An electrical connector wire-wrap module for permitting electrical access from either the front or the rear of a high contact density miniature connector to each of the contact tails of the connector by one or more relatively low-gauge, wire-wrap connections affixed to one or more of a plurality of wire-wrap terminal posts arranged in a relatively low density configuration on a printed circuit board in close juxtaposition to the connector. The connector and wire-wrap posts are affixed to the printed circuit board with the relatively fragile, closely spaced contact tails of the connector extending from the upper to the lower surface of the board through apertures in the board. The wire-wrap terminal posts are in turn arranged in a low density configuration around the periphery of the connector and also extend through apertures in the board with sections of each post being well above and well below the board surfaces to permit relatively low-gauge, wire-wrap connections to be made thereto either frontwardly or rearwardly of the connector. The tails of the connector contacts are electrically coupled to specified ones of the wire-wrap posts by means of conductive circuit paths carried on the lower surface of the printed circuit board, each path terminating in an apertured conductive terminal pad aligned with one of the apertures through which the contact tails and terminal posts extend with solder bridges electrically connecting the pads with their associated contact tails or terminal posts.

3 Claims, 10 Drawing Figures
ELECTRONIC CIRCUIT ASSEMBLIES AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

With the increase in the number of electrical connections associated with modern communication, miniature multiple-contact connectors have gained acceptance for use in installations where space is limited. These contacts usually include polarized mating sections such as a plug and a receptacle, each having a multiplicity of small, closely spaced metallic contacts as well as mechanical means for securing a flange on the connector to insulators, plug boards and the like. The contacts are each formed to include a yieldable blade or active portion for engagement with an external contact, a mounting shank, and a terminal portion or contact tail. A section of each contact tail extends a short distance vertically below the base plate of the connector housing and is adapted for external connection to a lead-in wire or other form of electrical conductor by soldering, crimping or the like.

A plurality of these contacts are arranged in one or more rows within the connector shell with minimum spacing being provided between adjacent contacts in order for a maximum number of contacts to be located in the connector. Illustratively, a connector may have as many as 50 individual contacts physically and electrically separated by a dielectric insert and enclosed within a small metallic shell having an outer dimension in the order of about $3 \times \frac{3}{8} \times \frac{3}{8}$ inches. The contacts are arranged in a high density configuration with spacing between the adjacent flat blade portions being in the order of about 0.040 inches.

Recently, increased importance has been placed on adapting the small, closely spaced contacts of the miniature connectors for connection to external conductors by a wire-wrapping technique. As described in detail in U.S. Pat. No. 2,759,166 issued to Mallina, one form of wire-wrapping technique now widely known in the electronic art consists essentially of winding several turns of the stripped end of a flexible insulated wire around a rigid, sharp-edged terminal or "post" so that the sharp edges of the post impinge into convolutions of the wire enough to hold the wire in position on the post and establish an intimate, low-resistance, gas-tight, electrical contact without the need for solder.

While the small tail sections extending from the miniature connector can be configured to accept wire-wrap connections, their small size is an inherent limitation. In some industrial standards for wire-wrapping, the amount of torque required to wrap several turns of a wire under a high degree of tension is greater than many of the small tail sections can withstand without permanent distortion or destruction. In addition, it is frequently desirable to connect several individual conductors by the wire-wrap technique to one connector contact and this requires a contact tail length usually much greater than that which will at the same time afford sufficient rigidity to accept the required wire-wrapping torque and not cause distortion of the contact tail.

Another problem with the high density configuration of contacts in the miniature connector is the very limited spacing between adjacent contact tail sections for wire wrapping. To illustrate, 50 contact, miniature connectors may have approximately 0.030 inches available on each side of a contact for wire wrapping a tail section of about 0.025 inches per side of a square cross section. Although a single wire can be wire wrapped on each tail section, in some instances the outer surfaces of the resultant adjacent wire wrappings are so close that mechanical vibration of the connections can cause electrical shorting between adjacent contacts. It becomes necessary to provide insulation on the wire, thus requiring smaller wire of about 26 gauge in order to join the wire-wrap connections without electrical shortings. Therefore, the miniature connectors are not always adaptable for wire wrapping with larger diameter wire (lower gauge).

Also, it is often desirable to have access to individual contacts from the front of the miniature connector for test or other purposes without disconnecting the mating sections of the connector. Since the individual blade and shank portions of the contacts are hidden by the outer metallic shell of the connector and the exposed tail sections are on the rear of the connector, access to the individual contacts from the front of the connector is therefore difficult. In addition, the close spacing of the exposed tail sections even if extended to the front of the connector, would generally prohibit access to each of the individual contacts.

Therefore, the development of new miniature connector assemblies is commercially important. It is also desirable that the miniature connectors utilized with wire-wrap connections retain the close spacing between contacts and other characteristics which make them adaptable for coupling with other miniature, standardized mating sections.

SUMMARY OF THE INVENTION

This invention is directed to a miniature connector assembly comprising a miniature high density connector having a plurality of contacts, the spacing between adjacent contact tails being so close as to obviate the use of wire-wrap connection techniques. The assembly includes a printed circuit board on which the miniature connector is mounted and a plurality of wire-wrap terminal posts are arranged on the board in a low density configuration around the periphery of the connector and accessible both from the upper and lower sides of the board. Advantageously, the contact tails of the connector are electrically coupled to specified wire-wrap posts by means of conductive circuit paths carried on the board.

The invention is also directed to the manufacture of the miniature connector assembly in which both portions of the terminal posts adapted for wire wrapping and the miniature connector are protected during the formation of solder bridges which electrically interconnect the terminal posts via the circuit paths with the contact tails. In the completed assembly, the wire-wrap terminal posts are sufficient in size to withstand the higher torques necessary during wrapping of a lower gauge wire conductors and are capable of being wrapped with a plurality of separate conductors. In addition, the assembly provides front access to one or more contacts in the miniature connector without disconnecting the mating sections of the connector. Also, the board serves as a convenient support for rigidly mounting one or more of the miniature connectors in a larger housing for permanent installation.

The assembly in accordance with the present invention is manufactured from a sub-assembly comprising an electronic circuit board having a pattern of conduc-
active circuit paths and corresponding terminal pads of high conductivity metal on at least one side of a circuit sheet of dielectric material, at least one miniature connector mounted on the upper side of the board with its terminal or tail portions extending through apertures in the board to the lower side thereof and in juxtaposition with predetermined ones of the terminal pads and a plurality of electrically conductive wire-wrap terminal posts frictionally mounted or otherwise affixed in other apertures in the board, each terminal post being in close juxtaposition with a predetermined terminal pad or pads of the conductive circuit. Each terminal post has an elongated section extending from the side of the board opposite to that on which the multiple contact connector is positioned and shaped to have at least two flat longitudinal surfaces meeting at an abrupt edge for connection by wire-wrap techniques to one or more lead-in wires.

The manufacture of the assembly is carried out by applying a protective mask over the lower portion of each of the post sections to a height below the lower surface of the board and terminal pads, applying molten solder from below the board to the unmasked post sections, terminal pads and contact tail sections together with the masked post sections to form electrically conductive solder bridges between the wire-wrap terminals, terminal pads, and contact tail sections, and applying a cleaning material from below the board to each of the masked post sections to remove the mask and expose underlying abrupt edges adapted for wire wrapping.

DESCRIPTION OF THE DRAWING

In the drawings:

FIG. 1 is a perspective view of a miniature connector assembly of the invention.

FIG. 2 is a partial view of reduced size of the underside of a printed circuit board of FIG. 1 having electrically conductive paths for interconnecting wire-wrap terminals to be mounted in outer apertures with contact tail sections of a miniature connector which extend through the inner apertures.

FIG. 3 is a side view in cross section along line 3-3' of FIG. 2 of a printed circuit board and illustrates the positioning of wire-wrap terminal posts in a first set of apertures in the board together with the mounting of the miniature multiple-contact connector with its tail sections extending through a second set of apertures in the board.

FIG. 4 is an enlarged, detailed, partial sectional view of the miniature multiple-contact connector with an individual metallic contact taken along the side of the connector of FIG. 1.

FIG. 5 is a cross-sectional view along line 5-5' of FIG. 3 of an illustrative wire-wrap terminal post.

FIG. 6 diagrammatically illustrates an apparatus for applying solder-resist to the bottom portions of the post sections adapted for wire-wrap connections.

FIG. 7 diagrammatically illustrates apparatus for spraying solder flux on the terminal pads, wire-wrap terminal posts, and contact tail sections.

FIG. 8 diagrammatically illustrates apparatus for preheating the solderable surfaces of the conductive terminal pads, terminal posts and contact tails.

FIG. 9 diagrammatically illustrates apparatus for applying molten solder to the solderable surfaces of the subassembly.

FIG. 10 diagrammatically illustrates apparatus for applying cleaning material to the masked terminal post sections and solderable surfaces for removal of the mask and flux residue.

GENERAL DESCRIPTION

In the miniature connector assembly of the invention, one or more miniature connectors and a plurality of wire-wrap terminal posts are affixed to the printed circuit board with the relatively fragile, closely spaced contact tails of each connector being in a relatively high density configuration and extending from the upper to the lower surface of the board through apertures in the board. The wire-wrap terminal posts are arranged in a low density configuration around the periphery of the connector and also extend through apertures in the board with sections of each terminal being well above and well below the board surfaces to permit relatively low-gauge conductors to be wire wrapped to the terminals either forwardly or rearwardly of the connector. The board also includes a series of metallic paths on its lower side, each path being terminated in an apertured conductive terminal pad aligned with one of the apertures through which the contact tail extends and a second apertured conductive terminal pad aligned with one of the apertures through which the wire-wrap terminal post extends. Solder bridges are formed on the adjacent surfaces of the contact tails, terminal pads and terminal posts to electrically interconnect each contact tail and wire-wrap terminal post. Portions of each terminal post extending above and below the board surfaces remain free from solder and provide sharp-edged surfaces capable of being wire wrapped with relatively low-gauge conductors. In a low density configuration of the wire-wrap terminal posts, the adjacent terminal posts are separated by a distance greater than that of the adjacent contact tails of the miniature connector. Each terminal also has a cross section exceeding that of each contact tail.

The printed circuit board of the assembly comprises a support sheet of dielectric material having a pattern of high conductivity metallic paths on its lower side and a plurality of apertures extending between its upper and lower sides. The dielectric material suitably is glass-impregnated epoxy or phenolic or other suitable resin and the metal is copper of high purity or other similar high conductivity metal.

A portion of the apertures are disposed in a relatively low density configuration along two of the opposition outer edges of the board conveniently in a staggered pattern of two rows with each aperture being offset from the adjacent aperture. These apertures serve as mounting surfaces for the wire-wrap terminal posts. Additional apertures are centrally disposed in a relatively high density pattern on the board and are arranged to receive the tail sections extending in registered alignment from the miniature multicontact connector. Additional apertures are disposed on the board for mounting the miniature connector and for fastening the board in a permanent installation.

The miniature connector is mounted on the upper side of the board and has a plurality of small, closely spaced contacts enclosed within a single housing which also provides physical and electrical separation between the contacts. The housing includes a bottom plate with apertures in registered alignment with apertures in the central portion of the board. The contact
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5 tail sections extend through the apertures in the housing and board to the lower side of the board. In the prepared embodiment the extension of the contact tail sections below the board is very slight and normally below about 0.1 inch.

A plurality of wire-wrap terminal posts are frictionally mounted in the outer apertures of the board and have post sections which extend in a general parallel pattern from the underside of the board. Each post section has at least two flat longitudinal surfaces which define in cross section four exterior square corners. In some instances the surfaces can be "spanked" to provide corners which have an interior angle slightly less than 90°.

The terminal posts are usually long, slender rods having the desired edges for wire wrapping and are constructed of a nickel alloy or other metallic composition which provides sufficient resistance to deformation to create adequate tension in the turns of wire and also is of adequate electrical conductivity. The wire-wrap terminal posts and tail sections of the contact members are arranged in juxtaposition to the conductive terminal pads of the circuit pattern so that upon soldering, at least one of the terminal posts is interconnected to at least one of the contact members.

The combination of printed circuit board, miniature connector, and plurality of wire wrap terminal posts before solder connections are made is conveniently identified as a sub-assembly. In the method of converting the sub-assembly to the completed assembly, the circuit board serves as convenient platform for connection to external clamping means or other means for moving the sub-assembly through the various process steps. In addition, the circuit board provides protection to the miniature connector and the small, closely grouped blade portions of the contacts and the upper post sections extending above the board during the processing.

The method comprises simultaneously applying a protective mask over the lower portion of each of the post sections to a height below the board and electrical circuit, applying molten solder to the unmasked post sections, contact tail sections, and terminal pads of the metallic circuit and simultaneously therewith to the masked portions of the post sections, and applying a cleaning material from below the board to each of the masked post sections to remove the mask and expose the underlying flat, longitudinal metallic surfaces and abrupt edge adapted for wire wrapping. Preferably, the method includes the application of a solder flux from below the board to the unmasked post sections, contact tail sections, and terminal pads to form solderable surfaces. Also, the method preferably includes a preheating step subsequent to the application of solder flux to preheat the solderable surfaces prior to the application of molten solder.

FIG. 1 is a perspective view of a miniature connector assembly of the invention and illustrates a high contact density miniature connector 8 centrally positioned on printed circuit board 12 for engagement above the board with a mating connector member (not shown) and a plurality of wire-wrap terminal posts 32 arranged in a relatively low density configuration and in close juxtaposition to the connector. Wire-wrap terminal posts 32 include sections 34 which extend well below the board to permit relatively low-gauge wire-wrap connections to be made thereto and sections 36 which extend well above the board for connection by the same technique to external conductors. Thus, wire-wrap terminal posts 32 permit relative low-gauge wire-wrap connections to be made either frontwardly or rearwardly of connector 8.

In FIG. 2, the underside 13 of printed circuit board 12 is illustrated with a first set of apertures 14 centrally disposed in the board and a second set of apertures 16 disposed along the opposite outer edges of the board. The outer apertures are generally arranged in two rows in a staggered pattern with the inner apertures being disposed in a pattern to receive the contact tail sections (not shown) of the miniature connector. Running between apertures 14 and 16 is ribbon 18 composed of a high-conductivity metal such as copper and having apertured terminal pad 20 surrounding the lower extremity of aperture 14 and apertured terminal pad 22 surrounding the lower extremity of aperture 16. Also shown in FIG. 2 are other conductive ribbons between the other apertures and apertures 24 and 26 for mounting the miniature connector. Apertures 28 and 30 serve as means for mounting the completed assembly in a permanent installation. For convenience of illustration, the board is adapted for a miniature connector having 20 contact members and 20 wire-wrap terminals although the assembly readily accommodates connectors with 50 contact members.

Inserted into aperture 16 of board 12, of FIG. 3 is wire-wrap terminal post 32 with a major portion 34 of its length extending below the underside 13 of board 12 and a minor portion 36 extending above the upper side 15 of board 12. The upper portion 36 serves as a convenient means for connecting additional wires to terminal 32 for circuit testing, additional connections, etc. Miniature connector 8 is mounted on the upper side 15 of board 12 and as illustrated, includes outer metallic shell 42 with a flat base plate 44 having an aperture 46 in registered position over aperture 26 of board 12 and inner housing 56 in which contacts 58 are mounted. Base plate 44 is rigidly secured to board 12 by screw 52. Shell 42 includes sidewalls 54 which prevent electrical access to contacts 58 on the upper side of the board when connector 8 is mated with the external connector (not shown).

In FIG. 4, an enlarged cross-sectional, partial view of miniature connector 8 is illustrated with an outer wall 54 of outer shell 42, base plate 44 and dielectric insert 56. Electrical contact 58 is illustrated with blade 59, mounting shank 60 and tail section 62 which extends through aperture 64 in dielectric insert 56 and aperture 66 in base plate 44. As illustrated, blade 59 is a single, narrow ribbon of sheet metal stock and includes horseshoe bend 68 with protuberance 70 to provide surface-to-surface engagement with a flat portion of a mating contact. As illustrated in FIGS. 2 and 4, tail sections 62 are disposed in one of the plurality of apertures 14 extending between sides 13 and 15 of board 12 in a high density pattern. Each tail section 62 is disposed in one aperture 14 and is thereby insulatorly separated from adjacent tail sections.

The sections of the wire-wrap terminal posts (FIG. 3) are shaped to include at least two flat longitudinal surfaces meeting at an abrupt exterior edge and advantageously have long, flat longitudinal surfaces and sharp edges which in cross section are square corners with interior angles of 90° as illustrated in FIG. 5. In some instances, the sharp edges 72, 74, 76, and 78 of FIG. 5...
have angles slightly less than 90° formed during "spanking" of flat surfaces 73, 75, 77, and 79. In forming the sub-assembly, the wire-wrap terminal posts of tin plated phosphor-bronze or other suitable material, are press mounted intermediate their ends into the board from the circuit side to obviate forcing any circuit elements away from the board. A major length of each terminal post extends below the circuit or lower side of the board to provide wire-wrap surfaces for connection to lead-in wires. A minor length of the terminal post provides wire-wrap surfaces for test purposes or other connections.

After the miniature connector is mounted on the top side of the board, the sub-assembly is passed through a masking step in which a masking material is simultaneously applied to each of the lower portions of the post sections to a height below the board and circuit. Suitably, a liquid masking material is applied into the lower portion of the post sections by dipping these sections into a bath of silicone oil at approximately 72° F for approximately one-half second. As illustrated in FIG. 6, the liquid 80 in container 82 reaches a height just below board 12 and provides masked portions 84 and unmasked portions 86 of terminals 32. As illustrated in FIG. 7, a solder flux is then applied to the underside 13 of board 12, terminal posts 32, contact tail sections 62, and the adjacent terminal pads 22 of the circuit 18 to provide solderable surfaces. Conveniently, this is carried out by applying a resin core solder by sprayer 88 against the underside 13 of board 12. In some instances, a solid flux can be applied during the subsequent soldering step.

The solderable surfaces are preheated prior to the soldering step by the application of air at an elevated temperature to the surfaces. Conveniently, a hot air blower 90 as illustrated in FIG. 8 provides a source of hot air for the preheating step.

Subsequently, molten solder is applied from below board 12 to the solderable surfaces and simultaneously therewith to the masked portions of terminal posts 32. In the preferred embodiment as illustrated in FIG. 9, the masked portions of terminal posts 32 are dipped into molten solder 92 in container 94 and solder wave 95 is generated such that its upper moving ridge 96 wets the solderable surfaces and provides a fused solder bridge as an electrical path between each terminal post and circuit and the contact and circuit. The molten solder is at about 500° - 600° F. and the dipping time is about one-half second. In some instances, the circuit elements between the terminal pads 20 and 22 (FIG. 2) are protectively coated prior to the masking step to obviate solder adhering to these surfaces and causing electrical short circuits.

The solder sub-assembly is then passed into a cleaning bath in which a liquid fluorocarbon 97 such as Freon or other degreasing liquid is applied from below board 12 to the masked portions of terminal posts 32 to remove the mask and expose the underlying flat longitudinal edges 75 and sharp edges 74 adapted for wire wrapping. The cleaning liquid in container 98 is also advantageously applied to the soldered connections and adjoining surfaces to remove flux residues. Treatment times in the order of one-half second are common in this step.

As described above, the method of manufacture is carried out without subjecting the small, closely-spaced blade portions of the contacts in the miniature connec-