

July 22, 1958

W. H. BURKHART
SWITCHING CIRCUITS

2,844,811

Filed Aug. 20, 1952

3 Sheets-Sheet 1

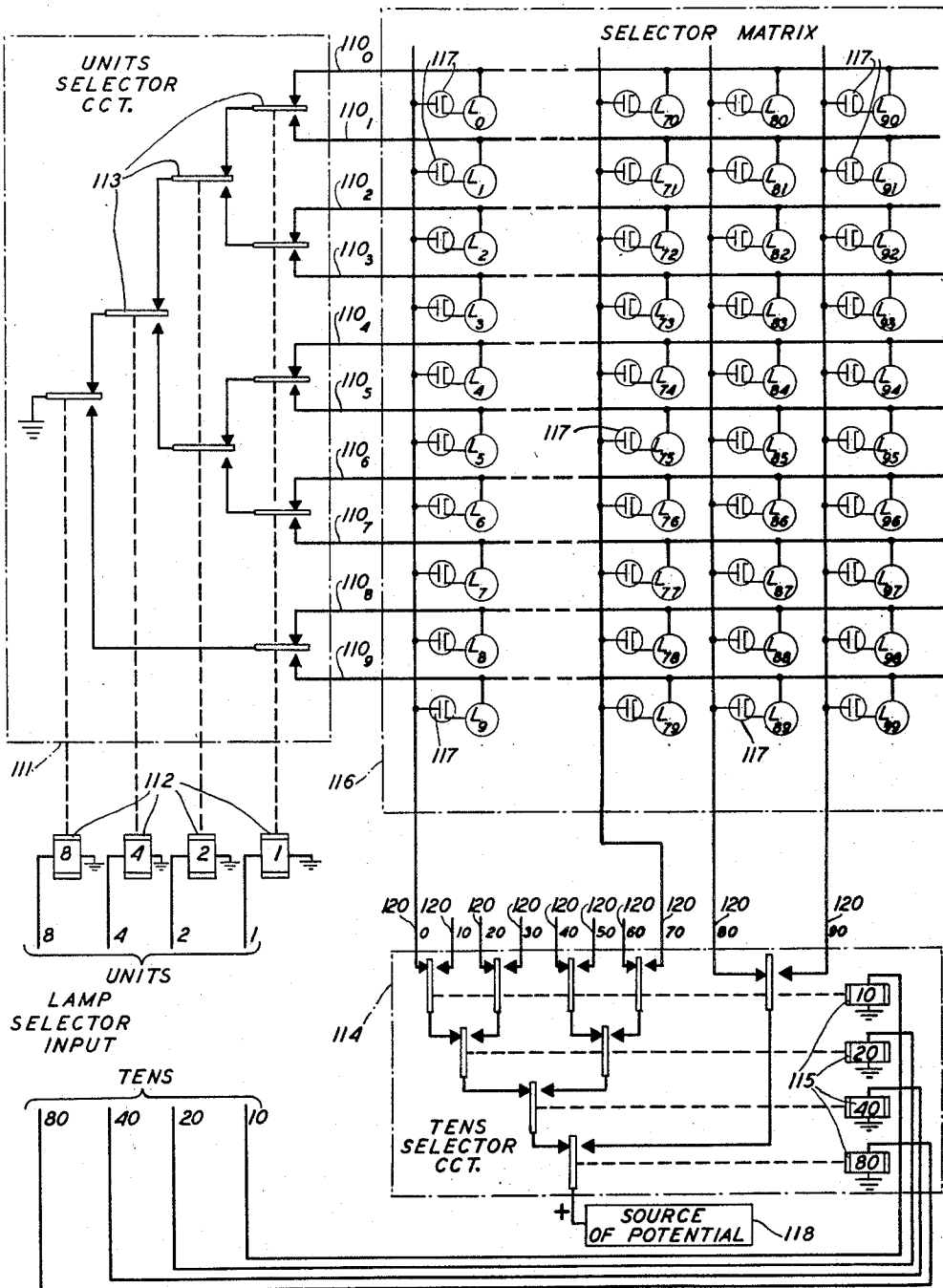


FIG. 1

INVENTOR
WILLIAM H. BURKHART
BY
William H. Burkhardt
AGENT

July 22, 1958

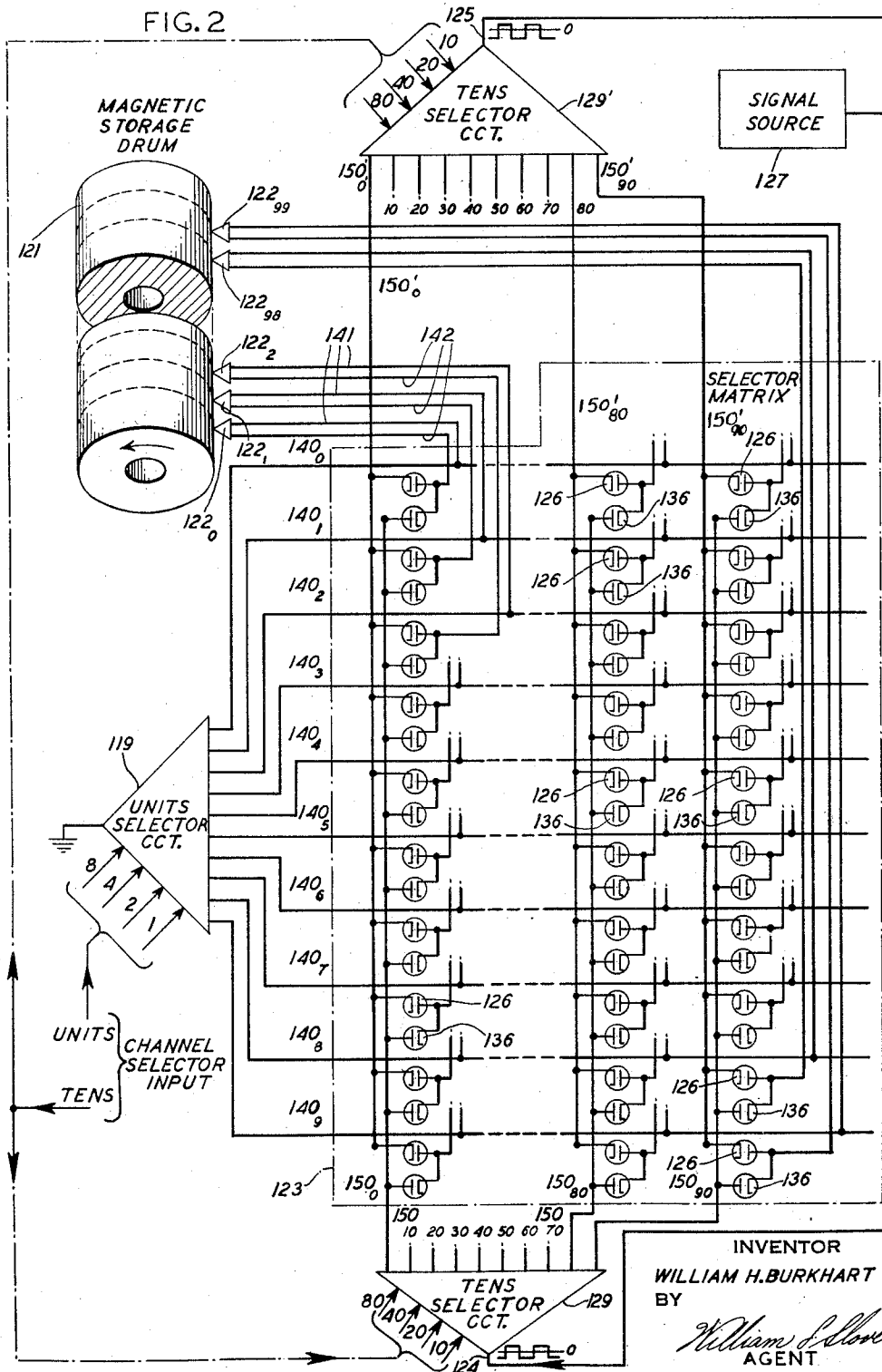
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3 Sheets-Sheet 2

FIG. 2



INVENTOR
WILLIAM H. BURKHART
BY
William H. Burkhardt
AGENT

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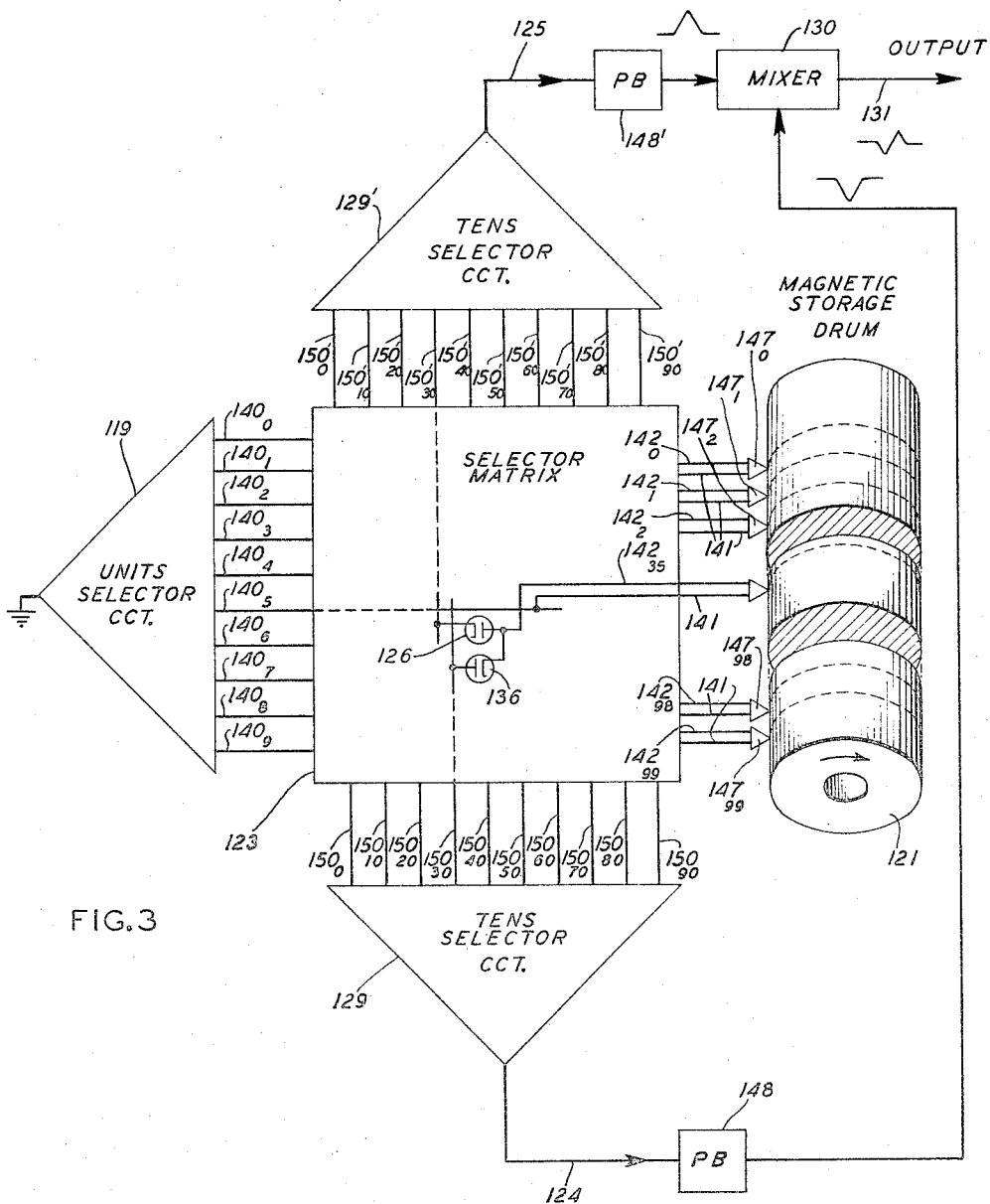


FIG. 3

INVENTOR
WILLIAM H. BURKHART
BY
William H. Burkhart
AGENT

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2,844,811

SWITCHING CIRCUITS

William H. Burkhart, East Orange, N. J., assignor to
Monroe Calculating Machine Company, Orange, N. J.,
a corporation of Delaware

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2 Claims. (Cl. 340-166)

This invention relates to new and useful improvements in switching circuits.

A switching circuit finding wide application in transferring signals from a single source to any one of a multiplicity of destinations or vice versa is generally referred to as a "pyramid" or "tree."

Relay "pyramids" or "trees" comprise a multiplicity of transfer contacts connectable together differentially to provide a desired number of switching paths under control of a plurality of selectively energizable relays. One or more relays are provided for each of the variables controlling the operation of the circuit depending on the total number of transfer contacts involved and the contact capacity of each relay at the required speed of operation. Where the required speed of operation is low, each relay may control a large number of transfer contacts, but where high speed operation is required each relay may be capable of controlling only three or four or less transfer contacts. This condition necessitates the use of more than one relay for each variable and greatly increases the original and maintenance costs of the circuit.

Obviously, any method of decreasing the number of transfer contacts required in a circuit of the sort under discussion effects a proportionate decrease in the number of relays required, and, therefore, a saving in cost, and is most desirable.

One method of reducing the number of transfer contacts and, therefore, the number of relays required in a switching pyramid is to split the pyramid into two smaller pyramids and to connect the devices which are to be selected by the switching circuit for individual operation, between the output lines of the two pyramids, one device between each output line of each pyramid and every output line of the other pyramid. The saving in the number of transfer contacts required in a pyramidal switching circuit, which is effected by utilizing the "split-pyramid" design, is dependent on the manner in which the pyramid is split and the selection capacity required of the circuit. A relay transfer pyramid having a capacity to differentiate between N devices requires $N-1$ transfer contacts. For example, a circuit having a capacity of 100 requires 99 transfer contacts when a single pyramid is utilized. On the other hand, when a "split-pyramid" is adopted, each smaller pyramid requires only $X-1$ transfer contacts where X is the number of pyramid output lines. For a selection capacity of 100, each said smaller pyramid may include 10 output lines with the result that only eighteen transfer contacts are required in all. Of course, the smaller pyramids may not have equal numbers of output lines and transfer contacts, but, for example, one may include twenty output lines and the other five. However, this design results in the use of a greater number of transfer contacts, namely, twenty-three. For maximum economy of transfer contacts, the number of output lines with which each pyramid of a "split" circuit is provided should approach as nearly as is consistent with whole numbers to the square root of the number of devices

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which are to be differentiated between by the overall circuit.

However, "split-pyramid" switching circuits inherently include sneak circuits which, heretofore, have negated or at least greatly reduced their utility in many switching applications. An illustration of the sneak circuit nature of "split-pyramid" circuits is set forth on pages 167-170 of the book "Relay Engineering" by Charles A. Packard, published by Struthers-Dunn, Inc.

The principal object of this invention, therefore, is the provision of a "split-pyramid" switching circuit which minimizes the number of transfer contacts required for a given selection capacity and yet which is free of sneak circuits.

According to this invention, in order to transmit a signal to one of N devices, a diode matrix including a first group of A lines and a second group of B lines is provided where $AB=N$. Each of the N devices is connected in series with a rectifier between a line of the first and a line of the second groups. A pair of pyramids are provided each to select a line of one of said groups, and, in combination, to apply a difference in potential across the rectifier and the device connected in series therewith between the two selected lines.

The minimum number of transfer contacts required is $A-1$ for the first pyramid and $B-1$ for the second pyramid or a total of $(A+B)-2$ contacts. Preferably, $A=B=\sqrt{N}$.

In those instances wherein it is desired to operate or energize a selected one of N devices under control of alternating current signals, there is provided a diode matrix having first, second, and third groups of lines, the lines of the first group being A in number, and the lines of each of the other two groups being B in number, where $AB=N$.

Each of the N devices is connected between a line of the first group and a line of each of the second and third groups, said connections (for each device) being through a pair of oppositely oriented rectifiers, that is, a first rectifier having its cathode connected to a line of the second group and a second rectifier having its anode connected to a line of the third group. Three pyramids are utilized, one to apply an intermediate potential to a selected one of the lines of the first group and the others to apply potentials which are positive and negative with respect to said intermediate potential to selected lines of the second and third groups respectively. The device connected between a given line of the first group and a line of each of the second and third groups is operated or energized when the appropriate potentials are applied to the first pyramid and to either of the second and third pyramids. In order to energize one of N devices with this circuit, the first pyramid requires $A-1$ transfer contacts and the second and third pyramids each require $B-1$ contacts, where $AB=N$, and the total number of contacts necessary is $(A+2B)-3$. Preferably, $A=B=\sqrt{N}$.

The switching circuit as last set forth is usable also to connect any one of N signal sources with a single output line. In this arrangement each of the N devices described above as receptive of signals is replaced by a signal source, but the matrix and pyramids remain unchanged. One pyramid applies an intermediate potential to a line of the first group and the other two pyramids connect one line of each of the second and third groups to a mixer circuit. Signals of positive potential from the source connected between a selected line of the first group and a selected line of each of the second and third groups are provided with a path through one pyramid to the mixer circuit, and signals of negative potential are routed through the other pyramid to the mixer circuit. The mixer circuit produces

a composite serial array of positive and negative signals on a single output line.

Other objects and features of the invention will become apparent when viewed in the light of the attached drawings, of which:

Fig. 1 is a schematic wiring diagram illustrating in detail one embodiment of the invention;

Fig. 2 is a partially diagrammatic wiring diagram illustrating a second more complex embodiment of the invention; and,

Fig. 3 is a partially diagrammatic wiring diagram illustrating a modified means of the invention as shown in Fig. 2.

In perhaps its simplest form the invention contemplates the connection of a selected one of a multiplicity of devices with a source of operating potential or the like. An arrangement of this sort is illustrated in Fig. 1 and includes a first selection circuit 111 and a second selection circuit 114. In the illustrated embodiment of said circuits the former is controlled by signals which appear on four lines 1, 2, 4 and 8 in accordance with the binary coded decimal system of notation, while the second, namely circuit 114, is controlled by binary coded decimal signals which appear on four lines 10, 20, 40 and 80. Evidently, circuit 111 is controlled in accordance with the units digit of a number whereas circuit 114 is controlled in accordance with the tens digit of a number. Any desired means for applying appropriate signals to the lines 1, 2, 4, 8, 10, 20, 40 and 80 may be provided. For example, said lines may be the output conductors of an electronic computer or a manually operable keyboard.

The selection circuit 111 includes four relays 112 which are energized by signals on the lines 1, 2, 4 and 8 and a pyramidal array of transfer contacts 113 operated by said relays. The contacts 113 are interconnected in known manner to provide paths from each of ten lines 110₀, 110₁, . . . 110₉ to ground, such paths being completed selectively in accordance with the states of energization of the relays 112. Normally, the line 110₀ is connected to ground while all of the other lines 110₁, 110₂, etc. are open circuits.

Circuit 114 is identical with circuit 111 and includes four relays 115 which are energized selectively by signals appearing on the lines 10, 20, 40 and 80. Circuit 114 serves to connect a selected one of ten lines 120₀, 120₁₀, 120₂₀, . . . 120₉₀ with a source of positive potential 118.

It will be seen, therefore, that when signals indicative of the units and tens digits of a number are applied to the input lines of circuits 111 and 114, a selected line 110 is connected to ground while a selected line 120 is connected to a source of positive potential.

The lines 110 and 120 are included in a selector matrix 116 which also includes 100 rectifiers 117 and a like number of lamps L₀, L₁, . . . L₉₉. Each lamp is connected in series with a rectifier 117 between a line 110 and a line 120. The anodes of the several rectifiers are, of course, applied to the lines 120.

The connections of the parts are such that when ground potential is applied to a selected line 110 and a positive potential is applied to a selected line 120 as described above, a positive potential is applied to the anodes of all of the rectifiers associated with the said line 120, while the cathodes of all of the diodes associated with the selected line 110 are connected through lamps to ground. Evidently, only one of the rectifiers associated with the selected lines 110 and 120, namely that which is connected between the two, conducts and only the lamp L₀-L₉₉ associated therewith is illuminated.

It is to be mentioned that the selector circuits 111 and 114 may be controlled by other types of inputs and that the lamps L₀-L₉₉ may be replaced by any other suitable load.

Referring now to Fig. 2, the invention is embodied in a channel selection circuit for a magnetic storage

drum 121. Drum 121 comprises a rotating cylinder whose periphery is divided into a series of contiguous channels or tracks in which minute areas or spots are magnetized with opposite polarities to indicate binary one and binary zero. The magnetizing of spots is accomplished by a series of recording heads 122, one for each channel. In the present instance, 100 recording heads are provided and the reference character for each is given a suitable subscript 0, 1, . . . , 99. The recording heads each comprise a pole piece and a coil which is energized to produce lines of flux in the pole piece. In order to vary the direction of the lines of flux and thus to magnetize spots with opposite polarities, it is necessary that recording signals applied to the coils of the recording heads be capable of effecting current flow in either direction in the coils. This is readily accomplished by connecting one end of each coil to ground and by applying positive and negative voltage signals to the other end of the coil.

The function of the means of Fig. 2, therefore, is to select which of the recording heads 122₀-122₉₉ is to be energized and to deliver either a negative or a positive signal thereto.

Means to these ends include a selection circuit 119 which is identical with the selection circuit 111 described above in connection with Fig. 1, and two selection circuits 129 and 129' which are identical with the selection circuit 114 described above. Selector circuit 119 is controlled in accordance with the units digit of a number designating the recording head 122 to be energized and applies ground potential to a selected one of ten lines 140₀, 140₁, 140₂, . . . 140₉. Selection circuits 129 and 129' are both controlled in accordance with the tens order digit of a number designating the recording head to be energized, and each serves to apply recording signals from a signal source 127 to a selected one of the output lines of the circuit. The recording signals, as indicated in the drawing, may be of square wave form and may extend either positively or negatively from a zero volt or ground potential level. The output lines of selector circuit 129 are ten in number and are designated 150₀, 150₁₀, 150₂₀, . . . 150₉₀, while the ten output lines of selector circuit 129' are designated 150'₀, 150'₁₀, 150'₂₀, . . . 150'₉₀.

The several lines 140, 150 and 150' are included in a selection matrix 123 which also includes a multiplicity of diodes 126 and a multiplicity of diodes 136. Each of the recording heads 122 is connected directly to a line 140 of matrix 123 through a conductor 141. Remembering that the lines 140 are representative of the units digits of numbers and identifying the 100 recording heads 122, ten recording heads are connected to each line 140. For example, recording heads 122₀, 122₁₀, 122₂₀, 122₃₀, etc. are connected by a conductor 141 with the line 140₀ of the matrix. Selector circuit 119, therefore, connects ten of the recording heads 122 to ground at each operation thereof.

The output lines 150 of selector circuit 129 are applied to the anodes of the several rectifiers 136, ten of the latter being connected with each said line. The output lines 150' of selector circuit 129' are connected to the cathodes of the several rectifiers 126, ten of the latter being connected with each said line. The rectifiers 136 associated with each line 150 are paired with rectifiers 126 of the like valued line 150', the anode of the rectifier 126 of each pair and the cathode of rectifier 136 of each pair being connected through a conductor 142 to a recording head 122.

The connections are such that when a negative signal is applied through selector circuits 129 and 129' to selected lines 150 and 150', the diode 126 in each of the ten pairs of diodes associated with said lines has its cathode potential lowered. At the same time the anode potentials of the diodes 136 in each of said ten pairs of di-

odes is lowered. Evidently, none of the diodes 136 can conduct. One of the ten rectifiers 126 does conduct however, namely that which is connected by conductors 141 and 142 with the line 140, that is connected to ground through a recording head 122 by selector circuit 119. Evidently, the recording head 122 associated with the conducting diode 126 is energized and a spot on the surface of drum 121 is magnetized with a given polarity.

When a positive signal is applied to selector circuits 129 and 129' the conditions are reversed, that is, one of the diodes 136 becomes conductive while all of the diodes 126 and the remainder of the diodes 136 are cut off. Also, the selected recording head 122 magnetizes a spot on the surface of the drum with the polarity opposite to that achieved under control of a negative signal.

It is believed evident that, if desired, the capacity of the arrangement of Fig. 2 can be increased to accommodate more than 100 recording heads or the like.

Referring now to Fig. 3 wherein like parts are given the same reference numerals as in Fig. 2, the selection means for the record heads of Fig. 2 are shown as connecting the playback heads 147 for the magnetic drum 121 to an output line selectively, there being one such head for each channel of the drum. Each playback head 147 comprises a pole piece and a coil in which signal voltages are generated as a result of the passage of magnetic spots past the pole piece. In Fig. 3 only one unit of matrix 123 is illustrated in detail, it not being deemed necessary to duplicate the extensive illustration thereof found in Fig. 2. As shown, the playback heads are connected by the lines 141 and 142 with the diodes 126 and 136 of the selector matrix 123 and also with the lines 140 associated with selector circuit 119. The selector circuits 129 and 129', however, instead of having record signals applied thereto serve to apply the played back signals to playback amplifiers 148 and 148' wherein the played back signals are amplified and shaped. Evidently, the rectifying operation of diodes 126, 136 described above permits only positive signals to be applied to playback circuit 148' and negative signals to be applied to playback circuit 148. The outputs of the playback circuits 148 and 148' are applied to a suitable mixer circuit 130 which produces on an output line 131 a composite serial array of positive and negative signals.

It is not deemed necessary to redescribe the operation of the selector circuits 119, 129, 129' and the several connections for the diodes 126 and 136 in connection with this form of the invention as the same operate in exactly the same way as described previously.

The invention above is capable of many modifications and changes without departing from the spirit of the invention, and it is not desired, therefore, to limit the scope of the invention other than as pointed out in the appended claims or as dictated by the prior art.

I claim:

1. A switching circuit for passing both positive and negative signals between a signal line and a selected one of a plurality of signal receiving-transmitting devices, comprising: a matrix having a set of conductors designated as rows and a pair of sets of conductors designated as columns, a source of reference potential, means for connecting said source of reference potential to one of said row conductors, a signal line, means for connecting said signal line to one of said column conductors and to the corresponding paired one of said column conductors, a plurality of signal receiving-transmitting devices each having a pair of terminals respectively connected with one terminal to a respective one of said row conductors, a plurality of unilateral conducting devices each respectively connected for current flow in one direction between the other terminal of a respective one of said signal receiving-transmitting devices and a respective one of said

column conductors of one set of column conductors, and a like plurality of unilateral conducting devices each respectively connected for current flow opposite to said one direction between the other terminal of a respective one of said signal receiving-transmitting devices and the corresponding paired one of said column conductors of the other set of column conductors, whereby signals positive relative to said source of reference potential are routed by one set of column conductors and signals negative relative to said source of reference potential are routed by the other set of column conductors between the selected one of said signal receiving-transmitting devices and the signal line.

2. A switching circuit for passing both positive and negative signals between a signal line and a selected one of a plurality of magnetic recording and reproducing heads, comprising: a matrix having a set of conductors designated as rows and a pair of sets of conductors designated as columns, a source of reference potential, means for connecting said source of reference potential to one of said row conductors, a signal line, means for connecting said signal line to one of said column conductors and to the corresponding paired one of said column conductors, a plurality of magnetic recording and reproducing heads each having a pair of terminals respectively connected with one terminal to a respective one of said row conductors, a plurality of unilateral conducting devices each respectively connected for current flow in one direction between the other terminal of a respective one of said magnetic recording and reproducing heads and a respective one of said column conductors of one set of column conductors, and a like plurality of unilateral conducting devices each respectively connected for current flow opposite to said one direction between the other terminal of a respective one of said magnetic recording and reproducing heads and the corresponding paired one of said column conductors of the other set of column conductors, whereby signals positive relative to said source of reference potential are routed by one set of column conductors and signals negative relative to said source of reference potential are routed by the other set of column conductors between the selected one of said magnetic recording and reproducing heads and the signal line.

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