Aug. 4, 1953 A. C. DYER 2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Filed Aug. 11, 1951

5 Sheets-Sheet 1

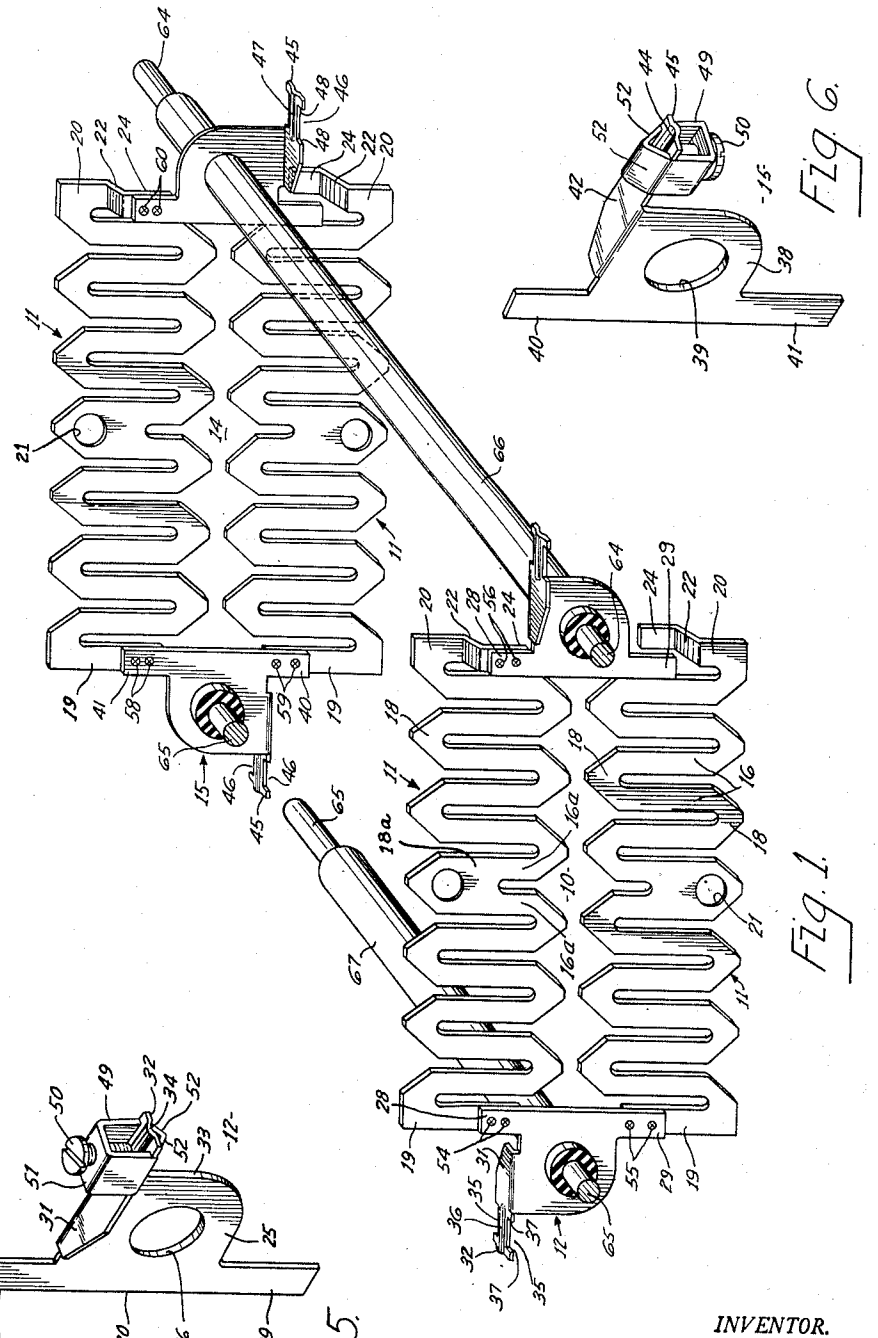

Fig. 1.

Fig. 6.

Fig. 5.

INVENTOR.
ALVIN C. DYER
BY John A. Lawson & Harold J. Rathbun
ATTORNEYS.

Aug. 4, 1953 A. C. DYER 2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Filed Aug. 11, 1951 5 Sheets-Sheet 2

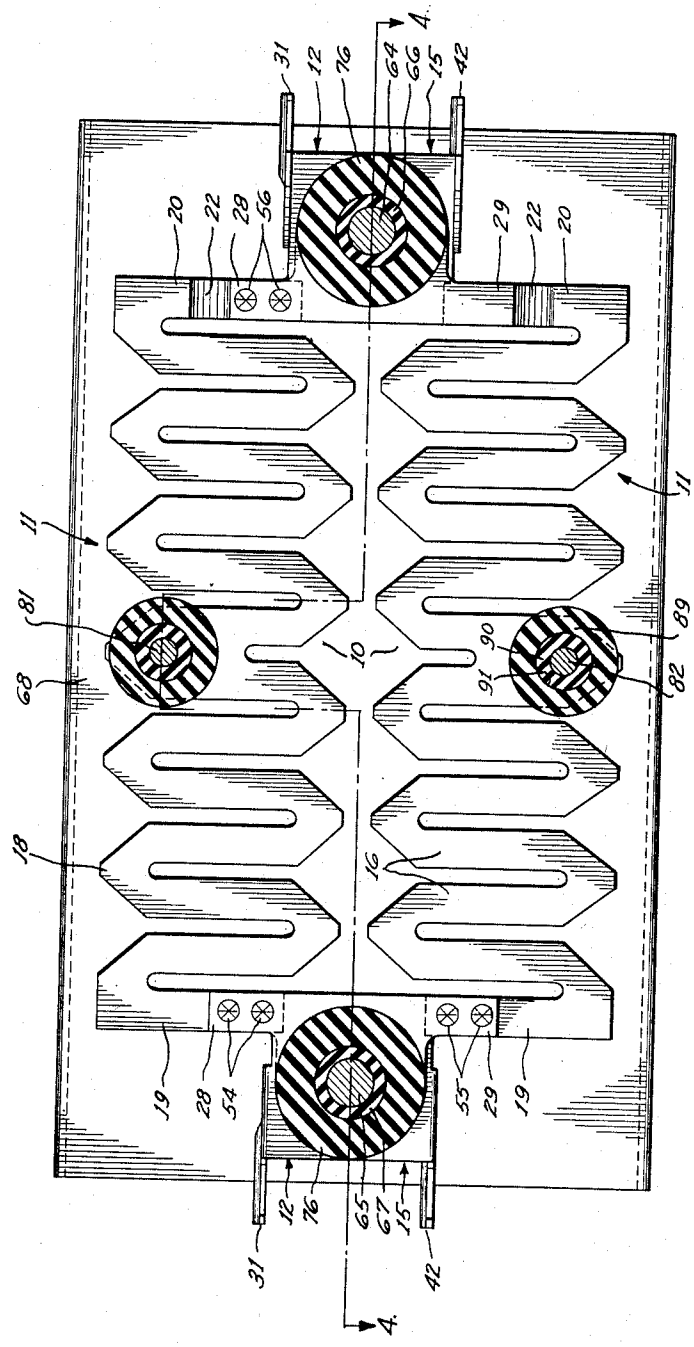

Fig. 2.

INVENTOR.
ALVIN C. DYER
BY Johnston Davis & Harold J. Kathman
ATTORNEYS.

Aug. 4, 1953 A. C. DYER 2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Filed Aug. 11, 1951 5 Sheets-Sheet 3

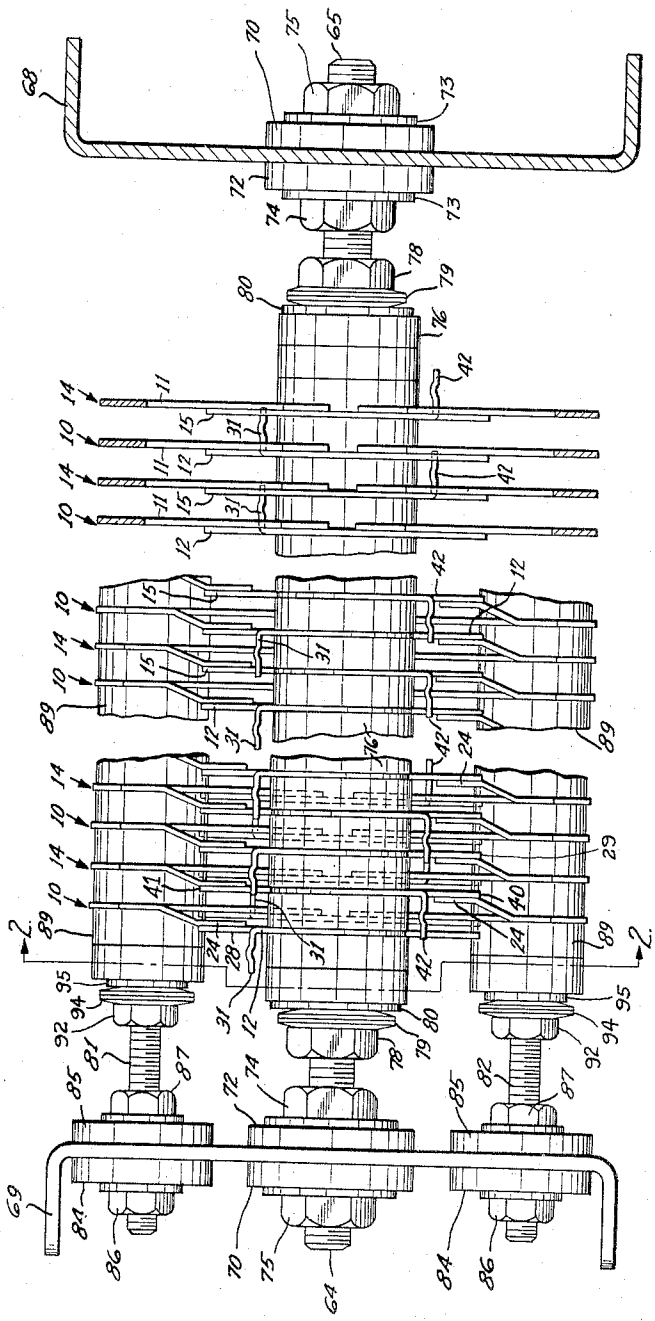

Fig. 3

INVENTOR.
ALVIN C. DYER
BY John H. Leonard
Harold J. Rathbun
ATTORNEYS.

Aug. 4, 1953 A. C. DYER 2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Filed Aug. 11, 1951

5 Sheets-Sheet 4

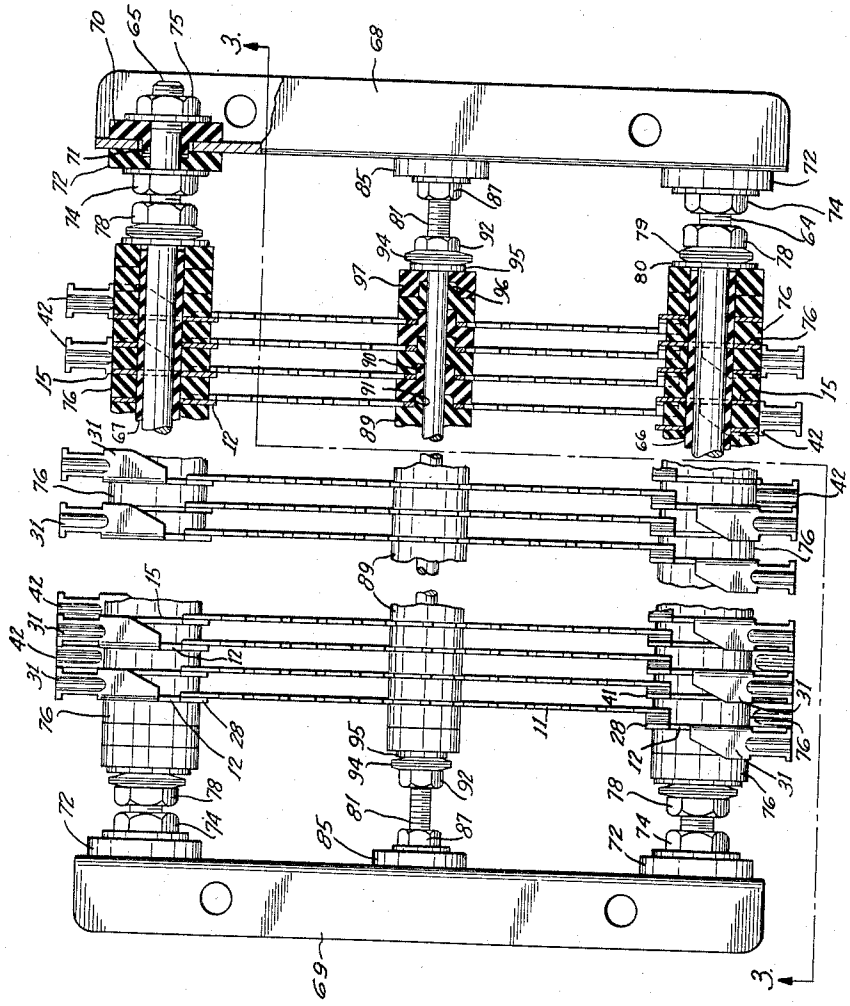

Fig 4

INVENTOR.
ALVIN C. DYER
BY John H. Raymond & Harold J. Rathbun
ATTORNEYS.

Aug. 4, 1953 A. C. DYER 2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Filed Aug. 11, 1951

5 Sheets-Sheet 5

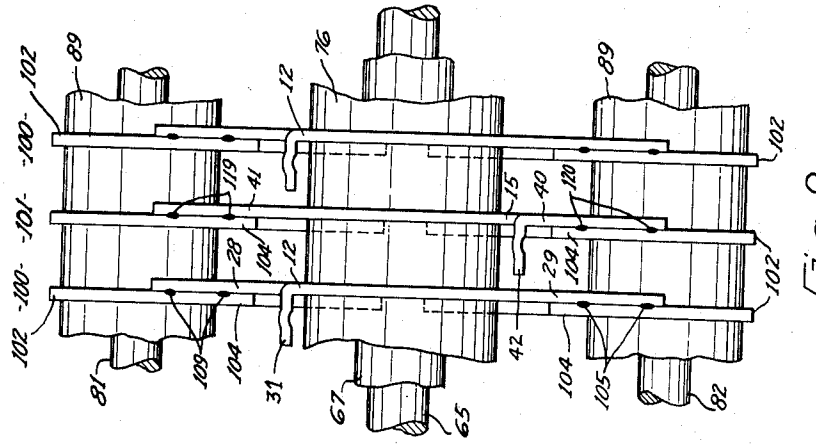

Fig. 8.

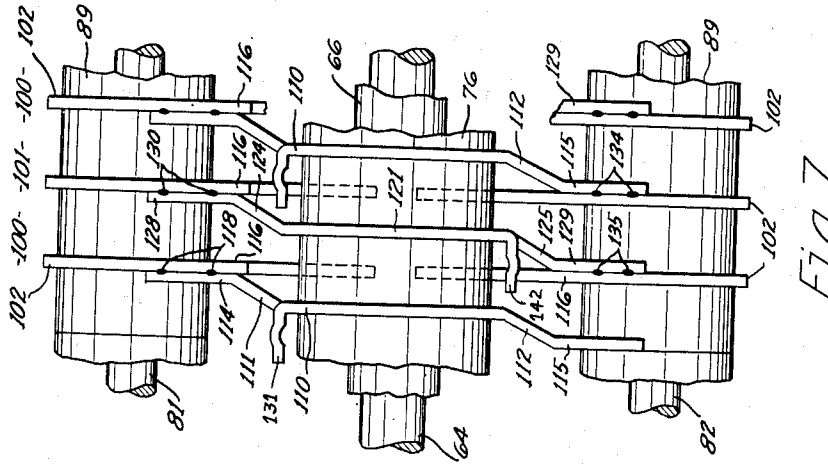

Fig. 7.

INVENTOR.
ALVIN C. DYER
BY Johnston Simmons & Harold J. Rathbun
ATTORNEYS.

Patented Aug. 4, 1953

2,647,978

UNITED STATES PATENT OFFICE

2,647,978

RESISTANCE UNIT AND ELEMENT THEREOF

Alvin C. Dyer, Shaker Heights, Ohio, assignor to The Electric Controller & Manufacturing Company, Cleveland, Ohio, a corporation of Ohio

Application August 11, 1951, Serial No. 241,408

17 Claims. (Cl. 201—69)

1

This invention relates to electric resistance elements and electric resistance units containing the same, and more particularly to composite resistance elements formed by attaching a pair of individual resistance grids, preferably stamped from sheet metal, to a common supporting member which also serves as a wiring terminal and to resistance units which comprise an assemblage of such composite resistance elements and which are suitable for various purposes such as, for example, the control of electric motors of the smaller integral horsepower sizes.

A general object of this invention is to provide a resistance unit or resistor possessing the advantages of the resistor disclosed and claimed in David C. Wright Patent No. 2,373,056 issued on June 12, 1945, but capable of having a wider range of resistance per unit volume, particularly a greater resistance per unit volume, and of having a larger number of intermediate taps.

In the resistor of the Wright patent, lug portions at opposite ends of a sheet metal resistance element shaped in the form of a grid are offset in opposite directions from the plane of the intermediate portion of the grid and lie in respective planes which are spaced from but parallel to the plane of the intermediate portion. When a plurality of the grids of the patent are properly assembled in flatwise spaced relation on a supporting means to form a resistor, the lug portions at a given end of a pair of adjacent grids extend away from each other and the lug portions at the other end of the same adjacent grids extend toward and engage each other. The lug portions in engagement with each other are spot welded together after the resistor is assembled.

Resistors such as disclosed in the Wright patent and using grids stamped from a chromium-aluminum-steel alloy of high specific resistance are currently being manufactured with a minimum continuous rating of 32 amperes at a temperature rise of 375 degrees centigrade. The resistors of this rating with forty-eight grids have a resistance of approximately seven ohms.

A more specific object of this invention is to provide a resistor of the same or similar outline dimensions which has a resistance considerably in excess of seven ohms and which is capable of having a larger number of intermediate taps than the resistor of the Wright patent, thus enabling more precise selection of increments of the total resistance of the resistor for utilization in an external circuit.

Since suitable metals or alloys of higher specific resistance than the alloy described above are not

2

available, the resistance of a resistor built in accordance with the disclosure of the Wright patent can be increased only by decreasing the cross-sectional area of the current path through the grids, using more grids, making the current path of each grid longer, or by a combination of any two or all three of these expedients. To provide the desired higher resistance by reducing the cross-sectional area of the current path through grids proportioned and supported like those of the Wright patent, either by using thinner metal or narrowing the width of the grid bars, or both, is not a satisfactory solution of the problem beyond a limited range because the grids become too flexible and have to be supported at so many intermediate locations that the cost of the resistor is materially increased and its heat dissipating ability is seriously impaired. Increasing the length of the grids or using more grids in flatwise spaced relation likewsie are not adequate solutions of the problem because the ratio of resistance to unit volume is either lessened or not materially increased and the shape and outline dimensions of the resistor deviate too much from standard practice. Furthermore, none of these expedients, or any combination of them, results in a resistor which can be provided conveniently with the desired large number of intermediate taps. For these and other reasons it is not practicable economically to manufacture resistors such as disclosed in the Wright patent which have the desired higher resistance or the greater number of taps.

Accordingly, another object of the present invention is to provide an improvement of the resistor of the Wright patent capable of being manufactured economically with a much larger resistance per unit volume and without deviation from standard outline dimensions for such resistors.

A further object is to obtain the increased resistance to volume ratio by the provision of a novel composite resistance element formed by spot welding a pair of identical sheet metal grids to a common combined terminal and supporting member. The composite resistance element in accordance with this invention has a longer current path for a given area than prior resistance elements, and the individual grids thereof are so proportioned and arranged in cooperation with novel combined terminal and supporting members that they can be made of relatively thin metal and have relatively narrow grid bars and still be conveniently supported for operation at elevated temperatures. The cooperative relation

between the individual grids and the combined terminal and supporting members is such that taps to which lead-in conductors can be secured are provided at opposite ends of each of the individual identical grids thereby to provide the desired large number of intermediate taps. The principal advantages of the off-set end portions of the grids of the prior resistor are retained in the improved resistor.

Additional objects are to provide an improved composite resistance element, to provide a composite resistance element comprising a pair of substantially coplanar identical sheet metal resistance elements secured to and extending in the same direction from a common combined terminal and supporting member, to provide an improved electric resistor comprising a plurality of composite resistance elements arranged in flatwise spaced relation and having a relatively large number of intermediate taps, to provide an improved resistor comprising an assemblage of flatwise spaced resistance elements than can be economically manufactured with a relatively large resistance per unit volume, to provide a resistor comprising a spot-welded assemblage of composite resistance elements of improved design, and to provide an electric resistor in which a plurality of complementary composite resistance elements are supported in flatwise spaced relation with an offset portion of each of the elements extending toward and engaging a portion of an adjacent element at an area accessible for spot-welding therebetween.

An individual resistance element of the composite resistance element of this invention preferably is stamped from resistive sheet metal in the form of a relatively long and narrow substantially uniplanular grid having a plurality of relatively narrow transverse grid bars of substantially the same width. The bars at opposite ends of the grid constitute respective lug portions one of which is in the plane of the grid and the other of which is offset so that its terminal portion is spaced from and parallel to the plane of the remainder of the grid. A pair of the individual grids are assembled into a composite resistance element by spot-welding the respective end bars thereof that are not offset to respective tongue portions of a common combined terminal and supporting member. When assembled into a composite resistance element, the pair of individual grids are arranged in edgewise spaced relation in a common plane with their respective longitudinal axes parallel to each other and with the respective offset end bars of the two individual grids offset in opposite directions from the plane of the remainder of the composite resistance element. The composite resistance element is completed by spot-welding another of the combined terminal and supporting members to one of the two offset end bars.

A resistor in accordance with this invention comprises an assemblage of such composite resistance elements held in flatwise spaced relation by a supporting means with those of the respective terminal members which are spot welded to the off-set end bars extending toward and in engagement with the respective oppositely off-set end bars of adjacent composite resistance elements which do not have terminal members welded to them. After the resistor is assembled on the supporting means, spot welds are made between these terminal members and these oppositely off-set end bars engaged thereby. Alternate ones of the composite resistance elements have terminal members of slightly different configuration from each other so that extending portions of adjacent terminal members are spaced apart to provide adequate electrical clearance and to facilitate accessibility and the connection of lead-in conductors thereto.

Other objects and advantages of this invention will become apparent from the following specification wherein reference is made to the accompanying drawings, in which

Fig. 1 is an exploded perspective view showing how a pair of the composite resistance elements of this invention are complementary to each other when arranged side by side on a pair of supporting bolts,

Fig. 2 is a sectional view taken generally along the line 2—2 of Fig. 3,

Fig. 3 is a front elevation of a resistance unit, embodying an assemblage of the resistance elements of Fig. 1, with an intermediate portion having parts at the rear of the unit omitted, and partly in section as indicated by the line 3—3 of Fig. 4,

Fig. 4 is a top plan view with an intermediate portion having parts at the bottom of the unit omitted and partly in section along the line 4—4 of Fig. 2,

Figs. 5 and 6 are perspective views of the combined terminal and supporting members of the unit of Figs. 2, 3, and 4,

Fig. 7 is a fragmentary front elevation of a modified resistance unit with parts at the rear omitted, and

Fig. 8 is a fragmentary rear elevation of the unit of Fig. 7 with parts at the front omitted.

Since the resistance unit or resistor may be used in any turned position as well as in the position in which shown, such positionally descriptive words as front and rear, upper and lower, and the like as used herein are used for convenience in describing relative positions only.

Referring principally to Figs. 1 and 2, one of a pair of complementary composite resistance elements in accordance with this invention, indicated by the reference numeral 10, comprises a pair of identical individual resistance elements 11 suitably fastened to a common combined terminal and supporting member 12 as by spot-welding, and another one of the pair of composite resistance elements, indicated by the reference numeral 14, comprises a pair of the individual resistance elements 11 similarly fastened to a common combined terminal and supporting member 15.

Each of the individual resistance elements 11 is preferably an integral piece of sheet metal of suitable thermal, mechanical and electrical characteristics, such as a high resistance alloy of chromium, aluminum, and steel, and is preferably shaped in the form of an elongated grid having a plurality of parallel spaced intermediate leg portions 16 transverse to its longitudinal axis and interconnected alternately at opposite ends by connecting portions 18 to form a uniplanular circuitous current path between opposite end leg portions 19 and 20 which are preferably parallel to the intermediate leg portions 16 and which constitute supporting lugs for the individual resistance elements or grids. An adjacent pair of the intermediate leg portions 16, preferably a pair 16a midway between the end leg portions 19 and 20, are of reduced length and are connected by a connecting portion 18a of correspondingly increased width to provide space for a circular

opening 21 which cooperates with an intermediate supporting means to be described.

The grids 11 may be formed directly from sheet metal by a stamping operation or may be formed by edgewise bending of a long straight strip, and may be of any suitable configuration, the convolutions defined by the leg portions 16 and connecting portions 18 being merely illustrative of a preferred embodiment which provides a relatively long current path within a relatively small area with only a small amount of metal being wasted in the stamping operation. Preferably, the leg portions 16 are relatively short as shown so as to impart sufficient rigidity to the grids 11 to enable them to be relatively long and to be formed of relatively thin sheet metal and still not vibrate excessively or warp at elevated temperatures.

The end leg 20 of each of the grids 11 is bent intermediate of its length to define an angularly disposed portion 22 between an inner end portion of the leg 20 which remains in the plane of grid and an outer end portion 24 which is bent so that it lies in a plane spaced from but parallel to the plane of the remainder of the grid. The end legs 20 are made slightly longer than the legs 19 so that, after the bending operation, the end edges of the end legs 19 and 20 are substantially equidistant from the longitudinal center-line of the grid. Preferably, the opening 21 is on the opposite side of the longitudinal center-line of the grid 11 from the end edges of the legs 19 and 20.

As shown most clearly in Figs. 1 and 5, the combined terminal and supporting member 12 comprises a piece of sheet metal, preferably cold-rolled steel, having a body portion 25 provided with a centrally disposed circular opening 26. A pair of aligned tongue portions 28 and 29 extend from the top and bottom, respectively, of the body portion 25 in the plane thereof and preferably have their respective outer side edges aligned with a side edge 30 of the body portion 25. A bracket portion 31 which extends from the top of the body portion 25 is spaced a short distance from the tongue portion 28 and has a portion 32 overhanging a side edge 33 of the body portion 25 opposite the side edge 30. The bracket portion 31 is bent at right angles to the plane of the body portion 25, to the left as viewed in Fig. 5, and the overhanging portion 32 is formed to define a downwardly directed wire receiving channel 34. Notches 35 (Fig. 1) formed in opposite side edges of the portion 32 define an intermediate portion 36 of reduced width between pairs of opposing shoulders 37.

As shown most clearly in Figs. 1 and 6, the combined terminal and supporting member 15, which is similar to the terminal and supporting member 12, has a body portion 38 provided with a centrally disposed circular opening 39, a pair of tongue portions 40 and 41 corresponding to the tongue portions 28 and 29 of the member 12, and a bracket portion 42 similar to the bracket portion 31 but bent in the opposite direction or to the right as viewed in Fig. 6. A wire receiving channel 44 formed in an overhanging portion 45 of the bracket portion 42 opens upwardly, as viewed in Fig. 6, and notches 46 (Fig. 1) in opposite side edges of the overhanging portion 45 define an intermediate portion 47 of reduced width between pairs of opposing shoulders 48.

A pentagonal collar 49, which may be received on the overhanging portion 32 of the bracket 31 of the terminal member 12 between the shoulders 37, has a set screw 50 threaded through an opening in a relatively short side wall 51. The set screw 50 may be turned to engage the upper surface of the intermediate portion 36 thereby to force a pair of side walls 52 of the collar 49, which intersect at an acute angle opposite from the lower end of the set screw 50, against a lead-in conductor (not shown) received in the channel 34 thereby to hold the lead-in conductor in good electrical contacting engagement with the terminal member 12. Similarly, a collar 49 may be received on the overhanging portion 45 of the bracket 42 of the terminal member 15 between the shoulders 48 so that its set screw 50 may be turned to engage the lower surface (Fig. 6) of the intermediate reduced portion 47 to cause a lead-in conductor (not shown) to be gripped between the acutely intersecting side walls 52 and the channel 44.

Although the terminal members 12 and 15 are shaped to accommodate a specific form of wire securing means, it is to be understood that they may be arranged in other suitable ways to facilitate the attachment of conductors thereto. For clarity of illustration, the collars 49 have been omitted from the resistor shown in Figs. 1, 2, 3, and 4, it being understood that they may be placed either on all or selected ones of the members 12 and 15 thereof.

Again referring principally to Figs. 1 and 2, each of the composite resistance elements 10 is assembled by overlapping the outer end portion of the end leg 19 of one of the grids 11 on the tongue portion 28 of one of the terminal members 12 and securing it thereto as by a pair of spot welds 54, and by overlapping the outer end portion of the end leg 19 of another one of the grids 11 on the other tongue portion 29 of the same one of the members 12 and securing it thereto as by a pair of spot welds 55. When so welded to the tongue portions 28 and 29, the two grids 11 of the resistance element 10 lie in a common plane and extend in edgewise spaced relation from the terminal member 12 in the same direction with their longitudinal axes parallel and, as viewed in Fig. 1, with the offset portion 24 of the leg 20 of the uppermost grid 11 offset in a direction away from the resistance element 14, and the offset portion 24 of the leg 20 of the lowermost grid 11 offset in a direction toward the resistance element 14. The offset portion 24 of the uppermost grid 11 overlaps the tongue portion 28 of another of the terminal members 12 and is secured thereto as by a pair of spot welds 56. It should be noted that the terminal members 12 of each of resistance elements 10 overlap the grids 11 thereof on the side facing in the direction of offset of the portion 24 of the uppermost one of the grids.

Each of the composite resistance elements 14 is assembled in a similar manner by overlapping the outer end portion of the end leg 19 of one of the grids 11 on the tongue portion 41 of one of the terminal members 15 and securing it thereto as by a pair of spot welds 58, and by overlapping the outer end portion of the end leg 19 of another one of the grids 11 on the other tongue portion 40 of the same one of the members 15 and securing it thereto as by a pair of spot welds 59. When so welded to the tongue portions 40 and 41, the two grids 11 of the resistance element 14 are so positioned that they lie in a common plane and extend from the terminal member 15 in edgewise spaced relation in the same direction with their longitudinal axes parallel and, as viewed in Fig. 1, with the off-set portion 24 of the leg 20 of the uppermost grid 11 off-set in a direction toward the resistance element 10, and the offset portion

24 of the lowermost grid 11 offset in a direction away from the resistance element 10. The offset portion 24 of the uppermost grid 11 of each of the resistance elements 14 overlaps and is secured as by a pair of spot welds 60 to the tongue portion 41 of another of the terminal members 15. It should be noted that the terminal members 15 of each of the resistance elements 14, like the terminal members 12 of each of the resistance elements 10, overlap the grids 11 thereof on the side facing in the direction of off-set of the portion 24 of the uppermost one of the grids.

The composite resistance elements 10 and 14 are complementary to each other and a complete resistor in accordance with this invention and shown in Figs. 2, 3, and 4 comprises a plurality of the elements 10 and 14 arranged alternately in flatwise spaced relation along a pair of elongated main supporting bolts 64 and 65 held in parallel spaced relation in a manner to be described and surrounded throughout most of their length by respective insulating tubes 66 and 67. The resistor is assembled by slipping the openings 26 in the terminal members 12 of one of the resistance elements 12 over the tubes 66 and 67, respectively, with the brackets 31 above the bolts 64 and 65, and then slipping the openings 39 in the terminal members 15 of one of the resistance elements 14 over the tubes 66 and 67, respectively, with the brackets 42 below the bolts 64 and 65. Additional resistance elements 10 and 14 are received alternately in like manner on the bolts 64 and 65 until the desired number of elements have been assembled to form a row or stack. Since, when so assembled, the brackets 31 of the terminal members 12 are above the longitudinal center line of the resistor, their respective channels 34 open downwardly, and since the brackets 42 of the terminal members 15 are below the longitudinal center line of the resistor, their respective channels 44 also open downwardly.

The uppermost grids 11 of the resistance elements 10 and 14 are in an upper row with their respective intermediate openings 21 in alignment and the lowermost grids 11 of the resistance elements are in a lower row with their respective intermediate openings 21 in alignment.

The brackets 31 and 42 at the rear of the resistor all extend from their respective terminal members 12 and 15 in the same direction or toward the right as viewed in Figs. 3 and 4, and the brackets 31 and 42 at the front of the resistor all extend in the same direction from their respective terminal members 12 and 15 or to the left as viewed in Figs. 3 and 4. The brackets 31 and 42 of adjacent ones of the resistance elements 10 and 14, respectively, are thereby spaced apart from each other both horizontally and vertically of the resistor thereby to provide adequate electrical clearance therebetween and between lead-in conductors (not shown) connected thereto.

Since the channels 34 and 44 open downwardly, the set screws 50 of the collars 49 when received on the brackets 31 and 42 have their respective heads facing upwardly, and since the brackets 31 and 42 on the same side of the resistor extend in the same direction, clearance is provided for a screw-driver to reach the set screws 50 of the collars 49 when received on the brackets 42 as clearly seen in Figs. 3 and 4.

Referring particularly to Fig. 3, it will be noted that the upper offset portions 24 of the resistance element 10 and 14 all extend in one direction endwise of the row from the plane of their respective elements, and the lower offset portions 24 all extend in the opposite direction. As seen from the front of the resistor as in Fig. 3, the upper offset portions 24 extend to the left and the lower offset portions 24 extend to the right.

Because the elements 10 and 14 are disposed alternately in the row or stack along the bolts 64 and 65, the terminal members 12 and 15 which depend from respective ones of the upper offset portions 24 at the front of the resistor are disposed alternately along the row, and their respective tongue portions 29 and 40 engage the lower offset portions 24, respectively. Thus the offset portion 24 of the lowermost grid 11 of each of the resistance elements 10 extends toward and engages in overlapping relation the tongue portion 40 of the front terminal member 15 of the next adjacent resistance element 14, and the offset portion 24 of the lowermost grid 11 of each of the resistance elements 14, except the one nearest an end frame 68 at the right-hand end of the row, extends toward and engages in overlapping relation the tongue portion 29 of the front terminal member 12 of the next adjacent resistance element 10. The offset portions 24 engage the respective tongue portions 29 and 40 at respective areas accessible by the electrodes of a spot-welding machine (not shown) and, after the resistor is assembled, pairs of spot-welds (not shown) may be made between the abutting portions 24 and tongue portions 29 and 40, respectively. The adjacent resistance elements 10 and 14 are thus held in flatwise spaced relation at the front of the resistor and an electric circuit is completed from element to element through spot-welds.

The main supporting bolts 64 and 65, each of which is threaded at its opposite end portions, are received at one end in respective horizontally spaced openings in the end frame 68 and at the other end in similar respective openings in an end frame 69. Preferably, the openings in the end frames 68 and 69 are elongated horizontally, as indicated in Fig. 4, so as to provide space for thermal expansion of the resistance elements 10 and 14 carried by the bolts 64 and 65.

Each of the bolts 64 and 65 is preferably insulated from the end frame 68 by an outer insulating washer 70 having a centrally disposed annular boss 71 (Fig. 4) which extends through its associated opening in the end frame 68 into a complementary centrally disposed cylindrical recess in an inner insulating washer 72, and each is retained in position with respect to the end frame 68 by inner and outer nuts 74 and 75 tightened against the washers 72 and 70, respectively, metal washers 73 performing their usual function as indicated. The opposite end portion of each of the bolts 64 and 65 is similarly insulated from and secured to the end frame 69.

As mentioned, the resistance elements 10 and 14 are arranged alternately in a row or stack along the bolts 64 and 65 with the insulating tubes 66 and 67 passing through the respective openings 26 and 39 in the terminal members 12 and 15. The respective end portions of the resistance elements 10 and 14 at the front of the resistor or in the region of the bolt 64 are additionally held in flatwise spaced relation by suitable heat resisting insulating washers 76 received over the insulating tube 66 and interposed

respectively in the spaces between adjacent ones of the terminal members 12 and 15 disposed along the tube 66. Similarly, the respective end portions of the elements 10 and 14 at the rear of the resistor or in the region of the bolt 65 are held in flatwise spaced relation by additional insulating washers 76 received over the insulating tube 67 and interposed respectively in the spaces between adjacent ones of the terminal members 12 and 15 disposed along the tube 67. In other words, both at the front and rear of the resistor adjacent ones of the terminal members 12 and 15 are spaced apart by engagement of the margin of the metal around the respective openings 26 and 39 with the planular side faces of one of the washers 76. Additional washers 76 may be placed on the insulating tubes 66 and 67, respectively, at opposite ends of the row of resistance elements, the outermost ones of the washers 76 at each end of the row preferably extending slightly beyond the end of their respective tubes as shown in Fig. 4. The row of resistance elements 10 and 14 is held together by nuts 78 threaded on the end portions of the bolts 64 and 65, respectively, suitable lock washers 79 and plain metal washers 80 being disposed between the nuts 78 and the outermost of the insulating washers 76, respectively.

The uppermost ones of the individual grids 11 are supported intermediate of their respective end portions by a supporting means comprising an elongated bolt 81 passing through the aligned openings 21 in the upper row of grids and having its opposite end portions threaded and received in horizontally elongated openings near the top of the respective end frames 68 and 69. A supporting means for the intermediate portions of the lowermost ones of the individual grids 11 comprises a similar bolt 82 passing through the aligned openings 21 in the lower row of grids and having its opposite end portions received in respective horizontally elongated openings near the bottom of the respective end frames 68 and 69. Each of the end portions of the bolts 81 and 82 is preferably secured to and insulated from its associated one of the end frames 68 and 69 by a pair of telescoping insulating washers 84 and 85, similar to the washers 70 and 72, respectively, and outer and inner nuts 86 and 87. The upper and lower intermediate supporting means also comprise respective groups of insulating washers 89 to be described and received on the respective bolts 81 and 82 thereof.

The intermediate portions of the grids 11 in the upper row are held in flatwise spaced relation by the group of the insulating washers 89 received on the bolt 81, and the intermediate portions of the grids 11 in the lower row are held in flatwise spaced relation by the group of the insulating washers 89 received on the bolt 82. As shown most clearly in Fig. 4, each of the washers 89 has a central annular boss 90 on one side, and, on the other side, a central cylindrical recess 91 of slightly larger diameter than the boss 90 and slightly deeper than the height of the boss 90. Washers 89 of the group disposed along the bolt 81 are interposed respectively in the spaces between adjacent ones of the uppermost grids 11 with the bosses 90 thereof fitting snugly into the next adjacent ones of the openings 21, respectively, and extending respectively therethrough into the recesses 91 of the next adjacent ones of the washers 89. Similarly the washers 89 of the group disposed along the bolt 82 are interposed respectively in the spaces between the adjacent ones of the lowermost grids 11. Additional washers 89 may be placed on the bolts 81 and 82 at opposite ends of the row of resistance elements. The margin of metal around the opening 21 of each of the grids 11 is thus disposed between an annular surface around the boss 90 of one of the washers 89 and an annular surface around the recess 91 of the next adjacent one of the washers 89.

The respective groups of the washers 89 on the bolts 81 and 82 are held in position by nuts 92 threaded on respective opposite end portions of the bolts. At the end portion of the bolt 81 nearest the end frame 69, a suitable lock washer 94 and a plain washer 95 are interposed between the nut 92 and the outermost one of the washers 89 on the bolt 81 and, at the end portion of the bolt 82 nearest the end frame 69, a lock washer 94 and a plain washer 95 are also interposed between the nut 92 and the outermost one of the washers 89 on the bolt 82. Similar lock washers 94 and plain washers 95 are used respectively on the end portions of the bolts 81 and 82 nearest the end frame 68. At the end nearest the end frame 68, however, the respective bosses 90 of the outermost ones of the insulating washers 89 are received respectively in recesses 96 (Fig. 4) of insulating washers 97 received on the respective bolts 81 and 82 and having planular outer surfaces in engagement with the respective washers 95.

An electric circuit through the resistor of Figs. 2, 3, and 4 can be traced as follows:

Starting at the terminal member 12 at the front of the resistor and which forms part of the resistance element 10 closest to the end frame 69, the circuit is from the bracket portion 31 thereof through its tongue portion 28 and the spot welds 56 (Fig. 1) into the offset portion 24 of the uppermost grid 11 of this first one of the resistance elements 10 and thence through this grid 11 across the upper portion of the resistor. At the rear of the resistor, the circuit continues from the uppermost grid 11 of the first of the resistance elements 10 downwardly through the spot welds 54 (Fig. 1) into the tongue portion 28 of the other or rear terminal member 12 of the first resistance element 10 and from the tongue portion 29 thereof through the spot welds 55 (Fig. 1) into the lowermost grid 11 of the first resistance element 10. The circuit is then through this lowermost grid 11 back across the bottom portion of the resistor to its offset portion 24 which is spot welded to the tongue portion 40 of the front terminal member 15 of the first of the resistance elements 14 nearest the end frame 69. From the tongue portion 41 of this terminal member 15 the circuit is through a pair of the spot welds 60 (Fig. 1) into the offset portion 24 of the uppermost grid 11 of the first of the resistance elements 14 and thence through this grid 11 across the top portion of the resistor. At the rear of the resistor, the circuit continues downwardly through a pair of the spot welds 58 into the other or rear terminal member 15 of the first of the resistance elements 14 and from this member 15 through a pair of the spot welds 59 (Fig. 1) into the lowermost of the grids 11 of the first of the resistance elements 14. The circuit then extends through this lowermost grid 11 across the bottom portion of the resistor towards the front and into its offset portion 24 which is spot welded to the tongue portion 29

of the front terminal member 12 of the next adjacent one of the resistance elements 10.

The circuit continues in like manner back and forth across the resistor until the resistance element 14 nearest the end frame 68 is reached.

It will be understood that lead-in conductors may be secured to any of the terminal members 12 and 15 at the front and rear of the resistor to select increments of the total resistance of the resistor for use in an external electric circuit. Although in the resistor as shown all of the resistance elements 10 and 14 in the row are connected to form a continuous series circuit from one end of the resistor to the other, it will be understood that groups of series-connected resistance elements 10 and 14 may be disposed along the supporting bolts 64 and 65 and electrically isolated from each other.

In the modified resistor of Figs. 7 and 8, complementary composite resistance elements 100 and 101, each comprising a pair of individual grids 102 similar to the grids 11 but not having off-set portions, are arranged alternately in a row along the main supporting bolts 64 and 65 and the bolts 81 and 82 are used to support intermediate portions of the grids 102. The insulating washers 76 and 89 may be used as in the resistor of Figs. 2, 3, and 4 to hold the elements 100 and 101 in flat-wise spaced relation.

Each of the composite resistance elements 100 is assembled by overlapping the outer end portion of an end leg 104 (Fig. 8) of one of the individual grids 102 on the tongue portion 28 of one of the terminal members 12 and securing it thereto as by a pair of spot welds 109, and by overlapping the outer end portion of the end leg 104 of another one of the grids 102 on the tongue portion 29 of the same one of the terminal members 12 and securing it thereto as by a pair of spot welds 105. When so welded to the tongue portions 28 and 29, the two grids 102 lie in the same plane and extend from the terminal member 12 in the same direction with their longitudinal axes parallel to each other.

Each of the resistance elements 100 also comprises a terminal member 110 (Fig. 7), similar to the terminal members 12, but having its tongue portions bent in opposite directions from its body portion to define respective angularly disposed portions 111 and 112 between its body portion and respective outer end portions 114 and 115 of the tongues. The end portions 114 and 115 are bent so that they lie in respective planes which are spaced from but parallel to the plane of the body portion. Each of the resistance elements 100 is completed by overlapping the offset end portion 114 of one of the terminal members 110 on an end leg 116 opposite from the end leg 104 of the uppermost one of the grids 102 thereof and securing it thereto as by a pair of spot welds 118.

Each of the composite resistance elements 101 is assembled by overlapping the outer end portion of the end leg 104 (Fig. 8) of one of the grids 102 on the tongue portion 41 of one of the terminal members 15 and securing it thereto as by a pair of spot welds 119, and by overlapping the outer end portion of the end leg 104 of another one of the grids 102 on the tongue portion 40 of the same one of the terminal members 15 and securing it thereto as by a pair of spot welds 120.

Each of the resistance elements 101 also comprises a terminal member 121 (Fig. 7), similar to the terminal members 15, but having its tongue portions bent in opposite directions from its body portion to define respective angularly disposed portions 124 and 125 between its body portion and respective outer end portions 128 and 129 of the tongues. The end portions 128 and 129 are bent so that they lie in respective planes which are spaced from but parallel to the plane of the body portion. Each of the resistance elements 101 is completed by overlapping the offset end portion 128 of one of the terminal members 121 on the end leg 116 of the uppermost one of the grids 102 thereof and securing it thereto as by a pair of spot welds 130.

The resistance elements 101 and 102 are assembled alternately in a row on the bolts 64 and 65 to form a resistor with the bracket portions 31 and 42 of the terminal members 12 and 15, respectively, at the rear of the resistor extending in the same direction, or to the left as viewed in Fig. 8, and with bracket portions 131 and 132 of the terminal members 110 and 121 at the front of the resistor extending in the same direction or to the left as viewed in Fig. 7.

Except for the offset end portion 115 nearest the left hand end of the resistor (Fig. 7), the end portions 115 of the terminal members 110 extend toward and engage the end leg 116 of the lowermost grid 102 of the next adjacent resistance element 101 to which they are electrically connected after the resistor is assembled as by a pair of spot welds 134. Likewise, the offset end portions 129 of the terminal members 121 extend toward and engage the end leg 116 of the lowermost grid 102 of the next adjacent resistance element 100 to which they are electrically connected after the resistor is assembled as by a pair of spot welds 135. Thus an electric circuit through the resistor of Figs. 7 and 8 is completed through spot-welded joints as in the resistor of Figs. 2, 3, and 4 and the offset tongue portion of the terminal members 110 and 121 provide the advantages of the offset portions 24.

Having thus described my invention, I claim:

1. An electric resistor comprising a group of generally planar metallic grid members arranged in pairs with the individual grids of each pair in generally edgewise spaced and generally parallel relation and the several pairs arranged in flatwise spaced and generally parallel relation to each other, whereby adjacent ones of the pairs are offset laterally one from the other, each of the grid members of each pair having, at one end of the pair, a first integral lug portion, electrically conductive rigid supporting members respective to the pairs and each electrically interconnecting and permanently bonded to the first lug portions of its associated pair and thereby holding the grid members of its associated pair fixedly in said generally edgewise spaced and generally parallel relation, each grid member of each pair having a second integral lug portion at its opposite end, additional electrically conductive rigid supporting members for the pairs, respectively, each additional supporting member being electrically connected and permanently bonded at one portion to the second lug portion of one grid member of its associated pair, and at another portion to the second lug portion of a grid member of a next adjacent pair, and means cooperating with said supporting members and said additional supporting members for holding said pairs in said flatwise spaced and generally parallel relation.

2. The resistor of claim 1 characterized in that

each of said first lug portions is substantially coplanar with the major portion of its associated grid member.

3. The resistor of claim 1 characterized in that each of said grid members comprises a row of spaced bar portions and integral connecting portions at the ends of adjacent bar portions and forming therewith a sinuous electrical path extending endwise of the row, and said lug portions are the respective end ones of said bar portions.

4. The resistor of claim 1 characterized in that all of the grid members are substantially identical.

5. The resistor of claim 1 characterized in that each of the two grid members connected together by an additional supporting member are also offset edgewise from each other.

6. The resistor of claim 1 characterized in that each of said second lug portions is offset laterally from the plane of the major portion of its associated grid member.

7. The resistor of claim 1 characterized in that said second lug portions of each pair of grid members are offset laterally from, and in opposite directions respectively from, the plane of their associated pair.

8. The resistor of claim 1 characterized in that each additional supporting member has a planar portion and the connected portions of each of said additional supporting members are offset laterally of the planes of the pairs in opposite directions, respectively, from its planar portion.

9. The resistor of claim 1 characterized in that said supporting members and additional supporting members have mounting holes, respectively, and said last mentioned means comprises a pair of bolts passing through the mounting holes in said supporting members and in said additional supporting members, respectively.

10. The resistor of claim 1 characterized in that at least some of said supporting members, and at least some of said additional supporting members, have extending portions, respectively, and each of said extending portions is arranged for connection with a wire.

11. The resistor of claim 10 characterized in that the extending portions of adjacent ones of the supporting members extend laterally of the planes of the members, each in the same direction from its associated member at least close to the plane of the next adjacent member, and said extending portions on said adjacent ones of said supporting members are spaced from each other in the general direction of the edgewise spacing of the grids of each pair.

12. An electric resistor comprising a plurality of generally planar U-shaped metallic resistance elements each having a rigid base portion and a pair of arm portions extending therefrom and fixedly held in generally endwise spaced relation to each other thereby, each of said elements having a first mounting means at its base portion and a second mounting means electrically connected to, and permanently bonded to, the free end portion of one of said arm portions, said second mounting means being offset from the plane of the remainder of said element and lying in a plane spaced from and generally parallel to the plane of said element, and supporting means for said resistance elements cooperating with said first and second mounting means, respectively, of each element, and thereby supporting said elements in substantially parallel and flatwise spaced relationship with respect to each other with each of said second mounting means extending toward, and being in electric contact with, and permanently bonded to, the free end portion of an arm portion of an adjacent element.

13. The resistor of claim 12 characterized in that one of said arm portions comprises a metal strip forming a circuitous current path including a succession of parallel legged loops alternately extending in opposite directions from the longitudinal axis of their associated arm portion and including an elongated portion at the free end of the strip and extending toward but not intersecting the longitudinal axis of the resistance element as a whole, and said second mounting means are electrically connected to, and permanently bonded to, said strip portions, respectively.

14. The resistor of claim 12 characterized in that each of said arm portions of each element is a separate strip of electric resistance material and each base portion of each element is a separate electric conductive member electrically connected to, and permanently bonded to, the strips of the element of which it forms a part, and constitutes said first mounting means.

15. The resistor of claim 14 characterized in that each of said conductive members is spot welded to the strip of the element of which it forms a part.

16. The resistor of claim 12 characterized in that both of said free end portions of each of the U-shaped resistance elements are offset in opposite directions, respectively, from the plane of the remainder of their associated element.

17. An electric resistance element adapted to be assembled in a resistance unit which includes a plurality of said resistance elements arranged in flatwise and generally parallel spaced relationship, said element comprising a pair of metal supporting members permanently bonded to, and supported in fixed position by, and electrically connected by, a generally planar intermediate metallic resistive portion, one of said supporting members lying substantially in the plane of said resistive portion and the other of said supporting members being offset from the general plane of said resistive portion and lying in a plane which is generally parallel to the general plane of said resistive portion, a second substantially planar resistive portion permanently bonded to, and supported in fixed position by, and electrically connected to, said one of said supporting members and disposed in edgewise spaced and generally parallel relation to said first resistive portion and generally coplanar therewith.

ALVIN C. DYER.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,501,638	Weimer et al.	July 15, 1924
1,525,460	Miller	Feb. 10, 1925
2,378,056	Wright	June 12, 1945

FOREIGN PATENTS

Number	Country	Date
361,986	Great Britain	Dec. 3, 1931

OTHER REFERENCES

Kutcher et al., The Welding Journal, Oct. 1948, pgs. 827–830.