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D. G. BINDON ET AL

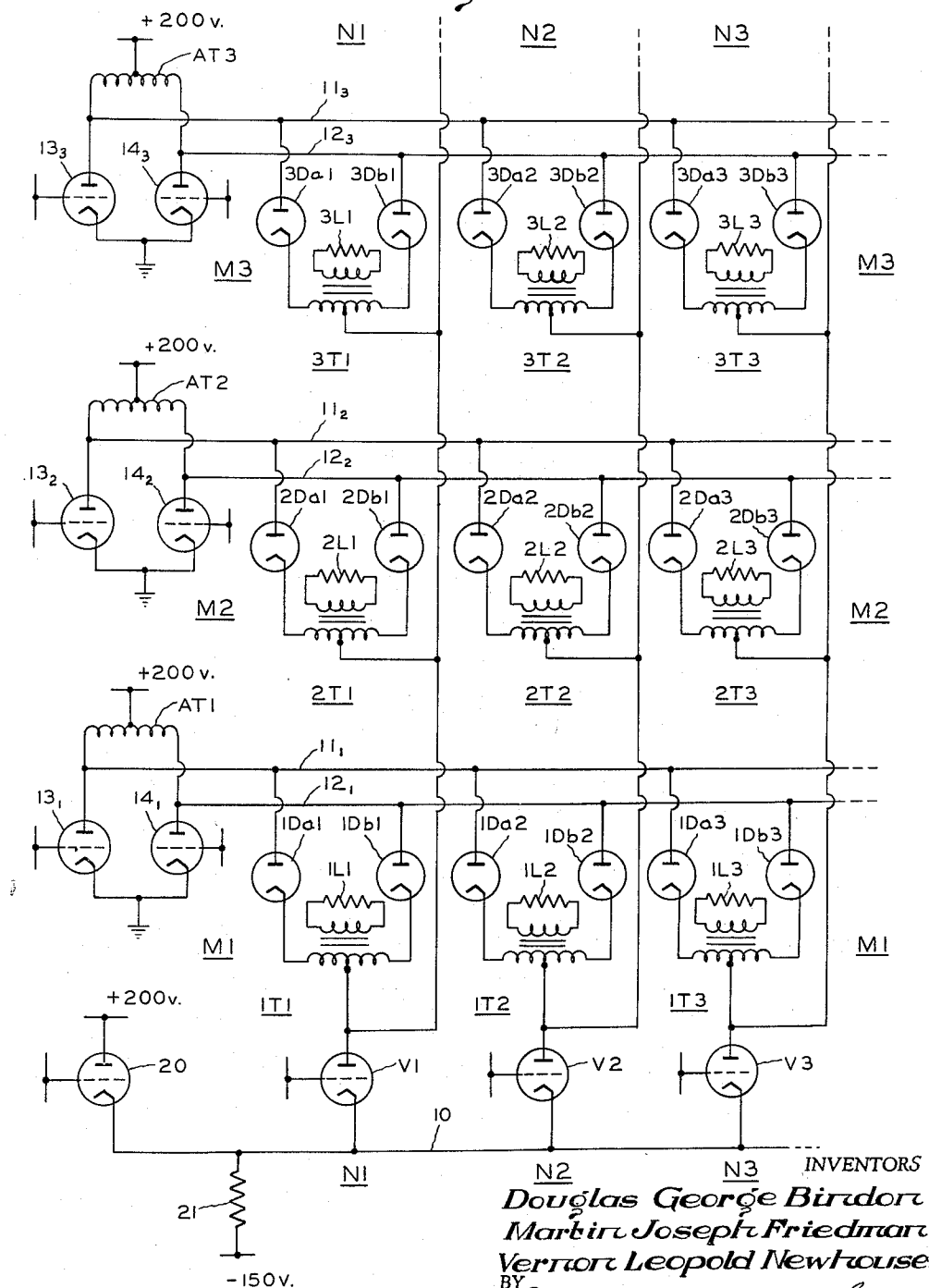
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ELECTRONIC SELECTOR STAGES

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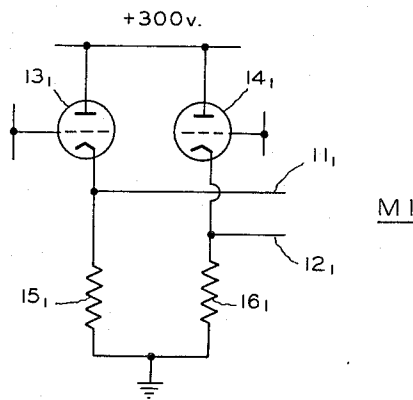
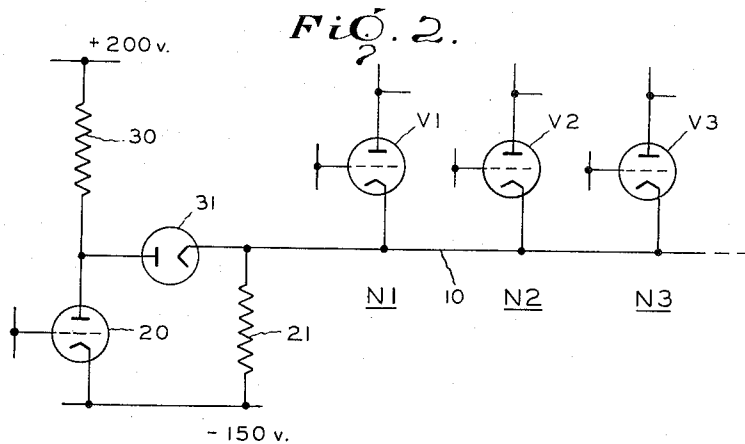


FIG. 3

INVENTORS
Douglas George Bindon
Martin Joseph Friedman
Vernon Leopold Newhouse
BY *Cameron, Kerkam & Sutton*
ATTORNEYS

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ELECTRONIC SELECTOR STAGES

Douglas George Bindon, Withington, Manchester, and Martin Joseph Friedman, Handforth, England, and Vernon Leopold Newhouse, Moorestown, N. J., assignors to Ferranti, Limited, Hollinwood, Lancashire, England, a company of Great Britain

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6 Claims. (Cl. 340—166)

This invention relates to electronic selector stages for pulse-energizing any selected one of a plurality of loads.

The invention has particular but not exclusive application to magnetic-core stores of the kind including a large number of wound saturable cores acting as bi-stable elements for the storage of digital information, these elements constituting the loads above referred to.

In such stores it is desirable to be able to produce in any selected core two sequential current pulses of opposite sense. Circuits for effecting this are available but all require a considerable quantity of components, especially where the number of store elements is large.

An object of the present invention is to provide an electronic selector stage for producing in any selected one of a plurality of loads two sequential current pulses of opposite sense, in which the number of components is reduced to a minimum.

In accordance with the present invention an electronic selector stage for producing in any selected one of a plurality of loads two sequential current pulses of opposite sign comprises a row-and-column array of load-energising transformers the primary winding of each of which is electrically divided into two parts by an intermediate tapping, individual to each column of transformers a column-selecting discharge tube having at least a cathode, an anode, and an intermediate control grid electrode, the tube being included in the connection to the intermediate tapping of each transformer in that column, individual to each row of transformers a pair of sense-determining discharge tubes each tube having at least a cathode, and anode, and an intermediate control grid electrode, the two tubes of each pair being associated with the circuits of one and the other, respectively, of the said parts of the primary winding of each transformer of that row, driving means for energising by each of two sequential voltage pulses the column-selecting tube of the column containing the transformer for energising the selected load, and control means for so controlling the sense-determining discharge tubes of the row containing that transformer as to ensure that said two pulses energise said two parts of the primary winding sequentially, thereby energising the selected load in opposite senses.

In the accompanying drawings,

Figure 1 is a schematic diagram of one embodiment of the invention, and

Figures 2 and 3 show modifications of parts of the embodiment of Figure 1 in accordance with further embodiments.

In carrying out the invention in accordance with one form by way of example, see Fig. 1, an electronic selector stage for use with a binary digital computer includes for the pulse-energisation of loads 1L1, 1L2, 1L3, . . . , 2L1, 2L2, 2L3, . . . , etc. (each load being shown for convenience as a resistor) an array of load-energising transformers.

These transformers are arranged electrically in n col-

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umns N1, N2, N3, . . . Nn, containing (in column N1) transformers 1T1, 2T1, 3T1, etc. (in column N2) transformers 1T2, 2T2, 2T3, etc. and so on. The same transformers are also arranged electrically in m rows M1, M2, M3, . . . Mn containing respectively transformers 1T1, 1T2, 1T3, etc., transformers 2T1, 2T2, 2T3, etc., and so on. Only the first three columns and rows are shown.

There are therefore nm transformers, each for energising one of the loads.

The terms "row" and "column," as applied to the array of transformers, are used to simplify the description. As will be appreciated from the ensuing description, the terms indicate the electrical rather than the physical arrangement of the transformers, which may be arranged physically in any desired manner.

The primary winding of each transformer is divided into two parts by an intermediate tapping—conveniently a centre tapping.

The secondary windings of the transformers are connected to the respective loads, transformer 1T1 being associated with load 1L1, transformer 2T1 with load 2L1, and so on.

Individual to each column N1 to Nn of transformers is a column-selecting discharge tube or valve V1, V2, . . . Vn as the case may be. These valves are shown as triodes; valves having additional electrodes, such as pentodes, may alternatively be employed if desired. The anode of valve V1 is connected to the centre tap of each transformer 1T1, 2T1, 3T1, . . . etc. in row N1. The anode of valve V2 is similarly connected to the centre tap of each transformer 1T2, 2T2, 3T2, . . . etc. in row N2; and so on. Hence each of these valves is included in the connection to the intermediate tapping of each transformer in the column associated with that valve.

The cathode of each valve is connected by way of a common lead 10 to one end of a cathode load resistor 21 the other end of which is connected to a source of —150 volts. Resistor 21 thus serves as a cathode load common to all these valves.

Bias means are provided for varying the voltages on the control grids of valves V1 to Vn as described below. As this may be effected in some conventional manner the bias means are not shown.

One end of each primary winding (the left-hand end, as depicted) of the transformers in row M1 is connected to the cathode of a diode valve 1Da1, 1Da2, 1Da3, . . . as the case may be, the anode of which is connected to a lead 11₁ common to that row. The other (the right-hand) end of each primary in this row is similarly connected by way of a diode 1Db1, 1Db2, 1Db3, . . . as the case may be, to another lead 12₁, also common to that row.

Similar arrangements are made for each of the other rows; the common leads in row M2 are 11₂ and 12₂, and so on.

The potentials of the common leads 11₁ and 12₁ of row M1 are respectively controlled by a pair of sense-determining discharge tubes or valves 13₁ and 14₁, which are individual to that row and determine the sense of each load-energising pulse in it. The anodes of these valves are connected to leads 11₁ and 12₁ respectively; the anodes are also connected to the respective ends of an autotransformer winding AT1. The mid point of this winding is connected to a source of +200 volts, which serves as the source for all the valves in the stage. The cathodes of the valves are earthed. Valves 13₁ and 14₁ are thus associated with the circuits of one and the other, respectively, of the two parts of the primary winding of each transformer in row M1.

The ends of the primary windings of the transformers in row M2 are similarly connected by way of diodes

2Da1, 2Db1, 2Da2, 2Db2, etc. to common leads 11₂ and 12₂ the potentials of which are respectively controlled by sense-determining valves 13₂ and 14₂.

Similar arrangements are made for the remainder of the rows.

Control means are provided for applying pulse waveforms having an amplitude extending from about -40 volts to earth potential to the control grids of valves 13₁ and 14₁, 13₂ and 14₂, etc. as described below. These control waveforms may be derived in some conventional manner, for example by modification of waveforms already existing in the computer.

The driving means for the stage includes a further triode valve 20 the anode of which is connected to the +200 volt source and the cathode to lead 10. This valve therefore has as its cathode load resistor 21, the common cathode load of valves V1 to Vn.

In the quiescent condition of the stage the control grids of valves V1 to Vn are held at -40 volts by the bias means. The grids of the sense-determining valves 13₁ and 14₁ etc. are held at the -40 volt level by their respective control waveforms. The grid of valve 20 is held at +25 volts.

Valve 20 is therefore conducting, drawing current through resistor 21 and so holding the potential of lead 10 at about +25 volts, thereby maintaining valves V1 to Vn biased to cut-off. Valves 13₁ and 14₁ etc. are also cut off; the potentials of leads 11₁ and 12₁ etc. are therefore +200 volts.

Suppose now it is desired to energise one of the loads by two sequential current pulses of opposite sense. It is assumed for the sake of example that the load is that indicated at 3L2, this load being energised by the transformer 3T2 defined by the intersection of column N2 and row M3.

To the grid of valve 20 is applied two sequential negative-going voltage pulses (which may conveniently be referred to as the driving pulses) of amplitude sufficient to carry the grid down to about -25 volts to ensure cut-off. These driving pulses may also be derived in some conventional manner, such as by a triggered flip-flop stage or by modification of waveforms already existing in the computer. They have the same width as the required current pulses for the load and are spaced apart to the required extent.

In advance of the first of these pulses the bias means raises the grid of the valve V2 (of the column N2) to earth potential.

At approximately the same time—very slightly in advance of the first driving pulse—the control waveform of the sense-determining valve 14₃ (of row M3) is raised from -40 to earth potential. The effect of this latter voltage excursion is to cause valve 14₃ to bottom, its anode falling from +200 to +10 volts. By autotransformer action the other end of winding AT3—the end connected to the anode of valve 13₃—rises to about 400 volts, thereby raising simultaneously the potential of lead 11₃.

The effect of cutting off valve 20 by the first driving pulse is to carry the potential of lead 10 down to approximately earth level; at this point valve V2 conducts, owing to the raised potentials of its control grid and of lead 11₃, and holds lead 10 at this potential. Thus V2 is energised, the anode circuit being completed through the left-hand part of the primary of transformer 3T2, diode 3Da2, and the left-hand part of autotransformer AT3 to the positive pole of the supply. The time constant of the circuit is such that the potential of lead 11₃ remains sufficiently high for this current to continue to flow throughout the application to driving valve 20 of the first driving pulse. Diode 3Db2 remains non-conducting so that no current flows in the right-hand part of the primary. The grid of valve 14₃ is maintained at earth potential throughout the application of the driving pulse; otherwise a return to the negative potential would cause a reverse autotransformer action and prematurely lower the potential of lead 11₃.

The selected load 3L2 is thus energised in a particular sense by the first of the two sequential pulses.

None of the other valves other than V2 can be energised in response to this pulse because the bias on their control grids remains at -40 volts. The current flow is thus confined to column N2, but as the sense-determining valves of the rows other than row M3 remain cut off only the load 3L2 is energised.

At the conclusion of this first pulse valve 20 becomes again conducting, the potential level of lead 10 being raised sufficiently to cut off valve V3 despite the presence of the raised bias on its control grid.

It will be seen that the action of this driving arrangement is in effect to apply the driving pulse across the common cathode load resistor 21 and hence to the grid-cathode circuit of each of the column-selecting valves N1 to Nn, of which however only valve V2 is biased for response.

The effect of the second negative-going driving pulse on the grid of valve 20 is similar to that of the first pulse, except that this time it is valve 13₃ that is rendered conductive and accordingly it is lead 12₃ the potential of which is raised. The current path is therefore through the right-hand part of the primary of transformer 3T2 (and through diode 3Db2), with the result that the load is energised by a pulse of the same amplitude and width as before but of opposite sense.

The two parts of the primary winding are thus energized sequentially, the selected load being thereby energized in the required manner by sequential poles of opposite sense.

At the end of this second driving pulse the potentials of the various grids revert to the values appropriate to the quiescent condition.

The purpose of the diodes, which may of course be replaced by non-thermionic types of rectifier, is to prevent currents flowing in the primary windings of the other transformers.

It will be appreciated that the stage is very economical in components. Apart from diodes or other rectifiers the number of valves required to control a total of mn loads is only $(n+2m+1)$. E. g., 100 loads arranged in a 10 x 10 array require only $(10+20+1)$ or 31 valves for their control—a marked saving in components over arrangements as hitherto disclosed.

Details of the above-described embodiment may be varied within the scope of the invention.

For example, the appropriate bias changes of the grids of the column-selecting and sense-determining valves need not be effected in advance of a driving pulse but may take place in synchronism with it or even slightly after its leading edge.

The driving means may alternatively be arranged as shown in Fig. 2. Here the driving valve 20 is in parallel with the common cathode load 21 of the valves V1 to Vn. The cathode of the valve is connected to the -150 volt source. The anode is connected to the +200 volt source by way of a load resistor 30 and to the anode of a diode valve 31 the cathode of which is connected to lead 10.

With this arrangement valve 20 is maintained cut off in the quiescent condition. Diode 31 is then conducting, and the value of resistor 30 is such that lead 10 is at a positive potential, thereby maintaining all the valves V1 to Vn, including the selected one, cut off. The two sequential voltage pulses applied to valve 20 are now positive-going. Each of these driving pulses causes valve 20 to conduct. The resulting fall of its anode potential cuts diode 31 off and so allows the potential of lead 10 to fall until caught at approximately earth level by the selected one of valves V1 to Vn as before, this selected valve then conducting. The operation of this embodiment is otherwise as described with reference to Fig. 1.

It is not essential to employ valve 20. The two sequential driving pulses may be applied direct, in a positive-

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going sense, to the grid of the appropriate column-selecting valve, or to the appropriate pair of sense-determining valves (one pulse to one of these valves and the next pulse to the other valve). In the latter case these valves serve not only to determine the sense of the load-energising pulses but also to apply those pulses.

The sense-determining valves may alternatively be arranged as shown in Fig. 3, where for simplicity only the valves for row M1 are depicted.

The valves 13₁ and 14₁ are arranged to operate as cathode followers, the cathodes being connected to leads 11₁ and 12₁, respectively, and to earth by way of load resistors 15₁ and 16₁, respectively. The anodes are connected direct to the positive pole of the source, which is here 300 volts.

In the quiescent condition the grids of these valves are maintained at +200 volts; leads 11₁ and 12₁ therefore have approximately these potentials. Slightly in advance of or in synchronism with the application to valve 20 of the first of the two sequential driving pulses the grid potential of one of the valves 13₁ and 14₁—the latter, say—is depressed from +200 to +100 volts. The potential of valve 13₁ is maintained at +200 volts to render it conductive, with its cathode at approximately 100 volts positive with respect to the cathode of valve 14₁, throughout the application of the first driving pulse to valve 20. The circuit for the current flowing through the selected valve—valve V2, say—is therefore completed by way of the left-hand part of the primary of transformer 1T2, diode 1Da2, and valve 13₁. The potential of the cathode of valve 14₁ is low enough to render diode 1Db2 non-conductive so that no current flows in the right-hand part of the primary. The selected load is thus energized as before by a current pulse of a certain sense.

In the interval between the end of the first driving pulse and the application of the second the potentials on the grids of valves 13₁ and 14₁ are changed over, the grid potential of valve 14₁ being restored to +200 volts whilst that of valve 13₁ is simultaneously depressed to +100 volts. During the next pulse, therefore, valve 14₁ conducts, and the current flow through the right-hand part of the primary of transformer 1T2 and diode 1Db2a to cause the energisation of the load in the opposite sense.

At the end of the second pulse the potential on the grid of valve 13₁ is restored to +200 volts.

In any of the above-described embodiments damping resistors may if necessary be connected across the secondary windings of the load-energising transformers to prevent parasitic oscillations. Damping resistors may similarly be connected across the autotransformers AT1 etc. of the embodiment of Fig. 1 for the same purpose.

Where only a few loads are to be selectively energised the array may be reduced to a single row of transformers; the arrangement may then be as shown in Fig. 1 (which may be modified in accordance with Fig. 2 and/or Fig. 3) but with all rows other than row M1 omitted. In this arrangement the total of valves required (other than diodes) is one per load (V1 to Vn) plus three valves common to all loads (the two sense-determining valves 13₁ and 14₁, and valve 20).

What we claim is:

1. An electronic selector stage for producing in any selected one of a plurality of loads two sequential current pulses of opposite sense comprising a row-and-column

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array of load-energizing transformers the primary winding of each of which is electrically divided into two parts by an intermediate tapping, individual to each column of transformers a single column-selecting discharge tube having at least a cathode, an anode, and an intermediate control grid electrode, the tube being included in the connection to the intermediate tapping of each transformer in that column, individual to each row of transformers a pair of sense-determining discharge tubes each tube having at least a cathode, an anode, and an intermediate control grid electrode, the two tubes of each pair being associated with the circuits of one and the other, respectively, of the said parts of the primary winding of each transformer of that row, driving means for energising by each of two sequential voltage pulses the column-selecting tube of the column containing the transformer for energising the selected load, and control means for so controlling the sense-determining discharge tubes of the row containing that transformer as to ensure that said two pulses energise said two parts of the primary winding sequentially, thereby energising the selected load in opposite senses.

2. A stage as claimed in claim 1 wherein said column-selecting discharge tubes share a common cathode load and said driving means is adapted to apply said pulses to that load, bias means being provided to allow only the selected one of said tubes to take anode current in response to such application.

3. A stage as claimed in claim 2 wherein said driving means includes a further discharge tube having a cathode, an anode, and at least one intermediate control grid electrode, this tube having as its cathode load said common cathode load, and means for applying each of said pulses to cut off said tube.

4. A stage as claimed in claim 2 wherein said driving means includes a further discharge tube having a cathode, an anode, and at least one intermediate control grid electrode, this tube being in parallel with said common cathode load, and means for applying each of said pulses to energise said tube.

5. A stage as claimed in claim 1 wherein the anodes of each pair of said sense-determining tubes are connected to the ends of an autotransformer winding having an intermediate tapping connected to the positive pole of a source of high tension, the said anodes being also connected to one and to the other end, as the case may be, of the primary winding of each transformer in that row, and said control means being such as to render sequentially conductive each tube of only the selected pair of said pairs of sense-determining tubes.

6. A stage as claimed in claim 1 wherein said sense-determining tubes are adapted to operate as cathode followers, the cathodes of each pair of these tubes being connected to one end and to the other end, as the case may be, of the primary winding of each transformer in that row, and said control means being such as to render sequentially conductive each tube of only the selected pair of said pairs of sense-determining tubes.

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