

[54] **ELECTRICAL CONNECTOR**

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[51] Int. Cl. **H01r 23/52, H01r 23/54**

[58] Field of Search **339/17 F, 17 L, 17 LM, 75 M, 339/75 MP, 94 M, 176 M, 176 MP, 176 MF, 191 M, 192 R, 195 M, 196 M, 143 R, 143 C, 60 M**

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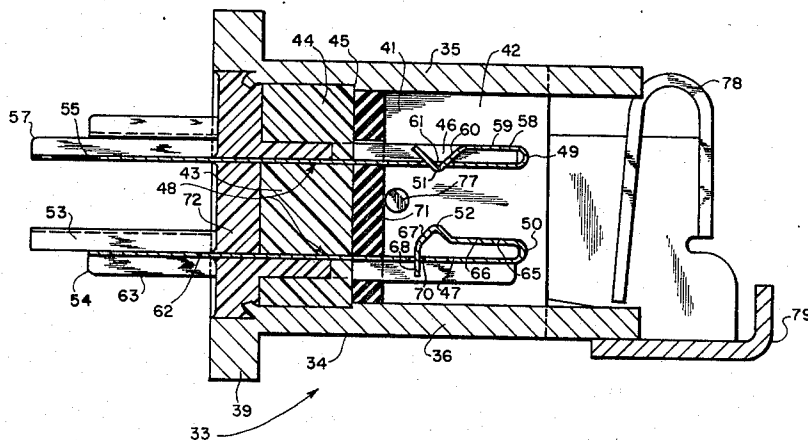
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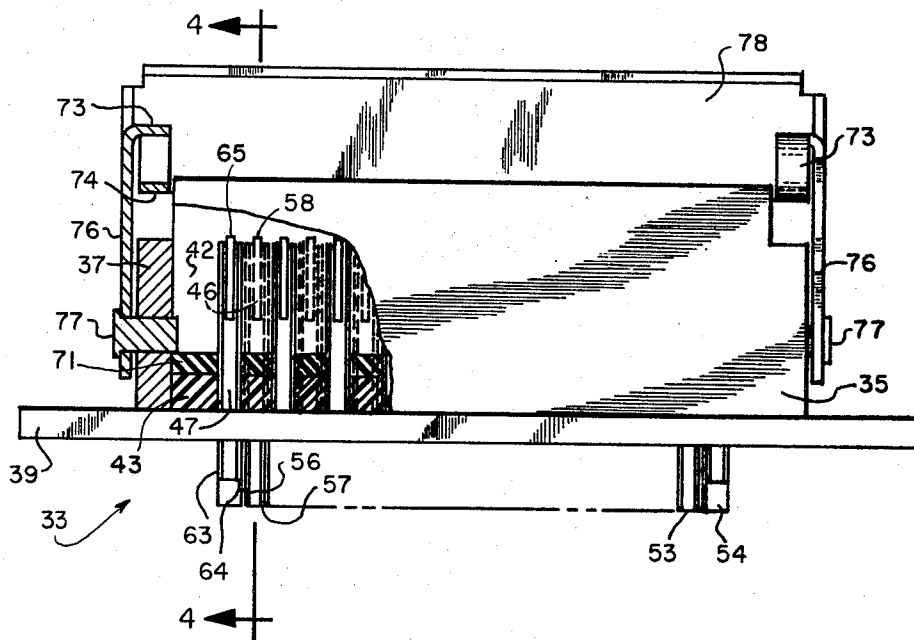
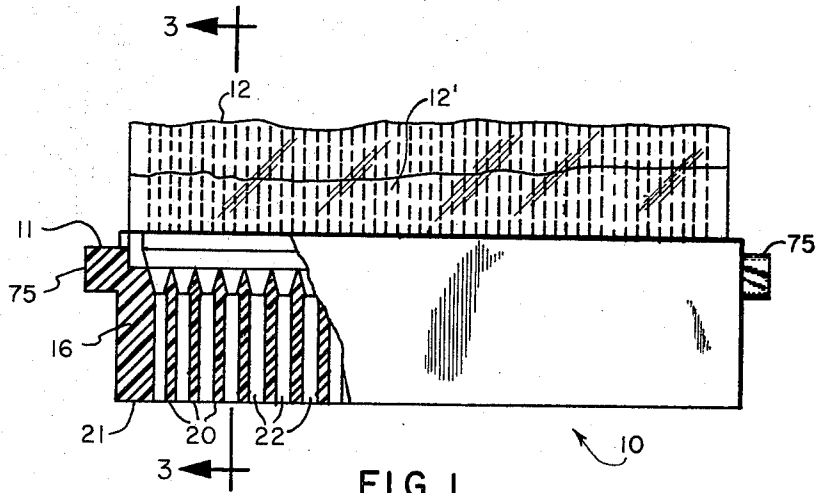
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[57] **ABSTRACT**

A separable flat cable connector having each pair of mating electrical contacts fully isolated from one another by means of insulating compartments extending rearwardly from the mating face of the plug half. The plug body is an integral, molded plastic member with two rows of compartments separated by a central wall. Two flat conductor cables, introduced through the rear of the plug, have exposed conductors extending forward along the central wall, with the conductor ends being secured in grooves defined by projections on the central compartment wall spaced back from the mating face. The receptacle half of the connector has an outer housing adapted to receive the plug body and forward-projecting spring contact elements with arcuate surfaces for engagement with the exposed conductors in the plug. Spring contact elements of the receptacle are disposed so that their rearwardly extending ends are alined in four spaced-apart rows to facilitate soldering thereto of conductors of round wire or flat conductor cables.

10 Claims, 8 Drawing Figures





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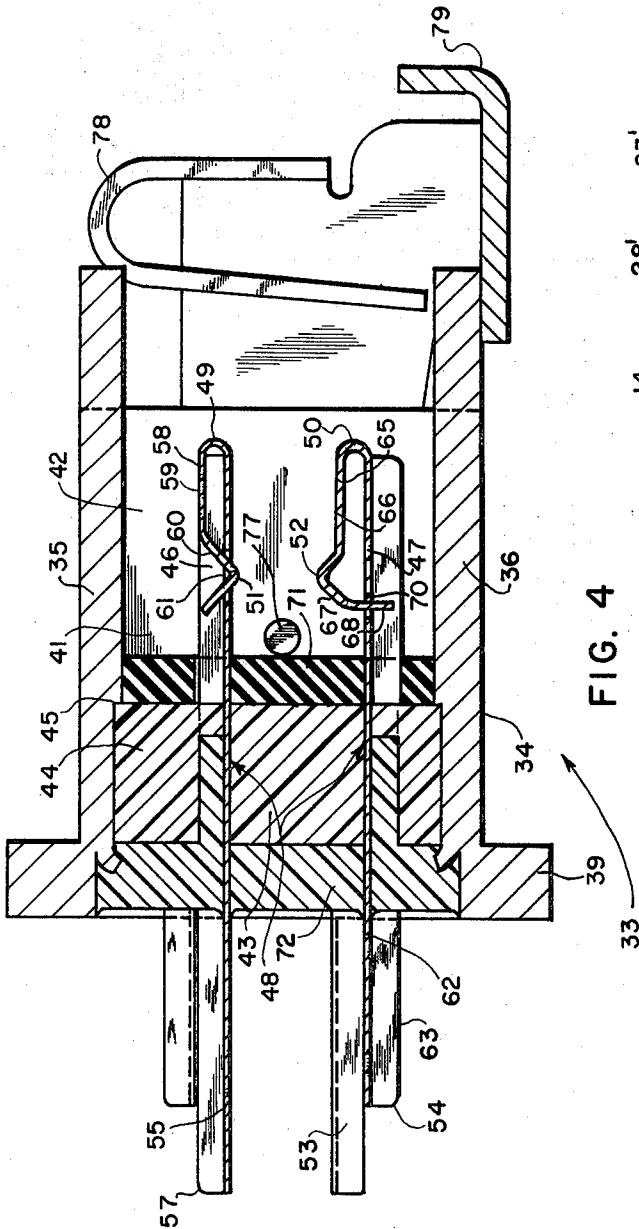


FIG. 4

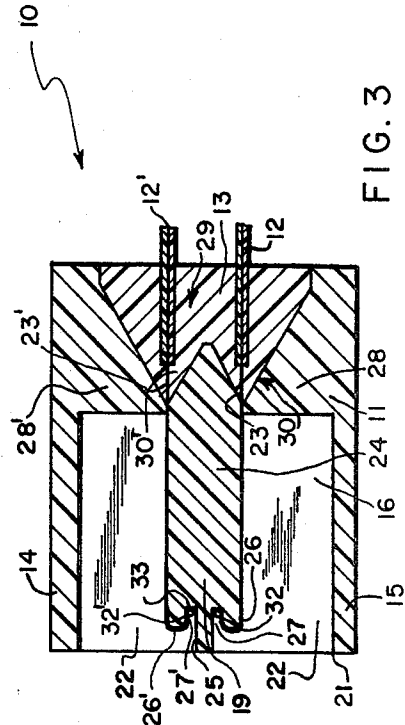


FIG. 3

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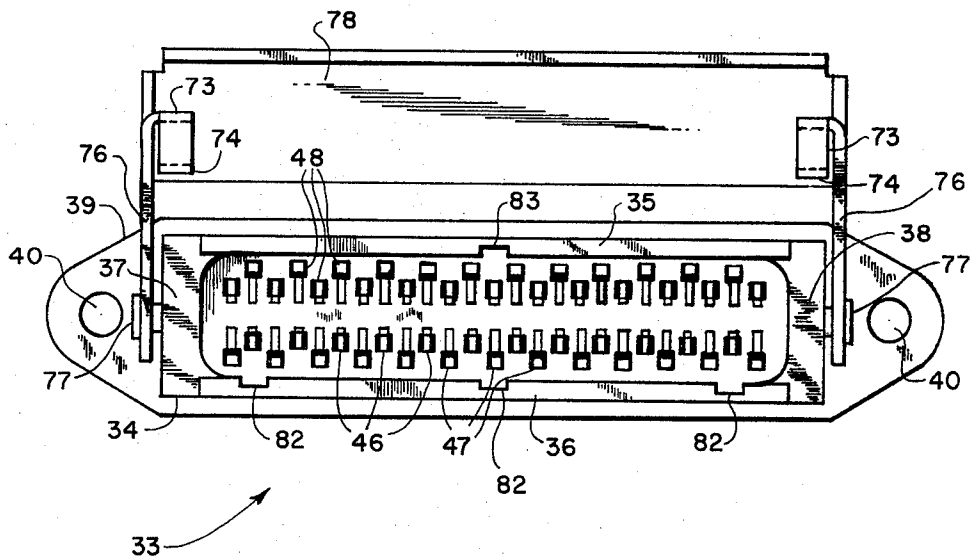


FIG. 6

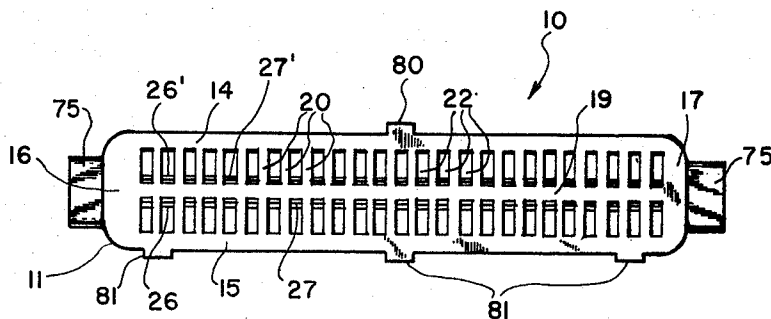


FIG. 5

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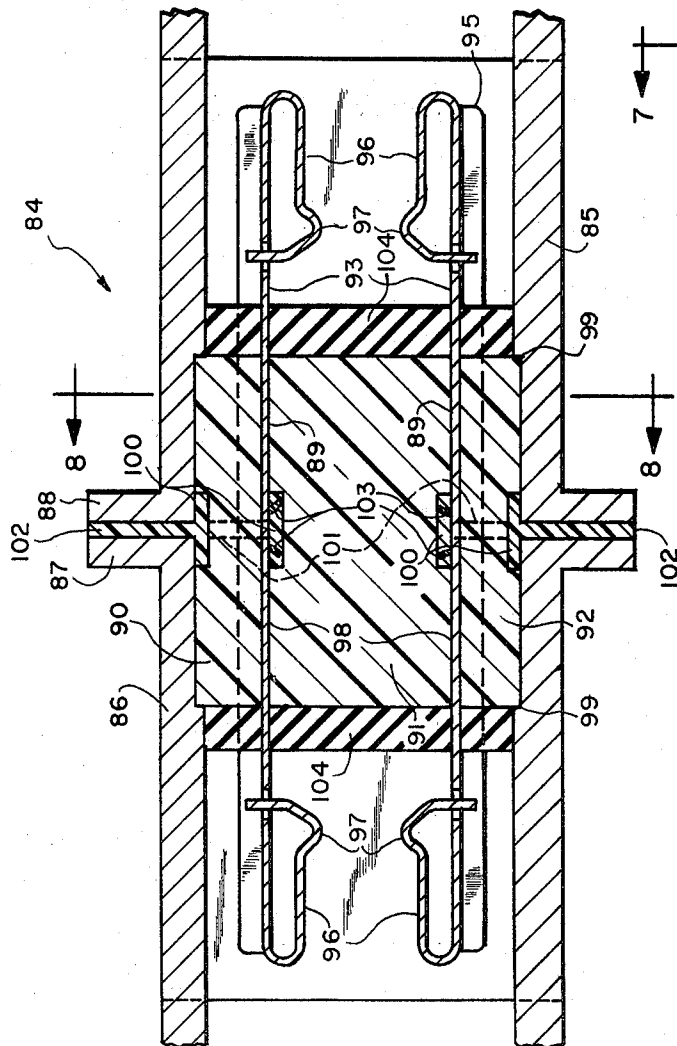


FIG. 7

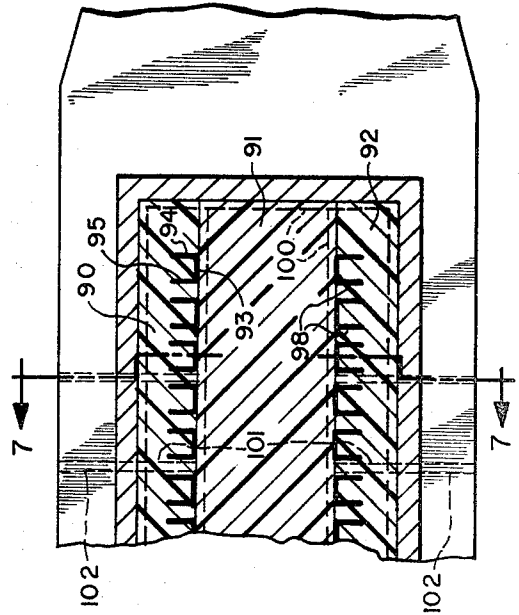


FIG. 8

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ELECTRICAL CONNECTOR

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government of the United States of America without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to electrical connectors and more particularly to separable connectors for engaging flat cables with round wire cables or with other flat cables.

Flat conductor cables, which are made up of multiple flat ribbon conductors disposed edge-to-edge in a strip of insulating material, offer important advantages over round wire cables for many applications. Flat cables provide lighter weight, smaller space requirements and better heat dissipation than round wire cables having equivalent electrical capabilities.

More widespread use of flat conductor cables necessitates the availability of improved connectors both for flat cable to flat cable and round wire cable to flat cable transitions, particularly for applications involving service in the space environment. Previous flat cable connectors have not provided isolation or sealing between mated pairs of contact elements, the engaged contact elements having been contained in a common air-filled cavity with limited sealing capability against an external vacuum. Once the cavity becomes partially evacuated, especially at altitudes of 75,000 to 150,000 feet or a gas pressure of 20 to 1 mm Hg, corona discharge between contacts will occur in accordance with Paschen's law if the voltage is allowed to exceed 230 volts. Provision of a connector constructed so as to preclude corona between contacts would allow the use of higher voltages independent of gas pressure. Another disadvantage of previous connectors has been that plug contact elements in most constructions extend forward of the mating face and are subject to accidental touching when disengaged, thus creating a safety hazard as well as a source of contamination of contact surfaces. In addition to correcting these deficiencies, improved cable connectors should be characterized by ruggedness and reliability of electrical contact along with minimum size and weight.

SUMMARY OF THE INVENTION

In accordance with the present invention a separable flat cable connector includes an insulating plug body having two rows of compartments extending rearward from a flat mating face. Each compartment has a projection spaced back from the mating face on the central wall between compartment rows, and exposed conductors from two flat cables, which extend forward along the central wall and into grooves defined by the projections, provide electrical contact elements. The plug is adapted to be received by a receptacle having spring contact elements which are forced against the exposed conductors in the plug upon engagement. The plug compartments, together with a sealing gasket disposed between mating faces of the plug and receptacle, fully isolate engaged pairs of contact elements from one another and thus prevent corona discharge in vacuum. Exposed conductors in the plug, being spaced back from the mating face, are protected from accidental touching or contamination of contact surfaces when disengaged. Contact elements of the receptacle are similarly protected by the forward portion of the receptacle housing. Connectors embodying the invention also exhibit highly reliable electrical contact, and the double-row compartment feature enables two pairs of cables to be connected with one device, thus reducing size and weight requirements.

It is therefore an object of the invention to provide a flat cable connector wherein engaged pairs of contact elements are protected from corona discharge in vacuum.

Another object is to provide a flat cable connector having contact elements disposed in a manner such as to prevent accidental touching thereof when the connector is disengaged.

Yet another object is to provide a flat cable connector of minimum size and weight.

Still another object is to provide a flat cable connector wherein the mating contact elements make secure and highly reliable contact with one another.

A further object is to provide a connector capable of electrically engaging two flat cable ends with two other flat cable ends in a single device.

Another object is to provide a connector for engaging a flat conductor cable with a round wire cable.

Other objects and advantages of the invention will be apparent from the following detailed description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like references refer to like parts throughout:

FIG. 1 is a plan view of the plug part of a connector embodying the invention, with a portion of the insulating body being broken away;

FIG. 2 is a plan view of the receptacle part of the connector, with a portion of the outer housing being broken away;

FIG. 3 is a vertical sectional view of the plug part, taken along line 3—3 in FIG. 1;

FIG. 4 is a vertical sectional view of the receptacle part, taken along line 4—4 of FIG. 2;

FIG. 5 is a front end elevational view of the plug part shown in FIG. 1;

FIG. 6 is a front end elevational view of the receptacle part shown in FIG. 2;

FIG. 7 is a vertical sectional view of the receptacle part in an embodiment for connecting flat cable to flat cable wherein two plug parts are engaged with one receptacle part; and

FIG. 8 is a sectional view, on a slightly reduced scale, taken along a portion of line 8—8 in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The connector embodiment described herein includes a plug portion shown in FIGS. 1, 3 and 5 and a receptacle portion shown in FIGS. 2, 4 and 6 adapted to be separably engaged with the plug portion in a manner such that mating pairs of electrically conductive elements in the two parts are brought into contact.

Referring to FIGS. 1, 3 and 5, plug 10 includes an integral molded insulating body member 11, two flat conductor cables 12 and 12' inserted therein and insulating potting compound 13 disposed around the cables at the point of entry. Plug body member 11 has relatively flat upper and lower walls 14 and 15 and end walls 16 and 17 integral therewith forming an elongated generally rectangular hollow shape coextensive in length with the width of flat cables 12 and 12'. A central wall 19, parallel to the upper and lower walls, extends from the middle of end wall 16 to the middle of end wall 17, bisecting the body member along its length. A plurality of parallel inner walls 20 extend vertically from lower wall 14 to upper wall 15 intersecting central wall 19 at right angles. One edge of each wall terminates at flat front face 21 which is disposed to confront receptacle part 33 when the connector is engaged. The wall structure of the plug defines two parallel rows of hollow, rearwardly extending compartments 22, one side of each compartment being defined by central wall 19. The upper row has one compartment for each conductor 23 of flat cable 12 and the lower row has one compartment for each conductor 23' of flat cable 12'.

Central wall 19 has a relatively thick base portion 24 extending forward from the rear of compartments 22 to a point spaced back from front face 21, a thin portion 25 extending therefrom to the front face and a rounded, forward-extending projection 26, 26' within each compartment at the juncture of the thick and thin portions. The projections 26, 26' are spaced apart from thin wall portion 25 so as to define grooves 27, 27' therebetween. The rear ends of compartments 22 are defined by shelves 28, 28' integral with and extending inward from upper and lower walls 14 and 15 to central wall 19. The back sides of shelves 28, 28' slope outward from the central wall to

the rear edges of walls 14 and 15 so as to define a generally wedge-shaped, longitudinally extending cavity 29 within the rear of the plug. Base portion 24 of central wall 19 extends rearwardly past its juncture with shelves 28, 28' and into the forward end of cavity 29, and its thickness is progressively reduced toward its rear edge so as to define grooves 30, 30' for receiving conductors 23, 23' of flat cables 12, 12'. Shelves 26, 26' are penetrated by a plurality of conductor-receiving slots 31, 31' communicating grooves 30, 30' with the interior of each compartment. Exposed flat conductors 23, 23' are disposed through slots 31, 31' forward in contact with flat upper and lower surfaces of base portion 24 and around projections 26, 26' with conductor ends 32, 32' being secured within narrow grooves 27, 27'. Secure retention of the conductor ends is obtained by forming a partial rearwardly extending loop in the conductors near the ends and placing the loops within the grooves in a manner such that the conductor ends 32, 32' come in contact with thin wall portion 25 at an acute angle. The conductors have sufficient resiliency that upon application of tension from the rear of the plug the conductor ends are pushed against the wall with enough force to prevent movement of the loops out of the grooves. Other means for restraining the conductor ends such as friction-fitted inserts could also be used. Contact elements of the plug part are provided by the portions of conductors 23, 23' which extend from front to rear along and in contact with base portion 24 of central wall 19.

As shown in FIGS. 2, 4 and 6, receptacle part 33 has an outer metal shell 34 made up of four rectangular walls, upper wall 35, lower wall 36, and side walls 37 and 38, and a flat flange portion 39 perpendicular to the walls and integrally joined to their rear edges. The flange portion has holes 40 at each end for attachment to a bulkhead or other support means if desired. The shell defines an elongated cavity 41 adapted to receive within its front portion 42 the body member 11 of plug part 10. A rigid rectangular block 43 of insulating material is disposed within the rear end 44 of cavity 41 in contact with walls 36, 37, 38 and 39 and a shoulder 45 defined by a rearwardly extending recess in the walls.

A plurality of contact elements 46, 47 extend through and are rigidly mounted within apertures 48 in block 43. The contact elements are so constructed and arranged that their forward projecting portions 49, 50 each of which has an arcuate contact surface 51, 52 for engagement with an exposed conductor 23, 23' in plug part 10, are aligned in two parallel, spaced-apart, longitudinally extending rows and their rearwardly extending portions 53, 54 are aligned in four rows to facilitate soldering of conductors thereto. In order to provide this alignment pattern, the apertures 48 are arranged in four parallel rows, and the contact elements 46 disposed through apertures in the two innermost rows embody a different construction than the contact elements 47 disposed through apertures in the two outermost rows.

Contact element 46 has an elongated body portion of U-shaped transverse cross-section including a flat base portion 55 and two sides 56 and 57 perpendicular thereto. A resilient strip 58, which is a narrowed integral extension of flat base portion 55 forms a loop of U-shaped longitudinal cross-section with a leg portion 59 thereof extending rearwardly between sides 56 and 57 in a plane parallel to base portion 55. A tip portion 60 of strip 58, formed by bending the terminal segment thereof inwardly at an angle of 45° and outwardly at an angle of 90° extends vertically through a slot 61 in base portion 55. The point of tip portion 60, which is displaced slightly inwardly from the plane of base portion 55, is rounded to provide an arcuate contact surface 51 corresponding to the surface of a sphere having a predetermined radius. Upon insertion of the plug half, arcuate surface 51 slidably engages an exposed conductor 23, and tip portion 60 is slightly deflected in a vertical direction. Strip 58 has a predetermined resiliency so that the force which surface 51 exerts on conductor 23 falls within prescribed limits and the resulting actual area of contact between the mating elements is precisely controlled. The

arcuate shape of the contact surface prevents variations in the actual area of contact such as would occur due to slight misalignments where two flat surfaces are brought into contact.

Contact element 47 has an elongated body portion similar to contact element 46, made up of flat base portion 62 and sides 63 and 64 perpendicular thereto. Resilient strip 65, a narrowed integral extension of base portion 62 forms a loop of U-shaped longitudinal cross-section with a leg thereof 66 extending rearwardly in a plane parallel to and displaced inwardly from base portion 55. A vertically displaceable tip portion 67 formed by a 45° inward turn and a 90 degree outward turn of leg 66, has an arcuate contact surface 52 for engagement with a conductor 23 in plug part 10. The terminal segment 68 of leg 66 extends perpendicularly through a slot 70 in base portion 55 and operates vertically therein. Contact element 47 is so constructed that the force exerted on the conductor by arcuate surface 52 is the same as that exerted by surface 51 of contact element 46.

Receptacle part 33 has a gasket 71 disposed forward of and in contact with block 43 to provide complete isolation of compartments 22 when the connector is engaged and front face 21 of the plug part is brought into contact therewith. Void space within the rear end 44 of cavity 41 and in apertures 48 is filled with an insulating potting compound 72. Rearwardly extending portions 53, 54 of contact elements 46, 47 are adapted to have joined thereto by means such as soldering exposed conductor ends of round wire cables, individual round wire conductors or flat conductor cables (not shown). Alternating conductors of a first flat cable can be joined to contact elements 46 in the innermost row and contact elements 47 in the outermost row of the two upper rows of contact elements, and conductor ends of a second cable can be similarly joined to contact elements of the lower two rows. Where a transition connection between round wire conductor cables and flat cables is desired, round wire conductors can be joined to rearwardly extending portions 53, 54. The round wire conductors can be individual wires or conductors of a round cable. The channel configuration of portions 53, 54 of the contact elements and their arrangement in rows with alternating elements disposed in spaced apart rows facilitates soldering of conductors and minimizes the possibility of exposed ends coming into contact with one another.

To retain plug part 10 securely in operative relationship with receptacle part 33 the latter is provided with releasable latching means. Such means in the embodiment shown takes the form of a movable latching assembly including a pair of U-shaped metal members 73 having a resilient leg 74 adapted to engage projecting lugs 75 on each end of the plug part. Members 73 are mounted on end plates 76, which are pivotally secured to end walls 37, 38 by means of pins 77. End plates 76 are connected by means of a longitudinally extending, folded-over metal sheet 78 joined thereto and having a grippable extension 79 integral therewith. The latching assembly is shown in the closed position in FIGS. 2, 4 and 7 and in the open position in FIG. 6. As is best shown in FIG. 6, downward movement of the assembly forces legs 74 into contact with the back side of lugs 75. This construction enables engagement and disengagement of the latching means with one hand, such feature being of particular importance to astronauts in space applications.

Plug part 10 has projecting keys 80, 81 on the outside surface of upper and lower walls 14 and 15 extending rearward from the front face. The upper key 80 and the middle of the three lower keys 81 serve to guide the plug into the proper location upon engagement. The outer two keys 81 on the lower wall ensure correct polarization, that is, they prevent insertion of the plug upside down. By varying the location or size of the outer keys the possibility of mislocation in the incorrect receptacle can also be avoided. Keys 81 on the lower wall operate in lower grooves 82 in the receptacle part and key 80 on the upper wall operates in upper groove 83 in the receptacle.

FIGS. 7 and 8 show an alternate embodiment for connecting two flat cable ends to two other flat cable ends. In this em-

bodiment two plug parts identical to the plug part described above are used in combination with the receptacle part shown in FIGS. 7 and 8, which is adapted to receive one of the plug parts in each end. The receptacle part 84 includes two outer metal shells 85, 86 having integral flange portions 87, 88, placed back-to-back and joined after assembly, the shells and flange portions being similar to shell 34 and flange portion 39 of FIGS. 2, 4 and 6. Two rows of contact elements 89 are disposed within the cavity defined by the shells, the contact elements being supported and held in parallel, spaced apart relation by means of three rigid insulating blocks 90, 91 and 92. The contact elements 89 have an elongated body portion of U-shaped transverse cross-section including a flat base portion 93 and two sides 94 and 95 perpendicular thereto. Both ends of each contact element have an integral resilient contact strip 96 identical to strip 65 of contact element 47 of FIG. 4 and an arcuate contact surface 97 displaceable vertically in the same manner as surface 52. The alinement of contact surfaces 97 with relation to shells 85 and 86 is the same as for contact surfaces 51 and 52 and shell 34 of FIG. 4. Each row of contact elements 89 is supported by a substantially rectangular block 90, 92 of rigid insulating plastic, the blocks being disposed within and in contact with the shells at the juncture of flanges 87 and 88. The contact elements 89 penetrate blocks 90 and 92 through U-shaped apertures 98 extending therethrough parallel to the shell walls adjacent the inner side of the blocks. Blocks 90, 92 rest against shoulders 99 defined by a recess in shells 85, 86 so that movement toward the shell ends is prevented. Spacer block 91 is disposed between and firmly in contact with blocks 90, 92. Blocks 90, 91 and 92 have grooves 100 extending around their periphery in parallel alinement with flange portions 87 and 88. The grooves communicate with a plurality of apertures 101 in blocks 90 and 92 and apertures 102 in the receptacle shell at the juncture of the flange portions. Void space defined by the grooves and apertures and between the contact element body portions, and apertures 98 in blocks 90, 92 is filled with an insulating potting compound such as epoxy resin, the potting compound being forced into position by means such as injection molding. Contact elements 89 have anchoring tab portions 103 of their flat base portions 93 which project into the adjacent groove so as to be imbedded in the potting compound, the imbedded tabs serving to prevent movement of the contact elements toward the receptacle ends. Each end of the receptacle is provided with releasable latching means (not shown) which can be the same as for the previously described embodiment. A gasket 104 is disposed in contact with the exposed ends of blocks 90, 91 and 92 at each end of the receptacle in the same manner as gasket 71 of FIG. 4.

The plug body can be made up of an insulating plastic material such as a polyimide resin or diallyl phthalate, glass filled, and it is preferably formed by molding. The same materials can be used for the insulating block of the receptacle part. The gaskets for the receptacle are made of a flexible material, with silicone rubber being preferred. Epoxy resin can be used as the insulating potting compound. The receptacle housing is shown constructed of metal, and aluminum can be used unless electromagnetic shielding is desired, in which case a magnetic metal is employed. Molded insulating plastic could also be used for some applications.

In the embodiments described above each compartment in the plug parts is shown as having therein an exposed flat cable conductor, and the conductors for each compartment row are shown as making up the conductors of two flat cables. However other combinations of cables can be connected by making use of less than all of the compartments. For example, only one compartment row could be employed for connection of a single cable to one or more cables joined to the receptacle part. Instead of one integral flat cable for each row of compartments, two or more narrower flat cables could be placed edge-to-edge, their conductors incorporated in a single compartment row. It may be seen that the present invention provides a high degree of latitude for various combinations of cable connections with a single device.

Although the invention is described with respect to specific embodiments, it is to be understood that various changes and modifications such as in the relative dimensions of the parts and in the materials used may be made by one skilled without departing from the spirit and scope of the invention.

What is claimed is:

1. A separable electrical connector comprising a plug part having a laterally extended insulating body said body including upper and lower walls, end walls perpendicular thereto, a central wall extending from end to end between and parallel to said upper and lower wall and a plurality of vertically extending walls intersecting said central wall at right angles, said wall defining two parallel rows of compartments extending rearward from a front face defined by one edge of said walls, shelves defining the rear end of said compartments, slot means penetrating said shelves for introduction therethrough of flat conductors, conductor end securing means on said central wall in each of said compartments spaced back from said front face, flat conductors of one or more flat conductor cables extending rearward from said securing means and having an exposed flat surface contiguous to said central wall and substantially perpendicular to said front face and insulating means disposed around said conductors rearward of said compartments and a receptacle part adapted to be engaged with said plug part, said receptacle part including an outer housing for reception therein of said insulating body, an insulating block disposed rearward of the insulating-body-receiving portion of said housing, said block being penetrated by a plurality of imbedded resilient conductive contact elements projecting forward of said block, the forward projections of said contact elements being arranged in two laterally extending parallel rows corresponding to the compartment rows of said insulating body, each of said forward projections having a vertically displaceable tip portion with an arcuate contact surface for engagement with said exposed flat surface of the conductor in the corresponding compartment, means for joining rear portions of said contact elements to electrical conductors, gasket means disposed forward of said said block for engagement with said front face of said plug part and insulating means disposed between and around the rear portions of said contact elements.

2. The connector of claim 1 wherein said central wall of said plug part has a thick portion spaced back from said front face and a thin portion extending from said front face to said thick portion and a forward-extending projection in each of said compartments at the juncture of said portions and said conductor end securing means comprises the groove defined by said projection.

3. The connector of claim 2 wherein said contact elements are so constructed and arranged that projecting rear portions thereof are alined in four spaced-apart, parallel rows.

4. The connector of claim 3 including means for releasably securing said plug part and said receptacle part together.

5. The connector of claim 4 wherein said contact elements are so constructed that said arcuate surfaces exert a predetermined force against said exposed conductor surface upon engagement of the connector.

6. The connector of claim 5 wherein said contact elements have an elongated body of U-shaped transverse cross section and the forward projections thereof include integral, narrowed extensions of the base portion of said body, formed into a loop with said arcuate surface being located on a vertically displaceable tip portion of a leg of said loop.

7. The connector of claim 6 wherein the body portions of said contact elements are arranged in four longitudinally extending, spaced apart parallel rows, the loop portions of said elements of the outermost two of said rows are displaced inwardly so that legs thereof are disposed in planes parallel to and spaced inwardly from the planes of the base portions thereof and the loop portions of said elements of the innermost two of said rows are displaced outwardly so that legs thereof are disposed in planes parallel to and spaced outwardly from the planes of the base portions thereof.

8. The connector of claim 7 including round wire electrical conductors joined to said rear portions of said contact elements of said receptacle part.

9. The connector of claim 7 including flat electrical conductors joined to said rear portions of said contact elements of said receptacle.

10. A connector for joining two flat conductor cable ends to two other flat conductor cable ends comprising a plug part for the first two of said cable ends and a plug part for the second two of said cable ends, each of said plug parts having a laterally extended insulating body, said body including upper and lower walls, end walls perpendicular thereto, a central wall extending from end to end between and parallel to said upper and lower wall and a plurality of vertically extending walls intersecting said central wall at right angles, said walls defining two parallel rows of compartments extending rearward from a front face defined by one edge of said walls, shelves defining the rear end of said compartments, slot means penetrating said shelves for introduction therethrough of flat conductors, conductor end securing means on said central wall in each of said compartments spaced back from said front face, flat conductors of said flat conductor cables extending

rearward from said securing means and having an exposed flat surface contiguous to said central wall and substantially perpendicular to said front face and insulating means disposed around said conductors rearward of said compartments and a receptacle part having a housing open at opposing ends and defining a cavity adapted to receive one of said plug parts in each of said ends so that the front faces of said plug parts are maintained in opposing, parallel, spaced apart relation therein, insulating contact-element-supporting means disposed across said cavity between said opposing ends, two rows of conductive contact elements penetrating said contact-element-supporting means and rigidly supported thereby, said contact elements being disposed in spaced apart relation, each of said contact elements having at each end a projecting portion including a displaceable arcuate contact surface for engagement with said exposed flat surface of the conductor in the corresponding compartment of a plug part, and gasket means disposed outward of said contact-element-supporting means within each of said housing ends for compressible engagement with the front faces of said plug parts.

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