, a commutating device is used to encode the output of the antenna array in a form suitable for transmission through a single receiver channel. The output of the receiver would be analyzed, using sampled data techniques, to obtain the required bearing information. The second system makes use of a twin-channel receiving system to avoid the necessity for relatively slow scanning, thus permitting essentially instantaneous acquisition of bearing data (by "instantaneous" is meant a time small enough to permit obtaining a bearing on the shortest pulse transmittable through the receiver). The unusual feature of both systems is the use of an electronic digital computer to perform the bearing interpolation between planes of symmetry of the array, and to provide the final numerical output of the system. The conventional "indicator" is retained in modified form as an operator aid, and to permit the operator to "censor" information fed to the computer, or to "backstop" the computation system in situations where it would fail.

NOTE: A more detailed discussion of the material presented in this paper will be available in printed form during the first quarter of 1961. It will appear in *Interim Engineering Report No. 9, Wullenweber Direction-Finding System* to be published by the Radio Direction-Finding Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, for the Bureau of Ships, under Contract Nobsr 64723.

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[1] Contribution from Radio Direction Finding Research Group, Department of Electrical Engineering, University of Illinois, Urbana, Ill.

[2] Summary of paper presented at the Conference on Transmission Problems Related to High-Frequency Direction Finding, at UCLA, June 21–24, 1960.