

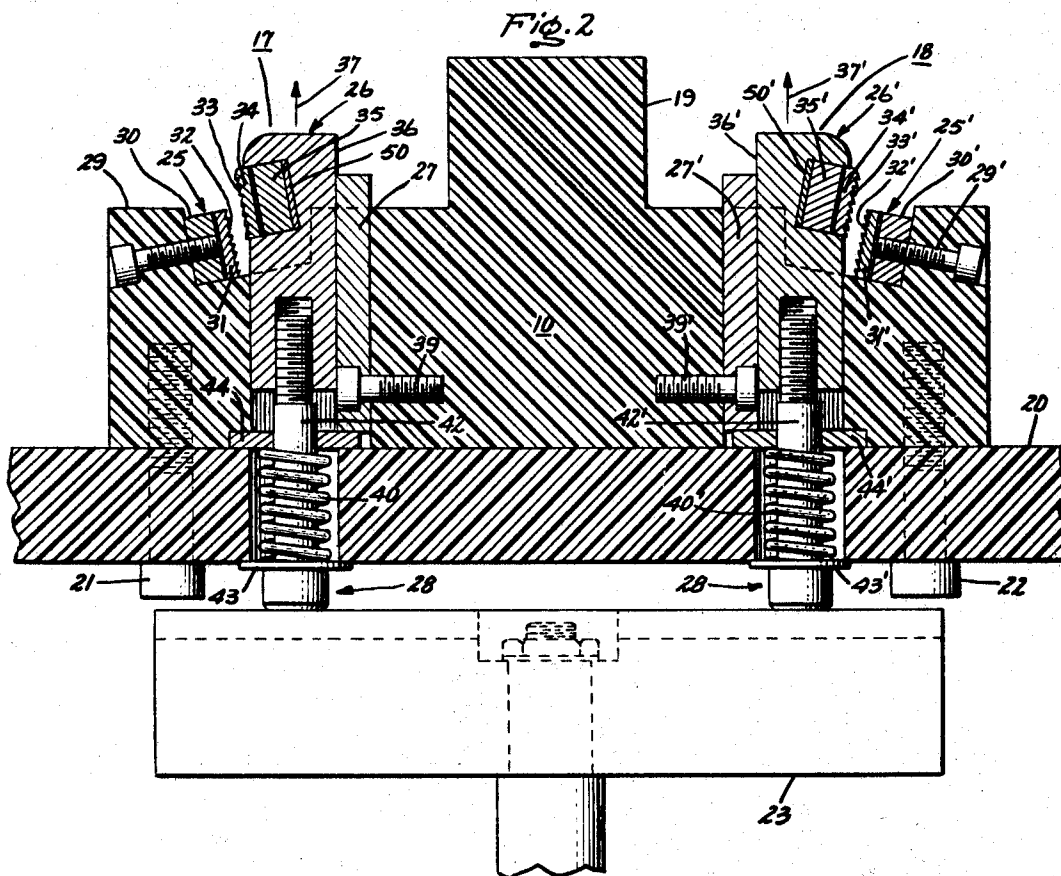
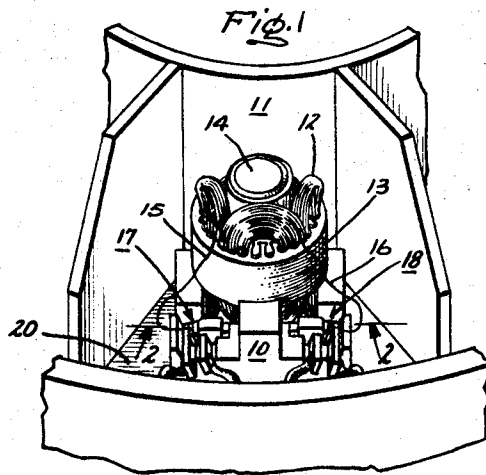
July 2, 1968

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ELECTRICAL CONNECTOR FOR ESTABLISHING A MULTIPOINT CONTACT
WITH AN INSULATED CONDUCTOR

3,391,379

Filed July 20, 1966

2 Sheets-Sheet 1



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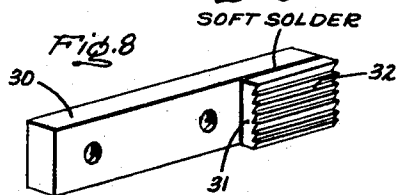
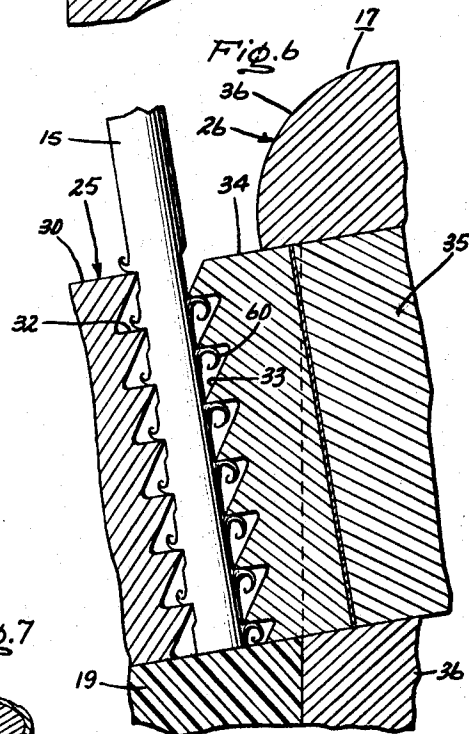
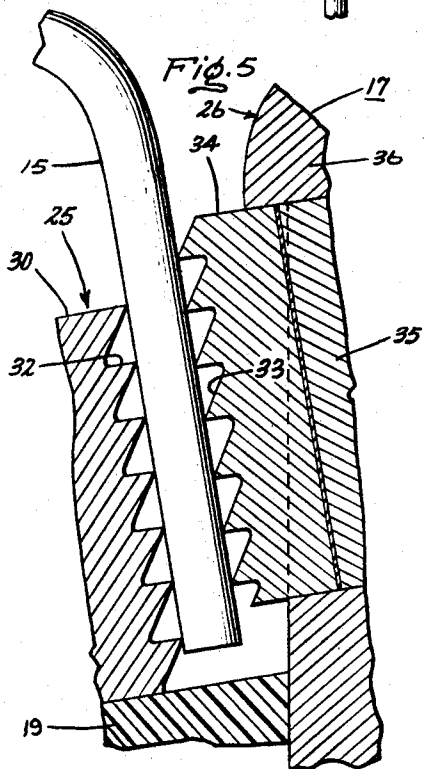
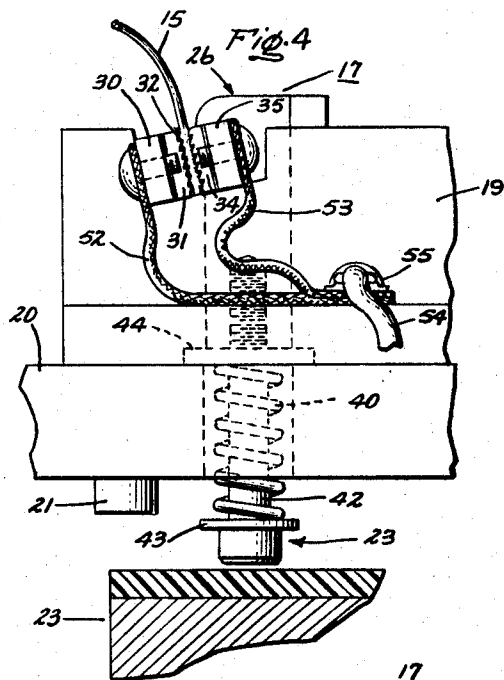
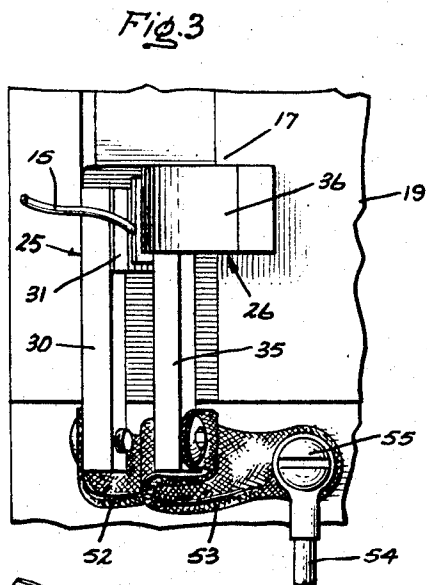
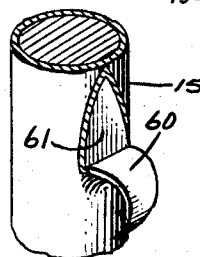


Fig. 7



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3,391,379

ELECTRICAL CONNECTOR FOR ESTABLISHING A MULTIPOINT CONTACT WITH AN INSULATED CONDUCTOR

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Filed July 20, 1966, Ser. No. 566,516
9 Claims. (Cl. 339-99)

ABSTRACT OF THE DISCLOSURE

An electrical connector consisting of a movable and a fixed jaw. Each of the jaws have a contact portion formed of teeth. The teeth of the movable jaw have cutting faces disposed for cutting in one direction while the cutting faces of the teeth of the contact portion of the stationary jaw are disposed for cutting in an opposite direction. After the insulated conductor is inserted between the jaws, the movable jaw is urged to a conductor-biting position wherein the contact portion of the movable jaw bites the insulated conductor and forces it against the contact portion of the other clamping jaw to effect a relative movement between it and the other side of the insulated conductor. As a result of this relative movement between the jaws and the insulated conductor, the teeth of the clamping jaws strip portions of the insulation coating on the conductor and establish a multipoint electrical contact at both sides of the conductor capable of handling a high energy rate current discharge.

This invention relates to electrical connectors, and more particularly to connectors suitable for use in conjunction with high energy rate supply circuits where frequent connections are required to be made between the circuit and the end portions of one or more insulated conductor wires.

In establishing good electrical connections with a high energy rate supply circuit, such as a capacitor discharge circuit, it is important that good metal-to-metal connections be established between the connector and the insulated conductors which are to be connected to the circuit. A poor electrical contact between the connector and the insulated conductor will result in severe arcing and consequently in a rapid deterioration of the metal parts of the connector. In a manufacturing operation where a surge from a high energy rate supply circuit is utilized to carry out various coil placing and compacting operations on a motor winding, it is necessary that an operator place the leads of the motor winding in a connector to establish an electrical connection between the conductor and the high energy rate circuit. In such applications of high energy rate supply circuits, it will be appreciated that between 400 and 500 amperes are discharged from a capacitor bank in a time interval ranging from 4 to 6 milliseconds and this current passes through the connector and the motor winding. In one such apparatus about 270 such connections are made by an operator per hour.

Heretofore a number of different connectors have been proposed for connecting the ends of insulated electrical conductors to the terminals of an electrical apparatus. For example, such connectors may comprise one or more sets of jaws which receive the ends of the insulated conductors. An inherent disadvantage in such prior art connectors is that the conductor insulating material accumulates between the jaws after relatively short periods of time causing the contact surfaces to become clogged with insulating material. Consequently, a poor electrical contact is established between the jaws and the metallic surface of the electric conductor. Where the electrical apparatus is a high energy rate supply circuit, the arcing

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resulting from the poor electrical contact destroys the jaws in a relatively short period of time.

In other prior art devices for connecting electrical conductors to terminals of an electrical apparatus, it is necessary to remove the insulating coating around the insulated conductor for a predetermined portion of the length of the conductor adjacent to the end. The exposed metallic surface of the conductor is brought into contact with the terminal of the electrical apparatus. Although efficient electrical contacts can be made with such prior art devices, a disadvantage in such devices is that they require that the insulating coating be initially removed before the connection is made and therefore such devices are not satisfactory in a high production manufacturing operation.

There is a need, therefore, for an improved connector that will permit efficient electrical connections to be made to the terminals of an apparatus, such as a high energy rate supply circuit, easily and quickly without having to strip the end portions of the insulated conductors. Further, there is need for a connector wherein the insulating material is removed from the end portion of the insulated conductor and simultaneously a good multipoint electrical contact is made with the metallic surface of the conductor. It is, of course, always desirable that the contact surfaces of the connector be kept free of insulating material.

Accordingly, it is a general object of the invention to provide a new and improved electrical connector.

It is a further object of the invention to provide a new and improved electrical connector that exposes the metallic surface of the insulated conductor and simultaneously establishes a good electrical contact with the exposed metallic surface without clogging the electrical contact surfaces of the connector.

It is an additional object of the present invention to provide a device for quickly and easily connecting insulated electrical conductors to the terminals of an electrical apparatus such as a high energy rate supply circuit.

In accordance with one form of my invention, I have provided an improved electrical connector that includes a first jaw supported in stationary relationship and a second jaw movably supported relative to the first jaw. Each of the jaws have a contact portion formed with parallel teeth, each of the teeth have a cutting face. The teeth on the contact face of the first or stationary jaw have their cutting faces disposed in one direction while the teeth on the contact portion of the second or movable jaw have their cutting faces disposed in an opposite direction. A biasing means is associated with the second jaw to urge the contact portion on the second jaw in one direction relative to the portion of the insulated conductor inserted between the jaws thereby to bite the insulated conductor at one side. Further, the other side of the insulating conductor is yieldingly forced against the teeth of the contact portion of the first jaw thereby effecting a relative movement between the insulated conductor and the teeth on the contact portion of the first jaw to bite the insulated conductor at the other side. Thus, a multipoint electrical contact is established on both sides of the insulated conductor. Also a means is provided for moving the second jaw from a conductor-biting position to an open position to permit the insertion and removal of an insulated conductor.

According to another aspect of the invention I have provided a guide means to direct the movement of the movable jaw in a longitudinal direction. The second or movable jaw has a contact portion formed with parallel teeth having their cutting edges disposed in a plane inclined at a predetermined angle with respect to the longitudinal direction of movement of the movable jaw. These cutting edges are arranged to effect an incision or bite into the insulated conductor at a bite angle essentially

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equal to the predetermined angle when the movable jaw is biased along the guide means to a conductor-biting position. The stationary jaw also has a contact portion formed with a plurality of teeth having their cutting edges disposed essentially in a plane parallel to the plane of the cutting edges of the contact portion of the movable jaw. Preferably, the predetermined angle is not less than 5 degrees and not more than 15 degrees.

In accordance with another aspect of my invention, the contact portions are formed of a steel file segment cut out of a file so that the teeth of the file extend serially across the contact portion. The file segment is soft-soldered to the jaw member. Preferably, the steel file segment should have a Rockwell C hardness of not less than 65 and not more than 75.

An important advantage of the improved connection is that repeated connections can be made of leads to a high energy rate supply circuit without need for stripping the insulation off the terminal portion of the leads in order to make a good electrical connection. Further, repeated connections can be readily and quickly made without need for cleaning or frequent replacement of the contact portions of the jaws. In addition the improved connector provides an electrical contact capable of handling a discharge current as high as 500 amperes discharged in an interval 6 milliseconds through the contact.

As used herein, the bite angle is equal to the angle between the axis of the portion of the insulated conductor positioned between the clamping jaws essentially at right angles to the cutting edges of the jaw teeth and the line of movement of a cutting edge i.e., the locus of a contact point on the cutting edge, of a tooth on the movable jaw. In the illustrative embodiment of my invention the bite angle is equal to the angle of inclination of the contact portion of the movable jaw.

The subject matter which I regard as my invention is set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof may be better understood by referring to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a perspective view of a portion of an apparatus in which one form of my improved connector is utilized to connect the leads of a stator winding in circuit with a high energy rate supply circuit;

FIGURE 2 is an enlarged vertical sectional view as seen essentially along a plane passing through line 2—2 of FIGURE 1 with the jaws being shown in the open position rather than the closed position of FIGURE 1;

FIGURE 3 is a plan view of the connector shown at the left hand side of the connector assembly illustrated in FIGURES 1 and 2;

FIGURE 4 is an end view of the connector shown in FIGURE 3 with parts of the turntable and actuating member being illustrated;

FIGURE 5 is an enlarged view of the contact portions of the clamping jaws of one form of my improved connector showing the conditions of the jaws just before the teeth of the contact portions bite into the insulated conductor;

FIGURE 6 is an enlarged view of the contact portions corresponding to the view of FIGURE 5 wherein the clamping jaws are shown in the conductor-biting position;

FIGURE 7 is a fragmentary view of a portion of the insulating conductor illustrating an incision effected by a tooth of the contact portion of the movable jaw; and

FIGURE 8 is a view in perspective of a conductor bar and contact portion of a clamping jaw.

Referring now to the drawings in more detail, and particularly to the view shown in FIGURE 1, I have illustrated therein the improved connector assembly 10 adapted for use in conjunction with an apparatus 11 for altering the configuration of the stator winding 12 of a magnetic stator core 13 of a fractional horsepower motor. As seen in FIGURE 1, the magnetic stator core 13 is positioned

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on a cylindrical member 14 and the left and right leads 15, 16 of the stator winding 12 are connected to the high energy rate supply circuit (not shown) by means of the connectors 17, 18. An operator generally stands in front of the apparatus 11 where he can handle the left and right leads 15, 16 with his left and right hands, and can open the jaws of the left and right connectors 17, 18 by depressing a foot pedal or by actuating some other conveniently located control device.

It will be appreciated that in carrying out coil placing operations with the type of apparatus shown in FIGURE 1, each stator winding must be connected to the high energy rate supply circuit, and after one or more high energy rate pulses are discharged through the stator winding 12 and connectors 17, 18, the stator winding 12 is then disconnected from the high energy rate supply circuit with the apparatus 11 shown in FIGURE 1. An operator will normally handle about 270 stator windings per hour or, in other words, the connectors 17, 18 are actuated about 540 times per hour.

For a more complete description of the apparatus, reference may be made to application Ser. No. 513,028, entitled, "Apparatus for Altering The Configuration of Electrical Coils of Inductive Devices and Improved Method for Achieving Such Alterations," filed Dec. 10, 1965, in the name of William E. Baldwin and assigned to the same assignee as the present application.

Referring now to FIGURES 2 to 8, I will now more fully describe one form of my improved connector for establishing a multipoint electrical contact with an insulated conductor. The left and right hand connectors 17, 18 are mounted in a common support block 19 made of insulating material. The support block 19 is attached to a table 20 by means of screws 21 and 22. A single push block 23 driven by a pneumatic cylinder (not shown) actuates both connectors 17, 18. It will be appreciated that any number of connectors may be used depending on the number of leads that are to be connected to the high energy rate supply circuit. Connectors 17, 18 of the assembly 10 are functionally and structurally similar, and as seen in FIGURE 2 are mirror images of each other. In the interest of simplification, I have identified the parts of connector 18 corresponding to the parts of connector 17 by primed reference numerals. It will be understood that the detailed description of the structural features and mode of operation of connector 17 that follows, applies also to connector 18.

Turning now to the left hand connection 17, it will be seen that this connector is comprised of the support block 19 of insulating material, a stationary jaw 25, a movable jaw 26, a guide plate 27, and a bias or spring assembly 28. The stationary jaw 25 is attached to the support block 19 by means of a screw 29 which securely holds the conductor base 30 of stationary jaws 25 in a channel formed in support block 19 to position contact portion 31 so that the plane passing through the tips or edges of the teeth 32 of contact portion 31 is essentially parallel to the plane passing through the edges of the teeth 33 of contact portion 34. The conductor base 35 of movable jaw 26 is secured in a channel formed in support member 36 to position the conductor base 35 at a predetermined angle with respect to the longitudinal direction of movement of the movable jaw 26 as indicated by arrow 37. Preferably, this angle should be not less than 5 degrees and not greater than 15 degrees. In the illustrated embodiment of my invention an angle of 10 degrees was used.

Movable jaw 26 is slidably disposed in a guide means comprised of a guide opening defined by three walls in the support block 19 and a wall provided by the metallic guide plate 27 secured to the support block 19 by a screw 39. The jaws 25, 26, as shown in FIGURE 2, are in the open position, in which position the jaws 25, 26 are ready to receive the end portion of an insulated conductor of the stator winding to be energized by a high energy rate pulse or to allow an inserted conductor to

be removed. Normally in this position, the push block or actuating member 23 has been forced against the adjusting screws 42, 42' to place the springs 40, 40' under compression. When the push block 23 is released, springs 40, 40' will bias the movable jaws 26, 26' into engagement with the insulated conductors inserted into the jaws.

The spring assembly 28 of connector 17 includes the coil spring 40, adjusting screw 42, and a pair of washers 43, 44. It will be seen that washer 44 is securely held in position by an edge of guide plate 27 and a slot formed in the support block 19. Thus, as the push block 23 is moved upwardly against the head of adjusting screw 42, the movable jaw 26 moves upwardly and coil spring 40 is urged against stop washer 44 and compressed. It will be seen that when push block 23 is released from engagement with the head of adjusting screw 42, as is shown in FIGURE 4, spring 40 will bias the movable jaw 26 into engagement with the insulated conductor 15. Thus, the contact portion 34 is urged against one side of the insulated conductor 15 thereby making incisions or bites at this side while yieldingly forcing the other side of the insulated conductor 15 against the teeth 32 of contact portion 30. In this manner a relative movement is effected between the teeth 32 and the insulated conductor 15 thereby causing incisions to be effected on the opposite side of the insulated conductor 15, as is shown in FIGURE 6.

The circuit connections from the conductor 15 to the high energy rate supply circuit are made through the conductor bases 30, 35 and the flexible leads 52, 53 which are joined with each other and with the supply circuit lead 54 at a terminal 55 mounted on a shelf 38 extending from support block 19, as is best seen in FIGURE 4.

In the illustrated embodiment of the invention, it was desirable that the connectors 17 and 18 handle insulated conductor wire having a diameter ranging from .018 to .054 of an inch and to establish an efficient electrical contact through insulation ranging in thickness from 1.8 to 3.6 mils. The required spring force on springs 40 and 40' was determined experimentally by trial and error by adjusting the screws 42, 42' until a satisfactory electrical contact for both a .018 and a .054 of an inch wire was obtained.

By way of a more specific exemplification of one aspect of the invention, the contact portions 30, 34 were fabricated from a portion of a file having 28 teeth per inch cut to a depth of .020 of an inch. The essentially rectangular file segments with parallel tooth edges were used since it was found that parallel edges provided a better indication of the correct meshing of the file teeth. The contact portions were checked for hardness before soldering to the conductor bar and were also checked after soldering. It was found that if the contact faces were braised to the copper bars that some softening occurred and the desired hardness could not be maintained. Preferably, the contact portion should be attached to the conductor base (see assembly of conductor base and file segment in FIGURE 8) by soft soldering or by gluing with an epoxy resin adhesive.

For the file segments used in the illustrated embodiment of my invention, it was found that faces of contact portions 30, 34 should have a snug fit when a .002 of an inch feeler gage is inserted between the closed jaws. To obtain this fit, a shim 50, as is shown in FIGURE 2, may be inserted between the conductive base 35 and support member 36.

To operate the improved connector 17 of my invention, an operator first actuates the control that will cause the push block 23 to open the clamping jaws 25, 26. With the jaws 25, 26 in the open position, the end portion of the insulated conductor 15 is inserted into the jaws 25, 26 essentially in a direction at right angles to the teeth 32, 33 of the contact portions 30, 34. When the end portions of the conductor 15 are properly in position in the jaws 25,

26, the movable jaw 26 is released from engagement with the heads of screws 42, 42'.

As will be seen in the enlarged fragmentary view of FIGURE 5, the cutting faces of the teeth 32 on contact portion 30 of the stationary jaw 25 are disposed for cutting when a direction is such that the insulated conductor 15 is moved downwardly from the position shown in FIGURE 5. Further, it will be seen that the cutting faces on the teeth 33 of contact portion 34 of the movable jaw 26 is disposed for cutting in the opposite direction or when the insulated conductor 15 is moved in an upwardly direction against the teeth 33 or when the teeth 33 are moved essentially in a downwardly direction relative to the insulated conductor 15.

When push block 23 is released, movable jaw 26 is spring biased to the contact-biting position shown in FIGURE 6. In the contact-biting position the teeth 33 of contact portion 34 bite the insulated conductor 15 at one side thereof and force the insulated conductor 15 against the teeth 32 of contact portion 30. A relative movement is brought about between contact portion 30 and the insulated conductor 15 and consequently, the teeth 32 bite into the conductor 15 to establish a multi-point contact with the conductive metal of insulated conductor 15.

As will be seen in FIGURE 7, individual strips 60 cut by the teeth 33 include both metal and insulating material and the metallic surface of the conductor 15 is exposed. The cutting edges of the teeth 33 expose the metallic surfaces 61 at the widest part. Further, it is important to note that the strip 60 is not severed from the insulated conductor 15 but curls up in the space between adjacent teeth (see FIGURE 6) so that the strips 60 do not clog the teeth 32 and 33 and allows the insulated conductor 15 to be readily removed when jaws 25, 26 are opened without breaking the strips 60.

From the foregoing description of the embodiment of my invention and its operation, it will be seen that I have provided an electrical connector that permits repeated connections of one or more insulated conductor wires to be made to an electrical apparatus with improved contact life. The connector is particularly adaptable for use in connecting insulated leads to a high energy rate supply circuit and is capable of handling a wide range of conductor wire sizes. Another advantage of the invention is that insulated lead wires can be readily and quickly connected and disconnected without need for stripping the terminal portions of an insulated conductor.

While only certain preferred features of my invention have been shown herein by way of illustration, it will be appreciated that many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes that fall within the true spirit and scope of the invention.

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

1. An electrical connector for use in conjunction with a high energy rate supply circuit for making a multipoint electrical contact with an insulated conductor, said insulated conductor having a coating of insulating material, said electrical connector comprising a first jaw supported in stationary relationship, a second jaw movably supported relative to said first jaw, each of said jaws having a contact portion formed with a plurality of teeth, said teeth of said contact portions having cutting edges disposed in parallel planes, each of said teeth on said contact portions having a cutting face at one side thereof for biting the insulated conductor, said teeth on the contact portion of said first jaw having their cutting faces disposed in one direction and said teeth on the contact portion of said second jaw having their cutting faces disposed in an opposite direction, means associated with said second jaw for moving the contact portion of said second jaw toward and away from the contact portion of said first jaw while maintaining the parallel relationship of said

planes of the cutting edges and effecting a movement along the longitudinal axis of said contact portion of said first jaw thereby to bite the insulated conductor at one side thereof and force the other side of said insulated conductor against the teeth on the contact portion of said first jaw to effect a relative movement between said insulated conductor and the last mentioned teeth and to bite the insulated conductor at said other side thereof whereby said teeth of said first jaw strip portions of said coating of insulating material in said one direction and said teeth of said second jaw strip portions of said coating of insulating material in said opposite direction to establish a multipoint electrical contact between said teeth of said first and second jaws and the insulated conductor.

2. The electrical connector set forth in claim 1 wherein said contact portions are comprised of a steel file segment having a Rockwell C hardness of not less than 65 and not more than 75.

3. The electrical connector set forth in claim 1 wherein said teeth of the contact portion of said second jaw bite the insulated conductor at a bite angle of not less than 5 and not more than 15 degrees.

4. An electrical connector for making a multipoint electrical contact with an insulated conductor having a coating of insulating material, said electrical connector comprising a pair of opposed clamping jaws, at least one of said clamping jaws being movable relative to the other, each of said clamping jaws having a contact portion formed with a plurality of parallel teeth extending serially across said contact portion, each of said teeth having a cutting face at one side thereof, said cutting faces having edges disposed in parallel planes, said cutting faces of the teeth on the contact portion of one of said clamping jaws being disposed for cutting in one direction and said cutting faces of the teeth on the contact portion of the other of said clamping jaws being disposed for cutting in an opposite direction, means for moving the contact portion of said movable jaw toward and away from the contact portion of the other jaw while maintaining the parallel relationship of said planes of the cutting edges and effecting a movement along the longitudinal axis of the contact portion of said movable jaw wherein the contact portion of said movable clamping jaw bites the insulated conductor inserted between said clamping jaws at one side thereof and forces the insulated conductor against the contact portion of the other clamping jaw to effect a relative movement between said last-mentioned contact portion and the insulated conductor thereby to bite said insulated conductor at the other side thereof whereby said teeth of one of said clamping jaws strip portions of said coating of insulating material in said one direction and said teeth of the other of said clamping jaws strip portions of said coating of insulating material in said opposite direction to establish a multipoint electrical contact at both sides of the insulated conductor, and means for retracting said movable clamping jaw from said conductor-biting position to an open position for receiving an insulated conductor.

5. The electrical connector set forth in claim 4 wherein said contact portions are comprised of a steel file segment having a Rockwell C hardness of not less than 65 and not more than 75.

6. The electrical connector set forth in claim 4 wherein said teeth of said movable jaw bite the insulated conductor at a bite angle of not less than 5 and not more than 15 degrees.

7. An electrical connector for making a multipoint electrical contact with an insulated conductor, said electrical connector comprising a stationary jaw of conductive material, a movable jaw of conductive material, said movable jaw having a contact portion with a longitudinal axis disposed at an angle with respect to the longitudinal axis of the movable jaw and formed with a plurality of insulation piercing teeth in a plane inclined at an angle with respect to the longitudinal axis of said movable jaw, said cutting edges of said teeth on said contact portion of the movable jaw being arranged to effect an incision into the insulated conductor at a bite angle essentially equal to said predetermined angle when the movable jaw is moved to a conductor-biting position, said stationary jaw having a contact portion formed with a plurality of teeth having cutting edges disposed essentially in a plane parallel to said plane of the cutting edges of said contact portion of said movable jaw, said cutting edges on the stationary jaw being arranged in opposed relationship to the cutting edges on the contact portion of said movable jaw, means for moving said jaw along the longitudinal axis thereof to said conductor-biting position wherein the teeth on the contact portion of said movable jaw effect incisions at one side of the insulated conductor essentially in one direction and the teeth on the contact portion of the fixed jaw effect incisions at the other side of the insulated conductor in an opposed direction, and retracting means for moving said movable jaw out of said conductor-biting position to an open position for receiving an insulated conductor.

8. The electrical connector set forth in claim 7 wherein said predetermined angle is not less than 5 and not more than 15 degrees.

9. The electrical connector set forth in claim 7 wherein said contact portions are comprised of a steel file segment having a Rockwell C hardness of not less than 65 and not more than 75.

References Cited

UNITED STATES PATENTS

1,625,485	4/1927	Maurer	339—95
2,923,910	2/1960	Golder	339—99
3,309,645	3/1967	Noschese	339—98
3,333,327	8/1967	Larsen.	
3,333,328	8/1967	Rushing.	
3,333,329	8/1967	Linkous.	
3,333,330	8/1967	Linkous.	
3,333,335	8/1967	Sims.	

FOREIGN PATENTS

1,107,571	8/1955	France.
1,136,393	9/1962	Germany.
1,212,609	3/1966	Germany.

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