ELECTRICAL CONNECTOR

FIG. 1

FIG. 2

FIG. 3

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1. The present invention relates to electrical connectors and, particularly, to such connectors for use on the end of a coaxial transmission line usually, although not always, to provide a detachable connection therefor.

Coaxial transmission lines are widely used to propagate wave-signal energy along a restricted path between two spaced points such, for example, as between a wave-signal transmitter and its associated wave-signal antenna system or between a receiving antenna system and a wave-signal receiver. It frequently is desirable to provide an electrical connector between two sections of such transmission line or between the end of the line and a wave-signal apparatus coupled thereto, the connection usually being of the detachable type.

It is well known that reflections of wave-signal energy occur at any point along a wave-signal propagation path where an abrupt change of impedance occurs and that such reflected energy produces standing waves of wave-signal voltage and current along the propagation path. Thus, reflections of wave-signal energy are produced at the junction of a coaxial transmission line and its electrical connector whenever the characteristic impedance of the connector is not the same as that of the transmission line. Such standing waves are undesirable in many applications for numerous well known reasons.

To minimize reflections of wave-signal energy, electrical connectors for use on coaxial transmission lines are conventionally of coaxial construction and it is usual so to select the parameters of the connector that each incremental length of the latter has a characteristic impedance equal to that of the transmission line. Relatively little difficulty is experienced in the design and construction of such connectors where they are to be used with a coaxial transmission line of relatively large physical size since the inner and outer conductors of the line are then sufficiently large that the inner and outer conductors of the connector may readily be constructed of approximately the same diameters while yet possessing adequate rigidity and mechanical strength. In those instances where it is desired or necessary that the inner and outer conductors of the electrical connector have diameters larger than the corresponding conductors of the transmission line, it is conventional so to taper the conductors of the connector at the end or ends thereof adjacent the transmission line that the desired characteristic impedance of the connector is maintained through each incremental length thereof.

2. The present-day trend is toward coaxial transmission lines of relatively small physical size often of external diameter of the order of a quarter inch or less. Electrical connectors for use with such small transmission lines cannot readily be constructed to have their inner and outer conductors of approximately the same diameters as corresponding conductors of the line since the inner conductor of the connector then becomes so small that it not only does not possess the required rigidity and mechanical strength but can be connected to the inner conductor of the transmission line only with great difficulty. The tapered type of connector construction previously mentioned does not lend itself readily to the construction of connectors of such small physical size since it is difficult to maintain the mechanical tolerances between the conductors thereof required to preserve uniform characteristic impedance through the connector.

The tapered type of construction is also relatively expensive and is not well suited for mass production. Additionally, the tapered construction usually results in an electrical connector of larger physical size than is desirable for many applications.

It is an object of the present invention, therefore, to provide a new and improved electrical connector for an end of a coaxial transmission line which avoids one or more of the disadvantages and limitations of prior connectors of the type described.

It is a further object of the invention to provide an electrical connector, for an end of a coaxial transmission line, adapted to be constructed of small physical size yet one which is not only capable of withstanding without failure wave-signal voltages of the order of several thousand volts, but, additionally, possesses impedance characteristics such as substantially to avoid any reflection of wave-signal energy consequent upon the use of the connector with the transmission line.

It is an additional object of the invention to provide a new and improved electrical connector for an end of a coaxial transmission line and one which while of sturdy mechanical construction may have a physical size appreciably smaller than heretofore readily obtainable.

It is a further object of the invention to provide a new and improved electrical connector, for an end of a coaxial transmission line, of relatively simple and inexpensive construction which permits ease mechanical tolerances to be maintained during manufacture and assembly thereof.
In accordance with a particular form of the invention, an electrical connector for an end of a coaxial transmission line of given characteristic impedance comprises an inner conductor for electrical connection to the inner conductor of the line to form with the end thereof a co-axially linear conductor having a diameter appreciably larger than that of the inner conductor of the line and sufficiently large as to provide a relatively rigid member. The connector includes an outer conductor shell for electrical connection to the outer conductor of the line to provide, with the inner connector conductor and with an end portion of the inner conductor of the line, a coaxial transmission line. The last-mentioned coaxial transmission line includes at least one line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value larger than the aforesaid given characteristic impedance. The last-mentioned coaxial transmission line also includes at least one other line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than the aforesaid given characteristic impedance. The length of each of the aforesaid line portions is so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of the connector to the total effective capacitance thereof and the ratio of inductance to capacitance of an incremental length of the transmission line.

For better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. The device described in the present application has a simplified form of electrical connector embodying the present invention; Fig. 2 is a cross-sectional view illustrating a detachable electrical connector embodying a modified form: Fig. 2a graphically represents the impedance levels existing along a connector of the Fig. 2 type and is used as an aid in explaining the operation of the invention; and Fig. 3 is a cross-sectional view illustrating a detachable electrical connector generally similar to the Fig. 2 type but involving additional and preferred features of construction.

Referring now more particularly to Fig. 1 of the drawing, there is illustrated in cross-sectional view an electrical connector, for use on the end of a coaxial transmission line of given characteristic impedance $Z_0$, embodying the present invention in a simplified form. The connector includes an inner conductor 16 of circular cross section adapted to be coupled, as by soldering or the like, to the inner conductor 14 of a coaxial transmission line 12. The conductor 10 has a diameter appreciably larger than that of the inner conductor 14 of the line and one sufficiently large as to provide a relatively rigid member of adequate mechanical strength. In an electrical connector of small physical size, adequate rigidity and mechanical strength of the conductor 10 require that the latter have a diameter comparable to that of the outer conductor 13 of the transmission line 12. The electrical connector includes an outer con-
electrical connectors each embodying a modified form of the invention. These connectors are essentially similar to that of Fig. 2 being designated respectively by the same reference numerals as in Fig. 1 and the same reference numerals primed, while the corresponding elements and analogous elements of Fig. 2 are designated by the same reference numerals with subscripts and the same reference numerals primed with subscripts. The conductor 10' of the female connector preferably is provided with an axial bore 17 for receiving the inner conductor 11 of the transmission line 12 and has an aperture 18 in which solder or the like may be flowed electrically to connect the conductors 10' and 11. The conductor 10' also is provided at the other end with an axial bore 19 conductively to receive an axial pin 20 provided on the end of the conductor 10' of the male connector. A split resilient construction is preferably used along the length of the bore 19 of the conductor 10' to insure a firm conductive engagement between the latter and the pin 20 of the male connector. The inner conductor 10' of the male connector likewise is provided with an axial bore 17a to receive the inner conductor 11a of the transmission line 12a and a solder hole 18a, provided by which to effect a solid electrical connection between the conductors 11a and 11. The insulating sleeve 14a of the male conductor has secured thereto or integrally formed therewith at its end a shell extension 21 which fits snugly over and provides a firm conductive engagement with the end of the shell 14 of the female connector when the male and female connectors are engaged.

The connectors of Fig. 2 are each provided with an insulating sleeve 23 for maintaining the inner conductor 10' in coaxial relation with the conductive shell 14. The sleeve 23 has such end configurations that one end 24 thereof preferably is closed by a dielectric surface covered by a suitable dielectric coating of the transmission line 12 thereby to improve the voltage breakdown characteristics of the connector. The other end 15 of the insulating sleeve 23 and the insulation of the cable 12. The other end 25 of the insulating sleeve 23 has such configuration that the sleeve provides at this end and between the conductor 10' and shell 14 only surface paths long in relation to the radial spacing between the conductor 10' and the shell 14, thereby to insure an improved voltage breakdown characteristic for the connector. In this regard, the end 25 of the insulating sleeve 23 of the female connector is arranged to telescope with the end 25a of the insulating sleeve 23a of the male connector when the male and female connectors are engaged. The operation of the connector just described will now be considered with reference to Fig. 2a which graphically shows the more important impedance levels indicated in Fig. 2 for a wave signal traveling through the connector embodiing the present invention. For convenience of reference, the lower-case letters a, b, c, etc. indicate the termini of the several line sections in the connector. Assume that a wave signal travels through the connector from left to right. When a transmission line is terminated by a resistive impedance of value higher than the characteristic impedance of the line, it is well known that the line so terminates the terminating impedance to the network appearing at point c has a characteristic impedance of the line so terminated by a resistive impedance having a value lower than the characteristic impedance of the line so transforms the impedance that the latter appears to have increasingly larger absolute values with increasing larger inductive phase angles when viewed under the same conditions. It was earlier mentioned that the connector preferably has a length unpreciseable in relation to the wave length of the translated wave signal. This avoids any tendency of the connector, or of any of its several line sections a—b, b—c, c—d, etc., to effect large impedance transformations such as characterize the operation of quarter-wave lines. At the same time, however, it should be kept in mind that even small lengths of line effect some impedance transformation so that the characteristic impedance at point 'f is transformed to increasingly larger absolute values of impedance having increasingly larger lagging phase angles at successive points on the section e—f in progressing from the point f to the point e. The line section e—f thus may be considered as having a value of inductance varying both with the difference of the impedance levels Z0 and Z0 and its length.

The portion d—e of the connector and having the low impedance Z0, is effective to transform the impedance appearing at point e to a slightly higher absolute value of impedance e' and slightly decreased lagging phase angle. The line section d—e may be conveniently considered as having a value of capacitance varying both with the difference of the impedance levels Z1 and Z0 and its length.

The portion c—d of the connector has a value of impedance Z1 higher than the section e—d and approximating the characteristic impedance Z0 of the transmission line. The section c—d is thus effective to transform the impedance appearing at point d to a higher absolute value of impedance d' but one which at the center of the section c—d is purely resistive. From the center of the section c—d to the point e thereof, the resistive impedance at the center is transformed to a smaller absolute value of impedance but one having a substantially leading phase angle; i.e., one having a capacitively reactive component of impedance. This section thus also may be considered as having a value of capacitance varying with the difference of the impedance levels Z1 and Z0 and with the length of the section.

The section b—c of the connector has the low value of impedance Z1 and thus transforms the impedance appearing at point c to an even smaller absolute value but one having an even larger leading phase angle.

The section a—b of the connector having the higher value of impedance Z2 then is effective to reduce the absolute value of the impedance appearing at point b substantially to the value of impedance Z2 of the line and also is effective to reduce the phase angle of the impedance appearing at point b substantially to zero with the result that the impedance appearing at point a is purely resistive and has substantially the value Z2.
The several lengths of the connector sections c—d, b—c, c—d, etc., and the impedance levels thereof differing from the line impedance $Z_0$ thus are so selected that, while the value of impedance appearing at any point in one-half of the connector may differ from the line impedance $Z_0$ in absolute value and in phase angle, whatever value of impedance appears at the center point of the connector is transformed back to the line impedance $Z_0$ through the other half of the connector. These relationships can be expressed in a more simplified manner by stating that the connector has line portions of characteristic impedances sufficiently larger and smaller than the line impedance $Z_0$ as to maintain approximate equality between the ratio of the total inductance of the connector to the total capacitance thereof and the ratio of inductance to capacitance of an incremental length of the transmission line.

The connector of the present invention consequently has an input impedance of value equal to that of the characteristic impedance $Z_0$ of the transmission line and no reflection of wave-signal energy consequently occurs at the juncture of the transmission line and connector.

Since the connector of Fig. 2 has the same impedance-level characteristic considered from left to right as from right to left, it will be apparent that the connector matches the impedance of the transmission line $Z_0$ and, consequently, that wave-signal energy flowing along the latter line toward the connector experiences no reflection of wave-signal energy at the juncture of the line and connector.

In arriving at suitable values selected for the parameters of the connector, several factors must be considered. The minimum length of the connector portion $l$ must be so selected that the path between the conductor $f$ and shell $f'$ traced over the outer surface of the insulation of the transmission line $l_2$ is sufficiently long, in relation to the wave-signal voltages to be encountered in operation, as to ensure freedom from voltage breakdown of the connector by arc-over at this point. This minimum length is to some extent the length of the remaining portion of the shell since, as earlier mentioned, it is desirable to maintain approximate equality between the ratio of the total inductance of the connector to the total capacitance thereof and the ratio of inductance to capacitance of an incremental length of the transmission line $l_2$ or $l'_2$. The connector conductor $l_0$ also has a minimum length having to do with the preferred method of connecting the inner conductor $l_0$ of the transmission line $l_2$ to the conductor $l_0$ and the preferred method of providing a detachable connection between the conductor $l_0$ and the corresponding conductor $l_0'$ of the similar cooperating half of connector. Essentially then, the physical length of the connector is determined in large part by the length required for the portions based upon the desired voltage-breakdown characteristic, and upon the length of the conductor $l_0$ based upon mechanical considerations as both of these factors are related to maintaining the ratio of total inductance to total capacitance of the connector equal to the ratio of inductance to capacitance of an incremental length of the transmission line $l_2$.

It should be noted in connection with the Fig. 2 arrangement that the pin $A$ and the shell extension $f_1$ of the male connector half do not in operation affect the impedance characteristic of the latter and therefore are ignored in selecting the connector parameters to provide the desired value of over-all characteristic impedance of the male connector.

Fig. 3 is a cross-sectional view illustrating a male and female connector essentially similar to those of Fig. 2, similar elements being designated by similar reference numerals, except that the instant connectors are each provided with a suitable arrangement for mechanically securing the connector to the end of the transmission line and for providing an easily made electrical connection between the outer conductor of the transmission line and the conductive shell of the connector. The instant connectors also have a bayonet type of securing arrangement by which to secure the male and female connectors in engaging relation.

Considering first the arrangement by which the connector is secured to the end of the transmission line, and referring for convenience of description to the male connector in particular, the conductive shell $l_4$ of the connector is provided with an elongated end portion $l_2$, which extends well over the end of the transmission line $l_2$, and has a coaxial bore $l_3$ internally threaded at its outer end to receive a threaded nipple $l_3$. The outer conductor $l_5$ of the transmission line is clamped against the end of the bore $l_3$ of the extension $l_2$ by a conductive thimble $l_4$ which, with a water-proofing gasket $l_3$ and washer $l_3$, is compressed in assembled relation upon tightening the nipple $l_3$. This mechanically secures the connector to the end of the transmission line $l_2$ and provides a firm electrical engagement between the outer conductor $l_5$ of the line and the conductive shell $l_4$ of the connector.

The bayonet securing arrangement for maintaining the male and female connectors in engaged relation comprises a sleeve $34$ which loosely fits over the conductive shell $14$ of the female connector and has conventional L-shaped slots $35$ to receive bayonet projections $33$ provided on the exterior end surface of the conductive thimble $42$ to secure the sleeve $34$ includes a knurled ring $37$ at one end and an enlarged housing $38$ at the other, the housing enclosing a corrugated spring washer $39$ which biases a flat disc washer $40$ and rubber water-proofing gasket $41$ into engagement with the end of the shell extension $31$ of the male connector thus to bias the sleeve $34$ into locked position and also to provide a water-tight joint between the male and female connectors in engaging relation. The operation of this modified form of the invention is otherwise essentially similar to that of the Fig. 2 type of connector and will not be repeated.

It will be apparent from the foregoing description of the invention that an electrical connector embodying the invention has the advantages that it is of sturdy mechanical construction yet may have a size appreciably smaller than heretofore readily obtainable. While an electrical connector embodying the invention is of small physical size, it nevertheless is one capable of withstanding without failure wave-signal voltages of the order of several thousand volts and possesses no undesirable characteristics such as substantially to avoid any reflection of wave-signal energy consequent upon the use of the connector with a transmission line of suitable characteristic impedance. The electrical connector of the invention has the additional advantages that it is
of relatively simple and inexpensive construction which permits close mechanical tolerances to be maintained during manufacture and assembly of the connector.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electrical connector for an end of a coaxial transmission line of given characteristic impedance comprising, an inner conductor for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit having a diameter appreciably larger than that of the inner conductor of said line and sufficiently large as to provide a relatively rigid member, and an outer conductive shell for electrical connection to the outer conductor of said line to provide with said inner conductor connector and with an end portion of the inner conductor of said line a coaxial transmission line including at least one central portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value larger than said given characteristic impedance, and said last-mentioned coaxial transmission line also including at least one other line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said given characteristic impedance, the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of said connector to the total effective capacitance thereof and the ratio of the inductance to capacitance of an incremental length of said first-mentioned transmission line.

2. An electrical connector for an end of a coaxial transmission line of given characteristic impedance comprising, an inner conductor for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit and having a diameter comparable to the inner diameter of the outer conductor of said line to provide with said inner conductor connector and with an end portion of the inner conductor of said line a coaxial transmission line, said last-mentioned coaxial transmission line including at least one line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value larger than said given characteristic impedance, and said last-mentioned coaxial transmission line also including at least one other line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said given characteristic impedance, the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of said connector to the total effective capacitance thereof and the ratio of the inductance to capacitance of an incremental length of said first-mentioned transmission line.

3. An electrical connector for an end of a coaxial transmission line of given characteristic impedance comprising, an inner conductor for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit and having a diameter appreciably larger than that of the inner conductor of said line and sufficiently large as to provide a relatively rigid member, and an outer conductive shell for electrical connection to the outer conductor of said line to provide with said inner conductor connector and with an end portion of the inner conductor of said line a coaxial transmission line, said last-mentioned coaxial transmission line including at least one central portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value sufficiently larger than said given characteristic impedance as to insure freedom from voltage breakdown of said connector because of the large diameter of its said inner conductor, and said last-mentioned coaxial transmission line also including at least one central portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said given characteristic impedance, the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of said connector to the total effective capacitance thereof and the ratio of the inductance to capacitance of an incremental length of said first-mentioned transmission line.

4. An electrical connector for an end of a coaxial transmission line of given characteristic impedance comprising, an inner conductor for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit and having a diameter appreciably larger than that of the inner conductor of said line and sufficiently large as to provide a relatively rigid member, and an outer conductive shell for electrical connection to the outer conductor of said line to provide with said inner connector connector and with an end portion of the inner conductor of said line a coaxial transmission line, said last-mentioned coaxial transmission line including at least one line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value larger than said given characteristic impedance and said last-mentioned coaxial transmission line also including at least one other line portion so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said given characteristic impedance, the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of said connector to the total effective capacitance thereof and the ratio of the inductance to capacitance of an incremental length of said first-mentioned trans-
mission line, and the effective electrical length in
wave lengths of said connector being inapprorp-
iable in relation to the wave length of a wave
signal to be translated by said first-mentioned
transmission line.
5. An electrical connector for an end of a co-
axial transmission line of given characteristic
impedance comprising, an inner conductor for
said connector adapted to be coupled to the inner
corector of said line and having a di-
diameter appreciably larger than that of the inner
conductor of said line and sufficiently large as
to provide a relatively rigid member, an outer
conductive shell for said connector adapted to
be coupled to the outer conductor of said line to
provide with said inner conductor conductor and
with an end portion of the inner conductor of
said line a coaxial transmission line having at
least one line portion of characteristic imped-
ance larger than said given characteristic im-
pedance and at least, as other line portion of
characteristic impedance sufficiently smaller
than said given characteristic impedance as to
maintain approximate equality between the ratio
of the total inductance of said connector to the
total capacitance thereof and the ratio of the in-
ductance to capacitance of an incremental
length of said first-mentioned transmission line,
and an insulating sleeve for maintaining said
inner conductor conductor in coaxial relation
with said conductive shell, said sleeve having
such end configurations that one end thereof
fits closely over and may be cemented to the
insulation of said first-mentioned transmission
line to minimize paths extending through air
over the surface of said one end between said
inner connector conductor and said shell while
the other end of said sleeve provides only sur-
face paths between said inner connector con-
ductor and said shell long in relation to the
radial spacing therebetween.
6. An electrical connector for an end of a co-
axial transmission line of given characteristic
impedance comprising, an inner conductor for
said connector adapted to be coupled to the inner
conductor of said line and having a diameter
appreciably larger than that of the inner con-
ductor of said line and sufficiently large as to
provide a relatively rigid member, and an outer
conductive shell for said connector adapted to
be coupled to the outer conductor of said line to
provide with said inner conductor conductor and
with an end portion of the inner conductor of
said line a coaxial transmission line, said shell
having a stepped concentric bore with a first
step thereof of relatively small diameter and co-
operating with said end portion of the inner
conductor of said first-mentioned transmission
line to provide a transmission-line portion for
said connector having a characteristic imped-
ance greater than said given characteristic im-
pedance and the remainder of said bore includ-
ing another step of larger diameter and co-
operating with said inner conductor conductor to
provide a transmission-line portion for said
connector having a characteristic impedance
sufficiently smaller than said given characteristic
impedance as to maintain approximate equality
between the ratio of the total inductance of said
connector to the total capacitance thereof and
the ratio of the inductance to capacitance of an
incremental length of said first-mentioned
transmission line.
7. An electrical connector, for a coaxial trans-
mission line having a given characteristic im-
pedance, comprising: an inner connector con-
ductor for electrical connection to the inner con-
ductor of said line in spaced relation to the end
of the outer conductor of said line to form with
the end of said inner conductor of said line a
continuously linear conductive circuit and hav-
ing an outer diameter approximating the inner
diameter of said outer conductor; a conductive
shell for electrical connection to said outer con-
ductor and extending therefrom to surround said
inner connector inner conductor to form with said
inner conductors a coaxial transmission line hav-
ing opposing conductive surfaces primarily of
cylindrical configuration and providing along
said connector at least a pair of line sections
each of which has a uniform value of impedance
along its length; and dielectric material filling
the space between said shell and said inner con-
ductors; at least one of said pair of line sections
being so proportioned with relation to a paramete-
therof and the dielectric constant of said material
as to have a characteristic impedance larger than
said given characteristic impedance; at least the other of said pair of line sections
being so proportioned with relation to a paramete-
therof and said dielectric constant as to have a characteristic impedance smaller than said
given characteristic impedance; and the length of at least each of said pair of line sections being
so proportioned with relation to the characteris-
tic impedance thereof as to provide for said
connector with said given characteristic imped-
ance as the terminating impedance at one end
thereof an input impedance at the other end
thereof approximately equal to said given char-
acteristic impedance.
8. An electrical connector, for a coaxial trans-
mision line having a given characteristic im-
pedance, comprising: an inner connector con-
ductor for electrical connection to the inner con-
ductor of said line in spaced relation to the end
of the outer conductor of said line and having
an outer diameter approximating the inner di-
ameter of said outer conductor; a conductive
shell for electrical connection to said outer con-
ductor and extending therefrom to surround said
inner connector inner conductor to form with
said inner conductors a coaxial transmission line
having opposing conductive surfaces primarily of
cylindrical configuration; said shell having a
stepped internal bore providing along said con-
nector at least a pair of line sections each one of
which has a uniform value of impedance
along its length to reduce the effect of impedi-
ance discontinuities in said connector caused by
the enlarged size of said connector inner con-
ductor; and dielectric material filling the space
between said shell and said inner conductors;
at least one of said pair of line sections being
so proportioned with relation to a parameter
thereof and the dielectric constant of said ma-
terial as to have a characteristic impedance
larger than said given characteristic impedance;
at least the other of said pair of line sections
being so proportioned with relation to a paramete-
therof and said dielectric constant as to have a characteristic impedance smaller than said
given characteristic impedance; and the length
of at least each of said pair of line sections being
so proportioned with relation to the characteris-
tic impedance thereof as to provide for said
connector with said given characteristic imped-
ance as the terminating impedance at one end
thereof an input impedance at the other end
thereof approximately equal to said given characteristic impedance.

9. An electrical connector for a dielectric-filled coaxial transmission line having a given characteristic impedance comprising: an inner connector conductor adapted to be connected to the inner conductor of said line in abutting relation to the dielectric thereof but spaced from the end of the outer conductor of said line; a conductive shell adapted to be connected to said outer conductor and extending therefrom to surround said connector inner conductor to form with said inner conductors a coaxial transmission line having opposing conductive surfaces primarily of cylindrical configuration; and dielectric material filling the space between said shell and said connector inner conductor and adapted to extend over a length of the dielectric material of said first-mentioned transmission line to improve the voltage-breakdown characteristic of said connector; the parameters of said shell and said inner conductors being proportioned with relation to the dielectric constant of said material to approximate the characteristic impedance of said first-mentioned transmission line.

10. A detachable electrical connector for a coaxial transmission line having a given characteristic impedance comprising: an inner connector conductor having coaxially aligned detachable portions at least one of which is adapted to be connected to the inner conductor of said coaxial transmission line in spaced relation to the end of the outer conductor of said line; a conductive shell surrounding said connector inner conductor to form therewith a coaxial transmission line having opposing conductive surfaces primarily of cylindrical configuration, said shell having coaxially aligned detachable portions of which the one thereof corresponding to said one inner-conductor portion is adapted to be connected to the outer conductor of said first-mentioned transmission line; and dielectric material filling the space between said shell and said connector inner conductor but having two detachable coaxially aligned portions of corresponding ones of said inner-conductor and shell portions and with telescopically interengaging end sections effective to increase the voltage-breakdown characteristic of said connector; the parameters of said shell and said inner conductors being proportioned with relation to the dielectric constant of said material to approximate the characteristic impedance of said first-mentioned transmission line.

11. A coaxial electrical connector, having a desired characteristic impedance, comprising: an outer linear conductive shell and a coaxially supported linear inner conductor providing disconnectable terminals at a common end thereof, the opposing conductive surfaces of said shell and conductor being primarily of cylindrical configuration and at least one thereof being of stepped diameter to provide through said conductor a nonuniform port corresponding ones of said inner-conductor and shell sections being so proportioned as to have a characteristic impedance larger than said desired characteristic impedance; at least the other of said pair of line sections being so proportioned as to have a characteristic impedance smaller than said desired characteristic impedance; and the length of at least each of said pair of line sections being so proportioned with relation to the characteristic impedance thereof as to provide for said connector a ratio of total effective inductance to total effective capacitance corresponding to said desired characteristic impedance.

12. An electrical connector for translating wave signals in a predetermined frequency range and adapted for connection to an end of a coaxial transmission line of given characteristic impedance comprising: an inner connector for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit and having a diameter appreciably larger than that of the inner conductor of said line and sufficiently large as to provide a relatively rigid member; and an outer conductive shell for electrical connection to the outer conductor of said line to provide with said inner connector conductor and with an end portion of the inner conductor of said line a coaxial transmission line; said last-mentioned coaxial transmission line including at least one line portion having a length inappreciable with relation to each of the wave lengths of said wave signals and so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value substantially larger than said given characteristic impedance; and said last-mentioned coaxial transmission line also including at least one other line portion having a length inappreciable with relation to said each wave length and so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said given characteristic impedance; the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to maintain approximate equality between the ratio of the total effective inductance of said connector to the total effective capacitance thereof and the ratio of the inductance to capacitance of an incremental length of said transmission line.

13. An electrical connector for translating wave signals in a predetermined frequency range and for electrically connecting a coaxial transmission line having a given characteristic impedance to an electrical device having a given input impedance comprising: an inner conductor for electrical connection to the inner conductor of said line to form with the end thereof a continuously linear conductive circuit and having a diameter appreciably larger than that of the inner conductor of said line and sufficiently large as to provide a relatively rigid member; an outer conductive shell for electrical connection to the outer conductor of said line to provide with said inner connector conductor and with an end portion of the inner conductor of said line a coaxial transmission line; said last-mentioned coaxial transmission line including at least one line portion having a length inappreciable with relation to each of the wave lengths of said wave signals and so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value substantially larger than said given characteristic impedance; said last-mentioned coaxial transmission line also including at least one other line portion having a length inappreciable with relation to said each wave length and so proportioned as to have a characteristic impedance which is substantially uniform along the length thereof and which has a value smaller than said
given characteristic impedance; the length of each of said line portions being so proportioned with relation to the characteristic impedance thereof as to provide for said connector with said given characteristic impedance as the terminating impedance at one end thereof an input impedance at the other end thereof approximately equal to said given input impedance.

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REFERENCES CITED

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

2,540,012

2,152,604 Scott et al. Mar. 28, 1939
2,173,643 Moser Sept. 19, 1939
2,372,429 Jones Mar. 27, 1945
2,376,725 Richardson et al. May 22, 1945
2,424,545 Bard July 29, 1947
2,427,752 Strempe Sept. 23, 1947

OTHER REFERENCES