Analog Computers: RCA Typhoon, 1951

Analog computers were used to solve sets of generic simultaneous differential equations, to compute trigonometric functions, to perform coordinate transformations, multiplication, integration and similar tasks in real time. These computers used analog building blocks, as integrators, summing amplifiers, logarithmic amplifiers, function generators, and electromechanical sensors, actuators or displays. Analog computers offered several advantages over digital ones: they were faster, simpler, lighter and more reliable. Their major drawback was their moderate accuracy, 0.5% or less, usually obtainable. Many analog computers were small dedicated equipment, often almost entirely electro-mechanic, with synchro repeaters, cams, potentiometers, differential gears and just some electronic error amplifiers, designed to accomplish a specific function, i.e. the position and the course computation in a navigation system. Here an example of an air-data analog computer.

Fig. 1 - An air-data analog computer of the sixties, using few semiconductor devices and a lot of electro-mechanical miniaturized components.

Larger computers were designed for the study and the simulation of generic n-variable systems and their dimensions became impressive when complex problems had to be investigated, with the simultaneous handling of many variables. These computers had a number of operational amplifiers, some additional building blocks and one or more programming boards. The transfer functions to be simulated were programmed connecting the building blocks as required by plugging wires on the programming boards and setting the required parameters. Analog computers were widely used in the past, and some were also sold in kit form, as Heathkit EC-1 or ES-400 series.

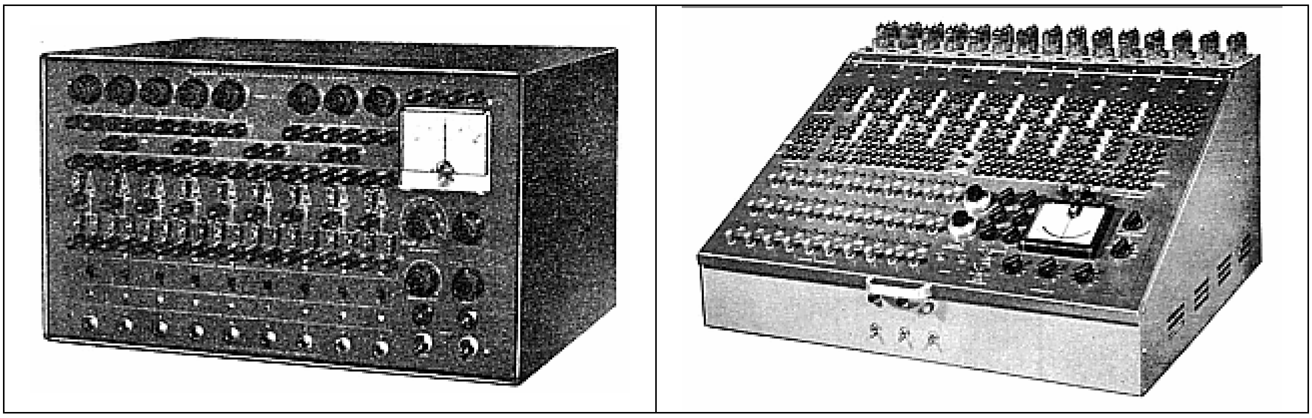


Fig. 2 - Heat EC-1 and the more complex ES400 series were analog computers sold even in kit form.

With its 4000 vacuum tubes, RCA Typhoon, built to a contract with Navy Bureau of Aeronautics, probably was the largest analog computer ever made. Entered in service early in 1951, after three years of research and development under the direction of Arthur W. Vance, it had been intended for the investigation of complex problems, such as the evaluation of the performances of ships, planes and submarines, up to the design of complete guided missile systems. A staff of nine engineers and mathematicians plus six technicians was required to operate the computer. The problem was set up on approximately 100 dials and 6,000 plug-in connections on the programming switchboards. Output devices included two Electronic Associates Variplotter units and 18 GE photoelectric recording voltmeters, plus a three-dimensional trajectory indicator.

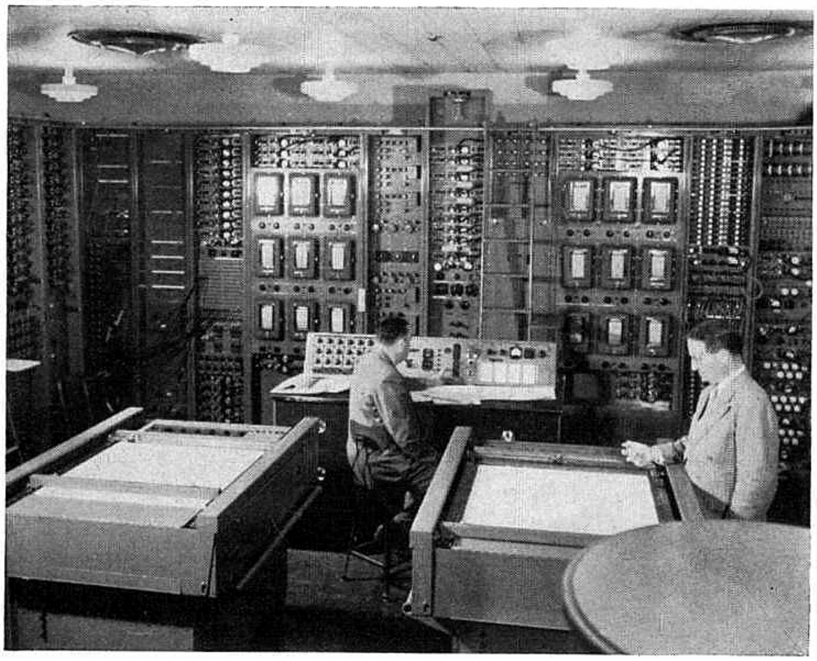


Fig. 3 - Picture of the operation control room with the control console and two plotting boards. Some of the computing racks are visible in the background. Below, Arthur W. Vance, head of the RCA Computer Section, at the control console.

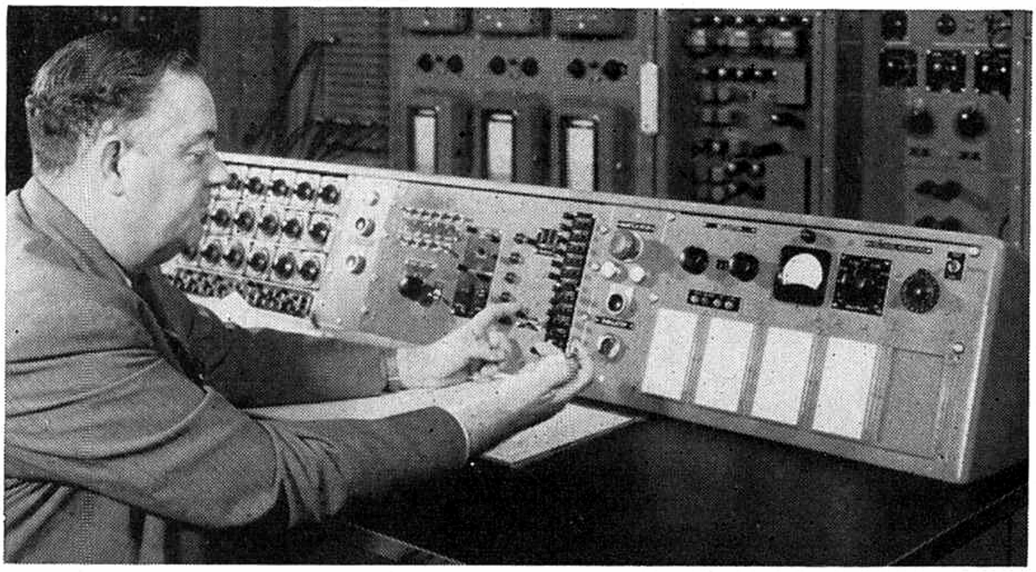


Fig. 4 - Close-up view of Arthur Vance at the control console.

The Typhoon computer had some 450 precision DC amplifiers and 20 computing servo units with multipliers, plus a large number of other components, as a bank of polystyrene capacitors that made possible up to 80 simultaneous integrations. The circuits were mounted in 43 racks, each 9 feet high; three racks were double standard width, 36 inches. Total power required was 46 kilowatts.

Hybrid step multipliers were included for fast coordinate conversions. Special circuits and components were developed to achieve a precision within 0.001% of full-scale. Very fast relays, capable of switching in 0.1 millisecond with no bounce were developed for the DAC sections. For maximum speed relay coils were driven by circuits with three 807s in parallel. Just few years later, simple inverted connection transistors should have performed the same function. Hybrid multipliers, using the above DACs, were capable to change from zero to full scale in 1 second.

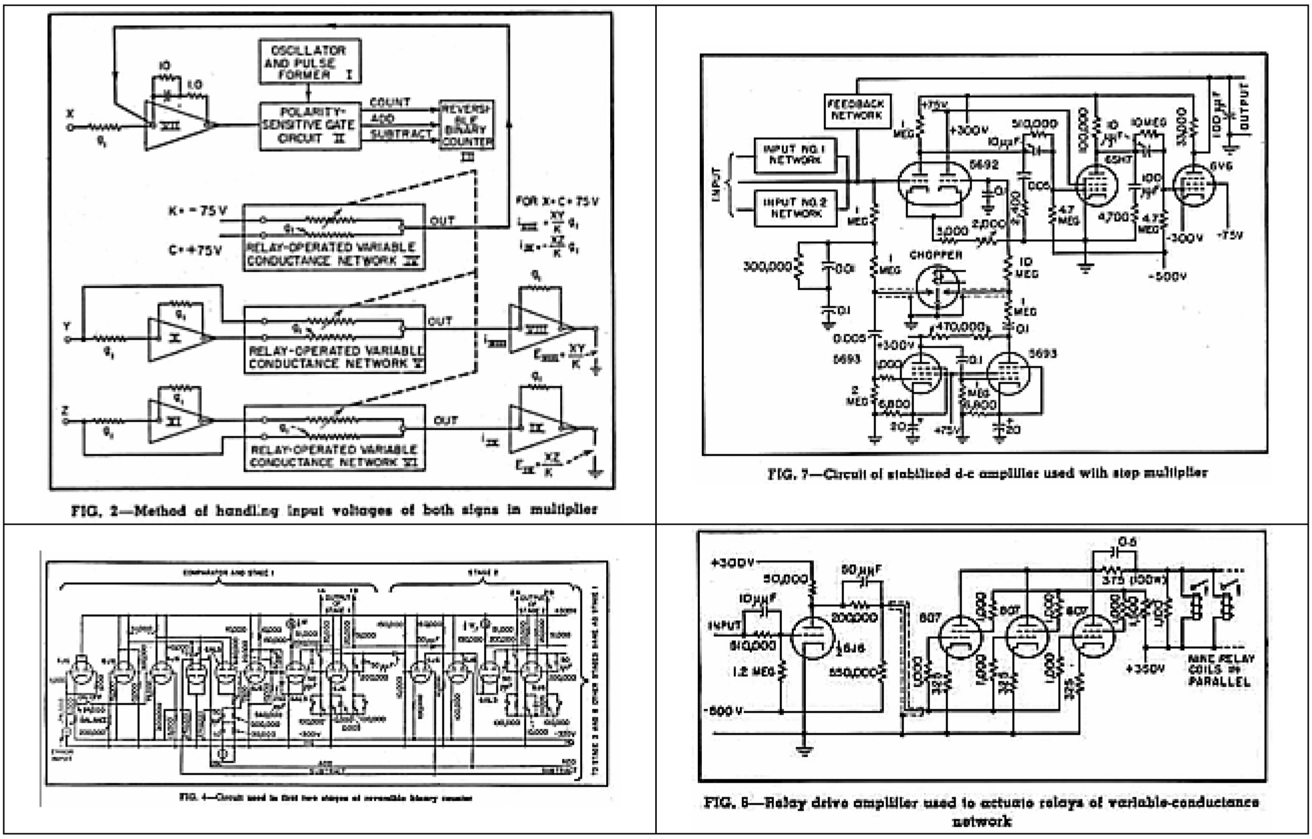
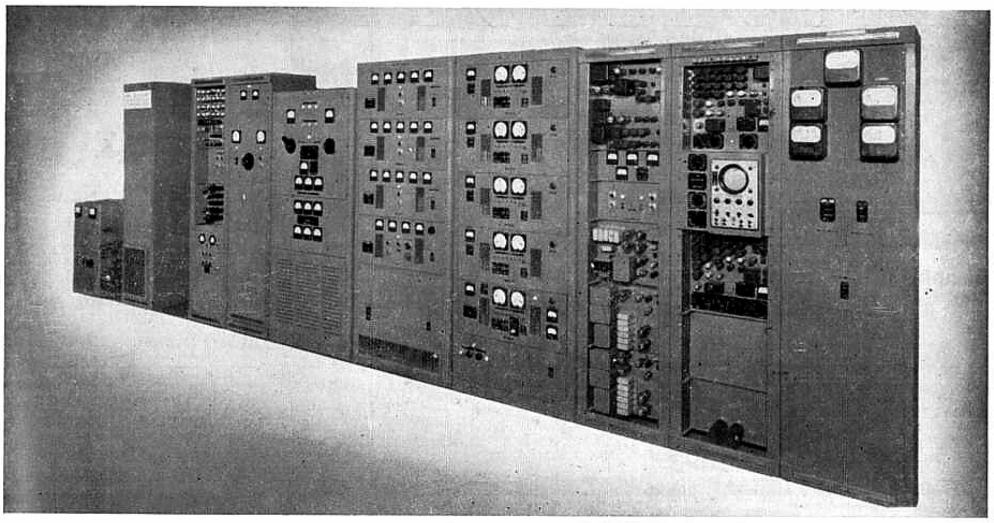


Fig. 5 - Top row left, the block diagram of analog multipliers. Right, the diagram of a stabilized DC amplifier. Bottom row left, circuit of reversible counter. Right, relay drive amplifier with parallel of three 807s. (Click each diagram to enlarge)

The stabilized power supply section occupied ten racks. Plate supplies generated +300 and –300V, each at 20A, regulated to 0.001-percent. Bias supplies gave ±75V at 6A and –500V at 3A. The ±300V power supplies included thyratron preregulators, followed by superregulator sections, each using twenty 6AS7 twin triodes. The coarse voltage drop on the series pass regulators was kept to 50V by the preregulators. Pictures below show the entire supply section, one preregulator and one chassis of a superregulator section.



Complete power supply system for the 4,000-tube computer is a research engineer's dream, filling an entire room and providing plate voltages that stay constant within 0.001 percent. The ten racks are, from left to right: servo power; filament filter; odd-frequency power; relay power; filament power; preregulators and rectifiers; superregulators; auxiliary and plotting-board power; calibrator and scope; incoming three-phase power panel

Fig. 6 - Wiev of the power supply section, occupying six racks to supply the ultra-stabilized voltages to the analog circuits of Typhoon.

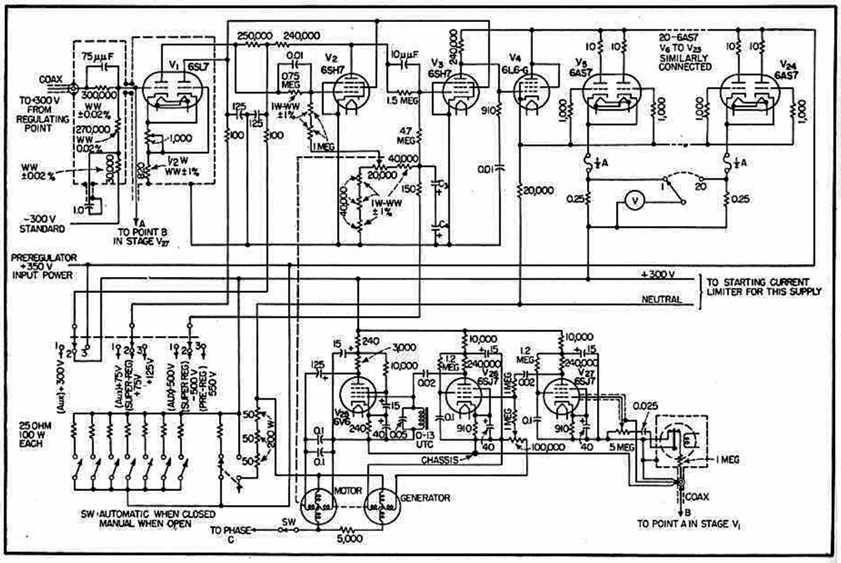


FIG. 4—Circuit of 300-volt superregulator. Voltage drop across 20 paralleled 6AS7 double-triodes is controlled by d-c amplifier and motor-generator servo system to drop exactly 50 volts of the 350-volt input power from preregulator even though load current varies from zero to 20 amperes

Fig. 7 - Schematic diagram of 300 volt superregulator, using twenty parallel 6AS7 twin triodes as series regulators.

Sources: ‘Electronics’, February, April, August and December 1951.