

Sept. 21, 1965

A. KRAUS
ATTENUATORS

3,208,016

Filed Feb. 9, 1961

2 Sheets-Sheet 1

FIG. 1.

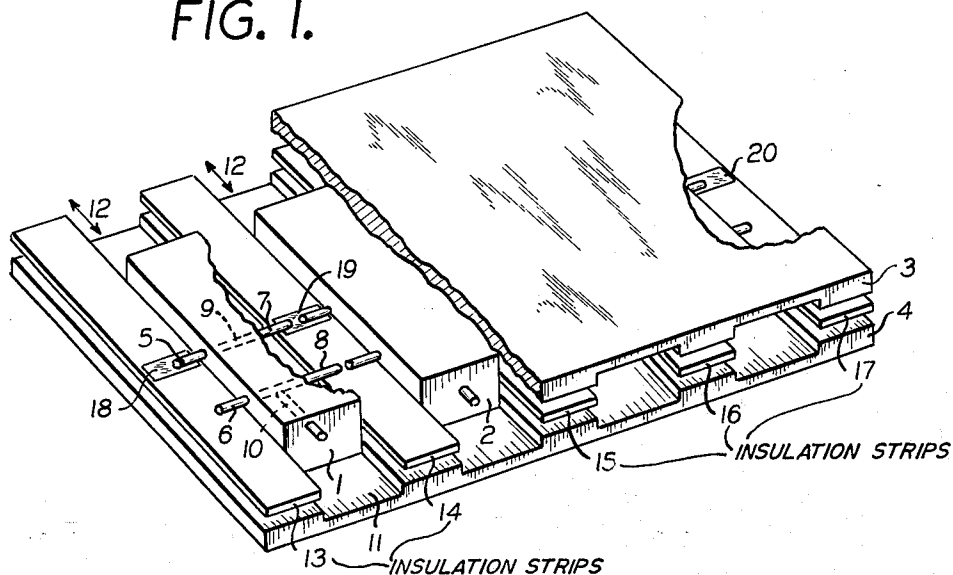


FIG. 2B.

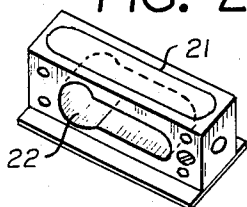


FIG. 2A.

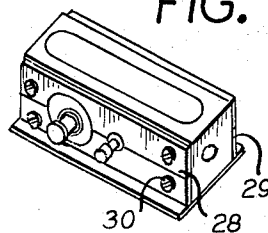


FIG. 2E.

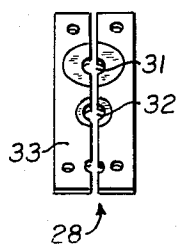


FIG. 2D.

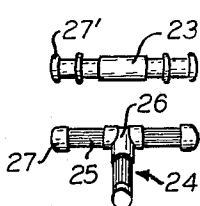
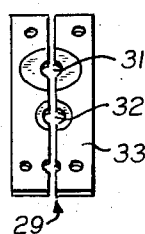


FIG. 2C.

FIG. 2F.



INVENTOR
ALEXANDER KRAUS

BY *Theodore Payne*
ATTORNEY.

Sept. 21, 1965

A. KRAUS
ATTENUATORS

3,208,016

Filed Feb. 9, 1961

2 Sheets-Sheet 2

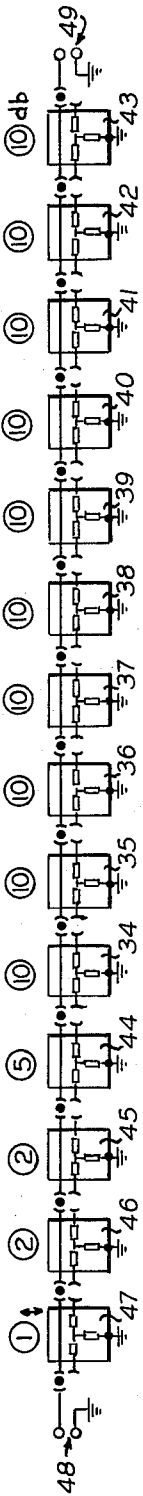


FIG. 3.

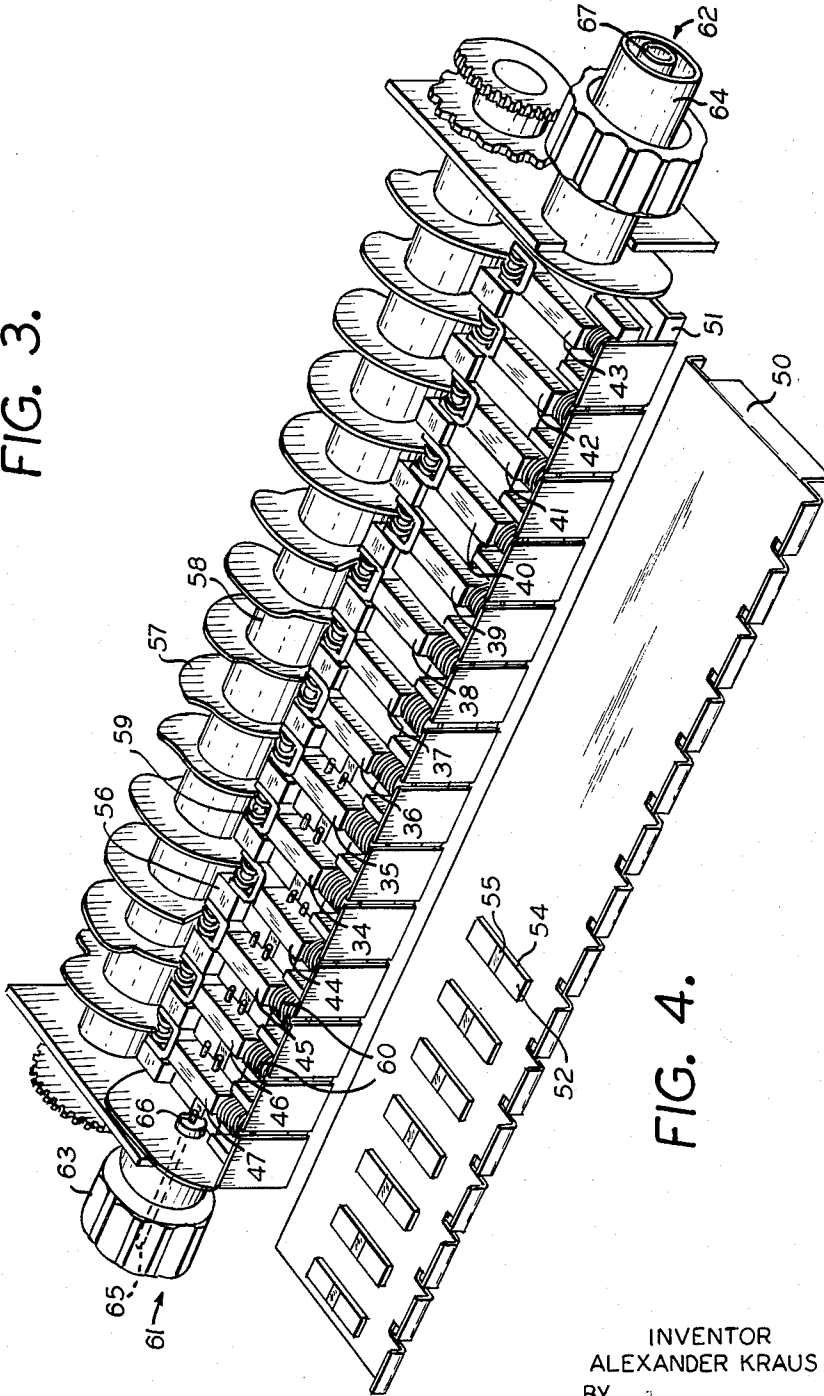


FIG. 4.

INVENTOR
ALEXANDER KRAUS
BY
Alexander Kraus
ATTORNEY

1

3,208,016

ATTENUATORS

Alexander Kraus, Munich, Germany, assignor to Rohde & Schwarz, Munich, Germany, a partnership
Filed Feb. 9, 1961, Ser. No. 88,182
Claims priority, application Germany, Mar. 11, 1960,
R 27,530; Feb. 20, 1960, R 27,382
8 Claims. (Cl. 333-81)

This invention relates to high frequency attenuators and, more specifically, variable attenuators of the unbalanced type, providing a number of predetermined standard attenuation steps.

Variable attenuators for high frequencies have been known in many various forms.

In one known system the attenuator consists of a number, mostly ten, of attenuation units corresponding to a number of attenuation steps, one of which is permanently connected to a switch. This switch is usually a two-pole type because input as well as output must be switched over.

In another known system the attenuation units are arranged on a drum and are switched by rotating the drum relative to a fixed contact. Since at high frequencies the attenuation depends on the frequency, each attenuation unit cannot be made of a single pi or T-member but rather of a series connection of several parts, and it is necessary to provide for a complete attenuator a great number of such parts. For example, a decade of 10×10 db will require at least thirty parts. However, devices embodying this principle are expensive because of the great number of parts required therefor and the resulting complexity of its switching mechanism.

According to another known principle, an attenuator may consist of a single attenuation unit, i.e., the cascade connection of single parts of equal value. Generally ten such parts, each of 10 db, are connected in cascade. In order to vary the attenuation such devices require a switch which, on the one hand, connects the parts in series and, on the other hand, disconnects high frequency-wise those parts which are not being used. The range of application of such an arrangement and in which the parts are disposed over a cylinder surface is limited to a frequency range up to about 500 megacycles because the blind resistance caused by the switch cannot be compensated sufficiently.

According to a further known method, adjustable dividers for high frequency are produced by permitting the cascade to remain connected at the points of tapping. Such devices, however, do not represent attenuators proper because their wave resistance at output is half as large as the wave resistance at input. As a result, the attenuation cannot be switched down to zero value.

Other known systems involve attenuators consisting of a cascade connection of a number of fixed position parts, each part having attached to it a fixed position switch. This switch serves either to connect an attenuation member or, in its place, a bridging member so that, alternatively, either attenuations or pure conduction may be inserted into the cascade. Such devices, however, have been found useful only for relatively low frequencies as the imaginary components of the switching contacts and the lead-ins cannot be compensated.

One of the objects of the invention is to eliminate the disadvantages of the known attenuators for very high frequencies by providing attenuation and bridging members selectively connectable in such a manner that an attenuation member and a non-attenuating conducting member, combined into a movable unit, are displaceable between conducting, wave-resistance determining planar structures with the effect that, depending upon the move-

2

ment of the unit, either an attenuating or a non-attenuating connection is produced.

As a result of combining an attenuating with a non-attenuating conductor connection to a movable unit, the switching process can be produced by the movement of the unit itself, thereby eliminating the disturbing switch. In this way the movable unit can be displaced with respect to two fixed position contacts in such a manner that, in one position, non-attenuated conduction and, in another position, attenuation is connected or switched in the attenuator.

In order to eliminate disturbing imaginary components, the displaceable unit is arranged between conducting planar structures having an appropriately selected distance.

As a result, at high frequencies, the non-attenuating connection is effective as a lossless connection, while the attenuating connection acts as a loss affected connection having electrical values depending on its dimensions.

Another object of the invention is a movable unit of prismatic shape displaceable in a guiding groove between two parallel planes formed by conducting structures.

In still another object of the invention, several movable units can be connected in cascade by arranging the desired number of units juxtaposed and spaced from each other, and providing in the spaces between the units, fixed contact elements for frictional engagement by connecting parts of the movable units.

As a further embodiment of the invention, the contact elements may have a structure extending substantially into a plane, and such dimensions that the wave resistance of the entire arrangement remains independent of frequency. If the movable units are arranged very close to each other, the contact elements may become very small, resulting in a very high upper operating frequency.

A more specific object of the invention is to provide an attenuator decade of 10×10 db containing ten movable units and a decade of 10×1 db of particularly small dimensions utilizing four steps only, namely 1 db, 2 db, 2 db, 5 db, and containing only four movable units.

Generally it is an object of the invention to provide an attenuator of simple construction, with a minimum of elements and also capable of reaching a substantially higher frequency limit than could be reached hitherto and unto which attenuation and wave resistance will remain sufficiently constant.

In a specific embodiment of the invention the movable unit is made of a piece of conducting tube of rectangular cross-section and the conducting connection is made of a bar or rod extending inside the tube parallel to its axis, the attenuating member being also arranged in the interior of the tube.

As another feature of the invention the movable unit, preferably of tubular shape, serves as a return conductor for the conducting connection as well as for the attenuating member and, in order to compensate disturbing imaginary components, the conducting connection is so dimensioned that its wave resistance equals the resistance of the attenuator. This arrangement has the advantage that both conducting connection and attenuating member can be disposed within a simple hollow body of rectangular cross-section and that the resulting unit can be readily freed of wave resistance distortion by an appropriate selection of dimensions.

These and other objects of the invention will be more fully apparent from the drawings annexed herein in which:

FIG. 1 is a perspective illustration of a multiple-unit attenuator according to the present invention.

FIG. 2a represents in greater detail, and also in a perspective view, a movable attenuator unit while FIGS.

3

2b, c, d, e and f represent the dissolved parts of such a unit, 2b in a perspective view and 2c, d, e and f in top views, respectively.

FIG. 3 shows a circuit diagram of a variable attenuator in accordance with the invention.

FIG. 4 shows a modification of FIG. 1 embodying an assembly of units such as shown in FIGS. 2a-d.

An attenuator according to FIG. 1 is shown to consist of four movable units, two of which are schematically indicated at 1 and 2, respectively.

Such an attenuator would be suitable, for example, for a decade of 10×1 db provided the four attenuation steps of the unit correspond to 1 db, 2 db, 2 db and 5 db, respectively.

Attenuation units 1, 2 are arranged movable between the two parallel planes formed by the conducting planary structures 3, 4. In order to make movable units 1, 2 better visible, upper structure 3 is only shown partially; the other movable units are not visible.

Movable units 1, 2 . . . are of substantially identical mechanical structure. Unit 1 is illustrated in a partial section and consists of a piece of tubing of rectangular cross-section so that the entire form of the unit is that of a prism. On the two opposite sides of unit 1, two cylindrical contacts 5, 6 and 7, 8 are arranged respectively. Contacts 5, 6 and 7, 8 are arranged substantially in a common plane and the distance between contacts 5, 6 equals the distance between contacts 7, 8. Contacts 5, 7 are interconnected through conductor 9. Resistance member 10 is of T-shape, with its resistances being supported thereon insulated from tube 1. Movable units 1, 2 . . . are guided in grooves 11 so as to be moved in the direction of arrows 12 only.

On both sides of movable units 1, 2 . . . there are arranged insulation strips, such as shown at 13, 14, 15, 16, 17 . . . respectively, carrying planar contact elements 18, 19 so adapted to engage frictionally the cylindrical contacts 5, 6, 7, 8 . . . of units 1, 2 . . . respectively. The input and output connections for the entire attenuator are formed by end contact elements, such as shown at 18, 20 respectively. Ground or mass is connected through the metallic plates 1 and/or 2 which are interconnected.

As stated above, one of the features of the invention is a movable unit containing attenuating as well as non-attenuating connections.

Such a unit is illustrated in great detail assembled in FIG. 2a and consisting of parts illustrated in FIGS. 2b, c, d, e and f respectively.

More specifically, FIG. 2b shows a conducting prismatic body 21 provided with an oblong opening 22 transverse to the axis of prismatic body 21 and machined in such a way as to receive the non-attenuating connection as well as the attenuating member shown in FIGS. 2d and c, respectively. The non-attenuating connection 23 consists of a silver bolt, while the attenuating connection 24 consists of three carbon layer resistances 25 soldered together in T-form at 26 and provided at their ends with silver caps 27 for frictional contact with the fixed contacts of the attenuator, in the manner illustrated in FIG. 1 or in any other appropriate manner without departing from the scope of this invention.

Non-attenuating and attenuating connections 23, 24 are supported in body 21 by means of side plates 28, 29 attached to body 21 by means of screws 30 and having openings 31, 32 in which both silver bolt 23 and resistance member 24 are clamped in.

Side plates 28, 29 consist of insulating material and have a conductive outer coating consisting, for example, of a metal foil schematically indicated at 33. This permits adjustment of attenuation and wave resistance at high frequencies. This is achieved by removing the metallic coating 33 around openings 31 and 32 in the form of a circle. Thus parts 23 and 24 are only supported upon the insulating material of side plates 28, 29 while metallic layer 33 serves as an electric screen surrounding the lead-

4

throughs. Depending upon the size of this metallic screen at high frequencies, an increase or a decrease of the wave resistance or attenuation may be achieved, thereby affecting the properties of the attenuation member. The base point of member 24 is connected to body 21 and therefore is on ground or mass while the arm of the T, i.e., the longitudinal resistances, extend or project to about half of their length to the outside of body 21. The ends of resistance member 24, provided with caps 27, serve to connect to the circuit of the attenuator. Similarly silver bolt 23, i.e., the non-attenuation connection, is arranged in prismatic body 21 in such a manner as to permit its ends to establish contact with the circuit.

Such a movable unit has among others, the following practical advantages:

By providing a pair or pairs of fixed position contacts, as shown in FIG. 1 at 18, 19 . . . or in any other appropriate manner, the unit can be displaced to two operative positions: in one position the attenuating member and in another position a non-attenuating member will be connected, and thereby the attenuation stepwise varied. Because the ends of the resistances also form contacts, the connections between the movable attenuation elements and the fixed contact elements become extraordinarily short and represent a good wave resistance. The device therefore can be used up to very high frequencies.

The movable unit further has, among others, the following characteristic features:

The unit contains an attenuating as well as a non-attenuating connection and can be so displaced that conduction or attenuation can be switched in.

The unit consists of a conducting main body having two side walls consisting of insulating plates through which longitudinal resistances are extended in such a manner as to project to about half of their length outside of the main body, forming contact elements therefor.

The insulating plates serve as a mechanical support for both resistant and conducting members.

The insulating plates are covered on the outside with a metallic foil and the foil is removed around the points at which resistant and conducting members are passed through the insulating plates.

The ends of the resistant member are provided with metallic caps and thus serve directly as switching contacts.

The circuit diagram of FIG. 3 illustrates a complete attenuator, variable in steps, for very high frequencies and in which one pole is on mass, i.e., which constitutes an unbalanced transmission line.

The attenuator consists of ten movable units, schematically indicated at 35 . . . 43, each providing an attenuation of 10 db. A further unit, 44 provides 5 db; two more units, 45 and 46, provide 2 db each, and one last unit, 47, corresponds to 1 db. By displacing these units in accordance with the invention, and the resulting series connection of the corresponding resistant and conducting elements contained therein, any whole-numbered attenuation value between 0 and 110 db can be produced between input terminals 48 and output terminals 49.

An assembly of an open attenuator consisting of units such as shown in FIGS. 2a to f, and in accordance with the circuit diagram of FIG. 3, is illustrated in a perspective top view in FIG. 4.

Here, as in FIG. 1, the movable units are arranged between two parallel planes formed by conducting plates 50, 51. In order to facilitate inspection of the inside of this attenuator, plate 50 has been removed from the top of the assembly to permit a direct view of the array of movable units indicated in FIG. 4 at 34 to 47 respectively and corresponding to the arrangement shown in the circuit diagram of FIG. 3.

In the center plane between conducting plates 50 and 51, and in each case between two adjacent attenuation units, there is arranged a fixed contact piece, such as schematically indicated at 52, which, by means of a spring

(and actually not visible in the drawing) acting from above, is pressed against the elements, such as ends 27 and 27' of FIG. 2, projecting from movable units 34 through 47.

In order to facilitate understanding, in the illustration of FIG. 4 a number of contact pieces in the left-hand portion of the device have been removed therefrom and for better visibility arranged approximately in their normal relative position on the corresponding portion of top plate 50.

Each fixed contact piece 52 consists of a molded piece 54 of insulating material carrying at its center glued thereto a strip of silver foil schematically shown at 55.

For lateral guidance of attenuation units 34 through 47, spacing blocks 56 are used.

Displacement of the attenuation units is caused by means of notched discs or cams as indicated, for example, schematically at 57 arranged on a shaft indicated at 58. In order to cause an indirect transfer of the displacement movement from notched cams 57 to the attenuation unit, an intermediate member including a roller schematically indicated at 59 is used. Since notched disc 57 produces a pressing movement only, the movable attenuation units are urged into the opposite direction by means of telescoping springs schematically indicated at 60. In this way the movable attenuation units are constantly pressed against notched discs 57.

Input and output for the attenuation assembly is provided at 61, 62 respectively in the form of coaxial cable connections which are unbalanced and in which one pole, preferably the outer conductor 63, 64, is constantly on mass. The other pole is represented by the concentric inner conductor, schematically indicated for example at 65, which enters the attenuator at point 66 making contact with one of the contact pieces indicated in FIG. 4 at 52 at one side thereof. The other side of this contact piece is engaged by the corresponding end portions of the input parts of the attenuating or non-attenuating elements of the movable unit concerned. The corresponding output parts connect to the next following contact piece, and so on.

Inner conductor 65 of coaxial connection 61, therefore, is connected through contact pieces 52 and the corresponding parts of attenuating units 34 through 47 across and throughout the entire device to the inner conductor 67 of coaxial connection 62 at the end of the assembly.

The round outer conductors 63, 64 of coaxial connection 61, 62 are screwed onto parallel conducting plates 50, 51. In this way the coaxial system is transformed electrically into a parallel plate system which, as well known, may have substantially the same properties as the coaxial system. The movable attenuating units are also connected to ground, i.e., through their conducting prismatic bodies such as indicated in FIG. 1 at 1 (and in FIG. 2 at 21) by frictionally engaging conductor plates 3, 4. Similarly, as shown in FIGS. 3 and 4, by frictionally engaging conductor plates 50, 51, the galvanic connection between units 34 through 47 to the ground of the parallel conductor system is achieved.

The device illustrated in FIG. 4 has, among others, the following characteristic features:

Here again the unit consists of an attenuating member and a non-attenuating conducting connection.

This unit is displaced between conducting planary structures forming a wave guide of predetermined wave resistance.

The unit consists of a conducting main body which has two side walls consisting of insulating plates through which the longitudinal resistances are passed through in such a way that about half of their length is disposed outside of this main body.

The insulating plates serve as mechanical support and lead-through for resistant as well as conducting connections.

The insulating plates are coated on their outside with a metallic foil. The foil is removed in the proximity of the points' passage of resistant and conducting connections.

The resistances are provided with metallic caps directly forming switch contacts.

Several movable units can be arranged substantially parallel to each other.

The first position contacts are arranged between the movable units in the form of planary contact elements, forming parallel conducting planes having a wave resistance coincides with that of the input and output connector elements.

The attenuation of the movable units can be stepped in the order of 1, 2, 2, 5.

The movable unit can be made of a conducting tube of rectangular cross-section which may also form the return conductor for the attenuation member as well as the conducting connection.

The wave resistance of the conducting connection forming two parallel planes having a wave resistance or impedance which is made equal to the wave resistance of the attenuator.

I claim:

1. In a variable attenuator for very high frequencies having input and output connections of predetermined impedance, at least one movable unit containing an attenuating member and a non-attenuating conducting member both having terminals projecting from said unit, conducting means defining two parallel planes interrupted by at least one elongated guiding space, defining said predetermined impedance, and between which said unit is displaceable in said guiding space, fixed terminal means supported between said planes and cooperating with said terminals projecting from said unit in such a way that by moving said unit selectively either an attenuated or a non-attenuated connection is achieved from said input connection through said conducting means to said output connection, said movable unit having the form of a conducting prism insulatingly supporting said attenuating and non-attenuating members, and serving as a return conductor therefor, and said conducting means providing a groove for guiding said unit in its movement between said two parallel planes.

2. In an attenuator having input and output connections of predetermined impedance, an array of terminal means adapted to form a substantially continuous current path and supported to extend in a predetermined direction; an array of units aligned with said terminals, each containing an attenuating and a non-attenuating connection and each arranged selectively movable into two positions, one in which the attenuating connection and the other in which the non-attenuating connection is connected to said terminal means, and means for selectively moving said units into said operative positions substantially independently from each other, in a direction substantially perpendicular to said predetermined direction, and in a space between two parallel planes; conducting means defining said parallel planes and providing said predetermined impedance, plane insulating means extending into the space between and parallel to said planes, and supporting said terminal means, each of said units consisting of a substantially quadrangular piece of tubing of rectangular cross section having supported therein elongated elements forming said attenuating and non-attenuating connections, and extending beyond said tubing at both sides thereof for a distance of half of their length within said tubing, so as to form contacts with said terminal means.

3. Attenuator according to claim 2 wherein said elongated elements consist respectively of a fully conducting cylinder and a resistance carrying cylinder, the latter having a core of resistant material extending from said conducting cylinder substantially perpendicular thereto and connected to a front portion of said tubing; said tub-

7

ing having opposite side walls insulatingly supporting said connections, and said side walls being conducting apart from a predetermined portion surrounding the supporting point of said connections when passing through said side walls.

4. Attenuator according to claim 3 wherein said side walls consist of insulating material, the outside of said side walls being provided with a conducting layer, and said conducting layer being removed at the points where said connections are supported on said side walls, forming an insulating radius predetermined in accordance with the attenuation to be provided by the unit.

5. In an attenuator having input and output connections of predetermined impedance, at least one pair of attenuating and non-attenuating elements forming at least one single movable unit, conducting means defining two substantially parallel planes presenting said predetermined impedances and interrupted by prismatic grooves, fixed terminal means arranged in the space between said planes to connect with said elements, and means for moving said unit within said space and in said prismatic groove to connect selectively one of said attenuating and non-attenuating elements with said terminal means to provide, depending upon the position of said movable unit, an attenuating or a non-attenuating path from said input connection through said conducting means to said output connection, said non-attenuating element consisting of a conducting cylinder and said attenuating element consisting of an attenuating cylinder, both said elements extending across said unit spaced from each other substantially in a direction perpendicular to the movement of said unit, each of said elements extending outside of said unit at both sides thereof for a distance of about half the length of said connections within the unit, and forming at said outside extension contacts adapted to engage said fixed contacts, the non-attenuating connection having also an extension perpendicular to its longitudinal extension connected to a front portion of said movable unit.

6. In an attenuator having input and output connections of predetermined impedance, at least one pair of attenuating and non-attenuating elements forming at least one single movable unit, conducting means defining two substantially parallel planes presenting said predetermined impedances and interrupted by prismatic grooves, fixed terminal means arranged in the space between said planes to connect with said elements, and means for moving said unit within said space and in said prismatic groove to connect selectively one of said attenuating and non-attenuating elements with said terminal means to provide, depending upon the position of said movable unit, an attenuating or a non-attenuating path from said input connection through said conducting means to said output connections, at least part of said conducting means being provided with a recess to guide the movable unit in its movement with respect to said fixed terminal means, and said unit having a tubular shape of substantially rectangular cross section, the non-attenuating and attenuating elements being arranged in an elongated form extending, respectively, substantially parallel to the axis of said tubular unit and substantially perpendicular to the movement of said tubular unit, said unit having opposite conducting side walls in which said elongated elements are insulatingly supported, projecting therefrom forming contacts cooperating with said fixed terminal means.

7. In an attenuator having input and output connections

8

of predetermined impedance, at least one pair of attenuating and non-attenuating elements forming at least one single movable unit, conducting means defining two substantially parallel planes presenting said predetermined impedances and interrupted by prismatic grooves, fixed terminal means arranged in the space between said planes to connect with said elements, and means for moving said unit within said space and in said prismatic groove to connect selectively one of said attenuating and non-attenuating elements with said terminal means to provide, depending upon the position of said movable unit, an attenuating or a non-attenuating path from said input connection through said conducting means to said output connections, said side walls consisting of insulating material provided with an outer conducting layer except at the portions where said connections are supported on said side walls, said walls at said supporting portions being free from said conducting layer for a predetermined radius depending upon the attenuation desired for the unit.

8. An assembly of units each comprising an attenuator having input and output connections of predetermined impedance, at least one pair of attenuating and non-attenuating elements forming at least one single movable unit, conducting means defining two substantially parallel planes presenting said predetermined impedances and interrupted by prismatic grooves, fixed terminal means arranged in the space between said planes to connect with said elements, and means for moving said unit within said space and in said prismatic groove to connect selectively one of said attenuating and non-attenuating elements with said terminal means to provide, depending upon the position of said movable unit, an attenuating or a non-attenuating path from said input connection through said conducting means to said output connection, said assembly comprising a substantially rectilinear array of said units spaced from each other, the units being movable in a direction substantially perpendicular to the longitudinal extension of said array, terminal means arranged to both sides of each of said units in a plane substantially parallel and in the center of the planes bounding said array of units, conducting means forming said bounding planes, and said moving means consisting of notched cams pressed under control of springs against said movable units at one end thereof; so as to connect selectively any of the non-attenuating and attenuating elements to said terminal means of said array, other spring means being provided at the other end of said movable units to effect a reverse movement of said movable units.

References Cited by the Examiner

UNITED STATES PATENTS

2,429,401	10/47	Davis	333—81
2,597,090	5/52	Freeman	333—81

FOREIGN PATENTS

644,066	10/50	Great Britain.
675,210	7/52	Great Britain.
763,641	12/56	Great Britain.
795,415	5/58	Great Britain.
834,618	5/60	Great Britain.
834,619	5/60	Great Britain.

ELI LIEBERMAN, *Acting Primary Examiner.*

65 ELI J. SAX, HERMAN KARL SAALBACH, *Examiners.*