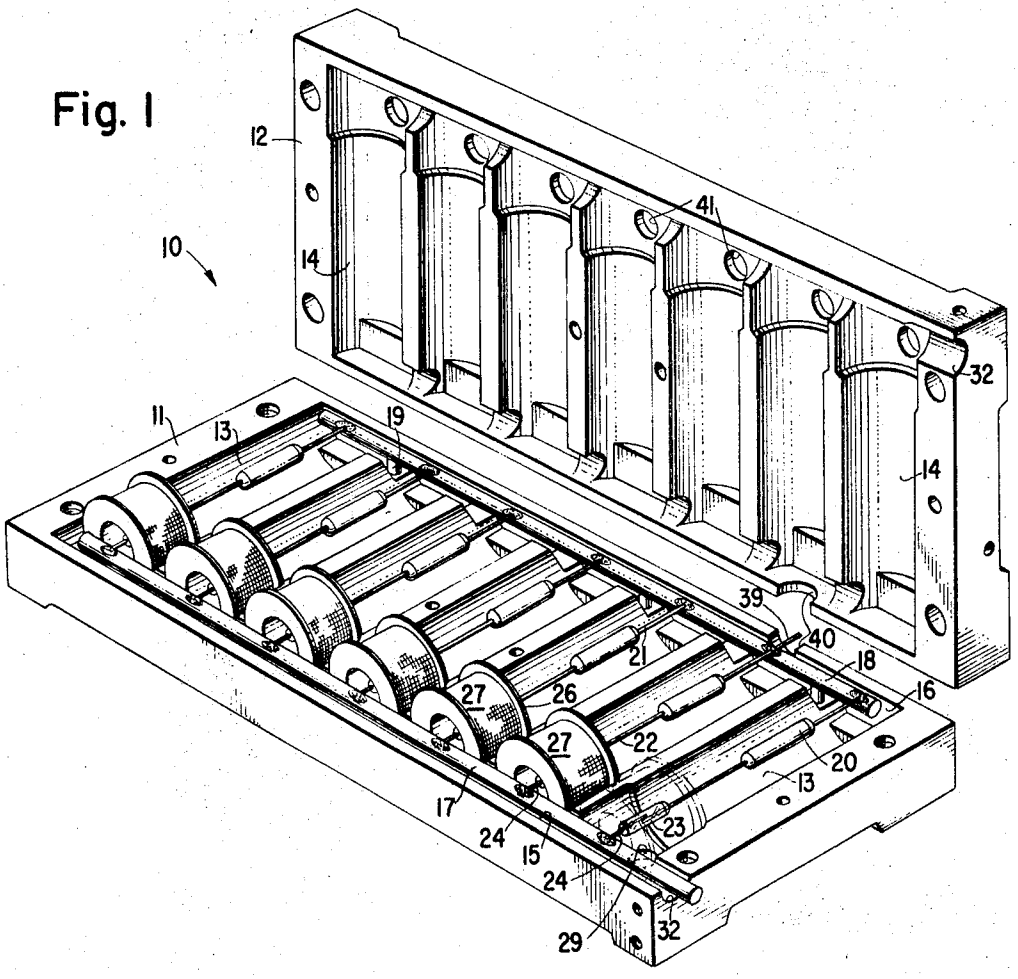
Nov. 3, 1970 M. M. FERNANDO 3,538,481

EXTERNALLY SWITCHED VARIABLE ATTENUATORS

Filed Dec. 9, 1968 2 Sheets-Sheet 1

Fig. 1



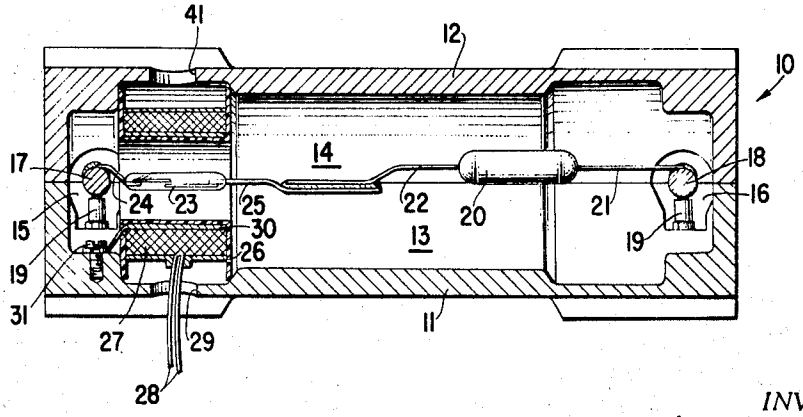


Fig. 3

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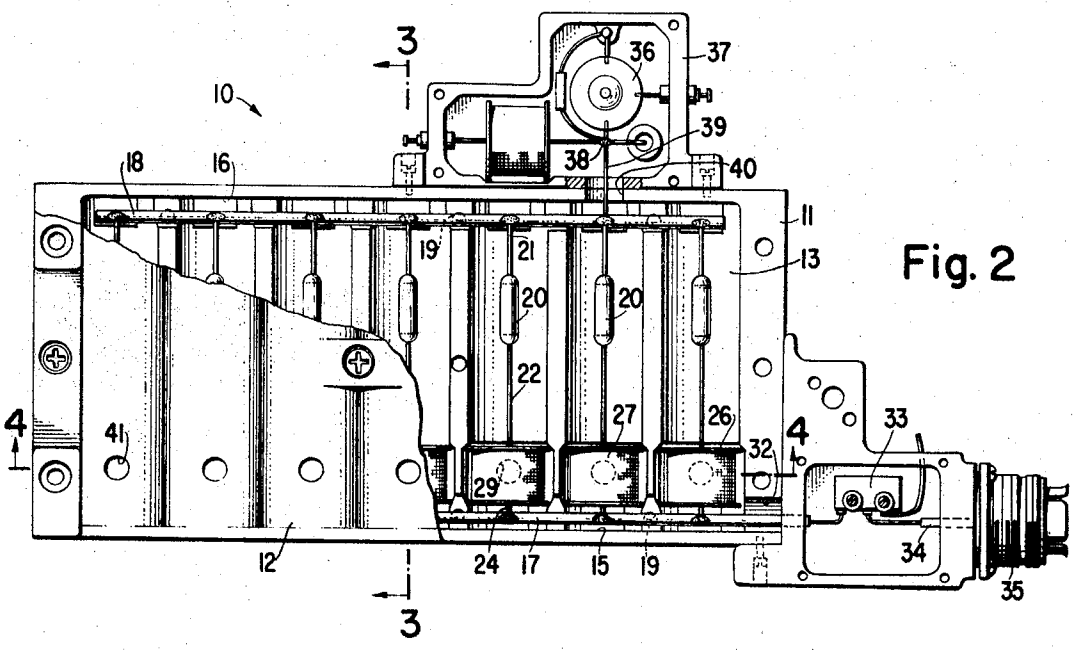

Fig. 2

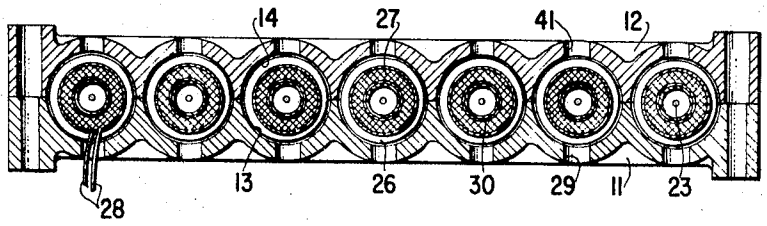

Fig. 4

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United States Patent Office 3,538,481 Patented Nov. 3, 1970

3,538,481

EXTERNALLY SWITCHED VARIABLE ATTENUATORS

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Filed Dec. 9, 1968, Ser. No. 782,313
Int. Cl. H01c 1/15
U.S. Cl. 338—201 3 Claims

ABSTRACT OF THE DISCLOSURE

An externally switched variable attenuator having low residual reactance for A.C. frequencies up to 1 mHz. is disclosed. An electrically-conductive cast housing is split along a transverse plane to form a base and a removable cover which, when assembled, provide a plurality of independent parallel-spaced internal cylindrical cavities. A pair of internal parallel ducts are positioned transversely of said cavities, one duct at each of the collective common ends of said cavities and intersect said cavities for communication therewith. A continuous rigid conducting bus is supported in each duct and insulated from the housing. A resistor and a reed switch connected in series circuit relation are supported in axially spaced relation and coaxially within each cavity by rigid conductors secured to each of said busses. A cylindrical winding is associated with each reed switch for magnetic actuation thereof. Each winding is secured in spaced coaxial relation with each reed switch by an insulated coil form which is held clamped within an enlarged end portion of each cavity.

BACKGROUND OF THE INVENTION

High accuracy AC–DC standards must be rigidly constructed to maintain reproduceable differences. They consist of a non-reactive attenuator and a thermoelement which senses the heating effect of a current and which has only a small difference in output characteristics between DC and AC inputs. To provide a practical range of voltage inputs, the attenuator must be variable so that the thermoelement is always operated near to its rated current for best accuracy.

Prior art variable attenuators have been proposed which require the mechanical insertion of different resistors in the circuit but these require rather complex mechanisms and disturb the desired fixed geometry of the circuit. Microswitches have been used to effect remote switching of resistors but they require mechanical push rod actuators having mass motion near to the circuit to be controlled and thus may adversely affect its AC vs. DC response. Ideally then, the attenuator of this invention should have zero-motion switching when changing values. The use in this invention of magnetically operated reed switches with spaced actuator windings comes very close to the ideal in this respect and, when combined with fixed and rigid coaxial geometry of the circuit relative to ground, reduce errors due to residual reactance to a minimum over a wide AC frequency band.

It is, therefore, an object of this invention to provide a low-voltage variable attenuator which is not sensitive to AC frequency.

It is a further object of this invention to provide a variable attenuator having the above desirable characteristics and which may be readily controlled from a remote point and without adversely affecting the circuit by the controlling means.

It is a still further object of this invention to provide a variable attenuator of the above type which is capable of being housed within a portable instrument.

Other objects and features of the invention will become

apparent to those skilled in the art as the disclosure is made in the following detailed description of a preferred embodiment of the invention as illustrated in the accompanying drawings in which:

FIG. 1 is an isometric view of a preferred embodiment of the variable attenuator of the subject invention.

FIG. 2 is a plan view of the attenuator with the cover partially broken away to reveal the interior.

FIG. 3 is a transverse sectional view of the attenuator taken on line 3—3 of FIG. 2.

FIG. 4 is a longitudinal sectional view of the attenuator taken substantially on line 4—4 on FIG. 2.

DESCRIPTION OF THE INVENTION

Referring now to the drawings, a housing **10** preferably made of cast aluminum is split along a horizontal transverse plane to form a base **11** and a removable cover **12**. Matching semicylindrical depressions **13** and **14** in the base and cover, respectively, form, when the parts are assembled, a plurality of independent internal parallel-spaced cylindrical cavities one of which is shown in section in FIG. 3.

The housing **10** provides a mechanical shield for the attenuator so that the rigid geometry of the circuit will not be disturbed. It also provides an electrical shield against the adverse influence of extraneous electrical fields with the attenuator circuit contained within.

The dividing walls between the cavities are cut away at each end thereof provide transverse internal ducts **15** and **16** which extend to the full length of the housing and interconnect with the cavities at the collective ends thereof as best seen in FIG. 1.

Rigid busses **17** and **18** are supported centrally of the respective ducts **15** and **16** on stand-off insulators **19** secured to the base **11** as shown in FIG. 3.

Located in each cavity is a metal film resistor **20** having leads **21** and **22**, and a magnetic reed switch **23** having leads **24** and **25**. Lead **21** is connected to bus **18** by any suitable means, such as soldering, and lead **24** is similarly connected to bus **17**. Leads **22** and **25** are connected together so that the resistor **20** and the reed switch **23** are supported in spaced relation and substantially coaxially of the cavity as shown and solely by the electrical connections described above.

As shown best in FIG. 3, an insulated coil form **26** of the flanged bobbin type is held in clamped position between the base **11** and cover **12** within an enlargement of the cavity formed by depressions **13** and **14**. A cylindrical winding **27** wound on the form **26** is spaced preferably in coaxial relation with the reed switch **23**. Leads **28** from the winding **27** are brought out through suitable apertures **29** in the base **11** for connection to an external switching circuit (not shown). A cylindrical conducting shield **30** may be placed in the coil form **26** between the winding **27** and the reed switch **23** and grounded to the base **11** at screw **31** to stabilize the distributed capacitance.

It will be seen that, by suitably energizing the various windings **27**, the reed switches **23** associated therewith may be selectively closed to insert any one or combination of resistors **20** in parallel relation between the busses **17** and **18** to control the attenuation furnished thereby.

The bus **17** extends through an aperture **32** in the housing **10** where it may be electrically connected through a microswitch **33** to the center conductor **34** of a coaxial connector **35** of conventional type which serves as the input connector.

A thermoelement **36** may be housed in a separate thermally lagged compartment **37** secured to the housing **10** and connection made to the input heater terminal **38** by means of a lead **39** extending through an aperture **40** in the housing **10** and connected to bus **18** as clearly shown in FIG. 2.

Although the thermoelement **36** is conventional and forms no part of this invention, it is shown in relation to the attenuator of this invention to illustrate a typical environment, in which the attenuator is used.

In addition to the apertures **29** for the leads **28**, apertures **41** may be provided for each cavity in the cover **12** and opposed to the apertures **29** in the base **11** to provide suitable independent ventilation for each of the windings **27**.

The large thermal mass of the housing **10** provides a substantially constant temperature environment for the attenuator in normal use and the independently supported and spaced relation between the ventilated windings **27** and the reed switches **23** provide good thermal isolation preventing any sudden changes in the environment temperature of the resistors **20**.

It will be understood that, in ordinary AC–DC transfer measurements, both the AC and DC voltages are measured under substantially identical conditions so that the *absolute* values of the resistors **20** are of no significance so long as they are the same for both AC and DC functions of the same transfer operation.

The parallel array of the cavities combined with the rigid coaxial spacing of the circuit elements and switching means therefor, in accordance with the teachings of this invention, provide a compact, thermally stable attenuator of low residual reactance especially suitable for the use in making precise AC–DC transfer measurements over a range of AC voltages from 0 to 32 and a frequencies up to 1 mHz.

In this attenuator, successively lower ranges are obtained by switching additional sections in parallel. This has the advantages of eliminating (from the lowest ranges which are most sensitive to reactive effects) the adverse effect of the shunt capacitances introduced through the open contacts on the higher ranges, were a single section used for each range.

Having thus set forth the nature of this invention what is claimed herein is:

1. A variable attenuator comprising: an electrically conductive housing split along a transverse plane to form a base and a cover which, when assembled, form a plurality of independent internal parallel-spaced cylindrical cavities, a pair of internal parallel ducts positioned transversely to said cavities, one at each of the collective common ends of said cavities and communicating therewith, a continuous conducting bust supported in each duct and insulated from the housing, a resistor and a reed switch connected in series circuit relation and supported in coaxially spaced relation within each cavity by rigid conductors secured to said busses, a cylindrical winding associated with each reed switch for magnetic actuation thereof, and means supporting said winding in each of said cavities in spaced relation to the associated reed switch.

2. A variable attenuator according to claim **1**, wherein the means supporting said winding is an insulated flanged bobbin held in clamped position between the base and the cover in each of said cavities.

3. A variable attenuator according to claim **2** wherein opposed apertures formed in the base and in the cover form independent means for ventilating each winding.

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U.S. Cl. X.R.

333—81; 335—152