

[54] **PLUG-IN ADJUSTABLE ATTENUATOR
CONSTRUCTION**

3,638,162 1/1972 McWade..... 323/80 X

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[58] Field of Search..... 323/74, 79, 80, 94 R;
333/81 R, 81 A; 338/48, 76, 220, 221, 320

[56] **References Cited**

UNITED STATES PATENTS

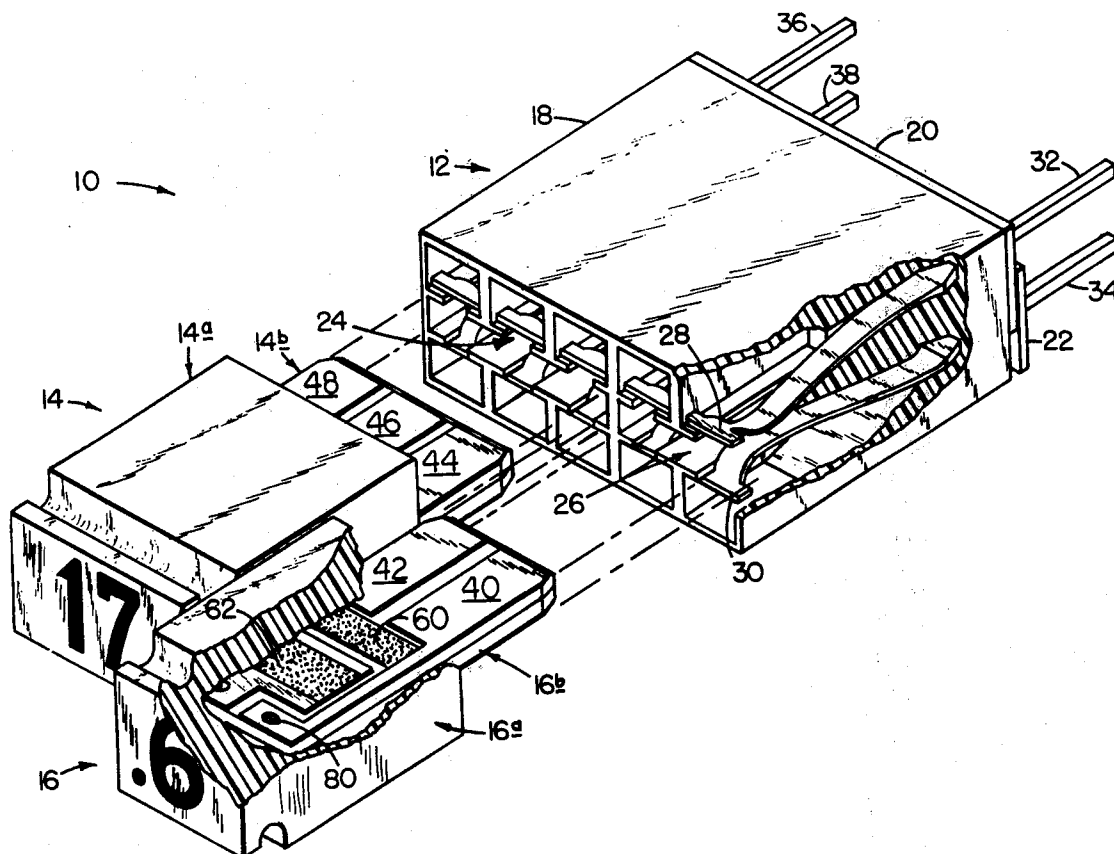
2,680,225	6/1954	Stevens, Jr.	323/74
2,892,147	6/1959	Bell	323/79
3,369,173	2/1968	Andrews	333/81 R X
3,553,608	1/1971	Mison	333/81 A

[57]

ABSTRACT

A plug-in adjustable attenuator including a receptacle base adapted to receive different selected pairs of mating plug-in units, one for setting integral values of attenuation, and the other for setting fractional values. Electrically, the attenuator comprises a pair of series-connected balanced resistance networks, one establishing integral attenuation values, and the other, proper fractional values in a line to which the attenuator is connected. In addition to other advantages, employing separate networks for integral and fractional values of attenuation greatly reduces the number of plug-in parts needed to cover a desired attenuation range in small increments.

18 Claims, 4 Drawing Figures



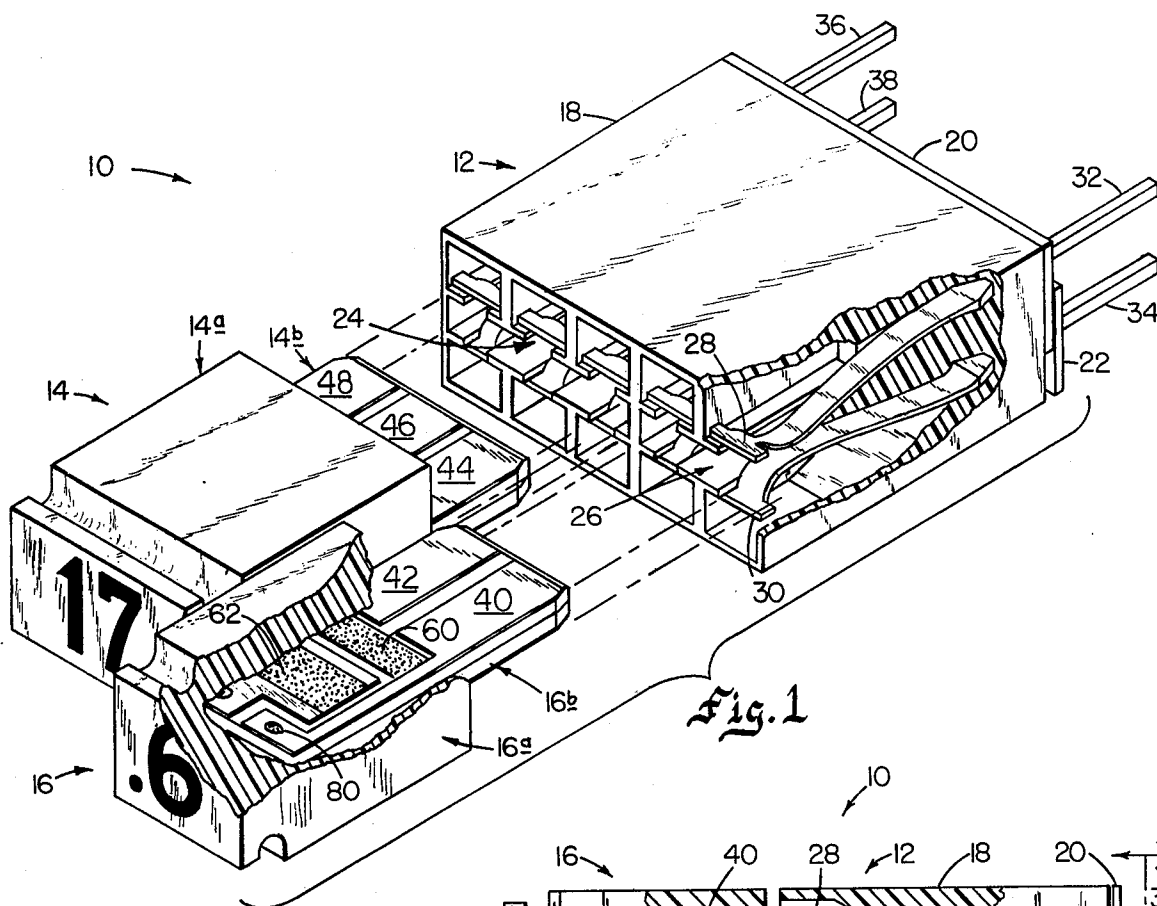


Fig. 1

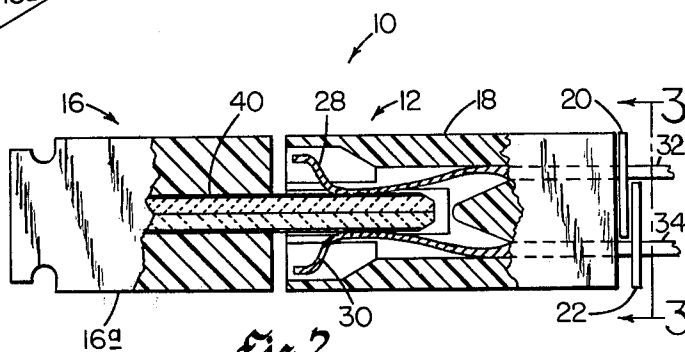


Fig. 2

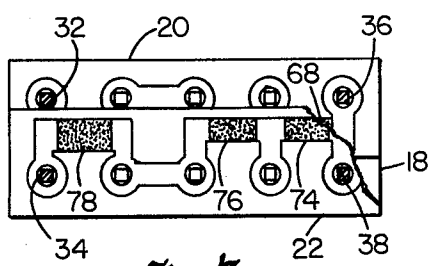


Fig. 3

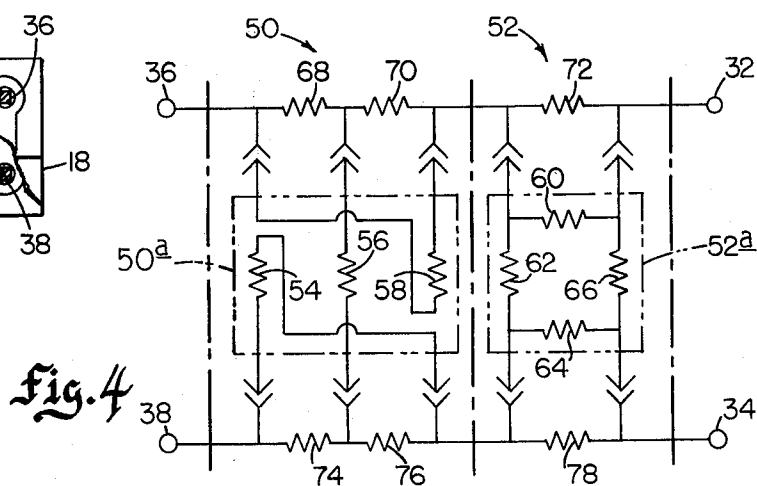


Fig. 4

PLUG-IN ADJUSTABLE ATTENUATOR CONSTRUCTION

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to electrical signal attenuators, and more particularly to a plug-in adjustable attenuator for low frequency, line-carried electrical signals.

In general terms, an attenuator is a resistive four-terminal network designed to provide a known amount of signal attenuation between its input and output terminals, while maintaining a given impedance level at either or both of those terminals. While such devices have many applications in electrical circuits, for purposes of illustration herein the invention will be described in the form of an attenuator adapted for adjusting signal amplitude levels in two-wire, balanced voice frequency telephone circuits having a nominal 600 ohm impedance.

Telephone systems make widespread use of adjustable attenuators, commonly called "pads," for setting signal amplitude levels in voice frequency circuits, i.e., those carrying signals having a frequency of about 300 to 3000 Hz. To provide sufficient level adjustment capability to meet all equipment and system design requirements, it is desirable that a pad intended for such service be able to cover a zero to 40 dB attenuation range in steps of 0.25 dB or less. It is further desirable that such an attenuator have an input and output impedance of 600 ohms over the entire range.

Signal level adjustments are frequently made while a circuit is in use. To prevent service interruptions, it is most important that there be no loss of circuit continuity during these adjustments. It is also desirable that, during changing of a pad's attenuation ratio, transient changes in pad impedance and attenuation are minimized.

Still further, it is desirable that a level setting pad have a small physical size to minimize mounting space requirements, and to allow, for example, direct mounting on standard cross-connect frames. And because telephone systems use large numbers of such pads, there is a need for a design having these features which can be manufactured in quantity at relatively low cost.

Accordingly, a primary object of the present invention is to provide an adjustable attenuator which satisfies these criteria in a practical and satisfactory manner. These and other related objects of the invention are realized in a novel plug-in adjustable attenuator which, according to the invention, includes a receptacle base adapted to receive different selected pairs of mating plug-in units, one for setting integral values of attenuation, and the other for setting proper fractional values. Electrically, the attenuator comprises a pair of series-connected balanced resistance networks, one establishing integral attenuation values, and the other, fractional values in a line to which the attenuator is connected.

Resistance elements forming portions of each network are permanently mounted in the receptacle base. Other, additional elements forming the remainder of each network, and which cooperate with the permanently mounted elements to produce a desired, predetermined attenuation value, are contained in different ones of the pair of plug-in units. Thus, changes in either the integral or the fractional value of attenuation can

be made independently by simply interchanging the appropriate plug-in unit with one which cooperates to provide a different value of attention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the novel plug-in adjustable attenuator of the invention will become more apparent as the detailed description which follows is read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view, partially cut away to illustrate details of construction, of a complete plug-in attenuator assembly, showing a pair of plug-in units fully withdrawn from a receptacle base;

FIG. 2 is a view of the right side of the FIG. 1 attenuator, showing plug-in units inserted in the base;

FIG. 3 is a view taken on line 3—3 of FIG. 2, showing permanently mounted resistance network elements on the rear of the base; and

FIG. 4 is a schematic diagram of the plug-in adjustable attenuator of the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Turning now to the drawings, and referring first to FIG. 1, indicated generally at 10 is plug-in adjustable attenuator assembly, or pad, constructed in accordance with the present invention. In general terms, pad 10 can be viewed as including three basic components—a receptacle base 12, and pair of plug-in parts—an integral value, or "unit," plug 14, and a fractional value, or "decimal," plug 16. Electrically, pad 10 comprises a pair of series-connected resistance networks, one for establishing unit values of attenuation, and the other for establishing decimal values in a signal-carrying line (not shown) to which the pad is connected. Each network may be thought of as including two portions, a fixed circuit portion in base 12, and a changeable circuit portion in the appropriate plug-in part. When plugs 14, 16 are inserted in base 12, as shown in FIG. 2, the respective portions of each circuit are coupled together electrically and cooperate to provide a certain value of attenuation. For example, in FIG. 1 plug 14 has the number 17 on its front face, indicating that it is constructed, when inserted into base 12, to provide 17 dB of attenuation. Similarly, plug 16 has the number 0.6 on its front face, indicating that it introduces 0.6 dB of attenuation when plugged into base 12. Although only a single pair of plugs, including one unit plug and one decimal plug, is shown in the drawings, it will be evident that other plugs, constructed to provide different values of attenuation, may be used in combination with base 12. Thus, the value of attenuation provided by pad 10 is adjusted simply by removing either or both of the plugs from base 12 and inserting other plugs which cooperate to provide the desired value of attenuation. In the preferred practice of the invention, a set of unit plugs having indicated attenuation ratios of 0, 1, 2, . . . 40 dB, and a set of decimal plugs having indicated values of .0, .1, .2, ...9 dB are provided. Thus, by choosing appropriate unit and decimal plugs, the attenuation ratio may be adjusted in 0.1 dB increments between 0.0 and 40.9 dB.

Considering now the construction of the various components comprising pad 10, and referring to FIGS. 1-3, base 12 includes a connector portion 18 mounting, on the back side of this portion as shown in FIG. 1, a pair of circuit boards 20, 22. Portion 18 is generally

similar in construction to a conventional double-sided circuit board edge connector, and thus need not be described in great detail. However, considering some of the features of the connector portion which play a particular role in the exemplified attenuator, portion 18 is seen in FIG. 1 to include two irregularly shaped cavities, each extending centrally inward from the portion's front face. The left cavity, the larger of the two, includes an elongate, horizontally disposed socket, or slot, 24, which is sized and adapted to receive a unit plug, such as plug 14. The right cavity includes a similar but narrower socket, or slot, 26, sized and adapted to receive a decimal plug, such as plug 16. Disposed above and below sockets 24, 26 are a plurality of laterally spaced-apart chambers arranged in vertically opposing pairs. As should be evident in FIG. 1, the cavity containing unit socket 24 includes six such chambers, and the cavity containing decimal socket 26 includes four. Aside from their orientation in connector portion 18, all of the chambers are essentially identical in configuration.

Suitably mounted within each of the chambers in portion 18 is an elongate, bowed electrical contact formed of a suitable spring material. As shown in FIGS. 1 and 2, the upper and lower contacts in a vertically opposing pair are bowed toward each other. Except for mounting orientation, however, all of the contacts in base 12 have the same configuration—that shown for upper and lower contacts 28, 30, respectively, in the figures.

Now considering FIG. 3 along with FIGS. 1 and 2, projecting out from the rear face of connector portion 18 is a plurality of elongate square pins, each one connected inside the body of portion 18 to a corresponding electrical contact. Thus, for example, the two projecting pins shown at 32, 34 connect with contacts 28, 30 respectively. Different ones of the pins have different lengths. As can be seen in FIG. 1, pins 32, 34, and the two pins located on the opposite side of base 12, pins 36, 38, project substantially beyond the rear faces of boards 20, 22. This is because these four pins form pairs of input and output terminals for the attenuator, and therefore need to be long enough to permit connection to a signal-carrying line. The other pins (un-numbered) project a lesser amount, only sufficiently far to make appropriate connection with circuit components on boards 20, 22. Thus, referring specifically to FIG. 3, the central three pins in the upper row of pins in that figure are shorter than the three pins underlying them because, as is evident from a comparison of FIGS. 1, 2, and 3, board 20 is disposed essentially directly against the rear face of portion 18, whereas plate 22 is separated from the body of portion 18 by about the thickness of board 20.

Referring again to FIGS. 1 and 2, the two plug-in parts have similar construction features, each including a main body from which projects an elongate tongue sized to mate with a corresponding socket in receptacle base 12. Thus, decimal plug 16 includes a body 16a and an elongate tongue 16b sized to fit decimal socket 26. Tongue 16b is provided with four conductive expanses, or strips, which connect with resistance network components within the body of the plug. With reference to FIG. 1, two of these conductive strips are indicated at 40, 42 on the top side of tongue 16b in the figure. The other two strips are similarly disposed on the bottom side of the tongue, and hence are concealed in FIG. 1.

It will be evident that with insertion of plug 16 into socket 26, the conductive strips on tongue 16b make electrical connection with the four contacts mounted above and below the socket, as indicated in FIG. 2.

Again with reference to FIG. 1, the construction of unit plug 14 is similar to that of decimal plug 16—including a body 14a and a projecting tongue 14b sized to fit socket 24. However, the unit plug has a somewhat greater width and is provided with six conductive strips on its tongue 14b, each connecting with components in plug body 14a. Three of the conductive strips, strips 44, 46, 48, are disposed on the top side of tongue 14b in the figure, with the remaining three similarly disposed on the bottom side. Again, it will be evident that the conductive strips on tongue 14b electrically connect with the six contacts mounted adjacent socket 24 upon insertion of the plug into the socket. The difference in the widths of the unit and decimal plugs, which widths correspond generally to those of sockets 24, 26, respectively, substantially reduces the likelihood of a plug being inserted into the wrong socket.

The plug bodies serve as handles for the plugs. Thus, the front end portions of plug bodies 14a, 16a are configured as shown in FIGS. 1 and 2 to provide gripping surfaces for easy removal of the plugs from base 12. In addition, as previously mentioned, the front faces of the plugs are provided, by printing, stamping, or the like, with an indication of the attenuation provided by the plug upon its insertion into the receptacle base.

Turning now to FIG. 4, the electrical circuitry contained within unit plug 14 and decimal plug 16, and included on circuit boards 20, 22 in base 12, comprises a pair of series-connected balanced resistance networks, one for unit values of attenuation, indicated at 50, and another for decimal values, indicated at 52. Networks 50, 52 each include a fixed circuit portion which is permanently mounted in the receptacle base on boards 20, 22, and a changeable circuit portion contained within one of the plug-in parts. Thus, plug 14 contains changeable portion 50a of the units network and plug 16 the changeable portion 52a of the decimal network. The changeable portions are indicated in FIG. 4 by enclosure within a box formed of dash-double dot lines. It should be noted at the outset that the circuitry of the changeable portions, indicated as including a plurality of resistance elements, is valid in general terms for any of the different unit or decimal plugs, regardless of their indicated attenuation value, even though, in some instances, a particular resistance element may be essentially a short circuit or an open circuit.

Changeable network portion 50a, contained within unit plug 14, includes three resistance elements, indicated at 54, 56, 58. The resistance values of these elements is, of course, dictated by the attenuation value desired. However, as will become apparent from a reading of the table of resistance values given later, elements 54, 58 will always have the same resistance value in a given unit plug. It will be seen in the figure how the opposite ends of each element are connected to the conductive strips on tongue 14b, these strips being represented in FIG. 4 as outwardly pointed arrows. Specifically, the central resistance element 56 has its opposite ends connected to the central strips on opposite sides of the tongue. Each of the other elements has its ends connected to the outer conductive strips on a single side of the tongue. Thus, for example, the ends of resis-

tance element 58 in network portion 50a are connected to conductive strips 44, 48 on the top side of tongue 14b in FIG. 1.

Changeable network portion 52a, contained within decimal plug 16, includes four resistance elements, shown at 60, 62, 64, 66. These four elements are connected to form a closed square loop, with the junctions between consecutive pairs of elements in the loop connected to appropriate ones of the four conductive strips provided on the tongue of decimal plug 16. Thus, for example, the junction between resistance elements 60, 62 is connected to conductive strip 42 on tongue 16b and the junction between elements 60, 66 is connected to strip 40. Further, as will become apparent, within a given decimal plug, resistance elements 60, 64 will always be of the same value, as will resistance elements 62, 66.

In terms of their electrical configuration, circuit boards 20, 22 are essentially identical. Each of them includes three resistance elements—a series-connected pair comprising one-half of the fixed portion of units network 50, and a single element comprising one-half of the decimal network's fixed portion. Thus, included on board 20 are the three resistance elements shown at 68, 70, 72. Elements 68, 70 have the same resistance value and are connected through appropriate square pins in the previously mentioned upper row of pins (FIG. 3) to the three upper contacts in socket 24 (FIG. 1). Resistance element 72 also connects through pins in the upper row to the upper two contacts in decimal socket 26.

Provided on board 22 are the three resistance elements shown at 74, 76, 78 in FIGS. 3 and 4. In a manner similar to that just described, elements 74, 76 connect with the three lower contacts in units socket 24, and elements 78 connects with the lower contacts in decimal socket 26. It may be noted that resistance elements 74, 76 are of the same value as previously mentioned elements 68, 70, and resistance element 78 has the same value as element 72. In addition to being essentially identical electrically, circuit boards 20, 22 are similar in physical configuration, one being the mirror image of the other, but otherwise differing only in their mounting orientation on connector portion 18. Thus, further describing circuit board 22, it being understood that the description equally applies to circuit board 20, and referring to FIG. 3, board 22 comprises a thin, insulating substrate having a plurality of apertures formed therein, suitably sized and spaced-apart for accommodating mounting of the circuit board on a row of the square pins which project out from the rear of connector portion 18, e.g., the lower row in FIG. 3. Disposed on one side of the substrate in registry with the apertures therein is a pattern of conductive and resistive expanses. As will be understood from the earlier description, the pattern includes one-half each of the fixed portion of networks 50, 52 (FIG. 4).

In the preferred practice of the invention, the substrates of boards 20, 22 are a suitable ceramic material, and the resistance elements are formed by the deposition of thick metal films. Suitable methods for forming patterns of conductive and resistive expanses on such substrate are well known. Circuit boards 20, 22 are secured to the square pins of connector portion 18, oriented as shown in FIGS. 1-3, in a suitable manner, as by solder deposits (not shown) joining each square pin

with the adjacent, encircling conductive expanse on a circuit board.

Referring again to FIGS. 1 and 2, portions of plug 16 are broken away in the figures to illustrate its construction. Tongue 16b comprises a pair of circuit cards bonded back-to-back, each of the cards having a pattern of conductive and resistive expanses thereon, including resistive elements, such as elements 60, 62, and conductive strips, such as strips 40, 42. The cards suitably have ceramic substrates, and the patterns thereon are formed in the same manner as those on circuit boards 20, 22. Interconnections are provided as required between conductive expanses on opposite sides of the tongue, such as the interconnection indicated at 80. Body 16a comprises a suitable insulating material, such as an electrical grade plastic material. The construction of unit plug 14 is substantially similar to that of plug 16. It will be understood, however, that the patterns of conductive and resistive expanses on tongue 14b will be different from those on tongue 16b. Moreover, the patterns for different values of either plug may vary, it being necessary only that the different plugs of a given type have the same arrangement of conductive expanses on the portion of the tongue projecting out of the plug's body.

Again referring to FIG. 4, unit network 50, which may be described as a bridged, balanced-H network, is connected in series with decimal network 52, a bridged, balanced-square network, between pairs of input/output terminals 36, 38, and 32, 34. As will be understood, networks 50, 52 are symmetrical, so either pair of terminals may be considered the input terminals, whereupon the other pair forms the output terminals for the pad. Also, since the changeable portions of each network are symmetrical, insertion of a given plug into the appropriate socket in base 12 produces a certain attenuation ratio even if inserted in a reversed, i.e., inverted, position.

As mentioned earlier, pad 10 is designed for adjusting signal amplitude levels in balanced voice frequency circuits having a nominal 600 ohm impedance. For such service, the resistance elements in the fixed portion of unit network 50, i.e., elements 68, 70, 74, 76 each have a value of 300 ohms. The resistance elements in the fixed portion of decimal network 52, elements 72, 78, have a value of 31.14 ohms. As will be evident the values for the resistance elements in the changeable portions of each network are selected to provide a desired ratio of attenuation in a signal-carrying line connected to the pad. Values for the resistance elements in the changeable portion of the unit network, which elements are contained in a unit plug 14, are given in Table A below for integral ratios between 0-40 dB, inclusive, and for essentially infinite (INF.) signal attenuation. Values for the resistance elements in changeable portion 52a of the decimal network, which elements are contained in a decimal plug 16, are given in Table B below for decimal values in the range 0-0.9, inclusive.

TABLE A

Loss dB	Units Plug Resistance Values - Ohms					
	Elements 54,58		56	Loss dB		Elements 54,58 56
0	0.000	INF.	21	3066		58.71
1	36.61	4917	22	3476		51.77
2	77.68	2317	23	3937		45.71

TABLE A-Continued

Loss dB	Units Plug Resistance Values - Ohms Elements		Loss dB	Elements	
	54.58	56		54.58	56
3	123.8	1454	24	4454	40.41
4	175.5	1026	25	5034	35.75
5	233.5	770.9	26	5685	31.66
6	298.6	602.9	27	6416	28.05
7	371.6	484.4	28	7235	24.88
8	453.6	396.9	29	8155	22.07
9	545.5	330.0	30	9186	19.59
10	648.7	277.5	31	10344	17.40
11	764.4	235.5	32	11643	15.46
12	894.3	201.3	33	13100	13.74
13	1040	173.1	34	14735	12.22
14	1203	149.6	35	16570	10.86
15	1387	129.8	36	18628	9.663
16	1592	113.0	37	20938	8.597
17	1823	98.69	38	23529	7.650
18	2082	86.41	39	26437	6.809
19	2373	75.83	40	29700	6.061
20	2699	66.67	INF.	INF.	0.000

TABLE B

Loss dB	Decimal Plug Resistance Values - Ohms Elements	
	62.66	60.64
0	INF.	0
.1	104200	3.885
.2	52120	8.877
.3	34750	15.53
.4	26060	24.85
.5	20850	38.82
.6	17380	62.10
.7	14900	108.60
.8	13040	248.30
.9	11590	INF.

The above-described plug-in adjustable attenuator provides a number of advantages. As briefly mentioned above, circuit continuity is maintained through the attenuator even when plug-in parts are not inserted in the base, preventing a loss of continuity during attenuation ratio changes. The provision of separate resistance networks for unit and decimal values of attenuation greatly reduces the number of plug-in parts required to cover a desired attenuation range in small increments. For example, the attenuator described herein is capable of covering a 0.0 to 40.0 dB attenuation range in 0.1 dB increments using a total of 51 plug-in parts—41 unit plugs and 10 decimal plugs. By contrast, a plus-in attenuator using a single plug-in part would require 401 different plugs to cover the same range in 0.1 dB increments or 161 plugs to cover the range in 0.25 dB steps.

A further advantage of the disclosed plug-in adjustable attenuator is that its design does not require the use of precision resistors in the attenuation networks to meet telephone system accuracy specifications. For example, if all of the resistance elements in the two networks are kept within $\pm 2\%$ of the values given in Tables A and B, the worst case deviation from the specified value of attenuation will range from about 0.26 dB at "40.0" dB to about 0.03 dB at "1.1" dB, well within major telephone system specifications. Typical deviation would, of course, be much less.

Another advantage is that, in an assembled condition, the disclosed attenuator provides a substantially constant 600 ohm input and output impedance over its specified attenuation range. In addition, the pad can be used satisfactorily in circuits carrying signals ranging in frequency from zero to 30 kHz.

The attenuator of the invention has a small physical size to minimize mounting space requirements. For example, by basing the construction of the attenuator on the use of a standard 0.125 inch double-sided circuit board edge connector for connector portion 18 (FIG. 1), the height and width of base 12 as shown in the figure need not exceed 0.25 inch and 0.625 inch, respectively. The body widths of plugs 14 and 16 would then be about 0.375 and 0.250 inches, respectively. Such miniaturized construction permits mounting of a large number of pads in a small space. For example, 50 such pads can be mounted in a 10 wide by 5 high matrix on a Western Electric No. 211AF type terminal strip.

Although a preferred embodiment of the invention has been described herein, it is understood that variations and modifications are possible without departing from the spirit of the invention. For example, different network designs may be employed—a bridged lattice network in place of bridged square network 52, for instance. Other design modifications will be apparent to those skilled in the pertinent arts.

It is claimed and desired to secure by Letters Patent:

1. An adjustable attenuator for a balanced, two conductor, low frequency telecommunication line, comprising

a fixed pad component having input and output means for connecting the component in series with such a line,

circuit means in said fixed pad component comprising plural, series-connected attenuation network portions interconnecting said input and output means, each of said portions including a different set of selected impedance elements, and

plural pad adjusting components removably connected to said fixed pad component, each of said pad adjusting components including impedance means combining with a different one of said network portions to provide a plurality of balanced attenuation networks connected in series between said input and output means, which networks cooperate to provide substantially equal attenuator input and output impedances.

2. The attenuator of claim 1, wherein

said input and output means comprises a pair of input terminals and a pair of output terminals, and

said circuit means comprises a series-connected pair of network portions interconnecting said pairs of terminals, said set of selected impedance elements in one of said network portions including first and second resistance elements, said set of selected impedance elements in the other of said network portions including first and second series-connected pairs of resistance elements, said first element and said first pair being connected in series between one of said input terminals and one of said output terminals, and second element and second pair being connected in series between the other of said input terminals and the other of said output terminals.

3. The attenuator of claim 2, comprising a pair of pad adjusting components connected to said fixed pad component, one of said pair comprising first resistance means (52a) combining with said first (72) and second (78) resistance elements to provide a bridged, balanced-square resistance network (52), and the other of said pair comprising second resistance means (50a) combining with said first (68, 70) and second (74, 76)

series-connected pairs of resistance elements to provide a bridged, balanced-H resistance network (50).

4. The attenuator of claim 3, wherein

said first and second resistance elements (72 and 78) have the same resistance value, and each resistance element in said first and second pair (68, 70 and 74, 76) has the same resistance value,

said first resistance means (52a) includes third (62) and fourth (66) resistance elements having the same resistance value and combining with said first and second elements to form with them a series-connected closed loop, and fifth (60) and sixth (64) resistance elements having the same resistance value and respectively combining in shunt relation with said first and second resistance elements to thereby bridge said elements, and

said second resistance means (50a) includes a seventh (56) resistance element combining with said first and second series-connected pairs to interconnect the junction between the elements of said first series-connected pair (68, 70) and the junction between the elements of said second series-connected pair (74, 76), and eighth (58) and ninth (54) resistance elements having the same resistance value and respectively combining in shunt relation with said first and second series-connected pairs of elements to bridge said pairs.

5. The attenuator of claim 4, wherein said attenuator is for a line having a nominal 600 ohm impedance, and, accordingly, said first and second resistance elements (72, 78) have a value of about 31.14 ohms, each resistance element in said first and second series-connected pairs (68, 70, 74, 76) has a value of about 300 ohms, and said third and fourth (62, 66), fifth and sixth (60, 64), seventh (56), and eighth and ninth (58, 54) resistance elements have the following values for different attenuations in said networks (52, 50) as follows:

Atten. dB	Network 52 Resistance Values - Ohms Elements	
	62,66	60,64
0	INF.	0
.1	104200	3.885
.2	52120	8.877
.3	34750	15.53
.4	26060	24.85
.5	20850	38.82
.6	17380	62.10
.7	14900	108.60
.8	13040	248.30
.9	11590	INF.

Atten. dB	Network 50 Resistance Values - Ohms Elements		Atten. dB	Elements	
	54,58	56		54,58	56
0	0.000	INF.	21	3066	85.71
1	36.61	4917	22	3476	51.77
2	77.68	2317	23	3937	45.71
3	123.8	1454	24	4454	40.41
4	175.5	1026	25	5034	35.75
5	233.5	770.9	26	5685	31.66
6	298.6	602.9	27	6416	28.05
7	371.6	484.4	28	7235	24.88
8	453.6	396.9	29	8155	22.07
9	545.5	330.0	30	9186	19.59
10	648.7	277.5	31	10344	17.40
11	764.4	235.5	32	11643	15.46
12	894.3	201.3	33	13100	13.74
13	1040	173.1	34	14735	12.22
14	1203	149.6	35	16570	10.86
15	1387	129.8	36	18628	9.663

-Continued

Atten. dB	Network 50 Resistance Values - Ohms Elements		Atten. dB	Elements	
	54,58	56		54,58	56
16	1592	113.0	37	20938	8.597
17	1823	98.69	38	23529	7.650
18	2082	86.41	39	26437	6.809
19	2373	75.83	40	29700	6.061
20	2699	66.67	INF.	INF.	0.000.

6. An incrementally adjustable attenuator for a balanced, two conductor, low frequency telecommunication line, comprising

a first pad component comprising a receptacle base having a pair of sockets therein, and additionally having input and output terminals for connecting said component in series with such a line,

circuit means in said first pad component comprising a pair of attenuation network portions interconnecting said input and output terminals, each of said pair including a set of selected impedance elements,

a second pad component comprising a first plug removably received in one of said sockets, and impedance means in said plug for combining with the impedance elements in one of said pair of network portions to provide a first attenuation network, and a third pad component comprising a second plug removably received in the other of said sockets, and impedance means in said second plug for combining with the impedance elements in the other of said pair of network portions to provide a second attenuation network.

7. The attenuator of claim 6, wherein said first and second plugs each include a projecting tongue configured for removable insertion in the appropriate one of said one and other sockets, the tongues of said plugs having conductive expanses thereon connected to impedance elements in said plugs, which elements comprise said impedance means, and said base includes electrical contact means in said sockets connected to said selected impedance elements in the base for contacting said conductive expanses and establishing electrical connections between certain ones of said selected impedance elements and certain ones of said impedance elements in the plugs to provide said attenuation networks.

8. The attenuator of claim 7, wherein said one and other sockets are sized differently, one from the other, and the tongues of the plugs received in said sockets have sizes corresponding to the sizes of the respective sockets.

9. The attenuator of claim 7, wherein said receptacle base further includes circuit board means bearing said selected impedance elements, and means establishing electrical connections between the impedance elements on the said board means and said contact means and input and output terminals.

10. The attenuator of claim 7, wherein said selected impedance elements in said base and said impedance elements in said plugs comprise electrical resistance elements, and said first and second attenuation networks are bridged, balanced-H and bridged, balanced-square resistance networks, respectively.

11. The attenuator of claim 10, wherein said first and second networks are connected in series between said input and output terminals, and the impedance elements providing said first and second networks are of

suitable impedance values for producing an integral value and a proper fractional value, respectively, of attenuation in a line connected to said input and output terminals.

12. An incrementally adjustable attenuation system 5
for use in combination with a balanced, two conductor,
low frequency telecommunication line, comprising
a receptacle base having a pair of sockets therein, a
pair of input terminals, a pair of output terminals,
and electrical circuit means comprising a series- 10
connected pair of attenuation network portions inter-
connecting said input and output terminals,
each of said portions being associated with a differ-
ent one of said sockets,
a first plug-in part configured for removable insertion 15
in one of said pair of sockets, and including circuit
means for combining with the network portion as-
sociated with said one socket when inserted to pro-
vide a first attenuation network, and
a second plug-in part configured for removable inser- 20
tion in the other of said pair of sockets, and includ-
ing circuit means for combining with the network
portion associated with said other socket when in-
serted to provide a second attenuation network.

13. The system of claim 12, wherein said first and 25
second plug-in parts each include a body portion, and
means defining a tongue projecting from said portion
for insertion in the appropriate one of said one and
other sockets, each of said tongues having conductive
expanses thereon connected to resistance elements in 30
the body portions of their respective plug-in parts,
which elements comprise said circuit means in said
parts, and

said base includes electrical contact means in each of
said pair of sockets connected to resistance ele- 35
ments comprising each socket's associated network
portion for contacting the conductive expanses on
a plug-in part's tongue upon its insertion into the
appropriate socket and establishing electrical con-
nections between the resistance elements in the 40
part's body portion and the resistance elements in
the socket's associated network portion.

14. The system of claim 13, wherein said receptacle
base further includes circuit board means bearing said
resistance elements comprising said network portions, 45
and means establishing electrical connections between
said resistance elements and said contact means and
input and output terminals.

15. In a balanced, two conductor, low frequency tele- 50
communication line, an incrementally adjustable atten-
uator comprising,

a fixed pad element in series with said line, said ele-

ment including a receptacle base having a pair of
sockets therein, input and output terminal means
connecting the element in series with said line, and
a series-connected pair of circuit portions intercon-
necting said input and output terminal means, each
of said portions being associated with a different
one of said sockets and each including selected re-
sistances in series with the conductors of said lines,
a first attenuation modifier element comprising a
plug-in part removably received in one of said
sockets, and including first resistance means combin-
ing with the selected resistances in the circuit
portion associated with said one socket to produce
one value of attenuation in said line, and
a second attenuation modifier element comprising
another plug-in part removably received in the
other of said sockets and including second resis-
tance means combining with the selected resis-
tances in the circuit portion associated with said
other socket to produce another value of attenua-
tion in said line,

said one and other values adding to produce a prede-
termined, desired attenuation in the line.

16. The attenuator of claim 15, wherein said first re-
sistance means combines with the selected resistances
in the circuit portion associated with said other socket
to produce an integral value of attenuation in said line,
and said second resistance means combines with the
selected resistances in the circuit portion associated 30
with said other socket to produce a proper fractional
value of attenuation in said line.

17. The attenuator of claim 15, wherein said input
and output terminal means includes a pair of input ter-
minals and a pair of output terminals, one of said cir-
cuit portions comprises a first resistance in series with
said one conductor and a second resistance in series
with said other conductor of the line, and the other of
said circuit portions comprises a first series-connected
pair of resistances in series with one conductor and a
second series-connected pair of resistances in series
with the other conductor of said line, said first resis-
tance and said first pair being connected in series be-
tween one of said input terminals and one of said out-
put terminals, and said second resistance and said sec-
ond pair being connected in series between the other
of said input terminals and the other of said output ter-
minals.

18. The attenuator of claim 17, wherein said first and
second resistances have the same resistance value and
each resistance in said first and second pairs has the
same resistance value.

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