GENERAL PURPOSE ANALOG COMPUTERS

Frequently, a customer will ask us to recommend an assortment of GAP/R modules for the construction of a computer to solve undefined problems. This is in contrast to the customer who has groups of problems with well-defined similarities. For the latter, a specific assortment of units can be listed. For the former, a generalized assortment must be assembled.

A completely generalized assortment of computer modules — one equipped to handle any likely problem in any field — would be large and expensive. While GAP/R would admire putting computer modules are compatible with all other models. Our newest models will function with our oldest models.

One criterion suggested for the size of an assortment and the variety of its content is the number of integrators. On this basis, we suggest minimum assortments for two, four, six, and nine integrators. The order of equations that can be solved with each Philbrick assortment is, of course, substantially larger than the number of integrators.

SALES AND APPLICATIONS


In our exhibition space, Booth 142, second floor, we will have a live display including a variable process simulator, a three term electronic control, plug-in computer networks, electronic graph paper, and precision regulated power supplies. All these utilize the versatile K2 Operational Amplifier.

The subjoined photograph illustrates a typical use of auxiliary amplifier capacity — specifically GAP/R K2-W Operational Amplifiers, K2-P Stabilizing Amplifiers, and HK Operational Manifolds.

This photograph, given us by a customer,* also illustrates the "sociability" of GAP/R modules. Three different makes of passive plug-ins are mounted on the manifold — a compatibility made possible by our adoption of the standard banana jack with ¾ inch spacing. * * *

Our New England — Upstate New York representative, Technical Instruments, Inc., Waltham, Mass., has handed us a circuit used by some of our customers for balancing K3 components. Simple — but very effective.

Among the advantages (compared) Name given on request.

* (Concluded on page 2)
The role of the analog computer in design is coextensive with the design problems themselves. With the computer, the design engineer can translate his conceptual and mathematical models directly into a physical model which can be manipulated as extensively as desired — even beyond the

**CHEMICAL PROCESS REACTION**

Consider a succession of chemical reactions in a process plant, each governed by the equation:

$$\frac{dX_k}{dt} = K_k X_0 X_k - K_{k-1} X_{k-1}^2$$

**Fig. 1. Chemical Process Reaction**
point where a real system would be destroyed. More of this later.

Construction of an engineering system is a matter of preparation, assembly, and installation. It has its own extensive and perplexing problems, but except as these problems involve redesign of system components, operation of parts installed, or the design and/or operation of construction facilities, these problems are outside the province of the analog computer.

Operation starts with the engineering system as installed. Given the system, the operator's job is to determine and apply optimum modes of operation.

The analog computor is a tool — a powerful model that an engineer can use to translate his ideas into simulated action. If the engineer has available a paneleric general purpose analog computor, he can model his system at slow, real, or fast time as desired. He can impose bounds and other non-linearities, vary parameters, and explore the range of possibilities of his conceptual model. In fact, it is good only as they are sound.

The analog computor is the most powerful model that an engineer can use. Its power arises from its versatility. It supplants and enlivens the engineer's conceptual model. It enables the solution of the mathematical model without recourse to confusing transformations and approximations. And it provides a vivid model of operation. This does not mean that the analog computor can supplant the conceptual and mathematical models and to verify operation.

Based on the loss formula of E. E. George:

\[ P_{\text{load}} + P_{\text{loss}} = \Sigma P_k \]

\[ P_{\text{loss}} = \Sigma B_m B_k P_m P_k \]

Expanding for two stations

\[ P_{\text{loss}} = B_{11} P_1^2 + (B_{12} + B_{22}) P_1 P_2 + B_{21} P_2^2 \]

Analogously, this becomes

\[ P_{\text{load}} = \text{Constant} \]

**POWER LOSS FORMULA**

Consider an electrical power system consisting of two generating stations and a load.

**Fig. 2. Power Loss in an Electric Power System**

(Concluded on page 4)
System Problems (Concluded)

AERODYNAMIC INSTABILITY

Consider a model of the roadbed of a bridge — or the wing of an airplane in flight — suspended as illustrated and subjected to the indicated forces and constraints.

**BIBLIOGRAPHY**

- **Breedon, D. B. and Ferguson, R. W.** Fundamental Equations for Analog Studies of Synchronous Machines. Transactions, AIEE. 1956. Paper No. 56-43. (Presents the equations used in a number of analog computer studies of synchronous machines and describes the representation of these equations on an electronic differential analyzer.)
- **Ezekiel, F. D. and Paynter, H. M.** Machine Computation of Fluid Transients in Engineering Practice. Paper for the ASME 1956 Annual Meeting. (A careful study of the problems of fluid mechanics supported by selected design situations.)*
- **Hainsworth, Bruce D., Tivy, Vincent V., and Paynter, Henry M.** Some Dynamic Effects in the Control of a Heat Exchanger. The Instrument Society of America. (An application of GAP/R components to a very practical problem.)*
- **Hillsley, R. H.** Analyzing Control Systems Graphically. Control Engineering. September 1956. (A very careful study in which several advantages of graphical analysis are developed and illustrated.)
- **Kuhnel, A. H.** Computer Control of a Rolling Mill Schedule. Instrumentation and Automation. July 1956. (Considers the problem of minimizing waste in the production of steel shapes.)
- **Oppelt, Winfried.** Kleines Handbuch Technischer Regelvorgänge Verlag Chemie, GMBH Weinheim/Berg. 1954. (One of the outstanding books on automatic control.)
- **Reque, S. G.** Simulate the System with an Analog Computer. Control Engineering. Vol. 3, No. 9, September 1956. (Describes the steps needed to set up an electronic analog model and the values in engineering time saved to be gained.)

*Refers to GAP/R products.

**CIRCUITS AND BLOCK DIAGRAMS**

Dissipationless Transmission System

Our good friends F. D. Ezekiel and H. M. Paynter have devised and employed a universal block diagram for a lossless transmission line for the Row of mechanical, electrical, and fluid energy.

A=Adder  S=Switch
C=Coefficient  TD=Time Delay
E=Effort (Force, Voltage, Pressure)
F=Flow (Velocity, Current, Flow)
T₁=Downstream Propagation Velocity
T₂=Upstream Propagation Velocity
Z=Characteristic Impedance

**Fig. 3. Problem of Aerodynamic Instability**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Form</th>
<th>Switch</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Impedance/Impedance</td>
<td>α —</td>
<td>E₁</td>
<td>E₂</td>
</tr>
<tr>
<td>II Impedance/Admittance</td>
<td>β +</td>
<td>E₁</td>
<td>F₂</td>
</tr>
<tr>
<td>III Admittance/Impedance</td>
<td>β +</td>
<td>F₁</td>
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<tr>
<td>IV Admittance/Admittance</td>
<td>α —</td>
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