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J. LORCH

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MICROWAVE ATTENUATORS WITH LOW D.C. RESISTANCE SHUNT PATH

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2 Sheets-Sheet 1

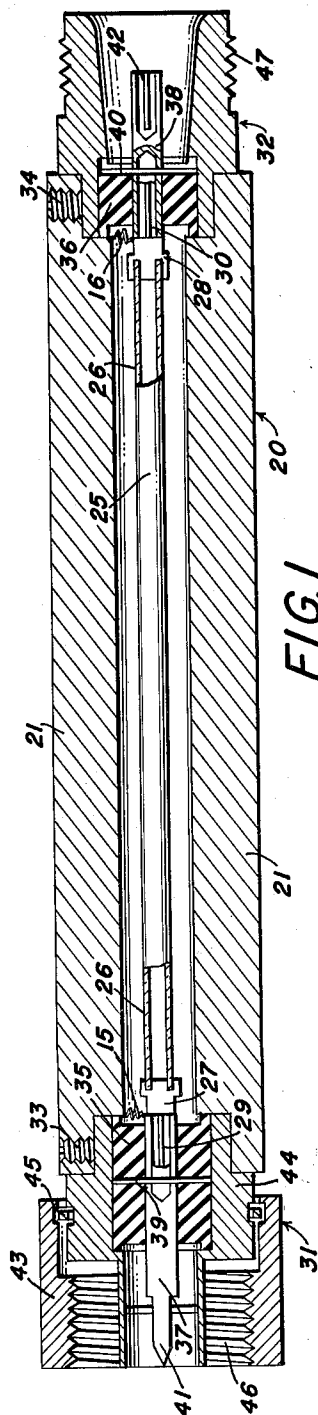


FIG. 1

FIG. 2

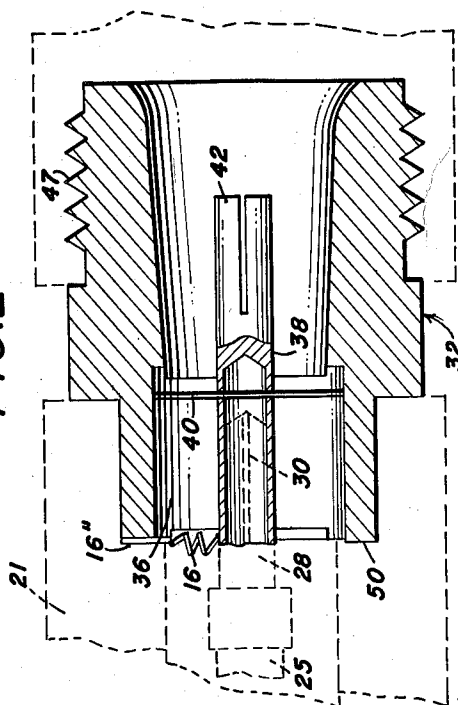


FIG. 3

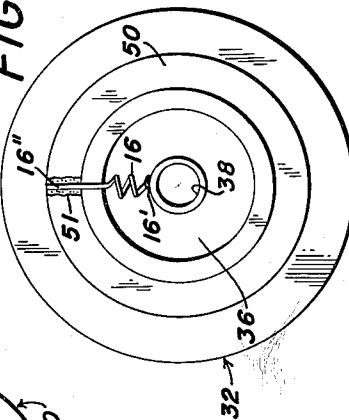
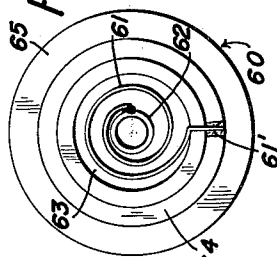


FIG. 4



BY

Richard A. Marson
his ATTORNEY

INVENTOR
JOSEPH LORCH

Aug. 6, 1963

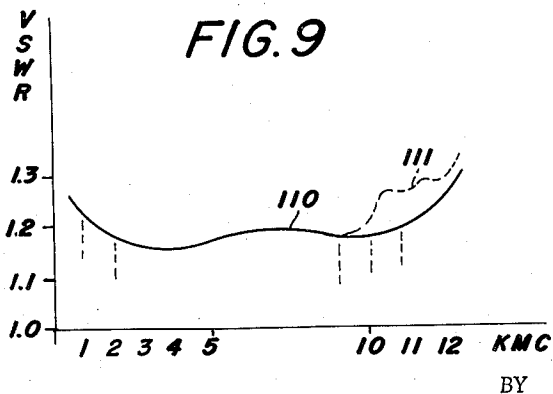
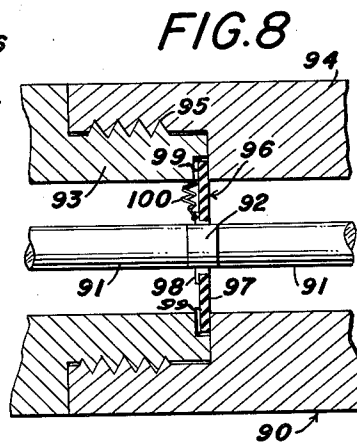
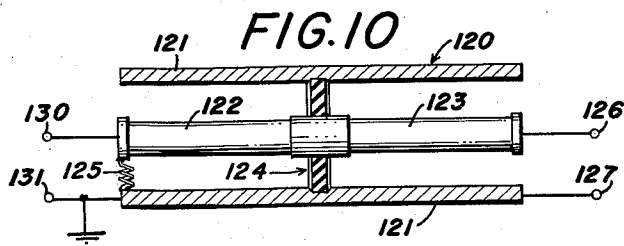
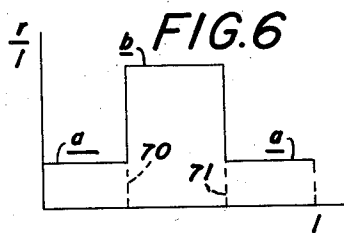
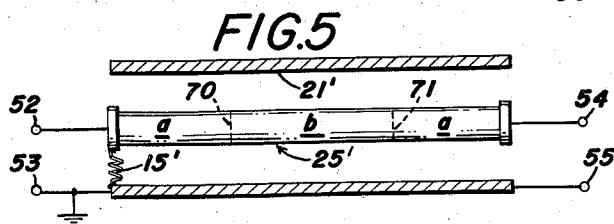
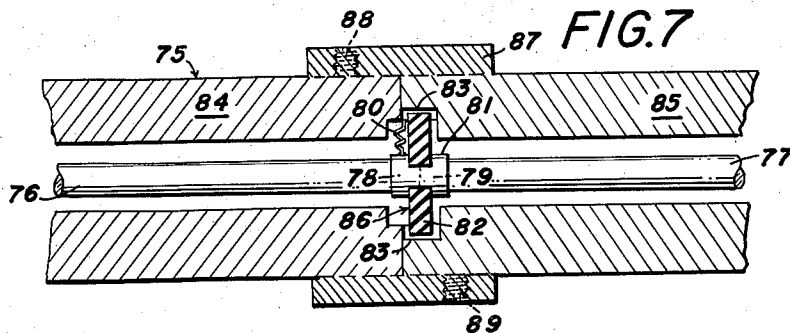
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INVENTOR
JOSEPH LORCH

Richard A. Marson
his ATTORNEY

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MICROWAVE ATTENUATORS WITH LOW D.C. RESISTANCE SHUNT PATH

Joseph Lorch, Albany, N.Y., assignor to Empire Devices Products Corp., Amsterdam, N.Y.
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9 Claims. (Cl. 333—81)

This invention relates generally to microwave attenuators, and more particularly relates to novel attenuators for the microwave range with relatively low resistance direct current shunt return path.

Coaxial attenuators of the "T" or "pi" pad variety include shunt resistors that provide a direct current return or path between the central and sheath conductors. Such pad type attenuators are used extensively in microwave applications, and are constructed with a predetermined characteristic impedance, as for example 50 ohms. In some applications it is desirable to have a relatively much lower value for the direct current return path resistance for such pad as compared to the characteristic impedance thereof otherwise suitable for the operating frequency range. The present invention provides such low D.C. resistance shunt path for a pad attenuator in the form of a novel small shunt coil that does not otherwise disturb the R.F. operating characteristics of the attenuator.

Attenuators of the distributed resistor type, with a central continuous film, contain no shunt return path. Such latter attenuators have excellent coaxial electrical properties up to the order of 11 to 12 kilomegacycles. Many microwave circuits with attenuators require direct current return paths therethrough, and heretofore could not therefore utilize the distributed resistor type therein. Applications that utilize direct current return paths include circuits with traveling wave tubes, crystal mixers, crystal detectors, etc. In accordance with the present invention a shunt path with low direct current resistance is arranged between the distributed resistor and its concentric shield in a manner that maintains the normal functioning of such attenuator over its wide operating frequency range.

The invention shunt path for both attenuator types comprises a very small inductor of only a few turns, that affords a very large reactive impedance at the operating frequencies of the attenuators, in a manner to leave practically undisturbed the operating characteristics thereof, primarily as to attenuation, magnitude and VSWR. The small inductor hereof is located in a practical form at either end or at both ends of the pad or distributed attenuator. The size of this shunt coil is proportioned to create least disturbance or reflections in the attenuator functioning over its operating range. In a preferred form of the invention the shunt coil is mounted across the interior face of an end connector, male or female type, of the attenuator unit. The coil is directly in proper electrical circuit when the end connector is assembled with the attenuator.

The small physical size of the shunt coil provides the high shunt reactance needed to least interfere with the R.F. attenuator characteristics in its microwave operation, as well as the low direct current resistance path at its location in the attenuator. In one form of the invention, the shunt coil is arranged centrally of the distributed resistor for balanced results. Its application to the "T" or "pi" pad attenuator affords the rated characteristic impedance throughout their conventional attenuator frequency operating range, plus the said direct current characteristic whereby a very low resistance shunt is effective.

It is accordingly the primary object of the present invention to provide a novel microwave attenuator with a low direct current resistance return path.

Another object of the present invention is to provide

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a novel microwave attenuator with a small inductor shunting either or both ends thereof to the concentric ground conductor, maintaining the attenuator microwave properties while providing a low resistance direct current path thereacross.

A further object of the present invention is to provide a novel central resistor attenuator having a direct current shunt path in the form of a very small coil that affords a large reactance in the attenuator frequency operating range, and with a low direct current resistance.

Still another object of the present invention is to provide a novel distributed resistor type attenuator with a practical, inexpensive, effective small coil shunt at its end or at its interior, for direct current return operation.

Still a further object of the present invention is to provide a novel microwave attenuator with a rugged coil shunt path arrangement that is easy to service and maintain in the field.

These and further objects of the present invention will become more apparent in the following description of exemplary embodiments thereof illustrated in the drawings, in which:

FIG. 1 is a longitudinal cross-sectional view through a distributed resistor attenuator embodying the invention.

FIG. 2 is an enlarged view of the end connector at the right of the attenuator of FIG. 1, in cross-section.

FIG. 3 is an elevational view of the connector of FIG. 2, at its interior end, from the left, showing the direct current return coil.

FIG. 4 is an end view of an attenuator connector showing a modified direct current return coil.

FIGS. 5 and 6 are schematic electrical representations of the distributed attenuator of FIG. 1.

FIGS. 7 and 8 are longitudinal cross-sectional views through the central portion of modified distributed resistor attenuator forms of the invention.

FIG. 9 is a graph illustrating the relative VSWR characteristics of the invention as applied to distributed type attenuators.

FIG. 10 is a schematic diagram of a "T" pad type attenuator incorporating the invention shunt coil arrangement.

FIGS. 1, 2 and 3 show the application, in accordance with the invention hereof, of small, few turn coils 15, 16 to an otherwise conventional distributed resistor coaxial attenuator 20. Attenuator 20 comprises a metallic body or housing 21 of tubular form with a cylindrical resistor element 25 axially positioned therein. The relative diameters of the outside of resistor 25 and interior of housing 21 are proportioned for the desired characteristic impedance of the attenuator 20, e.g. 50 ohms. The core of resistor 25 is of a suitable ceramic, as steatite, glass, etc. The resistive film 26 along the full outside surface of the core is a conventional metalized coating, e.g. boron. The linear resistive distribution of the resistor film 26 along the core is as conventionally used in such attenuators per se. Typical resistor films are described hereinafter in connection with FIGS. 5 and 6.

The ends of resistor 25 are secured to metal connector elements 27, 28 having respective bayonet-type or bullet prongs 29, 30. The central resistor 25 is mechanically supported by prongs 29, 30, and electrically connected in the attenuator therewith. End connectors 31, 32 of the attenuator serve to support the resistor, and connect it externally. These end connectors are coaxially related to the attenuator 20 proper, and are rigidly secured to the housing 21 by set-screws 33, 34.

Each end connector 31, 32 contains a central bead or bushing 35, 36 of a high grade low-loss dielectric material, such as Teflon. Centrally of beads 35, 36 are respective metallic tubular rods 37, 38. Rod 37 receives bayonet prong 29 of resistor 25; and rod 38, prong 30.

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The resistor 25 is thereby firmly supported precisely along the housing axis, and is in end electrical connection with the rods 37, 38. The insulation inserts 35, 36 are firmly imbedded within the shells of end connectors 31, 32. The tubular rods 37, 38 are secured within beads 35, 36, as by respective pins 39, 40 shown, or by a suitable glue such as "Hysol."

End connectors 31, 32 form an integrated assembly with attenuator section 20, and serve to centrally support the resistor element 25. The housing 21 is characteristically related to the central resistor 25, and is generally grounded circuitally; and shields the resistor 25. The metallic end connectors 31, 32 secured with housing 21 form a rugged assembly, protecting the more fragile resistor. Connection is made to the left end (27) of resistor 25 through rod 37 and extending male pin 41 centrally of end connector 31. Similarly, connection is made to the right end (28) of resistor 25 through rod 38 and female socket 42 extending therefrom in end connector 32.

The end connectors 31, 32 are of any conventional type. The exemplary male connector 31 is an "N" type, with an annular shell 43 rotatably connected to connector body 44 through ring 45. The interior of shell 43 is threaded at 46 for engagement with a circuit coaxial cable connector. Female connector 32 is threaded at 47 exteriorly, for engagement with a suitable coaxial circuit cable. Mating rod connections with central elements 41, 43 result in direct connection to either end of resistor 25; the bodies of connectors 31, 32 being grounded with housing 21 and the cable exteriors. The attenuator end connectors 31, 32 may of course connect directly with mating connectors of microwave components, as a crystal mixer, detector, etc. Also different end connector types may be employed, as for example the types C, TNC, etc.

The small shunt coil 16 is fixedly connected in end connector 32 across the Teflon insert 36, as shown clearly in FIGS. 2 and 3. The inner end 16' is suitably swaged, welded, soldered or brazed to the outer circumferential edge of the connector tube 38. The proportioning of coil 16 determines the resultant electrical action in the distributed resistor attenuator 20, as is described in more detail hereinafter. In the microwave range of about 1.0 to 12 kmc., a typical number of turns for coils 15 and/or 16 is of the order of two to five, of thin wire as B & S gauge 36, on a helical diameter of the order of 0.1 inch and less. As stated hereinabove, the coils 15, and/or 16 provide a high A.C. impedance and low D.C. shunt path across the attenuator (20), with minimal electrical impact on the attenuation and VSWR characteristics in the attenuator operating range.

However, for a particular distributed resistance attenuator (20), even a straight wire connection for inductors 15, 16 may be indicated; in other cases, even more than the referred to five turns. In practice, an approximate inductance is inserted, and varied as will be described, to an optimum size, and reproduced for like units in production. A narrow radial slot may be made across the ridge 36' of insert 36 and the annular edge 50 of the body of end connector 32. The outer lead 16'' of coil 16 is placed in such slot and suitably soldered to the edge 50, as indicated at 51. Excess length of end 16'' is trimmed off.

The size of coil 16 (and 15), while preferably made close to the design optimum for a given unit (20) is not critical of production onto connector 32 as herein set forth. The lead 16'' is drawn through the connector slot until the coil 16 is properly disposed across insert 36, with inner end 16' previously soldered in, and then lead 16'' is soldered and trimmed. While one male type and one female type of end connector (31, 32) is illustrated for the attenuator (20), it is understood that both may be male or female types if desired.

The normal connecting of end connector 32 to the attenuator 20, with bullet prong 30 engaged in rod 38, and annular portion 50 in electrical connection with housing 21, directly connects coil 16 across the associated end of

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resistor 25 and housing 21. Set screw 34 secures this connection. In a similar manner end connector 31 is coupled to the opposite end of attenuator 20, and shunt coil 15 is electrically connected across that attenuator end. A low D.C. resistance shunt path is thus established at each end of the attenuator 20 of FIG. 1, with negligible deleterious action in its operating frequency range.

Should it be unnecessary to have a low D.C. resistance shunt at one or the other end of the attenuator (20), the corresponding shunt coil (15, 16) is eliminated. This is readily accomplished by replacing the corresponding shunted end connector 31 or 32 by a normal end connector having no such shunting coil. In this manner a shunt path of low resistance is readily provided for the distributed resistance attenuator at the desired end of its microwave circuit application. FIG. 5 diagrammatically illustrates such single condition, with the distributed resistor 25' centrally of housing 21', and shunt coil 15' connected across its left end. The two wire input 52, 53 has the outer shell or housing 21' grounded with input lead 53. The output terminals 54, 55 has lead 55 at ground.

FIG. 4 is an end view of an end connector 60 with a spiral shunt coil 61 instead of a helical coil. The inner end of coil 61 is soldered to the edge of the connector tube 62 axially in Teflon insert 63. The outer lead 61' is soldered in a radial slot in annular portion 64 of the shell 65 of the end connector 60. The spiral coil 61 illustrated has two complete turns. More or fewer turns for this coil may be used as required. The spiral form for the shunt coil is practical, compact, and may be recessed in the insert 63. The operation of end connector 60 with coil 61 is otherwise identical as that described hereinabove for end connectors 31, 32 with respective helical coils 15, 16.

Referring again to FIG. 5, two transverse dotted lines 70, 71 are indicated in the central region of the resistor 25'. In practice, a distributed resistor (as 25') for medium and higher db attenuation levels, is constructed in three resistive sections: *a*, *b*, *a*; with the outer sections *a*, *a* being equal to each other, balancing either end. The central resistance section *b* is generally of a substantially higher resistivity than the outer sections *a*, *a*. The bulk of the resistance is at the central section (*b*), with the end sections (*a*, *a*) attenuating signal wave reflections.

A typical attenuator resistor (25') for higher attenuation levels, as 20 db, is diagrammed in FIG. 6, with its resistance per unit length r/l plotted against its axial dimension 1. The FIG. 6 unit, for a 50 ohm line impedance, has central section *b* three times the resistance of end sections *a*, *a*; with the total resistance of sections *a*, *a* at 50 ohms each, and *a* section *b* at 150 ohms for the 20 db attenuation (a series D.C. resistance of 250 ohms). It is noted that the linear resistivity or coefficient at regions 70, 71 in FIG. 6 changes abruptly for the relatively high attenuation level of 20 db. For medium attenuation levels, as about 5 to 10 db, the resistivity transition regions 70, 71 are generally made gradual. In low value attenuators, e.g. 1 to 3 db, a single resistivity coefficient is generally used all along its length, for the resistor 25'. The invention low direct current shunt path is advantageously applicable to all such attenuator types and constructions.

Other resistance values for sections *a*, *b*, *a*, prevail for other attenuations and for different line impedances of a particular distributed resistor attenuation unit, as is understood in the art. The application of the invention shunt coil for low D.C. shunt resistance with negligible electrical disturbance of attenuator operation, is however general over wide db and line resistance ranges. The size of the shunt coil or coils (15, 16, 61) used for a particular attenuator configuration can be directly determined empirically, as stated, or may be calculated to a first order approximation and then optimized.

Locating the shunt coil centrally of the central section (*b*) of the distributed resistor (25') will result in least electrical reaction over a greater operating frequency

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range than a coil at either or both ends thereof (as 15, 16). FIGS. 7 and 8 show two forms with such central shunt coil, resulting in symmetrical overall electrical action.

FIG. 7 illustrates the central section of a modified distributed attenuator 75, in accordance with the invention. Attenuator 75 has the shunt coil 80 located in the center, preferably midway in the resistor element 76, 77. The distributed resistor 76, 77 of attenuator 75 is of a type as described hereinabove for 25, 25'. Resistor 76, 77 however is composed of two serial members electrically joined at interior terminals 78, 79 thereof. The resistor elements 76, 77 at this mid region is for example the bulk resistance or *b* section of a higher level attenuator as of FIGS. 5 and 6; or the corresponding one for a lower level attenuator. In effect, the single resistance element 25 of FIG. 1 is split into two portions 76, 77 with end ferrules 78, 79 that set into a tube 81.

Metallic tube 81 is pressed into the center of low-loss insulation disc 82, and serves as a mechanical support for the resistance sections 76, 77. A metallic ring 83 surrounds disc 82 for establishing electrical connection with the housing sections 84, 85. The disc assembly 86 fits into a suitable recess in the housing 84, 85, with firm mechanical and electrical mounting. The disc assembly 86 comprises the insulation disc 82, resistor tube 81, annular ring 83, and the shunt coil 80.

Coil 80 is helical, of a few turns, proportioned to provide low D.C. resistance across resistor 76, 77 at its central region, and sufficiently high A.C. impedance thereacross as to not disturb its operation in the microwave range. Coil 80 is secured between ring 83 and tube 81 in the disc assembly 86, and is electrically connected in the attenuator 75 upon its incorporation in the attenuator. Assembly 86 thus centrally supports split attenuator axial resistor 76, 77, and inserts the associated shunt coil centrally in the attenuator circuit. The attenuator 75 assembly is completed, as by a suitable joint 87, and set screws 88, 89; or an equivalent arrangement. Connection of the shunt coil centrally of the resistance section (76, 77) of the attenuator 75 affords a balanced and symmetrical electrical action. Further, the two resistance paths to either attenuator end results in even less VSWR reaction at the above 10 kmc. range than the use of end shunt coils (as 15, 16).

FIG. 8 shows a further form of the central attenuator D.C. path coil shunt in accordance with the invention. Attenuator 90 is basically similar to attenuator 75. However, the axial resistor 91 is retained as a single element, with a band or conductive ring 92 at its central region. The ring 92 may be a silver layer. The outer housing is split as two sections 93 and 94 threaded together at 95. A central disc assembly 96 used herein has a disc 97 of dielectric material, inner and outer rings 98, 99, and a shunt coil 100 connected therebetween. Inner ring 98 is proportioned to snugly fit on and connect with resistor ring 92. Outer ring is pressed between housing tubes 93, 94 for connection therewith. Coil 100 is thus firmly supported in the attenuator, and in electrical connection across its central region. Other arrangements with equivalent electrical results may instead be employed.

The remainder of the distributed resistor attenuators 75 and 90 is conventional, and therefore not illustrated. Reference is made to the attenuators of FIGS. 1 and 5 described hereinabove. However, the end connectors of attenuators 75 and 90 need have no shunt coils. The central coils (80, 100) are symmetrically located, as noted. The wider disc assembly 86 of unit 75 is preferably used for attenuators of 10 db and above; while the narrower mode, assembly 96 of unit 90 may be used for smaller range attenuators as well. Whenever an end shunt coil is also desired, such is readily inserted through an end connector hereof as in the FIG. 1 unit.

FIG. 9 illustrates the effect on VSWR in a typical

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distributed resistor type attenuator with few turn low D.C. resistance shunt coil insertion, as per this invention. Curve 110, in solid line, represents the VSWR characteristic between 1 and 12 kmc. of a 50 ohm 10 db distributed resistor attenuator; the VSWR varying between 1.15 and 1.3. The insertion of one end shunt coil (as coil 15 or 16 of FIG. 1), results in a small rise in VSWR starting at about 10 kmc., indicated by dotted curve 111. Practically no VSWR change occurs below 10 kmc., therein. Results with a central shunt coil, as coil 80 or 100 of FIGS. 7, 8, show even less VSWR change.

Typical practical distributed resistance attenuators, for 50 ohm lines are: (1) Where the overall length of the resistor element (e.g. 25) is 3.39", the attenuation is substantially flat between 4 and 11 kmc.; (2) where the length is 7", the attenuation practically is flat from 1.0 kmc. up to 11 kmc. An exemplary end shunt coil, at 15 and/or 16, used for such attenuator with a 3.39" long resistor, in the 1 to 10 db sizes, was: 3 turns of B & S gauge 36 copper Formvar wire, with an I.D. of .035" and coil length of .0825". The Formvar wire is a low temperature coefficient wire for consistent wide ambient temperature conditions of operation. In another embodiment of a single end coil in a 7", overall 1 to 11 kmc. range distributed resistor attenuator, the coil was: 3 turns, .140" between housing and resistor, .090" coil length, B & S Formvar, I.D. of .040". The D.C. resistance of such small coils is only a fraction of an ohm.

FIG. 10 illustrates schematically the application of the invention to a "pi" or "T" pad attenuator. The same principles, features and characteristics of the few turn shunt coil described hereinabove for the distributed resistor type of attenuator also apply equally well for the pad type. Accordingly, its application thereto will now be readily understood by those skilled in the art. The pad attenuator 120 contains a tubular conductive sheath 121 that is generally at ground potential and shields the internally mounted components. Two equal and symmetrical axial resistors 122, 123 are supported in the attenuator center by a shunt disc resistor 124.

The shunt resistor 124 is composed of a thin dielectric disc uniformly coated on each face with resistance material, as boron of specified resistivity. The central resistors 122, 123 are composed of low loss dielectric cylinders each coated with a uniform film of resistive material to result in a predetermined ohmic value. The net effective resistance of the series resistors 122, 123 and that of each face of the shunt resistor 124 is selected in a known manner in accordance with the required characteristic impedance and attenuation insertion loss (in db) for the unit (120). The balanced, concentric construction of the pad attenuator 120 renders it electrically symmetrical from either end.

The conventional pad type concentric attenuators, as unit 120 (FIG. 10), have physical end connectors of the N, C, TNC or other types, male or female, in the same manner already set forth for the distributed resistor type hereinabove. A few turn small shunt coil 125 is connected to either end of the pad attenuator 120, being inserted at the left in illustrative FIG. 10. Such electrical insertion corresponds to that of coil 15' shown in FIG. 5; and is preferably accomplished in the same manner. This is the use of an end connector as 31 or 32 (or both) as used in the FIG. 1 attenuator, for the coil 125 of the pad attenuator. In other words, the end connector, conventionally used in such pad attenuators, has the suitable few turn coil therefore mounted radially as in FIGS. 1 to 3, or spirally as in FIG. 4, for the circuit relations.

The small coil 125 is proportioned with the few turns to give a sufficiently high reactance as compared with the characteristic impedance of the attenuator throughout the operating frequency range thereof. As the top frequency of pad attenuators is generally less than for the

distributed type, a coil size proportioned to prevent parasitic oscillations is readily attained. The low D.C. resistance of such coil (125), may provide a shunt resistance of a fraction of an ohm to direct current for the attenuator pad attenuators. A typical pad may have, for example, 50 ohms resistance at its terminals 126, 127 to its microwave signals. With the coil 125 across its other terminals 130, 131 its D.C. resistance thereat is a fraction of an ohm, while its operating impedance at its microwave frequencies, e.g. 0.5 to 4.0 mc. is 50 ohms. The servicing or removal of the coil (125) is readily attained by changing the end connector that contains the coil.

In design for production, a shunt coil of optimum size and reactance by measuring its VSWR effects at the attenuator end in which it is located; or by measuring the VSWR from either end if it is located in the center of a distributed type. Such measurements are made over the specified attenuator operating microwave frequency range. The initial inductance selected for the coil may thereupon be physically trimmed or slightly altered pursuant to the measurements to arrive at a practical optimum reactance size. Such shunt coil has been found to introduce an average of only .05 VSWR change (plus or minus) at the upper frequency range of the attenuators hereof, a value acceptable for most applications.

As high an inductance (and hence operative reactance) is desirable for the shunt coil consistent with avoidance of parasitical narrow "holes" or loss effects at specific frequencies within the range of the associated attenuator operating frequency curve. The least number of turns for the invention shunt coil in a particular attenuator unit that provides the desired or optimum results, is preferably used. The turns of the shunt coil have distributed capacitance whereby local oscillation at the coil may occur at a specific high frequency in the range. It has been found that practical small shunt inductance values are readily determined to give very low D.C. shunt resistance, yet having sufficiently high shunt reactance in the 1 to 12 kmc. range to avoid such parasitic local oscillation problems. The characteristic coil reactance or impedance, the attenuation factor, its turns or length, the operating frequency range involved, and the desired VSWR limits, all have a bearing on the selection of the few turn small shunt coil used in the microwave attenuators.

The invention coil-shunted low resistance D.C. shunt path attenuators are practical under military and rugged conditions of operation. The shunt coil assemblies hereof are readily installed, serviced or changed with respect to the basic attenuator. The provision of the low resistance D.C. shunt return for the attenuators hereof is relatively inexpensive, and very effective electrically. In production, the attenuator per se is common to its ready use with or without the shunt coil assembly, through suitable connector selection.

The invention has been described in connection with exemplary forms thereof and it is understood that modifications and variations may be made within the broader spirit and scope of the invention, as set forth in the following claims.

I claim:

1. A microwave attenuator having a cylindrical conductive sleeve, a tubular conductive end connector secured to each sleeve end and respectively containing an axial conductive terminal, a tubular resistive unit concentrically arranged within said sleeve, each end of said unit being in engagement with a respective terminal for exterior electrical connection, said resistive unit being proportioned to

establish a predetermined impedance between each terminal and said sleeve in the operating frequency range, and an inductance coil connected between one terminal and its connector, said coil presenting an impedance substantially higher than said predetermined impedance in said frequency range and a low resistance to direct current flow thereacross.

2. A microwave attenuator as claimed in claim 1, in which said coil is of the order of two to five turns on a helical diameter of the order of 0.1 inch.

3. A microwave attenuator as claimed in claim 1, in which said coil is of spiral configuration.

4. A microwave attenuator as claimed in claim 1, in which said coil extends between the inner surface of the inner edge of said connector and the adjacent outer surface of said one terminal.

5. A microwave attenuator as claimed in claim 1, further including a second inductance coil connected between the other terminal and its associated connector having comparable operating characteristics to the first said coil.

6. A microwave attenuator as claimed in claim 1, in which said resistive unit comprises an attenuation pad containing a central shunt disc resistance and two resistors extending therefrom to the respective end terminals.

7. A microwave attenuator having a cylindrical conductive sleeve, a tubular conductive end connector secured to each sleeve end and respectively containing an axial conductive terminal, a tubular resistive unit concentrically arranged within said sleeve, each end of said unit being in engagement with a respective terminal for exterior electrical connection, said resistive unit being proportioned to establish a predetermined impedance between each terminal and said sleeve in the operating frequency range, said resistive unit being a distributed resistor effecting a predetermined signal attenuation in said frequency range, an inductance coil presenting a substantially high impedance in said frequency range and a low resistance to direct current flow thereacross, and means for supporting said coil centrally in said attenuator between said sleeve and said distributed resistor and electrically connecting the coil therebetween to establish a low resistance direct current path thereacross with negligible VSWR effects in the attenuator operation.

8. A microwave attenuator as claimed in claim 7, in which said sleeve is separably joined at the coil mounting region, and a dielectric member supporting said resistor and said coil in said central region of the attenuator.

9. An end connector for a tubular microwave attenuator comprising an outer conductive shell for securement to the attenuator sleeve, a central axial terminal for connection with one end of the attenuator central resistive unit, an insulation member mounting said terminal coaxially within said shell, and an inductance coil connected between said terminal and said shell, said coil being proportioned to present a substantially high impedance at the operating frequency range of the microwave attenuator to establish a two terminal connection for one end of the attenuator by the end connector having low resistance to direct current flow thereacross and negligible VSWR effect on the microwave frequency operation thereof.

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