May 8, 1934. A. G. JENSEN 1,957,538

ELECTRICAL NETWORK

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FIG. 1

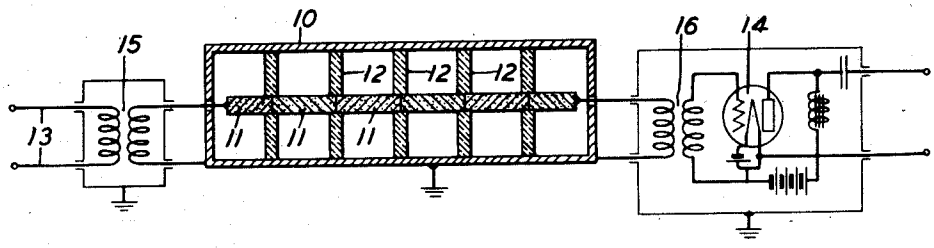
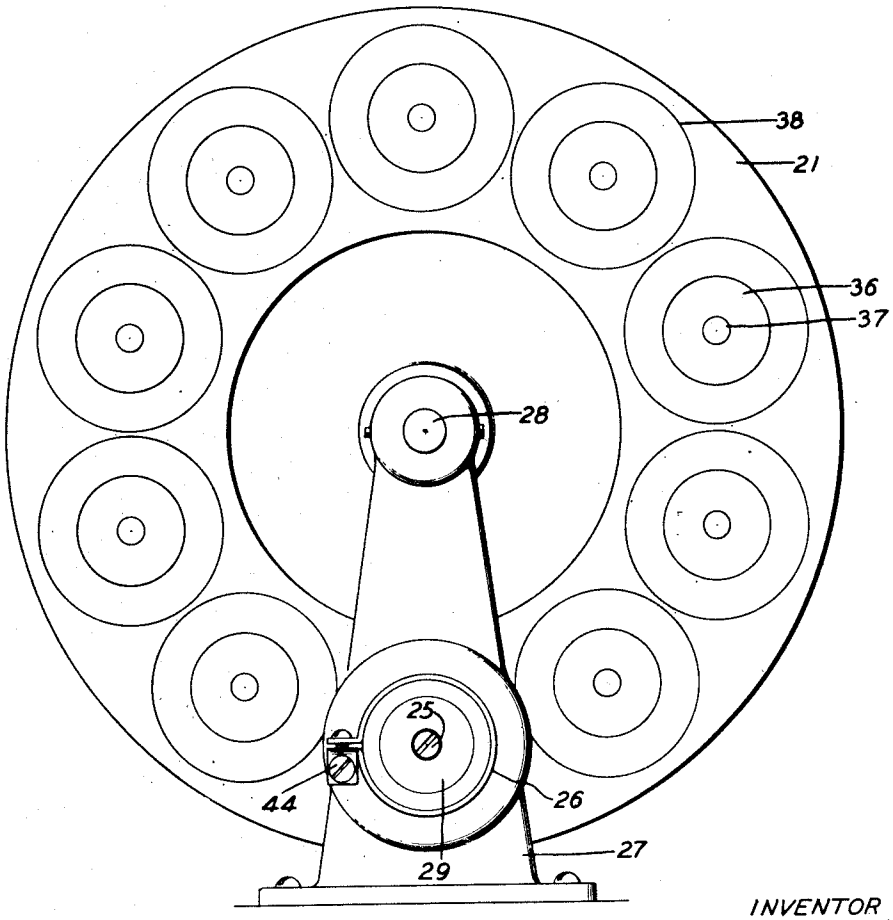


FIG. 3



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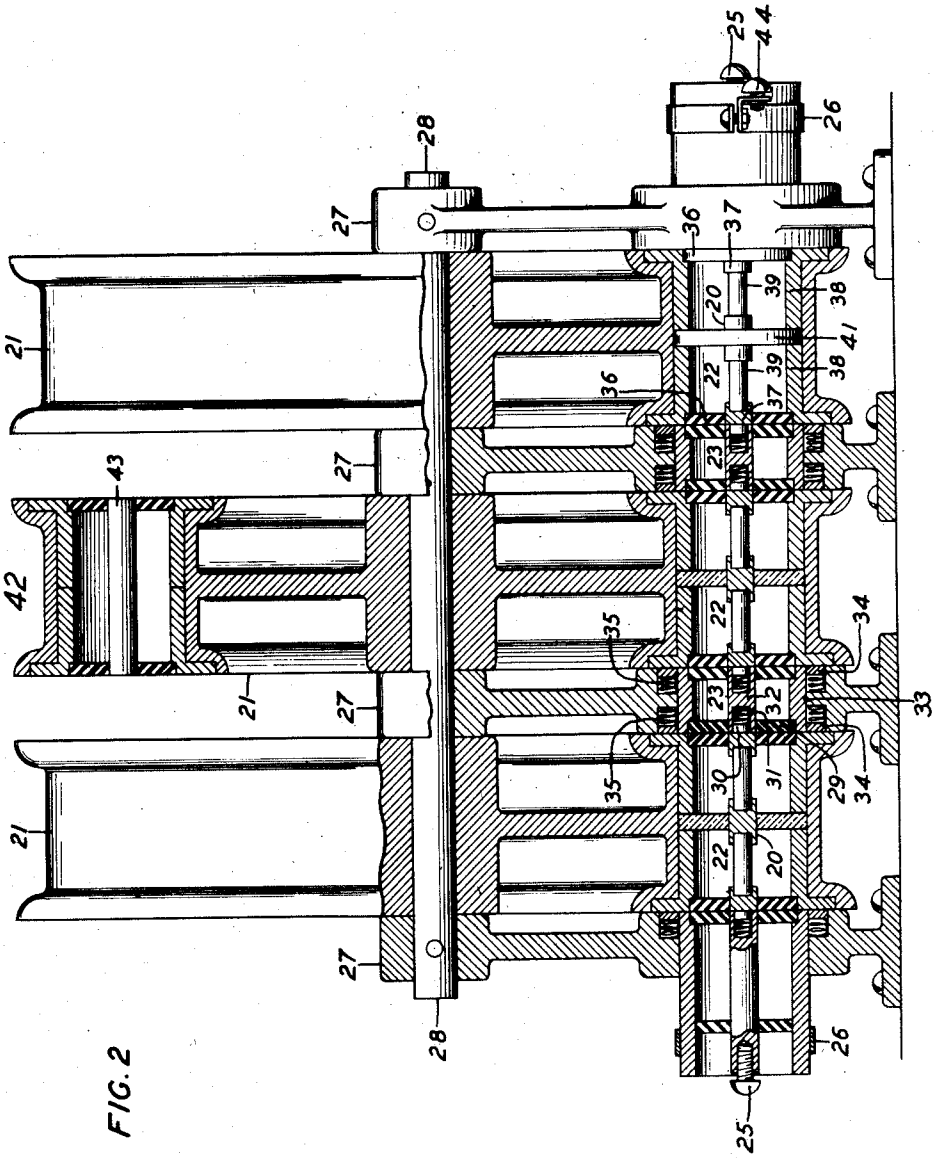

FIG. 2

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UNITED STATES PATENT OFFICE

1,957,538

ELECTRICAL NETWORK

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Application June 13, 1931, Serial No. 544,272

7 Claims. (Cl. 178—44)

This invention relates to electrical networks and more particularly to attenuators adapted for use at very high frequencies.

An object of the invention is to enable high attenuation to be obtained with great accuracy.

Another object is to provide a high degree of electrostatic shielding in attenuating devices.

A further object is the elimination of leakage impedances in an attenuator which would tend to act as by-passing paths reducing the attenuation of the device.

A feature of the invention is the use of a construction resembling a coaxial conductor line, the outer conductor constituting an electrostatic shield within which the attenuating impedances are enclosed.

Another feature is the use of resistance elements as the central conductor of the coaxial system in combination with disc or plate shaped resistors forming shunt impedances between the central and the outer conductors. In this way a multi-stage ladder type attenuating network is provided in which the individual stages are electrostatically shielded from each other.

A further feature of the invention is the adaptation of the coaxial construction to a variable attenuator in which the property of complete electrostatic shielding is maintained.

As an example of the effect of leakage impedances in an attenuator when used at high frequencies it is of interest to consider the case of a network designed to give an attenuation of 100 decibels when inserted in a line of 100 ohms impedance. At a frequency of 100 kilocycles per second, a leakage capacity of 0.159 micro microfarads between input and output terminals will pass as much current as does the attenuator, thus reducing the attenuation by 6 *db* to 94 *db* and a capacity as small as 0.0195 micro microfarads will reduce the attenuation by 1 *db* to 99 *db*.

The invention will be more fully understood by reference to the following detailed description in connection with the drawings in which:

Fig. 1 illustrates the invention schematically and shows the manner of its connection into an electric circuit;

Fig. 2 shows the embodiment of the invention in a variable attenuator; and

Fig. 3 shows an end view of the attenuator of Fig. 2.

In Fig. 1 the attenuating device, which is shown schematically, comprises an outer conducting tube 10 within which are disposed a plurality of series resistors 11 and a plurality of resistors 12 forming shunt paths between the junction points of the series resistors and the outer conductor. The resistors 11 are preferably of rod form and may consist of rods of insulating material, glass or porcelain or the like, coated with a thin film of metal. Resistors 12 are of similar type in disc or plate form and should be of such size and shape as to fill the cross section of the tube.

In use the central resistors 11 constitute the line conductor and the outer conductor 10, the return path. When the outer conductor is grounded or otherwise fixed in potential it acts as an electrostatic shield between the resistors and other apparatus. To make the shielding more complete the ends of the outer conductor may be partially closed as shown in the figure. The shunt resistors 12 moreover act as electrostatic shields preventing direct capacity effects between the several stages.

The figure shows the device connected between a line 13 and a shielded amplifier 14 through shielded transformers 15 and 16, the connections being made on one side to the outer ends of the terminal series resistors 11 and on the other side to the shielding conductor 10.

The units of each decade group are assembled in a metallic drum or wheel 21, the rim of which is drilled with a number of holes parallel to the axis of the drum to receive the units. The drums are mounted on a shaft 28 supported by metallic brackets 27 from a common base. The brackets 27, besides supporting the shaft also carry coupling means for connecting selected units of the decade groups in tandem. For this purpose each bracket includes near its base an enlarged portion which is drilled with a hole corresponding to the holes in the peripheries of the drums. In these holes are inserted the coupling elements each of which comprises an outer metallic tube 33, a central conductor 32 and a pair of insulating and spacing discs 29. The central conductor 32 is arranged to make contact with the ends of the series resistors 39 and to insure that good electrical connection is obtained the ends are recessed to receive springs 31 and plungers 30 which bear firmly on the terminal caps of the series resistors.

To insure good contact with the outer conductors of the attenuator units a similar arrangement is adopted. The enlarged portion of the bracket is recessed on both sides around tube 33 to accommodate contact rings 34, pressure on which is maintained by a plurality of springs 35 disposed at intervals around the recess.

In the end brackets a modification of the coupling means is provided to permit connection of

the attenuator to other apparatus, the tubular element and the central conductor being extended beyond the bracket in the manner shown. The ends of the extended inner conductors are drilled and tapped to receive a screw or binding post 25 and a ring clamp 26 is provided on the outer conductor on which is mounted a terminal screw 44.

In the variable device shown in Figs. 2 and 3, unit attenuators are used each constituting a symmetrical T-network comprising a pair of centrally located series resistances 39 and a shunt resistance 41 in the form of a circular plate. Connection between the series and the shunt resistances is made by means of a recessed metallic bushing 20 which passes through a centrally located hole in the shunt resistor 41, the series resistors fitting into recesses in the ends of the bushing. On the outer ends of the series resistors are placed metallic caps 37 which serve as supporting means and as means for making electrical contact. The outer conductor comprises in part a pair of flanged tubes 38, the inner ends of which butt against the circumferential edge of resistor 41 making contact therewith. The outer ends of tube 38 are closed by insulating discs 36 which are perforated at the center to take the end caps of the series resistors.

These unit attenuators are combined in groups of 10, the units of each group being graded in attenuation in proportion to the number zero to nine. Three groups are used, providing a decade system by means of which a range of variation from zero to 1000 in unit steps can be obtained. Preferably the unit steps should correspond to an attenuation of one-tenth decibel. A zero attenuation unit is shown in section at 42; this differs from the other units in the omission of the shunt resistor and the substitution of a metallic conductor 43 for the series resistors.

In operation, adjustment of the attenuation is accomplished by rotating the drums until units giving the desired value of attenuation are brought into axial alignment with the coupling sections. The aligned sections then constitute a multisection line of the concentric conductor type as shown schematically in Fig. 1. Any suitable indexing arrangement, various types of which are well known, may be used for indicating the attenuation introduced by each section.

More drums may be added if a larger range of attenuation is to be covered, or if finer gradations are required. Other groupings of the units than the decade system may also be used if desired.

What is claimed is:

1. An attenuation network comprising a tube of electrically conductive material, a plurality of longitudinal resistance elements arranged in serial order and concentrically located therein, and a separate shunt resistance connected between the said tube and each junction point formed by said longitudinal elements.

2. An attenuation network comprising a tube of electrically conductive material, a longitudinal resistance element concentrically located therein, the said element comprising a plurality of sections arranged end to end, and a plurality of shunt resistances each connected between the junction of adjacent sections of the said longitudinal resistance element and the wall of the said tube.

3. An electrical network comprising a tubular conductor and a plurality of resistance elements within said conductor disposed in series-shunt relation to form a ladder-type line, the series resistance elements being disposed along the axis of said tubular conductor and the shunt resistance elements having a form symmetrical about the axis of said conductor and connecting the junction points of the series resistors with said conductor.

4. A variable attenuator comprising a drum, a plurality of graduated attenuator units disposed about said drum, the axes of said units being parallel with the axis of said drum and passing through a point on the circumference of a circle whose center is concentric with the center of said drum, each of said attenuator units comprising a tubular conductor and a plurality of resistance elements within said conductor disposed in series-shunt relation to form a ladder-type line, the series resistance elements being disposed along the axis of said tubular conductor and the shunt resistance elements having a form symmetrical about the axis of said conductor and connecting the junction points of the series resistors with said conductor, a pair of input terminals, a pair of output terminals and means for connecting between said input terminals and said output terminals any one of said attenuator units.

5. A variable attenuator comprising a plurality of drums, a plurality of graduated attenuator units disposed about each of said drums at points equidistant from the center of said drum, the axes of said units being parallel with the axis of said drum, each of said attenuator units comprising a tubular conductor and a plurality of resistance elements within said conductor disposed in series-shunt relation to form a ladder-type line, the series resistance elements being disposed along the axis of said tubular conductor and the shunt resistance elements having a form symmetrical about the axis of said conductor and connecting the junction points of the series resistors with said conductor, a pair of input terminals, a pair of output terminals and means for connecting between said input terminals and said output terminals various combinations of said attenuator units.

6. An electrical attenuator comprising a cylindrical conductor and a plurality of resistance elements within said conductor arranged in series-shunt relation to form a ladder-type line, the series resistance elements being disposed along the axis of said cylindrical conductor, and the shunt resistance elements being discs connecting the junction points of the series resistance elements with said cylindrical conductor.

7. An electrical attenuator of the ladder type comprising a tubular conductor and a plurality of resistors within said conductor arranged in series-shunt relation, the series resistors being disposed along the axis of said conductor and the shunt resistors having a form symmetrical about the axis of said conductor and connecting the junction points of the series resistors with said conductor, said resistors being composed of insulating material coated with a thin layer of conducting material.

AXEL G. JENSEN.