Sept. 26, 1961 W. W. GARSTANG 3,002,162

MULTIPLE TERMINAL FILTER CONNECTOR

Filed Nov. 20, 1958 2 Sheets-Sheet 1

Fig. 1

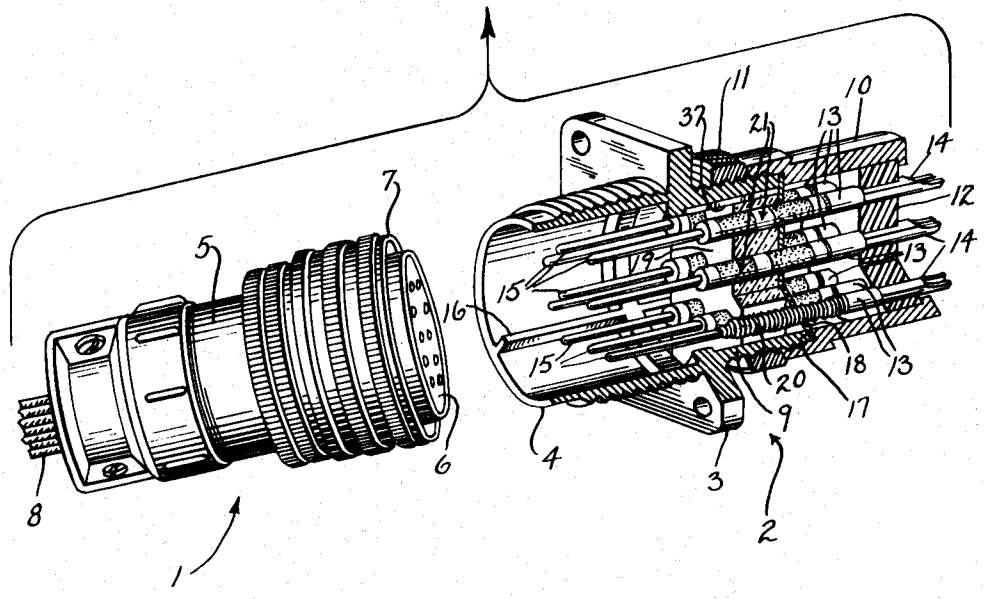

Fig. 2

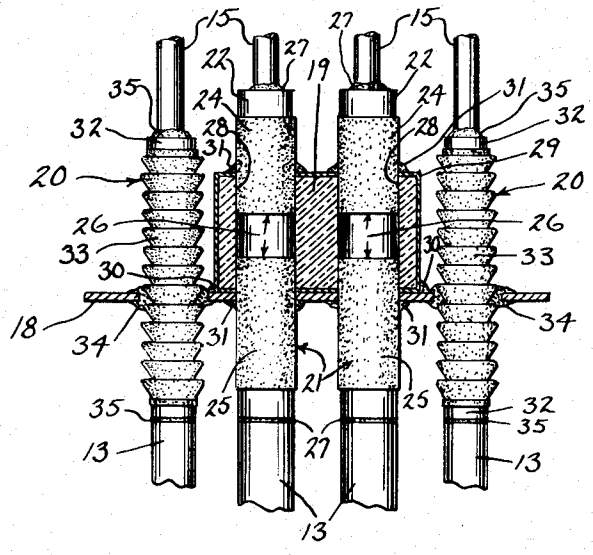

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Fig. 3

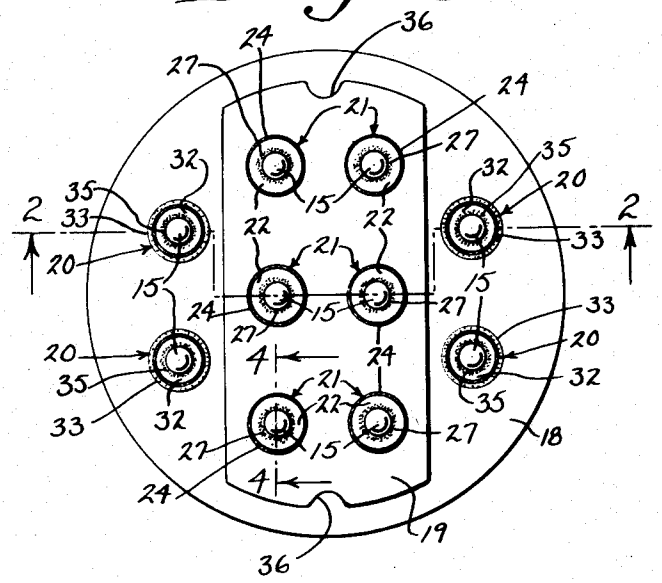
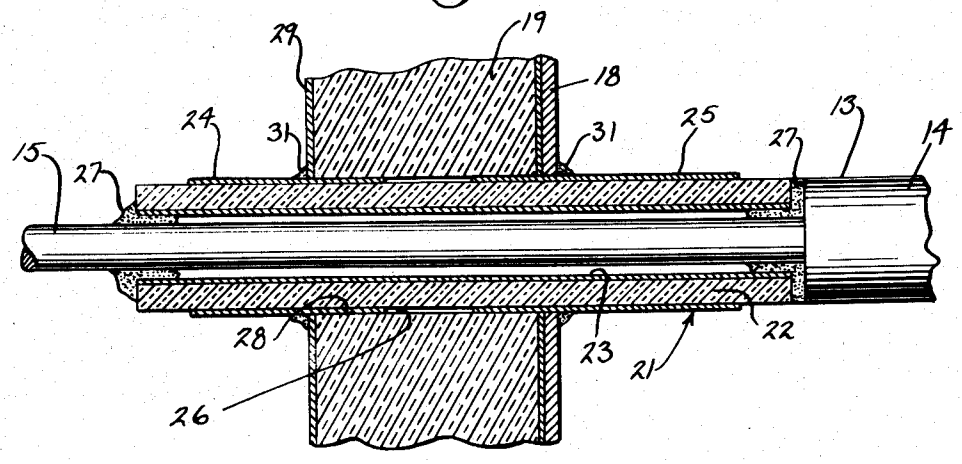


Fig. 4



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MULTIPLE TERMINAL FILTER CONNECTOR

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8 Claims. (Cl. 333—1)

This invention relates to multi-conductor current transmission systems for high frequency applications, and it more specifically resides in a plurality of conductors grouped together with each extending through a low reactance feed-through filter for by-passing high frequency currents from the conductors, wherein a plurality of such filters are mounted in a block of magnetic material to retain low reactance characteristics over a broad range of the high frequencies encountered.

Considerable investigation has been undertaken for the provision of single feed-through filters that function as by-passes for high frequencies ranging upwardly to the order of 1000 megacycles. It is a primary purpose of such filters to carry low frequency or direct currents along a conductor extending from within a shielded area, through an enclosing wall of such area, and hence to the exterior, while at the same time by-passing through the filter elements such high frequency currents as are present within the area enclosed by the wall. It is essential that the high frequency currents be channeled from the low frequency conductor to eliminate interference with circuits outside the shielded area, and it is apparent that the filter must accordingly present a low by-pass impedance throughout the frequency spectrum encountered.

High frequency phenomena causes a simple capacitor to exhibit an impedance quite different from the usual inverse relation to frequency that is had when pure capacitance alone is present. The high K dielectrics, such as the titanates developed for the purpose, have internal phenomena at very and ultra-high frequencies that causes them to behave as cavities that resonate in certain frequency bands. This inductive quality together with inductance of leads causes a capacitor to be analogous to a filter network, and the term "filter" as used herein refers to such capacitors subject to high frequencies. Resonant conditions of a filter are encountered at certain frequencies, and for these particular frequencies the impedance through the filter will sharply rise. The filter then fails to act as an effective by-pass. These resonant phenomena of high K dielectrics under influence of very and ultra-high frequencies have been investigated and it has been taught that inclusion of magnetic materials, such as the ferrites, in a filter will eliminate the undesirable increases in impedance or shift the resonant frequency bands outside the working frequency spectrum.

It would be advantageous to have an effective high frequency by-pass not only in single conductors exiting from enclosed areas, but also for groups of conductors entering or leaving a chassis or circuit unit. It is an object of the present invention to provide such a by-pass, through the grouping of a number of feed through filters in a magnetic block. The filters may be closely spaced and of small dimension for concentrating the arrangement in a confined area, and in one contemplated form of the invention the filters and supporting block may be housed within a connector plug. In this fashion the conductors that extend through the filters may fulfill the dual function of male connectors protruding from the plug and as filter components. Multi-conductor cables fitted with plug-type connections are common in complex apparatus for navigation, military, television, and like uses,

and the invention greatly facilitates the use of such apparatus which requires the particular high frequency by-pass characteristics described above.

It is another object of this invention to group a number of feed through filters within a minimal space.

It is another object of this invention to provide a cable connector having the improved electrical characteristics of by-passing unwanted frequencies from the cable conductors.

It is another object of this invention to provide a cable connector having conductors of differing impedances grouped together within a confined space.

The foregoing and other objects and advantages of this invention will appear from the description to follow. In the description reference is made to the accompanying drawings, which form a part hereof, and in which there is shown by way of illustration and not of limitation a specific embodiment of the invention.

In the drawings:

FIG. 1 is a view in perspective with parts broken away and in section of a receptacle and plug connector combination in which the invention is embodied,

FIG. 2 is an axial view in cross section of an internal portion of the plug connector of FIG. 1,

FIG. 3 is an end view of the portion shown in FIG. 2, and

FIG. 4 is a fragmentary view in longitudinal cross section of a filter forming a part of the apparatus.

Referring now to FIG. 1, there is shown therein a receptacle connector **1** and a plug connector **2** having a mounting flange **3** and an externally threaded thin walled skirt **4**. The exteriors of the connectors **1** and **2** are of conventional design, whereby the plug connector **2** may be secured upon a panel, or chassis, by insertion in an appropriate opening and bolting the mounting flange **3** to the panel with the skirt **4** extending outwardly therefrom. The externally threaded cylindrical skirt is thus exposed for making connection with the receptacle connector **1**. The connectors **1** and **2** are each adapted to carry a substantial plurality of electrical conductors, and hence a numerous number of electric circuits can be led from the interior of a chassis for connection with circuits exterior to such chassis.

The receptacle connector **1**, as shown in FIG. 1, is quite conventional and presents a housing shell **5** which has a pin socket **6** at one end with multiple openings to receive a plurality of contacts. Surrounding the pin socket **6** is a loosely fitting internally threaded coupling ring **7** adapted for engagement with the external thread of the skirt **4**. By moving the pin socket **6** into the skirt **4** and bringing the coupling ring **7** up tight on the exterior threads of the skirt **4** the connectors **1** and **2** are joined to one another. A number of flexible conductors **8** lead from the rear of receptacle connector **1**, and in the usual known manner each flexible connector **8** is connected within the connector **1** to an individual socket within the pin socket **6**.

The plug connector **2** has a rear housing **9** at the side of the mounting flange **3** opposite the skirt **4**. The rear housing **9** is externally threaded to receive and engage a rear shell **10** held tightly in place by an assembly lock ring **11**, which likewise is in threaded engagement with the rear housing **9**. The after end of the rear shell **10** is closed by a back wall **12** through which extends a plurality of conductors **13**. Each conductor **13** has a partially flattened terminal end **14** seated in a mating opening in the back wall **12**. Each end **14** protrudes from the rear for making connection with circuit leads, not shown, within the chassis upon which the connector **2** is mounted. The conductors **13** extend forwardly from the back wall **12** to terminate in exposed in contacts **15** housed within the skirt **4** at the forward end of the plug con-

nector 2. Each pin contact 15 is in a position for insertion within the pin socket 6, when the receptacle connector 1 is brought up into engagement with the plug connector 2. An aligning key 16 on the inner surface of the skirt 4 meets with a corresponding keyway, not shown, in the connector 1, so that each pin 15 will properly align with an opening in the pin socket 6. Upon bringing up the receptacle connector 1 in engagement with the plug conductor 2, so as to insert the pin contacts 15 in the pin socket 6, the coupling ring 7 is brought into threaded engagement with the external thread of the skirt 4 as previously mentioned, so as to retain the connectors 1 and 2 in firm, positive engagement with one another.

Clampingly engaged between the after end of the rear housing 9 and a step 17 wthin the rear shell 10 is a metallic by-pass mounting diaphragm 18 which extends across the open interior of the connector 2. Mounted upon and covering a portion of the diaphragm 18 is a ferrite block 19. The block 19 has a pair of longitudinal grooves 36, shown in FIG. 3, which engage keys 37 on the inner wall of the housing 9, one of which is shown in FIG. 1, for aligning the block 19 with the other parts of the connector 2. Each conductor 13 extends through the diaphragm 18 and a plurality of the conductors 13 also extend through the block 19. Conductors 13 that do not extend through the block 19 pass to the sides thereof, as more clearly shown in FIGS. 2 and 3.

Each of the conductors 13 shown in the drawings is encircled by a tubular filter at the point where it extends through the diaphragm 18. Those conductors 13 extending only through the diaphragm 18 are shown with corrugated filters 20, and the other conductors 13 which extend through the block 19 are encircled by smooth walled tubular filters 21. The arrangement of the filters 20, 21 with the by-pass mounting diaphragm 18 and block 19 is more clearly shown in FIGS. 2–4. The general purpose of these filters 20, 21 is to by-pass high frequency currents from the conductors 13 to the body of the plug connector 2 and hence to the chassis in which the connector 2 is mounted. In this manner stray high frequency currents which may have been induced in the circuit leads that are connected to the conductor terminal ends 14 are prohibited from escaping from the chassis in which such leads reside. Filters utilized for this purpose are commonly known as feed-through filters and for circuit networks dealing with very and ultra-high frequencies it is essential that such filters present a low reactance path to the chassis over a frequency spectrum reaching well above the order of 1000 mcs. The lower limit for the frequency range of the invention may be considered at 30 mcs., which is the minimum value of the very high frequency range.

In television circuits and other electronic circuits utilizing very and ultra-high frequencies, such as navigational aids, radar and military applications, portions of the circuits generate frequencies that readily radiate, which radiations in turn easily induce currents in circuit leads. It is especially desirable to shield the circuit elements generating and working with such frequencies. Conductors must, nevertheless, be provided for leading into and exiting from these shielded areas, such conductors being used to supply low frequency currents and direct currents for bias voltages, control voltages and the like. It is essential that the high frequencies be prohibited from the shielded area along such conductors. The present invention is directed, in part, to the object of retaining the high frequencies within the shielded area and to provide for the introduction of substantial numbers of conductors into and out of the shielded area through the medium of a single connector. Such a connector may have a conventional exterior and may be manipulated, in connecting and disconnecting the conductors at the point where they pass through the shielding, in usual manner. The high frequencies are by-passed from the conductors by a filter construction that will now be described in detail.

Reference is now made to FIGS. 2–4 for a description of the filters 20, 21. One of the tubular filters 21 is shown in longitudinal cross section in FIG. 4, where it is seen that the associated conductor 13 has a terminal end 14 of relatively thick cross section, from which it is necked down to a smaller diameter for forming its pin contact 15. A dielectric 22 encircles a portion of the conductor 13 that is of pin end diameter, and is positioned adjacent the terminal end 14, such that the outside diameter of the dielectric 22 closely matches the diameter of the conductor terminal end 14. The dielectric 22 is formed of a high K material selected from one of the titanates as commonly employed in capacitors particularly adapted for high frequency application. High K material has a K value of 250 or greater, and values of 5,000 are not uncommon. An inner filter electrode 23 is deposited on the inner wall of the dielectric 22 in the form of a silver paste, that is fired to secure a permanent electrode intimately bonded to the dielectric material. Opposite filter electrodes 24 and 25 are similarly formed on the outer surface of the tubular dielectric 22, and as clearly shown in FIGS. 2 and 4 electrodes 24, 25 are longitudinally separated to define a gap 26 therebetween. A solder 27 is deposited at both ends of the dielectric 22 to electrically join the inner electrode 23 with the conductor 13 and to mechanically adhere the filter construction in place.

The tubular dielectric 22, with its outer electrodes 24, 25, fits within a complementary opening 28 in the ferrite block 19. The block 19 is coated over its entire surface with a conductive film 29 which may take the form of a heavy fired silver paste similar to the electrodes 23, 24, 25, of the filter construction. The wall of the opening 28 is not coated, but remains bare and fits snugly about a portion of each of the electrodes 24 and 25 so as to span and encircle the gap 26. A solder 30, shown in FIG. 2, forms a fillet between the block 19 and diaphragm 18 to join these elements together, and a solder 31 is laid down around the electrodes 24 and 25 where they emerge from the block opening 28 to form an electrical path leading from the electrodes 24, 25 to the conductive film 29 and the diaphragm 18, whereby the electrodes 24, 25 are in direct electrical communication with the outer body of the plug connector 2. The construction of each of the filters 21 is like that described in connection with the particular capacitor 21 of FIG. 4.

The corrugated filters 20 are shown as being spaced to the sides of the ferrite block 19 such that each filter 20, together with its associated conductor 13, only passes through the diaphragm 18. Each corrugated filter 20 has a dielectric 32 that is formed as a series of adjacent truncated cones, from which a generally corrugated configuration is developed, and it is by reason of this appearance that these filters 20 have received the identifying term of corrugated. The corrugated dielectrics 32 each surround an associated conductor 13, quite similarly as a dielectric 22 of a filter 21 encircles its associated conductor 13. On the inner surface of each corrugated dielectric 32 is deposited an electrode, not shown, and on the outer corrugated surface of each dielectric 32 is deposited an outer electrode 33. The electrodes of the corrugated filters 20 are formed of deposited, fired silver paste and to electrically join the outer electrodes 33 with the diaphragm 18 a solder 34 is laid down at the point where each filter 20 extends through the diaphragm 18. In addition, a solder 35 is laid down at the ends of each filter 20 to join the inner electrodes thereof, not shown, with the associated conductors 13, similarly as the solder 27 of the tubular filters 21 joins the electrodes 23 to the associated conductors 13.

If it be assumed, for discussion, that the filters 20 and 21 were neither corrugated nor had an associated block of ferrite material, but rather were simple smooth walled tubular filters interposed electrically between the conductors 13 and the diaphragm 18, then such filters would

fail to exhibit desired low reactance throughout the very and ultra-high frequencies, which range from 30 to 3000 mcs. The conductors **13** introduce inductance at such frequencies and the high K dielectric exhibits cavity phenomena that introduces resonance effects in a number of frequency bands. The resonance effects are that of parallel resonance, and hence the by-pass impedance through a filter sharply rises in certain bands of frequencies. Increased impedance impairs the passage of high frequency currents to a chassis, and therefore simple filters, or capacitors, do not have a satisfactory low impedance throughout a sufficiently wide frequency spectrum. The present invention minimizes resonant effects and provides a low reactance throughout a wide working spectrum of frequencies for a group of filters confined closely to one another. Resonant frequency bands raising the reactance to an intolerable level are thereby eliminated and a plurality of conductors may be confined closely to one another, making it feasible to place them in a housing such as the particular plug connector **2** described herein, whereby convenience in working with high frequency circuits is greatly facilitated.

The individual corrugated filters **20**, which are set apart from the block **19**, are characterized by a physical geometry which acts to deresonate the dielectric **32**, and to thereby eliminate frequency bands of high transfer impedance, and the particular construction illustrated in the drawings is more fully set forth and described in the copending application of Heinz M. Schlicke entitled "High Frequency Capacitor of Corrugated Configuration" bearing Serial No. 721,577 and filed March 14, 1958. It is contemplated that in the practice of the present invention that for the deresonated filters employed as individual components separate from the block **19** forms other than the corrugated type may be utilized.

The tubular filters **21** eliminate undesirable bands of resonant frequencies through a phenomena differing from a geometrical selection, as in the instance of the corrugated filters **20**. It must first be recognized that the resonant phenomena that would occur in a simple tubular filter is due largely to the response of the high K ceramic material comprising the dielectric **22**. The materials suitable for a dielectric **22** exhibit cavity like characteristics at the frequencies under discussion, and magnetic and electric fields are present which create resonate conditions since the wave lengths in the dielectric are extremely short. The cavity resonance is minimized by dividing the outer electrode of a filter **21** into separate electrodes **24**, **25** of differing length. By providing different lengths for the electrodes **24** and **25** the dielectric **22** may be deemed as subdivided into a pair of cavity sections of different resonant frequencies, and the net effect is to partially eliminate the unwanted resonant frequency bands. In addition, electric and magnetic fields will appear across the gap **26** and such fields will enter the ferrite block **19**. The ferrite for block **19** is selected to have its Q value less than unity at the frequencies to be encountered. For such a relation the ferrite block **19** will appear as resistive in character, rather than inductive as in usual ferrite applications where Q is above unity. The fields present adopt a path extending into the ferrite block **19**, and the block **19** dampens the fields such that the net effect upon the current path through the capacitor is resistive in character. The very marked dampening that weakens the fields produces a corresponding lessening of the cavity phenomena whereby resonance within the ceramic dielectric **22** is lessened. A more detailed discussion of the above phenomena may be found in the copending application of Heinz M. Schlicke for "Feed Through Capacitor," Serial No. 720,266, filed March 10, 1958.

It is a discovery of this invention that a plurality of feed-through filters may be inserted within a common ferrite block to obtain desirable low by-pass impedance for very and ultra-high frequencies. The filters, and associated conductors, may be closely compacted to have a plurality confined in a small area suitable for inclusion in a connector or similar receptacle. The influence of the currents in one conductor upon other closely associated conductors has been found to be only of slight effect. For example, cross talk between two conductors **13** of adjacent filters **21** has compared very favorably with separate filters with similar spacing between centers.

Where large D.C. currents are to be conducted, the feed-through filter may be set to the side of the common ferrite, as in the instance of the filters **20**. While the individual filters **20** are electrically connected through the common diaphragm **18** to the housing connector **2**, large D.C. currents nevertheless do not pre-load or saturate the ferrite. Detrimental impairment of the function of the ferrite is eliminated.

The invention makes more practical the subdivision of a complex circuit into separable chassis assemblies. The individual assemblies can be removed and substituted to facilitate maintenance, and it is also possible to place assemblies in positions remote from one another. For example, shipboard apparatus requiring installation at several stations on different decks can have improved shielding for high frequency units through use of connectors for the interconnecting cables that embody the invention. A few multi-conductor connecting cables can be used to join several separate assemblies, with high frequency by-pass provisions being incorporated such that no separate connections need be provided for each conductor entering or leaving a shielded area. Handling and installation of electronic equipment requiring several stations for a number of chassis is thus enhanced.

The invention also teaches a suitable and desirable manner for incorporating filter components within a coupling connector. The manner includes the mounting of the components on a conductive diaphragm that may be clampingly held in position between portions of the housing proper. Quick, easy assembly is thus had for practical, commercial use.

I claim:

1. In a multi-conductor feed-through the combination comprising a ferrite block; and a plurality of filter components each embedded in said block and including a conductor extending through the block, a dielectric encircling said conductor and extending into said block, a first electrode on the dielectric in electrical connection with said conductor, and a second electrode on the dielectric disposed adjacent said ferrite which is of a length that exposes the dielectric for coupling between the ferrite and the fields of the filter component.

2. In a multi-conductor feed-through for by-passing very high and ultra-high frequency currents the combination comprising a mounting body adapted for connection to a panel; a ferrite block carried by said body having a value of Q less than unity for the frequencies to be by-passed; a plurality of conductors extending through the block; a dielectric encircling each conductor and extending into the ferrite block; and a pair of electrodes on each dielectric with one in electrical connection with the associated conductor and the other in electrical connection with said body at a position adjacent the ferrite block to have coupling between the ferrite and fields of the dielectric.

3. A multi-conductor feed-through as in claim 2 wherein one of the electrodes for each dielectric is subdivided with a gap between the subdivisions that is encircled by the ferrite block.

4. In a multi-conductor feed-through the combination comprising a connector body; a ferrite block within said body; a plurality of filter components each extending through said ferrite block with each component including a tubular dielectric of high K material, an inner electrode on the inside of the dielectric, and a pair of longitudinally spaced outer electrodes of unequal length on the outer surface of the dielectric which form a gap therebetween;

each component being disposed with the ferrite block encircling the gap between the spaced outer electrodes; electrical connections between the outer electrodes and the connector body; and a plurality of conductors each extending through a filter component and in electrical connection with the inner electrode thereof.

5. In a multi-conductor feed-through the combination comprising a connector body adapted to be electrically secured to a panel; a conductive mounting diaphragm electrically joined to said body; a ferrite block mounted upon said diaphragm with a conductive coating that is electrically connected to the diaphragm; a plurality of filter components each extending through said ferrite block with each component including a tubular dielectric, an inner electrode on the inside of the dielectric, and a pair of longitudinally spaced outer electrodes on the outer surface of the dielectric which define a longitudinal gap therebetween, each component fitting snugly within said ferrite block with the block encircling the gap defined by the spaced outer electrodes; electrical connections between one outer electrode and the conductive coating on the ferrite block and between the other outer electrode and said mounting diaphragm; and a plurality of conductors each extending through a filter component in electrical connection with the inner electrode of such component.

6. In a multi-conductor feed-through the combination comprising a connector body having an open interior; a conductive mounting diaphragm electrically joined to said body and extending across said open interior; a ferrite block mounted upon and covering a portion of said diaphragm; a plurality of filter components each within said ferrite block and each including a tubular dielectric, an inner electrode on the inside of the dielectric, and a pair of longitudinally spaced outer electrodes on the outer surface of the dielectric which define a longitudinal gap therebetween, each component fitting within said ferrite block with the block encircling the gap defined by the spaced outer electrodes; electrical connections between each outer electrode and said diaphragm; a by-pass filter extending through said diaphragm and disposed to the side of said ferrite block; and a plurality of conductors each extending through a filter component in electrical connection with the inner electrode thereof, and one of said conductors extending through said by-pass filter as a part thereof.

7. In a multi-conductor connector the combination comprising a tubular housing member; a shell engageable with said housing and extending axially therefrom with an abutment surface axially spaced from a surface of said housing; a conductive diaphragm within said tubular housing clampingly held between said surfaces of said housing and said shell; a plurality of filters supported by said diaphragm in electrical engagement therewith; a ferrite block supported on said diaphragm surrounding a portion of the filters and having a metalized surface electrically connected with the diaphragm and the filters it surrounds; and a plurality of pin conductors each extending through one of said filters to provide conductors passing from one side of the diaphragm and filters to the other side thereof.

8. In a multi-conductor connector the combination comprising a tubular metallic housing; a metallic diaphragm extending transversely across the interior of the housing to divide the interior with a magnetic shield separating one side from the other; a ferrite block attached to one side of said diaphragm having a conductive surface electrically joined to the diaphragm and housing; a plurality of connector leads extending through said ferrite; and a capacitor unit associated with each lead and entering the ferrite block that has a dielectric encircling the lead, a first electrode joined to the lead, and a second electrode that is subdivided into portions with each portion in electrical connection with said diaphragm and with the portions disposed to have the ferrite coupled to the fields of the capacitor unit where the dielectric is encircled by the ferrite.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,002,162 September 26, 1961

William W. Garstang

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 63, after "from" insert -- escaping from --.

Signed and sealed this 27th day of February 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents

UNITED STATES PATENT OFFICE

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