

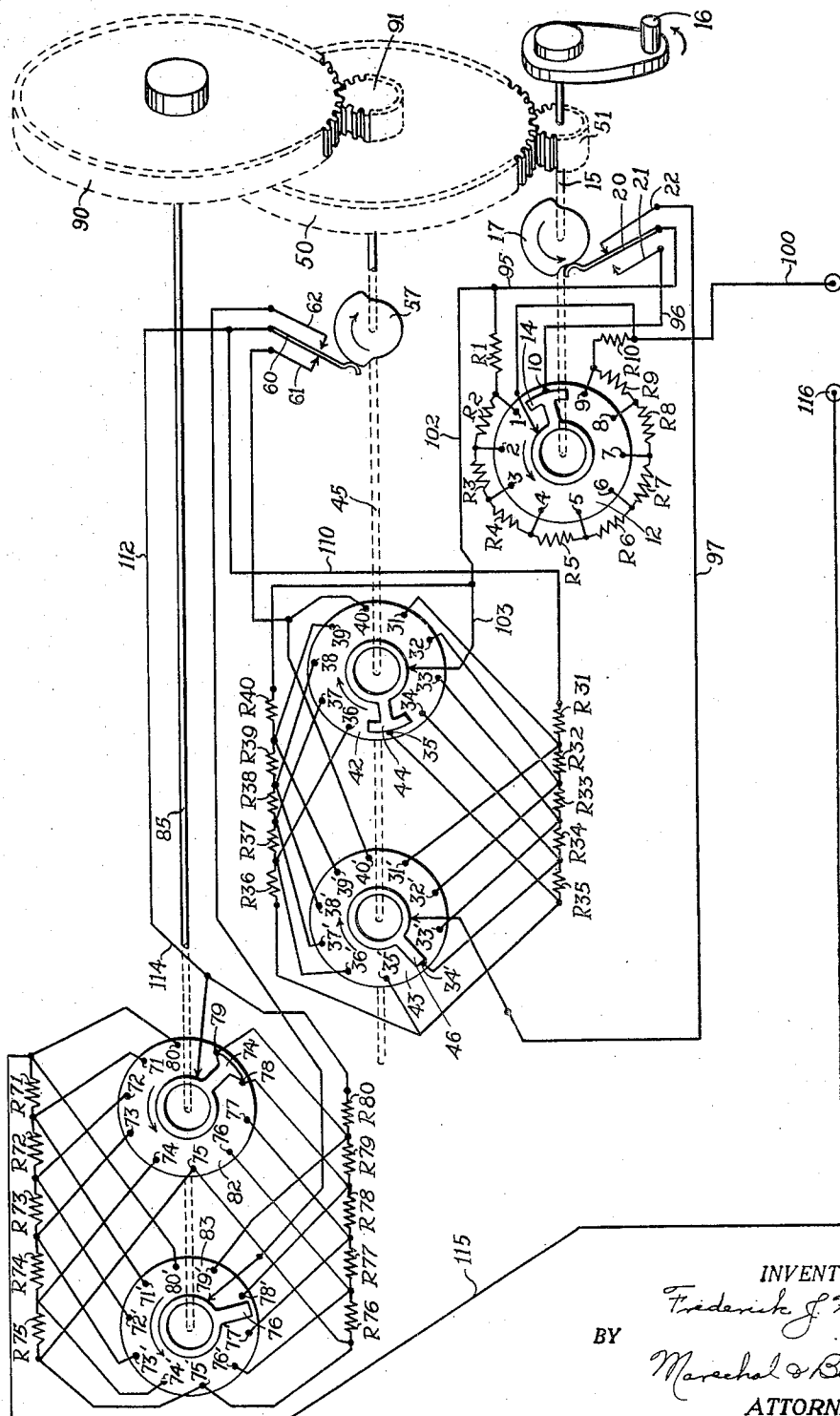
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ELECTRIC SYSTEM TO CONTROL IMPEDANCES

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ELECTRIC SYSTEM TO CONTROL
IMPEDANCES

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This invention relates to electrical circuits and more particularly to electrical systems.

It is the principal object to provide an electrical switching system for rapid and accurate control of a group of impedances from a single control member to vary the impedance progressively over a wide range in uniform increments.

It is also an object to provide control means for groups of impedances arranged in a units or first order group, and at least one higher order group in which the entire range of values may be traversed progressively in uniform increments, avoiding any open circuit positions or abrupt changes in the circuit values.

It is a further object to provide a system having circuits arranged in groups of a first and at least one higher order of values with switch means for each group coupled together and operable from a single shaft in which the total value of the groups included in the circuit is a function of the total angle to which such shaft is attached, the system providing for traversing the entire range of values in a continuous manner and with no greater change of values at any time than approximately that of the first order of values.

It is also an object to provide an electrical switching system having circuits of a first and at least one higher order of values which are arranged to be switched progressively in steps of the first order of values over the entire range without causing any change in values as great as the second or any higher order of values.

Other objects and advantages will be apparent from the following description, the accompanying drawing, and the appended claims.

In the drawing, the single figure is a schematic view showing the single control element and the group of switching arms operatively related thereto, in accordance with the present invention.

The provision of "decade type" switches is well known in which electrical circuits, such for example as resistors, reactors, or other impedances, are arranged to be adjustable and progressively included in an electrical circuit. For example impedances may be arranged in a group of a first order of values, and in other groups of a second, third, or still higher order of values. Thus, as a specific example, the first order group may comprise 10 resistors each having a resistance of 1 ohm, the second order group comprising ten resistors each having a resistance of 10 ohms, the third order group comprising ten resistors each having a resistance of 100 ohms, and

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so on. By providing separate switch arms for the resistors of each group, a total resistance may be selected to have any (integer) value between 1 and 1,000 ohms.

Further analysis will show that if the adjustable contact arm of the first order group of resistances is wide enough to span two adjacent contacts, it will not cause open circuits at any time and the maximum change in the total resistance in the circuit at any time will be only the value of a unit of the first order group, in the case above referred to, such value being 1 ohm. However when the contact arm of the second order resistance leaves one resistance point and passes to the next adjacent point, it will cause an abrupt change in the resistance in the circuit of a unit of the second order of values, namely, 10 ohms in the case assumed. Similarly the changes occurring upon movement of the third order switch arm will be abrupt changes or steps or 100 ohms each. With such an arrangement a sharp change in the electrical values in a circuit will thus occur at each transfer of the switch arms of the second and any higher order of values, interfering with the smooth and regular progression which is desired for many purposes. Similar analysis will show that if the switch arms are of less width so that they do not span adjacent contacts, open circuit conditions will occur in addition to the abrupt changes in values described, and additional objectionable line conditions will thus be involved.

The present invention provides a switching system of the so-called decade type in which resistors, reactances or other electrical circuits are arranged in a first order group and at least one higher order group. A single continuously adjustable control element is provided in conjunction with suitable switching means so that by continuous operation of the control member, the entire range of values may be progressively traversed with regular and uniform steps, the increments being those corresponding to the first order of values. This uniformity continues through the operation of the switching elements for the control of the second and higher order of values, there being no abrupt change in the circuit values at the time when the switch contacts establish or break connection with the circuits of the second or any higher order of values.

Referring specifically to the example above given, the present invention provides for including resistance in a circuit beginning with 0 ohm up through 10 ohms in the first order of values, then upon further operation of the control mem-

ber incorporating the first of the 10 ohm or second order values of resistance. Continued operation of the control member increases the resistance by one ohm steps up to 20 ohms when two of the second order resistors are included. This process is continued up to 100 ohms, at which time the first unit of the third order of values is included, and the values progress continuously in the same manner through the entire range of the circuits provided. At no time is the circuit left in an open condition and there are no abrupt changes in the resistance included in the circuit, the steps being regular and uniform and varying by 1 ohm values throughout the entire range. Further the actual resistance in the circuit, at any time is a direct function of the total angle through which the control member has been operated so that a highly desirable system is provided which is particularly suited by automatic or remote control.

Referring to the drawing which discloses a preferred embodiment of the invention, the electrical circuits are represented by way of illustration as resistances. They were arranged in groups comprising a first order group made up of resistors R1 to R10 respectively. While the system herein shown makes use of ten resistors in each group, and is thus based on a decimal system, it will be evident that the number of units in each group may be selected as desired and may be either less or greater than the ten which have been illustrated. For example, an advantageous arrangement is comprised of 12 units in each group and would thus be based on a duodecimal system. In any case the values of each one of the impedances of the second order group are the same as the value of entire bank of first order impedances.

The resistors of the second order group are shown at R31 through R40, and each has ten times the resistance of those of the first order group. The resistors of the third order group are shown at R71 through R80, each of which comprises 10 times the resistance of the units of the second order group or a resistance of 100 times that of the resistors of the first order group.

Resistors R1 to R10 are connected in series relation with each other and connections are brought out from each resistor to a series of contact terminals correspondingly numbered 1 through 10 which are mounted concentrically on a suitable insulating plate 12. A movable switch arm 14 is mounted on shaft 15 for movement in a continuous manner over the contacts 1' to 10. As shown it is of sufficient width so that it will span two adjacent contacts.

Shaft 15 is shown as being rotated by a handle 16 for manual operation, it being understood that any desired automatic operation or control may be utilized instead of the manual control. A cam 17 is mounted on shaft 15, the cam having high and low areas which are approximately equal in their arcuate extent.

Cam 17 controls a single pole double throw toggle or snap action switch comprising a movable contact arm 20 which is actuated by the cam between two positions where it closes alternately with contacts 21 and 22. The cam is so arranged relative to switch arm 20 that when rotated in the direction indicated by the arrow in the drawing, the high portion of the cam engages with spring arm 20 to cause the opening of switch contact 22 and the simultaneous closing of contact 21 at the time when

the switch arm 14 of the switch is centered over contact terminal 10.

Resistors R31 to R40 comprising the group of values of the second order, are also connected in series relation with each other and connections are made from the several resistors to contact terminals numbered 31 to 40 which are concentrically mounted on insulating plate 42. In addition a second insulating plate 48 is provided which is mounted in parallel but axially spaced relation with plate 42 and which also contains a series of contacts connected with the same group of resistors 31 to 40 and marked 31' through 40' respectively.

A main movable switch arm 44 is mounted on shaft 45 for movement over contacts 31 to 40 and like arm 14, is of sufficient width to span each two adjacent contacts. Shaft 45 also carries another switch arm 46 which traverses contacts 31' to 40'. Auxiliary switch arm 46 operates in unison with arm 44, but as shown is angularly displaced therefrom or retarded by one step or contact. Thus when arm 44 is on contact 35, for example, arm 46 is on contact 34. Further, arm 46 is not wide enough to span adjacent contacts, but is of such width that upon movement in either direction it establishes contact with the terminal toward which it is moving before arm 44 breaks contact with the terminal it is leaving.

Shaft 45 is driven by a large gear 50 engaging with small pinion 51 of shaft 15. The ratio is such that a complete revolution of shaft 15 causes the advance of shaft 45 and of the contacts 44 and 46 by one step. Shaft 45 carries a cam 57 similar to cam 17 which actuates the movable switch arm 60, forming part of a snap action switch similar to switch 20, to cause it to close alternately with its contacts 61 and 62.

Resistors R71 through R80, comprising the circuits of the third, and in this case the highest, order of values, are similarly connected in series relation with each other. A double set of insulating plates 82 and 83 are each arranged with its respective sets of contact terminals 71 to 80 and 71' to 80', similar to the arrangement of the resistors of the second order of values described above. Main and auxiliary switch arms 74 and 76 cooperate with contacts 71 to 80 and 71' to 80' respectively, arm 76 being displaced or retarded by one step relative to arm 74 as above described with respect to arms 46 and 44. Both switch arms are rotated in unison by shaft 85 from gear 80 driven by pinion 91 on shaft 45. Again the reduced ratio is such that shaft 85 and its contact arms 74, 76, are advanced by one step in response to a complete rotation of shaft 45.

Switch arm 20 is directly connected with resistor R1 by line 95, while contact 21 is connected with terminal 10 on the first bank of resistors by line 96. Contact 22 is connected directly to the auxiliary switch arm 46 of the second bank of resistors by line 97. One side of the main circuit is indicated at 100, connection from which is made directly to the resistor R10, and a parallel connection being made to the movable switch arm 14.

Resistor R1 is also connected directly to R40 as shown at 102 and by a parallel connection 103 to the movable switch arm 44. Resistor 31 is connected as shown at 110 to switch arm 60, and through line 112 with the first unit R71 of the third bank of resistors, a parallel connection 114 also being made to the switch arm 74. Contact 61 is connected to terminals 40 and 40' while contact 62 is connected to the auxiliary switch arm

76 of the third bank of resistors. Connection is made by a line 115 from the end of resistor R80 to the opposite main line terminal 116.

In operation, the system above described functions in the following manner. Assuming a rotation of shaft 15 in the direction of the arrow shown in the drawings, i. e., counter-clockwise, movable contact 14 moves over the terminals 1 to 10 in sequence, providing for gradually increasing the resistance in the circuit in uniform steps of the value of each individual resistance element. The circuit through the first bank of resistors may be followed from terminal 100, through the rotatable switch arm 14, to the contact terminal which it engages, into the successive resistors R_n down to R₁ which may be included, and out through line 102 to the resistors of the second and third banks which may be included. Thus with control in the position shown, the circuit may be traced through line 103, switch arm 44, resistors R35, R34, R33, R32 and R31, line 110, line 112, line 114, switch arm 74, resistors R78 through R71, and from line 115 to the opposite circuit terminal 116.

As the arm 14 moves from terminal 1 to terminal 5 the high portion of the cam 17 maintains switch arm 20 against contact 21 thus completing a circuit from terminal 10 directly to the outer terminal of R₁. Since however terminal 10 is not connected with the bank of resistors in any way, this circuit is ineffective under these conditions.

As the switch arm 14 moves from terminal 5 to terminal 6, the low point of cam 17 engages the switch arm 20 and allows the same to move under its spring action, opening contact 21 and closing against contact 22. This establishes a circuit from line 105 to the movable switch arm 46 which is trailing behind contact 44, but moving toward the same contact point which arm 44 is leaving. Thus by way of example when switch arm 44 leaves contact 34 and approaches contact 35, arm 46 approaches its contact 34', and establishes contact therewith before switch arm 44 leaves its contact 34. It will thus be evident that during the remaining half of the revolution of shaft 15, and even following the complete opening of the circuit between switch arm 44 and its contact 34, the line circuit is maintained through line 95, switch 20, contact 22, line 97, and auxiliary switch arm 46, which is in direct contact with its contact 34'. Thus there is no premature incorporation of the next step of resistance in the circuit, until that condition is desired, and the fact that main switch arm 44 has moved up to contact 35 is ineffectual.

As the final movement of switch arm 14 into contact with its terminal 10 is completed, it will be evident that the final unit value of the resistance has been included in the first bank of resistors, corresponding for example to four units in the second bank comprising resistors R31 to R34 and 10 units in the first bank comprising resistors R₁ to R₁₀. At this point, the rise of cam 17 engages switch arm 20, causing it to move rapidly from its closing position against contact 22 to its closing position against contact 21. This movement effects the opening of the circuit through auxiliary switch arm 46 which is on contact terminal 34', and the circuit is then completed through main switch arm 44 which engages contact 35, thus including the next unit or resistor R35, in the circuit. Simultaneously, the closing of switch arm 20 against contact 21 establishes a short circuit for the entire first bank

of resistors R₁ to R₁₀ so that the total resistance in the circuit remains the same. There is therefore no abrupt change in the total resistance included in the circuit, the switching operation above described providing for the simultaneous incorporation of an additional step of resistance of the second order of values concurrently with the exclusion of the entire first order group of resistances.

It will be evident from the above that further operation of shaft 15 provides for reincorporation of the first bank of resistors in a step by step manner, with similar switching of the circuits of the final or last step of the units resistances, in the manner described above. It will also be clear that the system works equally well in both directions, providing for selective increase or decrease of the resistance values in the uniform steps, in the manner already described.

The functioning of the third order group of resistances is similar to the operation already described, the lower value circuit being established through switch arm 76 while switch arm 74 completes its movement to the next succeeding position, with the final transfer of the circuits being governed by cam 57 to occur upon the movement of switch arm 44 to terminal 40. It will thus be clear that the inclusion or exclusion of one of the resistors R71 or R80, comprising resistors of the third order of values, effects no change in the overall value of the resistance in the circuit, and again there is no abrupt change in the circuit, the maximum change which occurs being approximately that corresponding to a single unit of the first order of values.

It will also be clear that the final position of all of the contact arms described above, as well as the total value of resistance (or other electrical values) included in the circuit will be a direct function of the total angle through which shaft 15 has been rotated. It is thus possible to provide for automatic control of a group of electric circuits over a wide range of values while assuring uniform and predetermined electrical circuit conditions at all times, the total value of which is a direct function of the total angle through which the control shaft has been operated. The device is extremely simple and both reliable and satisfactory in operation, providing for the obtaining of new and highly advantageous results in switching systems of the character described.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A continuously variable system comprising a group of electrical circuits of a first order of values, at least one additional group of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for connecting with said circuits of the higher order of values, means for operating said second control member in coordinated relation with said first control member, switch means actuated respectively by said control members for progressively connecting with said electrical circuits of both said first and said higher order of values in uniform incre-

means not greater than those of said first order of values and means establishing a continuously closed circuit through said switch means including said electrical circuits of both said first order of values and of said higher order of values.

3. A continuously variable system comprising a group of electrical circuits of a first order of values, at least one additional group of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for connecting with said circuits of the higher order of values, means for operating said second control member in coordinated relation with said first control member providing for an advance of one step upon a complete cycle of movement of said control shaft, switch means actuated respectively by said control members for progressively connecting with said electrical circuits of both said first and said higher order of values in uniform increments not greater than those of said first order of values, and means establishing a continuously closed circuit through said switch means including said electrical circuits of both said first order of values and of said higher order of values.

3. A decade type switching system operable from a single continuously adjustable control shaft comprising groups of electrical circuits of a first and at least one higher order of values, a control member continuously adjustable with respect to said first order of values, means coupled with said control member and operating in a reduced speed ratio therewith for connecting with said electrical circuits of said higher order of values, switch means operated respectively by said control members for switching said circuits in predetermined sequence to selectively traverse the entire range of values in uniform steps corresponding to those of the first order of values, and means establishing a continuously closed circuit through said switch means including said electrical circuits of both said first order of values and of said higher order of values.

4. A continuously variable switching system for use with groups of impedances of a first and at least one higher order of values comprising switch means progressively adjustable with respect to the impedances of said first order of values, a second switch means progressively adjustable with respect to the impedances of said higher order of values, a third switch means also progressively adjustable with respect to the impedances of said higher order of values, means for operating said second and third switch means in correlated relation with said first switch means to provide for a step of progression from one impedance to the next in said second order upon complete traverse of the impedances of said first order by said first switch means, means for operating said third switch means in offset relation by one step with respect to said second switch means, and auxiliary switch means operable at an intermediate point in the cycle of said first switch means for alternately establishing circuits through said second and third switch means to maintain a continuously closed circuit in which the impedance changes uniformly throughout the entire range in increments of said first order of values.

5. A continuously variable switching system comprising a group of electrical circuits of a first order of values, at least one additional group

of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for the circuits of said higher order of values, means for advancing said second control member by one step in response to completion of a cycle of movement of said first control member, and means for establishing a circuit through said succeeding unit and simultaneously excluding said first group of circuits upon completion of said cycle of said first control member.

6. A continuously variable switching system comprising a group of electrical circuits of a first order of values, at least one additional group of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for the circuits of said higher order of values, means for advancing said second control member by one step in response to completion of a cycle of movement of said first control member, means to maintain a circuit through a preceding unit of said second group while said second control member is moving into contact with the succeeding unit of said group, and means for establishing a circuit through said succeeding unit and simultaneously excluding said first group of circuits upon completion of said cycle of said first control member.

7. A continuously variable switching system comprising a group of electrical circuits of a first order of values, at least one additional group of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for the circuits of said higher order of values, means for advancing said second control member by one step in response to completion of a cycle of movement of said first control member, means establishing a main circuit through the next succeeding unit of said second order group in the direction of travel of said second control member, means concurrently establishing an auxiliary circuit through the preceding unit of said second order group, and means for switching from one of said circuits to the other at a predetermined point in the cycle of said first control member, means establishing a main circuit through the next succeeding unit of said second order group in the direction of travel of said second control member, means concurrently establishing an auxiliary circuit through the preceding unit of said second order group, and means for switching from one of said circuits to the other at a predetermined point in the cycle of said first control member.

8. A continuously variable switching system comprising a group of electrical circuits of a first order of values, at least one additional group of electrical circuits of the next higher order of values, a continuously adjustable control shaft, a first control member operable by said control shaft through a cycle of movement to progressively connect with all of the circuits of said first order of values, a second control member for the circuits of said higher order of values, means for

advancing said second control member by one step in response to completion of a cycle of movement of said first control member, means establishing a main circuit through the next succeeding unit of said second order group in the direction of travel of said second control member, means concurrently establishing an auxiliary circuit through the preceding unit of said second order group, and means operable simultaneously with completion of a cycle of said first control member for excluding said first order group and transferring from said auxiliary to said main circuit.

9. A switching system operable from a single continuously adjustable control shaft comprising groups of electrical circuits of a first and at least one higher order of values, a first control member continuously adjustable with respect to said first order of values over a cycle of movement successively including the units of said first order group, a second control member coupled with said first control member for connecting with said circuits of said higher order of values and advancing by one step for a complete cycle of said first control member, and switch means for progressively connecting with said circuits in uniform steps of said first order of values including a main contact arm operated relative to said higher order group by said second control member, an auxiliary contact arm also operated by said second control member and offset from said main contact arm by one step, means establishing a main circuit through said main contact arm before said main contact arm leaves a contact, means establishing an auxiliary circuit through said auxiliary contact arm and said same circuit before that circuit has been left by said main contact arm, and means for transferring between said auxiliary circuit and said main circuit.

10. A switching system operable from a single

continuously adjustable control shaft comprising groups of electrical circuits of a first and at least one higher order of values, a first control member continuously adjustable with respect to said first order of values over a cycle of movement successively including the units of said first order group, a second control member coupled with said first control member for connection with said circuits of said higher order of values and advancing by one step for a complete cycle of said first control member, and switch means for progressively connecting with said circuits in uniform steps of said first order of values including a main contact arm operated relative to said higher order group by said second control member, an auxiliary contact arm also operated by said second control member and offset from said main contact arm by one step, means establishing a main circuit through said main contact arm before said main contact arm leaves a contact, means establishing an auxiliary circuit through said auxiliary contact arm and said same circuit before that circuit has been left by said main contact arm, means for transferring between said auxiliary circuit and said main circuit, and means for excluding the circuits of said first order group simultaneously with a transfer from said auxiliary circuit to said main circuit.

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Certificate of Correction

Patent No. 2,448,885.

September 7, 1948.

FREDERICK J. HOOVEN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 2, line 14, after the word "order" insert *group*; line 20, for "or steps or" read *or steps of*; line 30, after "values" insert *above*; column 3, line 24, for "were" read *are*; column 5, line 26, after the numeral "5" insert a comma; column 7, line 2, after "values" insert a comma; column 8, line 9, for "responsie" read *response*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of November, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.