PATENT SPECIFICATION (11) 1 564 576

1 564 576

(21) Application No. 41262/77 (22) Filed 4 Oct. 1977 (19)

(31) Convention Application No. 731728 (32) Filed 12 Oct. 1976 in

(33) United States of America (US)

(44) Complete Specification Published 10 Apr. 1980

(51) INT. CL.[3] H01R 13/66

(52) Index at Acceptance
H2E 18 21 31 3A15 3A4A 3A4E 3B6 3C6C 3D4 3E22
H1R BB

(72) Inventor: KAMAL SHAWIKY BOUTROS

(54) AN ELECTRICAL FILTER CONNECTOR

(71) We, BUNKER RAMO CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 900 Commerce Drive, Oak Brook, Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to electrical filter connectors, and is particularly but not exclusively concerned with tubular pi filters and the interconnection thereof to a respective pin contact and the metal connector shell.

United States Letters Patent 3,588,758 discloses a tubular filter which is constructed as a pi filter. The filter is mounted surrounding a pin contact and disposed within a bore in a massive ground plane plate. A common terminal for two capacitors is electrically connected to the ground plate by way of at least one elongate spring within the bore. Connection to the pin contact is achieved by an elongate eyelash spring which extends through the central opening of the tubular filter so as to engage the pin contact.

U.S. 3,743,979 discloses a similar tubular filter in which electrical contact to a metal layer carried on the inner surface of the filter is achieved by the provision of radially outwardly bowed spring portions on a pin contact.

Prior art discloses a planar capacitor structure in which the capacitor plates extend radially of the pin electrodes. The plates which are to be connected to the pin electrode are interconnected by an inner surface metalization which is contacted by a separately formed spring contact mounted on and carried by the pin electrode.

According to the present invention there is provided an electrical connector assembly comprising: a metal connector shell; a dielectric support mounted in said shell and including a passageway therethrough; an electrical contact mounted in and extending through said passageway; a tubular filter mounted in said passageway with said electrical contact extending therethrough, said tubular filter including a tubular dielectric member having inner and outer surfaces, a first electrode carried on said outer surface of said tubular dielectric member, at least one second electrode carried by said tubular dielectric member, a tubular inductor within said tubular dielectric member, said tubular inductor having inner and outer surfaces, an inner conductor carried on said inner surface of said tubular inductor and electrically connected to said second electrode; a spring contact element mounted on said electrical contact and in engagement with said inner conductor; and a conductor extending radially of said tubular filter and in contact with said metal connector shell and said first electrode.

According to an embodiment of the invention, a pin contact is mounted in and extends through a passageway in a dielectric insert which is mounted within a metal connector shell. Conventionally, the metal connector shell is taken as ground. A tubular filter is mounted coaxially about the pin contact and includes an inner tubular inductor which is surrounded by a tubular capacitor, the tubular capacitor defining a pair of capacitors of a pi filter. The inner surface of the inductor tube , which may be a ferrite, carries a metal layer which is connected at the ends of the tube, with a pair of metal layers carries spaced apart on the inner surface of a dielectric, perhaps ceramic, tube which is a part of the capacitors. A metal layer is also carried on the outer surface of the dielectric tube in an overlapping relation to the metal layers carried on the inner surface of the tube. The outer metal layer constitutes the ground electrode for the filter and the inner metal layer constitutes a single terminal for electrical connection to the pin contact. The pin con-

tact carries a spring element having at least one bow which extends radially outwardly thereof to engage the metal layer on the inner surface of the ferrite tube. A simple generally flat spring structure may be mounted transversely of the filter to engage the outer metal layer and the metal connector shell, and serve as a ground plane and grounding connection.

The tubular filter may be constructed as a pi filter and constructed in a simple manner from a pair of multi-layer tubular capacitors. Each of the tubular capacitors comprises a plurality of hollow concentric dielectric layers each carrying a metal layer on the outer surface thereof. The multi-layer structure is fused into an integral element with alternate metal layers extending to opposite ends of the integral structure. At each end the metal layers extending to that end are connected by an additional metal layer. Two of the capacitors so formed are disposed, axially aligned, in end-to-end abutment so that the end layers which connect to the most radially outward layer contact each other. A ferrite tube, metalized as described above, is inserted so as to be coaxial with the capacitors and the end layers of the end-to-end combination are connected to the inner metal layer of the ferrite tube. The connection of the two capacitors and the connection of the two capacitors with the metal layer of the ferrite tube can be accomplished by soldering, thermo-fusion or the like.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawing, in which:

Fig. 1 is a fragmentary sectional view of an electrical connector assembly constructed in accordance with the present invention;

Fig. 2 is an elevational view, shown partially in section, of the pi filter illustrated in Fig. 1;

Fig. 3 is a perspective view of a spring contact element which may be employed in practicing the present invention; and

Fig. 4 is a longitudinal sectional view of another pi filter constructed in accordance with the invention.

Referring to Fig. 1, an electrical connector assembly is generally illustrated at 10 as comprising a metal connector shell 12 having a front end 14 for telescopic engagement with a mating connector assembly and a rear end 16 for attachment to a multi-connector cable. A dielectric contact supporting structure is mounted in the housing 12 and comprises a dielectric insert 18, a contact retention disc 22 and a dielectric insert 26. The dielectric inserts and the contact retention disc are preferably constructed of a high temperature resisting dielectric material. The dielectric insert 26 includes a passageway 28 which is aligned with a passageway 20 in the dielectric insert 18 and with a passageway 24 in the contact retention disc 22. Forward of the dielectric insert 26 is a front seal 30 which includes a passageway 32, and a peripheral rim seal 50. The passageway 32 is also axially aligned with the passageways 28, 20 and 24.

A plurality of electrical contacts 34 are mounted in the electrical connector assembly. More specifically, and as illustrated in detail in Fig. 1, an elongate pin contact 34 is mounted in the aligned passageways 20, 24, 28, 32 and includes a forward portion for mating engagement with a complementary contact of a mating connector assembly, a tail portion 38 for connection to an electrical conductor, and an intermediate portion 40 therebetween mounted generally within the dielectric inserts 18 and 26. The contact 34 includes a radially extending flange 41 having a forward surface for engaging a rear surface portion 43 of the di-electric insert 18 to prevent forward movement of the contact and a rear surface which engages flexible tines 39 to prevent rearward movement of the contact. Of course, outward deflection of the tines 39 with a suitable tool will permit release and removal of the contact 34. Such structure is generally known in the art as a rear release structure. Rearwardly of the contact retention disc 22 is a rear seal having a conductor passageway 44 therethrough for receiving the conductor which is to be attached to the tail portion 38 of the contact 34. As is well known in the art, compression of the rear seal causes a radial sealing expansion thereof against the inner surface of the metal shell 12 and sealing at the passageway 44 to the individual conductor. The front seal 30, the rim seal 50 and the rear seal 42 are formed of a rubber compound, preferably a fluorosilicone rubber.

Each of the inserts and the retention discs is essentially disc or cylindrically shaped. Forward movement of the insert 26 is prevented by engagement of a forward facing shoulder 52 thereof against a rearward facing shoulder 54 of the metal shell 12. The insert 18 bears against the insert 26, via an earthing plate 66 which will be discussed below and the retention disc 22 bears directly against the insert 18. It will be noted that the retention disc 22 includes a gently outwardly extending ramp portion 56 which snaps into a correspondingly shaped recess poriton 46 of the metal shell 12 so that a rearwardly facing shoulder 58 thereof engages a forwardly facing shoulder 60 of the metal shell 12 to retain the retention disc 22 and the inserts 18 and 26 within the metal shell 12.

A plane metal earthing conductor 66, in the form of a perforate disc, is mounted between the dielectric insert 18 and the dielectric insert 26. The ground plane conductor 66 includes a peripheral spring flange 68 which

engages the inner surface of the metal connector shell 12. At the location of each contact, the conductor 66 includes an aperture defined by an annular spring flange 70 which extends rearwardly and radially inwardly with respect to the longitudinal axis of the contact to engage a ground terminal 84 which is carried on the outer surface of a tubular filter 72. The tubular filter 72 also includes an inner conductor 80 which is electrically connected to the elongate pin contact 34 at the intermediate portion 40 by means of a spring contact element 106. The intermediate portion 40 includes a reduced diameter portion having a rearward facing surface 102 and a forward facing surface 104. The spring contact element 106 is mounted between and bears against these surfaces.

Referring to Fig. 2, the filter 72 is illustrated in greater detail as comprising a hollow tubular ceramic tube 82 having an inner surface and an outer surface. A metal layer 84 is carried on the outer surface and a pair of metal layers 86 and 88 are carried spaced apart on the inner surface in an overlapping relationship with respect to the metal layer 84. The metal layers 86 and 88 constitute capacitor plates or electrodes and the metal layer 84 constitutes a capacitor plate or electrode which is common to the plates 86 and 88. The metal layer 84 therefore constitutes, when connected as shown in Fig. 1, a ground terminal for the capacitors. Mounted coaxially within the tubular capacitor is a tubular inductor which comprises a ferrite tube 78 which also has an outer surface and an inner surface. The inner surface of the ferrite tube 78 carries a metal layer 80 which is connected at each end of the tube to the metal layers 86 and 88. The metal layers 80, 84, 86 and 88 are preferably constructed of a good electrically conductive material, preferably silver. The connections 90 and 100 between the metal layers 80, 86 and 88 may be provided as solder joints.

Turning back to Fig. 1, the filter 72 is mounted within the inserts 18 and 26 within the aligned passageways 20 and 28 and about the pin contact 34. Advantageously, stress isolating elastomeric membranes 74 and 76 may be disposed in front of and behind the filter.

Fig. 3 illustrates an embodiment of a spring contact element 106 which may be used to advantage in a field removable contact application, such as illustrated in Fig. 1. The spring element 106 comprises a generally annular portion 108 having an end face 110 and a generally annular portion 112 having an end face 114. As illustrated in Fig. 1, the end faces 110 and 114 would abut the radial faces or shoulders 102 and 104 of the pin contact 34. The spring element 106 also comprises a pair of outwardly bowed portions 116 and 118 extending between the annular portions 108 and 112. The annular portion 108 includes a longitudinal slit 120 and the annular portion 112 includes a longitudinal slit 122 to permit snapping of the spring element over the reduced diameter portion of the pin contact 34.

Experience has shown that, in general, a pi filter having the foregoing structure is limited to a maximum total capacitance of approximately *30,000* pf. A typical multilayer "C" type tubular capacitor can be constructed (generally elements 132-140 of Fig. 4) so as to produce approximately *60,000* pf capacitance. I have found that the structure discussed above with respect to Fig. 2 can be extended through the utilization of "C" type capacitances to provide a pi filter which has a high capacitance, e.g. up to about *120,000* pf. Such a pi filter is illustrated in Fig. 4.

The pi filter 124 in Fig. 4 may be mounted in the same manner as the pi filter 72 illustrated in Figs. 1 and 2 and comprises two "C" type capacitors which are soldered end-to-end and which have located coaxially therein a metalized ferrite tube.

More specifically, the pi filter 124 of Fig. 4 comprises a plurality of annular dielectric layers 132 which are concentric and which carry respective metal layers 134 and 136 as capacitor plates. The multi-layer structure is processed into a unitary structure and the metal layers 134 are interconnected at one end by a metal layer 140 and the metal layers 136 are connected together at the opposite end by a metal layer 138 to form a "C" capacitor. A second "C" capacitor comprises a plurality of annular dielectric members 142 which carry metal layers 144, 146. The metal layers 144 are connected together at one end of the capacitor by a metal layer 150, and the metal layers 146 are connected together at the opposite end of the capacitor by a metal layer 148. The capacitors are coaxially aligned with the metal layers 140 and 150 abutting each other and the metal layers 140 and 150 are soldered together. The outer metal layers 134 and 144 therefore constitute the ground electrode in the same manner that the metal layer 84 constitutes the ground electrode in Figs. 1 and 2. The metal layers 138 and 148 constitute separate terminals of the capacitors.

A ferrite tube 152 is inserted into the two capacitors so as to be coaxial to both capacitors and concentric within each of the capacitors with respect to a central axis 160. The ferrite tube 152 carries a metal layer 154 on its inner surface and a pair of metal layers 156 and 158 which cover its end surfaces and which are connected to a metal layer 154. The metal layers 156 and 158 are electrically connected, as by soldering, fusing or the like, to the metal layers 148 and 138, respectively. The two separate capacitor terminals 138 and 148 are thereby extended to become a

single terminal for the filter at the metal layer 154.

Although the invention has been described by reference to particular illustrative embodiments thereof, many changes and modifications of the invention may become apparent to thos skilled in the art without departing from the scope of the invention.

WHAT WE CLAIM IS:

1. An electrical connector assembly comprising: a metal connector shell; a dielectric support mounted in said shell and including a passageway therethrough; an electrical contact mounted in and extending through said passageway; a tubular filter mounted in said passageway with said electrical contact extending there-through, said tubular filter including a tubular dielectric member having inner and outer surfaces, a first electrode carried on said outer surface of said tubular dielectric member, at least one second electrode carried by said tubular dielectric member, a tubular inductor within said tubular dielectric member, said tubular inductor having inner and outer surfaces, an inner conductor carried on said inner surface of said tubular inductor and electrically connected to said second electrode; a spring contact element mounted on said electrical contact and in engagement with said inner conductor; and a conductor extending radially of said tubular filter and in contact with said metal connector shell and said first electrode.

2. An electrical connector assembly as claimed in Claim 1, wherein: said tubular filter is a pi filter and includes a pair of said second electrodes each extending over respective portions of said inner surface from opposite ends of said tubular dielectric; said first electrode extends over the central portion of said outer surface in overlapping relation to said second electrodes; and said inner conductor is electrically connected to each of said second electrodes at the end of said dielectric member and inductor.

3. An electrical connector assembly as claimed in Claim 1, wherein said tubular inductor comprises a ferrite tube and said inner conductor is plated metal layer.

4. An electrical connector assembly as claimed in Claim 1, wherein said tubular dielectric member is a ceramic tube and said first and second electrodes are plated metal layers on the outer surface and inner surface, respectively of said ceramic tube.

5. An electrical connector assembly as claimed in Claim 1, wherein said electrical contact includes a pair of spaced-apart shoulders; and said spring contact element is mounted between said shoulders and includes at least one radially outwardly extending resilient bow portion.

6. An electrical connector assembly as claimed in Claim 1, wherein said tubular dielectric member comprises ceramic material as the dielectric material.

7. An electrical connector assembly as claimed in Claim 1, wherein said conductor is mounted in said metal connector shell and extends from said shell to said filter, said conductor including a first spring contact engaging said shell and a second spring contact engaging said first electrode.

8. An electrical connector assembly as claimed in Claim 1, wherein: said at least one second electrode comprises a plurality of pairs of radially spaced, electrically connected annular second electrodes; one electrode of each pair of second electrodes is connected to like electrodes at one end of said dielectric body, the other electrode of each pair of second electrodes is connected to like electrodes at the other end of said dielectric body; said inner conductor is connected at its one end to said one electrode and at its other end to said other electrode of each pair of second electrodes; and additional paired annular electrodes, connected to said first electrode, are radially alternately spaced between said second electrodes.

9. An electrical connector assembly as claimed in Claim 1, wherein said tubular dielectric member and said first and second electrodes form two axially-aligned tubular capacitors.

10. An electrical connector assembly as claimed in Claim 9, wherein each of said tubular capacitors further include; a plurality of additional electrodes; a first metal layer on a first end of said capacitor electrically connecting said addition electrodes to said first electrode; and a second metal layer electrically connecting said at least one second electrode to said inner conductor.

11. An electrical connector assembly substantially as hereinbefore described with reference to the accompanying drawings.

For the Applicants
REDDIE & GROSE
Agents for the Applicants
16 Theobalds Road
London, WC1X 8PL.

Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1980.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

Fig-1

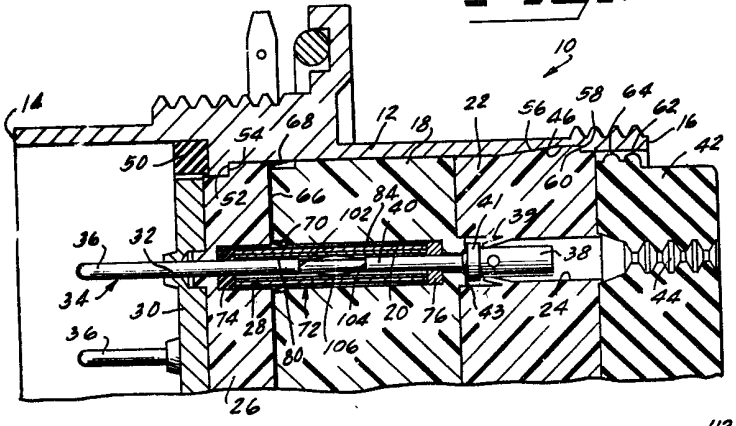


Fig-3

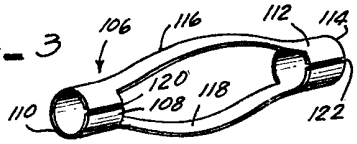
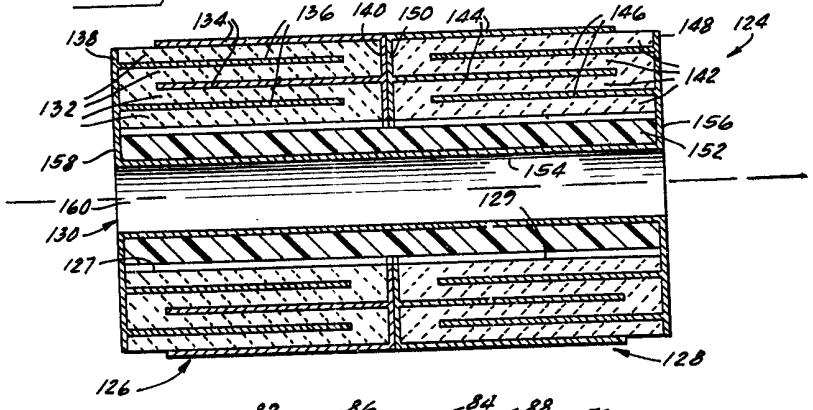


Fig-4



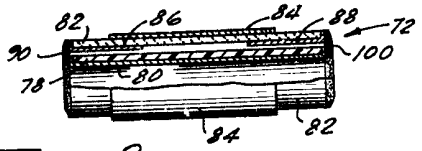


Fig-2