March 15, 1960 Q. BERG 2,929,046

ELECTRICAL CONNECTOR

Original Filed Oct. 20, 1950

Fig. 2.

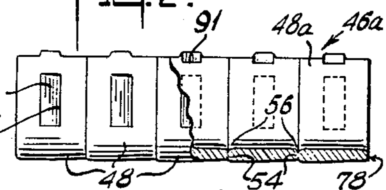


Fig. 1.

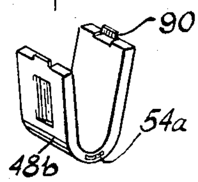


Fig. 3.

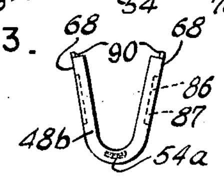


Fig. 4.

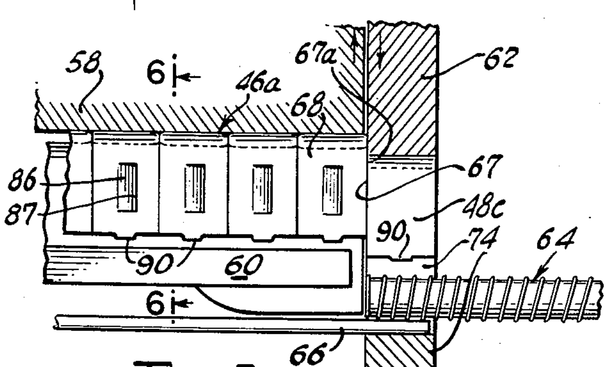


Fig. 5.

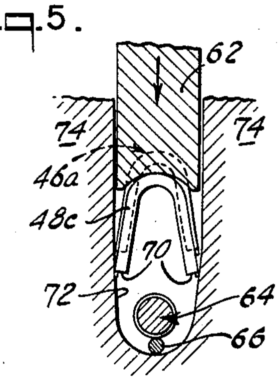


Fig. 7.

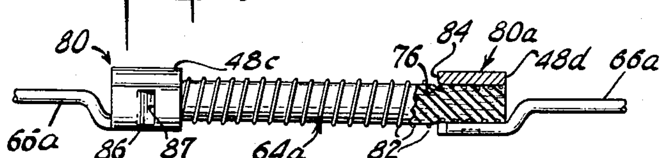
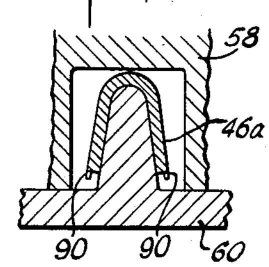


Fig. 6.



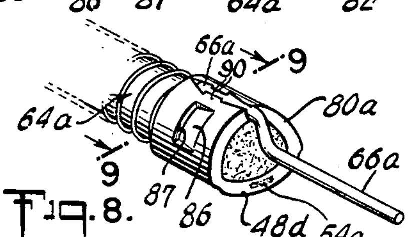
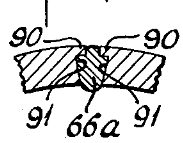


Fig. 8.

Fig. 9



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2,929,046

ELECTRICAL CONNECTOR

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Original application October 20, 1950, Serial No. 191,156, now Patent No. 2,748,456, dated June 5, 1956. Divided and this application September 9, 1955, Serial No. 536,893

6 Claims. (Cl. 339—276)

This invention is related to electrical connectors of the type which are used, in the form of a continuous strip of connectors, in machines which pressure-crimp the connectors individually onto wire conductors or the like. In preferred form, the subject connector is adapted to connect a lead wire to electrical elements with precision to embody them as useful components for electrical circuits (e.g., resistors, reactors, and capacitors). This application is a division of my copending application, Serial No. 191,156, filed October 20, 1950, now Patent No. 2,748,456, issued June 5, 1956.

The invention is applicable generally to the connecting of wires to circuit component elements, e.g., the resistance elements, choke coils etc., mentioned above. Such elements are commonly made in the form of wire helically wound onto a core of insulating material. This wire-wound insulation or other circuit element which is to be subsequently connected into a circuit as a component thereof is referred to herein as "electrical element." With lead wire connections made at each end of lengths of such elements, they become useful circuit components. The electrical values, e.g., resistance or reactance, of such components and consequently their performance in a given circuit are dependent on the active length of the element, that is, its length between the closest opposite-end contacts with the connectors or the lead-in wires. In the broader aspects of this invention, it is concerned with the making of connections on circuit component elements other than resistance or reactance coils, e.g., paper-foil capacitors and even simple conductors.

My new connector-strips are used to make permanent lead-wire connections to such electrical elements, and this with speed, economy, precision, accuracy and electrical and mechanical security. It has been found to be distinctly advantageous, however, to avoid the tearing out or extrusion of burrs, during cutting of the end connector from the strip, as such burrs could, under certain conditions, damage a fragile circuit component element, or reduce the spacing from other circuit elements or otherwise be detrimental to the excellence of the connection.

It is, therefore, a general object of this invention to provide a continuous strip of electrical connectors which will hold together under the handling to which it must be subjected in manufacture, transit and use but from which individual connectors can be severed without need for sharp edged tools, and with production of a connector, well adapted to join two conducting members with great precision accuracy, and electrical and mechanical stability, even where one conducting member to be joined is a fragile electrical element.

Beyond this, it is an object of the invention to make connections with such precision and stability.

With these and other objects, which will be apparent, my invention provides a continuous strip of electrical connectors which are in full edge contact with one another in the strip to maintain their parallelism while they are being subsequently severed, and which are joined in the strip by a thin section of metal spaced from the inner and outer faces of the strip, whereby each connector can be accurately severed from the strip without the use of sharp cutting members with greater precision than was known in the prior art, and this merely by the imposition of opposed, laterally off-set forces to the end connector and the adjacent connector of the strip to which it is attached.

It is also an important object to apply connectors from strip without the protrusion of any burrs, such as may be acquired during the severing of connectors from the strip.

I accomplish these as well as other objects through the use of novel joining areas between the connectors in the strip. These areas are longitudinally of small dimension, and, laterally, they are substantially thinner than the sheet metal which comprises the connectors. In combination with this small joining area, this invention in preferred form utilizes a recessed area in the inner surface of the connector strip adjacent each such joining area. Other novel features in combination particularly adapt my invention to certain specific applications.

The aforesaid, and other objects will in part be pointed out in and will in part become apparent from the following specification and claims, taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is an isometric view of a single connector in accordance with the present invention;

Figure 2 is a side elevational view of a series of connectors, as shown in Figure 1, integrally connected in a strip, partially broken away to present an axial cross-section of this strip;

Figure 3 is an end elevation of a connector as is shown in Figure 1;

Figure 4 is a side view of the strip of connectors, electrical element, lead wire, and their assembly apparatus, the latter shown partially in cross-section;

Figure 5 is a right end elevational view of certain elements in Figure 4;

Figure 6 is a partial cross-section taken at the line 6—6 in Figure 4;

Figure 7 is a side elevation of a precision electrical circuit component, partially broken away and presented in axial cross section;

Figure 8 is an isometric view of an end connection of the component shown in Figure 7;

Figure 9 is a cross section taken at the line 9—9 in Figure 8.

Referring to Figures 1 to 3, the various connectors **48**, so as to be suitable for use with automatic or semi-automatic applicating machines, are integrally attached in strip form by a joining area **54**, the strip being recessed, as at **56**, adjacent joining areas **54**. It is to be noted that the joining area is of relatively small cross-section, and, preferably, does not extend laterally into contact with either surface of the strip. Among the advantages accruing from this latter feature is the fact that the dimensions of each individual connector are well pre-established by the placement of said joining area **54**; these connectors **48** are thereby adapted to be accurately severed from the strip without the use of sharp cutting means, but rather with the mere imposition of a lateral force between the end connector **48a** and the strip **46** (Figure 2).

This shearing process is best seen in Figure 4, wherein the strip **46a**, here in an inverted position, is seen disposed between an upper guiding and supporting member **58** and a lower supporting member **60**. A third member, in practice one of two cooperating die structures, referred to herein as the upper crimping die **62**, is abutted against the bottom (here turned upward) of the end connector **48c** of the strip **46a**, and the upper crimping die **62** and the strip supporting members **58** and **60** are driven transversely (vertically) relative to one another, and the end connector is thus slid or wiped off the supported strip **46a**. In effect, the supported strip provides the "shearing edge" for this severing action—i.e., the connectors shear against one another. In the lateral movement of the end connector **48c** relative to the strip **46a** the vertical end edges **67** of the side walls **68** of the end connector **48c** slide along those **67a** of adjacent connector in the strip **46a**, thus advantageously limiting the motion of the end connector to a laterally shearing one and causing joining area **54** to be cleanly sheared rather than partially bent and torn off. The recessed area **56** previously described provides further assurance in that if by any chance this shearing should produce any burr it would be within this recess and within the thickness of the connector **48c** as well as of that in the adjacent connector in the strip **46a**.

Subsequent application of the end connector **48c** to a fragile electrical element **64** and a lead wire **66** is seen in Figures 4 and 5 taken together. Referring to Figure 4, after being severed from the strip **46a** the end connector **48c** is held between the upper crimping die **62** and a lower crimping die **74**, by virtue of sliding frictional engagement of the side walls **72** of this lower die **74** with the longitudinal end edges **70** of the connector **48c**.

In application to an electrical element and a lead wire, as is shown in Figure 5, the severed end connector **48d** is disposed between the crimping dies **62** and **74**, with a fragile electrical circuit element **64** and a lead wire disposed opposite the end edges **70** of the connector **48b**. Subsequent bringing together of the dies **62** and **74** encloses and compressively engages the electrical element **64** in the connector **48b** and securely grips the lead wire between the end edges **70** of the connector.

The previously discussed recessed areas **56** in the strip **46**, or **46a**, provide recessed end edges **76** in the severed connector **48c**. In the connection **80** (Figure 7), seen partially in cross-section in the opposite-end connection **80a**, these recessed edges **76** accommodate any burr which might conceivably be produced during the shearing of the connector from its strip, and thus preclude the cutting of the fragile wires **82** of the electrical element **64a**.

The formation of the recessed edges **76** also serves to avoid sharp corners, which even though free from burrs might impose damaging shear stresses on the fragile wires **82** when the connections **80** are crimped thereon.

Referring again to Figure 4, it is seen that the connector **48c** has a longitudinal dimension (length from left to right in Figure 4) great enough to permit the connector to grip a substantial length of the electrical element **64a**. This entire area is substantially uniformly compressed onto the element **64a** so that the element is securely gripped with a good electrical contact but without excessive pressure of the connector **48c** on the fragile wires **82** (because of distribution of the gripping force over an area sufficient to preclude the damaging of these wires). Further, it is distinctly advantageous to have this longitudinal dimension great enough to provide a secure grip on a lead wire **66a** between the end edges **70** of the connector **48d** even though this lead wire **66a** does not extend to the inner edge **84** of the connector (note the connection **80a**, Figure 7, also Figure 8). The inner edge **84** is thus relieved from great compression, and this produces a longitudinal gradient of pressure on the electrical element **64a** which helps to protect it against damage, and this also avoids any danger of driving the cut end of the lead wire into the electrical element **64a** in the critical area which determines its active length. The length of the connector **48** also determines the leverage which the lead wire **66** can exert tending to pry open the connection, although ordinarily the rigidity of the connection is so much greater than the bending strength of the wire that this leverage is not a controlling factor. Yet another function served by the length of the connector **48** is the strengthening against flexure of the connections **80**, **80a**, which in turn enhances the electrical and mechanical stability of these connections.

It is to be noted that, in the preferred embodiment shown in the drawings, the strip of connectors **46** presents the general appearance of a channel and, more particularly, one with a rounded bottom. In certain applications, such as that described herein, this rounded contour of the bottom of the connectors is distinctly advantageous in order that the connectors can receive and snugly fit round fragile electrical elements without damaging them during crimping. The radius of curvature of the bottom inner surface of the connectors, or of the channel comprising a strip of connectors, is in present practice, slightly less than the outer radius of curvature of a round electrical element to be gripped therein. The reason for this is that the forces on the connector as it is driven along the side walls **72** and into the lower crimping die **74** tend to spread its bottom as said connector is driven around and about said element. It is to be understood, of course, that strips with other than rounded bottoms can be successfully used, with appropriate male and female cirmping means, but it unnecessarily compicates the problem, when the element to be engaged is round. If the electrical elements to be used in the manufacture of circuit components were of a shape other than round, or if they were not fragile but were themselves sturdy structures, the cross-sectional shape of the connectors could be varied within broad limits providing that the generally channel-like form is adhered to.

With the round, fragile, electrical element to be connected in an embodiment of this invention and a lead wire gripped between the longitudinal end edges (i.e., the longitudinally directed, laterally extreme end edges) of the connector or channel, the lateral inner peripheral dimension (i.e., from one such edge transversely around the inner surface to the other end edge along a section normal to the axis) must be such that secure compressive gripping of the lead wire can be acquired while the enclosed element is held with adequate but not destructive pressure; and that such adequate gripping pressure is reached after the lead wire has been gripped between the edges **70** but before it has been weakened beyond the requirements of its use. When the crimping dies are at the end of their movement, the wire **66** should be substantially deformed between the edges **70** so that it is keyed against rotation and against axial pull-out. (Note Figures 8 and 9.) In order that the element **64** will not be scratched by the connector as it is being forced around the element during assembly (which could result in breakage of the fragile wires when the connector thereafter is peripherally compressed and worked or flowed beyond its yield point and thus given a permanent "set" to secure the lead wire and element) this peripheral dimension plus the diameter of the lead wire should be considerably greater than the compressed circumference of the electrical element used. With the dimensional relationships of connector, electrical element, and lead wire as shown in the accompanying drawings, this inner periphery is approximately four times the lateral width of the rounded bottom portion of the inner surface of the connector measured at an altitude equal to one half said width above the bottom of the interior.

In crimping, the element **64** is initially of diameter slightly greater than the said lateral width of the bottom portion of the connector and hence does not immediately bottom therein; but as the end edges **70** of the connector are bent around in the die the width is slightly increased and the element is pushed in toward the bottom. The lead wire is then gripped between the longitudinal end edges of the connector as the electrical element is enclosed thereby; and the connector is then finally compressed against the wire until, finally, in elastic radial extrusion and compression of the connector sets walls thereof in a form to maintain a strong but well distributed gripping pressure on the enclosed element. A general expression for the width of the strip of sheet metal stock from which these preferred forms of connectors are made has been found to be pi times the sum of the outside diameter of the electrical element plus the thickness of the sheet metal stock minus the lead wire diameter, and 3 to 25 percent of the remainder added thereto to allow for compressive "setting."

Although the 25% addition will ordinarily be more than necessary (and even larger excess can be used in extreme cases) it is permissible in my invention by reason of the crimping die set shown in Figure 4. As the pressure on the ferrule increases in the dies its frictional resistance against the die face increases so that instead of pinching off the wire, the compression tends to be relieved by thickening and extrusion of the metal in the zone where the surfaces of the male and female dies meet. Unless lead wires in the form of wider more or less flat, strips of metal were used, the connector itself would have an inner lateral periphery greater than three times the width of the curved bottom inner surface thereof, said width being taken at a point one-half this width above the bottom of said inner surface.

Various advantages accrue from having the side edges of the connectors face-to-face in the strip and lying in the same plane. As previously discussed, this construction gives sliding support to the end connector as it is moved laterally across the strip for shearing and holds the alignment of the connector so that it is properly oriented in the crimping die. Of great interest is the fact that this alignment of the side walls of the connectors, in the strip, enables the size of the crimping die surfaces to be reduced and permits crimping of the connectors onto fragile electrical elements with much less danger of damage by reducing the necessary clearance between said elements and the die surfaces. Advantageously this clearance is only slightly greater than the thickness of the connector metal, but sufficient so that it does not bind on the core. This small clearance of the side of the element can be filled in by thickening of the connector by compression during crimping. These features permit much greater accuracy and precision of the crimping operation. Furthermore, this essentially cylindriform shape of the connectors obviates the risk of having relatively inwardly disposed portions of the side walls making contact, with high unit pressure, with the electrical element as it is enclosed by the connector during crimping.

A yet further advantage gained in the use of strips comprised of such aligned cylindriform connectors is the fact that the strip can bend in only one direction. The joining areas between connectors are strong enough to permit the strip being handled, that is, loaded onto applicator machines in the form of rolls of strip and the end of the strip fed through guiding and indexing mechanisms in the machines, the abutting relationship of the connectors in the strip enables them to behave as if they were rigid members when subjected to columnar loading, greatly facilitating their being accurately fed in an automatic applicator. Furthermore, this strip is wound onto reels with easily achieved neatness, as it bends in only one direction and resists twisting. In order to gain these and other advantages a new means of providing an abutment for indexing members to engage in feeding the strip in the machine, is herein provided.

The thickness of the sheet metal stock out of which the connectors are to be made is, of course, dependent on such things as the diameter of the lead wire to be subsequently gripped between the longitudinal end edges of the connector, the hardness, elastic limit, and other characteristics of this sheet metal stock, the nature of the electrical element, or, possibly, electrical conductor to be gripped therein as well as other variables, such as the size and shape of the crimping dies, which could be adapted to meet specific connector-stock thickness requirements. With quarter or half-hard brass as stock, an electrical element whose circumference is .380 inch, a stock thickness of .023 to .029 inch has been found to be quite satisfactory for use with a soft copper lead wire whose diameter is slightly greater than this thickness. Such brass connectors have a yield point low enough to permit compressive flow of the metal therein during crimping and to thus allow a permanent "set" to be given to the compressed connectors, and yet are strong enough to securely grip the lead wire and electrical element gripped therein. If the sheet metal used is harder, it could be accordingly, of less thickness.

Related to the thickness of the sheet metal used in making the connectors is the problem of insuring the secure retention of the lead wire gripped between their longitudinal end edges. In order to insure that this wire is correctly engaged by these edges during the crimping operation (see Figures 4 and 5), as well as to subsequently strengthen the assembly, they are provided with thin flanges **90** extending from the outer surface of the side wall of the connector. The flanges **90** are disposed at the center of the longitudinal end edges **70** of the connector, and each is in part an extension of the outer surface of the connector. Although other types of wire-gripping end edge deformations may be used to enhance the security of the retention of the lead wire between the end edges of the connector, these flanges are particularly advantageous as they tend to "gather" the lead wire into the proper position between the end edges during crimping. Furthermore, the edge recesses **91**, left when metal is displaced outwardly to form the flanges **90**, receive extruded portions of the lead wire during the final high-compression stage of the crimping operation, thus serving to "key" the wire into place (note Figures 8 and 9). The flanges themselves, in combination with extrusion of the lead wire, also serve to "key" the wire against subsequent rotation, as is shown in Figure 9. This gripping of the wire is thus made independent of the enclosed element, and enables the pressure on the wire and on the element to be varied independently, as previously discussed.

If thinner and harder material, e.g., steel, is used in the manufacture of connectors which are to be used as described above, it would be distinctly advantageous to so form the longitudinal end edges that they are effectively thick enough to grip and retain the lead wire. Corrugated edges, for instance, would not only be effectively thick enough, but would enhance a "keying" of the wire by permitting extrusion thereof between the corrugations.

The minimization of burrs at the severed ends of the connectors, the minimization of the maximum radial dimension of the connections formed therewith by gripping the lead wire in an opening in the wall of the connector, and the secure "keying" or rigid gripping of the lead wire—these and other features enhance the subsequent molding of plastic insulating material over the electrical components so formed. For instance, the lead wire is used, advantageously, as a support for the component during such molding—if it is not properly disposed, and securely held, in the component, it may preclude the component being adequately covered with insulation.

I claim:

1. An electrical component comprising a length of electrical element, a cylindriform ferrule embracing at least one end of said length and in pressure contact therewith, said ferrule being circumferentially continuous but for spatially disposed end faces defining a longitudinal slot in

said ferrule, a lateral indentation in at least one of said faces, and a lead wire extending along and compressively engaged in said slot between said end faces, a portion of said wire projecting into said indentation to key said wire against longitudinal movement within said slot.

2. An electrical component comprising a length of electrical element, a cylindriform ferrule embracing at least one end of said length and in pressure contact therewith, said ferrule being circumferentially continuous but for spatially disposed end faces defining a longitudinal slot in said ferrule, at least one of said end faces having a flange extending therefrom adjacent the outer surface of said ferrule, and a lead wire extending along and compressively engaged in said slot between said end faces, said flange securing said wire from lateral movement out of said slot.

3. An electrical component comprising a length of electrical element, a cylindriform ferrule embracing at least one end of said length and in pressure contact therewith, said ferrule being circumferentially continuous but for spatially disposed end faces defining a longitudinal slot in said ferrule, a lateral indentation in at least one of said faces, at least said one face having flange means extending therefrom adjacent the outer surface of said ferrule in substantial transverse alignment with said indentation, and a lead wire extending along and compressively engaged in said slot between said end faces, a portion of said wire projecting into said indentation to key said wire against longitudinal movement within said slot, said flange means securing said wire against lateral movement out of said slot.

4. An electrical component comprising a length of electrical element, a cylindriform ferrule embracing an end of said length and in pressure contact therewith, the ferrule laterally terminating in longitudinally extending opposed side faces, and a lead wire extending along said side faces and gripped therebetween by the ferrule.

5. An electrical component comprising a length of electrical element, a cylindriform ferrule embracing each end of said length and in pressure contact therewith, each ferrule laterally terminating in longitudinally extending opposed side faces, and a pair of lead wires respectively extending along said side faces and gripped therebetween by the associated ferrule.

6. An electrical component according to claim 5 wherein said lead wires terminate short of the opposed longitudinal edges of said ferrules.

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