Dec. 6, 1949

E. C. CORK

2,490,622

HIGH-FREQUENCY TRANSMISSION LINE
OR CABLE AND CONNECTOR THEREFOR
Filed May 15, 1943

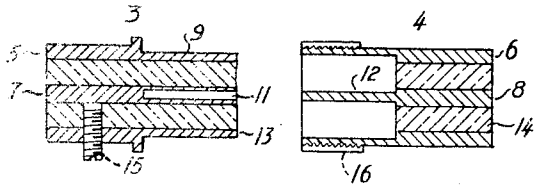

Fig. 1.

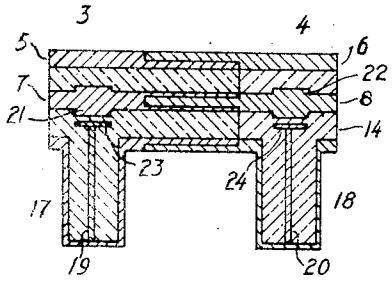

Fig. 2.

INVENTOR
Edward C. Cork
by H. B. Brower
ATTORNEY

Patented Dec. 6, 1949

2,490,622

UNITED STATES PATENT OFFICE

2,490,622

HIGH-FREQUENCY TRANSMISSION LINE OR CABLE AND CONNECTOR THEREFOR

Edward Cecil Cork, Ealing, London, England, assignor to Electric & Musical Industries Limited, Hayes, Middlesex, England, a company of Great Britain

Application May 15, 1943, Serial No. 487,166
In Great Britain January 15, 1941

Section 1, Public Law 690, August 8, 1946
Patent expires January 15, 1961

8 Claims. (Cl. 178—44)

1

This invention relates to high frequency transmission lines or apparatus and connectors therefor.

High frequency transmission lines are usually in the form of cables comprising an outer tubular conductor and an inner conductor disposed centrally within the outer conductor, such form of cable being usually referred to as of the concentric type. It is customary to connect two lengths of such cable together or to connect a portion of a cable to high frequency apparatus or to connect two pieces of high frequency apparatus together by means of various types of connectors. The term "connector" herein employed is intended to cover a device comprising essentially two separable parts, each part comprising an inner conductor and an outer conductor insulated therefrom, whereby each part can be connected to a transmission line of the concentric type so as to form a continuation both of the inner and outer conductors of said line, the two parts being arranged to be separated as by the provision of plug and socket portions, bayonet connecting portions, screw-threaded portions or the like which permit disconnection without the necessity of disconnecting the line from either part of the connector, the two parts of the connector when in engagement with one another serving to connect electrically the inner and outer conductors of one line to the inner and outer conductors respectively of the other line. The term "connector" also includes constructions in which the outer conductor of one or both parts of the connector is flanged for connection to the screening box of high frequency apparatus.

When the transmission lines or cables or the apparatus are designed for operating on wavelengths of a few centimetres it is found that the connectors introduce irregularities due to the inductance and/or capacity of the connectors which become of increasing effect as the wavelength of the energy it is desired to transmit becomes smaller. At such centimetre wavelengths the connector must be considered as forming a transmission line and is probably loaded with inductance and/or capacity at its ends and with additional loading along its length determined by the mechanical construction adopted. At longer wavelengths it is possible to reduce the size of the connector so that the irregularities produced are not appreciable, but at centimetre wavelengths this step is physically impossible, with the result that reflection occurs of the high frequency energy passing through the connectors.

2

One of the objects of the present invention is to overcome or reduce these difficulties.

According to one feature of the invention, a high frequency transmission line or apparatus is coupled to another line or apparatus having a similar characteristic impedance by means of a connector which is of such a length and has such a characteristic impedance that the connector substantially matches the impedances of the coupled elements, whereby high frequency energy can be transmitted through said connector substantially without reflection.

When reference is made herein to a high frequency transmission line or apparatus this means a transmission line or apparatus arranged to transmit energy of a wavelength up to 50 centimetres. The term "high frequency energy" means energy of a like wavelength.

According to another feature of the invention, a high frequency transmission line or apparatus is coupled to another line or apparatus having a similar characteristic impedance by means of a connector which preferably has a similar characteristic impedance and the length of which is equal or approximately equal to a half wavelength or to an integral multiple of half-wavelengths of the high frequency energy transmitted between said coupled elements, whereby said energy can be transmitted through said connector substantially without reflection.

In some cases it is desired to connect a high frequency transmission line or apparatus to another transmission line or apparatus having characteristic impedances which are not matched. In order to prevent reflection occurring due to mismatch it is the practice to insert between the elements to be coupled an impedance transforming device which at high frequencies is usually in the form of a transmission line.

According to another feature of the present invention, a high frequency transmission line or apparatus is coupled to another line or apparatus having a dissimilar characteristic impedance by means of a connector which has such a length and such a characteristic impedance that the connector acts as an impedance transformer whereby high frequency energy can be transmitted between said coupled elements substantially without reflection.

If desired, the connector may be provided with an adjustable element or elements arranged to afford a shunt or series loading impedance. This has the advantage that the electrical length of the connector need not be accurately determined since by adjusting the adjustable element the de-

sired electrical length or impedance can be imparted to the connector.

In the specification of United States Patent No. 2,270,416 issued January 20, 1942, to Edward Cecil Cork, there are disclosed various forms of filters in which the resistance, inductance and capacity of the filter can be introduced in the form of sections of transmission lines.

According to another feature of the invention one or both parts of said connector is or are provided with an additional portion or portions of transmission line which is or are so associated with said part or parts that the connector acts as a filter for some components of the high frequency energy transmitted between the coupled elements.

According to another feature of the invention there is provided a connector for coupling together high frequency transmission lines or apparatus having similar characteristic impedances, said connector having a substantially uniform impedance throughout its length thus avoiding lumped impedances along its length and the connector is such that if high frequency energy is transmitted therethrough of a wavelength such that the connector is a half wavelength long or a multiple of half wavelengths long, said energy will be transmitted substantially without reflection.

According to another feature of the invention there is provided a connector for coupling together high frequency transmission lines or apparatus having dissimilar characteristic impedances, said connector having a substantially uniform impedance along its length and has such a characteristic impedance that if high frequency energy is transmitted therethrough which is of a wavelength such that the connector is a quarter wavelength long or an odd integral multiple of quarter wavelengths and if said energy is transmitted via said connector from transmission lines or apparatus having such dissimilar characteristic impedance that the characteristic impedance of said connector is the geometric means of the impedance of said lines or apparatus, said energy will be transmitted substantially without reflection. Preferably the space between the inner and outer conductors of the elements of the connector is filled with insulating material, the insulating material employed, of course, being taken into consideration in determining the electrical length of the connector as distinct from its physical length.

In this specification where reference is made to the length of the connector this means the electrical length as distinct from its physical length, unless the context implies otherwise.

In order that the features of the invention may be clearly understood and readily carried into effect, they will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates a longitudinal section of one form of connector designed for use with transmission lines or apparatus having either similar impedance or dissimilar characteristic impedances, and

Figure 2 illustrates a longitudinal section of a connector designed to operate as a filter.

Referring now to Figure 1 of the drawing, the connector shown is of the plug and socket type comprising two parts 3 and 4 which are shown separated, each part comprising an outer tubular conductor 5 and 6 and an inner conductor 7 and 8, the outer conductor 5 having a reduced portion 9 arranged as a sliding fit within the

internally reduced portion 10 of the outer conductor 6, the inner conductor 7 being provided with a bore 11 whilst the inner conductor 8 is provided with a plug portion 12. The two parts of the connector are arranged to be plugged together in the well known manner so that the outer conductors 5 and 6 and the inner conductors 7 and 8 are electrically connected together respectively. The space between the outer conductor 5 and the inner conductor 7 is filled with insulating material 13, whilst the space between the outer conductor 6 and the inner conductor 8 is also partially filled with insulating material 14, the arrangement being such that when the two portions are plugged together the whole space between the inner and outer conductors is filled with insulating material. In order to connect the outer conductor of a concentric line to the outer conductors 5 and 6 and the inner conductor of the line to the inner conductors 7 and 8, any suitable clamping means may be provided for this purpose. In most cases the inner conductor of the line will be soldered to the inner conductors of the connector whilst the outer conductor of the line may be clamped to the outer conductors of the connector by a screw-threaded clamping device. The insulating material 13 and 14 may be of any suitable form such as that shown by the trade name "Polythene," this material being a polymer of ethylene.

Where the device shown in Figure 1 is intended to couple together two elements such as a cable or high frequency apparatus having similar characteristic impedances, the length of the conductor should be approximately equal to a half wavelength of the high frequency energy transmitted along the cable or by the apparatus or an integral multiple of half wavelength. It is preferred that the characteristic impedance of the connector should also be equal to the characteristic impedance of the elements to be coupled, it being readily possible to impart the desired impedance to the connector, taking into consideration its physical dimensions and the dielectric constant of the insulating material employed in its construction.

It is preferred that the impedance of the connector should be uniform throughout its length so as to avoid as far as possible the introduction of lumped impedances at points along the length of the connector. This can be achieved with the construction shown in Figure 1 by filling the space between the inner and outer connectors with the insulating material and by avoiding the introduction of metal parts which have dimensions greatly differing from one another in the two parts of the connector. Thus by employing a connector in this manner high frequency energy can be transmitted between the elements coupled by said connector without substantial reflection.

Where the connector shown in Figure 1 is intended to be employed as an impedance matching transformer, its length should be equal or approximately equal to a quarter wavelength or to an odd integral multiple of quarter wavelengths of the high frequency energy transmitted. The characteristic impedance of the connector in this case should be chosen to be equal to the geometric mean of the impedances to be matched as to produce the required transformation ratio, thus again permitting the transmission of high frequency energy substantially without reflection.

If desired the lengths of the connectors need not be accurately made equal to a half or quarter

wavelength or their equivalents, as the case may be, but may be made approximately equal thereto and the desired electrical length and impedance can be imparted to the connector by providing an adjustable element or elements so as to afford either a series or a shunt loading impedance, as suggested in the specification of British Patent No. 489,704. Thus the length of the connector may be such as to afford a partial impedance match and a loading impedance is provided to effect an accurate match. The loading impedance may take the form of an adjusting screw 15, which is threaded into a part of the connector at right angles thereto so as effectively to provide a shunt loading impedance or a screw threaded sleeve 16 may be provided, surrounding the outer conductor 6 and arranged so that it can be caused to engage, for example, an abutment in the part 3 so that instead of the two parts when plugged together being disposed with the insulating material 13 and 14 abutting, a space is left so as to constitute a series loading impedance.

Figure 2 of the drawings illustrates a connector which is provided with additional portions of transmission line so that the connector can function as a filter. A wide variety of filters can be constructed in accordance with this feature of the invention, and in the example shown each part 3 and 4 of the connector is provided with a lateral extension in the form of a portion of a transmission line, which in some cases may be a quarter of a wavelength long, the two portions being indicated by the reference numerals 17 and 18. The outer conductors of the portions 17 and 18 are directly connected to the outer conductors 5 and 6 respectively of the parts 3 and 4, whilst the inner conductors 18 and 20 of the portions 17 and 18 may be coupled to the inner conductors 7 and 8. Capacity coupling is shown in the figure, but other coupling means may be used if desired. This capacity coupling is afforded in the example shown by disposing the ends of the inner conductors 19 and 20 in proximity to the inner conductors 7 and 8, and in some cases this capacity coupling can be increased by enlarging the diameter of the inner conductors 7 and 8 as indicated at 21 and 22 and by providing the ends of the conductors 19 and 20 with plates 23 and 24. The spaces between the outer and inner conductors of the portions 17 and 18 are also preferably filled with insulating material. The length of transmission line between the portions 17 and 18 will depend on the type and design of the filter. The length of the conductor can, however, be such as to constitute a matching impedance or a transformer, as described above.

What I claim is:

1. A connector for connecting together high frequency transmission lines including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part, and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length, when said parts are in engagement, substantially equal to an integral multiple of one-quarter wavelength, the spacing between said conductive members and their dimensions being so related to the length of said connector that energy on one of said transmission lines is transferred to the other of said transmission lines without reflection, the conductive members of said parts being so arranged that the spacing and dimensions of said members is uniform over their entire length when said parts are in engagement.

2. A connector for connecting together high frequency transmission lines of similar characteristic impedance, including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length, when said parts are in engagement, substantially equal to the integral multiple of one-half wavelength, the spacing between said conductive members and their dimensions being so related as to not greatly differ in the two parts of said connector.

3. A connector for connecting together high frequency transmission lines including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part, and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length, when said parts are in engagement, substantially equal to an integral multiple of one-half wavelength, the spacing between said conductive members and their dimensions being so related that the characteristic impedance of said connector is equal to that of said lines whereby energy on one of said transmission lines is transferred to the other of said transmission lines without reflection, the conductive members of said parts being so arranged that the spacing and dimensions of said members is uniform over their entire length when said parts are in engagement.

4. A connector for connecting together high frequency transmission lines including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part, and adapted to engage the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, and arranged for telescopic engagement with the corresponding member in said other part, said connector having an electrical length, when said parts are in engagement, substantially equal to an integral multiple of one-half wavelength, the spacing between said conductive

members and their dimensions being so related that the characteristic impedance of said connector is equal to that of said lines whereby energy on one of said transmission lines is transferred to the other of said transmission lines without reflection, one of said pair of electrically conductive members being in the form of a tubular sheath concentrically arranged about another of said members as an inner conductor, the conductive members of said parts being so arranged that the spacing and dimensions of said members is uniform over their entire length when said parts are in engagement.

5. A connector for connecting together high frequency transmission lines of dissimilar characteristic impedance, including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by a solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so aranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length when said parts are in engagement substantially equal to an odd multiple of one-quarter wavelength, the spacing between said conductive members and their dimensions being so related as to not greatly differ in the two parts of said connector, and further so related to the length of said connector that energy on one of said transmission lines is transferred to the other of said transmission lines without reflection.

6. A connector for connecting together high frequency transmission lines of dissimilar characteristic impedance, including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by a solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length when said parts are in engagement substantially equal to an odd multiple of one-quarter wavelength, then spacing between said conductive members and their dimensions being so related as to not greatly differ in the two parts of said connector, and further so related to the length of said connector that energy on one of said transmission lines is transferred to the other of said transmission lines without reflection, one of said pair of electrically conductive members being in the form of a tubular sheath concentrically arranged about another of said members as an inner conductor.

7. A connector for connecting together high frequency transmission lines of similar characteristic impedance, including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in said other part, and adapted for telescopic engagement with the corresponding member in said other part, said connector having an electrical length, when said parts are in engagement, substantially equal to an integral multiple of one-quarter of a wavelength, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, the spacing between said conductive members and their dimensions being so related as to not greatly differ in the two parts of said connector, and an adjustable shunt loading impedance connected between said conductive members near one end of at least one of said parts.

8. A connector for connecting together high frequency transmission lines of similar characteristic impedance, including a pair of separable parts, each part including at least a pair of electrically conductive members maintained in position relative to one another by solid insulating means, each of the electrically conductive members of one part having a corresponding member in the other part and arranged for telescopic engagement with the corresponding member in said other part, said solid insulating means being so arranged that when said parts are in engagement the space between said conductive members is substantially entirely filled by solid insulating means, said connector having an electrical length, when said parts are in engagement, substantially equal to an integral multiple of one-half wavelength, the spacing between said conductive members and their dimensions being so related as to not greatly differ in the two parts of said connector, and an adjustable shunt loading impedance connected between said conductive members near one end of at least one of said parts, said impedance including a screw threaded member in engagement with one of said conductive members and in adjustable capacitive coupling relation with another of said members.

EDWARD CECIL CORK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,207,690	Cork et al.	July 9, 1940
2,233,166	Hahn	Feb. 25, 1941
2,241,582	Buschbeck et al.	May 13, 1941
2,267,371	Buschbeck	Dec. 23, 1941
2,332,952	Tischer et al.	Oct. 26, 1943
2,401,344	Espley	June 4, 1946
2,402,540	Espley	June 25, 1946

FOREIGN PATENTS

Number	Country	Date
488,254	Great Britain	June 23, 1938