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STORAGE DEVICES

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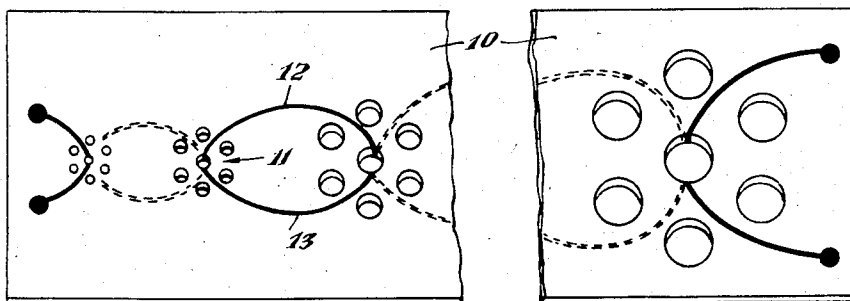
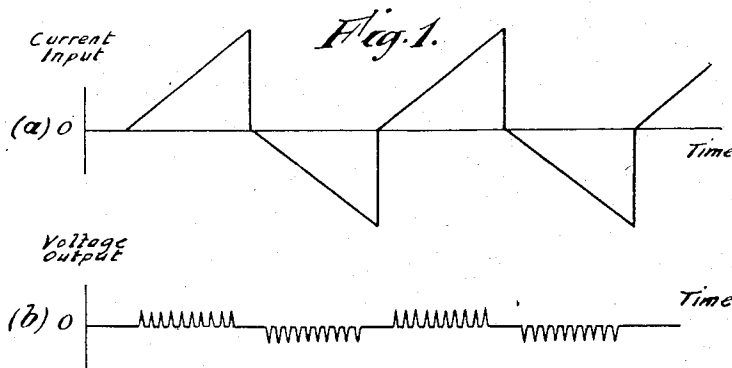


Fig. 2.

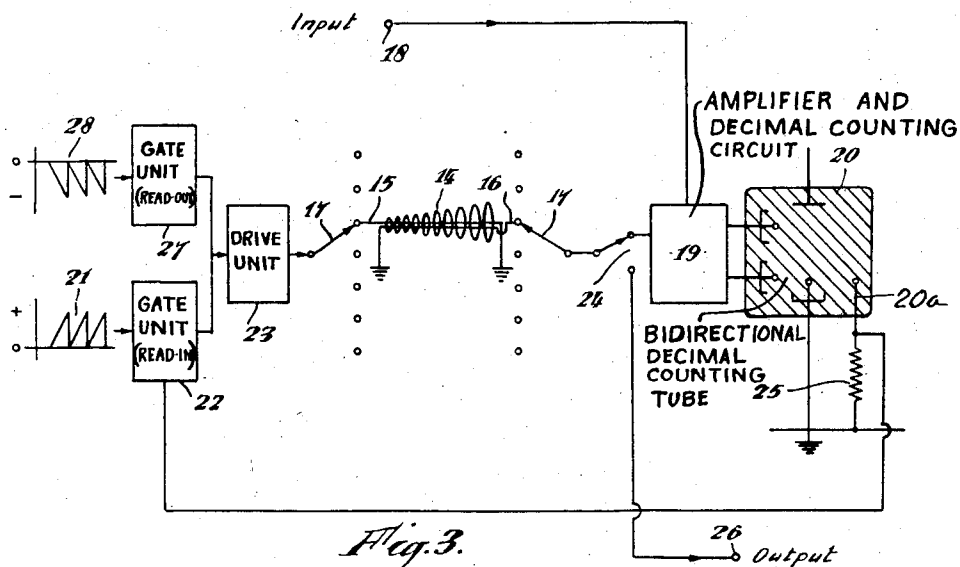


Fig. 3.

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STORAGE DEVICES

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Claims priority, application Great Britain July 26, 1954

3 Claims. (Cl. 340—174)

This invention relates to a device for storing an electric signal in the form of a train of pulses and to apparatus incorporating the device. The signal may represent a digit, the number of pulses being equal to the digit represented. A device in accordance with the invention is of particular value for use in the decimal counting tube type of digital computer, and in some circumstances can replace decimal counting tube storage circuits.

An important feature of the invention resides in the use of ferrite material having a square or rectangular hysteresis loop. One form of storage device or element that can be constructed in accordance with the invention, comprises a series of cores made of such ferrite material, each core in the series having a slightly greater radius than the preceding one. (For use in a computer operating in decimal notation, there would be ten cores in the series). Two conductors are threaded through all the cores of the series, one conductor serving as an input winding and the other as an output winding.

The coercivity of the ferrite material is not affected by its structural form, but the magnetic field induced in a core by a current flowing through a single conductor threaded through the core is inversely proportional to its radius. It follows that the greater the radius of the core the greater is the current required to induce a field equal to the coercivity. Consequently if all the cores are initially magnetized to remanance in one direction and a steadily increasing current is passed through the input winding so as to magnetize the cores in the opposite direction, then the core of smallest radius will be the first to experience a field sufficient to reverse its magnetization, the next smallest core will be the next to reverse its magnetization and so on. On each reversal of magnetization a pulse will be produced across the output winding.

In the drawing:

Fig. 1 is a graph of the wave forms of output and input pulses utilized in the device of the invention.

Fig. 2 is a top plan view of a storage element made according to the invention.

Fig. 3 is a diagrammatic view of a storage circuit employing an element like that of Fig. 2 or several of such storage elements.

In Figure 1 of the accompanying drawings, there is shown at (a) a sawtooth input current and at (b) the corresponding output pulses, it being assumed that there are ten cores in the series and that the peak value of the sawtooth current produces a field large enough to reverse the magnetization of the largest core.

Instead of constructing each element of a number of separate cores, the same effect can be achieved by means of a single sheet of ferrite material in which holes are punched. Each "core" in this case is formed by a set of holes comprising a central hole around which there are a number (say six) of equally spaced holes. Such a construction is described in copending U. S. patent application Serial No. 517,223 filed June 22, 1955, now

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Patent No. 2,825,046, in which the present inventor is co-inventor with John W. Herbert.

In Figure 2 of the accompanying drawing there is shown a storage element comprising a ferrite sheet 10 (partly broken away) in which there are ten sets of holes such as 11. As in the case of the cores previously described, the holes of each set are of different radii. The input and output windings are threaded through all the central holes and comprise conductors 12 and 13 respectively printed onto the ferrite sheet in silver by conventional printed circuit technique.

A circuit arrangement of a decimal storage device is shown in Figure 3 of the accompanying drawings. A storage element is indicated diagrammatically at 14 and has an input winding 15 and an output winding 16. The device may comprise a large number of elements such as 14, the same circuit being used for all the elements, and a multi-way, two-pole switch 17 is used to select any particular element.

A digit to be stored is applied to the input terminal 18 of the device as a train of pulses and is supplied by an amplifier and decimal counting tube circuit 19 to a bi-directional decimal counting tube 20. (An Ericsson valve type GC10/4B is suitable for tube 20). This tube is initially at zero setting, i. e., the discharge is between the anode and the zero cathode 20a, and the application of the input pulses from the unit 19 causes the discharge to move to the cathode corresponding to the digital value entered.

Initially the storage element 14 has all its "cores" (or sets of holes) magnetized in the opposite direction to the magnetization produced by a "read in" sawtooth voltage shown at 21. After sufficient time has elapsed for any digit to be set on the tube 20, a gate unit 22 is opened by timing means (not shown). The opening of the gate is arranged to occur at an instant when the voltage 21 is zero. The "read in" sawtooth is applied by a drive unit 23 to the storage element 14. This causes the cores to be reversed in magnetization in turn as previously described. On each such reversal a pulse is applied via the switch 24 to the unit 19, which responds to these pulses to cause the discharge in the tube 20 to move back towards the zero cathode 20a. When the discharge moves on to this cathode, a voltage is developed across the resistor 25 and is fed to the gate unit 22 to close the gate. At this stage, the number of cores having reversed magnetization is equal to the digit to be stored and accordingly that digit has been entered into the element 14.

In order to read out a stored digit from any particular element 14, that element is selected by means of the switch 17 and the switch 24 is moved from the position shown so as to connect the element to the output terminal 26. The timing means then open a gate unit 27 which supplies a "read out" sawtooth voltage 28 to the drive unit 23. It will be noted that the "read out" sawtooth is of opposite polarity to the "read in" sawtooth, and hence all the cores that were reversed in magnetization during the read in process will be returned to their original condition. Consequently there is produced at the output terminal a train of pulses equal in number to the stored digit.

One advantage of the storage device described above, apart from its simplicity, is that no narrow tolerances are necessary in the circuits, the waveforms or the storage element. Thus, the size or order of the cores is immaterial so long as no two in a series require exactly the same current to reverse the direction of magnetization. Again, the actual shape of the sawtooth waveform is not critical as long as the current reaches a peak value exceeding that necessary to reverse the magnetization of the largest core.

It is to be understood that the constructional and circuit

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details given above may be modified in various respects without departing from the scope of the present invention.

I claim:

1. In a magnetic storage device, a series of spaced cores made of a ferromagnetic ferrite materials which has a square hysteresis loop, each of said cores having a center opening and said center opening of each of said cores being spaced from the center openings of the other cores, each of the said cores of the series after the first having a larger diameter than the preceding one, at least two independent conductors threaded in sequence through the center of each of the cores of said series.

2. In a magnetic storage device, a series of at least two spaced cores of ferromagnetic ferrite material which has a square hysteresis loop, said cores being formed on a single sheet of said ferromagnetic ferrite material, each of said cores comprising a portion of said sheet between a substantially circular chain of closely spaced holes and

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an additional hole substantially centrally located within the circular chain of holes, each of the cores of said series after the first having a larger diameter than the preceding one, and at least two independent conductors threaded through the additional center holes of the cores of said series.

3. In a magnetic storage device as set forth in claim 2, comprising printed conducting lines on said ferrite material threadingly connecting the cores of said ferrite sheet together.

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