

Dec. 9, 1958

E. F. MOORE

2,864,008

RELAY SELECTING CIRCUIT

Filed Dec. 28, 1955

8 Sheets-Sheet 1

FIG. 1A

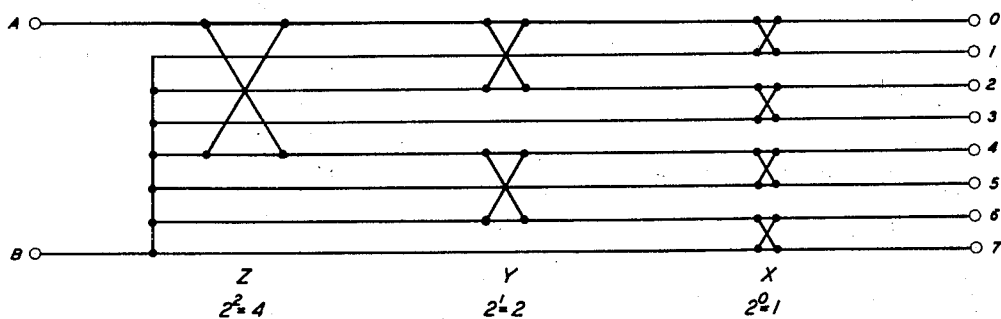
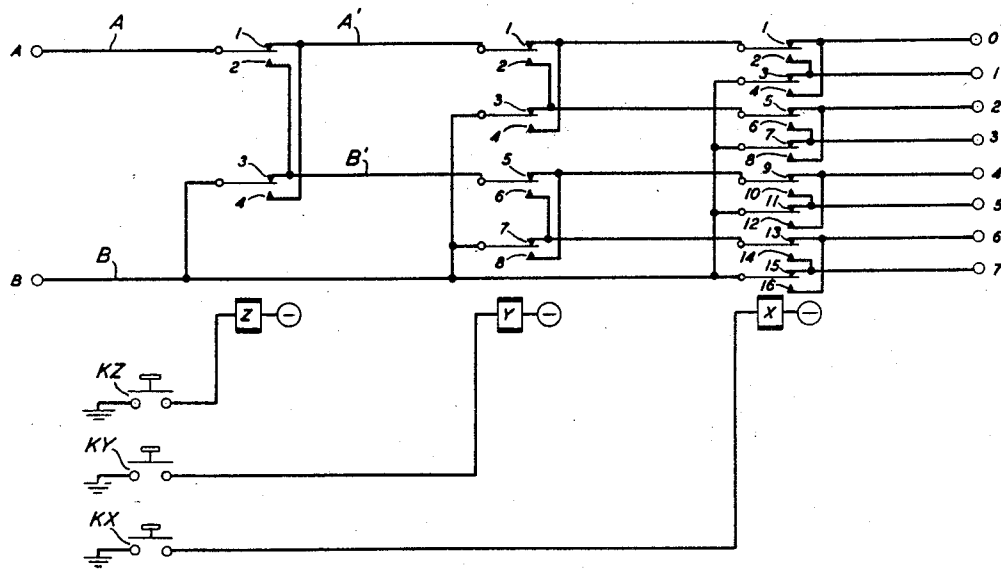


FIG. 1



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8 Sheets-Sheet 2

FIG. 2A

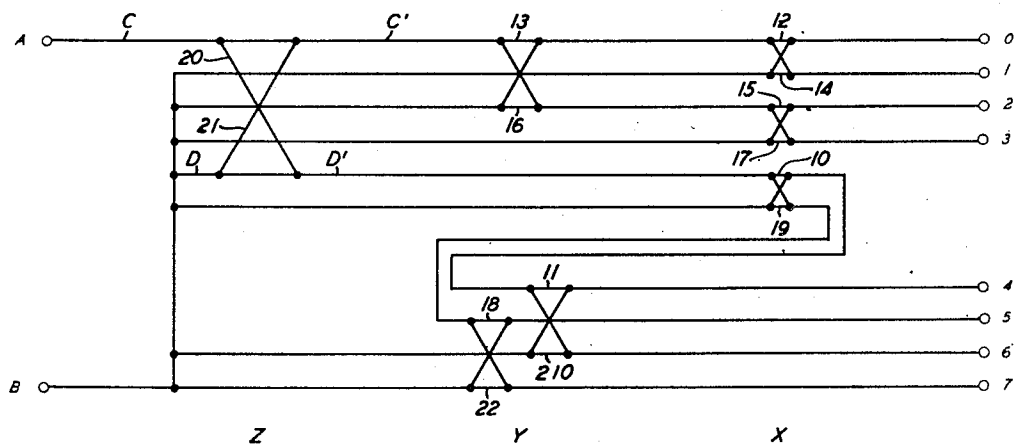
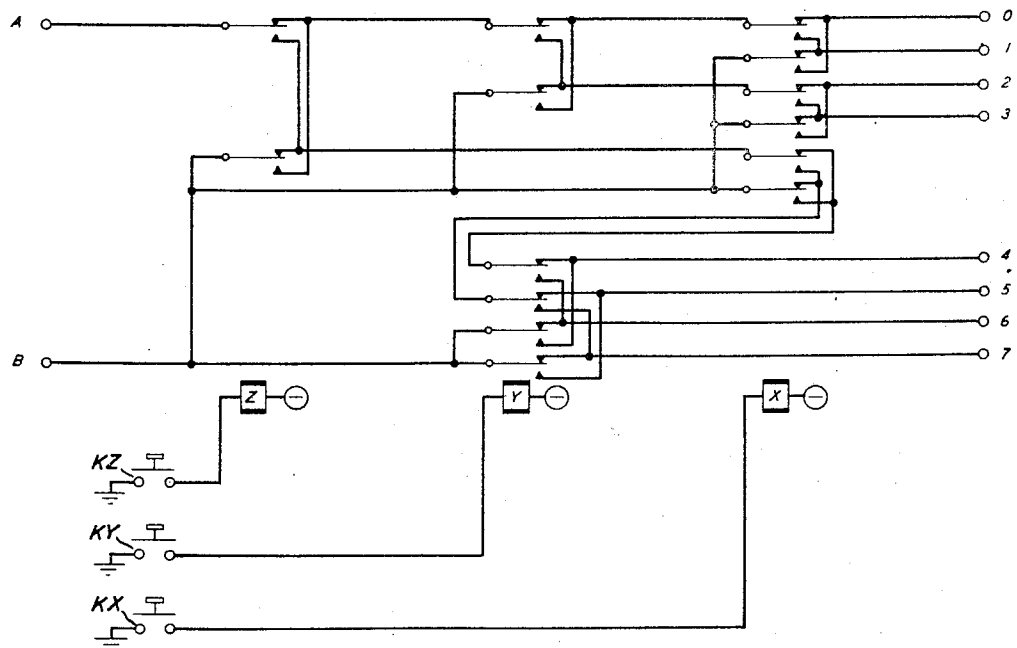


FIG. 2



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2,864,008

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8 Sheets-Sheet 3

FIG. 3A

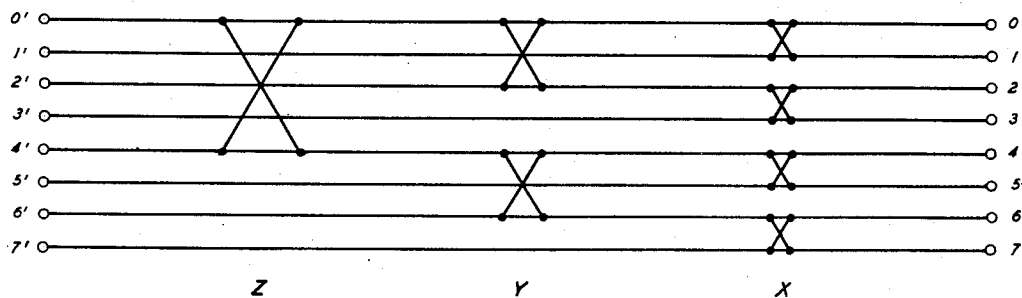
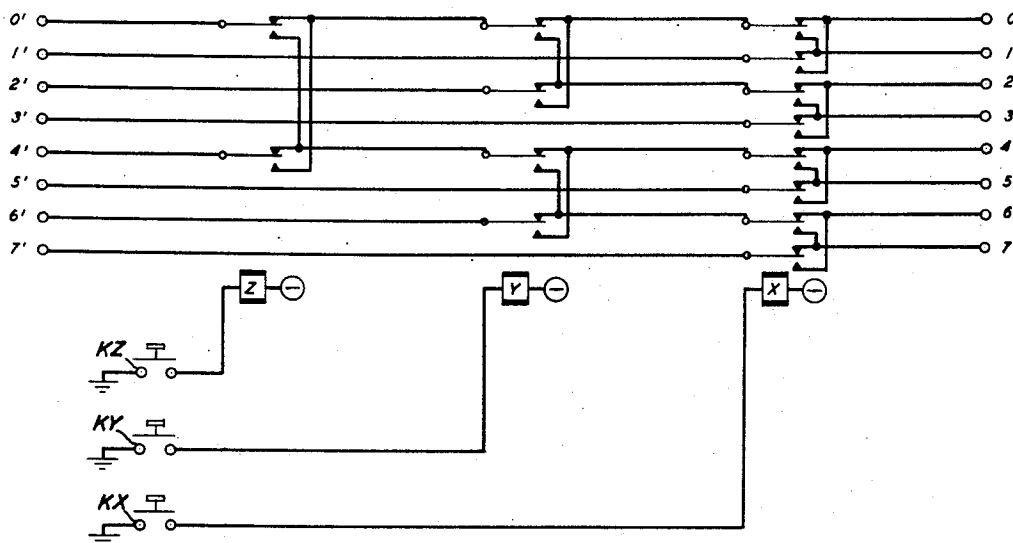


FIG. 3



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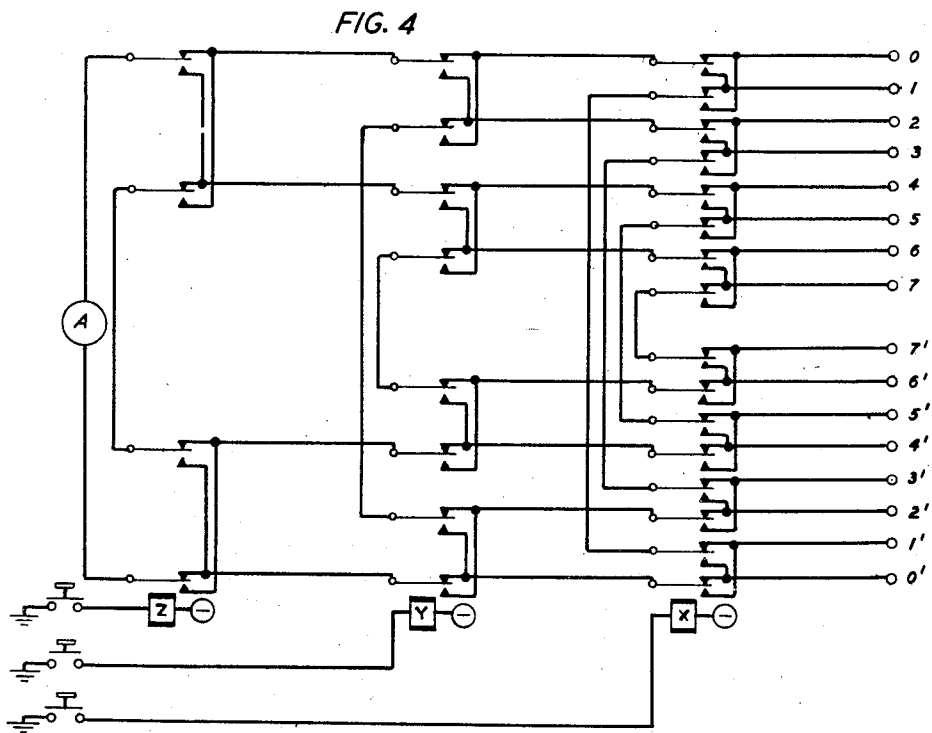
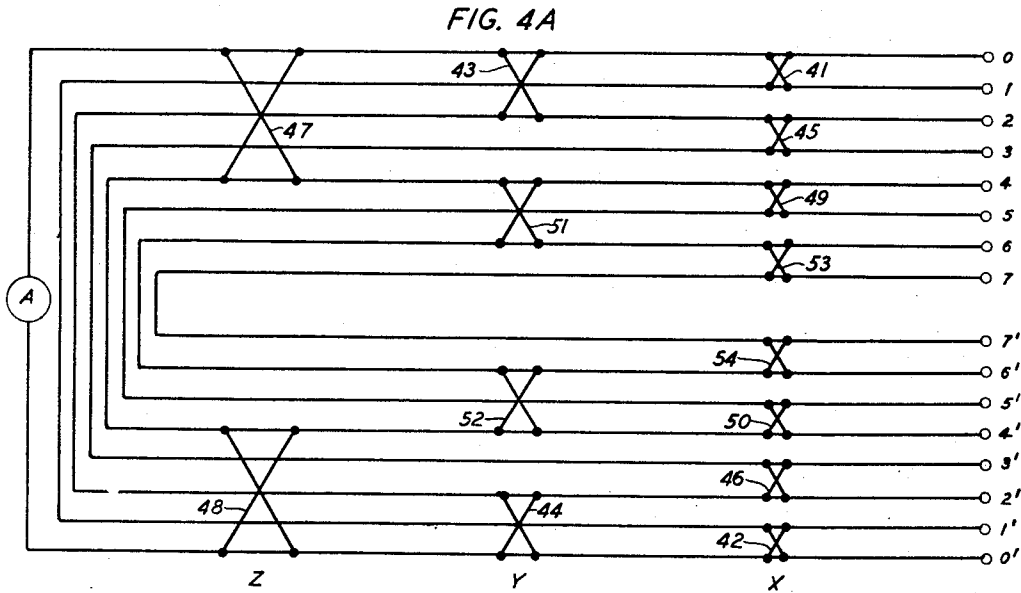
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RELAY SELECTING CIRCUIT

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8 Sheets-Sheet 4



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2,864,008

RELAY SELECTING CIRCUIT

Filed Dec. 28, 1955

8 Sheets-Sheet 5

FIG. 5A

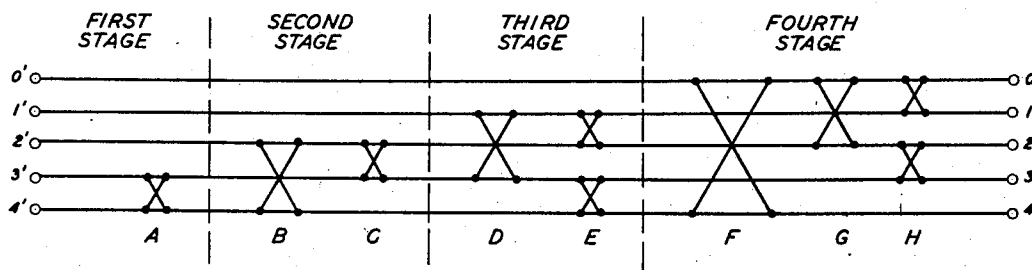
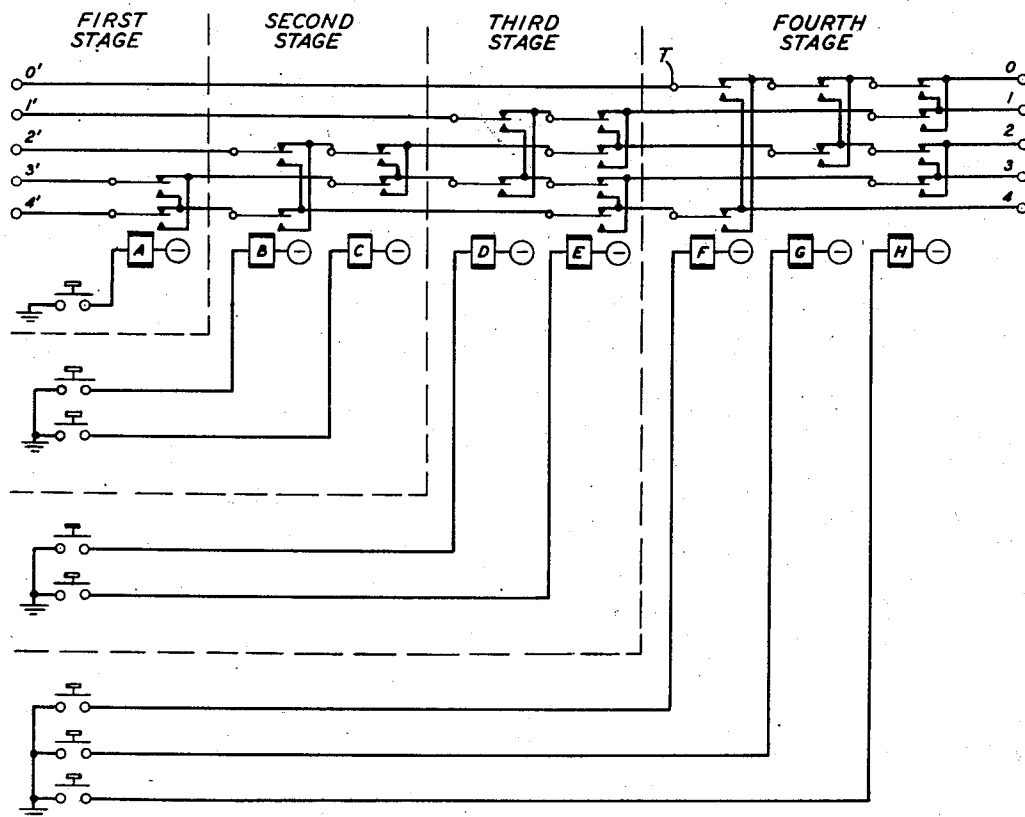


FIG. 5



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2,864,008

Filed Dec. 28, 1955

8 Sheets-Sheet 6

FIG. 6A

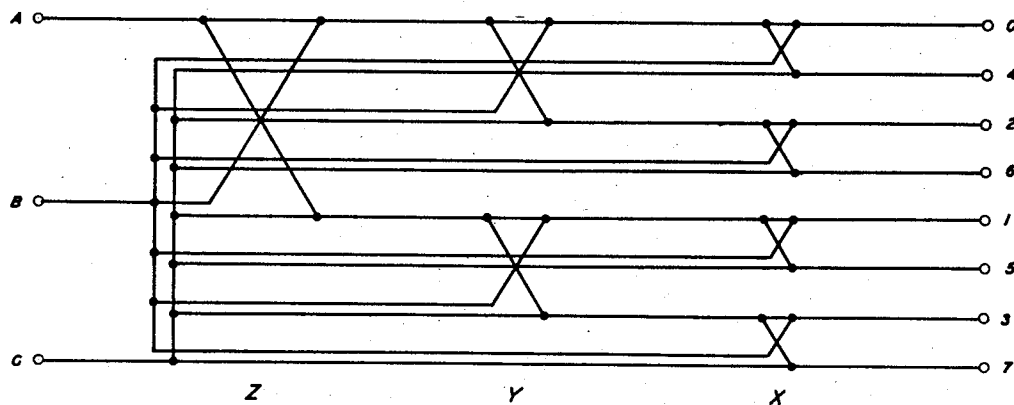
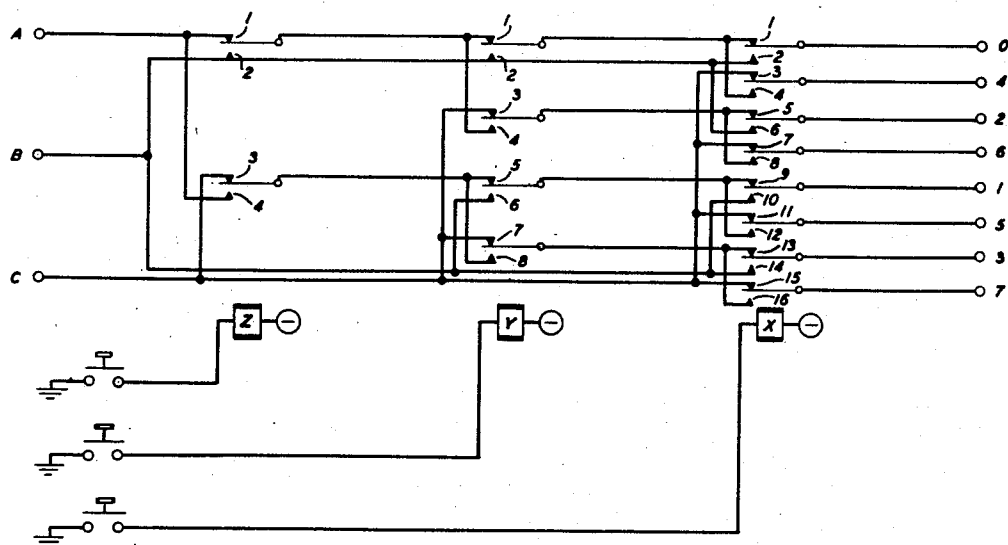


FIG. 6



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RELAY SELECTING CIRCUIT

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8 Sheets-Sheet 8

FIG. 8

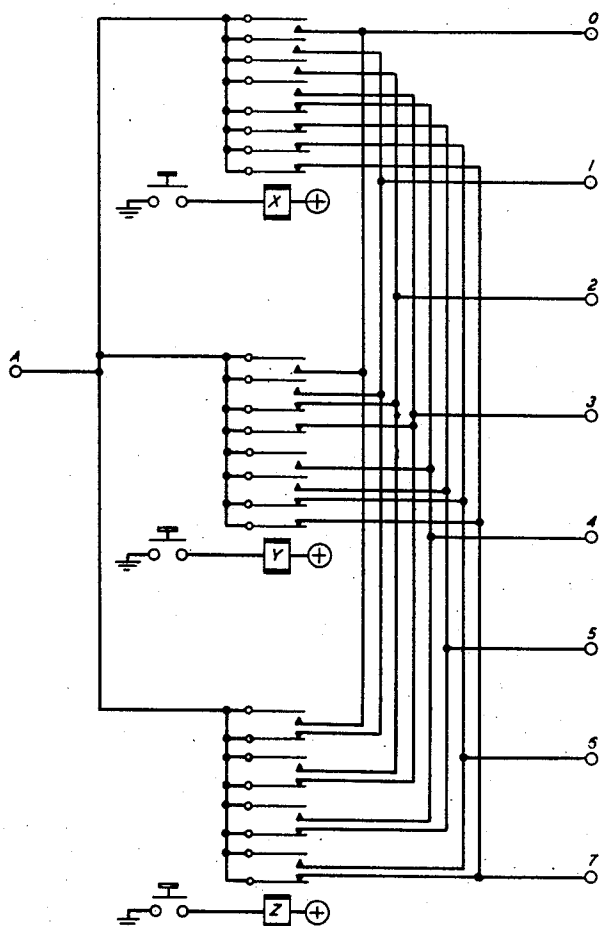
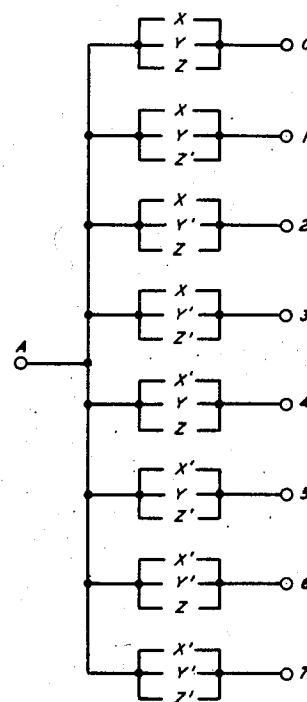


FIG. 8A



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1

2,864,008

RELAY SELECTING CIRCUIT

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Application December 28, 1955, Serial No. 555,853

21 Claims. (Cl. 307—112)

This invention relates to relay switching circuits and more particularly to improved relay switching selecting circuits affording increased selections with fewer contacts than heretofore required to perform the same function.

Relay switching circuits are presently well known in the art which employ n relays, where n is a positive integer, and afford 2^n selections. Thus, by means of four relays, for instance, a single circuit may be selectively connected through contacts on the relays to any one of 2^4 or sixteen other circuits. In one well-known contact configuration in such a relay circuit, the contacts are arranged in a branched arrangement frequently called a tree. An original single circuit is terminated on a single movable contact at the first relay, which movable contact is actuatable between two opposed contacts or circuit branches. Depending on the selection which is effected at the first relay, the circuit is extended to a particular one of two movable contacts, each actuatable between a pair of opposed contacts or branches on the second relay. Thus, depending on the conditions of the first and the second relays, taken together, the single circuit may be selectively connected to any one of four branches. The four branches of the second relay are individually connected to four movable contacts on a third relay, each of which movable contacts is actuatable, dependent on the condition of the third relay, between two contacts, or branches individual to each movable contact. Depending upon the condition of all three relays, taken together, the original single circuit or trunk may be selectively connected through the branching system of the tree of any one of eight circuits. The system may obviously be extended by adding relays and contacts, without limit.

In this tree arrangement, as should be obvious from the foregoing, only a single path is establishable through the tree from the original circuit or trunk to a single particular individual selected circuit or branch, for any permutative operation of all of the relays. Any one of the 2^n selectable circuits may be selected by the operation of the relays in a corresponding one of the 2^n possible operable relay permutations. However, this is the ultimate in selection which may be achieved with such tree circuits as presently arranged.

There is need at times for effecting a single selection and for effecting another selection or a multiselection, simultaneously. One example of such a need is the requirement for selectively connecting a single circuit to any one of a number of circuits in a group and for connecting another circuit to all of the non-selected circuits of the group. The present invention, in one of its embodiments, proposes a circuit having a group of contacts on a plurality of relays for performing these functions. The group of contacts is arranged so as to afford a tree selection and an inverted tree selection. The term "inverted tree" connotes, as it implies, resemblance of the contact selecting arrangement, wherein all of the non-selected circuits are connected to a single circuit, to an inverted tree selection. That is, an arrangement wherein

2

a group of branches are connected simultaneously to a trunk so to speak.

The present invention proposes a number of tree relay and control arrangements, to fill the foregoing and other needs and is characterized by the employment of minimum relays and minimum contacts to perform the required functions. There are a number of relay circuits described herein, each of which, like a tree circuit, uses n relays to selectively control individual access to 2^n terminals. Each of the 2^n possible combinations of operated and unoperated conditions of the relays can be used to designate one of the terminals. In addition the circuits perform another selecting function simultaneously with the tree branch selecting function. The other selecting function, as described hereinafter, is different for each of the circuits.

The invention may be understood from the following description when read with reference to the associated drawings which, when taken together, disclose preferred embodiments in which the invention is presently incorporated. It is to be understood that the invention may be incorporated in other forms which may be suggested to those skilled in the art from a consideration of the present disclosure.

In the drawings:

Figs. 1, 2, 3, 4, 5, 6 and 7 show embodiments of tree circuits, each arranged to afford a selection corresponding to that of a tree circuit and simultaneously to effect another selection, distinctive for each of the circuits; and

Figs. 1A, 2A, 3A, 4A, 5A, 6A and 7A show diagrammatically the contact arrangement of Figs. 1, 2, 3, 4, 5, 6 and 7 respectively, as an aid in understanding the operation of each.

Figs. 8 and 8A show another circuit for comparison as an aid in understanding the economy afforded by the present invention. Refer now to Figs. 1 and 1A.

Fig. 1 is arranged to connect conductor A selectively to any one of conductors 0-7 and to simultaneously connect conductor B to all of the non-selected leads in the group 0-7. Thus, for instance, if relays X, Y and Z, shown at the bottom of Fig. 1, are arranged by the manipulation of their respective control switches KX, KY and KZ, so as to connect conductor 4 to conductor A, then conductors 0, 1, 2, 3, 5, 6 and 7 will at the same time be connected to conductor B.

In the arrangement of Fig. 1, the number of the individual conductor, of the conductor group 0-7, to which conductor A is connected by permutatively operating relays X, Y and Z can be predetermined by adding values assigned to the relays when operated in accordance with the regular binary code and assuming that the value of each relay when unoperated is 0. Relays X, Y and Z have increasing binary values in alphabetical order. That is, relay X counts for 2^0 or 1. Relay Y counts for 2^1 or 2. Relay Z counts for 2^2 or 4. Additional relays in an expanded system would have values equal to increasing powers of 2 in numerical order.

In accordance with the foregoing, consider relays X, Y and Z released, and each relay for this condition counting for 0. For the tree selection, conductor A should be connected to conductor 0. Reference to Fig. 1 shows that this is the case. The circuit may be traced from conductor A through contact 1 of each of relays Z, Y and X in series to conductor 0. For this condition also, for the inverse tree connection, conductor 1 connects through contact 3 of relay X to conductor B. Conductor 2 connects through contact 5 of relay X and contact 3 of relay Y to conductor B. Conductor 3 connects through contact 7 of relay X to conductor B. Conductor 4 connects through contact 9 of relay X, contact 5 of relay Y and contact 3 of relay Z to conductor B. Conductor 5 connects through contact 11 of relay X to conductor B. Con-

ductor 6 connects through contact 13 of relay X and contact 7 of relay Y to conductor B, and conductor 7 connects through contact 15 of relay X to conductor B.

To consider one more pair of selections, consider the situation wherein relays X, Y and Z are all operated. For the tree selection, the operation of relay X counts as 2^0 or 1, of relay Y, 2^1 or 2 and of relay Z, 2^2 or 4, the total of $1+2+4$ equals 7. If the requirements set forth in the foregoing are to be met, conductor A should be connected to conductor 7, for the tree selection and conductors 0, 1, 2, 3, 4, 5 and 6 should be connected to conductor B for the inverse tree selection.

Reference to Fig. 1 shows that with relays X, Y and Z operated for the tree selection, a circuit may be traced from conductor A through contact 2 of relay Z, contact 6 of relay Y and contact 14 of relay X to conductor 7. For the inverse tree selection, conductor 0 connects through contact 4 of relay X to conductor B. Conductor 1 connects through contact 2 of relay X and contact 4 of relay Y to conductor B. Conductor 2 connects through contact 8 of relay X to conductor B. Conductor 3 connects through contact 6 of relay X, contact 2 of relay Y and contact 4 of relay Z to conductor B. Conductor 4 connects through contact 12 of relay X to conductor B. Conductor 5 connects through contact 10 of relay X and contact 8 of relay Y to conductor B, and conductor 6 connects through contact 16 of relay X to conductor B.

It will be found that each permutative operation of relays X, Y and Z connects conductor A by means of a tree selection to some particular one of conductors 0 to 7 and simultaneously connects all of the other contacts through an inverse tree selection to conductor B. The number of the particular conductor selected by the tree arrangement will correspond to the sum of the values assigned to each of the operated relays, in binary notation for each permutation combination, as described. All other conductors of the group 0 to 7 will be connected to conductor B.

Reference to Fig. 1 shows that relay Z has two sets of transfer contacts, relay Y has four sets of transfer contacts and relay X has eight sets of transfer contacts. Each two sets of transfer contacts, considered as a unit, is associated with two conductors and each two sets cooperatively effect the interchange of these two conductors. To explain this, reference to relay Z shows that for the upper transfer contacts, conductor A is normally connected to conductor A' and for the lower transfer contacts conductor B is normally connected to conductor B'. When relay Z is operated, conductor A is connected to conductor B' and conductor B is connected to conductor A'. And in general for each of the two sets of transfer contacts, operation of its control relay effects the interchange of connections of a pair of conductors connected to the pair of transfer contacts on the left with a pair of conductors connected to the pair of transfer contacts on the right.

Reference to Fig. 1 discloses that if the lower transfer of each pair of transfers were removed, what would remain would be the conventional tree circuit. This suggests that the conventional tree circuit may be converted into a circuit which affords both a tree and an inverted tree by providing an additional set of transfer contacts for each transfer set in the tree circuit and arranging them as in Fig. 1 so that each pair of transfer sets cooperatively interchanges two conductors connected to each pair of transfer sets.

The addition of a set of transfer contacts to a transfer set in a tree circuit to afford an inverted tree in addition to the original tree is not limited to a system having but three relays as shown in Fig. 1, but may be expanded as in the case of tree circuits, without limit.

It is particularly pointed out at this time, as will become more apparent later from a comparison of the number of contacts required in the arrangement of Fig. 8, that the circuit of Fig. 1 affords economy of contacts.

In the conventional tree circuit, there is one set of transfer contacts on the first relay, two on the second and four on the third, etc. The total number of sets of transfer contacts in a tree circuit having n relays, and affording 2^n selections, therefore, is $(2^0+2^1+2^2+2^3+\dots)$ or (2^n-1) . The total number of sets of transfer contacts in such a circuit as that of Fig. 1, since one set of transfers is required in addition to each set in the conventional tree, is twice as many as in the tree or $2(2^n-1)$.

Figs. 1A, 2A, 3A, 4A and 5A show the contact arrangement of Figs. 1, 2, 3, 4 and 5, respectively, diagrammatically, to facilitate an understanding of the operation of the circuits of Figs. 1, 2, 3, 4 and 5. In each of these diagrammatic figures, an "X" interconnecting two conductors represents two sets of transfer contacts connected so as to permit interchange of the pair of leads they connect. Reference to Fig. 1 shows the corresponding sets of transfers in full.

Refer now to Fig. 2. Fig. 2 shows a circuit which performs the same function as that of Fig. 1 but differs from Fig. 1 in that the contact load has been distributed more evenly. In the arrangement of Fig. 1, there are eight sets of transfer contacts on relay X. This requires the simultaneous actuation of eight movable contacts which places a relatively heavy load on the relay. In Fig. 2, the number of sets of contacts on relay X has been reduced to six by transferring two sets to relay Y. In all other aspects, the circuit of Fig. 2 is the same as that of Fig. 1.

The operation of each of the circuits of Figs. 1, 2, 3, 4 and 5 can be most conveniently understood from reference to the corresponding diagrammatic figures. With respect to Fig. 2, for instance, refer to Fig. 2A. In the diagrammatic figure, attention is called to the fact that if a relay is unoperated, any path through the relay continues in a horizontal line through the relay position. If a relay is operated a conductor coming to the relay position from the left or right follows one of the lines of the "X" to the other conductor and then continues in the same direction. For instance, in Fig. 2A, if relay Z is unoperated, conductors C and D connect directly to conductors C' and D', respectively. If relay Z is operated, conductors C and D connect to conductors D' and C', respectively.

Now consider how a tree connection of terminal A to terminal 4 is effected, using Fig. 2A. For the selection of terminal 4, relay Z which affords a binary count of 2^2 or 4 is operated. Relays Y and X are unoperated. A path may then be traced from terminal A through conductor C, contact 20, conductor D', contact 10, and contact 11 to terminal 4. For the inverted tree connection a path may be traced from terminal 0 through contact 12, contact 13 and contact 21 to terminal B. Terminal 1 connects through contact 14 to terminal B. Terminal 2 connects through contacts 15 and 16 to terminal B. Terminal 3 connects through contact 17 to terminal B. Terminal 5 connects through terminals 18 and 19 to terminal B. Terminal 6 connects through contact 210 to terminal B. And terminal 7 connects through terminal 22 to terminal B.

It is considered that, with the foregoing description of the diagram of Fig. 2A, all of the other selections possible in each of Figs. 1, 2, 3, 4 and 5 may be readily traced visually in Figs. 1A, 2A, 3A, 4A and 5A, if desired, by the reader.

Fig. 3 is a circuit identical with that of Fig. 1 except that conductor B has been omitted and each of the seven conductors connectable to it has been terminated on an individual terminal.

The circuit affords the usual tree, since terminal 0' may be selectively connected to any of terminals 0 to 7 as in the conventional tree. Fig. 3 also affords other selections to be described. It also supplies a means of better understanding the operation of Fig. 1.

When none of the relays X, Y or Z is operated the eight terminals on the right, numbered 0 through 7, are con-

nected directly to the corresponding terminals at the left, numbered 0' through 7'. The circuit therefore provides eight separate paths. If any of relays X, Y and Z is operated, each pair of contacts represented in Fig. 3A by an X-shaped connection will interchange two of the paths, while keeping them electrically isolated each from the other. Thus, with any possible combination of relays X, Y and Z operated, there will always be exactly eight separate paths through the network which undergo various rearrangements depending upon the eight permutative combinations of conditions of the relays.

To understand that the eight rearrangements are all different, it should be observed that the path of Fig. 3 which uses the upper set of transfer connections of each pair of transfer connections is the conventional tree circuit which connects terminal 0' to any one of the terminals 0 through 7.

Since all eight paths are continuous from the left to the right in Fig. 3, and since no two of them can connect together, it follows that the seven right-hand terminals not connected to terminal 0' must be connected to terminals 1' through 7'.

If the seven terminals 1' through 7' are shorted together, the circuit of Fig. 3 would be identical with that of Fig. 1 and this explanation shows why terminal B in Fig. 1 is always connected to all terminals 0 through 7, except whichever one is connected to terminal A.

Refer now to Figs. 4 and 4A. The circuit of Fig. 4 comprises three relays X, Y and Z controlling two sets of contacts such as the set in Fig. 3. The symmetry of Fig. 4 assures that eight separate paths such as the paths from 0 to 0' and 1 to 1', etc. through this network are maintained intact regardless of which combination of relays is operated, but that any one of these paths can be made to pass through the load A, which may be any of a large number of electrical devices, such as an ammeter, by operating the appropriate relays.

To demonstrate the foregoing, please refer to Fig. 4A. The conductor interconnecting terminals 0 and 0' passes through ammeter A when none of relays X, Y or Z is operated. If relay X is operated conductor 1 is connected through contact 41, ammeter A, and contact 42 to terminal 1'. With relay Y operated terminal 2 is connected through contact 43, ammeter A and contact 44 to terminal 2'. With relays X and Y operated, terminal 3 is connected through contacts 45, 43, ammeter A, contacts 44 and 46 to terminal 3'. With relay Z operated terminal 4 is connected through contact 47, ammeter A and contact 48 to terminal 4'. With relays X and Z operated, terminal 5 is connected through contacts 49, 47, ammeter A, contact 48 and contact 50 to terminal 5'. With relays Y and Z operated, contact 6 is connected through contacts 51, 47, ammeter A, contact 48 and contact 52 to terminal 6'. With relays X, Y and Z operated, terminal 7 is connected through terminals 53, 51, 47, ammeter A, contacts 48, 52 and contact 54 to terminal 7'.

Refer now to Figs. 5 and 5A. The contact arrangement in this circuit resembles that in Fig. 3. This circuit comprises a sequence of stages arranged in such manner that the "i-th" stage is a circuit for rearranging $i+1$ conductors for successive integers i between 1 and 4. This permits terminals 0 through 4 to be connected with any one of the 5 different permutations, to terminals 0' through 4'.

A similar type of circuit can be arranged to perform all permutations of n leads. Such a circuit comprises $n-1$ stages with the "i-th" stage requiring $2i$ transfers. Hence, the total number of transfer T_n required is given by:

$$T_n = \sum_{i=1}^{n-1} 2i = n(n-1)$$

Refer now to Figs. 6 and 6A. Fig. 6 shows another circuit related to an inverse tree. The transfer contacts are different from those of the other figures and are shown in full in Fig. 6 and in diagrammatic form in Fig. 6A.

It should be noted that the terminals at the right of Fig. 6 are numbered in an order which differs from the ordinary numerical order. This order is obtained from the other order by writing the terminal number as a three-digit binary number and reversing the positions of the binary digits. If the conditions of relays X, Y and Z of Fig. 6 are specified by the successive binary digits of the number k , then the terminal numbered k will be connected to terminal A, all terminals whose numbers are less than k will be connected to terminal B, and all terminals whose numbers are greater than k will be connected to terminal C.

It will be observed that this circuit uses exactly the same number of contacts as does the circuit of Fig. 1, and in fact if terminal B and terminal C are connected together, the circuit would be identical with that of Fig. 1. However, the contact load of the circuit of Fig. 6 apparently cannot be redistributed without changing its action so that it no longer groups the terminals according to numerical order.

Attention is called to the fact that if only one or the other of terminals B and C is required, all contacts connected to the non-required terminal may be omitted without affecting the circuit operation. The contacts which would be thereby eliminated are equal to one quarter of the number of contacts in the circuit.

To elaborate the foregoing, in circuits such as that of Fig. 1, with respect to the magnitude of the number of the selected contact, each of relays X, Y and Z when unoperated counts as 0. When operated relay X counts as 2^0 or 1, relay Y counts as 2^1 or 2, and relay Z counts as 2^2 or 4. Expressing the numbers from 0 through 7 as binary numbers, and the operated and unoperated conditions of relays of the group X, Y and Z by their values in accordance with the foregoing, the numbers of the terminals correspond to the value of the binary numbers and are shown in the right-hand column of Table 1 following:

TABLE 1

Z	Y	X
0	0	0=0
0	0	1=1
0	2	0=2
0	2	1=3
4	0	0=4
4	0	1=5
4	2	0=6
4	2	1=7

In Fig. 6 the terminals are numbered as shown in the right-hand column of Table 2 below. In this table the values of the digits assigned to relays X and Z when operated are in effect interchanged.

TABLE 2

Z	Y	X
0	0	0=0
0	0	4=4
0	2	0=2
0	2	4=6
1	0	0=1
1	0	4=5
1	2	0=3
1	2	4=7

The eight terminals shown at the right in Figs. 6 and 6A instead of being numbered from 0 through 7 from the top down are numbered from the top down in accordance with the right-hand column in Table 2.

The circuit per Fig. 6 affords the following selections:

(1) Terminal A is connected to a terminal numbered in accordance with the right-hand column in Fig. 2 when the relays indicated in the corresponding line in Table 2 are operated.

(2) Terminal B is connected to all terminals numbered lower than that to which terminal A connects.

(3) Terminal C is connected to all terminals numbered higher than that to which terminal A connects.

The foregoing operation requirements will be shown to be met for two sets of selections and the reader may

visually check the others, if desired, quite readily by means of the diagram of Fig. 6A.

Refer now to Fig. 6. When relays X, Y and Z are unoperated, the value of each is 0 and conductor A should connect to terminal 0. Reference to Fig. 6 shows this to be the case. The circuit for conductor A may be traced through contact 1 of relay Z, contact 1 of relay Y and contact 1 of relay X to terminal 0. Reference to the circuit connected to conductor B under the condition wherein all three relays are released shows that it is open at each of the contacts to which it connects. The requirement for conductor B, therefore, that it be connected to all terminals having numbers lower than that to which conductor A is connected is met. Since there are no terminals having a lower number than 0, conductor B connects to no terminals for this condition. It is required that conductor C be connected to all terminals having a number higher than 0 and since all terminals have a number higher than 0, it is required that conductor C connect to all terminals other than terminal 0. To test this requirement, with relays X, Y and Z all released as shown in Fig. 6, a circuit may be traced from terminal 1 in Fig. 6 through contact 9 of relay X, contact 5 of relay Y and contact 3 of relay Z to conductor C. A circuit may be traced from terminal 2 through contact 5 of relay X and contact 3 of relay Y to conductor C. A circuit may be traced from terminal 3 through contact 13 of relay X and contact 7 of relay Y to conductor C. A circuit may be traced from terminal 4 through contact 3 of relay X to conductor C. A circuit may be traced from terminal 5 through contact 11 of relay X to conductor C. A circuit may be traced from terminal 6 through contact 7 of relay X to conductor C. A circuit may be traced from terminal 7 through contact 15 of relay X to conductor C.

It will be assumed now that conductor A is connected to terminal 6 by the operation of relays X and Y. A circuit may be traced from conductor A through contact 1 of relay Z, contact 4 of relay Y and contact 8 of relay X to terminal 6. It is required that terminal B be connected to terminals having lower numbers than 6 and terminal C be connected to terminal 7 the only terminal having a number higher than 6. With respect to conductor B, a circuit may be traced from terminal 0 through contact 2 of relay X to conductor B. A circuit may be traced from terminal 1 through contact 10 of relay X to conductor B. A circuit may be traced from terminal 2 through contact 6 of relay X to conductor B. A circuit may be traced from terminal 3 through contact 14 of relay X to conductor B. A circuit may be traced from terminal 4 through contact 4 of relay X and contact 2 of relay Y to conductor B. A circuit may be traced from terminal 5 through contact 12 of relay X and contact 6 of relay Y to conductor B.

With respect to conductor C, a circuit may be traced from terminal 7 through contact 16 of relay X, contact 8 of relay Y and contact 3 of relay Z to conductor C.

It is considered that the reader can readily check any of the other possible selections from reference to Fig. 6 and Fig. 6A and the foregoing description.

Refer now to Figs. 7 and 7A which show an arrangement corresponding in function to that of Figs. 4 and 4A, that is to say, the circuit of Figs. 7 and 7A, like part of Figs. 4 and 4A, permits the selective connection of any one pair of 2^n pairs of conductors through a device such as an ammeter, for instance, and simultaneously interconnects corresponding ones of each of the remaining $2^n - 1$ pairs of conductors together, individually, while using n relays. The circuit of Fig. 7 uses fewer contacts than does the circuit of Fig. 4.

Refer now to Figs. 8 and 8A. These figures show an arrangement originally proposed for establishing an inverted tree selecting circuit only, which selectively omits any one of 2^n terminals, while connecting all others to a single terminal, and employing n relays. The circuit

does not afford also the tree selection. It will be recalled that the circuit of Fig. 1 affords both an inverted tree and a tree circuit by means of n relays and $2(2^n - 1)$ transfers.

In the circuit of Fig. 8, as shown in the drawing, there are three relays, therefore, n is 3. However, n is not limited to 3 but may be any number as required. It will be observed that each of the 2^n terminals has a contact on each relay, therefore, the total number of contacts required is $n \cdot 2^n$. For the three relay arrangement shown, $3 \cdot 2^3$ or 24 contacts are required. For the three relay arrangement in Fig. 1, $2(2^n - 1)$ or 14 transfers are required. Considering a transfer as being the equivalent of 2 contacts, the arrangement of Fig. 1 requires 28 contacts as against 24 in Fig. 8. For all cases in which n exceeds 3, however, there is, in addition to the tree selection afforded by the arrangement of Fig. 1 for all values of n , which Fig. 8 does not provide for any value of n , an economy of contacts in favor of the arrangement of Fig. 1. This is apparent from the following table:

Contacts required

Number of Relays or n	Fig. 1	Fig. 8
	$4(2^n - 1)$	$n \cdot 2^n$
2	12	8
3	28	24
4	60	64
5	124	160

Attention is particularly called to the fact that the present invention provides arrangements whereunder inverse trees having fewer contacts than 2^n , or incomplete inverse trees, are possible, n being, as usual, the number of relays employed. Examples of such circuits are the individual stages of Fig. 5. For instance, consider that the fourth stage of Fig. 5 is isolated and that a circuit is connected to terminal T in the upper conductor and that the other four conductors extending between the third and fourth stages are disconnected from the third stage and connected together. The fourth stage of Fig. 5 would then resemble Fig. 1 in general configuration and in operation except that there would be but any one of five selectable terminals available in the tree circuit and only four remaining interconnectable in the inverse tree for each combination. The other stages bear a corresponding resemblance to Fig. 1.

What is claimed is:

1. A relay system, said system having n relays where n is any positive integer greater than one, 2^n selectable terminals, and a first and a second conductor, means for actuating said relays in 2^n permutative combinations to selectively connect each of said 2^n terminals individually to said first conductor, and means incident to each selection, for selectively connecting all of the remaining $(2^n - 1)$ terminals simultaneously to said second conductor.

2. In an electrical switching system, a number n of switching elements, where n is a positive integer, a number 2^n of conductors, a conductor A and a conductor B, means for selectively controlling said n elements to interconnect conductor A individually to any one of said 2^n conductors, and means incident to said selection, for simultaneously interconnecting a predetermined remaining group of said 2^n conductors, to conductor B, in parallel.

3. In an electrical system, a group of switching controls, a first and a second group of switching elements responsive to said controls, a group of terminals, a conductor A and a conductor B, means for operating said switching controls in permutative combinations so as to actuate said first group of switching elements to selectively connect said conductor A to any one of said groups of terminals, said second group of switching elements simultaneously responsive to said operation of said switch-

ing controls to connect all of said terminals not connected to conductor A to conductor B.

4. In an electrical system, a group of n switching controls, where n is a positive integer greater than one, a first and a second group of terminals, each of said groups having 2^n terminals and means responsive to the permutative operation of said controls for selectively interconnecting any one of said first group of terminals to a corresponding one of said second group of terminals.

5. A system in accordance with claim 4, including an ammeter and means responsive to any said selective interconnection for effectively interconnecting said ammeter in said interconnection.

6. A system in accordance with claim 4, including an electrical measuring device and means responsive to any said selective interconnection for effectively interconnecting said device in said interconnection.

7. A system in accordance with claim 4 including a working load and means responsive to any said selective interconnection for effectively interconnecting said load in said interconnection.

8. An electrical system, said system having a group of n switches, where n is any positive integer greater than one, a group of 2^n conductors, and an individual element, means for operating said n switches in a number of permutative combinations, so as to selectively effectively connect said individual element individually to any one of said 2^n conductors and means dependent upon said selection and responsive simultaneously to said operation for selectively effecting another selection.

9. An electrical system, having a plurality of switching elements arranged in n stages, where n is a positive integer greater than one, a first group of $(n+1)$ terminals, a second group of $(n+1)$ terminals, $(n+1)$ conductors, and means, responsive to the permutative operation of said switching elements, for permutatively interconnecting said first and said second group of terminals through said conductors.

10. An electrical system having n switching elements, a first group of terminals having 2^n terminals and a second group of terminals having three terminals, means responsive to the operation of said elements in permutative combinations for selectively connecting a first one of said three terminals to any individual one of said 2^n terminals, means responsive to the operation of said elements and incident to said selective connection for connecting a second predetermined one of said 2^n terminals to a second one of said three terminals and other means responsive to the operation of said elements and incident to said selective connection for connecting a third predetermined one of said 2^n terminals to a third one of said three terminals.

11. In an electrical system, n relays, 2^n conductors in a first group, a first, second and third conductor in a second group, control means for said relays for actuating said relays in 2^n permutative combinations, means responsive to said operation for selectively connecting said first conductor to any individual one of said 2^n conductors, and means incident to said selection for connecting said second and said third conductors to predetermined individual groups of said 2^n conductors not including said first conductor.

12. In a relay switching system, a first, second and third conductor, a group of n relays, a group of 2^n conductors, means for actuating said relays in permutative combinations, means responsive to said operation for selectively connecting said first conductor to any individual one of said 2^n conductors, means responsive to said operation and incident to said selection for selectively connecting said second conductor to a first group of F conductors, and means responsive to said operation and incident to said selection for selectively connecting said third conductor to a second group of S conductors, F and S being any integers from 0 through (2^n-1) , and $(F+S)$ being equal to (2^n-1) .

13. A system in accordance with claim 11, said group of 2^n conductors each having a designating numeral in the sequence from 0 through (2^n-1) , said system having means incident to the connection of said first conductor to terminal numbered k , where k is any digit from 0 through (2^n-1) for including in said group F and in said group S , respectively, all conductors having designation numerals lower than k and higher than k , respectively.

14. In an electrical switching system, a selecting circuit, said circuit having n relays, where n is a positive integer greater than one, said circuit having k terminals where k is equal to or less than 2^n , a first conductor, a second conductor, means in said circuit for actuating said relays so as to selectively connect said first conductor individually to any one of said k terminals and means in said circuit responsive to said actuation for simultaneously connecting said second conductor to all of said terminals, in parallel, other than said individually selected terminal.

15. In an electrical system, a selecting circuit, said circuit having a conductor, n selecting relays, where n is any positive integer greater than one, and k selectable terminals, where $k \leq 2^n$, and means in said circuit, responsive to the operation of said relays in permutative combinations, for selectively connecting said conductor in parallel to any desired collection of $(k-1)$ of said terminals.

16. In an electrical system, where " n " is any positive integer greater than one, n relays, k terminals, where $k \leq 2^n$, a first and a second conductor, means for actuating said relays in permutative combinations so as to selectively connect said first conductor to any predetermined one of said k terminals and means responsive to said actuation for selectively connecting said second conductor simultaneously to another predetermined one of said k terminals.

17. In an electrical system, n relays, where n is any positive integer greater than one, k terminals, where $k \leq 2^n$, a first conductor, a second conductor, a first set of tree contacts on said relays, a second set of contacts on said relays, means, responsive to the operation of said relays in permutative combinations, for selectively connecting said first conductor through said tree contacts to any predetermined one of said terminals and means responsive to said operation and incident to said selective connection, for selectively connecting said second conductor through said second set of contacts to another predetermined one of said k contacts.

18. A group of three relays, said relays having a total of fourteen sets of transfer contacts thereon, a first group of two conductors consisting of conductors numbered 1 and 2, a second group of eight conductors, means responsive to the operation of said relays in any desired one of eight permutation combinations for controlling said contacts to selectively connect said conductor 1 to any desired one of said eight conductors in said second group, and means, responsive to said operation of said relays and controlling of said contacts and dependent upon said selective connection, for connecting said conductor 2 in parallel to all of said conductors, of said second group, other than the single conductor connected to conductor 1.

19. A multi-stage permutation selecting circuit, said circuit comprising a number n of individual selecting stages, where n is any positive integer greater than one, and a first and second group of $n+1$ selectable elements, said stages connected in tandem in increasing numerical order 1 to n , means in the first of said stages for permutatively interconnecting, in all combinations, two of said selectable elements in each of said first and said second groups, means in the first and second of said stages for permutatively interconnecting, in all combinations, three of said selectable elements in each of said first and second groups and means in said n stages for permutatively interconnecting, in all combinations, said

11

$n+1$ selectable elements in each of said first and second groups.

20. A relay system having two relays, a contact group having a total of six sets of transfer contacts on said relays, two conductors, numbered 1 and 2, connectable through said contacts to four conductors, numbered 3, 4, 5 and 6, means for controlling said relays in four permutative combinations at four different times, means responsive to said controlling for arranging said contacts in four different manners at four different times, means responsive to said arranging for selectively connecting said conductor 1, singly, to any desired different one of said contacts 3, 4, 5 and 6 at said four different times, and means responsive to said arranging and dependent upon each said single selection for connecting all of the non-selected conductors, of the group 3, 4, 5 and 6, simultaneously to said conductor 2, at each of said times.

12

21. A selecting system having a first and a second group of conductors, each of said groups having at least four conductors, means in said system for establishing a first selection which connects one of said first group of conductors to any desired one of said second group of conductors at a time, and means in said system dependent upon said first selection for interconnecting together the other conductors of each of said groups of conductors at said time.

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