No. 731,210. PATENTED JUNE 16, 1903.

E. F. NORTHRUP.

RESISTANCE SET.

APPLICATION FILED MAR. 31, 1903.

NO MODEL.

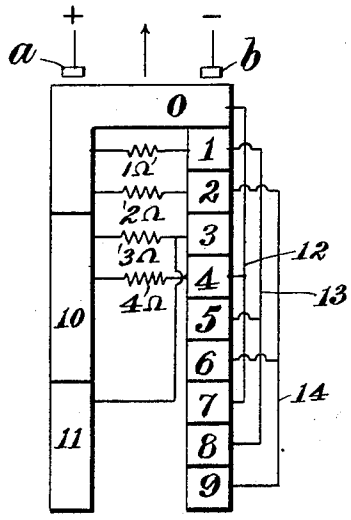


FIG. 1.

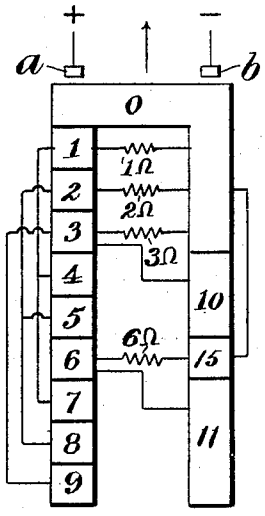


FIG. 2.

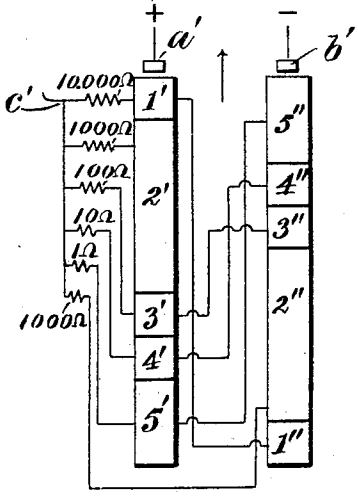


FIG. 3.

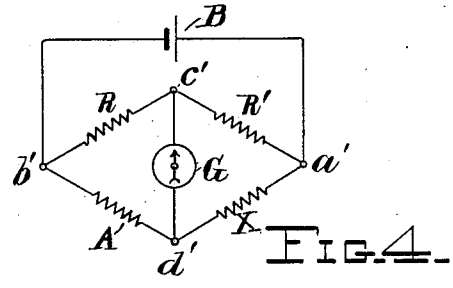


FIG. 4.

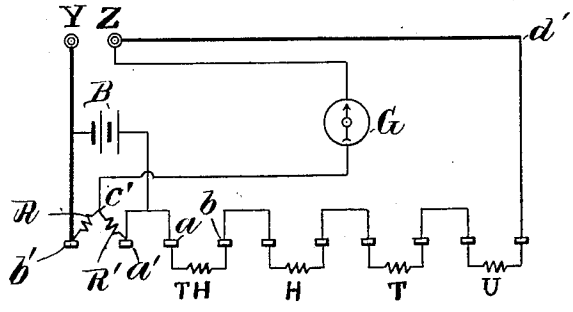


FIG. 5.

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No. 731,210. Patented June 16, 1903.

UNITED STATES PATENT OFFICE.

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RESISTANCE SET.

SPECIFICATION forming part of Letters Patent No. 731,210, dated June 16, 1903.

Application filed March 31, 1903. Serial No. 150,392. (No model.)

To all whom it may concern:

Be it known that I, EDWIN F. NORTHRUP, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Resistance Sets, of which the following is a specification.

The principal objects of this invention are to effect an arrangement of resistances whereby a comparatively large number of resistance values may be gotten from a small number of resistances and also to effect an arrangement of connections whereby these values may be obtained in regularly-increasing order by introducing the resistances between two contacts or brushes through which current passes to and from said resistances, and between which brushes and resistances there is relative movement.

A further object of this invention is to effect an arrangement of resistances whereby one may expeditiously obtain a series of ratios of resistance—such, for example, as are required in making a variety of tests with a Wheatstone bridge.

To the above ends this invention consists in the novel combination and arrangement of parts herein described, and particularly pointed out in the claims.

The invention will be more fully described with reference to the accompanying drawings, in which—

Figure 1 is a diagram showing a series of contact-plates, resistances, and electrical connections for effecting the combining of the resistances in order to give a series of regularly-increasing values of resistance greater in number than the resistances employed. Fig. 2 is a diagram showing means for accomplishing the same result with a different combination of resistances. Fig. 3 is a diagram showing a series of contact-plates, ratio resistance-coils, and connections for varying the ratios. Fig. 4 is a conventional diagram of a Wheatstone bridge, and Fig. 5 is a diagram of a Wheatstone bridge equipped with resistance sets and ratio-coils arranged according to this invention and constituting an improved form of testing set.

It has hitherto been customary in varying electrical resistance in a circuit to connect the terminals of the circuit to the resistances and to alter the resistance by cutting in or out of the circuit varying amounts of resistance by means of plugs, brushes, or other contact-makers, which form no part of the terminal connections or only one of the terminals. In the common form of rheostat the brush is usually connected to one of the terminals, while the other terminal is permanently secured to the resistance-coils. In contradistinction to all such methods the present invention contemplates varying the resistance by inserting varying amounts of resistance between two brushes or other suitable contacts, which are direct connected to the terminals of the electric circuit. The resistances are in this case of such values as may be combined to give regularly-increasing value of resistance greater in number than the resistances employed. These combinations of resistance are predetermined, and the said resistances are connected up in accordance with said combinations to a series of contact-plates. The resistance is then varied by bringing successive combinations of said contact-plates into engagement with said brushes. I have discovered that by giving the resistances certain values and by connecting them in certain prearranged combinations I may by means of the arrangement of connections above referred to get ten regularly-increasing values of resistance with only four resistances.

A specific case embodying the above principle of varying resistances is shown in Fig. 1, where a b represent brushes or other suitable contact-makers adapted to form the terminals of an electrical circuit, into which varying amounts of resistance is to be inserted, 1Ω, 2Ω, 3Ω, and 4Ω, four resistances having the values, respectively, of one ohm, two ohms, three ohms, and four ohms, and 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 a series of contact plates or segments, to which the said resistances are permanently connected in the combinations as shown. The variations in resistance may be effected by either moving the brushes a b over the segments or by making the brushes stationary and the segments

movable. In most cases the latter would be preferable, for should the brushes be made movable they would have to either make a sliding contact with the terminals of the circuit or be provided with flexible leads. The resistances and contact-plates may be readily mounted together upon a suitable movable support, such as a cylinder or sector, or otherwise. Considering the brushes *a b* stationary and the contact-plates and resistances movable, let it be required to get successive values of resistance from zero to nine ohms. For obtaining these values successively the contacts are moved beneath the brushes in the direction of the arrow. When the segment 0 comes beneath the brushes, no resistance will be introduced thereby into the circuit, since this segment acts merely as a connection of inappreciable resistance. The next step brings the brushes in contact with segments 0 and 1, and this will introduce the one-ohm coil into the circuit. For two ohms the contacts are moved up another step, when the brushes will be brought into contact, respectively, with segments 0 and 2, introducing the two-ohm coil into the circuit and cutting out the one-ohm coil. For three ohms the contacts are moved up another step, when the brushes come in contact with segments 3 and 10, connecting the three-ohm coil in circuit and cutting out the two-ohm coil, and by moving the contacts up another step the brushes are brought into contact with segments 4 and 10, when the four-ohm coil will be inserted in the circuit and the three-ohm coil cut out. For five ohms the brushes rest upon segments 5 and 10. In this case the current entering by brush *a* passes through the four-ohm coil to segment 4 and thence by wire 12 to segment 0 and through the one-ohm coil, conductor 13 to the segment 5 and negative brush *b*, making five ohms of resistance in the circuit. For six ohms the brushes rest upon segments 6 and 10. In this case the current passes through the four-ohm and the two-ohm coils in series and takes the following course: brush *a*, segment 10, four-ohm resistance, segment 4, conductor 12, segment 0, two-ohm resistance, segment 2, conductor 14, segment 6, to brush *b*. Likewise by bringing the segments 7 11, 8 11, and 9 11 in contact successively with the brushes I may obtain in so many steps the values of seven, eight, and nine ohms. For seven ohms the current passes through the three and four ohm resistances, for eight ohms through the three, four, and one ohm resistances, and for nine ohms through the three, four, and two ohm resistances. Thus it will be seen that a decade set may be gotten which employs only four coils and in which the successive values are gotten by merely moving step by step a series of contact plates or segments beneath a pair of circuit-terminals.

One other combination of four resistances which may be combined to give nine regularly-increasing values by being successively connected between two terminal contacts is the combination of one ohm, two ohms, three ohms, and six ohms. This combination of resistances with connections for effecting the regularly-increasing values is shown in Fig. 2. This combination of resistances necessitates a slight change in the contact-plates and connections, as will be readily seen from the diagram Fig. 2. In this latter case segment 10 is shortened and an extra segment 15 inserted between it and segment 11. In Fig. 2 segments 3 and 10 are connected together, as are segments 6 and 11 and 15 and 0. By moving the contact plates or segments in Fig. 2 beneath the brushes *a b*, as described relative to Fig. 1, successive values may be obtained from naught to nine ohms, inclusive.

While I have shown and mentioned two combinations of resistances having the values of one, two, three, and four ohms, and the other values of one, two, three, and six ohms, obviously by multiplying the values in each set by any constant, as ten, I may still get the same number of values. For example, I may use the combination 10, 20, 30, and 40 and get ten values from naught to ninety in steps of ten ohms, or by using the combination 100, 200, 300, and 400 may get ten values from naught to nine hundred by steps of one hundred ohms, and so on.

In Fig. 3 is shown my improved arrangement for obtaining a series of ratio values of resistance, where 10,000Ω, 1,000Ω, 100Ω, 10Ω, and 1Ω represent a plurality of ratio resistances or resistance-coils, and 1′, 2′, 3′, 4′, and 5′ a series of contact plates or segments connected to said resistances, as shown. 1″ 2″ 3″ 4″ 5″ represent a series of contact plates or segments similar to the series 1′ to 5′, but arranged in reverse order. The segments of the series 1′ to 5′ are electrically connected to corresponding segments in the series 1″ to 5″. The brushes *a′* and *b′* are adapted to make contact successively with the segments 1′ to 5′ and 1″ to 5″, respectively. For this purpose the said segments may be mounted upon any suitable moving support and the brushes mounted on a stationary support, or the brushes may be movable and the segments stationary, but the former arrangement is preferred. This arrangement of resistances and connections (shown in Fig. 3) is designed especially for varying the values of the ratio resistances of a Wheatstone bridge—such, for example, as the ratio resistances R and R′ of the Wheatstone bridge, shown in Fig. 4, where A represents the known and X the unknown resistance. In such a case $\frac{R}{R'}=\frac{A}{X}$. Let the point *c′*, Fig. 3, correspond to the point *c′* of Fig. 4 and let the contact-brushes *a′ b′*, Fig. 3, correspond to the points of current en-

trance and exit a' b' of Fig. 4. Then if it is required that the ratios $\frac{R}{R'}$ shall be $\frac{10,000}{1}$ the segments, Fig. 3, are advanced in the direction of the arrow until the brushes a' b' rest, respectively, on segments 1′ and 5″. This will introduce into the battery-circuit between the brushes a' b' and the galvanometer connection c' the resistance-coils 10,000 and 1 in the same relation as shown in Fig. 4. For a ratio of one thousand to one the segments of Fig. 3 are moved up until the brushes or contacts a' b' rest, respectively, upon segments 2′ and 5″, when the 1,000Ω and 1Ω coils will be connected in circuit, as R and R′ of Fig. 4. Further, if it is desired that the ratio $\frac{R}{R'}$ shall be as $\frac{10}{1,000}$, the segments of Fig. 3 are advanced until the brushes a' b' rest, respectively, upon segments 4′ and 2″, when the 10Ω and lower 1,000Ω coils will be connected in circuit. Therefore by advancing the segments step by step beneath the brushes a' b' nine ratio values may be gotten with the six resistances.

For the first step the value $\frac{10,000}{1}$ is obtained; for the second, $\frac{1,000}{1}$; for the third, $\frac{1,000}{10}$ for the fourth, $\frac{1,000}{100}$; for the fifth, $\frac{1,000}{1,000}$; for the sixth, $\frac{100}{1,000}$; for the seventh, $\frac{10}{1,000}$; for the eighth, $\frac{1}{1,000}$, and for the ninth, $\frac{1}{10,000}$.

Obviously the values thus given the resistances may be varied without departing from the spirit of the invention.

A testing set comprising a Wheatstone bridge equipped with my improved ratio and resistance sets is diagrammatically shown in Fig. 5, in which U, T, H, and TH represent the units, tens, hundreds, and thousand resistances of as many decade sets, constructed as shown in Fig. 1 or 2. R and R′ represent the ratio resistance-coils, which are arranged as shown in Fig. 3; B, the battery, and G the galvanometer, and a' b' c' d' points corresponding to similarly-lettered portions of the bridge shown in Fig. 4. Each decade set of resistances U to TH contains only four coils, from each of which may be derived ten values, as fully described with relation to Figs. 1 and 2. In using the testing set the unknown resistance is connected between the terminals Y Z, the ratio-coils R and R′ adjusted according to the method described with reference to Fig. 3, and the resistances U to TH varied by the method described with relation to Figs. 1 and 2 until a balance is obtained, when the values of resistance may be read off from the position of the brushes on segments of the sets U to TH.

While the application of my method of combining resistances to the Wheatstone bridge, as described, is quite a useful one, still I do not wish to be understood as confining my invention to such an application, as there are many other uses to which it may be put.

What I claim as my invention is—

1. The combination with a plurality of electrical resistances, of a plurality of contact-pieces of greater number than said resistances and connected in prearranged combinations to said resistances so as to give a series of values of resistance greater in number than the resistances employed, and a pair of terminal contacts adapted to make contact successively with combinations of said contact-pieces in the obtaining of said values.

2. The combination with a plurality of electrical resistances, of a double row of contact-pieces greater in number than said resistances and connected to said resistances in prearranged combinations so as to give a series of regularly-increasing values of resistance greater in number than the said resistances employed, and a pair of contact-makers forming the terminals by which the electric current is led into and out of said contacts and resistances, said contact-makers being adapted to make contact with combinations of said contact-pieces successively in obtaining said values.

3. A decade resistance set, having four resistances, a plurality of contact-pieces greater in number than said resistances connected together and to said resistances so as to give ten regularly-increasing values of resistance, and a pair of contact-makers forming the terminals by which current is led to and from said contact-pieces and resistances, said contact-makers being adapted to make contact with combinations of said contact-pieces successively in obtaining said values.

4. The combination with a plurality of electrical resistances, of a plurality of contact-pieces of greater number than said resistances and connected together and to said resistances in prearranged combinations so as to give a series of ratio values of resistance greater in number than the resistances employed, and a pair of terminal contacts adapted to make contact successively with combinations of said contact-pieces in the obtaining of said values.

5. The combination with a plurality of electrical resistances, of a double row of contact-pieces greater in number than said resistances and connected together and to said resistances in prearranged order so as to give a series of ratio values of resistance, and a pair of contact-makers forming the terminals by which the electric current is led into and out of said contacts and resistances, said contact-makers being adapted to make contact with combinations of said contact-pieces successively in obtaining said values.

6. In a Wheatstone bridge, the combination with a plurality of pairs of terminal contacts

connected in series in the arm of the bridge containing the known resistance, of a plurality of decade resistance sets each provided with a double row of contact-pieces and resistances of lesser number than said contact-pieces connected thereto in prearranged combinations, one double row of said contact-pieces being provided for each pair of said terminal contacts and adapted to make contact successively with said terminal contacts in the obtaining of the resistance values.

In testimony whereof I affix my signature in presence of two witnesses.

EDWIN F. NORTHRUP.

Witnesses:
FRANK G. GRIER,
HARRY W. RAUMEL.