May 24, 1960 J. P. SMITH, JR 2,938,156

ATTENUATOR NETWORK AND SWITCH

Filed June 24, 1957 2 Sheets-Sheet 1

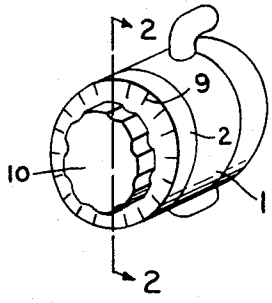


FIG. 1

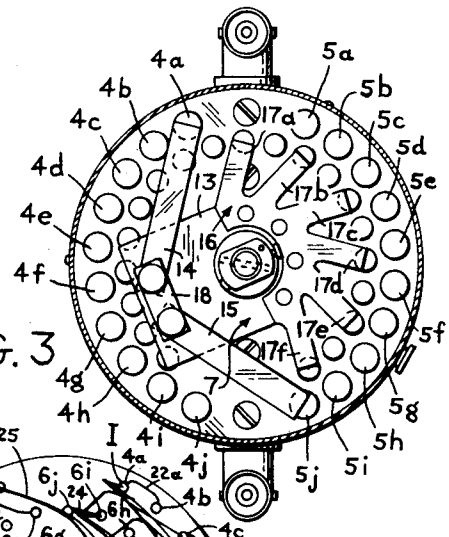


FIG. 3

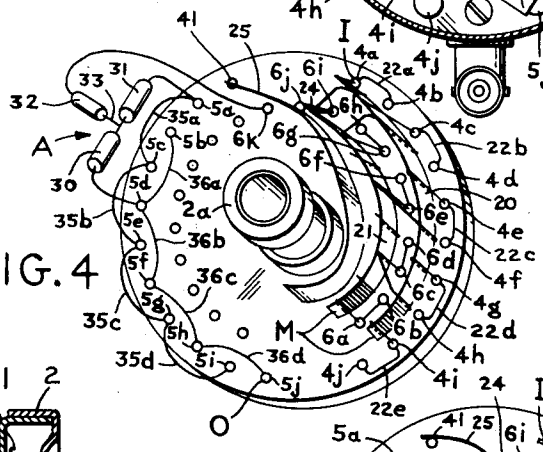


FIG. 4

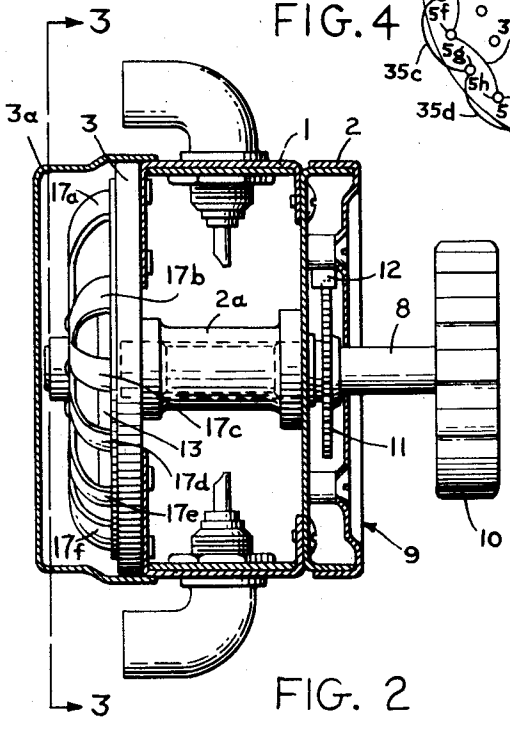


FIG. 2

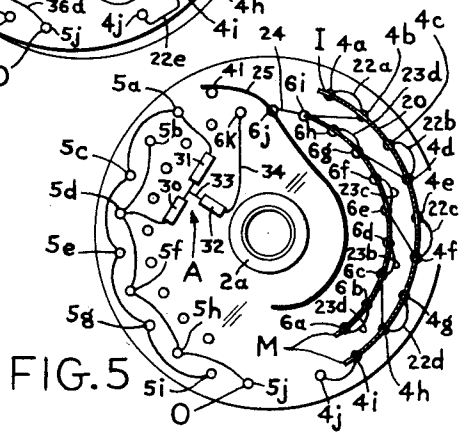


FIG. 5

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ATTENUATOR NETWORK AND SWITCH

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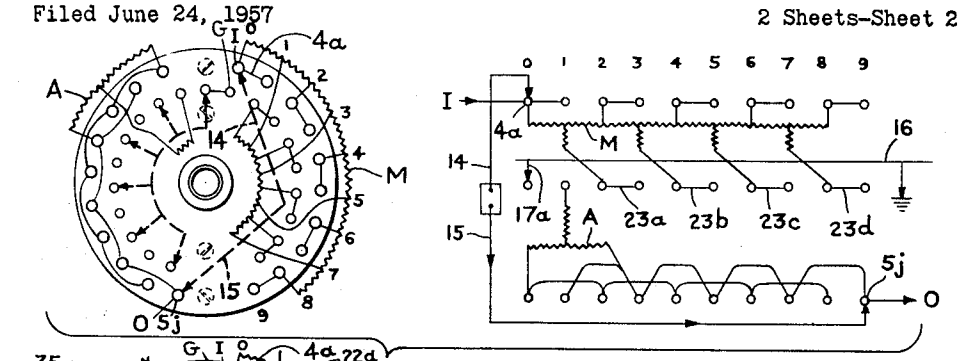


FIG. 6

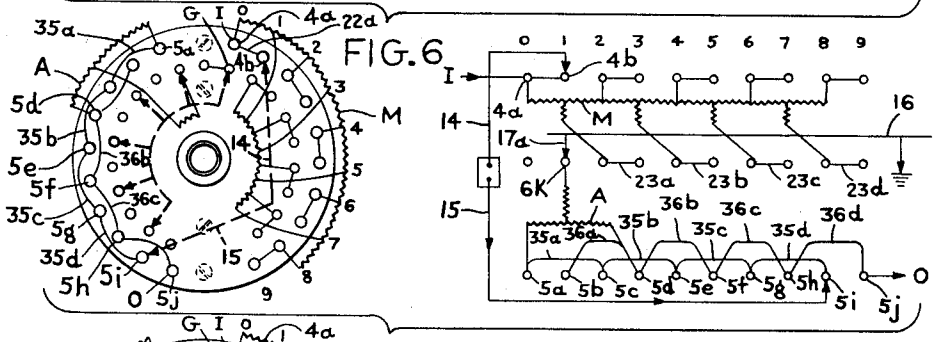


FIG. 7

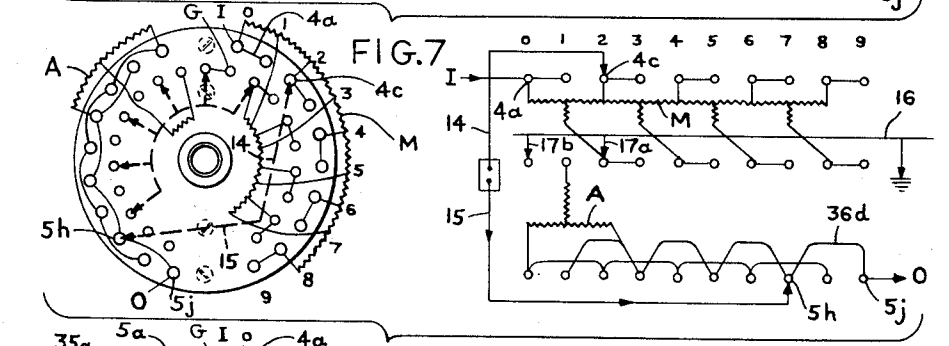


FIG. 8

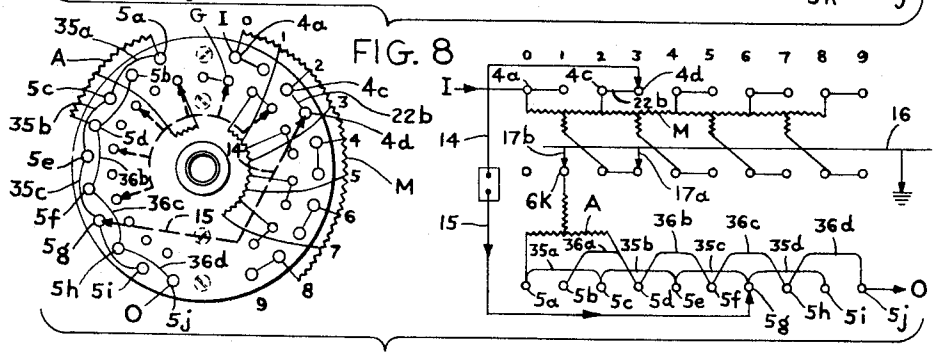


FIG. 9

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ATTENUATOR NETWORK AND SWITCH

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Filed June 24, 1957, Ser. No. 667,570

4 Claims. (Cl. 323—74)

This invention relates generally to attenuators and more particularly to an attenuator network arrangement and a switching arrangement for operation thereof.

Attenuator networks have been in use in the communication field wherein a plurality of resistors were coupled together so as to enable an operator to place various resistance values into a circuit or to adjust the circuit in accordance with the desired conditions of operation.

The present invention provides an attenuator network wherein the desired adjusting range is obtained but with a relatively reduced number of resistors which resistors are for the most part of the same value so that an attenuator network arrangement is provided which is cheaper to manufacture because of reduced set-up times and production costs, relatively simple in construction, permitting easy assembly and disassembly with corresponding ease of repair and replacement of parts.

This is accomplished by providing an attenuator for a circuit wherein actuating the switch in any stepwise direction will cause an auxiliary or independent resistance network unit to be connected into or removed from the circuit or to coact with one or more other resistance networks to provide a range of attenuation from the lowest to the highest value which the particular attenuator is adapted to introduce into the circuit to which it is connected.

Further objects and advantages of the invention will become evident from the following description with reference to the accompanying drawings in which:

Figure 1 is a perspective view of an attenuator constructed in accordance with the present invention.

Figure 2 is a longitudinal section taken on line 2—2 of Figure 1 with the resistance networks removed.

Figure 3 is an end view taken at 3—3 of Figure 2.

Figure 4 is a partial perspective of the contact panel with the resistors mounted thereon and showing the shielding means.

Figure 5 is a plan view of the contact panel with the resistors and shield.

Figure 6 is a combined diagrammatic sketch and schematic electrical configuration showing the switch in position with no resistors in the circuit.

Figure 7 is a combined diagrammatic sketch and schematic electrical configuration showing the switch in position for introducing the first step of attenuation into the circuit.

Figure 8 is a combined diagrammatic sketch and schematic electrical configuration showing the switch in position for introducing the second step of attenuation into the circuit.

Figure 9 is a combined diagrammatic sketch and schematic electrical configuration showing the switch in a still further position for introducing additional attenuation into the circuit.

Referring to the drawings, Figures 1 and 2 show the improved attenuator as including a cylindrical housing **1** having a detent panel cover **2** closing one end and a

contact panel **3** closing the other end and held in spaced relation to the detent panel cover **2** by a panel and bracket element **2***a* centrally disposed along the longitudinal axis of the cylindrical housing **1**. A contact panel closure **3***a* disposed outwardly of the contact panel engages the periphery of the cylindrical housing about the contact panel **3** and acts to fully enclose the attenuator assembly.

The contact panel **3** is made of any suitable insulating material and carries inwardly of its peripheral edge a first or outer plurality of hemi-grouped circumferentially spaced contacts respectively designated **4***a*, **4***b*, **4***c*, **4***d*, **4***e*, **4***f*, **4***g*, **4***h* and **4***i* for one hemi-group and **5***a*, **5***b*, **5***c*, **5***d*, **5***e*, **5***f*, **5***g*, **5***h* and **5***i* for the other hemi-group, and inwardly of the first or outer plurality of contacts a second or inner plurality of circumferentially spaced contacts **6***a*, **6***b*, **6***c*, **6***d*, **6***e*, **6***f*, **6***g*, **6***h*, and **6***i*, etc.

The contacts **4***a*, **4***b*, **4***c*, etc., **5***a*, **5***b*, **5***c*, etc. and **6***a*, **6***b*, **6***c*, etc. are engaged by a movable contact or switch structure generally designated **7** which is fixedly connected to one end of a shaft **8** extending outwardly beyond the contact panel **3**. The shaft **8** extends through the contact panel **3** and passes through a bore in the panel and bracket element **2***a* and the detent panel cover **2** beyond the indicating dial **9** on the outer surface thereof where it receives a knob or handle **10**. The shaft **8** has a detent gear **11** mounted thereon for a rotary movement with the shaft which detent gear is in the form of a disc and is mounted on the shaft inside the detent panel cover so that the gear and its cooperating pawl or detent **12** may be reached for repair or replacement. This mechanism is well known in the art and hence not more fully discussed herein.

Switch structure

The switch structure is shown in Figures 2 and 3 as having a body portion **13** with a pair of spaced arms **14** and **15** at one end, extending outwardly therefrom in substantially diverging or transverse directions, and a plate-like element **16** at the other end having a plurality of fingers **17***a*, **17***b*, **17***c*, **17***d*, **17***e* and **17***f* and extending outwardly therefrom on lines or at angles tangential with respect to the shaft **8**. The spaced transverse arms **14** and **15** and the finger-like elements **17***a*, **17***b*, **17***c*, etc. will be of sufficient length so that the ends of these respective elements will contact and sweep across the plurality of outer contacts and inner contacts, respectively. Finger elements **17***a*, **17***b*, **17***c*, etc. will be so disposed in space in respect with each other that as the switch **7** is moved from position to position there will always be an open contact element between the elements contacted by the respective fingers, all of which is clearly shown in Figure 3 of the drawings.

The spaced arms **14** and **15** are connected to a plate **18** of conductive material, hence current received at one end of an arm can be transmitted to the end of the other arm. The plate **16** will also be of conductive material and thus current received at any point will be transmitted to the remaining portions of the plate.

While the plurality of the fingers **17***a*, **17***b*, **17***c*, **17***d*, and **17***e* are shown at angles tangential with respect to the shaft **8**, it will be understood that they could be radially extended from a common center point as illustrated in the diagrammatic sketches of Figures 6, 7, 8, and 9.

The fingers are disposed tangentially so that the ends will wipe the face of the stationary contacts. Grooving of the face of the contact is then prevented. In radial position the ends of the fingers can be angled to accomplish the same result.

Resistance networks

The resistance networks in the illustrated form of this

invention mounted to the contact panel are of the T-type. It will be understood, however, that while this type of resistance network is shown that the invention is equally applicable to resistance networks such as the H-type, T-type, balanced and unbalanced ladder type, etc. which are in common use on electrical equipment.

While in the illustrated form of this invention we refer to the attenuation networks made up of resistance elements, it is believed to be well known in the art that capacitive and inductive networks requiring three terminals can also be adapted to this form of switch arrangement for communication and testing circuits. Hence, the modification of the attenuator circuit utilizing condensers, filters, etc. does not modify or vary the scope of the present invention.

Furthermore, the segments of the resistor element in the network can be adjusted so that there will be measured units of resistance from segment to segment substantially equal to one another. In the illustrated form of the present invention if a T 600/600 ohm resistance network is used we can obtain 8 units of 20 db from the main resistance network. By utilizing an independent auxiliary resistance network equivalent to 10 db therewith, an attenuator is provided which is adapted to introduce or remove from the circuit to which it is connected 9 different attenuation networks varying between or increasing in 10 db steps from 10 to 90 db.

Thus referring to Figures 4 and 5, the main resistance network generally designated M includes a pair of conventional coil-type resistance elements **20** and **21**, it being understood that while coil-type resistance units are shown that any other conventional type of resistors can be utilized without departing from the scope of the present invention.

The resistance elements or coils **20** and **21** are divided into measured resistance networks or units of 20 db each. This is accomplished by having segments of coil **20** disposed so that a segment is connected between alternate contacts **4***a*, **4***c*, **4***e*, **4***g* and **4***i*, these contacts in turn being connected by tie lines **22***a*, **22***b*, **22***c*, **22***d* and **22***e* to the adjacent contact elements **4***b*, **4***d*, **4***f*, **4***h* and **4***j*. Similarly, segments of the coil **21** are disposed so that each segment is connected between the alternate contacts **6***a*, **6***c*, **6***e* and **6***g*, and to intermediate points on each of the segments in the resistance coil **20** to complete the T-form in the manner well known in the art. The contacts **6***a*, **6***c*, **6***e* and **6***g* are in turn connected by tie lines **23***a*, **23***b*, **23***c* and **23***d* to the respective adjacent contacts **6***b*, **6***d*, **6***f* and **6***h*. The purpose of connecting the contacts **4***a*, **4***b*, etc., **5***a* and **5***b*, etc. and **6***a* and **6***b*, etc., by means of tie-lines will appear clear hereinafter when the operation of the present device is described.

The contact elements **6***i* and **6***j* have no resistances connected thereto. However, they are tied to each other by connecting line **24** and are grounded or provide a common line as shown at **25**. The term ground or common line will be understod by those skilled in the art to be equally applicable to those units where separate terminals are employed and no actual ground connection is necessary. For example, attenuator networks of the O and H type do not require a ground or common line yet the fundamental idea can still be applied. Since the fingers **17***a*, **17***b*, **17***c*, **17***d* and **17***e* are so disposed with respect to each other only by one contact, it is clear that on movement of the switch **7** at least one of the finger elements **17***a*, **17***b*, **17***c*, etc. will be brought into registry with either contact element **6***i* or **6***j* and therefore will provide direct connection to ground for whichever of the other contact elements **6***a*, **6***b*, **6***c*, etc. that are in contact with the fingers **17***a*, **17***b*, **17***c*, etc. Further, by reason of the existing tie-lines **23***a*, **23***b*, **23***c* and **23***d*, when a finger element engages one of the tied contacts it will also act to ground the other.

The independent auxiliary resistance network generally designated A is also of the T-type and for the purposes of illustration is a 10 db unit. It includes resistors **30** and **31** which are connected to each other at one end and at the ends remote therefrom to the respective contacts **5***a* and **5***d*. A resistor **32** to complete the resistance network has one lead **33** connected to the common connection for resistances **30** and **31** and the other lead **34** connected to the contact element **6***k*. It is believed apparent that by reason of the spaced construction of the fingers on the switch **7** that in one position of the fingers the switch will connect the contact element **6***k* to ground thereby grounding the auxiliary resistance assembly A connected to the contact **6***k* and in the other position the contact **6***k* will be open and hence the resistance assembly A will be open and no current will be able to flow therethrough.

The contact elements **5***a*, **5***c*, **5***e*, **5***g* and **5***i* are connected to each other by tie-lines **35***a*, **35***b*, **35***c*, **35***d* and **35***e* and contact elements **5***b*, **5***d*, **5***f*, **5***h* and **5***j* by the tie-lines **36***a*, **36***b*, **36***c* and **36***d*. Thus whenever the arm **14** sweeps across these contacts it will be in communication with one or the other of the group of contacts formed by means of the tie-lines **35***a*, **35***b*, etc. and **36***a* and **36***b*, etc. These contacts **5***a*, **5***b*, **5***c*, etc. will under specific conditions of operation be brought into communication with each other when current flows through the independent auxiliary resistance arrangement represented by the resistances **30**, **31** and **32**.

The input from the circuit (not shown) to which the improved attenuator is connected is received through the input line I at the contact element **4***a*. The output is delivered by the attenuator at the contact **5***j* to which the output line O is connected.

Figures 4 and 5 further show a shield element generally designated **40** which is disposed between the input line I and the output line O so that capacitive coupling will be prevented when the attenuator is switched to the high ranges of attenuation. The shield consists of a flat strip of metal such as copper or the like and it is mounted by any suitable means such as solder to the ground connection formed by contact **6***j* and the threaded member **41**. It extends transversely across the contact panel **3** between the inner resistance element **21** and the panel and bracket assembly **2***a* curling slightly thereabout and terminating substantially short of the periphery of the contact panel **3***a* for optimum effective operation.

Connecting the shield between the contact **6***j* and the threaded member **41** further provides a ground plane in the contact panel dielectric so that capacitive coupling through the contact panel is prevented. It will be understood that the shield is not utilized in the majority of units using 0.1 and 1 db per step, nor will it be required in units as high as 10 or 20 db per steps until high frequencies are carried by the units.

Operation

The operation of the attenuator is best understood with reference to the combined diagrammatic sketches and schematic electrical diagrams shown in Figures 6, 7, 8 and 9 indicating the switch **7** in several different operating positions.

Thus, in Figure 6 the switch **7** is disposed so that the spaced arms **14** and **15** are in the zero position. In this position, as is indicated by the electrical diagram, no attenuation is introduced into the circuit (not shown) to which the attenuator is connected. Referring to the electrical diagram, current enters through the input line I and passes to the contacts **4***a*. Since the spaced arms **14** and **15** are connected to the contact **4***a* the current flows therethrough to the contact **5***j* and then taking the simplest electrical paths returns back to the circuit through the output line O.

If the characteristic impedance of the attenuator is the same as the transmission line of the circuit to which it is connected it is obvious that the only resistance to the

flow would be the resistance of the lines in the attenuator itself. Since this is negligible no resistance will be introduced into the circuit to which the attenuator is connected.

Since no resistance is introduced into the circuit by the attenuator the position of the finger elements of the switch has little significance.

In Figure 7, the switch 7 is rotated to the first position of attenuation wherein the spaced arms 14 and 15 will be connected to the contacts 4*b* and 5*i*, respectively, and the plate 16 through one of the fingers 17*a* will register the contact 6*k* to ground thereby closing the T-type form of the independent auxiliary resistance network A. Since none of the fingers 17*a*, 17*b*, etc. are in contact with any of the segments of the main resistance M this resistance will be open. Now the current enters through the input line I passing through contacts 4*a*, tie-line 22*a* and contact 4*b* to the spaced arms 14 and 15 where it is transmitted to the contact 5*i*. From contact 5*i* the current flows through the respective tie-lines and contacts 35*d*, 5*g*, 35*c*, 5*e*, 35*b*, 5*c*, and 35*a* to the contact 5*a*. From contact 5*a* the circuit must now return through the independnet auxiliary resistance network A to contact 5*d* whence it passes through the tie-lines and contacts 36*b*, 5*f*, 36*c*, 5*h*, 36*d* and 5*i* to the output line O communicating with the circuit in which the attenuator is connected.

Since the auxiliary resistance network measures 10 db this will represent the lowest attenuation value to be inserted into the circuit utilizing this ohmic resistance value. It being understood that if other values of resistance networks are used that different attenuation values will be obtained.

In Figure 8 switch 7 is rotated to the second position of attenuation. In this position the spaced arms 14 and 15 now connect to contacts 4*c* and 5*h*, respectively, and the plate 16 is disposed to ground the first segment of the main resistance assembly and to open the circuit of the independent auxiliary resistance A. Current now flows from the input line to contact 4*a* through the first 20 db segment of the main resistance unit M to the contact 4*c*. Arms 14 and 15 then conduct the current to contact 5*h* where it passes through tie-line 36*d* to the output line O connected to the circuit in which the attenuator is connected.

Thus, the second position on the attenuator is 10 db greater in resistance than the first position, giving a total of 20 db.

In Figure 9 the switch 7 is rotated to the third position of attenuation bringing the spaced arms 14 and 15 into registry with contacts 4*d* and 4*g*, respectively. The plate 16 in this position grounds both the first segment of the main resistance assembly M and the independent auxiliary resistance unit, the function of the tie-lines 23*a* being apparent in this position of attenuation. The schematic electrical diagram shows that current now flows from the input line to contact 4*a*, then through the first 20 db segment of the main resistance assembly M to the contact 4*c* and tie-line 22*b* to the contact 4*d*. Arms 14 and 15 then conduct the current to the contacts 5*g*. The current next flows through the tie-lines and contacts 35*c*, 5*e*, 35*b*, 5*c* and 35*a*, respectively to the contact 5*a*. Since the independent auxiliary resistance assembly A is grounded the current returns through the 10 db of resistance passing to contact element 5*d* and then through the tie-lines and contacts 36*b*, 5*f*, 36*c*, 5*h*, 36*d* and 5*j* to the output line O communicating with the circuit to which the attenuator is connected.

The attenuation introduced into the circuit in this position totals 30 db which is once again 10 db higher than the previous switch position.

The additional positions shown provide means for introducing attenuation values up to 90 db by selectively connecting a predetermined number of segments of the main resistance network or combining a predetermined number of segments of the main resistance network with the independent auxiliary network. The stepwise difference in one position relative to the other in the present illustrated form of the invention representing attenuation of 10 db, it being understod that this is merely for the purposes of illustration and that the stepwise change could be varied in accordance with the type, circuit, and impedance values of the resistances in the attenuation networks utilized for the particular attenuator inserted in the circuit.

Thus, in position marked 4 with the spaced arms 14 and 15 in engagement with contacts 4*e* and 5*f* and the plate 16 opening the circuit to ground for the independent auxiliary resistance network A we would obtain 40 db while in the position marked 5 with the spaced arms 14 and 15 in engagement with contacts 4*f* and 5*e* and the plates 16 closing the circuit to ground for the independent auxiliary resistance network A we would obtain 50 db of resistance and this could be varied from position to position up to the position marked 9 on the diagrammatic sketches as shown in Figures 6, 7, 8 and 9, the resistance value in each instance varying from step to step only by indicated predetermined value of the independent auxiliary resistance network.

While the circuit diagrams in Figures 6, 7, 8 and 9 show the current flow pattern indicated, it is equally feasible to reverse the direction of flow by connecting the input line to contact 5*a* and the output line to contact 4*a*. However, the operation of the present device would not be modified by this change. The current would merely pass through the attenuator in a different flow path.

Further, the switch element 7 is shown with the arms 14 and 15 contacting the outer plurality of contacts and the fingers 17*a*, 17*b*, etc. contacting the inner plurality of contacts. It is believed that those skilled in the art will understand that the main resistance network and the independent auxiliary resistance network could be interchanged by connecting them between the inner and outer contacts and that other contacts could be changed accordingly and to obtain the same operation, the length of the arms 14 and 15 and fingers 17*a*, 17*b*, etc. could be altered so they contact the inner and outer contacts respectively, and that this variation would not alter the scope of the present invention.

In addition, while various contacts are illustrated and tied together by means of the tie-lines, it is also believed that those skilled in the art recognize that single contacts could replace the tied contacts in which case the contacts would be altered to make them oval, or elliptical or half moon-shaped so that the desired contact will be obtained on movement of the switch 7.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In an adjustable transducer having an input line and an output line for connection with a current conducting circuit, a contact panel of insulating material, switch means rotatably mounted relative the contact panel, said contact panel having a first arcuate array of stationary contacts and a second arcuate array of stationary contacts disposed in spaced relation to each other about the center of rotation of said switch means, said first arcuate array of stationary contacts formed into two hemi-groups, at least one of said hemi-groups having alternate contacts connected to each other in series, said hemi-group with the serially connected contacts having a contact at one end connected to the output line, said other hemi-group also having an end contact connected to said input line, a main impedance network having spaced terminals to delimit a predetermined range of resistance values connected to predetermined contacts of said other hemi-group and of said second arcuate

array of contacts, an auxiliary impedance network of predetermined value having terminals to permit said auxiliary impedance network to be connected to adjacent contacts in the serially connected hemi-group at the end remote from the output end and to one of said second arcuate array of stationary contacts, ground means, first conducting means on said switch means for connecting predetermined contacts of the respective hemi-groups of said first arcuate array of contacts to each other, second conducting means on said switch means spaced from said first conducting means and in continuous contact with the ground means, and means on said second conducting means for contacting said second arcuate array of stationary contacts, said first conducting means and said last mentioned means operatively associated whereby on indexing of the switch means said first conducting means will connect the main impedance network to the output line and said means on the second conducting means will alternately connect and disconnect said auxiliary impedance network into serial circuit with said main impedance network to introduce varying predetermined stepwise values of attenuation into the current-carrying circuit.

2. In an adjustable transducer having an input line and an output line for connection with a current conducting circuit, a contact panel of insulating material, switch means rotatably mounted relative the contact panel, said contact panel having a first arcuate array of stationary contacts and a second arcuate array of stationary contacts disposed in spaced relation to each other about the center of rotation of said switch means, said first arcuate array of stationary contacts formed into two hemi-groups, at least one of said hemi-groups having alternate contacts connected to each other in series, said hemi-group with the serially connected contacts having a contact at one end connected to the output line, said other hemi-group also having an end contact connected to said input line, a main impedance network having spaced terminals to delimit a predetermined range of resistance values connected to predetermined contacts of said other hemi-group and of said second arcuate array of contacts, an auxiliary impedance network of predetermined value having terminals to permit said auxiliary impedance network to be connected to adjacent contacts in the serially connected hemi-group at the end remote from the output end and to one of said second arcuate array of stationary contacts, ground means, said switch means including spaced arms disposed to conduct current between predetermined contacts of the respective hemi-groups of said first arcuate array of stationary contacts, and common conducting means on said switch means in spaced relation to said arms and in continuous contact with the ground means, said common conducting means having spaced fingers to engage contacts of said second arcuate array of stationary contacts, said arms and fingers so constructed and arranged that on indexing of said switch means the main impedance network will be connected to the output line and the auxiliary impedance network will be alternately connected and disconnected into serial circuit with said main impedance network to introduce predetermined stepwise values of attenuation into the current conducting circuit.

3. In an adjustable transducer as claimed in claim 1, a shield connected to said ground means disposed transversely of said contact panel between said main impedance network and said auxiliary impedance network to prevent capacitive coupling during operation of said adjustable transducer.

4. In an adjustable transducer as claimed in claim 2 including, a shield connected to said ground means disposed transversely of said contact panel between said main impedance network and said auxiliary impedance network to prevent capacitive coupling during operation of said adjustable transducer and to provide a ground plane in the insulating material of said contact panel.

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