

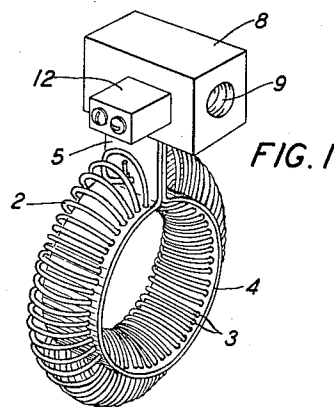
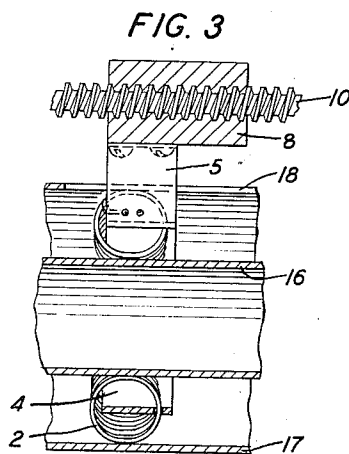
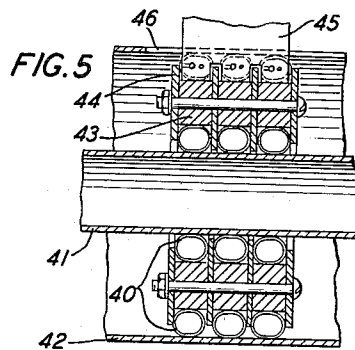
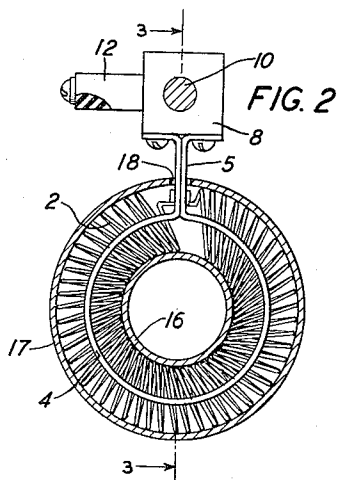
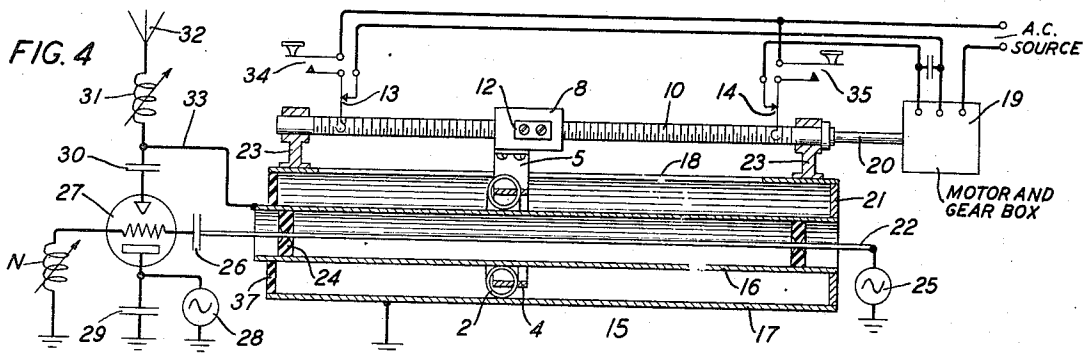
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A. B. THOMAS

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BRIDGING CONDUCTOR

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INVENTOR
A. B. THOMAS

BY B. F. Stoddard
ATTORNEY

UNITED STATES PATENT OFFICE

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BRIDGING CONDUCTOR

Alton B. Thomas, Morristown, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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4 Claims. (Cl. 178-44)

This invention relates to improvements in bridging conductors for electrically connecting two or more metallic surfaces and, more particularly, for short-circuiting the elements of adjustable coaxial line tuners.

This application is a continuation in part of my earlier application, Serial No. 411,032, filed September 16, 1941, for improvements in Bridging conductors.

Objects of the invention are to improve the mechanical operation of adjustable short-circuiting bridging conductors in coaxial line tuners; to increase the current carrying capacity of such bridging conductors; to maintain uniformity of the current distribution in bridging conductors; and to diminish arcing at points of contact.

In the use of sections of coaxial transmission lines as adjustable tuning elements in high frequency circuits, difficulties have been encountered in the design and construction of short-circuiting bridging conductors which could be moved with equal facility at all positions in the adjustment range and which, at the same time, would provide a uniformly low short-circuit impedance and a high current carrying capacity. In particular, where high powers are involved and large currents are carried by the short-circuiting bridge, it has been found difficult to avoid arcing at the points of contact with consequent burning of the contact surfaces.

The present invention avoids these difficulties by constructing the bridging conductor in the form of a helix of spring wire having closely spaced turns of relatively small diameter wire, the diameter of the turns being slightly greater than the distance between the conductors to be short-circuited. The helix is bent into the form of a torus and is held loosely in this form by a suitable guide or retainer. When inserted in the coaxial line, the helix accommodates itself to the restricted space by the angling of the planes of the individual turns with respect to the axis of the helix. This angling is facilitated by the close spacing of the turns. The use of relatively large turns of small diameter wire gives the construction a resilience which insures uniform contact with the surfaces of the coaxial conductors at all points. The wire may be of Phosphor bronze for resilience and may be plated with silver to increase its electrical conductivity.

The retainer or guide, which holds the helix in the toroidal form, provides the means by which the bridging conductor may be moved lengthwise of the line for tuning purposes. The coiled spring is so held by the retainer that only its movement

in the direction of the axis of the line is restrained, the individual turns being held loosely so that there is little or no restraint on the angling of the planes of the turns or in the communication of movement from one turn to another. Various constructions of holders accomplishing these objects are described hereinafter.

These and other features of the invention are more fully explained in connection with the following detailed description of the invention with reference to the drawing in which:

Figs. 1, 2, and 3 illustrate one embodiment of the invention, Fig. 1 showing the construction of the bridging conductor and Figs. 2 and 3 being respectively transverse and longitudinal sectional views of the assembly of the bridging conductor in a coaxial line;

Fig. 4 illustrates the application of the device, shown in Figs. 1, 2 and 3, in the circuits of an adj-

Fig. 5 illustrates an alternative form of the invention.

Referring to Figs. 1, 2, and 3, the short-circuiting device there illustrated comprises a helical metallic spring 2 held in the form of a torus by a retaining ring 4 which is attached to a carrier nut 8 by an integral radial bracket 5. The retaining ring 4 has the form of a short cylinder provided with a series of equally spaced holes close to one edge through which the turns of the spring are threaded. The spring occupies the interspace between the two concentric conductors 16 and 17 of a coaxial line section, the plane of the torus being perpendicular to the axis of the line. Bracket 5 extends outwardly through an axial slot 18 in outer conductor 17 to permit adjustment of the position of the short-circuiting device lengthwise of the line. Adjustment is effected by means of a rotatable lead screw 10 on which nut 8 rides and which may be mounted as shown in Fig. 4 in fixed relation to the coaxial line section and parallel to its axis.

Spring 2 is wound in a helix having a diameter slightly greater than the radial distance between the surfaces of conductors 16 and 17 and should be constructed of relatively small diameter wire wound in closely spaced turns. It accommodates itself to the restricted space between the line conductors by the angling of the individual turns relatively to radial planes of the line section in the manner shown in Fig. 2. The use of closely spaced turns of small diameter wire facilitates the angling of the planes of the individual turns and provides the spring with substantial resiliency in this respect so that good

contact with the tubular surfaces is maintained. The spring material may be Phosphor bronze wire and to insure conductivity and low contact resistance both the spring wire and the contact surfaces of conductors 16 and 17 may be silver plated. The holes in retaining ring 4 through which the spring is threaded should be slightly larger than the diameter of the spring wire to prevent friction or binding of the wire.

With regard to the choice of the dimensions of the spring in any particular case, a satisfactory design can usually be arrived at by a few experimental trials. However, a few general considerations that have been found to be advantageous will be given. The excess of the diameter of the helix over the radial dimensions of the interspace between the line conductors may be such that, when the helix is inserted into the interspace, the individual turns will be tilted through an angle of from 10 to 25 degrees. The diameter of the spring wire should be such as to insure a resilient resistance of the spring to the tilting deformation sufficient to maintain good electrical contact with the tubular surfaces. The wire should not, however, be so small in diameter that the individual turns can be readily crushed or compressed radially out of their circular form. The spacing of the turns is limited on the one hand by the crowding together of the wires at the inner diameter of the torus, particularly when assembled within the line structure, and on the other hand by the tendency of adjacent turns to brace each other against tilting when the spacing is large. It is advantageous, therefore, to space the turns just enough to avoid contact between adjacent turns at the inner diameter of the torus. It will be understood, of course, that these rules do not establish definite design limits, but are intended merely as general considerations that will insure the proper action of the short-circuiting device. In an actual device that has been used successfully, the dimensions were as follows:

Inside diameter of outer tube.....inches..	3 1/2
Outside diameter of inner tube.....do.....	1 3/4
Separation of tubular surfaces.....do.....	1 1/8
Outer diameter of helical spring.....do.....	1
Number of turns per inch.....	6
Diameter of spring wire.....inch.....	.032
Material.....	Phosphor bronze, silver plated

The angling of the turns of the spring 2 produces in each individual turn an elastic force resisting the deformation. Consequently, all the turns of the spring will exert uniform contact pressure against one surface of each of the concentric conductors 16 and 17 in spite of any irregularities or uneven spots in the surfaces of the conductors thereby preventing arcing and burning of the contact surfaces by large short-circuit currents. This adaptability of the spring to conform to the configuration of the interspace lessens the exactitude required in the construction of the coaxial line section. The construction of the bridging conductor is also advantageous in that it provides a large number of contact points and permits free circulation of air around these contact points to keep them cool.

Fig. 4 illustrates schematically a thermionic amplifier having a coaxial line section connected thereto as a variable inductance and having the bridging conductor of the invention mounted within the line section for movement by motor driven means. The bridging conductor is shown mounted inside a coaxial line section with the

spring 2 short-circuiting the concentric tubular conductors 16 and 17. The two line conductors are held in fixed relationship by a ring 37 of insulating material at one end and by a metal plug 21 attached to the other end of the line section.

A source 25 of signal modulated input voltage is connected by means of conductor 22, which passes through the center of inner conductor 16 and is supported therein by insulators 24, and a condenser 26 to the control grid of an amplifier tube 27. A neutralizing inductance N is also connected to the control grid. A source 28 of plate current is connected to the anode of tube 27 in parallel with a grounded blocking condenser 29. The output circuit of the amplifier extends from the cathode of tube 27 through a blocking condenser 30 and inductance 31 to the antenna 32. The circuits for providing grid bias and for heating the cathode have been omitted for the sake of simplicity.

The coaxial conductors 16 and 17 constitute an inductance which is connected by conductor 33 into the output circuit of the amplifier. This inductance can be tuned by varying the effective length, and consequently the reactance, of the conductors 16 and 17 by adjusting the position of the bridging conductor within the line section. The adjustment is effected by means of the reversing motor and gear box 19 which has its shaft 20 connected to the lead screw 10 journaled in the supports 23-23. The reversing motor is the well-known split-phase capacitor type and is operated from an alternating current source under the control of non-locking push-button switches 34 and 35. Switches 34 and 35 can be manually operated alternatively to effect a reversal in the direction of the rotation of the lead screw 10 by reversing the direction of the path from the alternating current source to the motor input terminals in a manner that is apparent from inspection of Fig. 4.

The rotation of the lead screw 10 drives the nut 8 longitudinally thereby effecting the movement of the bridging conductor back and forth within the coaxial line along a path of travel defined by the slot 18 cut in the surface of the outer conductor 17. The limits of this path of travel are determined by the limiting contacts 13 and 14 which are adapted to be alternatively operated by a tripping block 12, carried by nut 8, whenever handle 5 approaches either end of slot 18. Operation of either contact 13 or 14 opens the motor energizing circuit thereby stopping the motor. Thus, by alternative operation of the switches 34 and 35, the effective length and reactance of the coaxial line section can be adjusted empirically to obtain the optimum inductive tuning effect.

Fig. 5 illustrates a modified form of the bridging conductor having six helical coiled springs 40 of electrically conductive material for providing a large number of contact points for carrying large short-circuit currents without arcing and consequent burning of the contact surfaces. This form of the invention is also advantageous where the ratio of the concentric conductor diameters is large, for example greater than two. The springs 40 are each constructed of relatively small diameter wire helically wound in closely spaced turns and they are held in toroidal form by constraining means comprising four metallic retaining rings 44 separated by three metallic carrier rings 43, the retaining rings 44 being wider than the carrier rings 43. All seven rings are bolted together as shown in Fig. 5 to form constraining

means having three channels on its outer surface and three channels on its inner surface, the bottom of each channel being constituted by one of the carrier rings 43 and the two sides of each channel being constituted by two of the retaining rings 44. Thus, these six channels serve as receiving and constraining means for receiving the six springs 40 and for holding each spring in the form of a torus.

This assembly of rings and springs is inserted into the interspace existing between the concentric conductors 41 and 42 in such fashion that the three toroidal springs in the inside channels encircle the inner conductor 41 while the three springs in the outside channels contact the outer conductor 42. A handle 45 is attached to the assembly of rings by any suitable means and is adapted to project through a narrow longitudinal slot 46, cut in the side of the outer conductor 42, for moving the assembly of rings and springs back and forth in the interspace.

In selecting the dimensions of the springs 40, the considerations discussed above should be followed so that the springs in the inner channels will have a helical diameter that is slightly greater than the radial distance between the outer surface of the inner conductor 41 and the inner surface of the carrier rings 43 while the springs in the outer channels will have a helical diameter that is slightly greater than the radial distance between the outer surface of the carrier rings 43 and the inner surface of the outer conductor 42. By following the other considerations discussed above in connection with Figs. 1 to 3, inclusive, the springs will be able to adjust this diametrical inequality by angling their respective turns relative to planes normal to their respective circular axes. This angling is further facilitated by the channels being sufficiently large to hold the springs without cramping them or otherwise restricting them except in respect to the axial direction of the coaxial line. As in the preceding example, the elasticity of the springs will cause each turn to attempt to restore itself to the position in which it was before the angling took place. This causes the turns in each spring to exert uniform pressure at all points of contact.

It is to be understood that the number of springs used in the modified form of the bridging conductor can be varied in accordance with the current carrying requirements of a particular circuit. For example, the requirements of some circuits might be satisfied by using an assembly of just one pair of toroidal springs, one spring being in an outer channel of the constraining means and the other spring being in an inner channel.

What is claimed is:

1. A bridging conductor for electrically connecting the outer and inner conductors of a co-

axial line, comprising a helical wire spring having a helix diameter slightly greater than the radial distance between the conductors to be connected, and an annular member having holes therein throughout its entire surface through which the spring is threaded for retaining the spring in the shape of a torus encircling the inner conductor of the line.

2. In combination, a bridging conductor for electrically connecting a conductor of a coaxial line with a concentric electrical conducting surface, said bridging conductor comprising a helical wire spring having a helix diameter slightly greater than the radial dimension of the interspace between the concentric conductors to be connected, a retaining member having holes therein through which the spring is threaded, said retaining member and said spring being adapted to be inserted into said interspace, the diameter of the wire of said spring and the spacing of the turns being such that the spring is deformed elastically by tilting of the individual turns in adjusting itself to the radial dimension of said interspace, and means for adjusting the position of the spring longitudinally within said interspace.

3. In a tuner comprising a coaxial line section having inner and outer conductors, adjustable short-circuiting means for electrically bridging said conductors comprising a helical wire spring having a helix diameter slightly greater than the radial distance between said conductors, said helical spring encircling the inner conductor and in direct contact with both conductors, an annular element of diameter intermediate the diameters of the line conductors, said annular element engaging and holding the turns of said spring at a plurality of spaced points, and means for moving said annular element longitudinally within the conductor interspace to vary the effective length of the line section.

4. In a tuner comprising a coaxial line section having inner and outer conductors, adjustable short-circuiting means for electrically bridging said conductors comprising annular retaining means of diameter intermediate the diameters of the line conductors, a helical wire spring having a helix diameter slightly greater than the radial distance between said conductors, said annular retaining means having a plurality of apertures therein receiving and engaging turns of the spring for loosely holding the spring in the form of a torus encircling the inner conductor and in direct contact with both conductors, and means for moving said annular retaining means back and forth along the axis of the coaxial line section for varying the effective length of the line section.

ALTON B. THOMAS.