Nov. 9, 1948. J. K. SELLERS 2,453,462

MULTIPLE ELEMENT RHEOSTAT

Filed March 25, 1946 2 Sheets-Sheet 1

Fig. 4

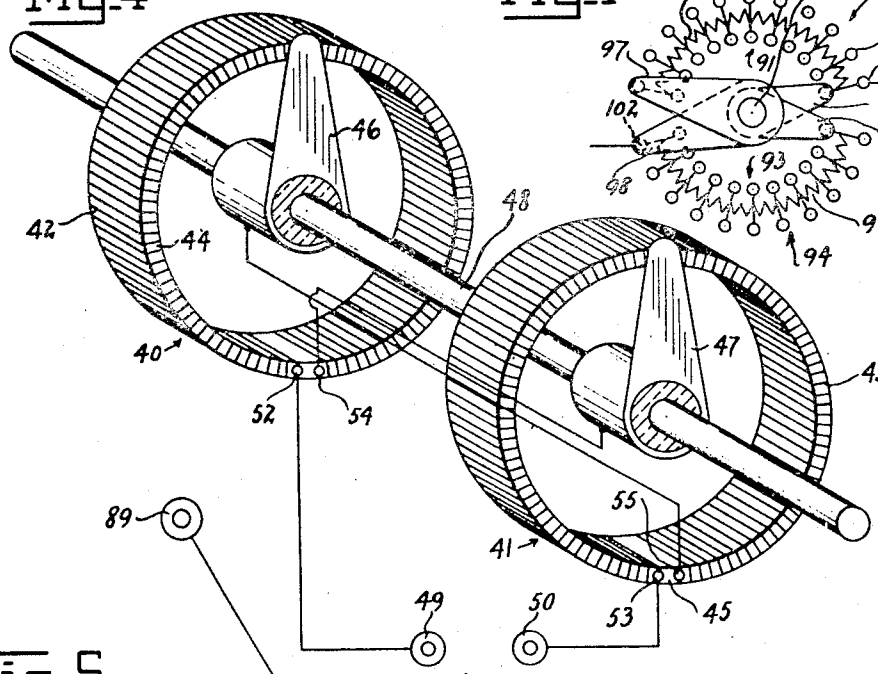



Fig. 7




Fig. 5

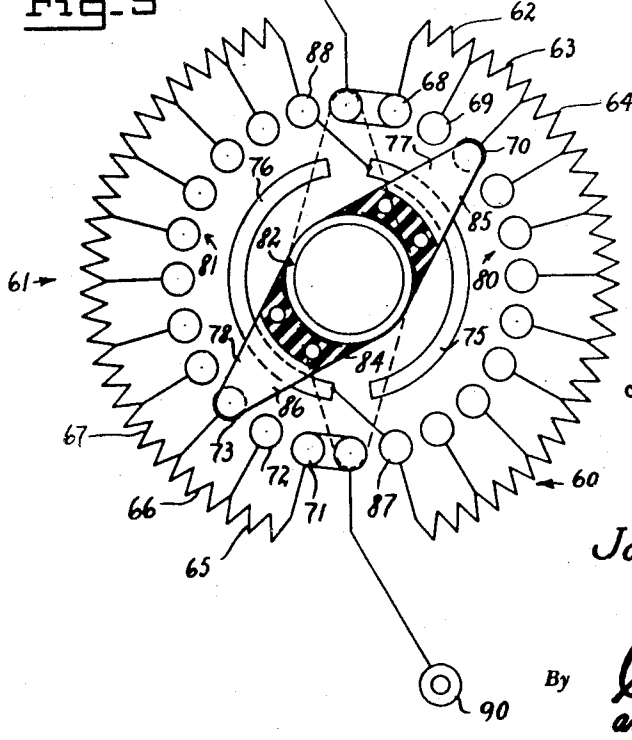
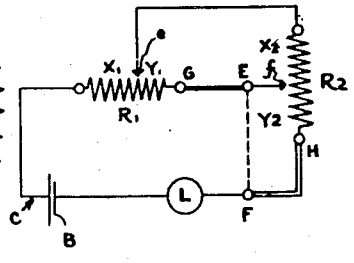



Fig. 1




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Fig. 3

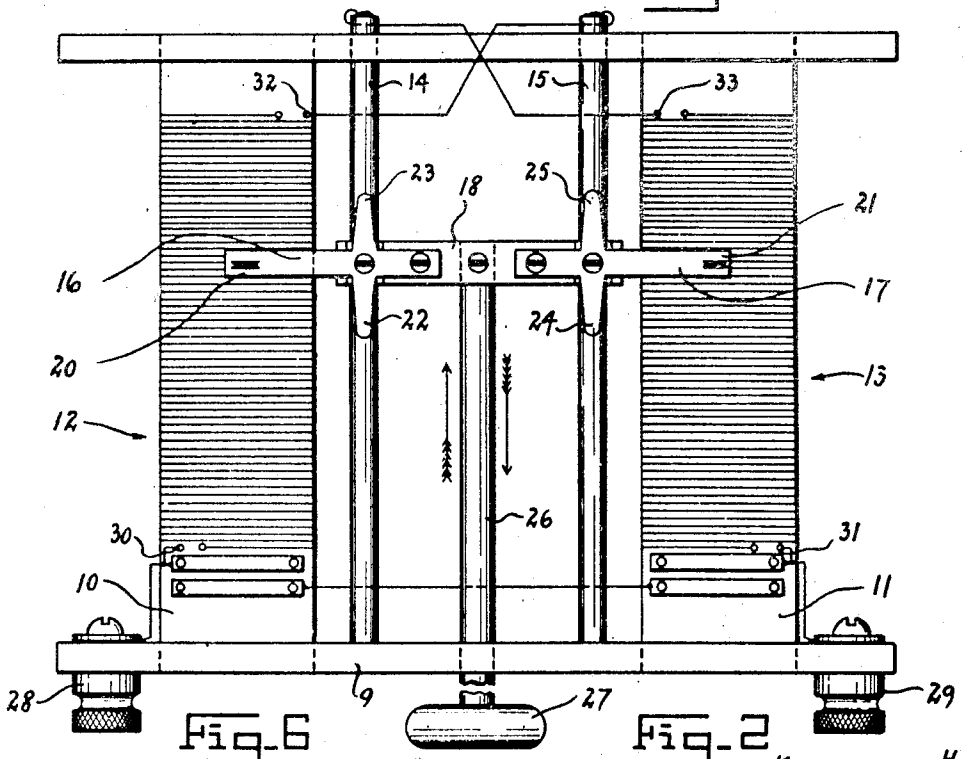



Fig. 6

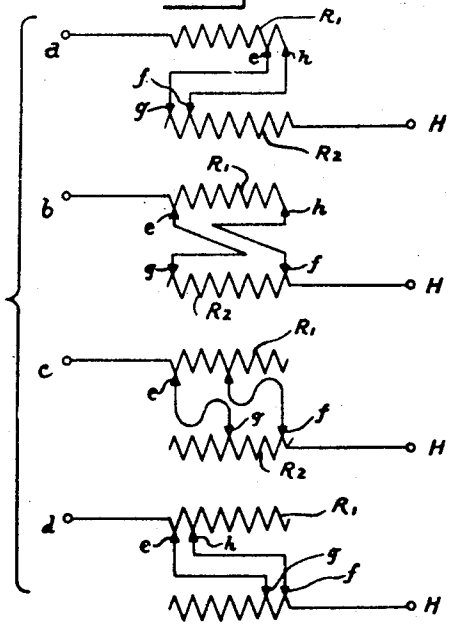
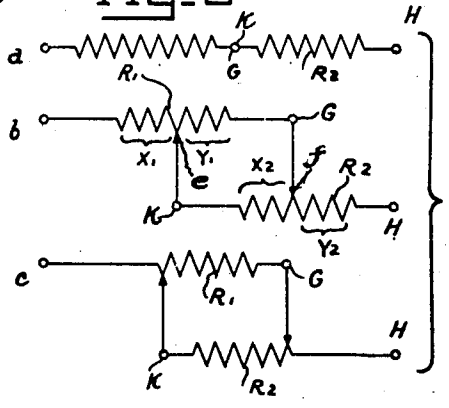



Fig. 2




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# UNITED STATES PATENT OFFICE

2,453,462

## MULTIPLE ELEMENT RHEOSTAT

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Application March 25, 1946, Serial No. 656,796

8 Claims. (Cl. 201—56)

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This invention relates to multiple elements rheostats and it has special reference to the method of connecting the elements of such rheostats of this type.

The circuits of generators, motors, electrochemical plants, instruments, apparatus of all kinds and other current producing or current consuming installations are, as a rule, regulated by means of rheostats, cutting down the amperage, voltage or wattage supplied to the said circuits or to some elements therein to the desired extent and dissipating the unwanted or surplus energy. While arrangements are made for transmission and adequate removal of the thermal energy produced no attention has been paid, as a rule, to a full utilization of the entire length of all resistance elements. This is due to the fact that in most cases the resistance elements are designed for the heaviest load which occurs and the load put upon them in other phases of the regulation is reduced and is supposed to require no further attention.

Therefore, it is the rule that the movable contacts when sliding along the resistances either reduce the active length of the elements or cut out some of them altogether. In both cases some portion of the resistance is rendered completely idle or inactive.

In cases where two different regulation phases require the operation with two different amperages, voltages, wattages or resistances, fixed resistances are sometimes preferred and in such a case two resistance elements are used adapted to be connected in series and in parallel. Two resistance values are thus provided for. No further or intermediate values can, however be derived from this arrangement.

It is the main object of the present invention to provide a multiple element rheostat in which all the elements are permanently active at full length or at the fullest possible length for the range selected, for all adjustments of the resistance which may occur in the course of operation and it is a further object to provide a connection of the aforementioned type in which a continuous adjustment of the resistance value is possible when the series-connection of the resistance elements is to be transformed into a parallel connection and vice versa.

Still further objects of the invention will be apparent from the following detailed specification.

Several modifications of the invention are described and illustrated in the drawings. It is to be understood, however, that this invention

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relates to the principle or to the mode of connection and not the details of the resistance elements used. Therefore, the specific embodiments of the invention described are only to be regarded as examples illustrating the principle or method of connection. These embodiments moreover are described in such terms and illustrated in such a way that further embodiments will be suggested to or foreshadowed for the expert skilled in this art and these further embodiments are, therefore, not to be considered as departures from but as part of the essence of the invention as defined in the annexed claims.

In the accompanying drawings:

Figure 1 is a diagram of connections illustrating the principle employed.

Figure 2 is a diagram showing a number of stages which are passed during an adjustment transforming a series connection of resistance elements into a parallel connection of the same elements.

Figure 3 is an elevational view of a resistance arrangement which may be used with currents of heavy amperage.

Figure 4 is a perspective view of a resistance arrangement using potentiometers or other resistances of relatively high value.

Figure 5 is a diagrammatic elevational view of a resistance arrangement permitting to obtain a stepwise adjustment and provided with a contactor arm rotating around a center and wiping over the contacts of a contact bank.

Figure 6 is a diagram of a further modification showing stages of adjustment of a resistance.

Figure 7 is a diagrammatic elevational view of a resistance arrangement, which may be adjusted in the manner illustrated in Figure 6.

The general principle on which the invention is based is illustrated in Figure 1.

Two resistance elements $R_1$ and $R_2$ of a rheostat are inserted into a circuit C containing a source of current B and a load device L. To obtain regulation of the current with this arrangement according to known principles the load L would be connected with the sliding or movable contact $f$ as indicated in dotted lines while the connections between the points G and E and between H and F (double lines) would be missing.

According to this known arrangement, therefore, the portion $Y_1$, $Y_2$ of the resistance elements $R_1$, $R_2$ is cut out. It does not participate in the dissipation of energy or in the regulation of the current in the system. Merely the portions $X_1$, $X_2$ are active.

According to the present invention shown in full and double lines the end G of the resistance element $R_1$ is connected with the slidable element *f* of the resistance element $R_2$, and the end H of the resistance element $R_2$ is connected with the load L at F. The entire length of each resistance element is thus permanently active.

The resistance of circuit C, therefore, consists of two components as seen clearly in Figures 2, *a*, *b*, *c*. The resistances $R_1$, and $R_2$, are connected in series in Figure 2*a*, in which the slidable contacts *e*, *f*, have been moved to the ends G, K. When moved to an intermediate position the sections $X_1$, $Y_2$, connected in series, form one component, while the other component is formed by sections $Y_1$ and $X_2$, of the resistances connected in parallel. Assuming $R_1$ to be equal to $R_2$ the resistance in the circuit thus varies by shifting the slidable contacts *e*, *f* from one end to the other between 2R and $R/2$ as seen in Figures 2*a* and 2*c* or expressed otherwise between the values of the resistance obtained by series connection (Figure 2*a*) and parallel connection of the resistance elements (Figure 2*c*).

The range is smaller than that obtained with the conventional arrangement, but all parts of all resistance elements are permanently in the circuit. Moreover with equal resistances included in each step of a step by step regulating device, regulation is finer and can be effected with greater precision and smoothness. The practical application of the invention is shown in Figure 3.

On a base plate 9 the tubular cores 10, 11 of insulating material are mounted, carrying coils 12, 13 of wire presenting their metallic surfaces. Bus bars 14, 15 in the shape of rods are arranged close to the coils and on them are gliding the sliding contacts 16, 17. In this arrangement the sliding contacts are mounted on an insulating bridge piece 18 and are provided with a resilient arm 20, 21 sliding on the coils and with resilient tongues 22, 23, 24, 25 sliding on the bus bars.

A handle bar 26 is mounted on the insulating bridge piece which may be provided with a handle 27 projecting outwardly beyond the base plate 9.

The base plate also carries the terminals or binding posts 28, 29 to make the necessary connections of the resistance with the circuit or circuits to be regulated.

One end 30, 31 of each resistance coil is connected with the binding posts 28, 29 while the other end 32, 33 is connected with the bus bar 15, 14, respectively of the adjacent coil, as indicated diagrammatically at the top of Figure 3.

This arrangement may be used for currents of moderate amperage developing much heat in a rather reduced space. The fact that the heat developed by the resistance wire is permanently distributed over the entire resistance wire reduces the local heat development and permits to use materials and arrangements which have less heat conducting qualities than those generally used.

Another arrangement for currents of small amperage using potentiometers or similar wire wound resistances is shown in Figure 4. In arrangements of this type such as are used in radio, telephonic, phonographic or public address arrangements and the like, the amount of heat developed is not large but as this type of apparatus is permanently kept near persons who should not be inconvenienced, even a relatively small temperature increase is objectionable and the temperature which is developed should therefore be kept as low as possible.



According to the invention two potentiometers 40, 41 may be used which are of the usual well known types having a resistance wire 42, 43, respectively, wound around a strip 44, 45 of insulating material which is bent so as to adopt a circular cylindrical shape and a rotatable contactor arm 46, 47 mounted on an axle or shaft 48 which is coincident with axis of the cylinder. The two contactor arms 46, 47 are insulated from the shaft but are fixedly mounted thereon so that they move in unison.

As seen in Figure 4 one end 52, 53 of the resistance wires 42, 43 is connected with the terminals 49, 50 indicated diagrammatically in the figure, while the other ends 54, 55 of each resistance wire 42, 43 are connected with the contactor arms 47, 46 of the adjacent potentiometer, respectively.

By virtue of the fact that the two contactor elements are coupled a regulation such as diagrammatically shown in Figure 2, *a*, *b*, *c* is obtained in which the components $X_1$ and $Y_2$ and $Y_1$ and $X_2$ are always equal, whereby the best distribution of the energy is obtained.

An arrangement for heavy currents and for step by step regulation is shown in Figure 5.

The resistance elements 60, 61 are subdivided in fractional resistances 62, 63, 64 . . .; 65, 66, 67 . . .; respectively, connected with fixed contacts 68, 69, 70 . . .; and 71, 72, 73 . . ., respectively. These contacts form circular contact banks 80, 81. The end contact of each bank is connected with the contact segments 75, 76, respectively. The two contact arms 77, 78 may be coupled so as to form a single contact arm 82 which is rotatable around the center of the circular segments and contact banks and is provided with a central insulated portion 84 and outer current conducting portions 85, 86, respectively, cooperating with the contact banks 80, 81 and segments 75, 76, respectively.

The end contacts 68, 71 on one end of the contact banks are connected with the terminals 89, 90, while the contacts 87, 88 on the other end are connected with the segments 76, 75, respectively.

The arrangement is again such that every one of the fractional resistances 62, 63 . . ., 65, 66 . . . is permanently operative in dissipating thermal energy and the heat dissipation is, therefore, materially improved. Moreover it will be clear that the steps of the regulation in rheostats of the type described are finer or less coarse than those performed in arrangements of the known type and that, therefore, either a better regulation or a reduced number of contacts will result when using the present invention.

The way in which resistance elements in further cases have to be arranged or connected will be clear to the expert skilled in the art.

Figure 6 illustrates a modification of the principle described and illustrated, with which the maximum range of adjustment may be obtained, but in which a portion of the resistance is cut out of the circuit and remains unused. This portion is however smaller than the unused portion of the resistance of the conventional arrangements. This modification as will be clear constitutes a compromise between the above described principle and the known arrangements, restituting the full range of resistance adjustment, but re-introducing, although to a restricted extent, non-participation of a portion of the resistance in the dissi-

pation of energy. A marked advantage is, however, obtained over the known arrangements. Non-participation of portions of the resistance starts only below a certain resistance limit; the value of the resistance which does not participate in energy dissipation is, however, much smaller than in the known arrangements, and the improvement in heat dissipation, resulting in a lowered temperature is of great importance as the resistance in this portion of the range is very low, while the current is near its peak value. The reduction of temperature obtained according to the invention is therefore a most desirable improvement.

Figure 6 shows diagrammatically the utilization of the above explained princinple. According to the invention, two connections are provided between the resistance elments $R_1$ and $R_2$, each connection carrying slidable contacts *e, h, g, f*, respectively at its ends.

In an extreme position of these slidable contacts (shown in Fig. 6*a*) the two resistance elements $R_1$, $R_2$ may be connected in series, with the total resistance in the circuit equal to 2R if $R_1$ and $R_2$ are equal. This position corresponds to that shown in Figure 2*a*.

In the position shown in Figure 6*b* the resistances $R_1$ and $R_2$ are connected in parallel. The resultant resistance is therefore R/2 provided $R_1=R_2$. This position of the slidable connections corresponds to that shown in Figure 2*c*.

Intermediate values of the resultant resistance may be obtained in the manner shown in Figure 2*b*, using the entire length of the resistance elements. The connections for these intermediate values are identical with or similar to those shown in Figure 2*b*, and may easily be obtained by shifting contacts *e* and *f*. They are not shown separately in Figure 6.

In addition to these values of the resistance, intermediate between the values R/2 and 2R, further values of the resultant resistance may be obtained by shifting contacts *g* and *h*, as shown in Figure 6*b*, while leaving contacts *e* and *f* in their respective positions.

Figure 6*c* shows the result. A portion of the resistances $R_1$ and $R_2$ is now cut out. The resultant resistance may be smaller than R/2 if the slidable contacts have been shifted to the necessary extent. Assuming that one-half of each resistance $R_1$ and $R_2$ has been cut out, the resultant resistance will be R/4; it will entail the cutting out of one-half of each of the two resistances $R_1$ and $R_2$. With the known arrangement, three-fourths of the resistance value have to be cut out in order to obtain a resistance of the value R/4.

Finally Figure 6*d* shows the complete cutting out of the two resistances so that the resultant resistance is 0. It will thus be seen that this arrangement permits a range of adjustment varying between 0 and 2R, with a part of the resistance, smaller than that cut out in known arrangements, made idle or non-participating in the resistance range between 0 and R/2, while the full length of the resistance participates permanently in the dissipation of heat in the range between R/2, and 2R.

In Figure 7 a modification is diagrammatically shown permitting to realize the advantages illustrated in Figure 6.

The arrangement shows four arcuate or semi-circular contact banks **91**, **92**, **93**, **94** for the sake of better illustration; but as contacts in two concentric banks are connected with the same resistance elements, it is manifest that the two connected banks may be replaced by a single semi-



circular contact bank with contacts of suitable size on which two contact arms may side. Simultaneously, four contact arms **97**, **98**, **99**, **100** are provided, which cooperate with these four contact banks. These contact arms may either move independently, or they may be connected mechanically.

The contactor arms are rotatable around a common axis or shaft **101**.

The contactor arms are insulated from the shaft **101** and from each other. A connection is, however, established between each contactor arm **97**, **98** running on one semi-circular bank and contactor arm **99**, **100** running on the semi-circular bank on the opposite side. The electrically not connected contactor arms (**97** and **100**, **98** and **99** respectively) may be those which are mechanically connected, if desired.

The end contacts **102**, **103** of the pairs showing the same resistance elements are connected with the circuit to be regulated.

It will be easily understood that the contactor arms correspond to the slidable contacts *e, f, g, h* in Figure 6 and that the adjustments shown and explained in connection with this figure may be made with the arrangement shown in Figure 7.

It will also be understood that other embodiments similar to those shown in Figures 3 and 4 may be designed for realizing the same method of adjustment.

Finally it may be mentioned that the construction of the resistance elements, the way in which the contactor arms are moved, the handles, dials, arms and pointers for indicating the resistance values and other details have not been mentioned or shown as they do not form part of the invention and are conventional additions, which are used in actual practice but are unnecessary for the explanation and illustration of the invention.

I claim:

1. An adjustable multiple element rheostat, adapted for inclusion into a current carrying circuit, comprising a plurality of interconnected resistance elements each provided with permanent circuit connections at both ends, and with a contact member movable along said element, one of said permanent end connections being an interconnection between the resistance elements, connecting one end of a resistance element permanently with the movable contact member of another resistance element.

2. An adjustable multiple element rheostat rheostat adapted for inclusion into a current carrying load circuit, comprising interconnected resistance elements, each provided with permanent circuit connections at both ends and each cooperating with a movable contact member, adapted to establish connection with points between the two ends of the element, one of said permanent end connections of each of said elements being connected with the load circuit, the second end of each of the said elements being connected with the movable contact member of another contact element.

3. A multiple element rheostat adapted for inclusion into a current carrying load circuit, comprising two interconnected adjustable resistance elements, each provided with a permanent circuit connection at its two ends and each cooperating with a movable contact arm sliding on said resistance element, one of the end connections leading to the load circuit, the other leading to the contact arm of the second member and a mechanical connection between the

said contact arms, for shifting the points of contact with the resistance elements in both resistance elements simultaneously and to the same extent.

4. A multiple element rheostat for inclusion in current carrying load circuits, comprising two circular adjustable wire resistances coils, a rotatable shaft passing through the center of the circular coils, carrying a contact arm for each coil movable along said coil, means for rotating said shaft, a permanent fixed connection of the end of each coil with the load circuit, and a permanent fixed connection of the other end of each coil with the movable contact arm of the second coil.

5. In a multiple element rheostat arrangement, two contact banks, each comprising a plurality of contacts, a contact segment adjacent to said contact bank, resistance elements between the contacts of the contact banks, a rotatable contactor arm for each contact bank, said arms forming a mechanical unit, each contactor arm comprising an insulating section and metallic sections, establishing contact between one contact segment and the contacts of one contact bank, a current carrying load circuit, a connection between the same and the end contact of each bank and a further connection between the other end contact of each bank and the contact segment cooperating with the other contact bank.

6. A multiple element rheostat for inclusion in current carrying load circuits comprising a plurality of interconnected adjustable resistance elements, each element provided with a fixed permanent circuit connection at one end and with at least two slidable contact members, movable along said resistance element for establishing contact with intermediate points located between the two ends of said element, and a fixed



permanent connection between each movable contact member of one resistance element and one of the movable contact members of a second adjustable resistance element.

7. A multiple element rheostat arrangement comprising two semi-circular contact banks, each provided with a plurality of contacts, and each contact bank being connected with one set of resistance elements, at least two movable contactor arms for each contact bank connected with one set of resistance elements, a connection between each movable contactor arm cooperating with one semi-circular contact bank and one of the movable contactor arms cooperating with the other contact bank and, a current carrying load circuit having terminals, each connected with one of the end contacts of the two contact banks respectively.

8. A multiple rheostat arrangement comprising two semi-circular contact banks, provided with a plurality of contacts, each bank being connected with a set of resistance elements, two rotatable contactor arms for each contact bank, an electrical connection between each of said contactor arms of one contact bank with a contactor arm cooperating with the other bank, and a mechanical connection between each contactor arm of one bank with a contactor arm of the other contact bank.

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