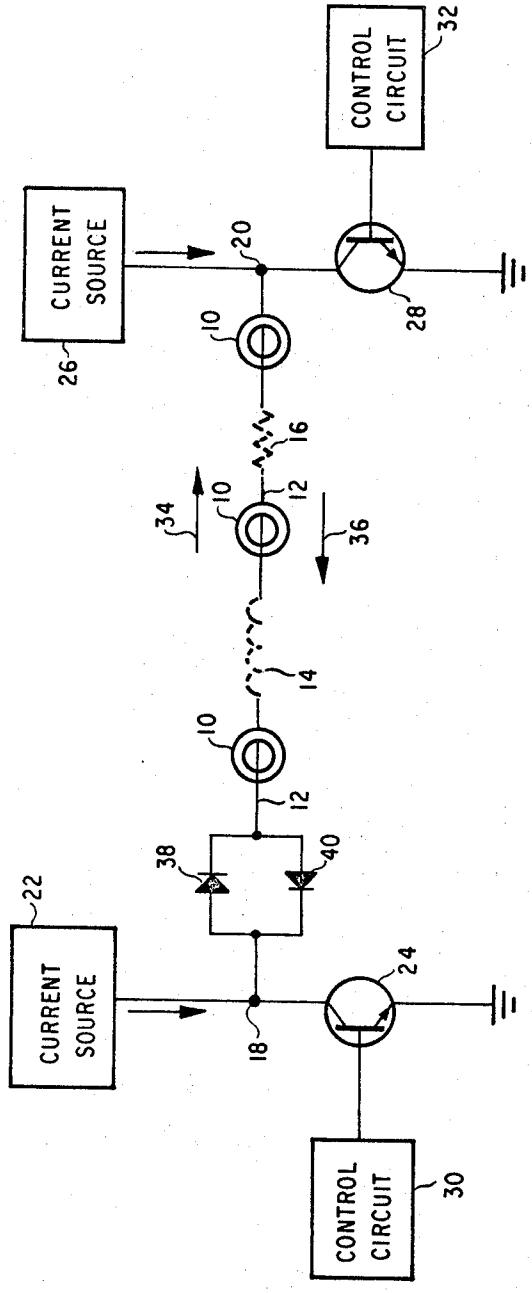
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ELECTRONIC SWITCHING CIRCUITS

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ELECTRONIC SWITCHING CIRCUITS

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ABSTRACT OF THE DISCLOSURE

To actuate rows of ferrite cores, a drive circuit employs two series combinations each having a current source and a transistor. A conductor is connected between common junctions of each of the series combinations and passes through the cores to be driven. Current can be driven in either direction between a source and a transistor at opposite ends of the conductor.

This application is a continuation of applicant's previous and now abandoned application Ser. No. 60,613, filed Oct. 5, 1960.

This invention is concerned with electronic switching circuits and particularly with such circuits useful to control driving current to inductive-resistive loads.

A common requirement of electronic data processing systems is that switching circuits be employed to control the current drive for inductive-resistive apparatus such as rows and/or columns of ferrite cores in equipments such as magnetic core memories, shift registers, recording heads, relay systems, etc. Typical examples of such current driving are found in magnetic core memory systems of the type disclosed in U.S. Patent 2,776,419, which issued to J. A. Rajchman on Jan. 1, 1957. In this apparatus a first matrix of magnetic switching cores is used to apply flux-reversing signals to the memory cores of a second matrix. The switching cores of the first matrix are arranged in a pattern of horizontal rows and vertical columns and vacuum tubes are employed to switch current to the individual conductors which link the cores of each row and column.

When a circuit of the type disclosed by Rajchman, wherein vacuum tubes are employed as the current switching elements, is modified to utilize transistors as current switching devices, difficulties are encountered with voltage rating, power dissipation, etc. Transistors can be designed to feature improved characteristics in these critical areas but at a cost in rise, fall and storage delays with consequent limitations on the operating speed of systems in which they are employed.

A principal object of the present invention is to overcome these difficulties with transistorized current drives to inductive-resistive loads. Further objects are to provide a bipolar current drive and an improved driving circuit for magnetic core switching systems.

These and related objects are accomplished in one embodiment of the invention by providing, for rows and columns of ferrite core switching matrices, a drive which features a current source at either end of a conductor linking a group of cores to be driven. A separate transistor is also similarly connected to either end of the conductor to provide a current path to ground. This path is direct from the current source on its side of the conductor, but leads through the conductor for the other current source. Consequently, if both transistors are conducting, the current from both connections flows directly to ground, but by selectively turning either transistor off, a current in either direction as desired may be caused to flow through the conductor.

Other objects, features, and embodiments of the invention will be apparent from the following description of the current drive shown schematically in the accompanying drawing.

In this illustrative embodiment of the invention a plurality of magnetic cores **10** are linked by a common conductor **12**. These cores are representative of any type of inductive load, but for the purposes of the present description should be assumed to constitute a row or column of switching cores of the type described in the Rajchman patent previously mentioned for driving a matrix of memory cores. The inductive and resistive characteristics of the load are indicated respectively at **14** and **16**.

The conductor **12** is connected at either end to terminals **18** and **20**. Terminal **18** is connected to a current source **22** and, through a transistor **24**, to ground. Similarly, terminal **20** is connected to a current source **26** and, through a transistor **28**, to ground. Control signal sources **30** and **32** are connected, respectively, to the base electrodes of transistors **24** and **28** and are capable of switching their respective transistors between conductive and cut-off conditions.

When the circuit is in operating condition, constant current, which may be derived from a conventional load resistor or transistor switching circuit, is applied from sources **22** and **26** to terminals **18** and **20**. If both transistors **24** and **28** are conducting in saturated condition, they connect their respective current sources directly to ground. When, however, transistor **24** is cut-off and transistor **28** is conducting, current flows in the direction of arrow **34** through conductor **12** and transistor **28**. Similarly, when transistor **28** is cut-off and transistor **24** is conducting, current flows in the opposite direction indicated by arrow **36** through conductor **12** and transistor **24**. Thus, by suitable control of transistor cut-off signals from sources **30** and **32**, a selectively bipolar current drive may be provided through conductor **12** to the magnetic cores **10**. As a substitute for perfect operational balance of transistors **24** and **28** and their respective current sources, a parallel arrangement of oppositely polarized diodes **38** and **40** may be employed to prevent current leakage through conductor **12** when both transistors are in conducting condition. If the characteristics of either transistor **24** or **28** change, a voltage unbalance will occur between junctions **18** and **20**. This voltage unbalance must exceed the forward biasing voltage, typically 0.5 volt, of diode **38** or **40** before leakage current can flow between the junctions. The diodes operate to prevent relatively light current flow from flowing through the conductor **12** when both transistors **24** and **28** are conducting. The degree of transistor operational unbalance tolerated, then, is set by the forward bias voltage required to turn on the diodes.

It will be appreciated that the constant current aspect of sources **22** and **26** simplifies the design of the circuit by relieving it of high speed current switching requirements; and, since transistors **24** and **28** are constantly in either saturated or cut-off condition, they dissipate little power. The only critical limitation on the speed of switching from one direction of drive to another is the rise and fall time of the transistors **24** and **28**. Another advantage of the circuit, from the viewpoint of electronic data processing systems, is that two transistors must be in proper condition, i.e. one off and one on, to provide a current drive in the desired direction. This permits logical matricing of groups of drive inputs, for such purposes as multiple row and column drives of magnetic core memories, etc. Another advantage of this drive circuit is that the voltage reaction to the inductive character of the load is always applied to the transistor which is cutting off. This makes it possible to use a transistor with approximately half the voltage rating that would

otherwise be required to accommodate the positive and negative voltage excursions resulting from the conventional practice of using the high impedance characteristics of a transistor collector circuit to regulate switching of current pulses through an inductive load.

One illustrative embodiment of the invention has been described with reference to specific circuit components. The invention is not limited to these particulars, however, but embraces the full scope of the following claims and may be employed with relays and other circuit devices as well as magnetic cores in both single conductor applications and matrixed arrangements.

What is claimed is:

1. Electronic apparatus comprising: a plurality of magnetic signal translating elements each being capable of assuming a first stable condition of magnetic flux in response to exposure to the magnetic field of electric current passing in one direction and assuming a second stable condition of magnetic flux in response to exposure to the magnetic field of electric current passing in the opposite direction; a conductor of electric current linking said plurality of elements and having first and second terminals at opposite ends thereof; a first source of electric current connected to said first terminal; a second source of electric current connected to said second terminal; a first point of reference potential; a second point of reference potential; a first current switch connected between said first terminal and said first point of reference potential; a second current switch connected between said second terminal and said second point of reference potential; and, means for selectively energizing said first or said second switch so that current may flow from said first source in one direction through said conductor and said second switch to said second reference point or from said second source in the opposite direction through said conductor and said first switch to said first reference point, as desired.

2. The invention according to claim **1** wherein: said sources supply constant current; said switches are normally closed to permit current flow; and, means is provided whereby said switches may be selectively opened to divert current flow from their corresponding reference point, through said conductor to the other switch and reference point.

3. The invention according to claim **2** wherein a parallel combination of unidirectional current conducting devices is connected in series with said conductor, said devices being arranged to permit relatively heavy current to flow through said conductor in one direction or the other when one or the other of said current switches is opened but to prevent relatively light current from flowing through said conductor when both of said switches are closed.

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