SELECTION SYSTEM

Filed April 26, 1955 2 Sheets-Sheet 1

FIG. 1.

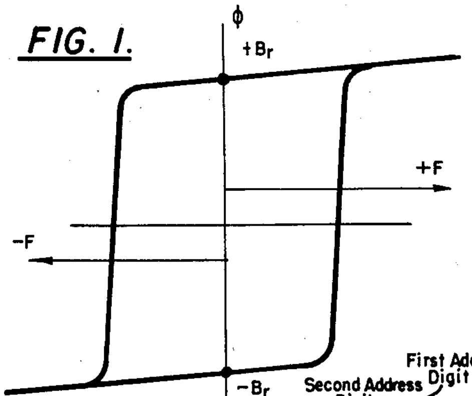
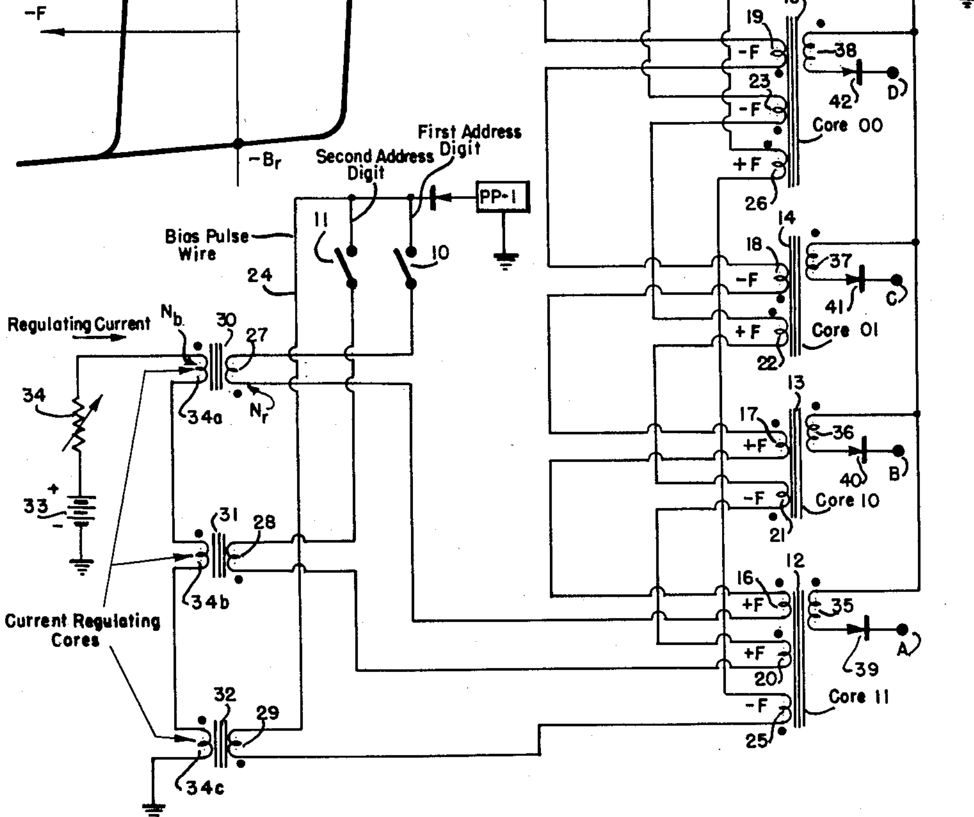


FIG. 2.



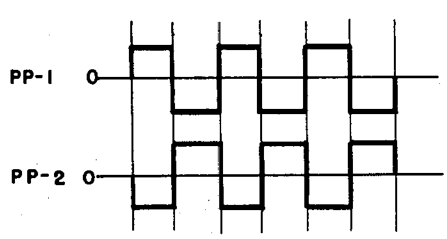


FIG. 3.

INVENTOR.
JOSEPH D. LAWRENCE, JR.
BY
Charles C. English
AGENT

SELECTION SYSTEM

Filed April 26, 1955 2 Sheets-Sheet 2

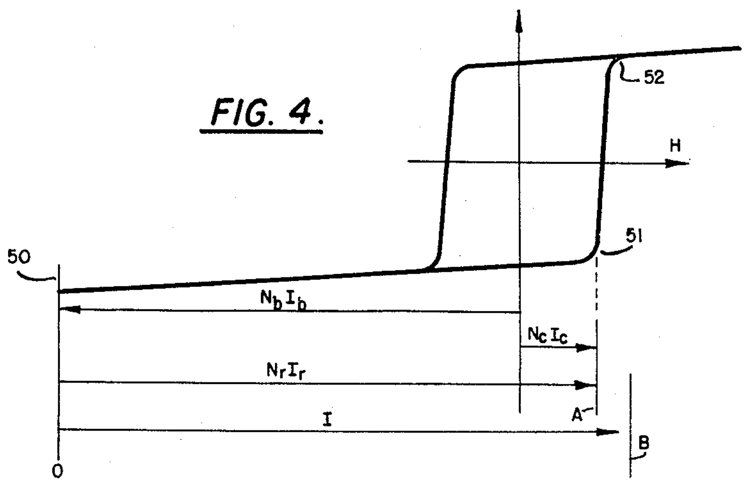


FIG. 4.

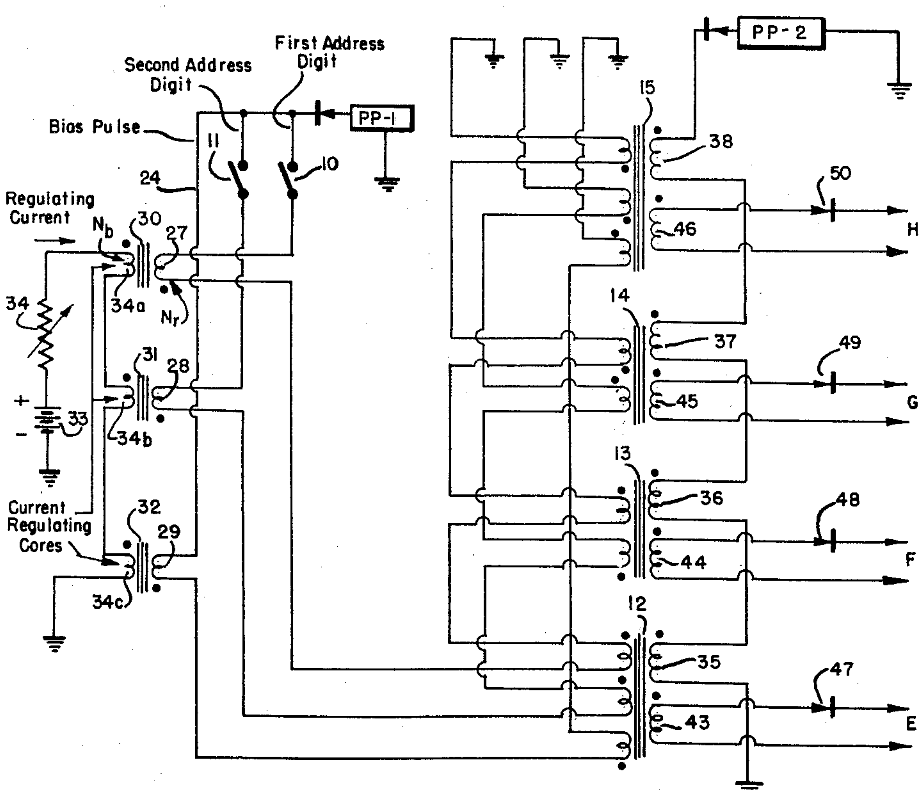


FIG. 5.

INVENTOR.
JOSEPH D. LAWRENCE, JR.
BY
Charles C. English
AGENT

United States Patent Office

2,923,833
Patented Feb. 2, 1960

2,923,833

SELECTION SYSTEM

Joseph D. Lawrence, Jr., Philadelphia, Pa., assignor, by mesne assignments, to Sperry Rand Corporation, New York, N.Y., a corporation of Delaware

Application April 26, 1955, Serial No. 504,072

27 Claims. (Cl. 307—88)

This invention relates to selection systems and more particularly to such systems in which particular outputs are selected according to which of several binary signals are fed to the input. The present invention is particularly applicable to selection systems having magnetic amplifiers or transformers as components thereof.

Selection systems of the general character hereinafter described have long been known. The prior art systems, however, are purely switching systems which select a given output according to a particular binary number fed to the input. The present invention not only performs this result but has gain at the output as well, that is, the power appearing at the output is greater than that required at the input. Moreover, in the prior art there were certain disadvantages in that when a large number of cores were involved, the impedance to the input currents varied widely and consequently the device was unreliable. The present invention provides for regulation of these currents to improve the reliability.

One object of this invention is to provide a magnetic selection system having gain.

Another object of the invention is to provide a magnetic selection system with improved reliability.

An additional object of the invention is to provide a magnetic selection system in which there is greater output than has heretofore been practical with a given input.

In carrying out the aforesaid objects, a plurality of magnetic amplifiers are provided, each with a plurality of input coils. The input coils are so connected with the inputs that particular cores are selected according to known principles. By virtue of the fact that magnetic amplifiers are employed in connection with each of said cores, the apparatus may be arranged to have gain. Moreover, a current regulating winding is provided in series with each input to prevent unreliable operation of the system. Other features of the invention will appear in conjunction with the detailed description which follows.

In the drawings:

Figure 1 is a hysteresis loop for the core materials used for cores **12**, **13**, **14**, and **15** of Figure 2.

Figure 2 is a schematic diagram of a simplified form of the invention.

Figure 3 is a timing diagram for the pulse generators of Figure 2.

Figure 4 is a hysteresis loop used in explaining the operation of cores **30**, **31**, and **32** of Figure 2.

Figure 5 is a schematic diagram of a modified form of the system.

In Figure 2, there are two pulse generators PP–1 and PP–2 which produce square wave alternating currents timed as shown in Figure 3. There are two input switches **10** and **11** which respectively represent the first and second address digits. There are four output cores **12**, **13**, **14**, and **15** which may be selected depending on the closure of switches **10** and **11**. Switch **10** is in series with coils **16**, **17**, **18**, and **19** respectively, on the cores **12**, **13**, **14**, and **15**. Switch **11** is respectively in series with coils **20**, **21**, **22**, and **23** respectively, on the cores

12, **13**, **14**, and **15**. A bias pulse wire **24** feeds coils **25** and **26** on cores **12** and **15**. The windings **16**–**19** inclusive, **20**–**23** inclusive, **25** and **26** produce magnetizing forces in the several cores in directions depending on the directions in which the coils are wound. Those coils marked —F produce a negative magnetizing force of substantially the magnitude shown by the arrow —F of Figure 1, while those coils accompanied by the legend +F produce positive magnetizing forces of approximately the magnitude shown by the arrow +F of Figure 1. If it be assumed at the start of the apparatus that all of the cores are at negative remanence $-Br$, it is clear that for any particular binary signals fed into the system by switches **10** and **11**, only one of the four cores will be flipped to plus remanence $+Br$. For example, if both switches **10** and **11** remain open, the only core which has a positive magnetizing force thereon is core **15**. This magnetizing force arises by virtue of pulses flowing from wire **24** through coil **26**. Since no currents are flowing through switches **10** and **11**, coils **16** to **19** inclusive, and **20** to **23** inclusive, have no currents flowing therethrough. Coils **25** and **26** have currents flowing therethrough but coil **25** produces a negative magnetizing force, hence the only core subjected to a positive magnetizing force is core **15**. It will then be flipped to positive remanence $+Br$ (see Figure 1). If it next be assumed that all cores are returned to negative remanence $-Br$ and then switch **10** is closed while switch **11** remains open, the only core which will be flipped will be core **13**. Core **12** will not be flipped, for although it has current flowing through coil **16** producing a positive magnetizing force, this is neutralized by the fact that the current flow through coil **25** produces a negative magnetizing force. Coil **20** is idle. Core **14** will not be flipped since only coil **18** is energized and it produces a negative magnetizing force. Core **15** will remain at negative remanence, since coil **23** is idle and the magnetizing forces of coils **19** and **26** oppose each other. The current from switch **10** flowing through coil **17** will, however, flip core **13** to positive remanence.

By similar reasoning, if switch **11** is closed and switch **10** remains open, the only core receiving a positive magnetizing force will be core **14**.

If switches **10** and **11** are concurrently closed, the only core receiving a positive magnetizing force will be core **12**. In this case the two coils **17** and **21** on core **13** will have opposing magnetizing forces. The coils **18** and **22** on core **14** also have opposite magnetizing forces. Core **15** would have a net magnetizing force of —F since all three of its coils would be energized, hence it would remain at negative remanence.

Figure 3 shows that the positive excursions of source PP–1 occur in the spaces between the positive excursions of source PP–2. Hence, after each positive excursion of source PP–1, one of the four cores **12** to **15** inclusive, will be driven to positive remanence as hereinabove described. During the next time interval, a positive excursion from source PP–2 will return the previously flipped core to negative remanence and insure that all of the other cores stand at negative remanence. Each positive excursion of source PP–2 is a resetting pulse that flows through coils **35** to **38** inclusive which apply negative magnetizing forces to the cores. Rectifiers **39** to **42** inclusive, which are respectively in series with said four coils, enable the device to have gain. In other words, if terminals A, B, C, and D are regarded as four output terminals, it is possible to produce greater power at these outputs than is fed into the input circuits **10** and **11**. Moreover, currents at the outputs A to D inclusive will indicate which of the four cores was flipped. The core which was previously flipped to positive remanence will cause the coil thereon to have high impedance to the next pulse from source PP–2 and hence the current to the output (A to D inclusive) associated with that core will be rather small compared to the other output currents. In the system described above, the amplifiers are series magnetic amplifiers, thus, during the positive portion of PP–2 all but one will have an output. If parallel magnetic amplifiers are used as shown in Figure 5, only one amplifier will have an output during the positive portion of PP–2. The power windings **35** to **38** inclusive are connected in series. The output coils **43** to **46** inclusive provide outputs at E to H inclusive. The selected core is driven from negative remanence $-Br$ to positive remanence $+Br$ by the positive pulse of source PP–1. This would not normally produce an output at E to H inclusive, since the rectifiers **47** to **50** inclusive are in the wrong direction to permit such. However, the next positive excursion of source PP–2 will provide a resetting pulse that will drive the selected core from positive remanence back to negative remanence and induce a potential in the coil (**43** to **46** as the case may be) associated with the selected core but not in any of the other coils. Hence a signal will only appear at one of the outputs E to H inclusive. Except as described in this paragraph, the system of Figure 5 operates the same as the one of Figure 2.

Systems somewhat similar to the ones just described have been previously described but they are magnetic switching systems only. In other words, they perform a switching function only without having the property of gain. By virtue of the rectifiers **39** to **42** inclusive and **47** to **50** inclusive, in combination with the circuits shown, it is possible to produce gain so that the signals arriving at the several outputs A to H inclusive have greater power than those fed through switches **10** and **11**.

The reason that the diodes **39** to **42** and **47** to **50** enable the apparatus to have gain is as follows. Taking Figure 5, for example, if the diodes were not present, the coil **46** would be shunted directly across the load. Hence, any pulse passing through the primary winding of the core **15** could not flip the core unless it had enough power to overcome the effect of the short-circuited coil **46**. However, when the diode **50** is present, it effectively isolates the load from the coil **46** during the period of time when pulses through the primary are flipping the core. Therefore, a pulse in the primary of the core **15** may flip the core without also energizing the load. It follows that only a small amount of power is necessary to flip the core. Thus, the output signal resulting when source PP–2 resets the core has a large amount of power as compared to the input power which is required when the diode **50** is present; yet would be about equal to that which is required at the input when the diode **50** is not present. A similar explanation applies to Figure 2.

The previous disclosures have carefully explained how the aforesaid systems may be expanded to have a large number of inputs and a very large number of cores, any one of which may be selected by closing particular input switches such as **10** and **11**. In the expanded form of this system, some of the bias windings, such as **25** and **26**, have two, three or four times the turns of other bias windings. Since the principle upon which the present system may be expanded is well known, it will not be elaborated upon. However, when so expanded, a difficulty arises in that the input circuits have varying impedances depending on the circumstances and as a result it is sometimes found that the current variations in one or more of the input circuits are so serious that the system gives a false indication. This may be overcome by employing a current regulator in series with each input. One convenient form of current regulator is shown in Figure 2 wherein there are coils **27**, **28**, and **29** respectively, in series with the inputs **10**, **11**, and **24** respectively. These coils are respectively wound on cores **30** to **32** inclusive.

The battery **33** and resistor **34** cause a flow of current through coils **34***a*, **34***b*, and **34***c* which produce magnetizing forces in the cores **30**, **31** and **32** in a negative direction so large as to drive the core very far into saturation region. Figure 4 illustrates this operation and shows that the bias current I_B produced by the battery **33** together with the number of turns N_B on coil **34***a* produces a negative magnetizing force driving the core into a highly negatively saturated region **50** of the hysteresis loop. During its positive excursion, source PP–1 produces more voltage than is dropped across the amplifier set windings. Therefore, the current output of PP–1 will increase until limited by back voltages developed in regulator coils **27**, **28**, and **29**. These coils will not develop appreciable voltage until magnetizing force N_RI_R (which derives from current produced by PP–1) reaches the knee of the hysteresis loop, point **51**. The magnetizing force of coil **27** is represented by a vector N_RI_R of Figure 4, where N_R is the number of turns on coil **27** and I_R is the peak pulse current in coil **27**. As the pulse current rises to the value I_R the coil **27** has low back voltage since the core is being driven in a positive direction along the hysteresis loop from point **50** to point **51** in which region there is very little flux change. However, as the current I_R tends to rise above a limiting value so that the vector N_RI_R becomes longer, tending to drive the core more positively than point **51** on the hysteresis loop of Figure 4, the back voltage developed in coil **27** begins to rise rapidly because of the large flux change occurring to the right of point **51**. In fact, the coil **27** would exhibit a very high back voltage if the current in coil **27** tended to drive the core from point **51** to point **52** on the hysteresis loop.

The current in coil **27** may be represented by vector I of Figure 4 and this current is limited to a value between A and B of Figure 4. Even though the impedances of one or more of the coils **16** to **26** should change considerably, the over-all current in each circuit will still be held substantially constant by reason of the current regulator.

I claim to have invented:

1. In a selection system for magnetic cores, a plurality of magnetic cores, a plurality of series circuits each of which has a coil on each of said cores, a pulse generator for producing a train of regularly spaced pulses and feeding said pulses to said series circuits, an address input for each series circuit and having different operating states for selectively controlling flow of said regularly spaced pulses from said generator through the series circuit to select one of said cores to be flipped, a bias series circuit connected to said pulse generator and having coils on some of the cores energized by each of said pulses, the winding directions and numbers of turns on any given core being such that the core has a magnetizing force therein in one direction when the address inputs are in respective states calling for flipping of the given core, a power winding on each core, and means for passing pulses through the power windings during the spaces between pulses of said generator for magnetizing the core in the other direction.

2. In a selection system as defined in claim 1, at least some of the series circuits having current regulating means therein to control the amplitudes of the pulses therethrough.

3. In a selection system as defined in claim 1, each series circuit having means therein for holding the maximum amplitudes of the pulses therethrough constant.

4. In a selection system for magnetic cores, a plurality of magnetic cores, a plurality of series circuits each of which has a coil on each of said cores, a pulse generator for producing a train of regularly spaced pulses and feeding the pulses to each series circuit, an address input for each series circuit and having different operating states for selectively controlling flow of said regularly

spaced pulses from said generator through the series circuit to select one of said cores to be flipped, a bias series circuit connected to said pulse generator and having coils on some of the cores energized by each of said pulses, current regulating means in each series circuit for holding the peak pulse current in each circuit substantially constant, the winding directions and number of turns on any given core being such that that core has a magnetizing force therein in one direction when the address inputs are in respective states calling for flipping of that given core, and means for applying pulses of magnetizing forces to the core in a second direction opposite to said one direction during the spaces between pulses of said generator.

5. In a selection system for magnetic cores, a plurality of magnetic cores, a plurality of selectors, a plurality of series circuits controlled by said selectors, each series circuit having coils on a plurality of cores and each core having at least two coils thereon whereby the regions of the hysteresis loops on which the cores operate may be controlled by operating said selectors, a pulse generator connected to said series circuits so that its pulses are controlled by said selectors, and current regulating means in at least some of the series circuits for holding the peak pulse current in said circuits substantially constant.

6. In a selection system for magnetic cores, a plurality of magnetic cores each having at least two coils thereon, means connecting said coils into groups of circuits with each circuit being separate from the others, means tending to pass regularly spaced pulses through each of said circuits, selecting means in said circuits for controlling the flow of pulses therethrough, a bias series circuit fed by said pulse generator and having coils on some of the cores, and current regulating means in each of said circuits for holding the peak pulse current of the circuit substantially constant.

7. In a selection system for magnetic cores, a plurality of magnetic cores, a plurality of series circuits each of which has a coil on each of said cores, a pulse generator for producing a train of regularly spaced pulses and feeding the pulses to said series circuits, an address input for each series circuit and having different operating states for selectively controlling flow of said regularly spaced pulses from said generator through the series circuit to select one of said cores to be flipped, a bias series circuit connected to said pulse generator and having coils on some of the cores energized by each of said pulses, the winding directions and numbers of turns on any given core being such that the core has a magnetizing force therein in one direction when the address inputs are in respective states calling for flipping of that given core, a power winding on each core, means for passing pulses through the power windings in a direction opposite said one direction during the spacing between pulses of said generator, and an output winding on each core.

8. In a selection system as defined in claim 7, means having a rectifier in series with each output winding.

9. A selection system as defined in claim 1 in which the last named means includes a unilateral conducting element disposed in series with the respective power windings wound on each core.

10. A selection system as defined in claim 4 in which the last named means includes each of the following associated with each core, a coil on the core, a rectifier, and an output, said coil, rectifier and output being connected in series.

11. A selection system as defined in claim 4 having an output coil on each core and a rectifier in series with each output coil whereby the system has gain.

12. A selection system as defined in claim 5 having output means associated with each core for sensing the cores and producing output pulses with greater power than was present in the series circuit having the greatest power.

13. A selection system as defined in claim 6 having output means associated with each core for sensing the cores and producing output indications with greater power than is fed into one of said circuits.

14. In a selection system for magnetic cores, a plurality of magnetic cores, a plurality of series circuits each of which has a coil on each of said cores, a pulse generator for producing a train of regularly spaced pulses and feeding said pulses to said series circuits, an address input for each series circuit and having different operating states for selectively controlling flow of said regularly spaced pulses from said generator through the series circuit to select one of said cores to be flipped, a bias series circuit connected to said pulse generator and having coils on some of the cores energized by each of said pulses, the winding directions and numbers of turns on any given core being such that the core has a magnetizing force therein in one direction when the address inputs are in respective states calling for flipping of the given core, and means cooperating with said cores for providing a signal that indicates which core has been flipped and which applies a resetting magnetizing force to each core during the spaces between pulses of said train.

15. A selection system as defined in claim 14 in which the last-named means includes two separate coils on each core, one of which is an output coil, and also includes means for passing resetting pulses through the other of said two coils during the spaces between pulses of said train.

16. A selection system as defined in claim 15 having a rectifier in series with the output coil, the rectifier being connected to allow a pulse to flow therethrough from the coil when the core is reset by a resetting pulse.

17. A selection system as defined in claim 14 in which the last-named means employs only one coil on each core and in which the last-named means feeds the resetting pulse to one end of each said coil, the other end of each said coil constituting an output.

18. A selection system as defined in claim 17 in which there is a rectifier in the output wire of each said output coil, each rectifier being connected to allow a pulse to flow therethrough from the coil when the latter has low impedance and is fed by a resetting pulse.

19. In a selection system for magnetic cores, the combination of a plurality of saturable magnetic cores, a plurality of circuits having coils on said cores, means for selectively applying pulses to said circuits and separate current regulating means in said circuits for holding the peak pulse currents therein substantially constant, each of said current regulating means comprising a further magnetic core, a first winding on said further magnetic core, said first winding being in series with one of said circuits to be regulated, a second winding on said further magnetic core, and a source of regulating current coupled to said second winding thereby to regulate current flow through said first winding.

20. A selection system as in claim 19 wherein said further magnetic core is formed from a material exhibiting a substantially rectangular hysteresis loop.

21. In a selection system for magnetic cores, the combination of a plurality of saturable magnetic cores, a plurality of circuits having coils on said cores, means for selectively applying pulses to said circuits and separate current regulating means in said circuits for holding the peak pulse currents therein substantially constant, each of said current regulating means comprising a further magnetic core, a first winding on said further magnetic core, said first winding being in series with one of said circuits to be regulated, a second winding on said further magnetic core, and a source of regulating current coupled to said second winding said source of regulating current being of intensity sufficient to bias said further core into a substantially saturated region of its hysteresis loop, the direction of current flow through said first winding being such as to drive said further core out of said saturated region whereby current flow up to a certain

maximum encounters relatively low impedance and current flow exceeding said maximum drives said core out of its saturated region thereby increasing the impedance of said first winding.

22. A selection system as in claim 21 further including means to control flow of said regulating current through said second winding on said further core thereby establishing maximum flow of said current to be regulated.

23. In a selection system for magnetic cores, the combination of a plurality of saturable magnetic cores, a plurality of circuits having coils on said cores in different combinations with each of said cores having coils from a plurality of said circuits, means for selectively applying pulses to said circuits in certain combinations to select one of said cores, and separate current regulating means in said circuits for holding the peak pulse currents therein substantially constant, each of said current regulating means comprising a further magnetic core, a first winding on said further magnetic core, said first winding being in series with one of said circuits to be regulated, a second winding on said further magnetic core, and a source of regulating current coupled to said second winding said source of regulating current being of intensity sufficient to bias said further core into a substantially saturated region of its hysteresis loop, the direction of current flow through said first winding being such as to drive said further core out of said saturated region whereby current flow up to a certain maximum encounters relatively low impedance and current flow exceeding said maximum drives said core out of its saturated region thereby increasing the impedance of said first winding.

24. In a system for selecting magnetic cores in accordance with binary signals, the combination of a plurality of magnetic cores, a plurality of input coils linked to each of said cores a plurality of address input switching means each corresponding to a digit position, a single series circuit for and controlled by each of said address input means, each of said series circuits including a coil on each of a plurality of said cores, a further series circuit having coils on each of a plurality of said cores, and a pulse source connected for applying each of its pulses to said address series circuits via said address input means and to said further series circuit directly, whereby said address input means are each adapted to control the driving or the absence of driving of the associated series circuit in accordance with said binary signals, said further series circuit being driven during every pulse period.

25. A selection system as in claim 24, wherein each of said cores has a separate set winding thereon, a further pulse source for supplying pulses to said set windings, said pulses from said further source being out of phase with respect to pulses from the first-named source, and means coupling an output terminal to each of said set windings so that pulses from said further source appear at the output terminals of all of said set windings except at the output terminal of the set winding on a selected core.

26. A selection system as in claim 24 wherein each of said cores has a separate set winding thereon and an output winding thereon, a further pulse source for supplying pulses to said set windings, said pulses from said further source being out of phase with respect to pulses from the first-named source, and means coupling an output terminal to each of said output windings whereby pulses from said further source are effective to revert a selected core driven by a pulse from said first-named source during a preceding pulse period, and an output appears at the output terminal of the output winding on said selected core.

27. In combination, a plurality of saturable magnetic cores, a plurality of windings on each of said cores, a plurality of circuits respectively comprising certain of said windings from different ones of said cores connected together in series, means for selectively supplying pulses to various combinations of said circuits so that for each such combination of circuits to which pulses are supplied a different one of said cores is driven to saturation, and separate current regulating means connected to said circuits for holding the peak pulse currents therein substantially constant, each of said current regulating means comprising a further saturable magnetic core, a first winding on said further magnetic core, said first winding being in a series circuit with the associated one of said circuits to be regulated and said pulse supplying means and having a sense of linkage to drive said further core in one direction in response to said pulses, a second winding on said further magnetic core, and a source of regulating current coupled to said second winding to bias said further core to saturation in the opposite direction thereby to regulate current flow through said first winding.

References Cited in the file of this patent

UNITED STATES PATENTS

2,730,694	Williamson	Jan. 10, 1956
2,734,183	Rajchman	Feb. 7, 1956
2,853,693	Lindenblad	Sept. 23, 1958