

# PATENT SPECIFICATION

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## (54) AN ELECTRICAL CONTACT FOR FLAT CONDUCTOR CABLE

(71) We, AMP INCORPORATED, a corporation organised and existing under the laws of the State of New Jersey, United States of America, of Eisenhower Boulevard, Harrisburg, Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electrical contacts and the electrical connections between electrical contacts and flat conductors of flat conductor cables. According to one aspect of the present invention, an electrical contact for crimp connection to a flat conductor of a flat conductor cable includes a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, the edges of the sidewalls being adapted to pierce the insulation of a flat conductor cable from one surface of the cable and to be curled inwardly to make contact with a conductor of the flat cable from the opposite surface of the cable, each sidewall being in the form of a pair of spaced teeth, each tooth tapering towards a free tip, the teeth defining between them a tapered space, the space extending to the intersection between the web and the respective sidewall.

According to a further aspect the present invention includes an electrical connection between an electrical contact and a flat conductor of a flat conductor cable in which the flat conductor is encased within a sheath of insulating material and the contact includes a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, each sidewall being in the form of a pair of spaced teeth each tapering towards a free tip and which define between them a tapered space, the space extending to the

intersection between the web and the sidewall, the distance between the sidewalls being less than the width of the conductor, the web lying along one surface of the cable with the teeth piercing the cable adjacent each side of the conductor so that portions of the side edges of the conductor engaged by the teeth are deformed inwardly whereas other portions of the side edges are wedged into the spaces between adjacent teeth, the teeth being curled inwardly towards the web to pierce the insulation from the opposite surface of the cable and contact the conductor.

An embodiment of the invention will now be described, by way of example, reference being made to the Figures of the accompanying diagrammatic drawings in which:—

Figure 1 is a perspective view of a ferrule of an electrical contact;

Figure 2 is a transverse cross-sectional view of the ferrule of Figure 1 supported on an anvil with a portion of a flat conductor cable arranged between the ferrule and a die;

Figure 3 is a transverse cross-sectional view of the ferrule of Figure 1 crimped to a conductor of a flat conductor cable;

Figure 4 is a perspective view of the ferrule of Figure 1 crimped to a conductor of a flat conductor cable;

Figure 5 is a longitudinal cross-sectional view of the crimped connection of Figure 4; and

Figure 6 is a detail in plan view, partly in cross-section of the ferrule of Figure 1 crimped to a flat conductor.

As shown, an electrical contact 1 includes an open ferrule 3 for crimp connection to a flat conductor 28 of a flat conductor cable 31. The ferrule 3 has a generally planar web 2 from opposite sides of which extend sidewalls each in the form of a pair of teeth 4, 6. The teeth 4, 6 extend generally normally of the web 2 in the same

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direction and each tooth is tapered having a relatively wide base joined to the web 2 and a relatively narrow free tip 4a, 6a. The teeth 4, 6 of each pair are spaced apart and define between them a tapered space 12, 14, the taper extending to the intersection between the web 2 and the respective sidewall as shown in Figure 1. The teeth 4, 6 of each pair are offset longitudinally with respect to each other so that one tooth 4, 6 of each pair is in alignment with a space 14, 12 between the opposite pair. Each tooth tip 4a, 6a is radiused but has a sharp edge, and the flanks of the teeth also have sharp edges.

The web 2 is formed with a longitudinally extending raised protuberance 8 between the pairs of teeth 4, 6. Channels 16 extend laterally across the web 2. Each channel 16 extends over the protuberance 8 and partially along the inner surface of a tooth 4, 6.

The channels 16 are advantageously formed by coining the surface of the web 2 and the inner surface of the teeth 4, 6 prior to bending the teeth out of the plane of the web 2. The coining operation not only produces the channels with sharp edges but also work hardens the metal from which the ferrule 3 is made thereby stiffening the ferrule. The stiffened ferrule 3 is thereby self-supporting and may be crimped to a conductor without substantial support around the ferrule 3.

Referring in particular to Figure 2, the ferrule 3 is shown supported on an anvil 20. A ridge 37 of generally trapezoidal cross-section integral with and extending from the anvil engages within the underside of the protuberance 8. Opposing the anvil 20 and relatively movable towards and away from the anvil 20 is a die 22. The die surface includes a pair of arcuate surface portion 26 spaced by a flat portion 27 in alignment with the ridge 37. Between the die 22 and the contact 1 there is shown a portion of a flat conductor cable 31 including a flat copper conductor 28 encased within a sheath 30 of insulating material. The flat conductor 28 has side edges 32, 34 and the width of the conductor, that is, the dimensions between the side edges 32, 34 is greater than the space between the pairs of teeth 4, 6.

During a crimping operation, the die 22 moving towards the anvil 20 will engage the cable 31 and force the conductor 28 into the space between the pairs of teeth 4, 6. In other words, the teeth tips 4a, 6a will penetrate through the sheath 30 adjacent each side edge of the conductor thereby curling up, compressing or deforming portions 32a, 34a of the side edge 32, 34 immediately adjacent the teeth (see Figure 6).

It has been found that when the ferrule 3 is blanked and formed from stock of .010 inch thickness the best radius for the tooth tips 4a, 6a, is .005 inch which permits penetration of the tips 4a, 6a through the sheath 30 while inhibiting penetration of the tips into the side edges 32, 34 of the conductor 28.

Thus as shown in Figures 4 and 6, portions 32a, 34a of the side edges are inwardly deformed but portions 32b, 34b between the portions 32a, 34a and in alignment with the spaces 12, 14 are not inwardly deformed. Thus the teeth 4, 6 positively grip the conductor 28 inwardly deforming the conductor 28 at the portions 32a, 34a.

As the teeth 4, 6 progressively penetrate the sheath 30 by virtue of their tapered shape, they gather or wedge a substantial length of the conductor side edges 32, 34 into the tapered spaces 12, 14. This gathering action causes the portions 32b, 34b to bow or buckle outwardly from the conductor 28 and enhances the inherent resilience of the conductor material to bow outwards into the spaces 12, 14 between the teeth.

As shown in Figure 6, the edges of the teeth 4 and 6 define relatively sharp corners which slice through the sheath 30 to establish multiple points of contacts with the conductor side edges 32 and 34.

After the tooth tips 4a and 6a have penetrated through the sheath 30, they will engage the arcuate surfaces 26 of the die 22 as the die 22 approaches the anvil 20. This will cause the tips to be curled over (see Figure 3), to penetrate through the sheath 30 to engage the conductor 28 and press the conductor against the protuberance 8. The pressure of the teeth 4, 6 forces the material of the sheath 30 into the channels 16 in the protuberance 8, causing the sharp corners of the channels to penetrate through the sheath 30 and contact the conductor 28, further establishing multiple points of contact between the ferrule 3 and the conductor 28.

Since the teeth 4, 6 of each pair are offset longitudinally with respect to each other the tooth tips 4a, 6a will not engage or interfere with each other during the crimping operation. In addition, the staggered relationship permits at least one tooth tip 4a to be disposed opposite to the space 14 which will press on the conductor 28 at a location immediately adjacent to the portion 34b of the conductor side edge 34. The pressure of the tooth tip 4a thus tends to flatten the conductor 28, further wedging the gathered portions 34b into the tapered space 14 and thereby enhancing the electrical connection between the sharp

corners of the teeth 6 with the conductor side edge 34. The same is the case with the tooth 6 opposite the space 12.

5 The finished connection resists separation of the conductor 28 from the positive and tenacious grip of the teeth 4, 6 on the inwardly deformed conductor side edge portions 32a, 34a. The resulting electrical connection is created by the  
10 contact of the teeth 4, 6 on the inwardly deformed connector side edge 32a, 34a and on the additional portions 32b, 34b of the conductor side edges wedged into spaces 12, 14. Also the teeth tips 4a, 6a penetrate the insulation jacket to engage the  
15 conductor 28 and establish additional points of electrical contact. Sufficient crimping pressure to establish the electrical connection is obtained without total reliance upon the amount of collapse of the  
20 teeth 4, 6. Variations in thickness of the conductor 28 and the sheath 30 will have little effect in varying the crimping pressure because of the reduced reliance upon the  
25 total collapse of the ferrule 3 to establish the desired electrical connection.

The protuberance 8 on the web 2 provides a relatively elevated surface against which the tips 4a and 6a will press the conductor 28. The presence of the  
30 protuberance 8 thus further reduces the amount of teeth collapse necessary to create the gripping pressure.

35 As shown in Figure 3, the teeth 4, 6 are curled to project the tips 4a, 6a normal to the surface of curvature of the protuberance 8. In many instances of crimping, this is not always attainable. However if properly designed, the tooth  
40 tips 4a, 6a will always have a tendency to project normal to the surface of the protuberance 8. This ensures that sufficient crimping pressure is attained without the need to produce an inordinate amount of  
45 teeth collapse.

The ridge 37 prevents collapse of the protuberance 8, when the dies are closed, as shown in Figure 3. The tooth tips 4a, 6a will press upon the protuberance 8 and will  
50 also be compressed by the presence of the portion 27 between the arcuate die surface portions 26. Although the portion 27 stops at a distance from the surface of the protuberance 8, the tooth tips 4a, 6a will be  
55 nonetheless sandwiched in compression between the die surfaces 26 and the protuberance 8. As more particularly shown in Figure 5, when the dies are closed, the teeth 4, 6 will not only penetrate  
60 through the sheath 30, but will also forcibly press portions of the conductor into the channels 16. The channels 16 are sufficiently wide to receive the teeth tips 4a, 6a therein together with portions of the  
65 conductor 28. The material of the sheath 30

will also be extruded or otherwise received into the channels 16, but the corners of the channels 16 will penetrate through the material to engage the conductor portions which are pressed into the channels by the teeth tips.

#### WHAT WE CLAIM IS:—

1. An electrical contact for crimp connection to a flat conductor of a flat conductor cable, including a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, the edges of the sidewalls being adapted to pierce the insulation of a flat conductor cable from one surface of the cable and to be curled inwardly to make contact with a conductor of the flat cable from the opposite surface of the cable, each sidewall being in the form of a pair of spaced teeth, each tooth tapering towards a free tip, the teeth defining between them a tapered space, the space extending to the intersection between the web and the respective sidewall.

2. An electrical contact as claimed in Claim 1, in which the teeth of each pair are offset longitudinally with respect to each other so that one tooth of each pair is in alignment with the space between the opposite pair of teeth.

3. An electrical contact as claimed in Claim 1 or 2, in which the web is formed with a protuberance extending longitudinally of the ferrule between the pairs of teeth.

4. An electrical contact as claimed in Claim 3, in which a plurality of channels extend laterally of the web over the protuberance, each channel extending partially along the inner surface of one tooth.

5. An electrical connection between an electrical contact and a flat conductor of a flat conductor cable in which the flat conductor is encased within a sheath of insulating material and the contact includes a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, each sidewall being in the form of a pair of spaced teeth each tapering towards a free tip and which define between them a tapered space, the space extending to the intersection between the web and the sidewall, the distance between the sidewalls being less than the width of the conductor, the web lying along one surface of the cable with the teeth piercing the cable adjacent each side of the conductor so that portions of the side edges of the conductor engaged by the teeth are deformed inwardly whereas other portions of the side edges are wedged into the spaces between adjacent teeth, the teeth being curled inwardly towards the web to pierce



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corners of the teeth 6 with the conductor side edge 34. The same is the case with the tooth 6 opposite the space 12.

The finished connection resists separation of the conductor 28 from the positive and tenacious grip of the teeth 4, 6 on the inwardly deformed conductor side edge portions 32a, 34a. The resulting electrical connection is created by the contact of the teeth 4, 6 on the inwardly deformed connector side edge 32a, 34a and on the additional portions 32b, 34b of the conductor side edges wedged into spaces 12, 14. Also the teeth tips 4a, 6a penetrate the insulation jacket to engage the conductor 28 and establish additional points of electrical contact. Sufficient crimping pressure to establish the electrical connection is obtained without total reliance upon the amount of collapse of the teeth 4, 6. Variations in thickness of the conductor 28 and the sheath 30 will have little effect in varying the crimping pressure because of the reduced reliance upon the total collapse of the ferrule 3 to establish the desired electrical connection.

The protuberance 8 on the web 2 provides a relatively elevated surface against which the tips 4a and 6a will press the conductor 28. The presence of the protuberance 8 thus further reduces the amount of teeth collapse necessary to create the gripping pressure.

As shown in Figure 3, the teeth 4, 6 are curled to project the tips 4a, 6a normal to the surface of curvature of the protuberance 8. In many instances of crimping, this is not always attainable. However if properly designed, the tooth tips 4a, 6a will always have a tendency to project normal to the surface of the protuberance 8. This ensures that sufficient crimping pressure is attained without the need to produce an inordinate amount of teeth collapse.

The ridge 37 prevents collapse of the protuberance 8, when the dies are closed, as shown in Figure 3. The tooth tips 4a, 6a will press upon the protuberance 8 and will also be compressed by the presence of the portion 27 between the arcuate die surface portions 26. Although the portion 27 stops at a distance from the surface of the protuberance 8, the tooth tips 4a, 6a will be nonetheless sandwiched in compression between the die surfaces 26 and the protuberance 8. As more particularly shown in Figure 5, when the dies are closed, the teeth 4, 6 will not only penetrate through the sheath 30, but will also forcibly press portions of the conductor into the channels 16. The channels 16 are sufficiently wide to receive the teeth tips 4a, 6a therein together with portions of the conductor 28. The material of the sheath 30

will also be extruded or otherwise received into the channels 16, but the corners of the channels 16 will penetrate through the material to engage the conductor portions which are pressed into the channels by the teeth tips.

#### WHAT WE CLAIM IS:—

1. An electrical contact for crimp connection to a flat conductor of a flat conductor cable, including a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, the edges of the sidewalls being adapted to pierce the insulation of a flat conductor cable from one surface of the cable and to be curled inwardly to make contact with a conductor of the flat cable from the opposite surface of the cable, each sidewall being in the form of a pair of spaced teeth, each tooth tapering towards a free tip, the teeth defining between them a tapered space, the space extending to the intersection between the web and the respective sidewall.

2. An electrical contact as claimed in Claim 1, in which the teeth of each pair are offset longitudinally with respect to each other so that one tooth of each pair is in alignment with the space between the opposite pair of teeth.

3. An electrical contact as claimed in Claim 1 or 2, in which the web is formed with a protuberance extending longitudinally of the ferrule between the pairs of teeth.

4. An electrical contact as claimed in Claim 3, in which a plurality of channels extend laterally of the web over the protuberance, each channel extending partially along the inner surface of one tooth.

5. An electrical connection between an electrical contact and a flat conductor of a flat conductor cable in which the flat conductor is encased within a sheath of insulating material and the contact includes a ferrule having a channel-shaped transverse cross-section comprising a web and two opposed sidewalls, each sidewall being in the form of a pair of spaced teeth each tapering towards a free tip and which define between them a tapered space, the space extending to the intersection between the web and the sidewall, the distance between the sidewalls being less than the width of the conductor, the web lying along one surface of the cable with the teeth piercing the cable adjacent each side of the conductor so that portions of the side edges of the conductor engaged by the teeth are deformed inwardly whereas other portions of the side edges are wedged into the spaces between adjacent teeth, the teeth being curled inwardly towards the web to pierce

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the insulation from the opposite surface of the cable and contact the conductor.

5 6. An electrical connection as claimed in Claim 5, in which the web is provided with a protuberance having a curved surface, the tips of the curled teeth engaging and extending normally to the curved surface of the dimple.

10 7. An electrical connection as claimed in Claim 6, in which a plurality of channels extend laterally of the web over the curved surface of the protuberance, portions of the conductor being pressed into the channels by the tips of the teeth.

15 8. An electrical contact for crimp

connection to a flat conductor of a flat conductor cable, constructed and arranged substantially as herein described, with reference to and as illustrated in Figures 1 and 2 of the accompanying drawings.

9. An electrical connection between an electrical contact and a flat conductor of a flat conductor cable substantially as herein described with reference to and as illustrated in Figures 3 to 6 of the accompanying drawings.

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