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C. O. BROWNE ET AL

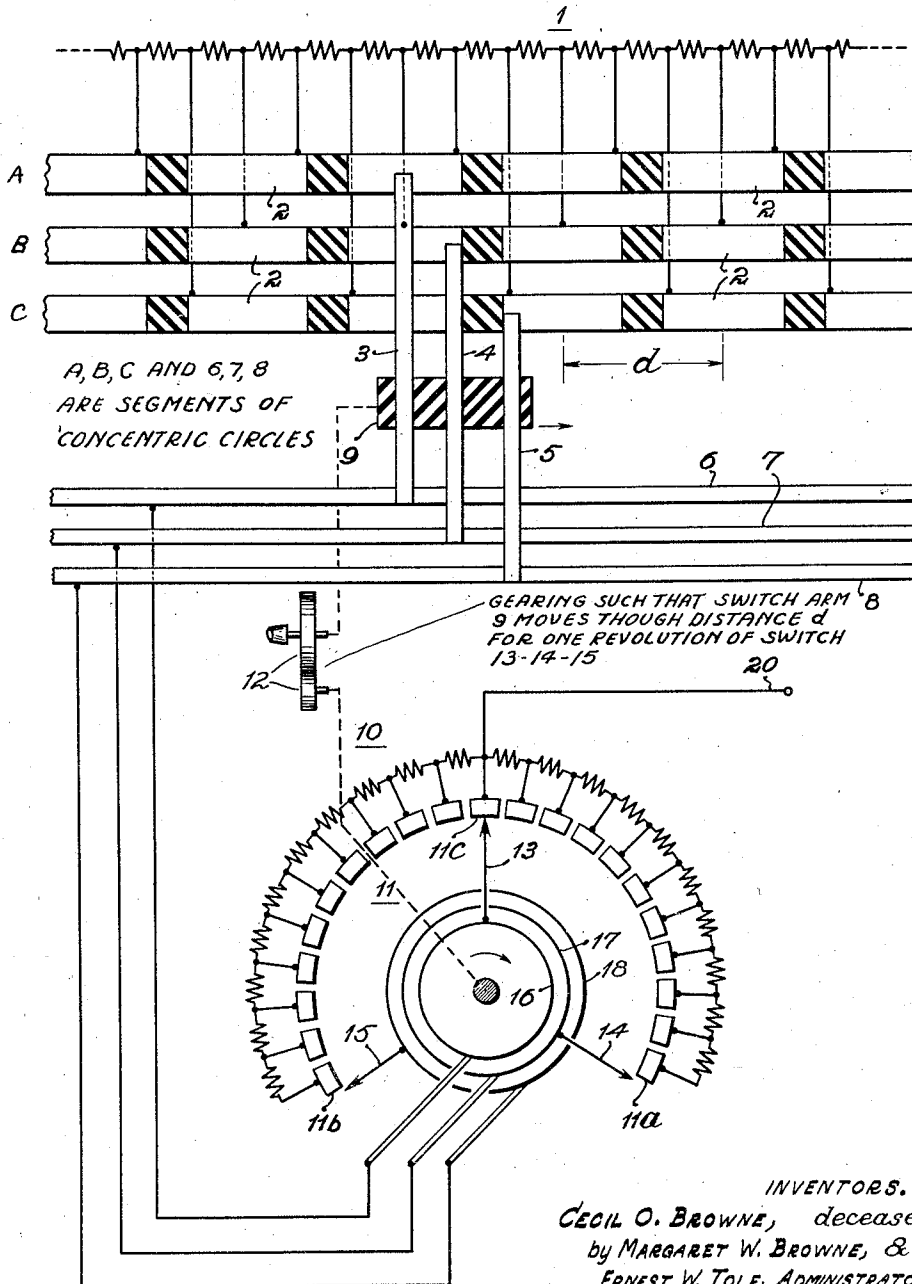
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MULTIPLE CONTACT ELECTRIC SWITCH

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2 Sheets-Sheet 1

Fig. 1.



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MULTIPLE CONTACT ELECTRIC SWITCH

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The invention relates to multiple contact electric switches and more particularly to the application of such switches to effect connection to tapping points on impedances.

Arrangements, such as continuously variable potentiometers and stud switches, for effecting electrical connections to a series of tapping points on an impedance are well known, but these arrangements have certain disadvantages when it is desired to employ a very large number of tapping points and high precision is necessary. If stud switches or the like are used, the large number of tappings and studs required give rise to practical difficulties, and continuously variable potentiometers cannot usually be adjusted with precision and are not always consistent in operation.

It is the object of the present invention to provide a multiple contact switch which will enable electrical connection effectively to be made to a relatively large number of tapping points by means of a relatively small number of contacts.

According to the present invention, multiple contact switch apparatus comprises a series of main contacts and means for making electrical connection with each of said main contacts in succession, a series of auxiliary contacts and further means for making electrical connection with each of said auxiliary contacts in succession, said means and further means being electrically inter-connected and arranged for simultaneous operation in such a manner that as said further means is caused to pass over said auxiliary contacts, a conductor associated with said auxiliary contacts is operatively connected sequentially with a main contact and a sequence of a given number of auxiliary contacts.

In particular applications of the invention the multiple contact switch apparatus is arranged to effect selection of desired values of resistive or reactive impedance and may be applied, for example, to a potentiometer arrangement, a time delay network or to an attenuator.

In order that the invention may be more clearly understood and readily carried into effect, such applications of the invention will now be described in greater detail by way of example with reference to the accompanying drawings wherein Fig. 1 discloses a multiple contact switch according to one embodiment of the invention, and Fig. 2

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discloses a multiple contact switch according to another embodiment of the invention.

Referring to Figure 1 of those drawings, tappings on a first impedance 1 are connected to contacts 2, which are spaced apart on three concentric circles, only parts of which are shown as rows A, B and C in the drawings. The length of each contact is arranged to be at least two-thirds and preferably three-quarters of the distance d between the centres of adjacent contacts, and the spaces between adjacent contacts are preferably filled with insulating material, shown cross-hatched. Three brushes 3, 4, 5 spaced apart from each other on the switch arm (shown diagrammatically at 9) by a distance equal to one-third of the distance between the centres of adjacent contacts 2 are arranged to slide over the contacts in the three rows A, B and C respectively. The brushes 3, 4, 5 are connected to slip rings 6, 7 and 8 respectively.

A second impedance 10 is tapped at intervals and the tappings are connected to contacts 11 which are spaced apart on a circular arc, three brushes 13, 14 and 15 set at an angle of 120° with respect to each other being arranged to rotate about a common axis so as to slide over the contacts 11. The contacts 11 extend over an angle of approximately 240° , so that as soon as one brush has passed off the extreme right-hand element 11a, another brush passes on to the extreme left-hand element 11b, the remaining brush sliding over the centre contact 11c in the meantime. The brushes 13, 14, 15 associated with the second impedance are coupled respectively to the brushes 3, 4, 5 associated with the first impedance 1 by gearing 12 or otherwise in such manner that the brushes 3, 4, 5 move through a distance equal to the distance d between the centres of adjacent contacts 2 during one complete revolution of each of the brushes 13, 14, 15. The brushes 13, 14, 15 are connected to three slip rings 16, 17, 18 which are in turn connected to the slip rings 6, 7, 8 associated with the first impedance 1, so that the brush 13 is connected to the brush 3, and so on. The contact 11c is connected to the output or "slider" terminal 20.

The arrangement operates as follows. Let it be assumed that the brushes 13, 14, 15 are rotated clockwise from the position shown in the drawings. In the position shown the output terminal

20 is connected via the slip rings 16 and 6 and the brush 3 to one of the elements 2 of the impedance 1. As the brushes 13, 14, 15 rotate, the brush 15 makes contact with the contact 11b, and that portion of the impedance 10 connected between the contacts 11b and 11c is connected in parallel with a pair of adjacent contacts 2 on the impedance 1. This connection is effectively maintained as the brushes 13, 14, 15 rotate, different portions of the impedance 10 being utilized in turn until when the brush 13 reaches the element 11a; and the brush 15 reaches the element 11c the portion of the impedance 10 between the elements 11c and 11a is connected in parallel with the above mentioned pair of adjacent contacts 2 on the impedance 1. As the brushes 13, 14, 15 rotate in this manner, the output terminal 20 is, in effect, connected in turn to the elements of a constant impedance connected in parallel with one element of the impedance 1 until when the brush 13 moves off the contact 11a, it is connected to the tapping point on the impedance 1 adjacent to the tapping point to which it was formerly connected. The brush 14, which has in the meantime been disconnected from the second impedance 10 then makes contact with the contact 11b and cooperates with the brush 15 in the same manner as the brush 15 previously cooperated with the brush 13. The result is thus that a tapped impedance equal to one-half of the impedance 10 is connected in parallel with adjacent tapping points on the impedance 1, and by means of the impedance 10 and the brushes 13, 14, 15, the intervals between successive tapping points on the impedance 1 are subdivided in turn without the necessity of a separate potentiometer for each pair of tapping points on the impedance 1.

The impedance 1 may conveniently be provided with three rows of 100 contacts 2, and each of these contacts may be three-eighths inch long and be spaced from each other by one-eighth inch. The impedance 10 may be provided with twenty-one contacts in all, only ten of which will be effective at any given time, so that the impedance 1 may effectively be provided with 3000 tapping points by the use of only 321 contacts, the maximum diameter of the apparatus being only 16".

In order to afford further sub-division, further impedances may be connected between the tapping points on the impedance 10 and the contacts 11 to which they are connected and the dimensions of the brushes 13, 14, 15 and number and dimensions of the contacts 11 are so chosen that one brush, for example, the brush 15 bridges two adjacent contacts 11 while brush 13 makes contact with only one contact and vice versa. When two adjacent contacts are bridged in this way, the brush bridging them will then assume a potential equal to the mean potential of the two tapping points on the impedance 10 to which the contacts are connected, so that the number of tapping points on the impedance 10 is effectively quadrupled.

If, on the other hand, brushes 15 and 13 are so arranged that they can simultaneously bridge two adjacent contacts 11, the number of tapping points on the impedance 10 is effectively doubled.

It will be appreciated that if it is desired to give the potentiometer a non-linear law, the impedance 1 should be tapped at intervals sufficiently close to ensure that the linear sub-division of those intervals by the impedance 10 and the brushes 13, 14, 15 will not give rise to any serious error in the desired law. In such cases, if resistances are inserted in series with the tappings

on the impedance 10 and the contacts 11, they should preferably be increased in value for the end contacts 11a and 11b, so that should all the brushes 13, 14, 15 momentarily make contact with contacts 11, the output terminal 20 will not tend to assume the mean potential of two adjacent tapping points on the impedance 1.

Although the impedances 1 and 10 will usually be resistances, if it is desired to divide a constant voltage, these impedances may be constituted by a tapped choke or a tapped condenser or other reactance when it is required to divide an alternating voltage. When tapped chokes are used, it is desirable to include resistances between the tapping points on the choke and the brushes 13, 14, 15 so as to avoid short-circuiting turns of the choke when any of these brushes bridge adjacent contacts 11. If desired, a condenser may be connected across the choke so as to increase the impedance which is connected in parallel with the adjacent elements 2 of the impedance 1. Alternatively, the number of contacts 11 may be increased so as to occupy a complete circle, a tapping on the impedance 10 being connected to each contact 11 as before, and the slip rings 6, 7, 8 permanently connected to three equidistant tapping points on the impedance 10, the brushes 13, 14, 15 being removed. If now the output is taken from a brush moving over the contacts 11, the voltage obtained from such a brush will be similar to that obtained from the terminal 20 in the arrangement described above. This alternative arrangement, although reducing the number of brushes required has, however, the disadvantage that it tends to place a larger load across the impedance 1, so that the impedance 10 has to be of a relatively high value if the law of the impedance 1 is to be substantially unaffected by the shunting effect of the impedance 10.

If the impedance 1 is tapped so that the ratio of potential on any two consecutive contacts 2 is the same for all pairs of contacts, the apparatus may be further simplified as will now be described with reference to Figure 2 of the drawings.

Referring to Figure 2, the impedance 1 which is shown as a time delay network, is tapped at equal intervals of time delay and the tappings are connected to contacts 2 which are spaced apart on two concentric circles, only parts of which are shown, as in Figure 1, as rows A and B. Two brushes 3, 4 spaced apart from each other on the switch arm, shown diagrammatically at 9, are arranged to slide over the contacts in rows A and B respectively and are connected to slip rings 6 and 7 respectively. The slip rings 6 and 7 are connected, if desired, each through a buffer valve 21, to a second impedance 10a, 10b respectively, each of said second impedances 10a, 10b being, in the arrangement shown, a time delay network terminated at its end remote from the end operatively connected with the slip ring 6 or 7 so as to prevent reflection. Each of the impedances 10a, 10b is provided with ten tapping points, and these tapping points are connected to sets of contacts 11a and 11b respectively spaced apart on a circle. A brush 13 is arranged to rotate so as to pass over the two sets of contacts 11a, 11b in succession and is mechanically connected by gearing 12 or otherwise with the switch arm 9 in such manner that for one complete rotation of the brush 13 the brushes 3, 4 move through a distance equal to the distance d between the centres of the adjacent contacts 2. The brushes 3, 4 are spaced apart by half the distance d , so that as the switch arm 9 moves,

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one brush remains in contact with the same contact, while the other changes from one contact to an adjacent contact. The second impedance 10a, 10b is tapped at equal intervals, and the total time delay is arranged to be less by the time delay of one of said intervals than the difference in time delay between adjacent tapings on the first impedance 1.

The operation of the arrangement disclosed in Fig. 2 is as follows: With the brush 13 in the position shown in the figure, the time delay corresponds to that of the tapping on the first impedance 1 to which the brush 3 is connected together with the additional delay introduced by two intervals of the second impedance 10a. As the brush 13 moves over the contacts 11a in a clockwise direction, the delay is successively increased, the brush 3 remaining in contact with the same contact in the row A of contacts associated with the first impedance 1, but the brush 4 passing over the insulation between two adjacent contacts in the row B of contacts associated with the first impedance 1. As the rotation of brush 13 continues, it passes off the extreme left-hand contact 11a on to the extreme left-hand contact 11b, by which time the brush 4 to which the latter contact is connected has made contact with the contact in row B connected to the next tapping in the first impedance 1. Further rotation of the brush 13 then adds the delay of the second impedance 10b by successive intervals until in due course the brush 13 passes on to the extreme right-hand contact 11a and makes contact via brush 3 with the next adjacent tapping point on the first impedance 1 and so on. It will be appreciated that each of the intervals on the second impedances 10a and 10b must, in the example shown, be one-tenth of each interval on the first impedance 1, so that as the brush 13 passes from the extreme left-hand contact of the impedance 10a to the extreme left-hand contact of the impedance 10b, for example, the increase in time delay is equal to the increase in delay between adjacent contacts 11a or 11b. A conductor connected to the brush 13 will therefore have a delay which can be adjusted by rotation of the brush 13, to intervals of one-tenth of the intervals between adjacent tapping points on the first impedance 1.

By replacing the reactive elements of the impedances 1, 10a and 10b by resistances, and adjusting the terminating resistances suitably, the arrangement which has just been described becomes an attenuator. If desired, the shunt resistances replacing the condensers of the time delay network may be omitted providing that the series resistances are graded so as to give the impedances 10a and 10b an exponential law.

Although the invention has been described with reference to voltage division and time delay by means of potentiometers and time delay networks respectively, it will be appreciated that the invention may be used generally for effecting electrical connection to a large number of contacts to which may be connected any desired kind of impedance or circuit.

What is claimed is:

1. Multiple contact switch apparatus comprising a plurality of sets of main contacts, each of said contact sets being arranged in a circle and the several contact sets being concentrically arranged in spaced relation, a plurality of main contact brushes each individually associated with one of said contact sets and adapted to make

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electrical connection therewith in succession, a series of auxiliary contacts, a plurality of auxiliary contact brushes, equal in number to the main contact brushes, adapted to make electrical connection with said auxiliary contacts in succession, an electrical connection between each of the main contact brushes and a corresponding one of the auxiliary contact brushes, a conductor associated with the auxiliary contacts, and means for effecting continuous and simultaneous operation of the main and auxiliary contact brushes in timed relation such that as the auxiliary contact brushes pass over said auxiliary contacts said conductor is operatively connected sequentially with a main contact and a sequency of a given number of auxiliary contacts.

2. Apparatus according to claim 1 arranged to effect selection of desired values of an impedance wherein said main contacts are connected to tapping points in said impedance and said auxiliary contacts are connected to tapping points in an auxiliary impedance, the arrangement being such that at any given instant in operation, the portion of said auxiliary impedance between any selected number of auxiliary contacts is connected effectively in parallel with a selected portion of said first-mentioned impedance.

3. Apparatus according to claim 1 arranged to effect selection of desired values of a potentiometer resistance wherein said main contacts are connected to tapping points in said resistance and said auxiliary contacts are connected to tapping points in an auxiliary resistance, the arrangement being such that at any given instant in operation, the portion of said auxiliary resistance between any selected number of auxiliary contacts is connected effectively in parallel with a selected portion of said first-mentioned resistance.

4. Multiple contact switch apparatus comprising a plurality of sets of main contacts, the contacts of each set being of uniform length and arranged in a circle and the several contact sets being concentrically arranged in spaced relation, corresponding contacts, one in each set, being aligned in the axial direction, a rotatable switch arm provided with a set of brushes equal to the number of contact sets, said brushes upon rotation of the switch arm adapted each to make electrical connection with the main contacts of its associated set in succession, a series of auxiliary contacts, a switch member provided with a set of brushes equal to the number of switch arm brushes, an electrical connection between each pair of corresponding brushes, one in each set, a conductor associated with said auxiliary contacts, and means for effecting continuous and simultaneous operation of said switch arm and switch member in timed relation such that as the switch member brushes pass over the auxiliary contacts said conductor is operatively connected sequentially with a main contact and a sequency of a given number of auxiliary contacts.

5. The combination with an impedance, of which it is desired to effect the selection of a predetermined portion, of a plurality of sets of main contacts, the contacts of each set being of uniform length and arranged in a circle and the several contact sets being concentrically arranged in spaced relation, corresponding contacts, one in each set, being aligned in the axial direction, an electrical connection from each of said corresponding aligned contacts to successive, equally spaced tapping points on said impedance, a rotatable switch arm provided with a set of brushes,

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one for each of said contacts sets, said brushes upon rotation of the switch arm adapted each to make electrical connection with the main contacts of its associated set in succession, a single set of auxiliary contacts, an auxiliary impedance provided with equally spaced tapping points electrically connected each to one of said auxiliary contacts, a switch member provided with a set of brushes equal to the number of switch arm brushes, an electrical connection between each pair of corresponding brushes, one in each set, and means for effecting continuous and simultaneous operation of said switch arm and switch member in timed relation such that at any given instant a selected portion of said auxiliary impedance is connected in parallel with that portion of said first impedance determined by the position of the switch arm brushes in relation to their respective main contacts.

6. The combination with an impedance, of which it is desired to effect the selection of a predetermined portion, of three spaced apart concentrically arranged sets of main contacts, the contacts of each set being of uniform length, insulated from one another and arranged in a circle, corresponding contacts, one in each set, being aligned in the axial direction, an electrical connection from each of said corresponding aligned contacts to successive, equally spaced tapping points on said impedance, a rotatable switch arm provided with a set of brushes one for each of said contact sets, said brushes upon rotation of the switch arm adapted each to make electrical connection with the main contacts of its associated set in succession, a single set of auxiliary contacts arranged in a partial circle and having less than the number of main contacts

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in any one set, an auxiliary impedance provided with equally spaced tapping points electrically connected each to one of said auxiliary contacts, a switch member provided with a set of three radially extending brushes only two of which are adapted to contact said auxiliary contacts at any instant, an electrical connection between each pair of corresponding brushes, one in each switch set, and means for effecting continuous and simultaneous operation of said switch arm and switch member brushes in timed relation such that for one complete revolution of the switch member brushes the switch arm brushes are moved a distance measured between the centers of adjacent main contacts, so that at any given instant a selected portion of said auxiliary impedance determined by the position of the switch arm brushes in relation to their respective main contacts.

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