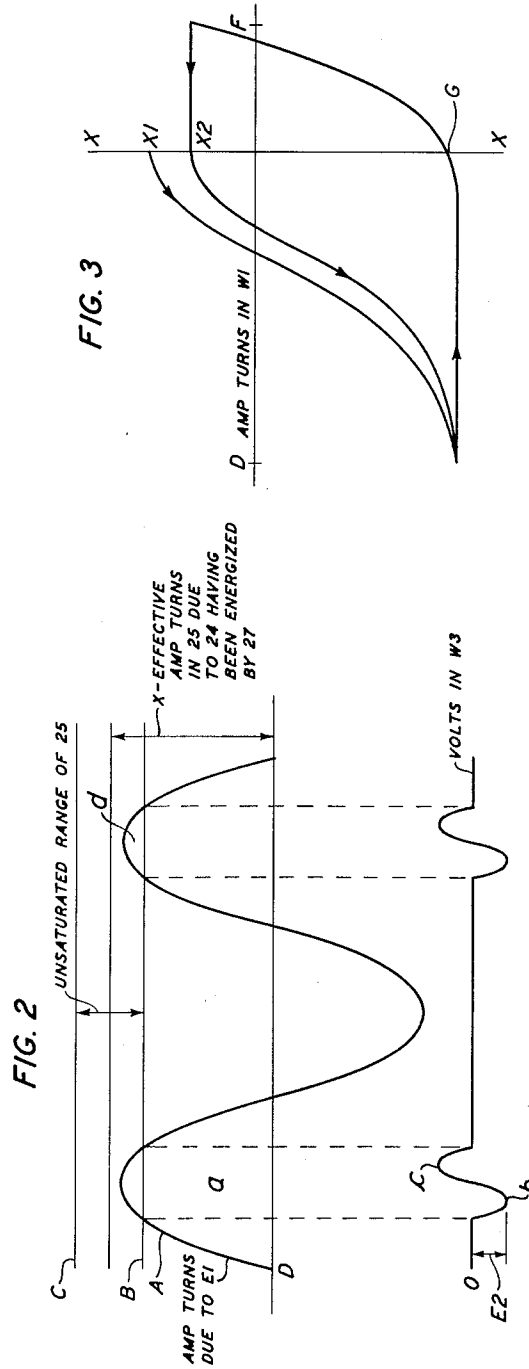
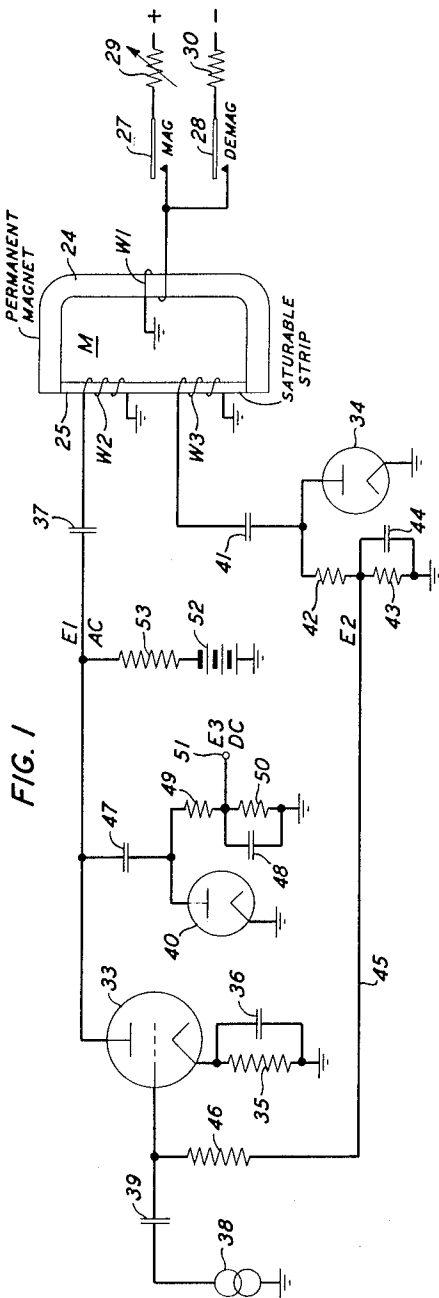


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T. L. DIMOND
PEAK VOLTAGE LIMITER

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1

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PEAK VOLTAGE LIMITER

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This invention relates to systems for storing electrically characterized items of information and particularly to a memory circuit which functions to retain items of information electrically characterized as momentary currents of predetermined amplitudes.

"Memory" or "storage" circuits, in general, are well known and find numerous and diverse applications in the electrical arts. In one type of memory circuit electric charges representing electric values are stored for comparatively short periods of time in condensers; the maximum storage time in such circuits is a function of current leakage and usually is of the order of seconds. Longer storage periods have been attained by organizations of circuits and apparatus which include some form of mechanical device such as a potentiometer or switch. Other circuits having retentive characteristics deal primarily with information items of the so-called "on-off" variety or which are characterized by different discrete electrical quantities or values.

It is the object of this invention to provide an improved method of and means for storing electrically characterized items of information.

In accordance with a particular feature of the invention a momentary current of any predetermined magnitude, representing an item of information, is translated into a voltage which is maintained indefinitely at a value which is a function of the magnitude of the momentary current.

In accordance with another feature of the invention a memory circuit is contemplated in which the information characterizing currents may be of a continuously variable pattern as opposed to one of discrete values.

A further feature of the invention resides in the use of a storage device, such as is shown in my Patent No. 2,430,457 of November 11, 1947, which comprises two serially joined magnetic elements, one of which has permanent magnet properties and is readily susceptible to magnetization and demagnetization and the other of which is a strip of material of high permeability which saturates sharply at low flux densities.

In accordance with other features, the method of operation of the memory circuit of this invention involves magnetizing the permanent magnet element of the storage device to an extent representative of the magnitude of the momentary current employed in characterizing an item of information, in order to bring the other element of the device to a condition considerably past that of magnetic saturation; subjecting the other said element of the storage device to the influence of a source of alternating ampere turns having an instantaneous peak value in excess of the effective ampere turns value of the magnetizing force employed in producing magnetic saturation of the said other element, whereby a condition of unsaturation is produced therein; deriving a voltage commensurate with the rate of change of flux in the said other element of the storage device as the peak value of the alternating ampere turns approaches the effective ampere turns employed to produce saturation of the said other element; and regulat-

2

ing the said source of alternating ampere turns in accordance with the derived voltage.

These and other features of the invention will be better understood from the following detailed description when read with reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of the memory circuit of this invention;

Fig. 2 is a diagram of curves showing, graphically, a value X of the effective ampere turns in the saturable element of the storage device due to the permanent magnet element of the device having been subjected to the momentary influence of a direct current of predetermined magnitude; the alternating ampere turns A which serve to cancel the effective ampere turns X and to produce a rate of change in the flux in the saturable element of the storage device such that a voltage commensurate therewith and with the extent the alternating ampere turns approaches the value required to render the saturable element no longer saturated is generated; and the generated voltage E₂; and

Fig. 3 is a curve which is the equivalent of a B—H magnetization curve for the permanent magnet element of the storage device.

Referring to Fig. 1 of the drawings the basic storage device M is a composite core comprising two serially joined elements 24 and 25. The element 24 is of a material having permanent magnet characteristics and is capable of being readily magnetized and demagnetized while the element 25 is a strip of material which has high permeability and which saturates sharply at low flux densities.

The permanent magnet element 24 of the storage device is provided with a winding W1 which terminates at one end at ground potential and at the other end in the make contacts of two switching devices 27 and 28. These switching devices may be controlled manually, electromagnetically or in any manner suitable to the conditions under which the memory circuit is employed. The switching device 27 functions, when operated, to complete a connection of momentary duration between the winding W1 and the positive pole of a direct-current source (not shown) by way of a variable resistance 29. The switching device 28 functions, when operated, to complete a circuit between the winding W1 and the negative pole of the direct-current source by way of resistance 30. When the switch 27 is operated to closed position current traverses the winding W1 so as to effect the magnetization of the element 24 in one direction whereas, when the switch 28 is closed current traverses the winding W1 so as to magnetize the element 24 in the opposite direction.

The saturable strip 25 carries two windings W2 and W3, the former being included in the plate circuit of a vacuum tube 33 and the latter being included in the plate circuit of the rectifier tube 34.

The plate, grid and cathode of tube 33 and the associated biasing resistance 35 and by-pass condenser 36 constitute a simple amplifier whose plate circuit includes the condenser 37 as well as the winding W2 and whose grid, or control electrode, is connected to a source of alternating-current voltage 38 by way of condenser 39. Plate battery is shown at 52.

The tube 34 whose plate circuit includes the condenser 41 as well as the winding W3, together with resistances 42 and 43 and condenser 44 constitute a simple rectifier, the output voltage of which is applied to the grid of tube 33 by way of conductor 45 and resistance 46.

The tube 40 and its associated condensers 47 and 48 and resistances 49 and 50 constitute a second rectifier whose output voltage appears at terminal 51. This output voltage is a measure of the magnitude of the momentary input current traversing the winding W1. If an alternating-

current voltage is desired instead of a direct-current voltage the rectifier tube 40 and its associated circuit elements may be omitted.

In describing the operation of the memory circuit disclosed in Fig. 1, it will be assumed that the switches 27 and 28 are open and that the element 24 of the storage device M has been partially magnetized by a momentary closure of the switch 27. The extent to which the element 24 becomes magnetized depends upon the magnitude of the current which traverses the winding W1 but is sufficient to more than saturate the element 25. The magnetic saturation of the element 25 results from the fact that the magnetization of the element 24 is the equivalent of a certain number of ampere turns linking the strip 25. This value of ampere turns is herein designated X and is shown on the curve diagram of Fig. 2.

The alternating-current source 38 applies a voltage to the grid of tube 33 and produces a voltage E1 in the plate circuit of the tube. This voltage produces an alternating current in the winding W2 which produces the alternating ampere turns represented by the curve A in Fig. 2.

The ampere turns resulting from the flow of current in the winding W2 are maintained at a peak value somewhat less than the value X, or to a value somewhat above the line B in Fig. 2 by the back biasing of the tube 33 due to the following action: As the instantaneous ampere turns in W2, due to the voltage E1, reach a value such that they cancel the effective ampere turns X sufficiently that the strip 25 is no longer saturated, the flux in the strip 25 will change at a rate dependent on the slope of the ampere turns curve A where it enters the unsaturated range of strip 25, which range is indicated as confined between the lines B and C in Fig. 2. Because of this rate of change of flux in the strip 25 a voltage is induced in the winding W3. This voltage is indicated by the downward pip *b* on the voltage curve in Fig. 2. Assuming the ampere turns in winding W2 start to decrease a short time later, another voltage pip shown at *c* is generated. On the next positive peak *d* of ampere turns the action just described is repeated.

The voltage thus generated in the winding W3 is rectified by the conventional rectifier including tube 34 and appears as a direct-current voltage E2 which is applied to the grid of tube 33 by way of conductor 45 and resistance 46. This is the negative bias voltage for the tube 33 and determines the gain of the tube.

It will now be assumed that the alternating-current voltage increases. When this occurs the current in winding W2 experiences a corresponding increase with the result that the peak of the ampere turns, curve A, extends further into the unsaturated range of strip 25 and because the slope of the curve is greater in the unsaturated region and the rate of change of flux in the strip 25 correspondingly greater, the resulting peak voltages produced in the winding W3 will be greater as will also the voltage E2 which is applied to the grid of tube 33. Thus the gain of tube 33 is reduced so that the voltage E1, which is the output voltage of the tube 33, remains at substantially the value it had before the alternating-current voltage increased. It is apparent therefore, that the voltage E1 is held to a practically constant value dependent upon the effective ampere turns X in the strip 25 due to the element 24 of the storage device having been energized by the momentary closure of switch 27. In other words, the alternating-current voltage E1 and therefore, the direct-current voltage E3 appearing at terminal 51 are held at a constant value which is a function of the magnitude of the current which traversed the winding W1 of the storage device M incident to the momentary closure of switch 27.

From the foregoing it is apparent that the tube 33 tends to seek a gain which makes the peak value of the ampere turns in the winding W2 substantially equal to the effective ampere turns X produced by the winding W1 regardless of the value of the current used in magnetizing the element 24.

The resistance 29 in Fig. 1 is shown to be variable indicating that any value of current may be used to produce the ampere turns X. Assuming it is desirable to store an item of information which is characterized by some other value of current and therefore, by a different value of ampere turns in the winding W1, it is necessary that the following procedure be carried out: Assuming it is desirable to change X from a value X1 to a value X2 (Fig. 3), the switch 28 is operated to its closed position. The ampere turns in W1 immediately drop to the point D on the curve (Fig. 3) and the effective ampere turns due to the magnetization drop to the point G. The point G is beyond saturation so that it represents a starting point for X for various values of resistance 29. The switch 28 is then released and the switch 27 closed after the resistance 29 has been changed to the appropriate value to produce F ampere turns in the winding W1. Switch 27 then is opened and the ampere turns value is established at X2.

While the memory circuit of this invention has many applications in the electrical arts the following possible application is described by way of example and involves a number of amplifiers, the output level of which should be equal and of predetermined level. Each such amplifier would obtain grid bias for its tubes from the voltage E3 in its own circuit such as shown in Fig. 1. A test circuit would measure the output of each amplifier, one at a time, and if the output is not the proper value the test circuit would adjust the gain until it is. This is done by changing the amount of magnetization in the permanent magnet element 24 of the storage device. The test circuit would proceed from amplifier to amplifier, setting the grid bias of each for proper gain. The grid bias remains fixed between settings because of the memory action of the circuit of this invention.

What is claimed is:

1. A memory circuit comprising, in combination, a storage device including two serially joined magnetic core elements, one of which is readily magnetizable and demagnetizable and the other of which is of high permeability and saturates sharply at low flux densities, a source of direct current of predetermined magnitude, means for momentarily subjecting the first said core element to the influence of current from said source to magnetize said core element to an extent representative of the magnitude of the current from said source whereby a condition of magnetization which exceeds saturation is produced in the second core element, means including a source of alternating current for producing an alternating magnetic flux in the second core element whose peak value is more than sufficient to cancel the saturating flux therein whereby periodic flux reversals are set up in said second core element, means responsive to the periodic flux reversals for generating voltages commensurate with the rate of change of flux during the flux reversals, and means for regulating the said alternating flux producing means in accordance with the generated voltages.

2. A memory circuit including, in combination, an electromagnet comprising a permanent magnet core section and a serially joined saturable section of highly permeable material which saturates readily at low flux densities, a winding on the permanent magnet section of said electromagnet, first and second windings on the saturable section of said electromagnet, means for causing the winding on the permanent magnet section to be traversed momentarily by direct current of predetermined magnitude whereby said permanent magnet section is magnetized to an extent representative of the magnitude of the direct current and the saturable section is magnetized in excess of saturation, means including a source of alternating current and a vacuum tube amplifier having a control electrode for applying an alternating voltage to said first winding on the saturable section of said electromagnet whereby a condition of unsaturation is produced in the said saturable section

5

6

and a voltage is generated in the second winding on said saturable section which is commensurate with the extent to which the applied alternating voltage exceeds that required to produce the condition of unsaturation in saturable section, and means for regulating the applied alternating-current voltage in accordance with the voltage generated in said second winding on the said saturable section of said electromagnet including a connection between the said second winding of said saturable section and the control electrode of said vacuum tube amplifier.

3. A memory circuit comprising, in combination, a storage device including two serially joined magnetic elements, one of which is readily magnetizable and demagnetizable and the other of which is of high permeability and saturates sharply at low flux densities, a source of direct current of predetermined magnitude, means for momentarily subjecting the first said core element of said storage device to the influence of current from said source to magnetize said first core element to an extent commensurate with the magnitude of said current whereby a condition of magnetization which exceeds saturation is produced in the said second core element of said storage device, means including a source of alternating current and a vacuum tube amplifier having a control electrode for producing an alternating flux in said second core element having an instantaneous peak ampere turns value in excess of the effective ampere turns value of the saturating flux in said second element whereby said second element becomes unsaturated and periodic flux reversals are produced therein, means responsive to the periodic flux reversals for deriving a voltage commensurate with the extent to which the instantaneous peak ampere turns value of the flux produced by said alternating flux producing means exceeds the effective ampere turns of the saturating flux, and means for regulating said alternating flux producing means in accordance with the magnitude of the derived voltage including means for subjecting the control electrode of said vacuum tube amplifier to the influence of the derived voltage.

4. In a memory circuit, in combination, a storage device comprising two serially joined magnetic sections, the first of which is readily magnetizable and demagnetizable and the second of which is of high permeability and saturates sharply at low flux densities, a winding on the said first section of said storage device, a pair of windings on the second section of said storage device, a source of direct current, switching means for momentarily connecting said source of direct current to the winding on the said first section whereby said first section is magnetized to an extent representative of the magnitude of the current from said source which trav-

ersed said winding and said second section is magnetized to a condition exceeding saturation, a source of alternating current, a vacuum tube amplifier having a plate circuit which includes one of the windings on the said second section of said storage device and a control electrode connected to one terminal of said alternating-current source whereby the condition of magnetization of the said second section is altered in accordance with the peak voltage output of said tube and an alternating flux is generated in the said second section whose rate of change varies with the extent to which the peak value of the generated flux extends within the range of unsaturation of the second section of said storage device, means including the other winding on the said second section of said storage device for deriving a voltage commensurate with the said rate of change of flux in the said second section, and means for applying the derived voltage to the grid electrode of said vacuum tube to adjust the gain thereof in accordance with the magnitude of the derived voltage.

5. In a peak voltage control circuit, a source of variable potential to be controlled, an electromagnet comprising a permanent magnet core section and a serially joined saturable section of highly permeable material and saturable at low flux densities, means for magnetizing the permanent magnet core section of said electromagnet to a degree representative of the desired peak voltage and to thereby produce in said saturable core section a condition of magnetization considerably beyond saturation, means including said source of variable potential for subjecting said saturable core section to a magnetizing force such that a condition of unsaturation is produced in said saturable core section and the magnetic flux therein changes at a rate commensurate with the extent to which the magnetizing force producing unsaturation extends within the unsaturated range of said saturable core section, means for deriving a voltage commensurate with the rate of change of flux in said saturable core section, and means for regulating the said magnetizing force producing unsaturation of said saturable core element in accordance with the derived voltage.

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