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SELECTIVE ATTENUATOR COMPRISING A PLURALITY OF
SLIDABLE ATTENUATION UNITS

3,553,608

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2 Sheets-Sheet 1

Fig. 1.

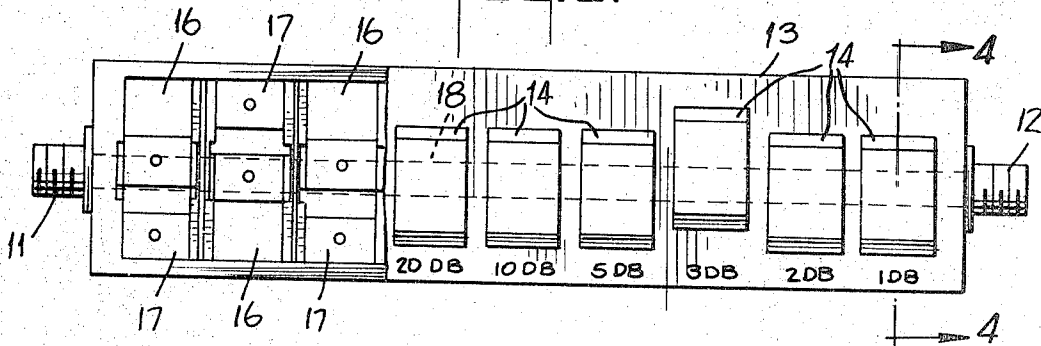
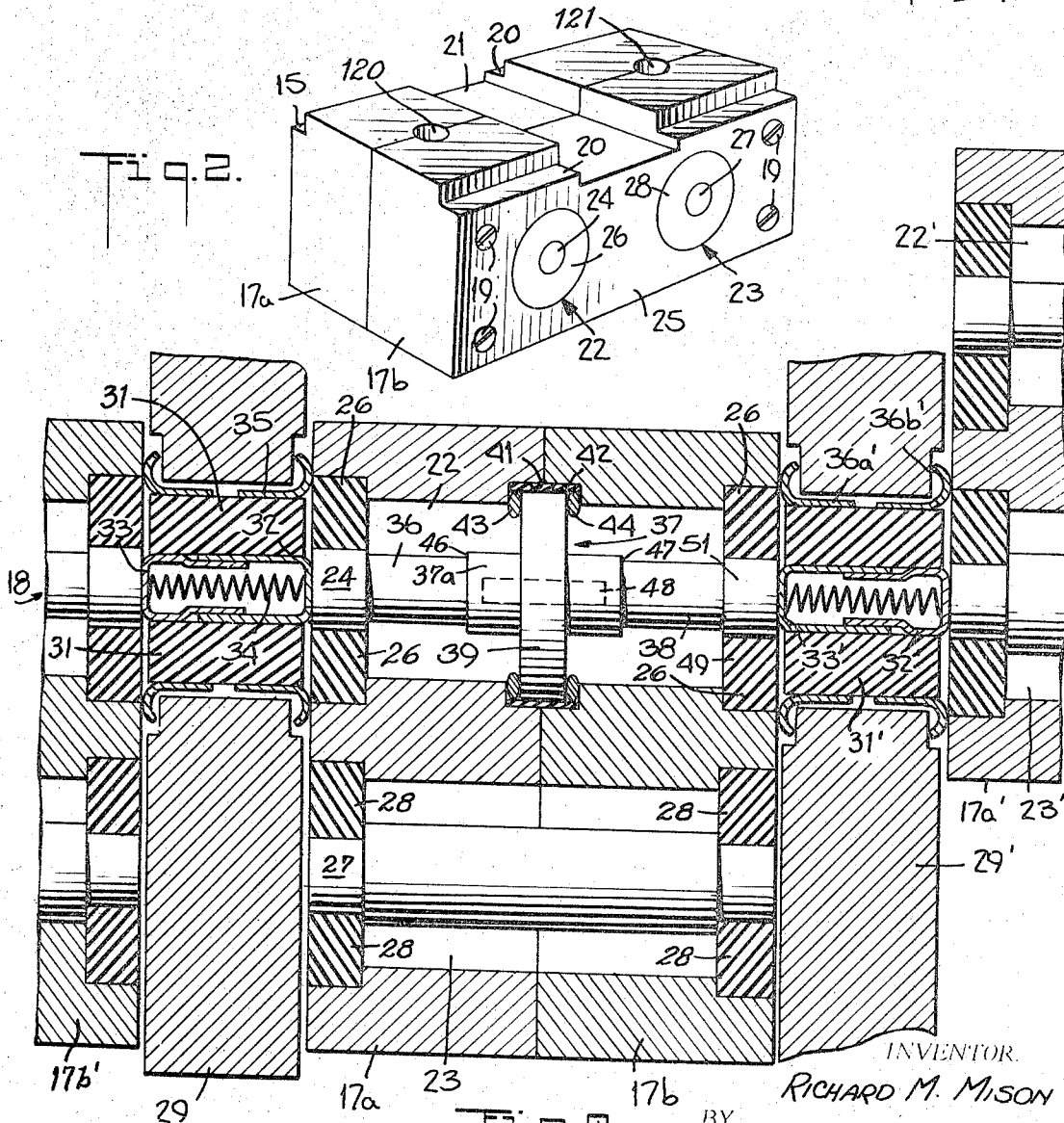


Fig. 2.



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Fig. 3.

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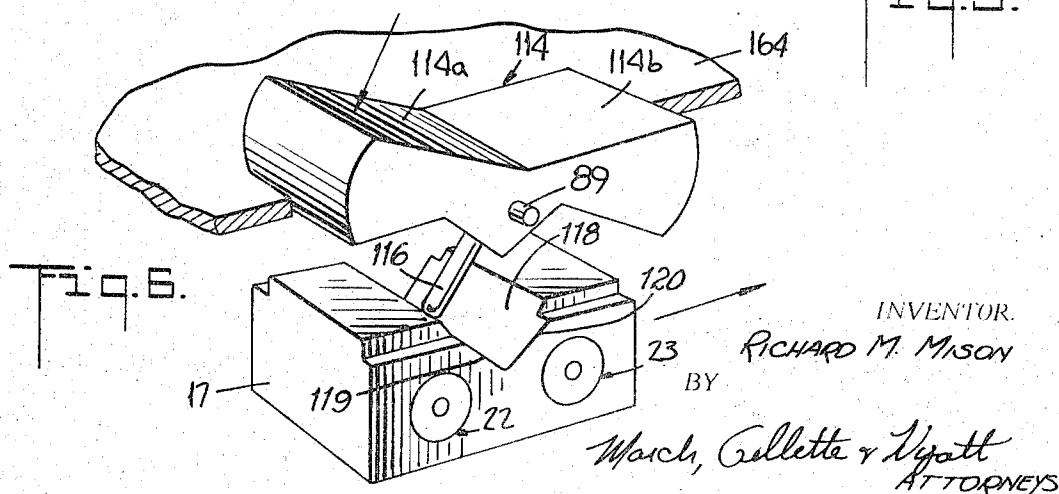
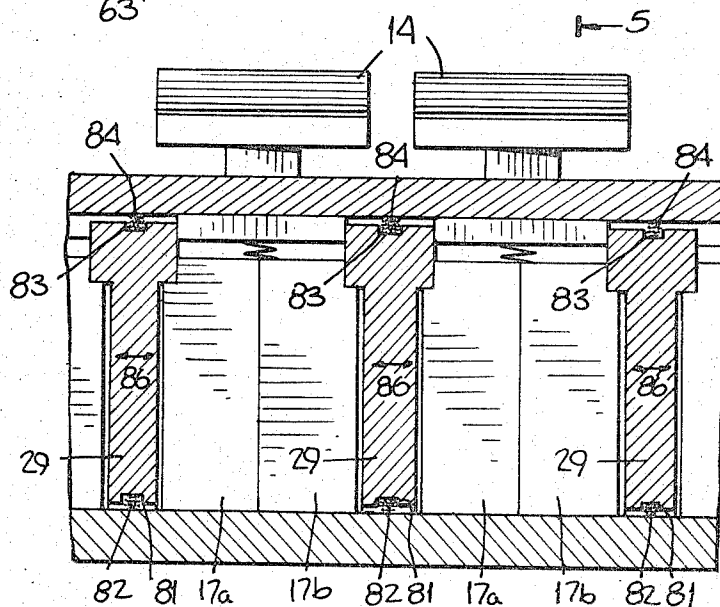
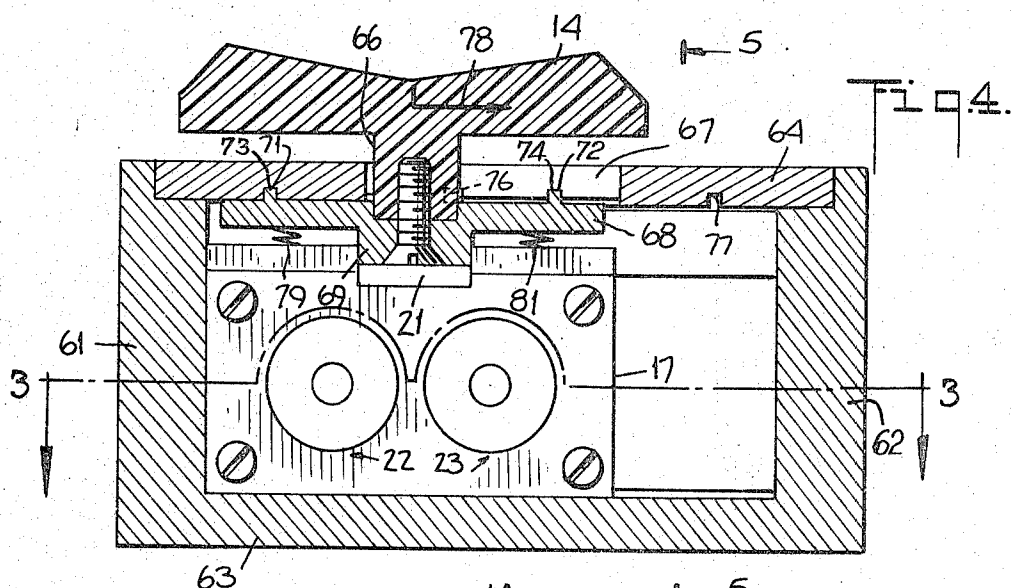
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1 Claim

ABSTRACT OF THE DISCLOSURE

A sliding attenuator including input and output terminals and a sliding member therebetween supporting a high attenuation section and a second section having little or no attenuation. The member can be moved to two positions, one bringing the second section between the input and output terminals and the other bringing the high-attenuation section between these terminals. Several such movable members can be placed side by side and moved separately to form a path having many different attenuation levels between the input and output terminals. Individual movable members can be separated by conductive barriers, each having a short transmission coupling line to allow passage of the signal. The barriers may be free to move slightly to accommodate the movable members.

This invention relates to a sliding attenuator and particularly to a coaxial line attenuator having one or more sliding members each with a pair of coaxial line sections, one section of each pair having a relatively low attenuation and the other a relatively high attenuation, with the members mounted side by side so that either section of any member may be brought into alignment as part of a transmission path between an input and an output terminal.

Attenuators having a relatively wide range of attenuation and a large number of discrete values of attenuation within that range have long been found useful in conjunction with other electrical apparatus, particularly testing apparatus. There are two types of attenuators in common use, each of which has a number of attenuation sections made up of either a single resistor or group of resistors. In the first type of attenuator all of the attenuation sections are connected to a single multiple-position switch which has input and output terminals and one or more movable contacts to connect each attenuation section in turn as part of the attenuation path between the input and output terminals. The other type has a number of separate two-position switches, each connected to one of the attenuation sections. The switches are so interconnected that any one or any group of attenuation sections may be connected as part of the attenuation path between the input and output terminals of the attenuator at any time. For the same number of attenuation sections and for the same overall range of attenuation the latter type of attenuator permits the attenuation to be changed in much smaller increments than the first type but it has heretofore been impossible to produce the latter type of attenuator in a form capable of operating at ultra high frequencies.

In accordance with the present invention, a sliding attenuator is formed of a number of individual attenuation sections arranged in a common support structure between an input terminal and an output terminal. Each section comprises a movable member that supports two short, elemental transmission lines one of which has a relatively low attenuation, preferably as nearly zero as possible, and the other of which has a relatively high

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attenuation, at least in comparison with the low-attenuation line. The transmission lines of each section are the same length, and adjacent sections are separated by conductive barriers, each of which has a short coupling transmission line through it to join the attenuation sections on each side together, except for the end barriers in which the coupling lines may be replaced by connectors that form input and output terminals for the attenuator. In effect, the several attenuation sections form a complete transmission line which is made up of either the high attenuation elemental transmission line or the low attenuation elemental transmission line of all the sections, depending on the position selected for the movable member of each attenuation section, and the short coupling lines through the barriers. The barriers need not be fixed in position but may be allowed to move slightly in the longitudinal direction of the complete transmission line to accommodate the attenuation sections. Assuming the lower attenuation transmission lines to have virtually no attenuation in comparison with the high attenuation transmission line, the total attenuation of signals passing from the input terminal to the output terminal of the attenuator will be equal to the sum of those high attenuation transmission lines in the signal path.

One of the principal objects of the present invention is to provide an attenuator capable of operating over a wide range of signal frequencies and having means to adjust the attenuation level by small increments from a relatively low attenuation value to a relatively high value. Further objects will become apparent from the following specification together with the drawings in which:

FIG. 1 shows a plan view of an attenuator constructed according to the invention with a part of the attenuator case broken away to show some of the interior construction;

FIG. 2 is a perspective view of one attenuation section of the type shown in FIG. 1;

FIG. 3 is an enlarged view of a fragment of the attenuator of FIG. 1 shown in cross section;

FIG. 4 is a cross-sectional view looking along the length of the attenuator of FIG. 1;

FIG. 5 is a cross-sectional view of one of the barriers in FIG. 1; and

FIG. 6 shows a modified form of actuator for the attenuator of FIG. 1.

The attenuator in FIG. 1 comprises an input terminal 11 and an output terminal 12 connected to opposite ends of a conductive enclosure 13. On one side of the enclosure are several thumb plates 14, or actuators, for actuating a group of sliding switches. The upper surface of the enclosure adjacent to each of the thumb plates is labelled with the value of the attenuation controlled by that thumb plate the upper surface being that as seen in FIG. 1. In FIG. 1, the thumb plate 14 corresponding to an attenuation of 3 db is in the operative position while the other thumb plates from 1 db to 20 db are in their inoperative positions.

The upper surface of the enclosure 13 has been broken away at one end to show that inside are separate compartments 16, each of which contains a slidable member 17. These slidable members contain the impedances that produce the attenuation, and it is their position within each of the compartments 16 that is controlled by one of the thumb plates 14. A coaxial transmission line connecting the input and output terminals 11 and 12 is shown in dotted form and identified by the reference character 18 to represent the signal path through the attenuator.

In the embodiment of the invention shown in FIG. 1 each of the nine attenuation sections comprises a mov-

ble member in the form of a sliding metal parallelepiped block which is shown in FIG. 2 to be divided into two sections 17a and 17b. These sections are held together by machine screws 19 at each corner and the block has a central recess 21 and two smaller recesses 15 and 20 on one side. The attenuation section has two short coaxial transmission lines 22 and 23 passing through it in a direction perpendicular to the surface 25 and the rear surface parallel to surface 25 but not visible in this figure. The elemental transmission line 22 has a conductive inner member 4 supported by an insulator 26 from the body of the metal block 17 that forms the outer conductive member for the coaxial transmission line. The other transmission line 23 has an inner conductive member 27 supported by means of an insulator 28 from the conductive block 17. The end faces of both members 24 and 27 as well as the visible (as seen in FIG. 2) surfaces of the insulators 26 and 28 are flat and substantially coplanar with the surface 25, and the same configuration of parts is also found at the rear surface parallel to the surface 25.

FIG. 3 is an enlarged cross-sectional view of one part of the attenuator in FIG. 1. The signal path of the coaxial transmission line 18 comprises a short coupling section through a first barrier 29, the transmission line 22, which is the high attenuation transmission line through the block 17, a second coupling section through a second barrier 29' and the low attenuation transmission line 23' of a second attenuation section.

Considered in greater detail, the coupling line through the barrier 29 comprises an inner conductor in the form of two hollow cup-like members 32 and 33 biased apart by a spring 34 and supported by an insulator 31. A conductive connecting spring 35 surrounds and supports the insulating member 31 and extends outwardly from the barrier 29 just far enough to provide excellent conductive connection across the barrier 29 between the left-hand section 17b' of the adjacent attenuation section and section 17a. The spring 35 thus forms part of the coaxial outer conductor of the short, coupling transmission line.

The attenuation section comprises three resistors 36, 37, and 38 that make up the attenuating impedances for this section. The resistors 36 and 38 are elongated cylindrical devices having a resistance layer of metal or another suitable material on the cylindrical surface thereof of the proper diameter of the inner surface of the cylindrical bore through the two halves 17a and 17b to form a transmission line section of the proper characteristic impedance to match the coupling sections and the input and output terminals of the attenuator. The central resistor 37 is in the form of a disk with resistive material on one or both radial surfaces to act as a shunt effectively in parallel with the transmission line. At the outer perimeter of the resistor 37 there is a conductive band 39 that fits into matching cylindrical recesses 41 and 42 in the facing surfaces of the two halves 17a and 17b of the attenuation section. The outer cylindrical band 39 is electrically securely connected to the two halves 17a and 17b by conductive rings 43 and 44. At the center of the disk-shaped resistor 37 is a conductive cylinder 37a which forms the second terminal of the resistor 37 and is connected to conductive end caps 46 and 47 of the resistors 36 and 38, respectively, by any suitable means such as by soldering or by a central conductive stud 48, as shown. The outer ends of the resistors 36 and 38 are supported by annular insulators 26 and 49, respectively. The left-hand end of the resistor 36 is connected to member 24 which receives the pressure of the cup-like member 32 of the coupling section through the barrier 29. Similarly, the right-hand end of the resistor 38, which is supported by the insulating washer 49, is connected to member 51 (corresponding to member 24) which receive the spring-biased pressure of the cup-like member 33 that forms part of the coupling transmission line through the barrier 29'. As is well

known, the relative diameters of the inner and outer conductors of the components making up the coupling transmission line must be selected to form the proper characteristic impedance, and in fact, the same thing is true of the components making up the high attenuation and low attenuation lines of each attenuation member 17. There are two springs 36a' and 36b' that support the insulator 31' in the barrier 29'. Both of the springs 36a' and 36b' extend slightly outwardly beyond the surface of the barrier and have contact portions in the form of multiple turned-back spring fingers that engage the sides of sections 17b of the continuation block to the left of the barrier and section 17a' of the block to the right of the barrier.

The attenuation member 17a' is in the alternative position in which its low impedance transmission line 23' is operative and its relatively high impedance transmission line 22' is inoperative.

As the respective attenuation members 17 slide back and forth between their two alternate positions they must not be impeded by any projections extending either from the barrier 29' or from the attenuation members themselves, and it is for this reason that the surfaces of the attenuation members are substantially planar with no indentations or projections of either the insulators or the inner conductors of the low attenuation and high attenuation transmission lines. It is necessary for the springs 36 that make contact with the conductive portions of blocks 17 to extend longitudinally outwardly a slight distance to assure good contact, but since there is always pressure against the springs because of the fact that the attenuation members 17 never move out of contact with the springs, the slight outward extension of the spring does not adversely affect operation of the attenuator, and in fact helps it by preventing loose motion of the attenuator sections 17 and 17'. Similarly, the fact that the two parts 32 and 33 of the inner conductor of the coupling transmission line through the barrier 29 and the corresponding members through the barrier 29' are spring-biased outwardly creates no problem because they are never free to move out of the insulators 31 and 31'. They are always held in place by some portion of the attenuation members 17 and 17'. In order to make good contact, the members 32 and 33 and the corresponding members 32' and 33' must have an easy sliding fit in the central bore of the insulators 31 and 31'.

FIG. 4 is a cross-sectional view of the attenuator in FIG. 1 showing one of the attenuation sections 17 in one of its two positions. The attenuator enclosure is a channel-shaped structure with sides 61 and 62 and a flat bottom 63. A flat top 64 is attached to the upper edges of the sides 61 and 62 to complete the enclosure. Above the top 64 is a thumb piece 14 by means of which the sliding block 17 is moved from one to the other of its two positions. The thumb piece 14 has a stem 66 that extends through a slot 67 in the cover 64 and is attached to a detent plate 68 beneath the top. The detent plate has a downwardly extending projection 69 that engages the slot 21 in the upper surface of the block 17 and two upwardly extending detent ridges 71 and 72 that engage corresponding grooves 73 and 74 in the lower face of the cover 64 when the thumb piece 14 and the block 17 are in the position shown. The ridges 71 and 72 engage alternative grooves 76 and 77 when the block 17 is moved to its other position.

Although the projection 69 is always engaged within the slot 21, its height is greater than the height of the detent ridges 71 and 72 so that when the block 17 is to be moved, the thumb piece may be depressed and then moved to the right as indicated by the arrow 78. In order to keep the block 17 from moving freely and to hold the detent ridges in engagement with either the slots 73 and 74 or 76 and 77, two compression springs 79 and 81 nested within the recesses 120 and 121 in the block 17

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press upwardly on the lower surface of the detent plate 68.

Preferably, the two transmission line sections 22 and 23 are equidistant from the center of the block and are also equidistant from the edges of the block 17. In that case, the transmission line along which signals are transmitted through the attenuator will lie on the center line of the box 13 and in the position shown, the center of the transmission line 23 is aligned with the other transmission line components making up the line 18 shown in FIG. 1 while the transmission line 22 is in its inoperative position. The groove 76 is displaced from the groove 71 by the center-to-center distance between the transmission lines 22 and 23 and, of course, the groove 77 is displaced from the groove 74 by the same distance. Thus, when the block 17 is moved to its alternate position, the transmission line 23 is as far to the right of the central plane of the box 13 as the transmission line is to the left of that central plane in the position shown in FIG. 4. Preferably, the length of the block 17 from left to right in the position shown in FIG. 4 is so related to the internal left-to-right dimensions of the container 13 that the left hand end of the block engages the inner surface of the wall 61 when the block is in the position shown, and the right hand end of the block 117 engages the inner surface of the wall 62 when the block is in its alternate position.

FIG. 5 shows a cross-sectional view of one part of the container 13, including the barriers 29. Each barrier 29 has a groove 81 in its lower edge with a length of wire mesh 82 stuffed into it to form a good connection between the bottom of the barrier 29 and the bottom surface 63 of the enclosure and another groove 83 at the top of each barrier 29 with another piece of wire mesh 84 in it. The depth of the groove 81 and the cross-sectional area of the mesh 82 are such that the bottom edges of each barrier 29 can either contact the bottom surface 63 or can almost do so. The groove 83 is not as deep as groove 81 and therefore the mesh 84 normally extends slightly above the top edge of the barrier. The barriers 29 are preferably not rigidly affixed to the enclosure 13 but can be moved slightly in the directions of the arrow 86 to accommodate attenuation members 17 of slightly different size. As a result, the assembly of the attenuator is quite simple, and the entire structure is self-aligning.

While the movements in the attenuator shown in FIG. 4 are rectilinear, a pivotal movement may be provided as an alternative. An actuator 114 is shown in FIG. 6 arranged to pivot about an axle 89 journaled on a modified form to cover 164 and engaging the block 17 to move it back and forth between its alternate positions. As in the embodiment in FIG. 4, it is essential that the block 17 move far enough to bring either the high-attenuation transmission line 22 or the low-attenuation transmission line into the operative position, depending on which end 114a or 114b of the actuator 114 is depressed.

An appendage, or tongue, 116 extends downwardly from the actuator 114 and is positioned within the V-shaped slot 118 in the block 117. When the actuator 114 is turned to pivot about the axis 89 a clockwise rotation of the actuator (looking at FIG. 6) moves the tongue against the edge 119 of the slot 118 and forces the block

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to the left and in the direction opposite that shown by the arrow on the drawing. A counter-clockwise rotation of the actuator 114 causes the dependent tongue 116 to bear against the opposite side 120 of the V-shaped notch 118 and moves the block 17 in the direction of the arrow.

What is claimed is:

1. An attenuator comprising: a block member having a coaxial transmission line input terminal at one end and, a transmission line output terminal on the other end, a plurality of attenuation units each comprising a relatively low attenuation transmission line element and a relatively high attenuation line element, all of said high attenuation line elements being of different value, said transmission line terminals and said high and low attenuation line elements being coaxial transmission lines of substantially known characteristic impedance, means supporting each of said units to move selectively either said low attenuation element or said high attenuation element into alignment with said terminals, said supporting means comprising for each unit a rigid conductive parallelepiped block having parallel channels therethrough perpendicular to two surfaces of said block and a coaxial line extending through one of said channels to form said low attenuation transmission line, resistive means extending through the other of said channels and coaxial therewith to form said relatively high attenuation transmission line said units selectively forming the lines between the input and output terminals and having an impedance which is dependent upon the block positions as shifted, a hollow, conductive enclosure with said input and output terminals at opposite ends thereof and centered on the central plane perpendicular to said opposite ends, a plurality of conductive barriers perpendicular to the path between the input and output terminals, each of said barriers having a coaxial transmission line coupling therethrough centered on the path on the transmission line elements, an annular insulating member and a pair of telescoping cylinders supported in said annular member and concentric therewith, each of said cylinders having a closed end facing outwardly and a compression spring within said telescoping cylinders to push said cylinders apart enough to make contact with said transmission line elements on each side of said barrier, and a resilient contact ring surrounding and supporting said insulating member and having contact fingers to engage an outer conductor of the transmission line elements on one side of barrier.

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U.S. Cl. X.R.

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