The present invention relates to an electrical connector having a body of resilient insulating material molded on the end of a flexible electric cord having twisted insulated conductors. This type of connector will be used mainly on a separable power supply cord for a portable electric tool or appliance such as a drill, saw, sander, or lawn trimmer. A suitable plug or receptacle will be mounted in either the handle or the housing of the tool, and the connector of the present invention may be inserted into the receptacle to make both a mechanical and electrical connection to the tool. Most portable electric tools receive rough treatment during usage in home workshops, factories, and in the building construction trade. Accordingly, a long flex life for the resilient connector is difficult to attain with standard connector designs.

The principal object of this invention is to provide a resilient connector for an electric cord wherein the portions of the conductors of the cord within the connector are clustered close around the neutral axis of the connector so that the flex life of the connector will be substantially equal to that of the cord.

A further object of this invention is to provide a cord connector of the class described wherein the conductors of the cord are fastened to the contacts of the connector by means of a reverse crimp thereby taking most of the strain off the conductors and the contacts during the flexing of the connector.

A further object of this invention is to provide a holding means for the cord during the molding of the connector so that the high pressure of the molding compound will not displace the cord and possibly prestress the connection between the bare conductors and the contacts.

A still further object of this invention is to provide a connector of the class described of elongated tapered form adjacent its inner end so as to localize the bending of the cord and connector away from the terminal ends of the contacts, as well as to provide a hand grip portion and facilitate the removal of the connector from a mating plug or receptacle.

The present invention is embodied in a grounding connector for a three conductor electric cord. A female contact is fastened lengthwise to each one of the stranded conductors. The strands of each conductor are not brought in directly and fastened to the terminal portions of the contacts in the usual manner. Instead, the insulated conductor overlies the terminal portion and then the bare strands are doubled under ported and or coiled around the terminals. The cord with the contacts attached is then positioned in a mold with the doubled-back portions of the conductors clustered inwardly of the terminal portions of the contacts and closely adjacent the longitudinal axis of the connector. An important technique to follow is to push the cord into the mold to provide a small loop where the copper strands enter the crimp section of the contact. Also, the construction is improved by adding a twist near the ends of the conductors in the direction of the lay of the conductors within the jacket of the cord. This refinement binds the conductors together and prevents prestressing the bare strands. Hence, the conductors are only slightly more spread apart within the connector than within the cord. Accordingly, the flex life of the conductors molded in the connector should be substantially equal to that of the cord proper.

Also, the inner end of the connector body is elongated and tapered to serve as a resilient reinforcement for the cord adjacent its connection to the contacts of the connector to limit the radius of bend of the cord and thereby take the strain off of the conductors at the terminal ends of the contacts.

Since the connector body of the present invention is of rubber or vinyl material that is to be injection molded at high pressures, it is imperative to take measures to prevent the stream of molding compound in a fluid state from displacing the conductors or the cord and perhaps prestress the cramped connection of the conductors or moving the cord off center within the connector body. Excellent results have been obtained by using vanes in the mold that clamp the cord and hold it fixed while the insulating compound is being squirted into the mold to form the connector body. After the mold is opened and the connector withdrawn, small slots may be seen in the connector where the vanes were holding the cord. These slots are located in a transverse weakened plane in the connector body and they are helpful in localizing the bending of the connector at this weakened point, thereby relieving the strains on the conductors where the conductors are fastened to the contacts.

Our invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Figure 1 is a side view of an elongated flexible connector embodying our invention showing a small portion of electric cord on which the connector is molded.

Figure 2 is a right end view of the connector of Figure 1.

Figure 3 is a cross-sectional view taken on the vertical line 3--3 of Figure 2.

Figure 4 is a transverse cross-sectional view taken on the line 4--4 of Figure 1.

Figure 5 is a perspective view of the terminal end of one of the female contacts of the connector before the conductor is crimped therewith. This view also shows a short length of the conductor to explain how it would be placed in the terminal portion of the contact for the crimping operation.

Figure 6 is a perspective view similar to that of Figure 5 after the conductor is crimped to the terminal portion of the contact and showing the conductor doubled back so that the contact will extend lengthwise of the conductor.

Figure 7 is a diagrammatic showing of the terminal portions of the three contacts with the outline of the cord shown in dotted lines to illustrate the detail that the doubled back conductors extend inwardly of the terminal portions of the contacts and closely adjacent the longitudinal axis of the connector as well as the cord.

Figure 8 is a perspective view showing a small section of cord with its three conductors fastened by means of a reverse crimp to the terminal portions of the contacts, and a single insulating sleeve that is adapted to be telescoped over each contact including its terminal portion. Also to be noted are the small loops in the bare strands, and the tight twist near the ends of the conductors.

Referring in detail to the drawing and in particular to Figures 1 and 3, there is shown a flexible electric cord having molded on its end a grounding connector...
11. The cord comprises three stranded conductors 12 each individually insulated by the layer of material 13. These three insulated conductors are twisted together with a left-hand twist and the interstices between the conductors are filled with jute or paper fillers 14 to form a substantially round core over which is extruded an insulating jacket 15 as best seen in Figure 8. A female electric contact 16 is connected lengthwise to each of the conductors. The three contacts 16 are arranged parallel to each other and adjacent the free end of the connector body 11. Openings 17 in the end wall of the connector communicate with the contacts 16 and permit the insertion of pin contacts (not shown) for making both a mechanical and an electrical connection between the different types of contacts. The spacing between the contacts 16 is established by electrical and mechanical requirements of the mating receptacle based on the electrical rating and service requirements of the device.

Since the female contacts 16 are spaced apart from each other, it is necessary to remove a portion of the jacket material 15 from the insulated conductors 12 so the conductors may be spread apart and attached to the terminal portions 18 of the contacts 16. This is shown in both Figures 3 and 8. In most cases the weakest link in a resilient electric connector which shortens the flex life of the connector is the mechanical joint between the conductors and the contacts. A typical test to determine the expected life of such a connector under extreme conditions is made with the free end of the connector 11 attached to a mating plug in a fixture and held rigid therein. A weight is attached to the cord 10 at a point about 18 inches from the connector and the connector is moved in a vertical plane from a horizontal position on the left through the vertical position and over to a horizontal position on the right. It will be understood that the weight on the cord holds the cord down below the connector, thereby bending the inner end of the connector 11 that is remote from its fixed end in the testing fixture. Standard connector constructions, where the conductors 12 are cramped in the usual manner to the terminal portions 18 of the contacts, have given a flex life of about 3000 cycles, which is considerably below an acceptable standard of performance. The present invention has shown a remarkable increase in flex life which has consistently exceeded the 40,000 cycle mark.

Looking at Figures 5, 6 and 7, the female contact 16 is shown with a tubular portion 20 and a terminal portion 18. The contact 16 is made from flat metal sheet material that is folded together to produce a D-shaped tube 20 with a closed longitudinal seam 21 formed by the abutting edges of the sheet. The terminal portion 18 of the contact is of channel shape with a bottom wall 22 and upwardly extending side walls or tabs 23. The inner end of the tube 20 is closed by a lancing 24 that is struck from the bottom wall of the tube and folded inwardly as best seen in Figure 5. The usual manner of fastening the conductor 12 to the terminal end 18 of the contact would be to hold the conductor 12 at the left of the contact 16 in Figure 5 and crimp the sides 23 over the bare conductor. This procedure has been discarded in the present invention as will be explained in the "before" and "after" views of Figures 5 and 6. First, the bare strands of the conductor 12 are placed in the open channel shape of the terminal end of the contact, as suggested in Figure 5 with the insulated portion of the conductor overlying the tubular portion 20 of the contact. Then the bendable tabs or side walls 23 of the terminal portion are folded inwardly of each other and down onto the bare conductor to hold the conductor firmly against the bottom wall 22 of the contact. Finally the conductor is folded over in a doubled back on itself to take the position shown in Figure 6 to form in effect a reverse crimp of each conductor to its contact.

All three of the contacts 16 are connected by a reverse crimp to the conductors 12 and, in addition, the three contacts are positioned as shown in Figures 5 and 6 with the doubled-back portions of the conductors clustered together inwardly of the contact terminals 18 and closely adjacent the longitudinal axis of the connector. This feature is shown in actuality in Figure 8, while it may perhaps be better understood by referring to the diagrammatic view of Figure 7. The figure shown in dash lines, represents the outline of the electric cord 10 while the terminal portions 18 of the contacts are shown in cross-section as they would be seen in a transverse plane through the contact terminals. Thus, it will be understood that the doubled-back portions of the conductors 12 are radially disposed inwardly of the terminal portions 18 of the contacts and clustered together as near as possible to the longitudinal axis of the connector which coincides with the neutral axis of the cord. Hence, the flex life of the connector at the point where the conductors are attached to the contacts should be substantially equal to that of the cord where the cord is bent under load through the smallest radius. A modification would be to bend the terminal portions 18 of the contacts inwardly a small amount toward the longitudinal axis of the connector.

It is common practice to insert a cylindrical insulating sleeve, such as sleeve 30 in Figure 8, over the tubular portions of female contacts to serve as a reinforcement for the contacts and prevent the longitudinal seam 21 of the tube from being pried open by a pin contact of a plug if it is being twisted in the connector body. Such insulating sleeves 30 are formed either of plastic or fiber material, and they insure a good mechanical and electrical connection between the pin contacts and the female contacts. In the present invention, the sleeves 30 have been increased in length to overlie the terminal portions 18 of the contacts and prevent short-circuits between any stray strands of the conductors which may have become displaced during the crimping of the contacts. Thus, each conductor is carefully insulated from the others because of the close proximity, as well as being further supported at the critical point where the insulation 13 is stripped from the conductor 12.

Turning back to a consideration of Figures 1, 3 and 4, it will be seen that the connector body 11 has been elongated to overlie a good portion of the jacket material 15 of the cord 10. The inner end 35 of the connector body 11 is tapered down to a minimum diameter to increase the flexibility of the connector where it merges with the cord 10. Thus, the inner end 35 of the connector body serves as a strain relief in a manner similar to that used on electric cords that are permanently attached to the housing or handle of a portable electric tool or appliance, as is well known in this art. The very end of the tapered portion 35 of the connector body 11 is enlarged as at 36, thereby forming a finger grip for pulling the connector from a mating plug or receptacle. An additional advantage of such an enlarged portion 36 is to limit the amount the inner end of the connector may be opened as the cord is bent, if it so happens that a good bond is not made between the insulating material of the connector 11 and the jacket material 15. Another precaution that is taken in the careful manufacture of the subject invention is the manner of clamping the cord 10 during the time the connector body 11 is being molded in an injection molding process over the conductors 12 and the contacts 16. The die for the tubular molding compound that is to form the insulating material of the connector body 11 is first transformed into a plastic or fluid state at a high temperature and forced into a mold at a high pressure where it is left to solidify before the mold is opened and the connector removed. This high pressure stream of compound tends to displace the conductors 12 and blow the cord 10 out of the mold, thereby moving the cord off center and possibly pressur-
ing one or more of the crimped conductors. This difficulty has been overcome partially by providing vanes (not shown) within the mold which are made to clamp the jacket material 15 of the cord in the area or plane designated as 37 in Figure 3. There are four vanes being used and they are each generally in the shape of a right triangle where the apex of the triangle is made to be
copied embedded slightly in the jacket material 15. An understanding of the vanes may be had by studying Fig-
ure 4 and noticing the triangular-shaped slots 38 which are formed in the connector body 11 in the plane of Figure 3. These vanes are made to grip the jacket ma-
terial and hold the cord fixed so as not to move the crimped conductors during the molding operation. The
vanes also center the cord within the connector body 11 and result in a better quality product. An additional fea-
ture of the slots 38 which are formed in the conductor body 11 is that they establish a transverse weakened plane in the connector to localize the bending stresses adjacent this plane, thereby relieving the load on the cramped
conductors.

Another refinement consists of pushing the cord 10 into the mold to establish a rounded loop in the bare
strands before the strands enter the cramped terminal portion. At the same time a tight twist is made in the insulated conductors between the vane 38 and the bare strands. The conductors are twisted in the same direction as they are assembled in the jacket, so as to increase their flexibility and prevent the compound from spreading them apart.

Having described above our invention of a novel grounding connector for an electric cord having a remark-
able increase in flex life over previous connectors, it will be well understood by those skilled in this art that we have achieved this result by reducing or eliminating the bending stresses that might be carried into the cramped connections between the conductors and the contacts. Also, it should be understood that other fastening means may possibly be used between the conductors and con-
tacts such as by soldering or equivalent methods. Al-
though only one set of four slots 38 have been shown in the drawing, it should be understood that a plurality of weakened planes may be established in the tapered inner end of the connector 11 by using several series of vanes in the mold.

Modifications of this invention will occur to those skilled in this art and it is to be understood, therefore, that this invention is not limited to the particular embarrassments disclosed but that it is intended to cover all modifications which are within the true spirit and scope of this invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In an electrical connector attached to one end of a cord having a plurality of separately-insulated stranded conductors twisted together in a spiral and covered by an outer jacket, a connector body of resilient insulating material attached to one end of the cord, a contact member fastened lengthwise to the end of each conductor, each contact member having a pin-receiving portion and a terminal portion, a portion of each contact having bendable legs, the jack of the cord terminating within the connector body and spaced from the ends of the conductors, each stranded conductor having a bare end section in the configuration of a small loop, said loop being formed by doubling the end of the bare conductor back upon a second portion thereof, said end being attached directly to an inner side of said terminal portion in an electrical engagement therewith, said second portion being flexibly disposed inwardly of, spaced from, and opposite to said end of the second portion of the conductors, the second portions of the conductors being clustered together inwardly of the terminal portions of the contact members, as well as toward and closely adjacent to the longitudinal axis of the connector, thereby to increase the flex life of the connector.

2. In an electrical connector attached to one end of a cord having at least three separately-insulated stranded conductors spirally wound together and covered by an outer jacket, an elongated connector body of resilient insulating material attached to one end of the cord, a contact member fastened lengthwise to the end of each conductor, each contact member having a pin-receiving portion and a terminal portion, the terminal portion of each contact having bendable legs, the jack of the cord terminating within the connector body and spaced from the ends of the conductors, each stranded conductor having a bare end section in the configuration of a small loop, said loop being formed by doubling the end of the bare conductor back upon a second portion thereof, said end being attached directly to said terminal portion, said second portion being flexibly disposed opposite said end, the second portions of the conductors being clustered together inwardly of the terminal portions of the contact members and toward and closely adjacent to the longitudinal axis of the connector to increase the flex life of the connector, and an insulating sleeve telescoped over each contact and disposed within said body thereby to completely enclose said contact and the loop of conductor attached thereto.

3. In an electrical connector attached to one end of a cord having a plurality of separately-insulated stranded conductors twisted together in a spiral and covered by an outer jacket, a connector body of resilient insulating material attached to one end of the cord, a contact member fastened lengthwise to the end of each conductor, each contact member having a pin-receiving portion and a terminal portion, the jack of the cord terminating within the connector body and spaced from the ends of the conductors, each stranded conductor having a bare end section in the configuration of a small loop, said loop being formed by doubling the end of the bare conductor back upon a second portion thereof, said end being attached directly to said terminal portion, said second portion being flexibly disposed opposite said end, the second portions of the conductors being clustered together inwardly of the terminal portions of the contact members and toward and closely adjacent to the longitudinal axis of the connector thereby to increase the flex life of the connector where each of the contact members has been fastened to its respective conductor, and a plurality of radial slots formed around the outer periphery of the connector body over the jacketed cord, said slots each extending inwardly to the outer surface of the jacket of the cord and being disposed in and forming at least one transverse weakened plane there-
by to increase the flexibility of the connector in that plane and concentrate the bending stresses away from the terminal portions of the contacts.

4. In an electrical connector attached to one end of a cord having at least three separately insulated stranded conductors twisted together in a spiral and covered by an outer jacket, an elongated connector body of resilient insulating material attached to one end of the cord, a contact member fastened lengthwise to the end of each conductor, each contact member having a tubular pin-re-
ceiving portion and a terminal portion, the terminal por-
tion of each contact having bendable legs, the jack of the cord terminating within the connector body and spaced from the ends of the conductors, each stranded conductor having a bare end section in the configuration of a small loop, said loop being formed by doubling the end of the bare conductor back upon a second portion thereof, said end being attached directly to said terminal portion, said second portion being flexibly disposed opposite said end, the second portions of the conductors being clustered together inwardly of the terminal portions of the contact members and toward and closely adjacent to the longitudinal axis of the connector thereby to increase the flex life of the connector.
closely adjacent to said axis thereby to increase the flex life of the connector where each of the contact members has been fastened to its respective conductor, an insulating sleeve telescoped over each contact and disposed within said body thereby to completely enclose said contact and the loop of conductor attached thereto, the elongated connector body being at least twice as long as the contact members, the inner end of the connector body being gradually tapered to a reduced size toward the end thereof overlying the jacketed cord to limit the radius of bending of the cord where it merges with the connector, and a plurality of radial slots formed around the outer periphery of the connector body over the jacketed cord, said slots each extending inwardly to the outer surface of the jacket of the cord and being disposed in and forming at least one transverse weakened plane thereby to increase the flexibility of the connector in that plane and concentrate the bending stresses away from the terminal portions of the contacts.