March 19, 1963 C. F. VALACH 3,082,398

ELECTRICAL CONNECTORS

Filed May 24, 1960 3 Sheets-Sheet 1

Fig. 1.

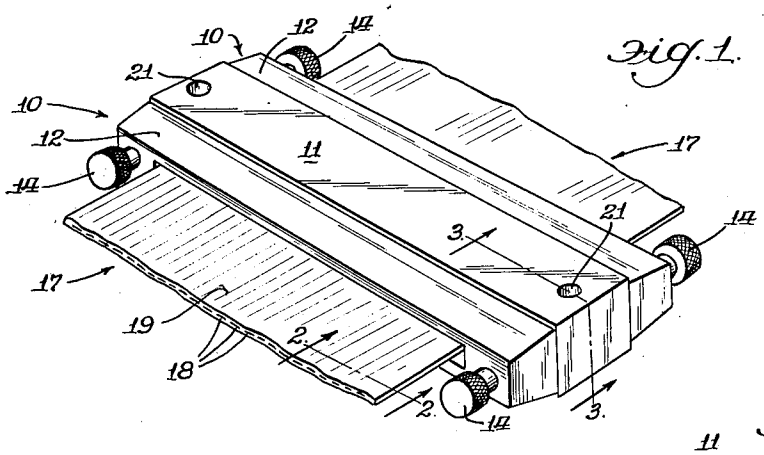


Fig. 2.

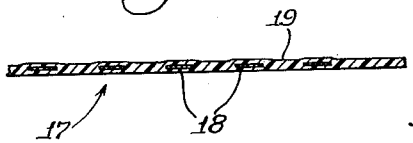


Fig. 3.

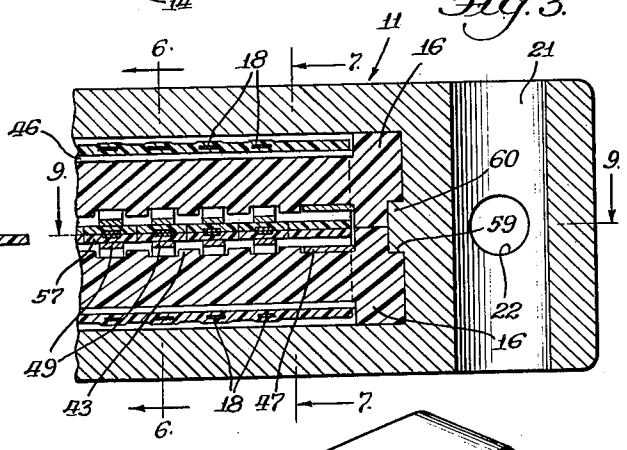
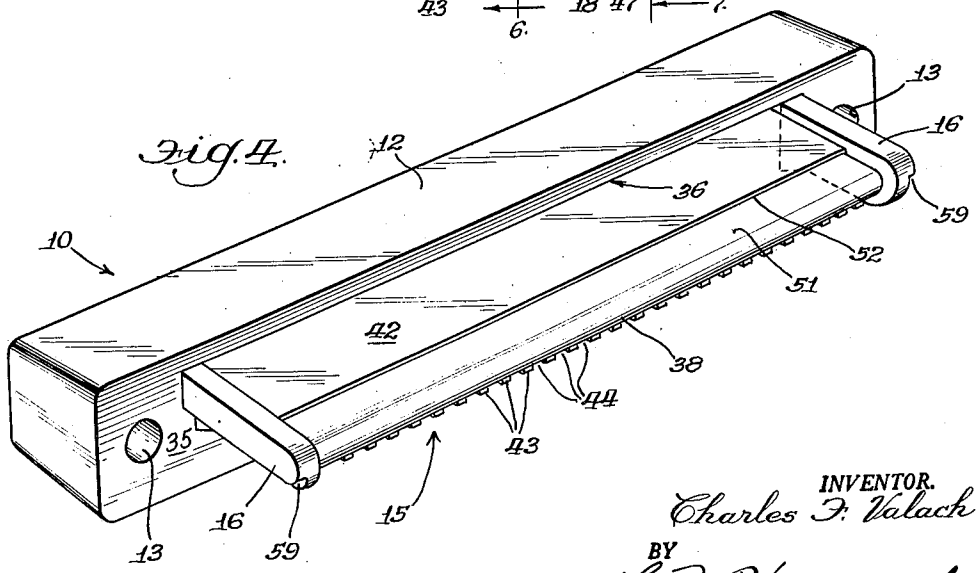


Fig. 4.



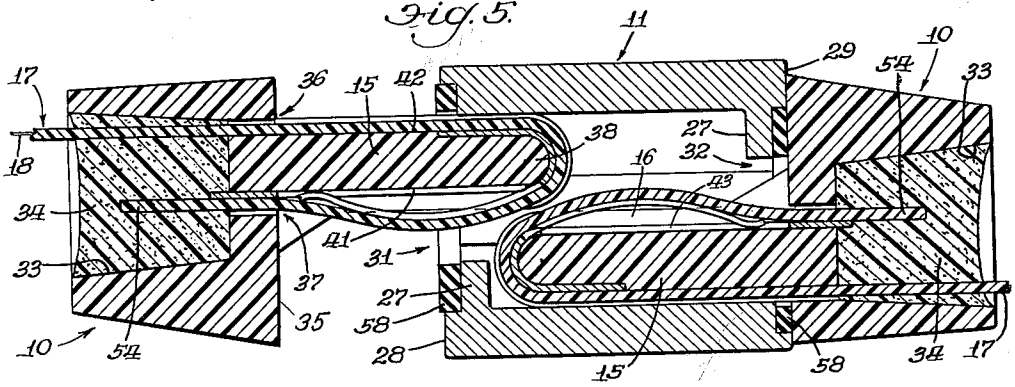
INVENTOR.
Charles F. Valach
BY
L. F. Hammond,
Atty.

March 19, 1963 C. F. VALACH 3,082,398

ELECTRICAL CONNECTORS

Filed May 24, 1960 3 Sheets-Sheet 2

Fig. 5.



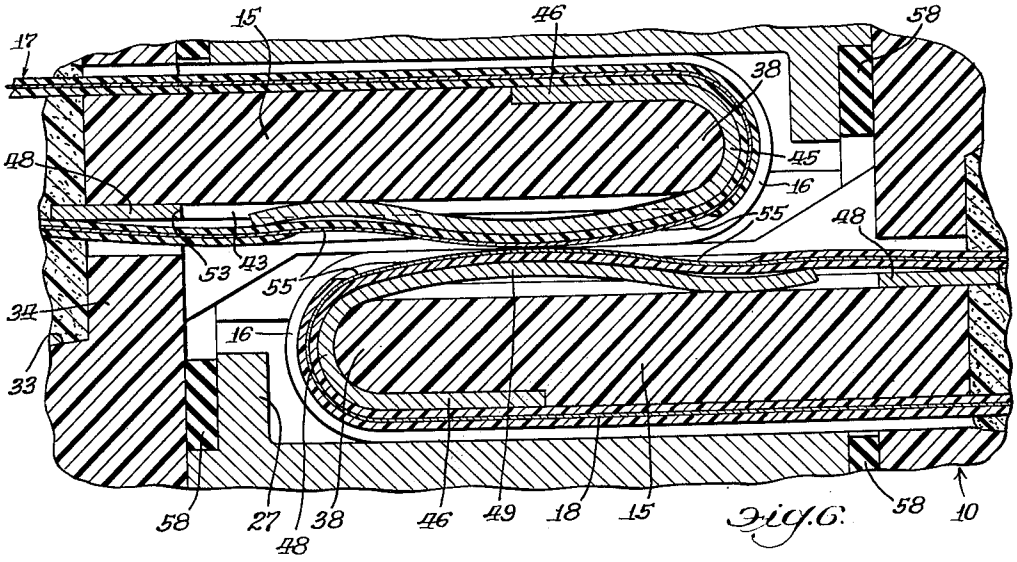


Fig. 6.

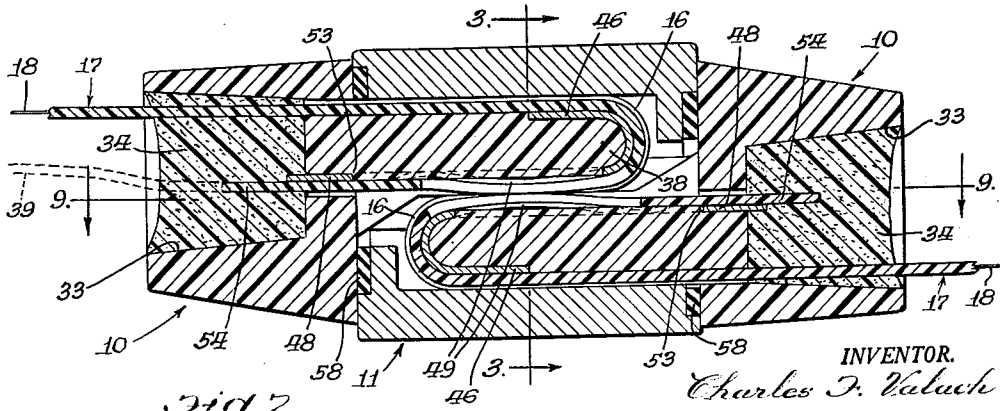


Fig. 7.

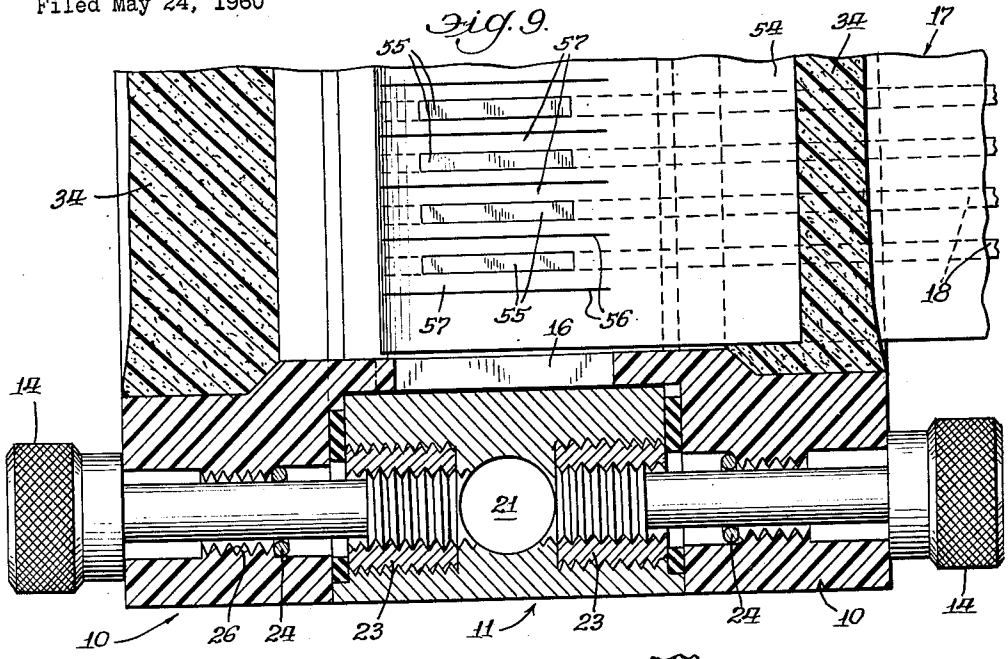
INVENTOR.
Charles F. Valach
BY
L. F. Hammond
Atty.

March 19, 1963 C. F. VALACH 3,082,398

ELECTRICAL CONNECTORS

Filed May 24, 1960 3 Sheets-Sheet 3

Fig. 9.



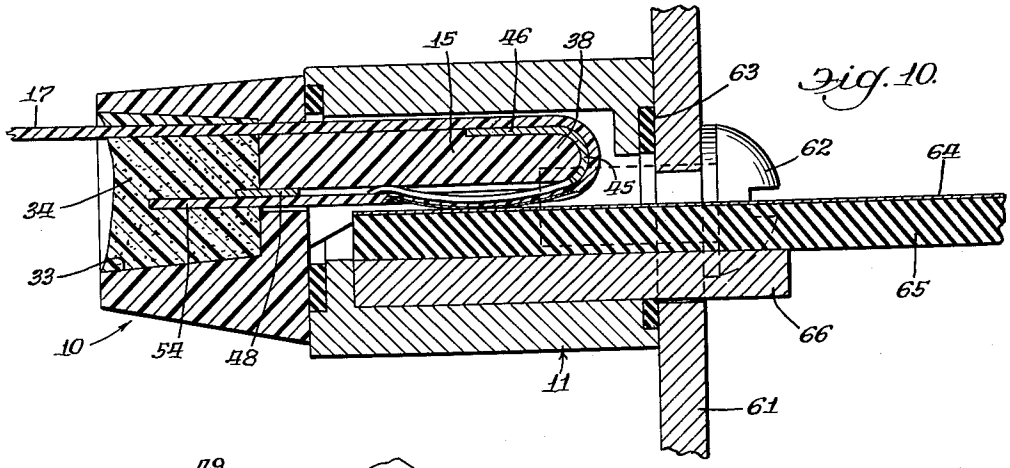


Fig. 10.

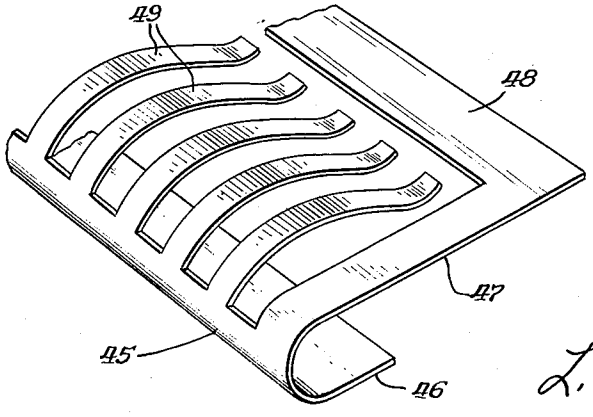


Fig. 8.

INVENTOR.
Charles F. Valach
BY
L. F. Hammand Atty.

United States Patent Office 3,082,398 Patented Mar. 19, 1963

3,082,398

ELECTRICAL CONNECTORS

Charles F. Valach, Western Springs, Ill., assignor to Amphenol-Borg Electronics Corporation, Broadview, Ill., a corporation of Delaware

Filed May 24, 1960, Ser. No. 31,395
6 Claims. (Cl. 339—176)

The present invention relates to electrical connectors and specifically to electrical connectors designed to interconnect the ends of flat multi-conductor cables of the type known in the trade as "Polystrip" or "Tape Cable," wherein the several conductors of the cable lie parallel to each other in the same plane, and are embedded in a thin flexible sheath of plastic insulation.

It is a primary object of the invention to provide a novel and improved connector for joining such cables to each other, to printed circuit boards, or to conventional wiring in a manner capable of overcoming the mechanical and electrical difficulties heretofore encountered in connectors for flat cables, and to provide a connector which is mechanically feasible and electrically acceptable, for even the most exacting requirements of modern aircraft, missile, and computer circuitry, where the inherent advantages of flat cable are best utilized.

The accomplishment of this basic object of the present invention involves the reconciliation of various electrical and mechanical considerations which have heretofore shown themselves to be conflicting in their basic concepts. This is believed to be demonstrated by the fact that adoption of flat cable has been retarded by the absence of any source of satisfactory connectors, notwithstanding that the cable itself is generally conceded to have rather outstanding advantages for certain applications.

More specifically, it is among the objects of the invention to provide a connector for flat multi-conductor cables wherein the connector is so designed as to achieve a dependable, low resistance electrical union between the conductors, with a high degree of uniformity as to voltage drop between the several conductors of the cable, and without production of noise or microphonic effects, even under severe conditions of vibration or after long continued use and abuse. This necessarily involves the development of a design that is sufficiently strong and rugged to withstand considerable impact as well as prolonged and extreme vibration, yet of such simple design as to be quickly, easily and conveniently attached to the cables with which the connectors are used, coupled with simultaneous accomplishment of an arrangement of parts such that the flash-over limits and insulation characteristics are capable of meeting the most exacting standards, notwithstanding the close spacing of the conductors of the cable and in spite of the fact that the connectors will be subjected to radical variations in atmospheric pressure and humidity and rapidly changing extreme temperatures.

A further object of the invention is the provision of connector plugs and related fittings accomplishing the objects noted above, yet quick and easy to attach to the cables, convenient to couple and uncouple, sufficiently small and compact as to be acceptable in connection with miniaturized equipment, and with an inherent flexibility of design such that the connector may be utilized for interconnecting cables to each other or for interconnecting a cable with a circuit board or other form of terminal, all without departure from the underlying concepts of the invention.

The foregoing objects are achieved in the present invention by an assembly of parts which departs radically from the concepts of conventional connectors heretofore used in that:

(1) The connector assembly has no contacts as such. In fact, there are no conducting parts. Also,

(2) The connector assembly is attached to the flexible cables with which it is used without soldering, crimping or welding;

(3) Moreover, conventional "male and female" or "plug and receptacle" parts are eliminated in favor of a design and construction of component parts such that the fittings attached to each end of each cable are identical, whereby any one may be coupled to any other.

The manner in which the foregoing are achieved is best described by reference to the drawings attached hereto, illustrating a present embodiment of the invention.

In the drawings:

FIGURE 1 is a perspective view of an electrical connector constructed in accordance with the present invention, interconnecting two similar flat insulated cables;

FIGURE 2 is a greatly enlarged cross-sectional view of a portion of one of the cables illustrated in FIGURE 1, the view being taken on the line 2—2 of FIGURE 1 and showing the several parallel metallic ribbons which constitute the individual conductors embedded in the plastic insulating sheath of such cables.

FIGURE 3 is a fragmental central sectional view of the connector assembly illustrated in FIGURE 1, the view being taken substantially along the plane of the lines 3—3 of FIGURES 1 and 7;

FIGURE 4 is a perspective view of one of the plugs of the connector, showing the projecting tongue thereof;

FIGURE 5 is an enlarged sectional view through the connector assembly, showing one of the paired plugs thereof only partially inserted;

FIGURE 6 is a fragmental sectional view taken on the line 6—6 of FIGURE 3 and further enlarged (to approximately eight times the actual size of the parts) to show the details of the manner in which the thin insulating sheath of the flat cable is stripped from one face of the conductors to provide for direct electrical union between interconnecting conductors of the mating cables;

FIGURE 7 is a detail sectional view through the connector assembly taken substantially on the plane of the line 7—7 of FIGURE 3;

FIGURE 8 is a fragmental perspective view of a pressure spring employed in the connector;

FIGURE 9 is a plan sectional view of the connector assembly taken substantially along the lines 9—9 of FIGURES 3 and 7; and

FIGURE 10 is another cross-sectional view of a connector assembly showing the manner in which the parts heretofore illustrated may be adapted for pressurized mounting of the connector receptacle on a panel, and arranged for engagement with the terminal edge of a typical circuit board.

As best shown in FIGURE 1, the typical connector assembly in accordance with the present invention employs two plug members generally indicated at 10, oppositely disposed with respect to an intermediate receptacle or shell 11. The plugs 10 may be of identical construction, illustrated as including exterior body portions 12 having apertures 13 by which they may be secured to the receptacle 11 by thumbscrews 14. Each plug also includes a relatively broad, flat tongue 15 (FIGURES 4–7) extending between guide flanges 16 spaced inwardly from the ends of the body 12 far enough to be clear of the screw holes 13. These tongue portions of each plug form a support over which a terminal portion near the end of each of the flat cables 17 is supported, so that the cables may be brought into direct contacting relationship with each other when the tongues of a pair of the plugs are inserted into apertures on the opposite faces of the receptacle housing 11 in reversed and oppositely oriented positions (FIGURE 5). Thus each of the plugs 10 func-

tions as a terminal element for the end of one of the flat multi-conductor cables **17**. As best shown in FIGURE 2, each cable consists of a multiplicity of thin, flat, flexible, parallel metal ribbons **18**, all lying in the same plane but spaced apart from each other and embedded in an insulating jacket or sheath **19**. The sheath obviously may be integral or homogeneous throughout, or may consist of two opposite sheets of insulating plastic material pressed together on the opposite sides of the conductors to form a laminate or "sandwich" type construction as is conventional in the art.

In practice, flat multi-conductor cables of this general type usually employ metallic conductors of substantially pure copper with a thickness of .0015 inch and a width of .030 inch, spaced .01 inch from each other center-to-center, and embedded in insulating polyester having a total thickness of .009 inch. The cables may be of various widths, including up to 50 or more parallel conductors.

As best shown in FIGURES 1, 3, 5 and 9, the receptacle member **11** consists of an elongated rectangular shell having paired mounting poles **21** at its opposite ends intercepted by threaded apertures **22** in which the thumbscrews **14** may be seated to hold the plugs **10**. If desired, the threaded openings **22** in the end of the receptacle shell may be provided with threaded metallic inserts **23** to receive the threaded end portions of the thumbscrews **14**. Also, it will be observed that the screws are mounted in counterbored openings in the plug shell and provided with retaining rings **24** so that they will not be dislodged, and the apertures **13** may be threaded at **26** (FIGURE 9) so that the screws can be removed by first removing the rings **24**.

The receptacle shell **11** provides, in essence, a confining housing in which the two plugs **10** are detachably mounted in a manner to interconnect their ribbon conductors **18** directly with each other. To this end, the receptacle **11** has a longitudinal flange **27** extending along each of its opposite faces **28**, **29** (FIGURE 5) with one elongated aperture **31** on its front face **28** offset from the corresponding aperture **32** on its face **29**, so that the opposed mating plugs are somewhat offset from each other, but interconnect when inserted in the reversely oriented positions shown.

The manner in which the fiat cable is connected to the plug is best seen by comparison of FIGURES 4, 5 and 8 from which it will be seen that the body portions **12** of the plugs **10** each include an open pocket **33**, arranged to receive the end of the flat cable **17** and to provide a receptable for potting compound **34** by which the connector is sealed after attachment to the cables, as later described. The forward wall **35** of each of the plug bodies has a pair of relatively long longitudinal slots **36** and **37** adjacent the upper and lower faces of the projecting tongue **15**, which has a smoothly rounded convex end **38**, interconnecting its innermost, or "contact" wall **41** with its outer or back wall **42**. The inner wall **41** of the tongue is provided with a multiplicity of spaced ribs **43** defining slots **44** into which the individual teeth of a pressure spring will seat.

The type of pressure spring utilized is best illustrated in FIGURE 8 of the drawings, from which it will be seen that the spring consists of what may be termed an elongated "comb" formed of a single thickness of sheet metal folded upon itself in a U-shaped bend **45** to provide a short hook **46** on the back side and a broader pressure plate on the other, punched out to provide a marginal retaining flange **47—48** encircling the free ends of a plurality of identical spring fingers **49** arranged to project rearwardly from the reverse bend **45** to a position adjacent the remote transverse strip **48** of the retaining flange **48—49**. The comb is arranged to be snapped into position over the flat tongue of the connector plug shown in FIGURE 4, and is accordingly so dimensioned that the back hook plate **46** of the comb will be received on the flat surface **51** of the plug between the rounded forward end **38** of the plug tongue and the offset notch **52** thereof. The spring fingers **49** of the comb are thus received in the slots **44** between the ribs **43** formed on the contacting face of the plug tongue with the cross strip **48** of the comb seated behind the shoulders **53** at the inner ends of each of the ribs **43** (FIGURE 7), in a manner to hold the comb against displacement from the tongue of the plug.

The cable is prepared for assembly by stripping a portion of the exterior layer of dielectric from the conductors, as shown at **55** in FIGURE 6, and also by splitting the insulating sheath of the cable longitudinally between the individual conductors, as best shown at **56** in FIGURE 8. When so prepared, a bared contacting portion of each of the individual conducting ribbons **18** is carried in each one of the individual narrow strips **57** of dielectric material which are joined to each other at both ends yet free to flex independently of each other in the zone of contact. With the cable so prepared and the comb thus positioned on the tongue of the plug, the terminal portion of a cable is slipped inwardly through the slot **36** (FIGURE 5) of the plug, and doubled back around the forward end **38** of the tongue so that the several conductors of the cable overlie the individual spring fingers of the comb, with the cable continuing back through the slot **37** and into the potting compound **34**, where it may end at **54** or extend to other equipment as indicated a **39**.

In the normal position of the parts before coupling the connector, the spring fingers of the comb underlying the individual strips of cable have an initially bowed contour (FIGURE 5) so that each of the conductors of the cable is flexed outwardly. When the connector is coupled, however, the parts move from the position shown in FIGURE 5 to the position of FIGURE 6. In so doing, the spring fingers of each of the interconnecting paired plugs are flexed in a manner to bring the bare surfaces of the individual conductive ribbons of the cable into direct surface-to-surface contact with each other. In this position, the conductors of the connected cables are held in direct intimate, low resistance electrical union by coaction of the spring fingers of each plug. Also, while they will normally lie in about the same plane as illustrated in FIGURE 3, it is to be noted that the splits **56** between the individual conductors (heretofore described in connection with FIGURE 8) permit the individual contacts to adjust themselves without interference from the contacts on either side (FIGURE 3).

When the connector is coupled, the tongues of the two interconnecting plugs are guided into position by engagement of the notches **59** on their guide flanges **16** (FIGURE 4) with the central rib **60** on the interior end wall of the shell **11** (FIGURE 3), to insure correct polarization of the connector and prevent inadvertent error in insertion of either plug. The thumbscrews **14** are then tightened to cause each of the connector plugs **10** to be drawn into firm engagement with the opposed faces of the receptacle **11**. Preferably, these are provided with gaskets **58** surrounding the apertures **31** and **32** thereof, so that compression of the gaskets effectively seals the interior of the connector against adverse environmental influences. It will also be observed that a seal around the flat cables themselves is accomplished by the potting compound **34** which may be poured into the cavities **33** in a plastic or semi-liquid state, and thereafter caused to harden by chemical or thermal means.

In the modification of the invention illustrated in FIGURE 10, the receptacle and plug as heretofore described have been illustrated in a form particularly adapted to use in connection with environmentally sealed circuitry, wherein the connector receptacle **11** is mounted on a panel or bulkhead **61** by screws **62**, to compress gasket **63**. Thus the connector may interconnect the terminal ends of the cable conductors to a plurality of parallel conductors **64** of a so-called printed or etched circuit board **65** enclosed within the housing of a piece of sealed electronic equipment. In this instance, the cable serves

to interconnect the flat tape cable to which it is particularly suited with a conventional circuit board, which as illustrated may be backed up with a spacer 66, and it will also be appreciated that the connector may be utilized to establish contact between the conductors of a flat cable and electrical wiring of more conventional design merely by substitution of conventional electrical contacts for the circuit board illustrated.

From the foregoing it will be apparent that the concepts of the present invention depart from the conventional practices in several respects and that in so doing, the present invention results in a unique combination and arrangement of parts which entirely eliminates the contact members heretofore conventionally employed in multiple connectors and establishes electrical union directly between the conductors of any one cable and the conductors of the cable to which it is united. Also, the present concept departs from the conventional practice of requiring male and female connectors or paired plugs and receptacles, since all of the terminal fittings attached to either end of the cable are identical, yet arranged to be coupled to each other by the utilization of a shell member adapted to receive two identical plugs. The arrangement is such that the physical size of the connector units is unusually compact in comparison to the number and capacity of the conductors involved, and the design of parts is such that satisfactory resistance to high voltage, breakdown and flash-over is accomplished even under high altitude conditions or other adverse environmental conditions.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. In an electrical connector, a connector plug having an elongated body portion with a longitudinal potting pocket therein, and at least one elongated aperture between said pocket and a relatively broad, flat, rigid tongue portion of the plug projecting therefrom; in combination with a flat cable having a multiplicty of conductors consisting of thin, flat, parallel, metallic ribbons embedded in and extending longitudinally of a thin, flexible sheath of insulating material; with the cable extending into the potting cavity of the plug and a terminal portion of said cable passing through an aperture therein to the projecting tongue, and doubled over the forward end of the tongue with the extreme end of the cable reversely extending and sealed in insulating potting compound received within the aforesaid potting pocket; with the portion of the cable overlying the projecting tongue of the plug having at least a portion of the conductive metallic strips therein bare of insulation, and with the insulating sheath longitudinally split between the conductors thereof to form separate parallel strips of the cable and allow limited lateral movement of said separate strips independently of each other; with a plurality of pressure devices comprising a series of independently yieldable metallic spring strips individually bearing against at least some of the individual strips of the cable to urge the bare surfaces of the metallic ribbons carried thereby individually into into surface-to-surface contact with corresponding conductive parts.

2. In an electrical connector, a connector plug having an elongated body portion with a longitudinal potting pocket therein, and at least one elongated aperture between said pocket and a relatively broad, flat, rigid tongue portion of the plug projecting therefrom; in combination with a flat cable consisting of a multiplicity of conductors consisting of thin, flat, parallel, metallic ribbons embedded in and extending longitudinally of a thin, flexible sheath of insulating material; with the cable extending into the potting cavity of the plug and a terminal portion of said cable overlying the projecting tongue, with the portion of the cable overlying the projecting tongue of the plug having at least a portion of the conductive metallic strips therein bare of insulation, and with the insulating sheath longitudinally split between the conductors thereof to form separate parallel strips of the cable and allow limited lateral movement thereof; with a plurality of pressure devices comprising a series of independently yieldable metallic spring strips individually bearing against at least some of the individual strips of the cable and adapted to urge the bare surfaces of the metallic ribbons carried thereby individually into surface-to-surface contact with corresponding conductive parts.

3. In an electrical connector, a connector plug having an elongated body portion with a relatively broad, flat, rigid tongue portion of the plug projecting therefrom; in combination with a flat cable consisting of a multiplicity of conductors embedded in and extending longitudinally of a thin, flexible sheath of insulating material; with a terminal portion of said cable overlying the projecting tongue, with the portion of the cable overlying the projecting tongue of the plug having at least a portion of the conductive metallic strips therein bare of insulation, and with the insulating sheath longitudinally split between the conductors thereof to form separate parallel strips of the cable and allow limited lateral movement thereof; with a plurality of pressure devices bearing against the individual strips of the cable and adapted to urge the bare surfaces of the conductors carried thereby individually into surface-to-surface contact with corresponding conductive parts.

4. In an electrical connector, the combination of a single hollow shell with imperforate top, bottom and end walls and a pair of elongated apertures on opposite side walls, with said apertures offset and reversely oriented with respect to each other; together with a pair of substantially identical connector plugs oppositely oriented with respect to each other and each having a relatively broad flat rigid tongue portion projecting into one of the apertures of the aforesaid shell and carrying a series of conductive terminals; with each terminal doubled back upon itself around the forward edge of said tongue portion, and with bare portions of each terminal directly engaging corresponding bare portions of mating terminals of the other plug; the terminals carried by each of said plugs being movable independently of each other while lying in generally parallel side-by-side relation; with spring means consisting of a single metallic comb-shaped member including a series of independently yieldable metallic spring strips in parallel relation to each other and each underlying one of the terminals but insulated therefrom and opposite the bared portion thereof, for urging said terminals toward each other to effect free-floating resilient engagement therebetween.

5. In an electrical connector for directly interconnecting a pair of flat flexible cables each consisting of a multiplicity of metallic conductors disposed in a common plane and embedded in spaced parallel relation longitudinally within a thin flexible insulating sheath, the combination of a single hollow shell with a pair of elongated apertures on opposite side walls, with said apertures offset and reversely oriented with respect to each other; together with a pair of substantially identical connector plugs oppositely oriented with respect to each other and each having a relatively broad flat rigid tongue portion projecting into one of the apertures of the aforesaid shell and carrying a terminal portion of said cable, with the terminal portion of each cable doubled back upon itself around the forward edge of the tongue portion of the plug, with the ends of the cable sealed in insulating compound within the plug and with bare portions of the cable conductors of each plug directly engaging corresponding bare portions of mating conductors of the other plug; the flat cable being split longitudinally between the conductors throughout an area of the inner face surface of the aforementioned rigid tongue portion whereby the conductors carried by each of said plugs are movable independently of each other while lying in

generally parallel side-by-side relation; with spring means consisting of a series of independently yieldable metallic spring strips in parallel relation to each other and each underlying one of the conductors of the cable in a position opposite the bared portion thereof for independently urging each conductor for each pair toward each other to effect free-floating resilient engagement therebetween.

6. In an electrical connector for directly interconnecting a pair of flat flexible cables each consisting of a multiplicity of metallic conductors disposed in a common plane and embedded in spaced parallel relation longitudinally within a thin flexible insulating sheath, the combination of a single hollow shell with a pair of elongated apertures on opposite side walls, with said apertures offset and reversely oriented with respect to each other; together with a pair of substantially identical connector plugs oppositely oriented with respect to each other and each having a relatively broad flat rigid tongue portion projecting into one of the apertures of the aforesaid shell and carrying a terminal portion of said cable, with the terminal portion of each cable doubled back upon itself around the forward edge of the tongue portion of the plug, with the ends of the cable sealed in insulating compound within the plug and with bare portions of the cable conductors of each plug directly engaging corresponding bare portions of mating conductors of the other

plug; the flat cable being split longitudinally between the conductors throughout an area of the inner face surface of the aforementioned rigid tongue portion whereby the conductors carried by each of said plugs are movable independently of each other while lying in generally parallel side-by-side relation; with spring means opposite the bared portion thereof for independently urging each conductor of each pair toward each other to effect free-floating resilient engagement therebetween.

References Cited in the file of this patent

UNITED STATES PATENTS

2,014,853	Ley et al.	Sept. 17, 1935
2,732,531	Janowiec	Jan. 24, 1956
2,858,515	Thunander	Oct. 28, 1958
2,956,260	Bennett	Oct. 11, 1960

FOREIGN PATENTS

8,743	Great Britain	of 1892
700,490	Great Britain	Dec. 2, 1953

OTHER REFERENCES

Electronic Design, August 15, 1957, pages 48, 49.
Electronic Design, October 28, 1959, pages 36–39.