Nov. 15, 1955 A. P. LAGON 2,724,033

STEP LADDER ATTENUATORS

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Fig. 3.

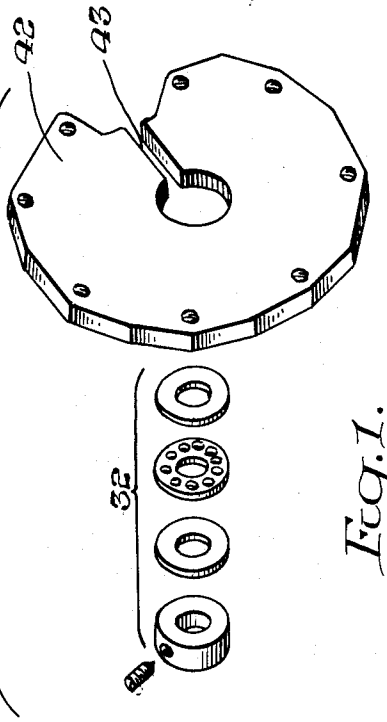


Fig. 1.

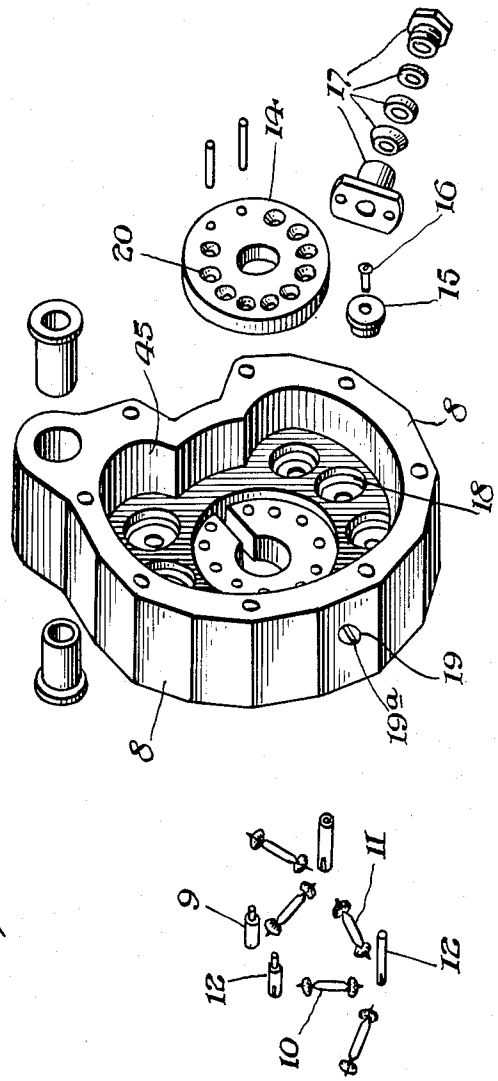
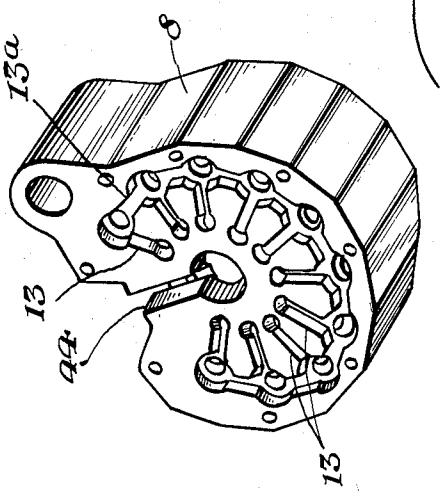


Fig. 2.



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STEP LADDER ATTENUATORS

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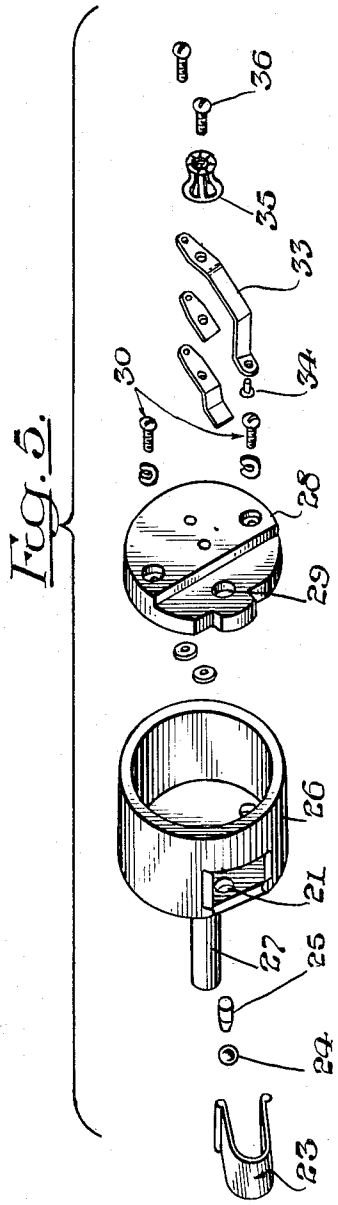


Fig. 5.

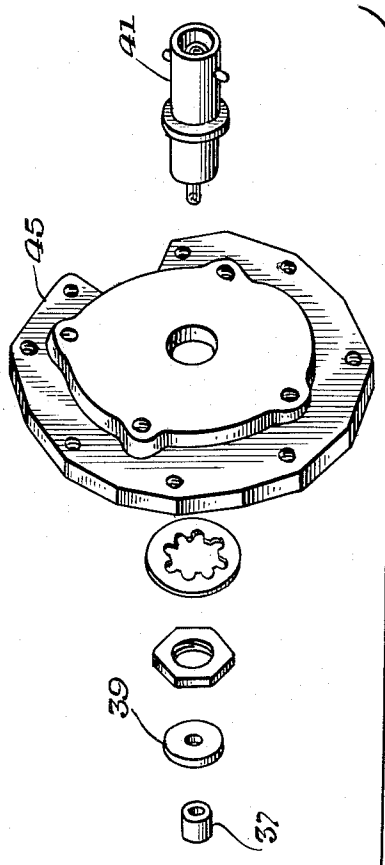


Fig. 4.

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STEP LADDER ATTENUATORS

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Fig. 6.

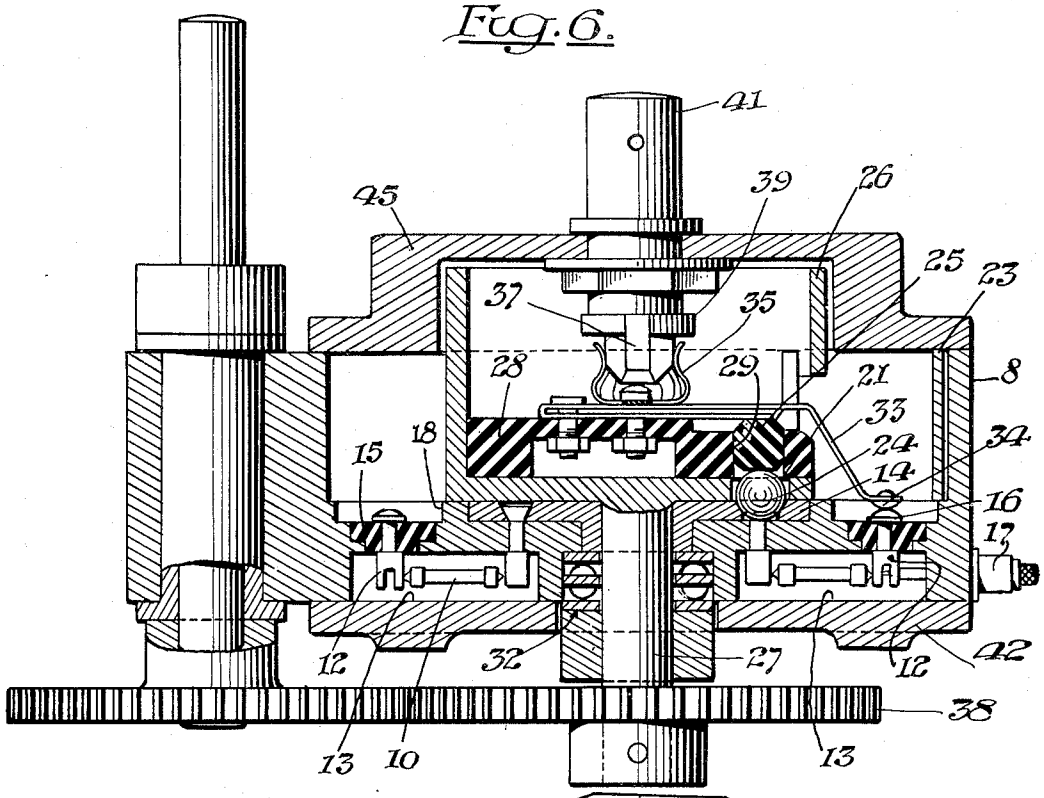
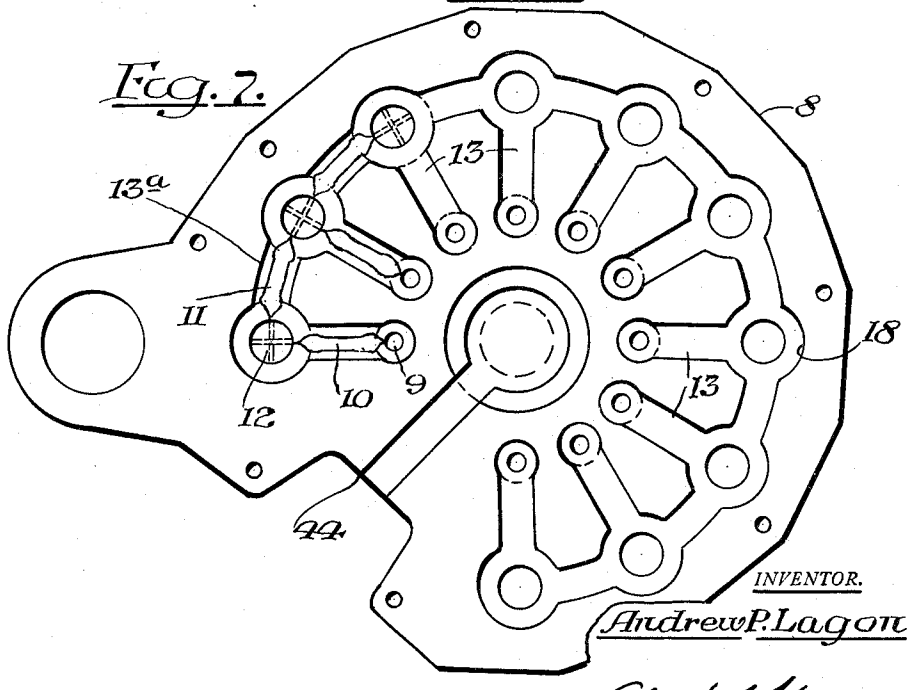


Fig. 7.



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2,724,033

STEP LADDER ATTENUATORS

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Application March 30, 1953, Serial No. 345,483

14 Claims. (Cl. 201—48)

This invention relates to attenuators, and more particularly those of the step ladder type. Step ladder attenuators as heretofore produced have been incapable of maintaining accuracy over a wide frequency range, such as is required for the purpose of using the attenuator for audio and radio frequency signal generators from low frequency to ultra-high frequency. The designs of presently known stepped attenuators, not of the ladder type intended for use over a wide frequency range, were such as to make them large, heavy, and inconvenient for many required applications, such as are found in the present electronic field.

Accordingly, it is an object of the present invention to provide a step ladder attenuator which will be accurate over a wide frequency range.

Another object of the present invention is to provide wide band attenuators having a very compact structure, whereby size and weight have been reduced considerably.

Another object of the present invention is to provide a wide band attenuator having the ease of operation possible by employing a simple knob control as contrasted to the "Push-Turn-Pull" operation of previously known structures.

A feature of the present invention is its compact, unitary block structure.

Another feature of the present invention is its contact arm and shield construction, which provides accurate attenuation, despite the proximity of adjacent contacts.

A further feature of the present invention is its adaptability to a large number of attenuator requirements, without specifically changing the structure thereof.

The invention consists of the construction, combination and arrangement of parts, as herein illustrated, described and claimed.

In the accompanying drawings, forming a part hereof, is illustrated one form of embodiment of the invention, in which drawings similar reference characters designate corresponding parts, and, in which:

Figure 1 is an exploded view of the body of the attenuator, made in accordance with the present invention.

Figure 2 is a view in perspective of the ladder network side of the attenuator block.

Figure 3 is an exploded view of the bottom cover plate of the attenuator, and various elements associated therewith.

Figure 4 is an exploded view of the top cover plate of the attenuator, and output terminal assembly.

Figure 5 is an exploded view of the switching device assembly, made in accordance with the present invention.

Figure 6 is a vertical section taken through a complete embodiment of the present invention.

Figure 7 is a bottom plan view of the attenuator block, showing the resistor and contact receiving bores therein, with most of the resistors removed for the sake of clarity.

Referring to the drawings, and particularly Figures 1, 2 and 7, there is shown an aluminum casting **8** having a substantially twelve-sided peripheral shape, each of said sides corresponding to one of the various positions at

which the attenuator may be set. A plurality of miniature high-stability carbon film resistors **10** and **11** are disposed within the casting **8** and are located in machined slots **13**, such as are shown on the rear view of the body in Figure 2. The shunt resistors **10** of the network are located in the radial slot **13**, and are soldered at one end to grounding pins **9**. The other end of the shunt resistors **10** are soldered to contact caps **12**. The series resistors **11** are located in the groove **13***a* forming an arc parallel with the periphery of the body of the casting **8**. The series resistors **11** are soldered at both ends to contact caps **12**.

The contact caps **12** are located below contact holders **15**, as is best shown in Figure 6. A suitable material of which the contact holders may be formed has been found to be a dielectric plastic sold under the trade-name "Teflon." The contact holders are centrally bored to receive therein pins **16**, which in turn are in electrical contact with the caps **12**. The contact caps **12** also serve as soldering lugs for the ladder network resistors **10**, **11**.

The Teflon contact holders **15** are disposed at the bottom of cavities **18** provided in the body **8** of the attenuator, as best shown in Figure 1. The input to the ladder network is fed through a cable termination assembly, generally indicated at **17** in Figure 1. The input cable is connected at the side of the attenuator body **8**, and the central conductor of the input cable (not shown) is soldered in the first contact cap of the ladder network. However, it is within the purview of the present invention to attach the input cable at other faces upon the periphery of the casting **8**, and connect it to the contact cap of the ladder network thereadjacent, for the purpose of varying the performance of the attenuator, as desired.

Alternately, the casting **8** may be provided with threaded openings **19**, into which plugs **19***a* may be inserted for the purpose of sealing up the wall of the casting **8**, until such time as the input cable **17** is to be led therethrough.

The switching device, whereby various ladder network relationships may be effected, is best shown in Figures 5 and 6. The switching device is mounted within and connected to a turret **26**, within which there is a beryllium copper contact arm **33**. The contact arm **33** is secured, as by screws **36**, to a phenolic turret core **28**. The core **28** is attached to the body of the turret **26** by screws **30**.

A silver contact **34** is secured to the end of the contact arm **33**, for the purpose of engaging the ladder network contact pins **16**. The other end of the contact arm **33** is permanently electrically connected to the output connector contact **37**, shown in Figure 4. The connection between the arm **33** and the output connector **37** is effected by means of a beryllium copper contact cup **35**.

To minimize output standing wave ratio, the switching device assembly was designed to approximate a constant—K artificial line π section of 50 ohms characteristic impedance. This result was achieved by proportioning the components of the switching device, so that the ratio of the inductance of the switching blade **33** to the capacity of the said blade to ground is in agreement with the design formulae for such artificial line sections. Consequently, the contact arm **33** was designed to have suitable inductance. The design results in low standing wave ratio up to frequencies of over 1000 megacycles. In order to achieve sufficiently low inductance, a wiping contact was developed, consisting of the beryllium copper cap **35**.

The entire switching device is carried within a well **45**, machined into the casting **8**. The walls of the well **45** lend certain shielding properties to the switching device, in which respect they co-operate with the cavities **18**.

Switching from one pin **16** to another is performed by rotating the shaft **27**, which is integral with the turret body **26**. As the turret body is rotated, the contact arm

33 is lifted, so that it clears the walls of the cavities 18, within which the contact pins 16 are recessed. By means of this structure, hereinafter described, there have been achieved certain shielding properties around each of the individual contacts, and in addition, a minimum amount of contact wear on the part of the sliding contact member 34 has been effected.

The arm-lifting structure comprises a disc 14, which may be, for example, stainless steel, as best shown in Figure 1, having therein a plurality of tapered holes 20 corresponding in number to the number of contact positions in the attenuator body. A small ball 24 (see Figure 6) is positioned upon the disc 14, so as to ride therearound in a path coincident with the holes 20 in the disc 14. The ball 24 underlies a phenolic spacer block 25, which in turn bears against the underside of a spring 31. The ball 24 is carried within an opening 21 in the bottom of the turret 26, and the phenolic block 25 is laterally supported by the walls of an opening 29 in the turret core 28. The spring 31 underlies the contact arm 33 on the switching assembly. The holes 20 in the disc 14 are in line with the contacts in the attenuator.

Accordingly, as the turret 26 is turned, the ball 24 is forced into and out of the holes 20 in the disc 14. As the ball 24 rises and falls, it actuates the block 25 and the spring 31, thereby lifting and dropping the contact arm 33 into and out of the various cavities 18.

As a further precaution against leakage between the contact point and the contact arm, there is provided a shield 23, best shown in Figures 5 and 6, which is secured to the outside wall of the turret 26 at a point defined by the extension of the arm 33 from the said turret 26. This contact arm shield 23 prevents electric and magnetic induction to the contact arm 33.

The switching device is held in place by means of the bearing assembly, generally indicated at 32, which bearing assembly is fitted to the turret body shaft 27. The attenuator may be driven by means of a knob (not shown), directly secured to the turret shaft 27, or by means of gears 38, as shown in Figure 6.

The output connector contact 37 is soldered to the center pin of the connector 41 journaled within a top cover member 45, and separated from the connector body, by a suitable washer 39, which may be made of Teflon.

The ladder network is shielded by means of a back cover member 42, best shown in Figures 3 and 6. The cover 42, and also the casting block 8 of the attenuator, are slotted, as indicated at 43 and 44, for the purpose of providing an air-gap which will minimize current leakage between the first and last ladder contact positions. By making the disc 14 of a dissimilar metal from that of the casting 8 and the cover 42, as for example, making the disc of stainless steel, additional properties, resulting in reduction of current leakage, have been effected.

It is also within the purview of the present invention to provide two input cables, each connected to a selected contact cap 12 of the ladder network, for the purpose of providing a differential attenuator, whereby an output voltage will appear at the previously described output connector, equivalent to a controllable ratio of the two voltages fed into the attenuator. The symmetrical structure of the present attenuator lends itself to this use of the device.

From the foregoing, it will be seen that there has been provided a step ladder attenuator, capable of handling an extremely wide variation of frequencies, at which the attenuator will function with a minimum amount of trouble, and with great accuracy, despite its small size and light weight. There have also been incorporated certain shielding and switching features which permit the attenuator to be driven by a simple knob control, while at the same time being able to cover a very wide frequency range, making it suitable, not only for use in signal generators, but also in a variety of types of test equipment, and in any laboratory of production control application, where a standard attenuator is required, but where speed and simplicity of operation is essential.

It is within the purview of the present invention to reverse input and output connections in the following manner: An input voltage can be applied to the terminal 41 (previously referred to as the output terminal). Thereafter, output voltages may be taken from two or more terminals 17 (previously referred to as input terminals). The symmetrical structure of the present attenuator, its excellent shielding properties and novel switching mechanism, make it possible to use the attenuator in these various ways.

It will be seen, therefore, that a highly flexible stepped attenuator structure, capable of a wide variety of applications and installations, has been arrived at by means of the foregoing structure.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A step ladder attenuator comprising, a block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

2. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening, and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected within the central opening in the block, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

3. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a centrally bored dielectric disc in the bottom of each cavity, a contact member carried within the bore in each disc, a plurality of resistors in the

form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

4. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a centrally bored dielectric disc in the bottom of each cavity, a contact member carried within the bore in each disc, a plurality of miniature high stability carbon film resistors in the form of a ladder carried in the block, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

5. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a centrally bored dielectric disc in the bottom of each cavity, a contact member carried within the bore in each disc, a plurality of miniature high stability carbon film shunt and series resistors in the form of a ladder carried in the block, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

6. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a plurality of radially disposed slots in the bottom of the block, said slots being joined at their outer ends by a continuous slot spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each

disc, a plurality of resistors in the form of a ladder carried within the slots in the bottom of the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

7. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a plurality of radially disposed slots in the bottom of the block, said slots being joined at their outer ends by a continuous slot spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of miniature high stability carbon film shunt and series resistors in the form of a ladder carried within the slots in the bottom of the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

8. A step ladder attenuator comprising, a block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a turret member secured to the shaft and rotatable within the central well, a dielectric core carried within and secured to the turret, a switching blade secured at one end to the core, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

9. A step ladder attenuator comprising, a block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally

bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a turret member secured to the shaft and rotatable within the central well, a dielectric core carried within and secured to the turret, a switching blade secured at one end to the core, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means comprising, a ring disposed within the block, concentric with the central opening therein, said ring having a plurality of tapered holes therein spaced from its periphery, a ball member rotatably positioned within the turret and top surface of the ring in a path defined by the tapered holes, a vertically slidable block carried by the core overlying and riding upon the ball and underlying and in contact with the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

10. A step ladder attenuator comprising, an aluminum block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a turret member secured to the shaft and rotatable within the central well, a dielectric core carried within and secured to the turret, a switching blade secured at one end to the core, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means comprising, a steel ring disposed within the block, concentric with the central opening therein, said ring having a plurality of tapered holes therein spaced from its periphery, a ball member rotatably positioned within the turret and top surface of the ring in a path defined by the tapered holes, a vertically slidable block carried by the core overlying and riding upon the ball and underlying and in contact with the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

11. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a turret member secured to the shaft and rotatable within the central well, a dielectric core carried within and secured to the turret, a switching blade secured at one end to the core, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means comprising, a ring formed of a metal dissimilar to that of the block disposed within the block, concentric with the central opening therein, said ring having a plurality of tapered holes therein spaced from its periphery, a ball member rotatably positioned within the turret and top surface of the ring in a path defined by the tapered holes, a vertically slidable block carried by the core overlying and riding upon the ball and underlying and in contact with the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

12. A step ladder attenuator comprising, a block formed from a single piece of metal, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, an air gap in the block describing a radial path from the central opening of the said block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, an input terminal secured to the outside of the block, an electrical lead carried within the input terminal, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

13. A step ladder attenuator comprising, a block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of resistors in the form of a ladder carried within the block and connected to the bottoms of the contacts members, a switching shaft journaled within the central opening in the block, a switching blade secured at one end to the shaft, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means supported by the block carried below the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, a plurality of terminals secured to the outside of the block, an electrical lead carried within each of the input terminals, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

14. A step ladder attenuator comprising, a block, said block having a central well and opening and being suitably bored to provide a plurality of electrically shielding cavities spaced from the periphery of the block, said cavities being cut into the bottom of the block well, a plurality of radially disposed slots in the bottom of the

block, said slots being joined at their outer ends by a continuous slot spaced from the periphery of the block, an air gap in the block describing a radial path from the central opening of the said block, a centrally bored dielectric disc in the bottom of each cavity and spaced from the top edge thereof, a contact member carried within the bore in each disc, a plurality of miniature high stability carbon film resistors in the form of a ladder carried within the slots in the bottom of the block and connected to the bottoms of the contact members, a switching shaft journaled within the central opening in the block, a turret member secured to the shaft and rotatable within the central well, a dielectric core carried within and secured to the turret, a switching blade secured at one end to the core, a blade contact point carried on the free end of the blade engageable with the tops of the contact members, blade elevating means comprising, a ring disposed within the block, concentric with the central opening therein, said ring having a plurality of tapered holes therein spaced from its periphery, a ball member rotatably positioned within the turret and

top surface of the ring in a path defined by the tapered holes, a vertically slidable block carried by the core overlying and riding upon the ball and underlying and in contact with the blade whereby the blade contact is lifted over the block structure separating adjacent cavities during switching operations, a plurality of input terminals secured to the outside of the block, an electrical lead carried within each of the input terminals, said lead being connected to a contact member within the block, a cover member over the bottom of the block, a cover member over the top of the block and an output terminal supported by the top cover member and in electrical contact with the switching blade.

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