coil through the relay contacts to the voltage source is completed, thus permanently connecting the relay coil to the voltage unless this path should be broken elsewhere. This path—called a hold lead—controls the operation of the memory. When it has voltage on it, the relays remember; when it does not, they forget. In a single memory (that is,

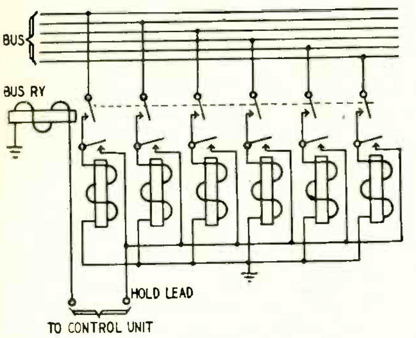


Fig. 6—Circuit of relay memory.

for six relays in the computer illustrated), the hold leads are generally connected together and are disconnected only when another number is to be put in the memory. A single relay is used in this computer to connect the relays of a memory to the corresponding wires of the bus, both for sending and receiving a number.

The computing unit is very similar to the simple combinational computer discussed above. Two sets of relays working as memories replace switches for storing input numbers. Lights on the output are replaced by a relay connecting the answer wires directly to the bus. This computing unit will perform three operations instead of one: addition, subtraction and selection. The purpose of the selection circuit is to select one of two numbers, depending on whether a third is 0 or 1. This is an important function in larger computers.

We have studied in this article the detail design of one type of circuit—the addition circuit—and some of the general principles that apply to the design of larger calculators. Some of these same ideas can be applied, moreover, to the construction of checker playing machines, mechanical turtles, automatic oil refineries, and immense telephone exchanges. Below is a short bibliography for those of our readers who would like to delve farther into this far-reaching field: END

BINARY NOTATION

This system writes numbers to the base 2 rather than 10. It uses two symbols (0 and 1) rather than 10 symbols (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). Thus a number expressed in decimals as:

$$45 = 4 \times 10^1 + 5 \times 10^0$$

is expressed in binary as:

$$101101 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

In both cases, the number is made up from the coefficients of the terms. Similarly

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 . . .

is expressed in binary as:

1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, . . .

Rather than a complicated addition table, in binary we have:

$$0 + 0 = 0$$
$$0 + 1 = 1$$
$$1 + 0 = 1$$
$$1 + 1 = 10$$

(or 0 with a carry of 1 to next digit) A larger addition is carried out just as in decimal notation: The first and smallest digits are added first, then the second digits plus the carry from the first, etc. For example:

$$101 = 5$$
$$111 = 7$$
$$\overline{1100 = 12}$$

References

[1]Keister, Alistair and Washburn, *The Design of Switching Circuits*, New York: D. Van Nostrand Co.

[2]Berkeley, RADIO-ELECTRONICS, October, 1950, through October, 1951; also December, 1951, and February, 1952.

[3]*Scientific American*, Automatic Control issue, September, 1952.

NOVEL HIGH-VOLTAGE SUPPLY

MANY instruments for detecting and measuring nuclear radiation require high-voltage low-current power supplies to provide a polarizing voltage for the ion chambers or G-M tubes. This voltage is usually obtained from miniature high-voltage batteries used directly or in combination with capacitors charged in parallel and discharged in series, from an r.f. type supply using a high-frequency oscillator and rectifier, or from a vibrator supply. (For details on these types of high-voltage supplies, see "Counters for Prospectors" in the October, 1949, issue.)

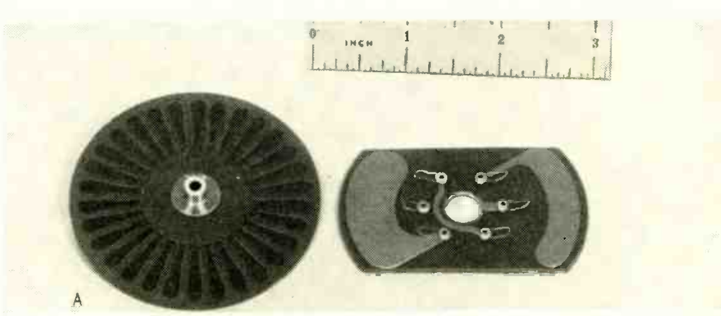
A new miniature electrostatic type high-voltage low-current supply has been developed by S. R. Gilford, S. Saito, and J. L. Herson of the National Bureau of Standards. This generator is simpler to construct, is potentially less expensive, has fewer components, and does not require special batteries that may be hard to obtain.

The electrostatic supply consists basically of a stator of two field plate conductors and a rotor with a number of of pairs of conducting sectors. (See photo A. The rotor is on the left and the stator on the right. These parts are fabricated by printed-circuit techniques using copper foil laminated phenolic etched to produce the desired patterns.)

The rotor is driven at speeds up to 6,000 r.p.m. by a lever-operated reciprocating drive system. Several sets of brushes transfer the electrical charge to the storage capacitors. The NBS generator with its reciprocating drive system is shown in photo B.

The problem of establishing a constant output polarity was solved by using a small external bias voltage to precharge the storage capacitor. This voltage is obtained from a supply used with the electronic equipment.

The NBS electrostatic generator can charge an .02-μf capacitor to 2,000 volts in about 15 seconds. In a survey instrument requiring a current of 10^{-12} to 10^{-14} amperes, the storage capacitor needs to be recharged only occasionally to make up for a leakage loss of about 100 volts. This charge can be restored with a single operation of the instrument's driving lever. END



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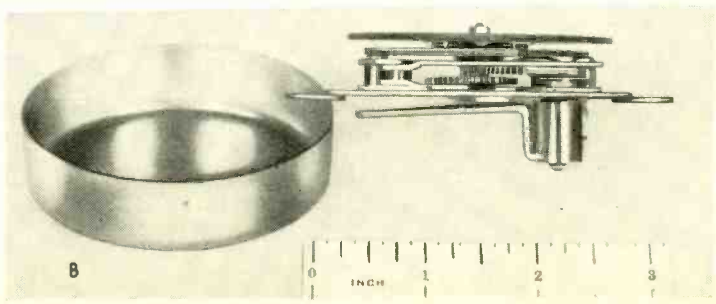

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