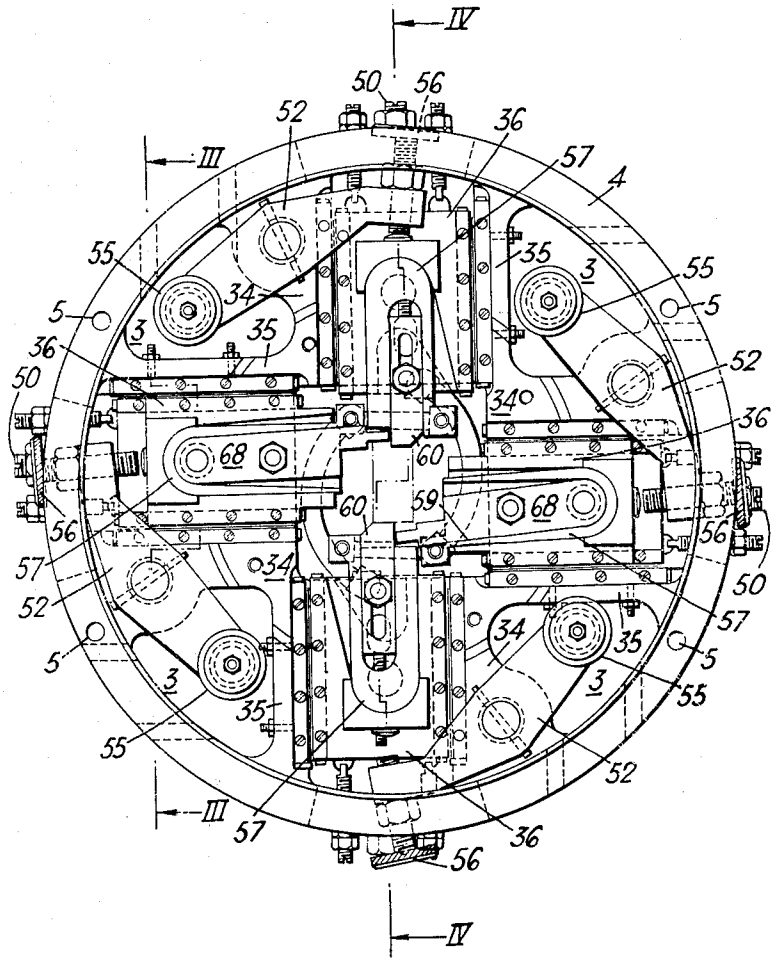
Oct. 19, 1965 R. HINDS 3,212,531

TRANSPOSING HEADS FOR USE IN THE MANUFACTURE OF TRANSPOSED MULTIPLE STRIP CONDUCTOR

Filed June 4, 1963 3 Sheets-Sheet 1

Fig. 1.



Inventor
Ronald Hinds

By
Wells Mackey & Burden
Attorney

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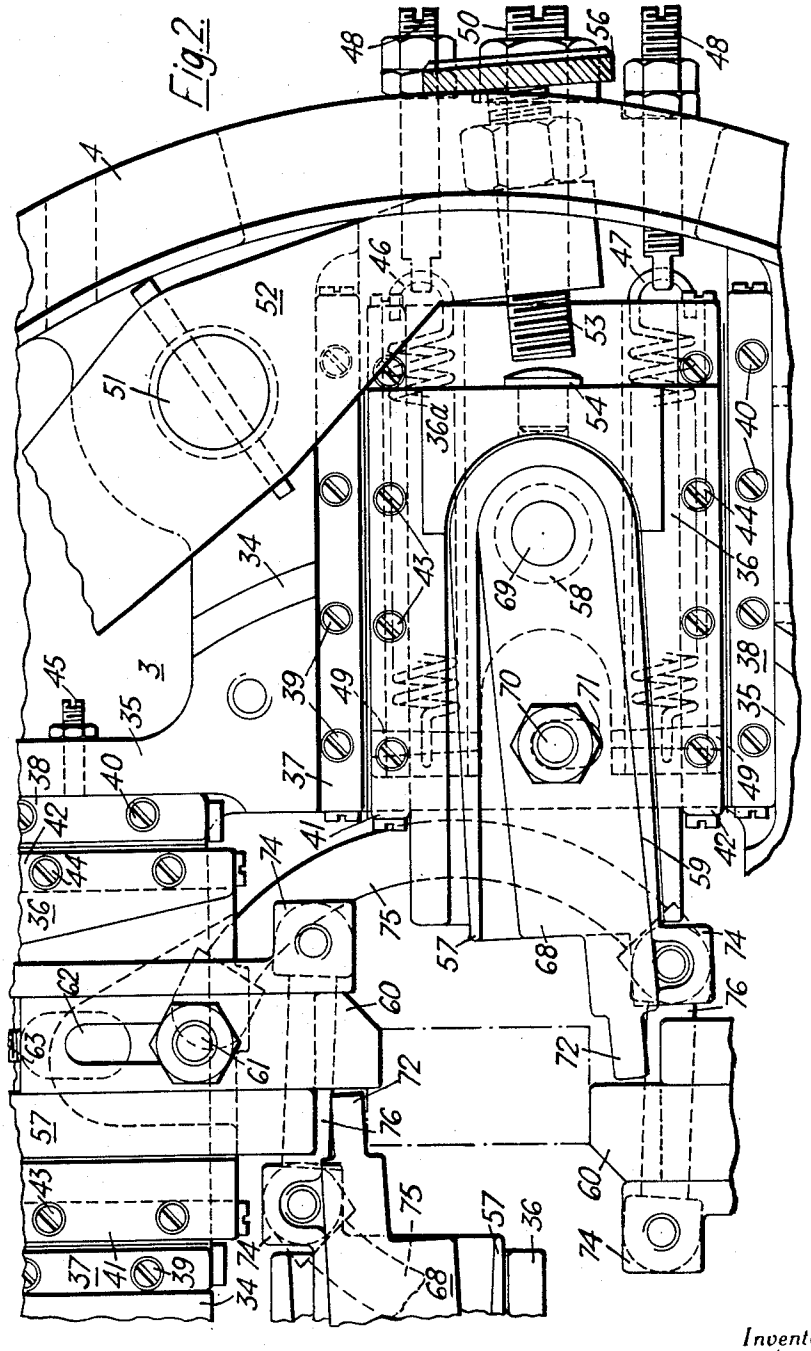
Filed June 4, 1963 3 Sheets-Sheet 2

Fig. 2



Inventor
Ronald Hinds
By
Webb Mackey & Burden
Attorney

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Filed June 4, 1963 3 Sheets-Sheet 3

Fig. 3.

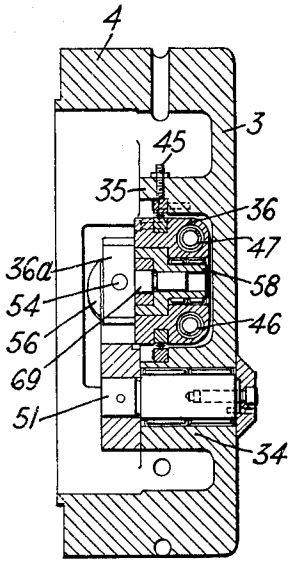
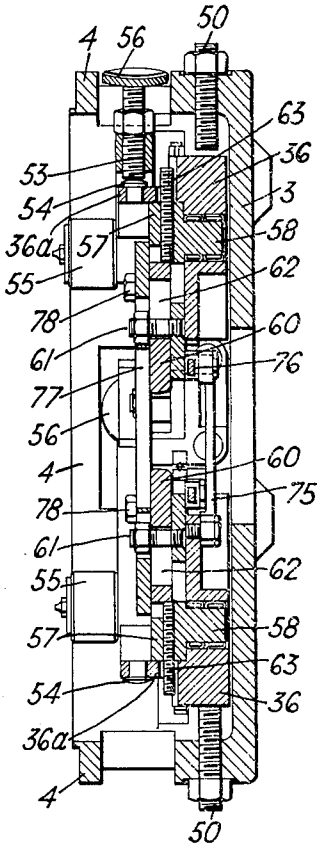


Fig. 4.



Inventor
Ronald Hinds
By
Mackey & Burden
Attorney

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3,212,531

TRANSPOSING HEADS FOR USE IN THE MANUFACTURE OF TRANSPOSED MULTIPLE STRIP CONDUCTOR

Ronald Hinds, Stockton Heath, England, assignor to British Insulated Callender's Cables Limited, London, England, a British company

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9 Claims. (Cl. 140—71)

This invention relates to the manufacture of a known type of transposed multiple conductor of substantially rectangular cross-section, that is to say to the manufacture of a conductor built up of a plurality of component conductors of rectangular cross-section grouped together to form a composite conductor of substantially rectangular form in which the position of each component conductor of the group or, in the case of a composite conductor comprising a core conductor or group of conductors and an outer group of conductors, of each component conductor of at least the outer group, changes step-by-step along the length of the composite conductor so that each component conductor occupies every position in its group in turn.

Each component conductor will normally be a single wire of rectangular cross-section and will hereinafter be referred to as a "wire," but it will be appreciated that the structure of the machine would be substantially the same if each component conductor were built up from two or more strips of rectangular cross-section possibly insulated from each other but operated on by the machine as a single conductor of rectangular cross-section.

Machines for manufacturing such transposed multiple conductors can be broadly divided into two types: a first type in which, if n is the number of wires subjected to transposition (i.e., ignoring any central rectangular core, consisting of one or more wires, not affected by the transposition), then a complete transposition is effected in $2n$ operations and a second type in which transposition is effected in $4n$ operations.

The first mentioned type of machine deals with conductors in which the number of wires as hereinbefore defined subjected to transposition is even and has an operating cycle consisting of two operations only: a first operation in which both outer stacks of wires are moved simultaneously relatively to each other, in opposite directions but always in the same direction as far as each stack is concerned, and by the height of two wires, and a second operation in which a number of wires at each end of the multiple stack equal to one less than the number of stacks is moved transversely simultaneously with an equal number of wires at the opposite end of the multiple stack.

The second type of machine deals with conductors in which the number of wires as hereinbefore defined subjected to transposition is odd and has a cycle consisting of four operations: a first operation in which one outer stack is moved relative to the other outer stack through a distance equal to the thickness of one wire, a second operation in which a number of wires at one end only of the multiple stack equal to one less than the number of stacks is moved transversely, a third operation in which the other outer stack is moved, through a distance equal to the thickness of one wire, in the opposite direction to that in which the first outer stack is moved in the first operation, and a fourth operation in which a number of wires at the opposite end of the multiple stack equal to that operated on in the first operation is moved transversely.

The manufacture of such transposed multiple strip conductor accordingly usually involves a stranding operation in which the bobbins carrying the supplies of wire are

caused to move in a circular orbit around the axis of a forming or closing die into which the wires are led and from which they are drawn off by a capstan or other appropriate haul-off device. The bobbins are constrained to orbit with their respective axes held parallel to a fixed plane (for instance, a horizontal plane) containing the machine axis and the wires, instead of taking a true helical path as in the case of the wires of a circular conductor built up of circular wires, each travel round the conductor closing die axis in a path comprising a succession of short straight portions which are connected by fairly sharp bends involving a forcible bending of the wires at frequent intervals along their lengths, this latter operation having been effected in a transposing head by cam actuated fingers which exert sufficient lateral pressure on the appropriate wire or wires to bend it or them into place as they enter a stationary rectangular closing die.

My Patent No. 3,060,976 relates to an improved form of transposing head that is capable of being used for the manufacture of a range of transposed multiple strip conductors which differ as regards the number and size of the component wires of rectangular cross-section of which they are formed. In that transposing head transposition of the wires of a multiple strip conductor comprising two neighbouring stacks of rectangular section wires or of an outer layer of rectangular section wires around a rectangular core in a multiple strip conductor is effected by means of four movable fingers having ends which are each adapted to engage one of the four component wires at the four corners of the multiple strip conductor. Each finger is mounted in one of a group of four carriers. Two of these carriers, which each carry one of a diagonal pair of fingers (i.e., two fingers for engaging two diagonally opposite corner wires of the conductor), are resiliently held by springs on slide beds extending parallel with two opposite side walls of the closing die of the head so as to be capable of sliding towards and away from and in a plane normal to the axis of the rectangular closing die. The remaining two carriers, which each carry one of a pair of fingers for engaging the other diagonally opposite corner wires of the conductor, are resiliently held by springs on slide beds extending parallel with the other two side walls of the rectangular closing die so as to be capable of sliding towards and away from and in a plane normal to the axis of the die, in a direction at right angles to the direction of sliding movement of the first two carriers. All of these carriers are capable of being lifted off their slide beds at their inner ends so as to pivot about their outer ends in the same sense, i.e., in a direction counter to the direction of transposition. The fingers of one diagonal pair are mounted in their respective carriers so as to be longitudinally adjustable with respect to their carriers; the fingers of the other pair are mounted in their respective carriers so as to be adjustable laterally with respect to their carriers and each of the four fingers is adapted to be positively impelled along its slide bed towards the closing die axis and against the pull of its retaining spring by a rotatably driven ring cam acting on the carriers through means permitting adjustment of the "lift" imparted by the cam to each carrier to suit the height or width of the component wires to be transposed.

By providing for longitudinal adjustment of the one pair of fingers the distance between the ends of these fingers can be adjusted to an infinitely variable extent within limits to suit not only a variation in the stack height due to a change in the number of wires in the stack but also those due to changes in the thickness of the rectangular wires or strips in the stack. By providing for lateral adjustment of the other pair of fingers in their carriers similar adjustment can be made of the distance in the direction of the height of the stack between the notched ends of that other pair of fingers.

By the present invention I provide a head which is a modification of the head forming the subject of my above-mentioned patent and which, as will be explained later, presents certain advantages over that head.

My modified form of transposing head is for use in machines of the second type referred to above and instead of there being four carriers resiliently held on slide beds so as to be capable of rectilinear reciprocating motions and of pivoting about their outer ends, there are four carriers, each of which is at its outer end pivotally attached to a carrier base which is constrained to move in a rectilinear direction parallel to two of the four side walls of the closing die. Each carrier base is spring biased in a direction away from the centre of the head and counter to the direction of movement imposed upon it by the rotating ring cam. Links are provided for interconnecting the carriers and/or carrier bases in such a way that cam imparted inward movement of one carrier and its base designed to displace one stack of wires relative to the rest, or to displace one wire or one layer of wires transversely of the multiple stack, causes the finger mounted in the carrier to engage the appropriate part of an end of the stack, or the wire or layer of wires to be displaced, as the case may be. The links also ensure that, during such cam-imparted movement of one finger, the next adjacent finger is caused to move outwards automatically to permit the transposition to take place instead of remaining until pushed aside by the stack, or by the wire or layer of wires itself.

The invention will be further illustrated by a description by way of example of a modified form of transposing head. Since the modifications only apply to the part of the head referred to in our above-mentioned patent as the "cover," the modified cover only will be described, this cover being designed to fit on to a base identical with that described with reference to FIGURES 1 and 2 of the specification of my above-mentioned patent. The modified cover will be described with reference to the accompanying drawings in which:

FIGURE 1 is a view of the cover equivalent to the view shown in FIGURE 4 of our above-mentioned patent.

FIGURE 2 is an enlargement of part of FIGURE 1,

FIGURE 3 is a sectional elevation in the direction of the arrow on line III—III in FIGURE 1 and

FIGURE 4 is a sectional elevation in the direction of the arrow on line IV—IV in FIGURE 1.

For the sake of clarity, in FIGURE 1 reference numerals are attached to the main parts only.

As described by way of example in my above-mentioned patent, the cover comprises an annular end wall **3** with a circumferential extending wall **4** upstanding from its outer peripheral edge and projecting therefrom in the direction of the movement of the wire. The wall **4** is adapted to make joint with the wall **2** of the base shown in FIGURES 1 and 2 of the specification of my above-mentioned patent and is adapted to be secured thereto by studs extending through bolt holes **5** into correspnding tapped holes in the base.

The annular wall **3** of the cover is formed with four pairs of integral upstanding walls each comprising a thicker wall **34** and a thinner wall **35**. Each pair of walls forms a channel of rectangular cross-section extending across the face of the annular wall **3**. As will be seen from FIGURE 1, there are two vertical channels and two horizontal channels and the centre lines of these channels are not diametrically located with respect to the peripheral wall **4**. The two vertical channels are offset one on each side of and equal distances from the vertical diametrical plane and the two horizontal channels are offset by equal distances from a horizontal diametrical plane, the horizontal channels being offset through a greater distance above and below the horizontal plane than the vertical channels are from the vertical plane.

In each channel is a channel shaped carrier base **36**, the cross-sectional shape of which can readily be seen from

FIGURE 3. To reduce sliding friction of the carrier bases to a minimum, each carrier base **36** is mounted in a channel formed by walls **34** and **35** between two sets of crossed roller linear bearings such as are manufactured and sold by the firm of W. Schneeberger A.G. Each bearing comprises a fixed part **37**, **38** (FIGURE 2) attaached by screws such as **39** and **40** to the channel walls **34** and **35** respectively and a moving part **41**, **42** (FIGURE 2) attached by screws such as **43** and **44** to the carrier base **36**. The bearings are adjustable by means of studs **45** (FIGURE 2) passing through the walls **35**.

The carrier bases **36** are spring biased in a direction away from the centre of the head, each by a pair of parallel tension springs **46** and **47** secured to the peripheral wall **4** by threaded hooks **48** and secured to the carrier base by pins **49** (see FIGURE 2). As will be seen from FIGURE 3 the springs run freely in bores in the carrier bases **36**. The extent of movement of each carrier base under the action of the springs **46** and **47** is limited by a positive adjustable stop **50**, best seen in FIGURE 4, to limit the extent of outward movement thus relieving the carriers pivotally attached to their respective carrier bases of shock loads leading to excessive wear and even breakages.

The thicker side walls **34** of the channels support through needle roller bearings pivot pins **51** for rocker arms **52**. At one end of each rocker arm is an adjustable pin **53** adapted to bear on a button **54** in an upstanding part **36***a* of the corresponding carrier base **36** and at the other end is a freely mounted roller **55** which rides on the external surface of a ring cam in the base of the casing, that is the ring cam **23** described in the specification of my above-mentioned patent.

To facilitate adjustment of the pins **53** they are provided with knurled heads **56** projecting through apertures in the peripheral wall **4** of the cover. As each roller **55** is lifted in succession by the cam, the pin **53** bears against the button **54** and moves the carrier base **36** inwards towards the axis of the head, against the tension of the springs **46** and **47**. In FIGURE 1 this action is shown occurring in respect of the upper of the vertically moving carrier bases **36**.

A U-shaped carrier **57** which is channel shaped in cross-section (as seen in FIGURE 3) is pivotally mounted on each of the carrier bases **36** by means of a tubular pivot pin **58** running in roller bearings within a bore in the carrier base **36**. As will clearly be seen in FIGURE 1, the carriers **57** can pivot freely through a limited angle with respect to the carrier bases, the extent of their movement being limited by contact as at **59** (FIGURES 1 and 2) between the carrier and a wall of the carrier base **36**.

The two vertically extending carriers **57** each support a finger **60** fitting in the channel in the carrier and held in the channel by a set screw **61** passing through a slot **62** in the finger into a threaded bore in the carrier. By slackening the set screws and manipulating adjusting screws **63**, passing through threaded bores in the carriers **57** (as best seen in FIGURE 4) a fine longitudinal adjustment of the position of the fingers **60** with respect to the carriers **57** can be made.

In the two horizontally extending carriers **57** are mounted a pair of fingers **68** secured to the carriers by pivot pins **69** and set screws **70**, passing through vertical slots **71** in the fingers into threaded bores in the carrier. In the drawings these slots are masked by lock nuts on the set screws but one of the slots **71** can be clearly seen in FIGURE 2. The angle which the fingers **68** make with respect to the direction of movement of the horizontally extending carriers **57** can be adjusted by moving the fingers about the pivot pins **69** after slackening the set screws **70**. It will be seen that the extremity **72** of each of the fingers **68** is formed with a notch on each side and it is the shoulder formed by one of these notches that engages the edge of the wire that is to be moved transversely across the stack. The extremity **72** presses on the

wire being transposed to inhibit vertical separation of the wires.

The fingers **68** can be removed from the pivot pins **69** and turned over, to increase the range of adjustment of the position of the extremities **72** of the fingers with respect to the centre of the die aperture, which is shown chain dotted at **73** in FIGURES 1 and 2. The fact that there is a notch on each side of each of the extremities **72** ensures that the finger when properly adjusted functions in the same way after being turned over.

Each of the carriers **57** is formed at its inner end on one side with a lug **74**, to which is pivoted a link interconnecting the carrier to one other carrier. There are four links in all, two long links **75** extending substantially vertically and two short links **76** extending substantially horizontally. The links **75** are each coupled at one end to one of the horizontally moving carriers **57** and at the other end to one of the vertically moving bases **36**.

In this arrangement, instead of each finger for displacing one stack of wires relative to the other stack being coupled by a link between the carrier of that finger and the carrier of the finger engaging the opposite end of the same stack, as described in the specification of my above-mentioned patent, it is coupled by a link **75** between the carrier base to which the finger carrier is pivotally coupled and the carrier of the finger engaging the opposite end of the stack. The advantage of this arrangement is that these links can be longer with the result that when the fingers to which these longer links are coupled are successively pushed over in a direction transverse to the length of these longer links to displace a wire from one stack to another, their lifts due to the restraint imposed by the longer links are less than in the head described in my above-mentioned patent. This reduction in lift is of especial value when dealing with component conductors of considerable width, for instance ½" wide strips. A further advantage obtained from the alternative arrangement described is that the cam actuated sliding movement of any one carrier of a finger engaging one wall of the conductor and the resulting pivotal movement imparted to the adjacent carrier of the finger engaging an opposite wall of the conductor, do not influence the two remaining carriers. Yet another advantage is that it enables the obliquity of the linkage to be reduced so that the motion of the fingers more closely approximates to a linear motion.

The fingers are protected by an annular plate **77** shown in situ in FIGURE 4 but removed in all other figures. It is secured to the upstanding walls **34** and **35** by bolts **78** fitting in threaded holes such as **79**.

It will be seen that by slackening the set screws **61** to enable the fingers **60** to be moved longitudinally and by slackening the set screws **70** to enable the fingers **68** to be rocked about their pivot pins **69**, a wide range of adjustment to the fingers can be made, to adapt the extremities of the fingers to conform to a variety of die sizes. When a greater adjustment is required than can be obtained in this way in respect of the positions of the extremities **72** of the fingers **68**, since the extremities of the fingers are asymmetrical with respect to their longitudinal centre lines and a notch is provided on each of the two corners of the extremity, such adjustment can be effected by removing one or both of the fingers **68** from the horizontally extending carriers **57** and turning them over.

The main advantage of the modified form of transposing head in accordance with the present invention over the head which is the subject of my above-mentioned patent, is that the rocking and reciprocation motions of the carriers are segregated and wear of moving parts is reduced by arranging for the biasing springs to act on and in the direction of movement of the respective carrier bases with which they are associated. This also reduces wear on the pivoted fingers and the links connecting them for, when these are pushed over by force transmitted via the links, there is no spring force to be overcome.

What I claim as my invention is:

1. For the manufacture of transposed multiple strip conductors of substantially rectangular cross-section, a transposing head comprising

(a) a rectangular closing die,

(b) a rotatably driven ring cam,

(c) four movable fingers having ends each adapted to engage one of the four component wires of the four corners of the conductor,

(d) a group of four carrier bases,

(e) means for constraining each carrier base to move in a rectilinear direction towards and away from and in a plane normal to the axis of the closing die,

(f) spring biasing means urging each carrier base away from the die axis,

(g) means for positively impelling each carrier base against the biasing means towards the die axis driven by the ring cam and acting on the carriers through means permitting adjustment of the movement imparted by the cam to each carrier base,

(h) a group of four carriers in each of which one of the fingers is mounted, two of the carriers for one diagonal pair of fingers for engaging two opposite corners of the conductor each being at its outer end pivotally attached to a carrier base which is constrained to move parallel to two opposite sides walls of the die, the other two carriers for the other diagonal pair of fingers each being at its outer end pivotally attached to a carrier base which is constrained to move in a direction at right angles to the direction of movement of the first two carriers,

(i) means for longitudinally adjusting the fingers of a first diagonal pair with respect to their carriers and laterally adjusting the fingers of the other (second) pair with respect to their carriers, and

(j) links interconnecting the carriers and carrier bases in such a way that an inward movement of each carrier and its base imparted by the ring cam and designed to displace at least one wire relative to the rest causes the finger mounted in the carrier to engage the appropriate part of the multiple strip conductor.

2. A transposing head as claimed in claim **1** in which the links are of such a length that during movement towards the die axis, imparted by the ring cam, of any of the fingers the next adjacent finger is moved automatically away from the die axis to permit transposition to take place.

3. A transposing head as claimed in claim **1** in which the links consist of a pair of links each linking the carrier for one of said first pair of fingers with the carrier for one of said second pair of fingers and a pair of longer links each linking a carrier base of one of said first pair of fingers with a carrier of one of said second pair of fingers.

4. A transposing head as claimed in claim **1** which comprises a group of positive adjustable stops limiting the movement of each carrier base under the action of the biasing means.

5. A transposing head as claimed in claim **1** in which the biasing means for each carrier base comprises a pair of tension springs each acting in a direction parallel to the direction of movement of the carrier base.

6. A transposing head as claimed in claim **1** in which each carrier base is mounted in the head between two sets of crossed roller linear bearings.

7. A transposing head as claimed in claim **1** in which the extremities of the fingers which are laterally adjustable with respect to their carriers are notched to provide a shoulder which engages the edge of a wire or layer of wires to be transposed and a surface to engage that face of the wire which is parallel to the direction of transposition.

8. A transposing head as claimed in claim **1** in which the fingers adjustable laterally with respect to their car-

riers have extremities which are asymmetrical with respect to their longitudinal centre lines and are capable of being used in a turned over position such that the spacing of their extremities from the axis of the die is changed.

9. A transposing head as claimed in claim **8** in which both corners of the extremities of each of the two fingers having asymmetrical extremities are formed with notches.

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CHARLES W. LANHAM, *Primary Examiner*.