OTHER AIDS TO COMPUTATION


This paper is mainly devoted to a theoretical discussion of a computer to be used in providing steering indications to an aircraft pilot during a blind landing using the Instrument Landing Approach System. The purpose of the computer considered is to combine signals from three sources used by a pilot in flying such an approach. These sources are the vertical gyro (bank...
angle), the directional gyro (deviation of heading from runway direction) 
and localizer receiver (lateral deviation from desired flight path).

The approach procedure is interpreted as a feedback control process. The 
characteristics of the data sources and the aerodynamic characteristics 
of the aircraft are considered in order to devise a steering indication capable 
of yielding suitable approaches. In particular, a system for deriving a desir-
able signal for rate of change of lateral deviation is described.

The computer is described briefly. It is of conventional 400-cycle analog 
type. The use of vacuum tubes is held to a minimum and limiters are em-
ployed to prevent indication of excessive bank angles.

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1122. A. R. Boothroyd, "Design of electric wave filters with the aid of the 
This article is intended as a “treatise” on the subject. An appendix gives 
details of tank construction.

1123. John Broomall & Leon Riebman, “A sampling analogue computer,” 
The analogue computer described in this article is based on an idea of 
C. J. Hersch and J. F. Felker. The input of the computer consists of three 
steady d. c. voltages with values X, Y and Z. The computation is based on 
the sampling of d. c. voltages by means of electronic switching circuits using 
diodes. The computer has two units; the first of these is an algebraic unit, 
which produces a voltage pulse whose amplitude W is given by \( W = kZYX^{-1} \).
The second unit produces a steady voltage \( U \) in the form \( aZYX^{-1} + b \) for 
constants \( a \) and \( b \). In the algebraic unit the voltages \( Z \) and \( X \) are sampled 
and the condensers of identical RC networks are charged to these voltages. 
At a time \( t \) after this sampling, the two condensers have voltages \( X \exp (-t/RC) \) and \( Z \exp (-t/RC) \). The first of these voltages is compared by an 
electronic circuit with the voltage \( Y \) and when these are equal a sample pulse 
whose size is proportional to the second voltage is emitted by this unit. At 
the time \( t_0 \) when the first of these voltages equals \( Y \), \( \exp(-t_0/RC) = Y/X \), 
and hence at this time the second voltage has the value \( ZYX^{-1} \) up to a con-
stant. The voltages involved have a full-scale range of 0 to 150 volts and 
accuracy of 1\% of full scale is claimed. The “settling time” of the pulse 
converter is given as 30 milliseconds and presumably this is the limit on the 
repetition rate of the unit.

F. J. M.

1124. E. H. Fritze, “Punched card controlled aircraft navigation com-
The computer described is for the purpose of enabling an aircraft pilot 
to fly to an arbitrarily selected point. It provides indications of the heading 
to be flown, the distance to the selected point and the displacement of the 
selected point from a “master” ground station. In addition, the equipment
indicates the directions from the aircraft to the master station and an auxiliary station. In flight test, the distance indications obtained during a 200 mile flight were in error by less than 2½ miles.

Input data to the computer are obtained from radio receivers which indicate the directions to a "master" and an auxiliary omnirange station. Such stations have been installed throughout the United States by the Civil Aeronautics Administration (CAA). The device is also capable of employing as input data the range and bearing of a single dme omnirange station. Dme is a system planned for future installation by the CAA. Through its use, an aircraft pilot can determine the distance to a station in addition to the direction found by means of the omnirange system.

A substantial amount of auxiliary data is needed by the computer to solve its problem. The problem is basically one of triangulation. A unique feature is that such auxiliary data is stored on plastic punched cards. By positioning the card to reveal the identities of the two stations on which the triangulation is based, a set of switches is caused to insert the auxiliary data. This includes information which tunes the receivers to the selected stations, the rectangular coordinates of one station relative to the other, and a correction to account for the difference in magnetic north at the two stations.

The computer is of conventional analog type employing servomechanisms and resolvers. The basic analogy is that of alternating voltage amplitude to distance. Sign is indicated by the time phase of the alternating voltage with respect to a reference. The most severe limitation on accuracy is the uncertainty in the bearing data provided by the omnirange system.

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There exist a number of methods for solving linear partial differential equations. Frequently one can use separation of variables and reduce the problem to ordinary differential equations, which equations can then be solved on an electronic differential analyzer (cf. references 1-4 of the paper). Another way is to replace the partial differential equation by finite differences in all variables and use an arrangement such as a resistance lattice. In the present article the authors consider various partial differential equations (heat equation in one and two variables, wave equation in one dimension, equation of the transverse vibrations of a beam) and replace the spatial derivative by finite differences obtaining a differential-difference equation. For example, in the case of the heat equation

\[ C(x) \frac{\partial u}{\partial t} = \frac{\partial}{\partial x} \left[ K(x) \frac{\partial u}{\partial x} \right] + f(x, t) \]

they obtain

\[ C_n(du_n/dt) = \left[ K_{n+1}/(\Delta x)^2 \right](u_{n+1} - u_n) - \left[ K_{n-1}/(\Delta x)^2 \right](u_n - u_{n-1}) + f_n. \]
A circuit is given solving this equation using operational amplifiers and passive elements. Similar differential-difference equations and circuits appear for the other equations considered. Sample solutions are given and comparisons with the solutions obtained by the method of separation of variables are examined.

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A solution obtained on the California Institute of Technology analogue computer is compared with a calculated result. The agreement is described as "fair."


This instrument is used both for classroom demonstrations and in research as a check against the mathematical analysis.


This is essentially an expository paper. It considers analog electronic differential analyzers of the classical type as well as those involving nonlinear elements. A brief description is given of linear computing elements (operational amplifiers used as summers, integrators, etc.) and their basic computing circuits;4 nonlinear computing elements such as multipliers and function generators; and input-output elements such as recorders and plotters. Some typical problems in dynamics are outlined mathematically, and closed loop block diagrams for their solution are given. A representative list of applications of electronic differential analyzers is included. Finally, a few brief remarks are made concerning the amount of equipment required for a typical general purpose analyzer.

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Three analog devices are described. One is the Phillips "66 Spectrocomputer," which is a direct current battery device for solving simultaneous linear equations by the Gauss-Seidel method. A second device is a servo de-
vice for solving an algebraic equation. The third is an electrical network analogue for flow problems.


The device described can be used as a recorder in plane cartesian coordinates or as a curve tracer type of function generator. The unit consists of a drum on which is wrapped a piece of graph paper. The drum’s rotation corresponds to one variable and the axial movement of a carriage carrying either a pen or a potentiometer type transducer corresponds to the other. Movements in both coordinates are controlled by servos and static accuracies within 0.2 per cent of full scale are claimed.

For recording purposes the unit functions in the same way as a conventional plotting board. When used as a function generator the desired function is plotted with conducting ink or a soft lead pencil and attached to the drum. The transducer, which consists of a printed circuit potentiometer card, makes electrical contact with the curve and provides the carriage servo with the error voltage required to follow the curve as the drum turns. The output is furnished by a potentiometer driven by the carriage motion. Errors in following the curve, caused by dynamic limitations of the carriage servo, are compensated by adding the servo error voltage to the output potentiometer voltage. The over-all accuracy seems to be better than one per cent within the range for which the unit is intended. The device was designed for use with the Geda computer.

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The use of electrolytic tanks for this purpose is described.

NOTES

160.—Inverse Interpolation for the Derivative in the Complex Plane. In a recent note formulas were given for finding the argument for which a function \( f(x) \) has a given derivative \( f'(x) \), when that function is tabulated for \( x \) at equal intervals \( h \). Those formulas are still applicable when dealing with an analytic function \( f(z) \) which is tabulated in the complex plane, so long as the arguments lie equally spaced upon any straight line in the complex plane. But for \( f(z) \) tabulated over a Cartesian grid \( x + iy \) of length \( h \), greater accuracy may be had by locating the arguments \( z_k = z_0 + kh \) closer together by choosing \( k \) to be small (generally complex) integers. Thus the problem is to find \( P \), or \( z = z_0 + Ph \), when given the values of \( f'_{*} = f'(z) = f'(z_0 + Ph) \) and \( f_k = f(z_k) \) at any conveniently located points \( z_k \). We choose the following configurations of points \( z_k \) for the