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(54) AN IMPROVED ELECTRICAL CONNECTOR

(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, State of 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 connectors for terminating conductors.

According to the present invention, an electrical connector for terminating a conductor is substantially planar and includes a pair of elongate jaws extending rearwardly from a yoke, each jaw of the pair having teeth extending towards complementary teeth on the other jaw of the pair, the jaws being relatively movable from a first position at which the jaws are spaced apart for receiving between them the conductor and a second closed position at which the teeth of the respective jaws are inter-digitated, one jaw of the pair including, at a position between the yoke and its teeth, a pair of serially interconnected arms inclined to each other to define an elbow toggle linkage, which arms, in the second position of the jaws, can be forced into substantial alignment thereby causing relative axial movement of the teeth of the respective jaws to clamp and electrically engage between complementary teeth, portions of the conductor, and means for inhibiting movement of the jaws from the second closed position towards the first position.

In one embodiment of the invention, the inhibiting means may be a portion of a surface on at least one tooth on the said one jaw which co-operates with a complementary portion of a surface on a tooth of the other jaw, the portions of the surfaces overlapping in the second position of the jaws.

Alternatively, when the teeth of each jaw are positioned immediately adjacent the free end of the jaw, the inhibiting means may be a deformable web extending between the pair of jaws and being joined to said one jaw at a location between the elbow toggle linkage and the teeth.

Embodiments 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 an electrical connector;

Figures 2 and 3 are side views of the connector of Figure 1 at various stages during the termination of a flat conductor forming part of a flat, flexible cable;

Figure 4 is a sectional view on an enlarged scale of a detail indicated in Figure 3;

Figure 5 is a perspective view of a carrier member for holding a plurality of the connectors of Figure 1;

Figure 6 is a sectional view taken along the line 6-6 of Figure 5 with a connector of Figure 1 mounted on the carrier member;

Figure 7 is a side view of an apparatus for simultaneously applying a plurality of the connectors of Figure 1 to respective flat conductors of a flat flexible cable;

Figure 8 is a partially exploded perspective view of a connector assembly, a housing of the connector assembly being shown removed from the end of a cable and from the carrier member in which the connectors of Figure 1 are mounted;

Figure 9 is a sectional side view of the connector assembly of Figure 8 mated with a corresponding connector assembly;

Figure 10 is a side view of a different embodiment of electrical connector; and,

Figure 11 is a view similar to Figure 10 but showing the connector of Figure 10 crimped to a conductor.

As shown in Figures 1 to 3, an electrical connector 8 for terminating a flat conductor

of a flat conductor cable 2 is substantially planar and is manufactured by stamping flat sheet material. The connector 8 comprises a contact part in the form of a pin 12 and a connecting part 10.

The connecting part 10 includes a yoke 14 and a pair of spaced apart elongate jaws 16, 18 extending rearwardly from the yoke 14.

The lower jaw 18 has an upwardly extending stop 22 and a lower depending ear 21 at its free end, and three generally semi-circular recesses 26 at spaced-apart locations on its inner edge. The recesses 26 define two upwardly projecting teeth 28 which have contact surfaces 30 facing and inclined towards the yoke 14. Each tooth 28 has a chisel edge 32 and has a downwardly sloping crown 34 on the opposite side from the contact surfaces 30. Intermediate the ends of the jaw 18 is a stop 24. The lower jaw 18 is connected to the yoke 14 by a wide shank portion 20 which because of its dimensions is relatively resistant to bending.

Upper jaw 16 extends divergently with respect to the lower jaw 18 from the yoke 14 and has two teeth 35 extending downwardly from its lower inner edge. The teeth 35 have rearwardly facing contact surfaces 37 which co-operate with the contact surfaces 30 to establish electrical contact with the flat conductor.

The upper jaw 16 includes an elbow toggle linkage. The toggle linkage comprises a pair of serially inter-connected arms 38, 39 inclined to each other to give an elbow configuration.

The arm 39 is connected to the remainder of the jaw 16 by a transition part 39' of reduced width and the arm 38 is connected to the yoke 14 by a transition part 38' of reduced width. The arms 38, 39 are inter-connected by a part 44 of reduced width. The parts 38', 39', 44 are formed by punching out the material of the jaw 16 at each end of each arm 38, 39 as shown.

The parts 38', 39', 44 function as the pivot joints of a conventional toggle mechanism by virtue of the fact that the material in these narrow parts yields and is plastically deformed when the elbow toggle linkage is straightened so that the toggle arms 38, 39 pivot with respect to the parts 38', 39', 44 until the arms 38, 39 are in substantial alignment with each other.

During a crimping operation, the flat conductor of a flat conductor cable 2 is positioned between the spaced apart jaws 16, 18 with the end extending past the inner one of the teeth 28. A downward force F_1 is then applied to the upwardly facing edge of the jaw 16 adjacent to its free end (see Figure 2). This force has the effect of pivoting the upper jaw 16 together with the arms 38, 39, as a unit downwardly with con-

comitant yielding and plastic deformation of the part 38'. The material in part 38' will yield and permanently deform during this initial bending step, rather than the material in either of the parts 39', 44 since the part 38' is an area of comparative weakness which is furthest removed from the point of application of the force F_1 , that is, from the free end of the jaw 16.

After the downward pivoting of the jaw 16 and the arms 38', 39', 44 as a unit, has been completed, that is, when the bottom edge of jaw 16 engages stop 24, the free end of the jaw 16 will be spaced inwardly, that is, forwardly from the free end of the jaw 18 and the teeth 35 will interdigitate with the teeth 28 and extend downwardly into the recesses 26 with the surfaces 37 of the teeth 35 substantially spaced from the contact surfaces 30 of the teeth 28 on the jaw 16. The conductor will be pushed downwardly by the teeth 35 so that portions of the conductor will extend between contact surfaces 30 and surfaces 37 (see Figure 2).

The force F_1 is maintained on the end of jaw 16 and a further downward force F_2 is applied to the upper edge of the elbow toggle linkage. The force F_2 causes the material in the parts 39' and 44 to yield and be plastically deformed until the two arms 38, 39 are in substantial alignment with each other.

When the elbow toggle linkage is straightened by application of the force F_2 while the force F_1 is maintained as a static force on the free end of the upper jaw 16, the upper jaw 16 moves leftwardly. The teeth 35 of the upper jaw 16 are thus moved leftwardly and towards the teeth 28 of the lower jaw 18 until they have clamped the portions of the flat conductor 2 between the contact surfaces 37, 30. The teeth 28 of the lower jaw 18 are longer and will be slightly flexed or stressed in the manner of an end loaded cantilever beam by the forces applied by the shorter teeth 35 of the upper jaw 16 so that the conductor is clamped very tightly between the surfaces 30, 37. This clamping of the flat conductor between the surfaces 30, 37 causes exposure of the metallic flat conductor with resulting electrical contact. Examination of a portion of a conductor removed from between the jaws of a connector 8 indicates that the plastic insulation is extruded from between the opposed surfaces 37, 30 under the influence of the extremely high pressures developed during straightening of the elbow toggle linkage. It also appears from examination of some specimens that the plastic insulation may fracture after some extrusion has taken place to expose the flat conductor. The actual reason for the electrical engagement with the flat conductor may thus depend upon the precise nature of the plastic insulation

whether it is highly plasticised and therefore extremely flowable or, on the other hand, whether it is not highly plasticised and tends to rupture or fracture.

5 The electrical connector can be manufactured by stamping any suitable conductive material, for example, a phosphor bronze (normally 4% Sn, 0.05% P, 99.5% Cu + Sn + P) or a cartridge brass (70% Cu, 30% Zn). When either of these alloys are used, they are preferably in a fully hardened condition and it has been found that the elbow toggle linkage will, notwithstanding the fully hardened conditions of the material, yield when the bending operations described above are carried out. It is necessary to dimension the parts 38', 39', 44 such that the material in these parts will yield in the manner described above; that is, the part 38' must yield rather than the parts 39', 44 when the initial closing force F_1 is applied and this result can be brought about by proper selection of the width of the part 39'.

25 The connector 8 can be made from sheet material of only 0.016 inches thickness for terminating a flat conductor of a flat flexible cable, the conductor width being approximately 0.025 inches.

30 An advantage of the connector 8, is that after crimping to a flat conductor, the possibility of the jaws 16, 18 opening due to relaxation of the material of the jaws is inhibited by the overlapping portions of the contact surfaces 30, 37 (see Figure 4). The arms 38, 39 are in compression as indicated by arrows C in Figure 3, and the jaw 18 is in tension as indicated by arrows T, the portions of the conductor being clamped tightly between the contact surfaces 30, 37. The slope or inclination of the surfaces 30, 37 is such, that for the jaws 16, 18 to relax and open, then a force would have to be applied to further compress the arms 38, 39 which are already in compression, so that the free ends of the teeth 35 can disengage from the teeth 28. Since the co-operating surfaces of the teeth are inclined rightwardly towards the yoke 14 and since the parts 38', 44, 39' have been plastically deformed the resistance to such a force would be considerable.

50 A plurality of connectors 8 form part of an electrical connector assembly 97 as shown in Figures 8 and 9. The electrical connector assembly 97 includes an insulating housing 98 of nylon having a cavity 100 open at a forward mating end for receiving a carrier 46. Mounted on the carrier 46 are a plurality of connectors 8 each terminating a flat conductor of a flat conductor cable 2. The cable 2 extends rearwardly from the housing 98, through a slot 102 in a rear end wall 101 of the housing, which slot 102 communicates with the cavity 100. A flange

105 extends rearwardly from the end wall 101. The flange 105 has ears 112 which accommodate screws 103 for engaging a clamping bar 108.

Referring also to Figures 5 and 6, the carrier 46 is a moulding of an electrically insulating material and includes a base 48, a rear wall 50 and opposed side walls 66. Between the side walls 66, a plurality of spaced, parallel partition walls 54 are upstanding from the base 48, which define between adjacent partition walls, cavities 52 for receiving connectors 8.

Each partition wall 54 is contoured as shown in Figure 5. Recesses 64 and 60 are formed in each partition wall 54, which recesses 64, 60 have upper surfaces level with upper surfaces of recesses 70, 68 formed in the side walls 66.

A recess 56 is formed in each cavity 52 for receiving an ear 21 of a connector 8. Extending rearwardly from the upper edge of the rear wall 50 is a horizontal flange 51.

On assembly, the connectors 8 are mounted in respective cavities 52 with their ears 21 in corresponding recesses 56. The free ends of the jaw 16 will project above the partition walls 54 and the parts 44 of the elbow toggle linkage will project above the level of the upper surfaces of the recesses 64, 70.

A housing 98 is then slidably fitted over the end of a flat conductor cable 2 to be terminated so that the end of the cable 2 extends forwardly of the mating end of the housing and over the flange 51 of the carrier 46. The individual conductors of the cable are then positioned between the jaws 16, 18 of respective connectors 8. The connectors 8 are crimped to their respective conductors by the apparatus of Figure 7 (to be described) and the carrier 46 is then positioned in the cavity 100 with the flange 51 extending rearwardly through the slot 102. The screws 103 are then tightened so that the flange 51 and the cable 2 lying on top of the flange are clamped between the clamping bar 108 and the flange 105.

An apparatus (see Figure 7) for crimping connectors 8 to flat conductors of a flat flexible cable 2 comprises a lower block 74 and an upper block 76. A pair of guide pins 78 (only one shown) extend from the lower block 74 and through openings in the upper block 76, springs 80 being interposed between the surfaces of the blocks 74, 76 and surrounding the pins 78 to bias the upper block 76 to the position shown. Four locating pins 82, 84 (only two shown) are mounted on the upper surface of the lower block 74 to precisely locate a carrier 46 with reference to punches 88, 90.

A tool holder block 86 is secured to the underside of the upper block 76 centrally between the guide pins 78. A bending punch

88 in the form of a generally rectangular plate is mounted in the tool holder block 86 and located such that when the upper block 76 is moved downwardly, the lower edge of the punch 88 will engage the free ends of the jaws 16 of the connectors 8 mounted in the carrier 46 supported on the lower block 74. The punch 88 is provided with spaced apart recesses (not shown) shaped to engage and centre the free ends of the jaws 16 of the connectors 8 when the upper block 76 is moved downwardly.

The punch 88 is slidably mounted in a recess in the tool holder block 86 and has an enlarged upper end 92 which is slidably supported in an enlarged upper end of the recess in the tool holder block 86. A spring 94 is provided in a recess 96 in the block 76 and bears against the enlarged head 92 of the punch 88 to permit overtravel in a downward direction of the tool holder block 86 during operation of the apparatus.

A plate-like toggle straightening punch 90 is mounted in the tool holder block 86 behind the punch 88 and has a downwardly facing edge 91 which is normally spaced from and above the lower edge 92 of the punch 88. The toggle straightening punch 90 is rigidly mounted in the tool holder block 86.

In order to apply a plurality of terminals mounted in a carrier 46 to the flat conductors of a flat flexible cable, the carrier 46 is located on the surface of the lower block 74 by means of the four locating pins 82, 84. The cable is then positioned between the open jaws 16, 18 of the connectors 8 with its individual flat conductors in alignment with the individual connectors 8. The upper block 76 is then moved downwardly so that the bending punch 88 first engages the free ends of the jaws 16 and bends the jaws 16 including the elbow toggle linkage of the individual connectors 8 downwardly. Thereafter, the bending punch 88 remains stationary and the upper block 76 and tool holder block 86 move downwardly with concomitant compression of the spring 94. The lower edge 91 of the toggle straightening punch 90 then engages the parts 44 of the elbow toggle linkages and straightens the arms 38, 39 as previously described.

Figures 10 and 11 illustrate a further embodiment of electrical connector 116 which is substantially planar and is manufactured by stamping from flat sheet material. The connector 116 comprises a contact part in the form of a pin 118 and a connecting part 120.

The connecting part 120 includes a yoke 126 from which extends rearwardly a pair of spaced apart elongate jaws 122, 124. The upper jaw 122 is connected to the yoke 126 by an elbow toggle linkage 130 similar to the linkage described with reference to the pre-

vious embodiment. The lower jaw 124 has a relatively wide shank portion 128 similar to the shank portion 20 of the previous embodiment.

Adjacent their rearward free ends, the jaws 122, 124 have teeth 134, 136 respectively. Forwardly of the teeth 134, 136 the jaws 122, 124 are interconnected by means for inhibiting movement of the jaws from the closed position, that is, when the connector is crimped to a conductor, in the form of a deformable web 132.

An elongate through aperture 138 extends axially of the jaw 124 in general alignment with the teeth 136.

The connector 116 is applied to a flat conductor by applying the forces F_1 , F_2 simultaneously to the free end of the movable jaw and the elbow joint of the elbow toggle linkage. The apparatus for applying this connecting device to a conductor differs from the apparatus shown in Figures 8 and 9 in that it would not have a spring loaded punch but would consist simply of a means for simultaneously applying the forces F_1 and F_2 . During the application of the connector 116 to a flat conductor the jaw 122 is swung downwardly and the web 132 is plastically deformed.

It will be apparent that when the connector 116 is applied to a conductor, there is very little movement of the upper jaw 122 in its own plane parallel to the lower jaw 124 as described with reference to the previous embodiment. The teeth 134 of the upper jaw are located such that their forwardly facing edges are adjacent to the rearwardly facing edges of the teeth 136 on the lower jaw 124. A connector 116 can be used to advantage where electrical connections to stranded or solid wires having relatively thick insulation are being made since the points of the teeth dig into and penetrate insulation to establish contact with the conducting core of the wire. Under some circumstances, the extrusion and/or fracture methods of establishing electrical contact may be impractical if the insulation is relatively thick.

The lower jaw 124 has an elongated slot 138 which divides the lower jaw into upper and lower strap sections 140, 142 and when the terminal is applied to a conductor, the upper strap section 140 is resiliently flexed in the manner of a beam fixed at each of its ends. This flexure provides additional stored energy for the maintenance of the electrical interface in that as a result of this flexure, the teeth 136 of the lower jaw are urged upwardly and against the conductor and the teeth of the upper jaw.

WHAT WE CLAIM IS:—

1. An electrical connector for terminating a conductor, the connector being substan-

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88 in the form of a generally rectangular plate is mounted in the tool holder block 86 and located such that when the upper block 76 is moved downwardly, the lower edge of the punch 88 will engage the free ends of the jaws 16 of the connectors 8 mounted in the carrier 46 supported on the lower block 74. The punch 88 is provided with spaced apart recesses (not shown) shaped to engage and centre the free ends of the jaws 16 of the connectors 8 when the upper block 76 is moved downwardly.

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20 A plate-like toggle straightening punch 90 is mounted in the tool holder block 86 behind the punch 88 and has a downwardly facing edge 91 which is normally spaced from and above the lower edge 92 of the punch 88. The toggle straightening punch 90 is rigidly mounted in the tool holder block 86.

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30 In order to apply a plurality of terminals mounted in a carrier 46 to the flat conductors of a flat flexible cable, the carrier 46 is located on the surface of the lower block 74 by means of the four locating pins 82, 84. The cable is then positioned between the open jaws 16, 18 of the connectors 8 with its individual flat conductors in alignment with the individual connectors 8. The upper block 76 is then moved downwardly so that the bending punch 88 first engages the free ends of the jaws 16 and bends the jaws 16 including the elbow toggle linkage of the individual connectors 8 downwardly. Thereafter, the bending punch 88 remains stationary and the upper block 76 and tool holder block 86 move downwardly with concomitant compression of the spring 94. The lower edge 91 of the toggle straightening punch 90 then engages the parts 44 of the elbow toggle linkages and straightens the arms 38, 39 as previously described.

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50 Figures 10 and 11 illustrate a further embodiment of electrical connector 116 which is substantially planar and is manufactured by stamping from flat sheet material. The connector 116 comprises a contact part in the form of a pin 118 and a connecting part 120.

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65 The connecting part 120 includes a yoke 126 from which extends rearwardly a pair of spaced apart elongate jaws 122, 124. The upper jaw 122 is connected to the yoke 126 by an elbow toggle linkage 130 similar to the linkage described with reference to the pre-

vious embodiment. The lower jaw 124 has a relatively wide shank portion 128 similar to the shank portion 20 of the previous embodiment.

Adjacent their rearward free ends, the jaws 122, 124 have teeth 134, 136 respectively. Forwardly of the teeth 134, 136 the jaws 122, 124 are interconnected by means for inhibiting movement of the jaws from the closed position, that is, when the connector is crimped to a conductor, in the form of a deformable web 132.

An elongate through aperture 138 extends axially of the jaw 124 in general alignment with the teeth 136.

The connector 116 is applied to a flat conductor by applying the forces F_1 , F_2 simultaneously to the free end of the movable jaw and the elbow joint of the elbow toggle linkage. The apparatus for applying this connecting device to a conductor differs from the apparatus shown in Figures 8 and 9 in that it would not have a spring loaded punch but would consist simply of a means for simultaneously applying the forces F_1 , and F_2 . During the application of the connector 116 to a flat conductor the jaw 122 is swung downwardly and the web 132 is plastically deformed.

It will be apparent that when the connector 116 is applied to a conductor, there is very little movement of the upper jaw 122 in its own plane parallel to the lower jaw 124 as described with reference to the previous embodiment. The teeth 134 of the upper jaw are located such that their forwardly facing edges are adjacent to the rearwardly facing edges of the teeth 136 on the lower jaw 124. A connector 116 can be used to advantage where electrical connections to stranded or solid wires having relatively thick insulation are being made since the points of the teeth dig into and penetrate insulation to establish contact with the conducting core of the wire. Under some circumstances, the extrusion and/or fracture methods of establishing electrical contact may be impractical if the insulation is relatively thick.

The lower jaw 124 has an elongated slot 138 which divides the lower jaw into upper and lower strap sections 140, 142 and when the terminal is applied to a conductor, the upper strap section 140 is resiliently flexed in the manner of a beam fixed at each of its ends. This flexure provides additional stored energy for the maintenance of the electrical interface in that as a result of this flexure, the teeth 136 of the lower jaw are urged upwardly and against the conductor and the teeth of the upper jaw.

WHAT WE CLAIM IS:—

1. An electrical connector for terminating a conductor, the connector being substan-



5 tially planar and including a pair of elongate
jaws extending rearwardly from a yoke, each
jaw of the pair having teeth extending to-
wards complementary teeth on the other jaw
of the pair, the jaws being relatively movable
from a first position at which the jaws are
spaced apart for receiving between them the
conductor and a second closed position at
which the teeth of the respective jaws are
interdigitated, one jaw of the pair including,
at a position between the yoke and its teeth,
a pair of serially interconnected arms in-
clined to each other to define an elbow toggle
linkage, which arms, in the second position
of the jaws, can be forced into substantial
alignment thereby causing relative axial
movement of the teeth of the respective jaws
to clamp and electrically engage between
complementary teeth, portions of the con-
ductor, and means for inhibiting movement
of the jaws from the second closed position
towards the first position.

2. An electrical connector as claimed in
claim 1, in which the inhibiting means is a
portion of a surface on at least one tooth on
the said one jaw which co-operates with a
complementary portion of a surface on a
tooth of the other jaw, the portions of the
surfaces overlapping in the second position
of the jaws.

3. An electrical connector as claimed in
claim 1 or 2, in which said one jaw is joined
to the yoke by a part of reduced width to
facilitate pivotal movement of said one jaw
from the first position towards the second
position relative to the other jaw, the other
jaw being joined relatively rigidly to the
yoke.

4. An electrical connector as claimed in
claim 1, 2 or 3, in which the arms of the

elbow toggle linkage are interconnected by a
part of reduced width, the arms at their
opposite ends being connected respectively
to the remainder of the one jaw and to the
yoke by parts of reduced width.

5. An electrical connector as claimed in
any one of claims 1 to 4, in which the teeth
extending from said one jaw are short rela-
tive to the teeth extending from the other
jaw.

6. An electrical connector as claimed in
any one of claims 1 to 5 in which a stop is
provided for limiting the interdigitation of
the teeth of the jaws.

7. An electrical connector as claimed in
claim 1, in which the teeth of each jaw are
positioned immediately adjacent the free
end of the jaw and in which the inhibiting
means is a deformable web extending be-
tween the pair of jaws and being joined to
said one jaw at a location between the elbow
toggle linkage and the teeth.

8. An electrical connector as claimed in
claim 7, in which one of the jaws has an
elongate through aperture extending axially
of the jaw in general alignment with the
teeth of the jaw.

9. An electrical connection between a
flat conductor of a flat flexible cable and an
electrical connector as claimed in any one of
claims 1 to 8.

10. An electrical connector for terminat-
ing a conductor constructed and arranged,
substantially as hereinbefore described with
reference to and as illustrated in Figures 1
to 9 or 10 and 11 of the accompanying
drawings.

For the Applicants,
R. G. STUART-PRINCE,
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