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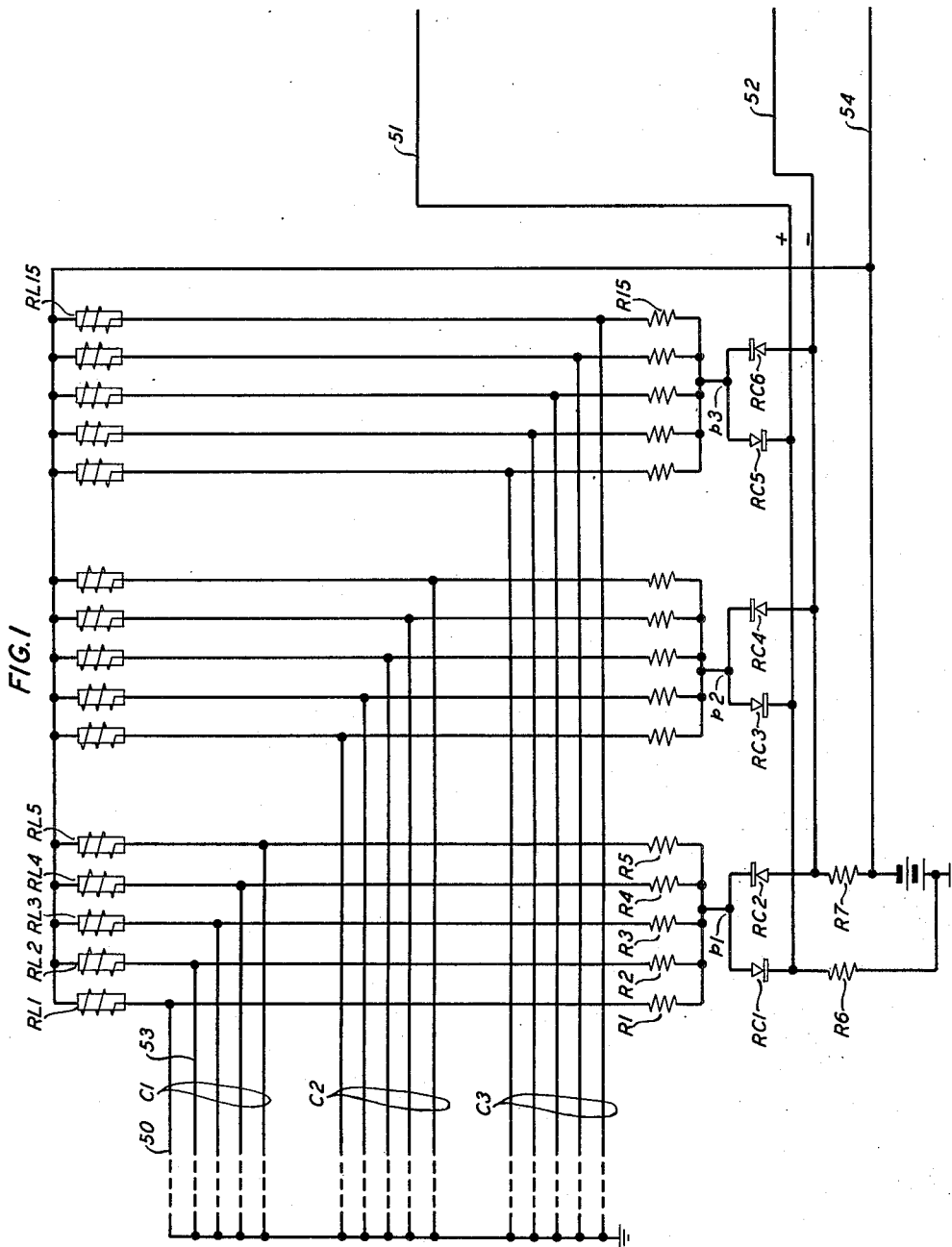
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2,484,226

INDICATING CIRCUIT

Filed Oct. 17, 1947

2 Sheets-Sheet 1



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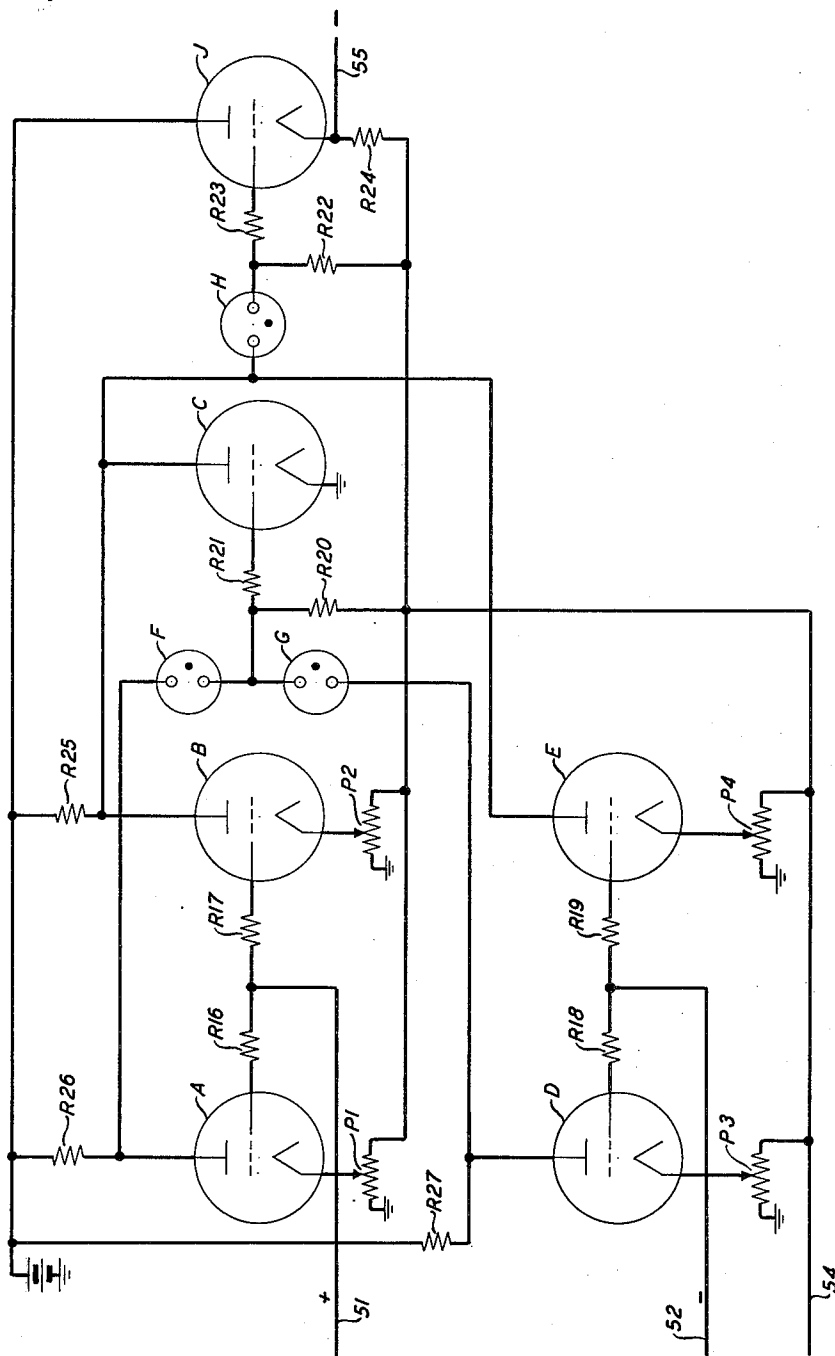
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FIG. 2



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INDICATING CIRCUIT

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6 Claims. (Cl. 177-353)

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This invention relates to indicating circuits and more particularly to circuits for indicating the number of conductors energized in groups of conductors.

In electrical recording and other systems, information is often indicated by the energizing of various combinations of conductors in one or more groups of conductors. For example, in the recording telephone system disclosed in the co-pending application of W. W. Carpenter et al., Serial No. 759,402, filed July 7, 1947, information to be recorded is indicated by the grounding of a combination of two conductors in each of several groups of five conductors. The grounding of less or more than two conductors in a group, however, has no significance and is an error. The present invention discloses a novel means for indicating, in systems of this kind, whether or not the proper number of conductors in each group is energized.

In its present embodiment, the invention is applied to a system of the kind disclosed in the above-mentioned application where two conductors in each of a plurality of groups of five conductors are normally energized. Its application, however, is not limited to systems of this kind but may be extended to systems in which any number of conductors are normally energized in groups of conductors of any number. The features of the invention and its mode of operation will be understood from the accompanying description, the appended claims, and the drawings, in which:

Fig. 1 shows the circuits of the conductors energized in combinations, and

Fig. 2 shows the indicating circuit.

To completely disclose the invention, Fig. 2 should be placed to the right of Fig. 1.

In Fig. 1, C1, C2 and C3 are groups of conductors of five conductors each which are grounded in combinations by any suitable means to operate corresponding combinations of the relays RL1 . . . RL15 or similar devices. For example, if conductor 50 is grounded, a circuit is completed from negative battery through the winding of relay RL1 and conductor 50 to said ground, operating relay RL1. In accordance with the present invention, the conductors of each group are connected together through individual resistances and to two oppositely-poled rectifiers. For example, the conductors of group C1 are connected together through resistances R1 . . . R5 and to rectifiers RC1 and RC2 which are oppositely poled. The resistances R1 . . . R15 should be substantially equal in value and said value should be high compared to the resistance of the winding of any of relays RL1 . . . RL15. A value for each of the resistances R1 . . . R15 thirty or more times the resistance of the winding of any of the relays RL1 . . . RL15 and a variation in

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resistance values of ± 10 per cent is satisfactory in the present embodiment of the invention. The rectifiers should have a high but finite resistance in the high-resistance direction of current flow and a resistance in the low-resistance direction small compared to the value of each of the resistances R1 . . . R15. A ratio of high to low resistance in the rectifiers of 1000 to 1 and a low resistance one-thirtieth of the value of resistances R1 . . . R15 is satisfactory in the present embodiment of the invention and can be obtained in commercial devices. The rectifiers may be of any type meeting the requirements. If vacuum tubes are used as rectifiers, it may be necessary to by-pass each of them with a high-resistance leak to secure a finite resistance in the high-resistance direction of current flow.

The conductors of each of the groups C2 and C3 are arranged similarly to the conductors of group C1. The negatively-poled rectifiers RC1, RC3 and RC5 are connected to ground through resistance R6 and over conductor 51 to the indicating circuit of Fig. 2. The positively-poled rectifiers RC2, RC4 and RC6 are supplied with negative battery through resistance R7 and connected to the indicating circuit of Fig. 2 over conductor 52. The values of resistances R6 and R7 should be high compared to the resistance of each of the rectifiers RC1 . . . RC6 in the high-resistance direction of current flow through said rectifiers. A ratio of two or more to one is satisfactory in the present embodiment of the invention.

When none of the conductors in the groups C1, C2 and C3 are grounded, resistance R7 and rectifiers RC2, RC4 and RC6 are virtually short-circuited by the parallel paths through resistances R1 . . . R15 and relays RL1 . . . RL15 and the junction points p1, p2 and p3 of the pairs of rectifiers are practically at the potential of negative battery. Current then flows from positive battery through resistance R6 and through rectifiers RC1, RC3 and RC5 to the points p1, p2 and p3. The potential of conductor 51 is thereby reduced below the potential of positive battery by the drop in resistance R6, but is still positive with respect to negative battery. As the potential drop in resistance R7 is very small, conductor 52 is practically at the potential of negative battery. When one of the conductors, for example conductor 50, is grounded, current flows not only from ground (which is at positive potential with respect to negative battery) through said conductor, and the winding of relay RL1 to negative battery, but also from ground through said conductor, resistance R1, and resistances R2 . . . R5 in parallel and in series, respectively, with the windings of relay RL2 . . . RL5, to negative battery. The negative potential at point p1 is thereby reduced to four-fifths of its previous value, less current flows from positive battery

through resistance R6 and rectifier RC1 to point p1, and the potential of conductor 51 becomes more positive. Current also flows from point p1 through rectifier RC2 and resistance R7 to negative battery, reducing the negative potential of conductor 52 by the potential drop in resistance R7. The potential difference across rectifier RC2 and resistance R7, however, being but one-fifth of that across rectifier RC1 and resistance R6, the negative potential of conductor 52 is nearer in value to that of the battery than the positive potential of conductor 51.

When two conductors, for example, conductors 50 and 53, are grounded, a circuit is established from ground through said conductors in parallel, resistances R3 . . . R5 in parallel and in series, respectively, with the windings of relays RL3 . . . RL5, to negative battery. The negative potential at point p1 is reduced to three-fifths of its original value and the potential of conductor 51 thereby made more positive. Again the negative potential of conductor 52 is also reduced but remains nearer to that of battery than the positive potential of conductor 51. It is obvious that the same result will be obtained when any two of the conductors in any one of the groups C1, C2 and C3 are grounded and that a similar result, differing only in degree, will be obtained when three or more of the conductors in any one of the groups C1, C2 and C3 are grounded. When the number of conductors grounded in each of the groups C1, C2 and C3 is the same, the potentials at points p1, p2 and p3 are the same. The values of resistances R6 and R7 may be chosen so that the potentials of conductors 51 and 52 are, under these circumstances, the same. In the present embodiment of the invention, the values of resistances R6 and R7 are such that the potentials of conductors 51 and 52 are the same when two conductors are grounded in each of the groups C1, C2 and C3.

Referring now to Fig. 2, the potentiometers P1 and P3, which control the potentials of the cathodes of tubes A and D, respectively, are adjusted so that each of said tubes will conduct when the potential at its control grid is the potential of conductors 51 and 52 when two conductors in each of the groups C1, C2 and C3 are grounded, and at more positive potentials, but will not conduct at more negative potentials. The potentiometers P2 and P4, which control the potentials of the cathodes of tubes B and E, respectively, are adjusted so that said tubes will not conduct at potentials on their respective control grids which obtain on conductors 51 and 52 when two of the conductors in each of the groups C1, C2 and C3 are grounded, or at more negative potentials, but will conduct at more positive potentials. The diode gas tubes F, G and H conduct at battery potential but do not conduct at substantially lower potentials. The negative bias on the control grid of tube C, produced by negative battery over conductor 54 and through resistances R20 and R21, normally prevents said tube from conducting. Tube J is normally prevented from conduction by the negative bias on its control grid produced by negative battery over conductor 54 and through resistances R22 and R23. Negative battery over conductor 54 and through resistance R24, therefore, normally makes the potential of conductor 55 negative. However, if tube J conducts, positive battery through the anode-cathode space of said tube makes the potential of conductor 55 positive, the value of resistance R24

being higher than the internal resistance of tube J.

Assuming, now, that two conductors in each of groups C1, C2 and C3 are grounded, conductors 51 and 52 are at the same potential, as previously described, and said potential is that at which tubes A and D conduct and tubes B and E do not conduct. Said potential being transmitted from conductor 51 through resistance R16 to the control grid of tube A and from conductor 52 through resistance R18 to the control grid of tube D, tubes A and D conduct and, the potentials at the anodes of said tubes being reduced by the potential drops in resistances R26 and R27, respectively, tubes F and G do not conduct. Tubes B, E and C do not conduct, the potentials at their control grids being insufficiently positive to cause conduction. Tube H, supplied with full battery potential, conducts, raising the potential of the control grid of tube J so that said latter tube conducts. The potential on conductor 55 is thereby made positive, indicating that the correct number of conductors in each of groups C1, C2 and C3 are grounded. Said potential may be utilized to operate any suitable indicating or other device.

If the minimum number of conductors grounded in any of the groups C1, C2 and C3 is two, but a greater number is grounded in one or more of said groups, the potential on conductor 52 will be that at which tube D conducts and tube E does not conduct, but the potential on conductor 51 will be more positive than before, as previously described. Tubes A, B and D, therefore, conduct and tube E does not conduct. With tube A conducting, the potential at its anode is reduced by the drop in resistance R26 and tube F does not conduct. By the conduction of tube D, the potential at its anode is reduced by the potential drop in resistance R27 and tube G does not conduct. The control grid of tube C remains negative and said tube does not conduct. The conduction of tube B lowers the potential at its anode by the potential drop in resistance R25 and tube H does not conduct. The control grid of tube J, therefore, remains negative and said tube does not conduct. The potential of conductor 55 is negative, indicating an incorrect number of conductors grounded in one or more of the groups C1, C2 and C3. Said potential may be used to operate any suitable indicating or other device.

If the maximum number of conductors grounded in any of the groups C1, C2 and C3 is two but a lesser number is grounded in one or more of said groups, the potential of conductor 51 will be that at which tube A conducts and tube B does not conduct but the potential of conductor 52 will be more negative than before. Tube A, therefore, conducts while tubes B, D and E do not conduct. The conduction of tube A lowers the potential at its anode by the potential drop in resistance R26 and tube F does not conduct. Tube G, however, being supplied with full battery potential, conducts. The potential of the control grid of tube C is thereby raised and said latter tube conducts. The potential at its anode is thereby lowered by the potential drop in resistance R25 and tube H does not conduct. The control grid of tube J remains negative and said tube does not conduct. The potential of conductor 55 is, therefore, negative, indicating an incorrect number of conductors grounded in one or more of the groups C1, C2 and C3.

If the number of conductors grounded in each of the groups C1, C2 and C3 is the same but

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less than two, the potentials of conductors 51 and 52 will both be more negative than the potentials for which tubes A, B, D and E are adjusted to conduct. None of said tubes, therefore, conduct. Tubes F and G both being supplied with full battery potential, both conduct, raising the potential of the control grid of tube C so that said latter tube conducts. The potential of its anode is thereby reduced by the potential drop in resistance R25 and tube H does not conduct. The control grid of tube J remains negative and said tube does not conduct. The potential of conductor 55 is negative, indicating an incorrect number of conductors grounded in the groups C1, C2 and C3.

If the number of conductors grounded in each of the groups C1, C2 and C3 is the same but more than two, the potential of conductors 51 and 52 will both be more positive than the minimum potentials for which tubes A, B, D and E are adjusted to conduct. All of said tubes, therefore, conduct. The potentials of the anodes of tubes A and D being lowered by the potential drops in resistances R26 and R27, respectively, tubes F and G do not conduct. The control grid of tube C remains negative and said tube does not conduct. However, the potential at its anode and at the anode of tube B is lowered by the conduction of tube B and the consequent potential drop in resistance R25. Tube H does not, therefore, conduct, the potential of the control grid of tube J remains negative, and said latter tube does not conduct. The potential of conductor 55 is negative, indicating an incorrect number of conductors grounded in groups C1, C2 and C3.

It will be understood that the values of resistances R6 and R7 may be made such that the potential of conductors 51 and 52 is the same for any desired number of conductors grounded in each of the groups C1, C2 and C3 and tubes A, B, D and E may be adjusted for said potential in the manner described above. Indications will then be given whether or not the selected number of conductors are grounded in each group in the same manner described above for two conductors grounded in each group. Also it will be observed that the number of groups of conductors, such as groups C1, C2 and C3, is immaterial and the invention will function successfully with a greater or a lesser number of groups of conductors.

What is claimed is:

1. A circuit comprising in combination a plurality of energizable conductors, rectifiers connected thereto, resistors connected to said rectifiers, first electronic devices responsive to the potentials at said rectifiers when said conductors are energized, gas discharge devices responsive to said first electronic devices, and second electronic devices responsive to said gas discharge devices for producing a signal when the number of said conductors energized is greater or less than a predetermined number.

2. A circuit comprising in combination a plurality of groups of energizable conductors, rectifiers for each of said groups, resistors connected to said rectifiers, first electronic devices responsive to the potentials at all of said rectifiers when said conductors are energized, gas discharge devices responsive to said first electronic devices, and second electronic devices responsive to said gas discharge devices for producing a signal when the number of said conductors energized in any of said groups is greater or less than a predetermined number.

3. A circuit comprising in combination a plurality of groups of energizable conductors, two

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oppositely poled rectifiers for each of said groups, a resistor connected to all of said rectifiers which are poled in one direction, another resistor connected to all of said rectifiers which are poled in the opposite direction, a first electronic device responsive to positive potentials at said rectifiers when said conductors are energized, a second electronic device responsive to negative potentials at said rectifiers when said conductors are energized, gas discharge devices responsive to said first and to said second electronic devices, and third electronic devices responsive to said gas discharge devices for producing a signal when the number of conductors energized in any of said groups is greater or less than a predetermined number.

4. A circuit as set forth in claim 1 in which said energizable conductors are all of substantially the same electrical resistance, said rectifiers are all of substantially the same electrical resistance, and said resistors are all of substantially the same electrical resistance, said resistance of each of said rectifiers to current flow there-through in one direction being not greater than one-thirtieth of the resistance of any one of said conductors, said resistance of each of said rectifiers to current flow therethrough in the opposite direction being not less than thirty times the aforesaid resistance of said rectifiers, and the resistance of each of said resistors being not less than twice the latter resistance of said rectifiers.

5. A circuit as set forth in claim 2 in which said energizable conductors all have substantially the same electrical resistance, said rectifiers all have substantially the same electrical resistance, and said resistors all have substantially the same electrical resistance, said resistance of each of said rectifiers to current flow therethrough in one direction being not greater than one-thirtieth of the resistance of any one of said conductors, said resistance of each of said rectifiers to current flow therethrough in the opposite direction being not less than thirty times the aforesaid resistance of said rectifiers, and the resistance of each of said resistors being not less than twice the latter resistance of said rectifiers.

6. A circuit as set forth in claim 3 in which said energizable conductors all have substantially the same electrical resistance, said rectifiers all have substantially the same electrical resistance, and said resistors both have substantially the same electrical resistance, said resistance of each of said rectifiers to current flow therethrough in one direction being not greater than one-thirtieth of the resistance of any one of said conductors, said resistance of each of said rectifiers to current flow in the opposite direction therethrough being not less than thirty times the aforesaid resistance of said rectifiers, and the resistance of each of said resistors being not less than twice the latter resistance of said rectifiers.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

70 Number	Name	Date
1,972,985	Gardner	Sept. 11, 1934
2,332,912	Hecht	Oct. 26, 1943
2,352,142	Vaughan	June 20, 1944
2,413,440	Farrington	Dec. 31, 1946
2,424,243	Lowell	July 22, 1947