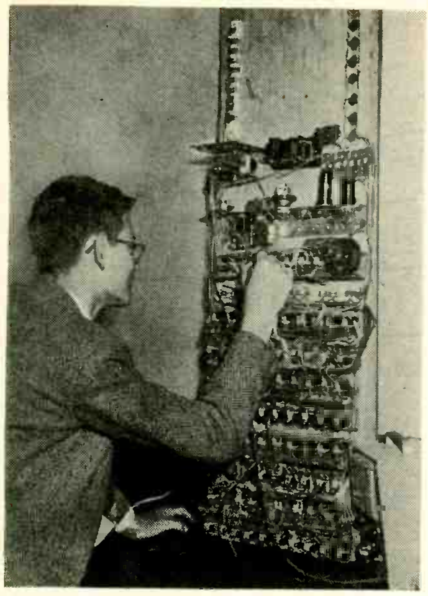

The author working on the 120-relay computer referred to in this article.

How a Computer Works

These simple basic circuits make it easier to understand how the more complex instruments operate

By DAVID B. MUMFORD

THIS is the story of a miniature relay computer designed and built by the author. It is the last in a series of progressively more complex computers starting from one containing 20 relays and ending with 120. Up to 1,500 feet of wire as well as a mechanical tape reader of our own design went into the largest model.

First, I shall describe the original computer in the series used as one section of the last and most powerful one. It performed the single operation of addition. It required you to give it numbers in binary notation (see box) and gave its answers likewise in binary. Since only two symbols are used in binary, 0 and 1, this system adapts itself readily to ?-position switches or relays, each position corresponding to a symbol. Furthermore, this system has a very simple addition table.

Next I will show how the original circuit can be modified to economize relays—a necessity when numbers of several digits are to be added. No constructional data on the 120-relay machine will be given—the diagram is too large and complex to print in a magazine article. What will be described is exactly how a simple circuit works and how it can be built into progressively more complicated circuits to handle bigger numbers, with a quick view of the final computer.

This—it is hoped—will interest the technician who would like to know how these circuits work but does not want to build one. It will also be helpful to the would-be computer constructor, who can use the information (and will need a great deal of additional study) to build a sizable machine of his own.

A simple adding circuit

Consider first the problem of adding 1-digit numbers or the first (smallest or right-hand) digit of larger numbers. The addition table page gives us the answers for the four input combinations: 0 + 0, 1 + 0, 0 + 1, 1 + 1. The circuit of Fig. 1 gives the correct answers when traced: 0, 1, 1, 0 + carry 1 to next digit. If either the first or second numbers are 1, the sum 1 appears (top lamp lights). If both are 1, the result is a 2-digit number 10. The top lamp goes out indicating zero and bottom one lights, indicating a carry to the second digit, and giving the sum, 10 (2 in decimal notation).

To add larger numbers, these elementary circuits are combined. To add 2-digit numbers, for instance, an identical circuit adds the second digits of the numbers and a third circuit adds the carry from the first digit to this result. The sums from the first and the second digits form the first and second digits of the sum, respectively, while the carry from the second digit forms the third digit of the sum. Rectifiers are added between circuits to prevent improper interaction. A 3-unit circuit is shown in Fig. 2.

Suppose the two figures 11 and 11 (3 and 3 in decimal notation) are to be added. The first digit (the unit, or smaller number) is entered at input A of unit I. The lower contact of relay Z1 is closed, lighting lamp 1. The second digit, entered at input 1, is entered at input A of unit II (the 2's unit). It closes the lower contact of relay Y1 and lights lamp 2 through the lower contact of X1.

The second 11 is entered at input 2. Its first digit goes to input B of unit I, drawing down both armatures of relay Z2. Since the armature of Z1 is down, drawing down Z2's upper armature has no effect; but the lower armature is drawn away from its upper contact, and

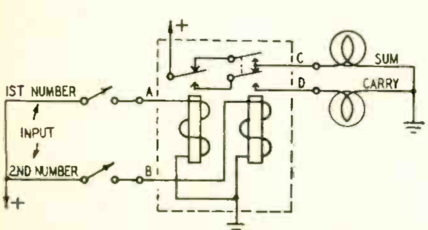

Fig. 1—The simplest addition circuit.

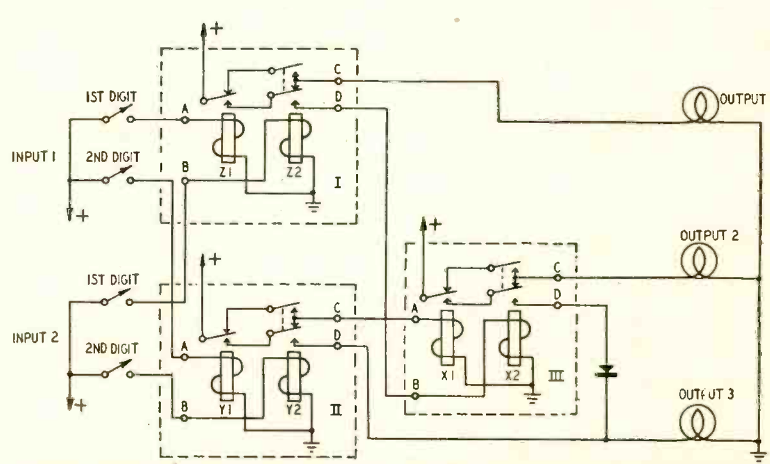

Fig. 2—Two-digit numbers can be added with this three-unit circuit.