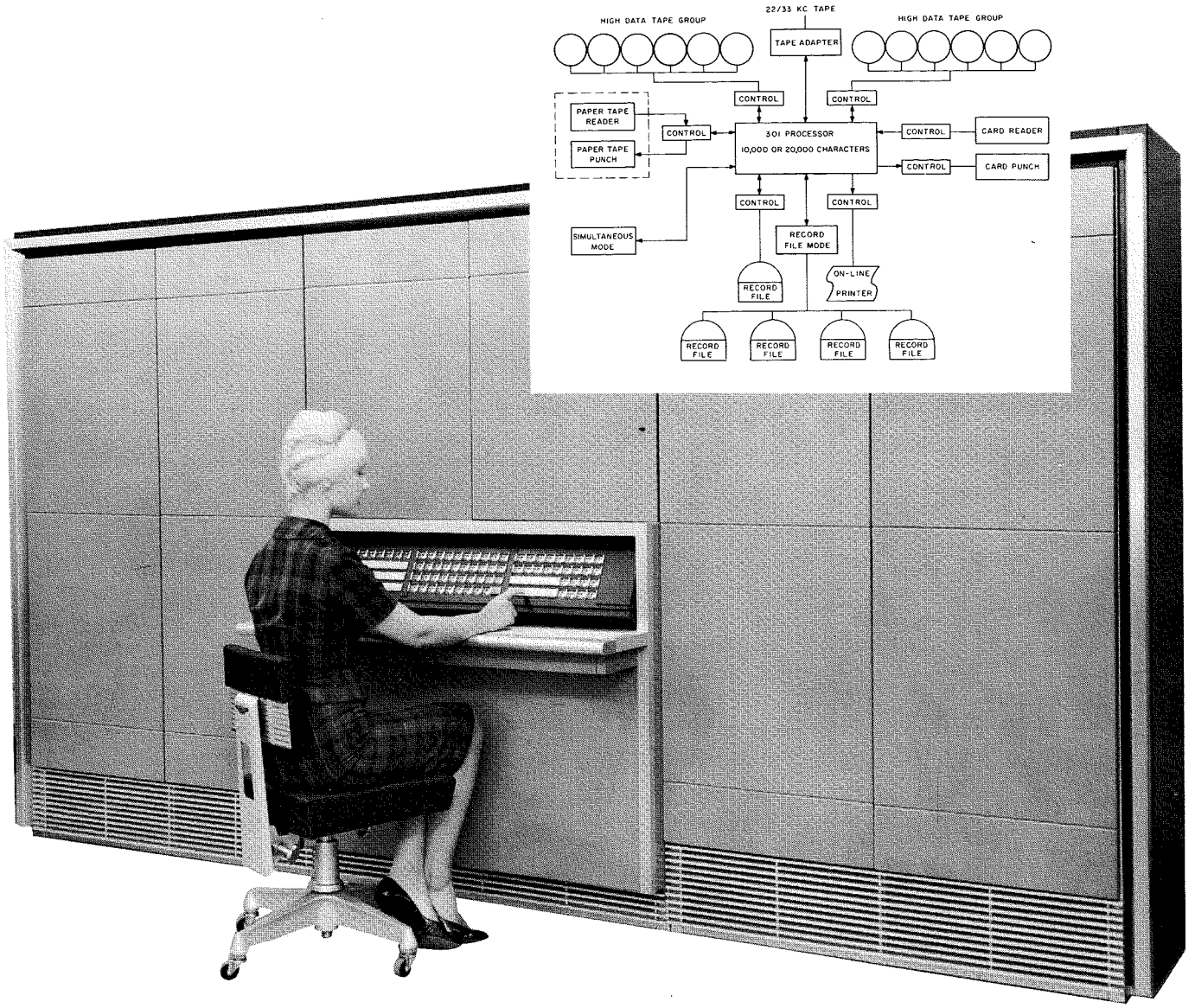

Fig. 1—The RCA 301 basic computer (center cabinet) with modular power-supply and control cabinets at left and right. Inset: The RCA 301 data-processing system.

THE RCA 301 . . . Flexibility at Low Cost – An Engineering Challenge

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MANY PARALLELS CAN be drawn between two apparently very different industries—automobiles and computers—over the course of the past few years. In both of them, a trend toward bigger, more powerful, more expensive machines was the rule, until very recently a reverse toward compact models has set in. While the analogy must not be overworked, one other point of similarity can be noted: Just as a large and a small car perform basically the same function with different load capacities, so the large and small business computers are faced with problems of equal complexity, but with different data volumes.

SMALL-COMPUTER DESIGN PROBLEMS

In the case of computers, small machines with the required capability have not been practical in the past, largely because of the lack of depth in supporting technology. Core memories, for example, presented a fixed cost to the designer of the small computer that invariably led him to the use of drum memories, with a consequent loss of speed by a factor of 1,000. Magnetic-tape units, highly reliable diodes, transistors, and almost every other system component presented a similar problem. It was only when these costs were lowered, through the volume production of large and medium systems, that the

successful design of powerful, low-cost computing systems became possible.

Another problem encountered in the successful design of a small computer lies in the production phase. In order to have a system that markets at a reasonable price, volume production of the same units is necessary. Customizing and tailor-making of systems cannot be economically supported. On the other hand, each customer for a data-processing system has a situation that differs in certain aspects from every other user of the same system. Some users rely on paper tape for their input, others rely on punched cards; some users have a large amount of internal computation, others have a large volume of output printing. Thus, in order to reach a wide market, the system must be flexible. This, of course, works in direct contradiction to the production requirements of a large volume of identical units. It is in this field that the RCA 301 system offers a most novel solution. Modularity, enabling customizing of systems to the specified need of the user, has been made compatible with the volume production required. The RCA 301 system is illustrated in the diagram of Fig. 1.

MODULARITY

This modularity has been achieved through the concept of separate control panels for each piece of input-output equipment. From Fig. 2, it can be seen that the basic computer includes the memory and control hardware necessary for the execution of instructions, but that it includes no input-output equipment. It is, in effect, a central brain with no means of communication with the outside world. This communication is provided by means of peripheral equipment (printer, card punch, etc.) through a set of control panels and associated cables. Each of these panels ties to the central processor and is specifically designed to work with a peripheral unit. Thus, a control panel is associated with the printer, a different control panel with the card reader, a third control panel with the paper-tape reader, and so on. These panels can be attached to the basic computer by means of plug connectors. They can be produced in any volume required and stocked separately. When a customer is to receive shipment of an RCA 301 system, he receives a basic computer, peripheral equipment as required, and a control panel for each of the pieces of input-output equipment that he receives.

INPUT-OUTPUT EQUIPMENT

The choice of input-output equipment for a small system presents a whole set of problems by itself. Again, a balance between cost and performance, between customer requirements and production volume must be found. The past emphasis on speed can no longer be the major determinant in specifying equipment. Two new input-output units have been specifically designed for the RCA 301 system—the *record file* and the *hi-data tape group* (see diagram, Fig. 1).

The record file is a storage device holding information on a set of magnetic recording disks. Each disk as used in the system can store 36,000 characters of information made up of 9,000 characters on each of two bands on both sides of the disk. Access time to information in the record file averages 4¼ seconds. This device is not truly a random-access unit as normally defined. It may not be applicable to a larger, much more powerful system such as the RCA 601 or the RCA 501, but it has specific uses and capabilities within the framework of the RCA 301 system such as program storage and file storage under certain conditions.

The hi-data tape group is a set of six magnetic-tape transports, each of which can handle information at the rate of 7500 characters per second. A set of common electronics is housed with the six tape drives, permitting access to any one of them at a time. Here again, economy has been the byword. Tape start time, including switching of the desired tape drive, is 30 milliseconds—again, a figure that would hardly be impressive within the framework of a large-scale system, but providing a unit which has a place and a function in the RCA 301 system.

Other input-output equipment is, of course, available. Card reading and card punching are provided, with the reading speed of 600 cards/minute and the punching speed of 100 cards/minute. Paper tape may be utilized, with reading and punching speeds of 100 characters/second. A line printer, providing hard copy at 600 lines/minute, 120 characters/line may also be included. The RCA 301 may work with other tape stations of the RCA product line at the rates of 22,000 or 33,000 characters/second. Special input-output equipment is available as required, and here again, the merits of a control-panel system show themselves. In one of the early systems the customer (in this case a large bank) required the ability to handle through the RCA 301 a magnetic-ink check-reading and -sorting device. There was no requirement to modify or redesign the basic computer for this function, since all tie-in to this system is handled by a specially-designed control panel.

BASIC COMPUTER

The basic computer (Fig. 2) is arbitrarily divided into the *high-speed memory* and *program control* units, although both are housed in a single rack (Fig. 3).

The memory comes in sizes of 10,000 or 20,000 characters. This choice is made at the time of purchase, and corresponds roughly to selecting a 4-passenger or 6-passenger car. The memory is organized so that two characters (14 bits) may be read in or out in a 7-microsecond cycle, which includes the regeneration time.

The program control unit consists of the necessary register for addressing the memory, holding information to be read out of or stored in the memory, and the registers necessary for execution of the instructions. The instructions are two-address, made up of ten RCA 301 characters. The *A* and *B* addresses normally specify the memory locations that are to be used in the instructions; they require four characters each. One character, the *N* character, contains information that usually pertains to the number of characters that are to be handled in this instruction. This is one of the ways in which

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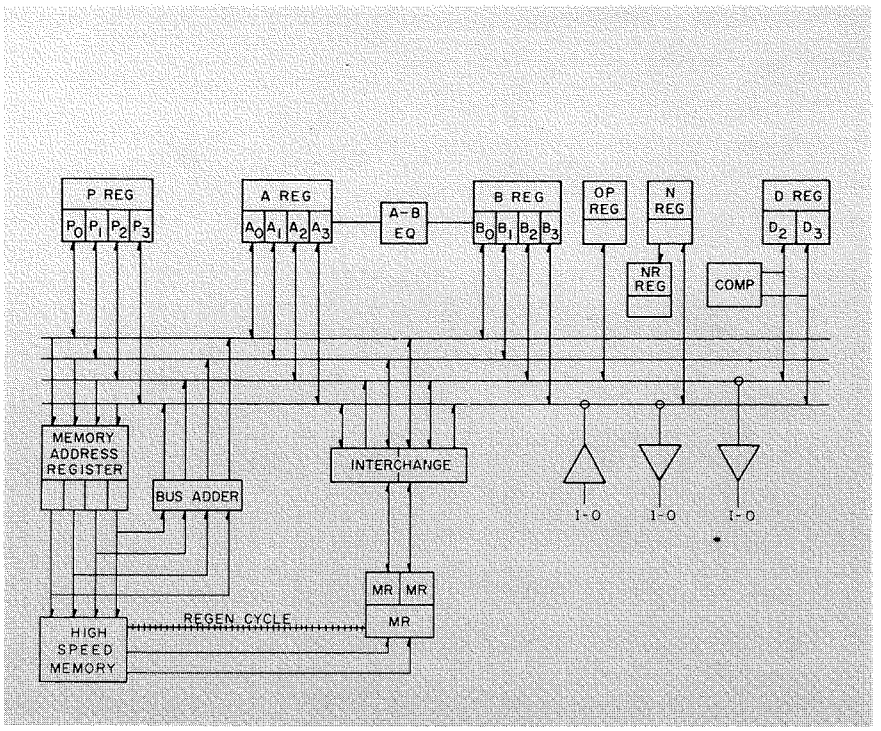
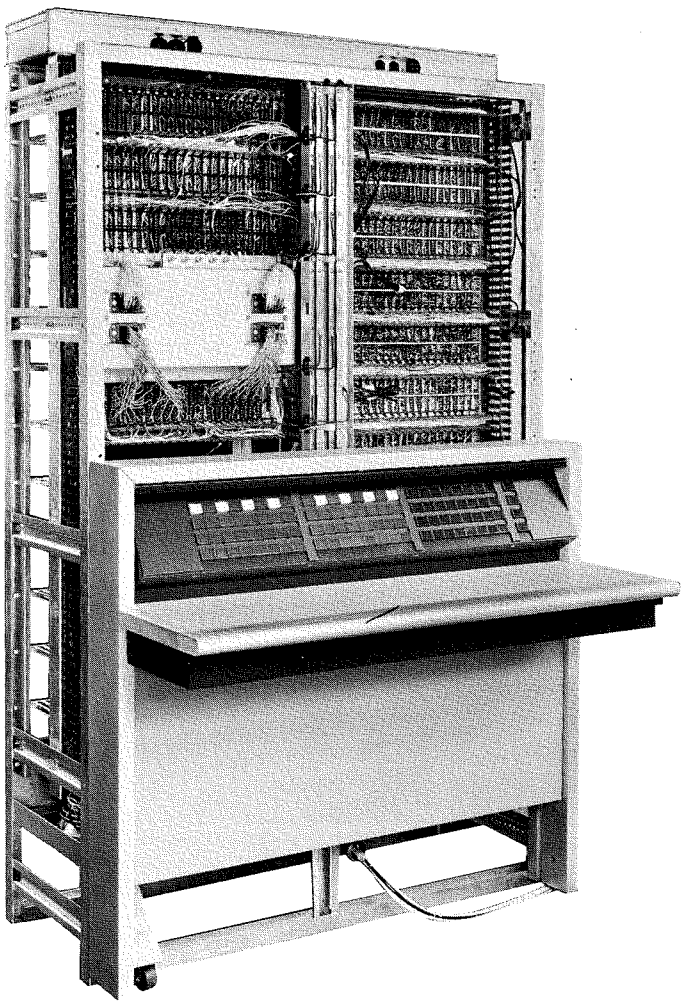


Fig. 2—RCA 301 basic computer.

Fig. 3—RCA 301 basic computer rack and console.



variable word length is handled within the computer. The tenth character of the instruction specifies the operation to be executed by the computer. Instructions are stored sequentially in the high-speed memory, each requiring ten consecutive memory locations.

Much of the packaging for the computer has been carried over from hardware used in the RCA 501 System. To achieve substantial cost reduction, a separate console was eliminated and the control console is now attached to the central computer rack (Figs. 1 and 3). This console swings aside for maintenance and testing of the computer rack itself.

CIRCUITRY

The choice of circuitry for a low-cost system such as the RCA 301 is one of the most basic and difficult portions of the design. Reliability is, of course, the prime consideration. To this has been added increased speed (compare 7-microsecond memory cycle with a 15-microsecond memory cycle in the RCA 501), the requirement for low cost, and the requirement for compactness of the total system. It may be seen that the design problem facing the circuit engineers was indeed formidable.

It should be pointed out that minimum system cost does not always follow from minimum cost of components used in the circuitry. Considerable negotiation and discussion between logic designers and circuit designers is necessary to optimize the final choice of circuits. For example, it may be found that a circuit costing 25 percent more will provide 75 percent more ability to drive loads in the form of other logic circuits. Application of such a new circuit would be worthwhile if enough "chains" of logic are used. Here, too, the problem of volume production versus custom design reappears. The logic designer would like many special-purpose logic plug-ins, while the circuit designer wants a small number of general types that may be produced in volume. A balance must be found that optimizes the over-all system cost.

SUMMARY

As RCA's entry into the low-cost computer field, the RCA 301 System presented a difficult challenge to the design engineer. At every step, the divergent needs of production, user, logic designer, circuit designer, and systems engineer had to be weighed, and the proper compromises made. The result is a powerful, competitively priced system that shows promise of having wide acceptance by customers.