

[54] **ELECTRO FORMED ELECTRICAL CONNECTOR PROCESS**

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1968, abandoned.

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317/101 C, 204/3.16

[51] Int. Cl.**H02g 15/00**

[58] Field of Search**29/624-630, 18-26,**
29/204, 117, 126, 174, 339, 307, 204, 425,
9, 212, 120, 68.5, 218, 101, 16, 3

[56] **References Cited**

UNITED STATES PATENTS

2,889,258 6/1959 Fialkoff204/9

2,955,351 10/1960 McCreadie174/68.5
3,325,881 6/1967 Engelking204/9 X
3,465,435 9/1969 Steranko174/68.5 X

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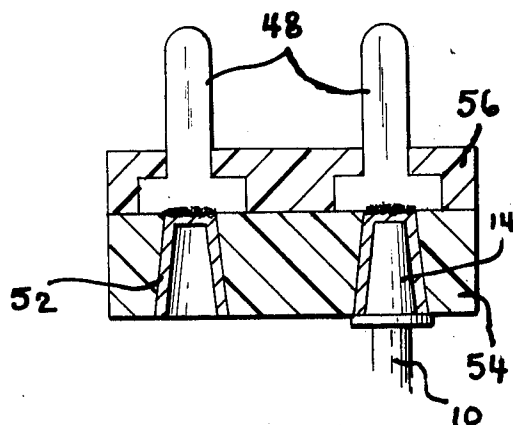
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[57] **ABSTRACT**

Method and means are disclosed wherein electrical connector elements are formed by electro-plating conductive material onto a passive metal mandrel with an insulating material then being molded about the plating with the mandrel being withdrawn. Selective plating of precious metal only where needed, as within a receptacle, is achieved directly in forming the element.

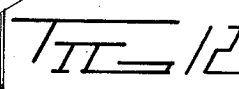
7 Claims, 13 Drawing Figures



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SHEET 1 OF 2



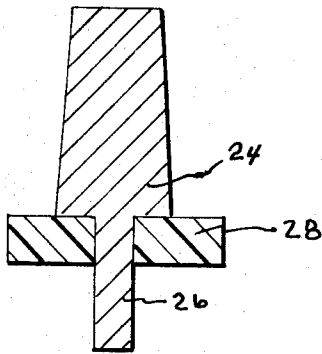


FIG 3

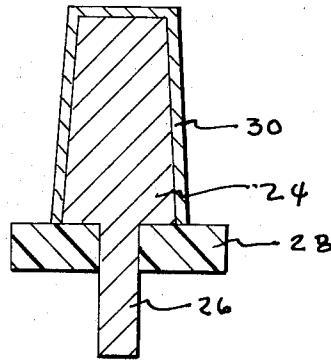


FIG 4

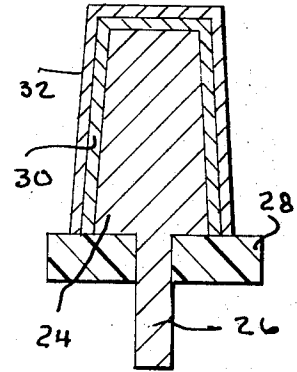


FIG 5

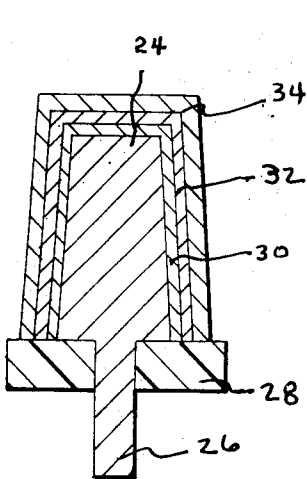


FIG 6

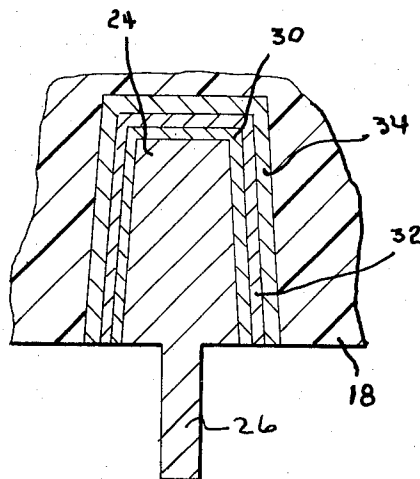


FIG 7

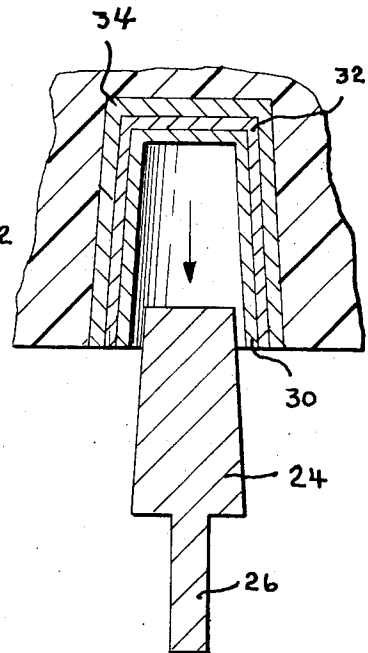


FIG 8

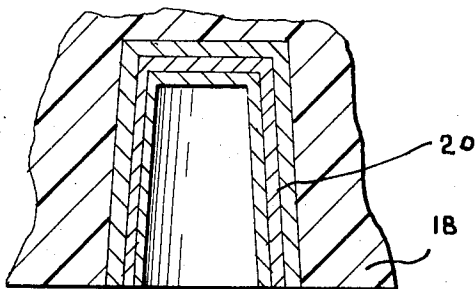


FIG 9

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ELECTRO FORMED ELECTRICAL CONNECTOR PROCESS

This is a continuation of U.S. application Ser. No. 722,297, now abandoned.

BACKGROUND OF THE INVENTION

Electrical connectors are usually comprised of mating parts which are manufactured by and large through a process resulting in a metallic body having at least some portion thereof plated to define a contact surface with at least one of the parts carried in an insulating body. Typical manufacturing processes include screw machining and stamping of metal stock to form a part body which is then plated. Typical plating processes call for a first plate of relatively hard metal such as nickel with a finished plate of gold or silver which serves to resist the build-up of oxides or films which cause deterioration of the interface between mated parts. As the trend toward miniaturization of connectors has continued, these various processes have been refined to a point where production tolerances on the order of several thousandths of an inch are common. Response by industry to this trend to smaller and smaller parts, however, has not been achieved without considerably adding to the cost of production, and in some respects, to a loss in part performance and reliability. For one thing, production of acceptable parts has been achieved with a substantial increase in rejection rate and scrap, a greater proportion of the parts made by screw machine and stamping and forming techniques being unsatisfactory. Another problem has been experienced with respect to providing an adequate plating of the small parts, the size of the parts making high speed plating techniques as by use of a carrier passed through a plating solution almost impractical. Many other problems have arisen relative to handling the very small parts and mounting such parts in supporting insulating blocks. The forming of insulating blocks having very small apertures to receive such elements is, in itself, a very substantial problem; the molding of plastics to very small tolerances being even more difficult than the forming of metal parts by screw machining or stamping and forming.

SUMMARY OF THE INVENTION

The present invention relates to a method and means of forming electrical connectors and particularly to a method and means for forming very small electrical connectors.

It is an object of the invention to provide a method and means for manufacturing electrical connectors which are physically so small as to make impractical the use of standard manufacturing techniques including screw machine or stamping and forming of metal stock. It is another object to provide a novel method and means for forming very small connector elements to substantially reduce the need of handling such elements during production and assembly into a functional device. It is still a further object of the invention to provide a method of forming plated electrical connector devices to yield a reliable connector device with a minimum use of material.

The foregoing objectives are achieved by the present invention by forming connector elements through an electro-forming process wherein a composite connector structure is built-up through electro-plating metal

layers onto a mandrel with the resulting plating structure then being positioned within a mold and plastic injected thereabout to form a connector block containing such structure. The mandrel is then removed to leave the connector structure permanently secured within the plastic medium and, upon withdrawal of molded plastic parts from the mold, to provide a finished connector device. In a further embodiment an electro-formed connector receptacle is caused to join connector elements made by other techniques to extend the utility of the invention through an association with elements having other functions such as, characteristics to facilitate termination by solder or Wire-Wrap techniques or through spring contact members.

In the drawings:

FIG. 1 is a perspective view of a terminal block connector providing an interconnection between a plurality of electrical leads by connector receptacles formed in accordance with the invention;

FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1;

FIGS. 3—9 are sectional views showing the method of the invention in various steps to form the connector receptacle shown in FIGS. 1 and 2;

FIG. 10 is a perspective view showing a connector receptacle including a tab structure in accordance with another embodiment of the invention;

FIG. 11 is a perspective view of a connector block having a connectors like that shown in FIG. 10 mounted in a plastic body member;

FIG. 12 is a perspective view of a connector block containing connector receptacles joined to terminal posts and springs in accordance with another aspect of the invention; and

FIG. 13 is a sectional view taken along lines 13—13 of the structure shown in FIG. 12.

DESCRIPTION OF THE PREFERRED INVENTION

Referring now to FIGS. 1 and 2, rows of electrical leads 10 are shown as terminated to each other through a connector block 18. The leads 10 may be considered to be comprised of a conductive center core of solid or stranded conductive material surrounded by an insulating sleeve. Each of the leads is terminated by a connector element 12 in the form of a taper pin having a forward tapering contact portion 14 and a rear sleeve portion 16 which is either crimped or soldered to the core of lead 10. The block 18 is of insulating material and contains rows of mating connector elements in the form of taper pin receptacles 20 dimensioned to receive the connector elements 12. Receptacles 20 are formed of conductive material so that an interconnection is provided between a given lead 10 and a given receptacle by plugging the connector element 12 into a receptacle. As shown in FIG. 2, a conductive element in the form of a wire 22 is made to link pairs of receptacles to provide an interconnection therebetween. The connector structure shown in FIGS. 1 and 2 will thus provide an interconnection between pairs of leads 10 through the insertion of pairs of taper pin connector elements into receptacles.

In the micro-miniature size range, it is the receptacle that is particularly difficult to form by standard techniques such as screw machining or stamping. The receptacle is also difficult to plate and to handle for as-

sembly into a connector housing such as a block of insulating material. In accordance with the invention concept, a receptacle like 20 shown in FIGS. 1 and 2 can be made without relying upon the usual manufacturing procedures through a process which is, in order of step, the reverse of usual procedures. FIGS. 3-9 depict the invention process and concept and in a number of steps which result in a receptacle 20 secured within an insulating block.

In FIG. 3, element 24 may taken to represent a core pin or mandrel which can be considered as approximately 10 times actual size. The upper portion of mandrel 24 has a tapered surface configuration defining the final interior configuration of a mating receptacle. A lower projecting portion shown as 26 is included to facilitate handling of the mandrel and positioning of a plastic disc 28 thereon which serves as a mask. The mandrel is preferably of a material which is passive to the plating solution used. Stainless steel is one such material which is passive to gold. The surface of the upper portion of the mandrel 24 is preferably polished as it is this surface that will determine the surface characteristics of the finish plate of the receptacle. In accordance with the invention, a mandrel assembly like that shown in FIG. 3, is positioned within an electroforming bath containing a desired plating solution for the finish plate of the receptacle. This plate may be considered as a suitable precious metal such as gold, silver, rhodium, palladium or the like. FIG. 4 depicts the mandrel containing thereon a finish plate 30 of said precious metal to a suitable thickness, the thickness being somewhat enlarged in relative dimension for clarity. Actual finish plate thicknesses may range from 15×10^{-6} to 200×10^{-6} of an inch. The assembly plated as shown in FIG. 4 is then further plated to provide a supporting structure for the plating 30 to lend strength to the receptacle. The assembly as shown in FIG. 5 represents the addition of a second plating 32 and FIG. 6 shows the assembly having a third plating 34 thereon. Plating materials such as copper or nickel are suitable and a combined plating thickness for plates 32 and 34 may be on the order of 1×10^{-3} to 5×10^{-3} of an inch. In the foregoing example 32 may be taken to be nickel and 34 may be taken to be copper, the nickel providing a hard barrier for the finish plate and the copper providing body to the composite plated structure. During the foregoing steps disc 28 serves to prevent plating from flowing around the lower edge of the forward portion of the mandrel 24 so as to preclude withdrawal of the mandrel from the composite plating structure at an appropriate time.

As a next step, the disc 28 is removed with the mandrel carrying the composite plating structure thereon jigged into a cavity mold with plastic of suitable insulating and/or dielectric characteristics then being closed about the composite plating structure to form a connector body or block 18. FIG. 7 shows this step as completed. It is contemplated that both thermoplastic and thermosetting plastic materials may be employed. Next, after the plastic has sufficiently hardened, mandrel 24 is removed in accordance with the view shown in FIG. 8 to leave a finished receptacle 20 having a configuration as shown in FIG. 9.

The structure shown in FIG. 9 can be made in multiple and can be made quite small, limited only by the

need for providing a rigid mandrel. Receptacles like that shown in FIG. 9 can be placed on extremely small centers. In the embodiment shown in FIG. 2, pairs of receptacles 20 are interconnected by a wire shown as 22. In accordance with the invention, the wire 22 may be placed around the plating 34 and soldered thereto prior to injection of plastic material about the receptacle. Patterns of receptacles may be interconnected in this manner if desired. As an alternative, a wire 22 may be placed around a mandrel plated as shown in FIG. 2 with the connection to the composite plating made through plating over the wire with the final plate 34. Alternatively, a wire or some other conductive structure such as a foil can be cut to the proper configuration and placed over the plating shown as 34 with a subsequent electro-plate applied to electrically and mechanically connect the receptacles to the wire or other conductive structure.

In the foregoing method the mandrels may be initially arranged in the form to be molded into a finished product and plated simultaneously or the mandrels may be plated loose piece in a production plating jig and then later utilized in different members and arrangements in different molding jigs as the need arises.

FIGS. 10 and 11 depict an alternative embodiment of the invention shown as a receptacle 40 formed to include an extension shown as 42 at the top thereof. The extension 42 may be formed by providing an extension on the mandrel extending from the base thereof to facilitate plating build-up out over the extended portion. Receptacles 40 may be secured within a connecting block 44 and in a manner shown in FIG. 11. It is to be observed that the six receptacles 40 disposed to the left end of the block have the extensions 42 thereof disposed inwardly. This would facilitate termination as by soldering or welding the leads of an electrical or electronic component mounted on block 44. It is also contemplated that the receptacles may be oriented in a different manner to better facilitate termination to components of other configurations including those which are square or circular, etc. The receptacles 40 shown to the right end of the block are oriented with the extensions 42 thereof extended outwardly in order to show the functional capability of the invention concept.

FIGS. 12 and 13 show an alternative embodiment of the invention in a connector block 46 made to include different types of terminals such as posts 48 and spring receptacles 50. These terminals are interconnected to receptacles 52 which may be considered as identical to the receptacles 20 heretofore described. From FIG. 13, the block 46 may be seen to be comprised of a pair of elements 54 and 56. The lower element 54 may be considered as being comprised of plastic material molded about receptacles 52 in the manner described with respect to FIG. 2. The upper element 56 may be considered as comprised of plastic sheet material molded or punched out to receive terminals 48 and 50 which are affixed therein in any suitable manner. In accordance with the invention concept, element 54 is prepared by grinding or abraiding to expose the upper ends of the receptacles 52 which are plated with tin or some solder material. With element 56 positioned down against the element 54 with the terminals bearing against the ends of the receptacles 52, heat may be ap-

plied through the terminals or through the receptacles or some other suitable fashion to cause tin or solder flow electrically commoning the receptacles to the terminals. In this manner the utility of the invention may be extended by providing an interconnection to standard connector and terminal configurations. For example, the posts 48 may be of the size and configuration to be plugged into contact spring receptacles or made to serve as solder posts. Posts 48 may be given characteristics to receive the application of Wire-Wrap or clip type terminations of leads thereto. The contact spring members 50 may be of the size to receive standard posts inserted therein, in turn, connected to component cards, components, or individual leads. It is, of course, contemplated that the various terminals 48, 50 may be of other configurations and, may in fact, be either large or smaller depending upon the particular functional use of the connector device. It is also contemplated that terminals like 48 and 50 may be joined to the receptacles 52 prior to molding block 56 as by soldering with the elements 54 and 56 formed of a one piece molding of plastic about the joined terminal structures.

While the invention has been illustrated in relation to a taper pin receptacle, other configurations are contemplated. Receptacles, pins, posts, strips and the like of other shapes having terminal or connector function may be made utilizing to advantage the concept of the invention of selective plating of precious metal, as long as the terminal configuration facilitates release of the plating mandrel.

Having now disclosed the invention in terms intended to enable preferred practice thereof in its various modes, claims are appended which are intended to define what is inventive.

I claim:

1. The method of forming electrical connectors comprising the steps of plating a mandrel, having the configuration of the desired contact shape with a given conductive material to a thickness providing structural integrity, said mandrel being of a material passive to the plating solution, placing a conductive member on the mandrel plating to extend away from the mandrel, and plating over the conductive member and mandrel plating to secure them together.

2. The method of claim 1 further including molding plastic about the plating and conductive member to secure them therein and then withdrawing the mandrel from the mandrel plating.

3. The method of claim 1 including repeating the said steps on at least an additional mandrel and then inter-

connecting all of the conductive members.

4. The method of claim 3 including molding plastic about the platings and conductive members to secure them therein and withdrawing the mandrels from the mandrel platings.

5. The method of forming electrical connectors comprising the steps of plating a mandrel having the configuration of the desired contact shape with given conductive material to a thickness providing structural integrity, said mandrel being of a material passive to the plating solution securing a further connector to the plating on the mandrel, molding plastic material about the plating while on the mandrel and a portion of the further connector to expose the free end of the connector and withdrawing the mandrel from the plating.

6. The method of claim 5 wherein the step of securing the further connector to the plating comprises placing the connector on the plating and further plating over the connector and plating on the mandrel.

7. The method of making a connector assembly comprising an insulator block assembly containing plural metallic male terminals freely extending from one side thereof and a plurality of axially aligned cup-shaped female receptacles exposed on the opposite side of said block assembly, and each said receptacle respectively butt joined to a said respective male terminal comprising the steps of: providing a material passivated mandrel having plural conical protuberances freely extending from one planar surface thereof, forming plural cup-shaped self-sustaining receptacles on said mandrel by locally plating said protuberances to a sufficient thickness, molding insulator materials over and between said receptacles by using the unplated planar surface of the mandrel as a mold surface and solidifying said material, exposing the outer surface of the bottom of each cup by removing said insulator material to leave a substantially planar insulating surface opposite to the surface formed by the mandrel surface, removing the mandrel leaving the receptacle in said solidified material, forming another insulator with a plurality of male through terminals extending freely beyond one surface thereof and substantially flush with the opposite surface and each terminal arranged to coincide with the orientation of a respective cup bottom outer surface, butting the male terminal containing insulator and the female receptacle containing insulator with the exposed outer surface of the cup-shaped bottom of the receptacles in bonding relation with the respective terminal of the flush surface of the male insulator, and bonding the butted terminals and receptacles together.

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