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TUNING PLUNGER FOR A COAXIAL LINE
TYPE ULTRAHIGH-FREQUENCY CIRCUIT
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FIG. 1

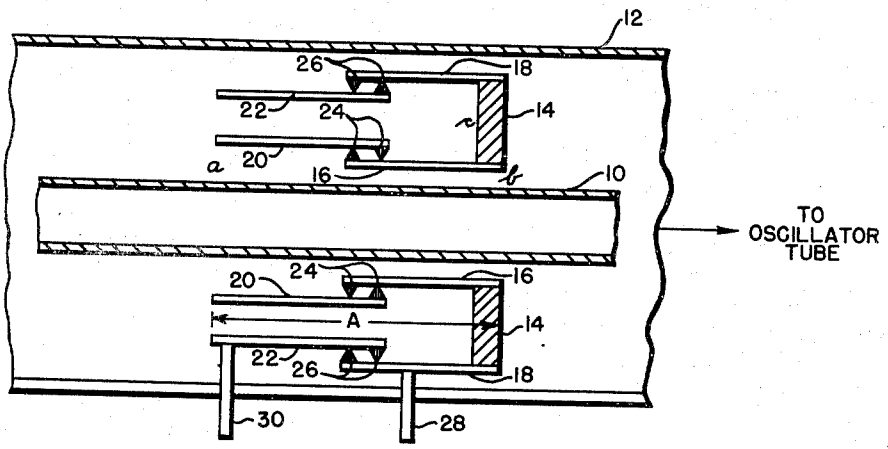


FIG. 2

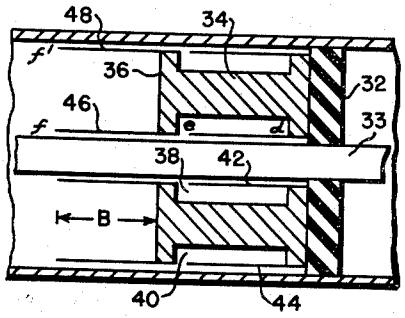


FIG. 3

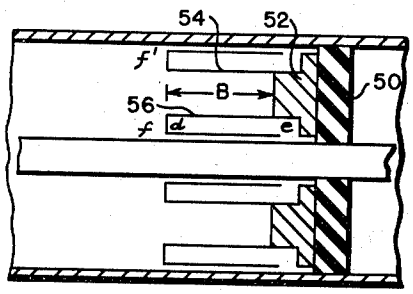
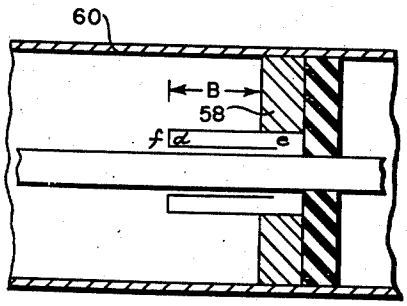


FIG. 4



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TUNING PLUNGER FOR A COAXIAL LINE TYPE ULTRAHIGH-FREQUENCY CIRCUIT

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11 Claims. (Cl. 333—97)

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This invention relates generally to electrical apparatus and more particularly to a means for adjusting the dimensions of a resonant coaxial cavity for tuning purposes.

In some types of radio apparatus employed at high frequencies use is made of resonant cavities to simulate equivalent circuit elements for tuning purposes. Some means is necessary to vary the dimensions of such a cavity so as to change its frequency of maximum response. If a cylindrically shaped cavity or one in the form of a coaxial transmission line is employed, the means of varying its dimensions ordinarily consists of a plunger or plug the position of which may be varied along the longitudinal dimension of the cavity. When such a cavity is used in conjunction with a vacuum tube, it is frequently desirable to have the shorting plunger offer an effective short circuit for the radio frequency energy and at the same time maintain an open circuit for direct voltage. This is necessary so that the plate voltage of the vacuum tube will not be short circuited if the cavity is used to form a tuned plate circuit. At the same time it is desirable to maintain a low capacity between the plate circuit and ground, suitable for wide band modulation.

It is therefore an object of the present invention to provide a means of tuning a resonant coaxial cavity over a wide range of frequencies. It is a further object to provide a means of isolating the inner and outer conductors of such a cavity insofar as direct voltages are concerned without employing a physically large, high-current capacitor. It is still another object to maintain a low capacitance between the inner and outer conductors of such a cavity. It is also an object to eliminate the necessity of using sliding contacts between a shorting plunger and a tunable cavity of the type mentioned.

Other objects, features and advantages of the invention will suggest themselves to those skilled in the art and will become apparent from the following description of the invention taken in connection with the accompanying drawing in which:

Fig. 1 is a longitudinal sectional diagram of a type of tuning plunger embodying the basic principles of the invention;

Fig. 2 is a longitudinal sectional diagram of a second type of tuning plunger incorporating a second means of obtaining a broad frequency response; and

Figs. 3 and 4 are longitudinal sectional diagrams of preferred embodiments of the invention incorporating substantially the same principles as the embodiment shown in Fig. 2.

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Reference is made now more particularly to Fig. 1, in which a cavity formed by an inner conductor 10 and an outer conductor 12 is terminated by a metal plate 14, which forms a part of the tuning plunger. Plate 14 is an annulus of such dimensions that it fits in the cavity without making electrical contact with either conductor 10 or conductor 12. Two metallic cylinders 16 and 18 are attached to the inner and outer peripheries, respectively, of plate 14 and extend for a short distance behind this plate. Two similar metallic cylinders 20 and 22, of such diameters that they fit within cylinders 15 and 16 as shown, are arranged so as to permit them to be moved in and out of the latter cylinders while making electrical contact with them by means of sliding contacts 24 and 26. The position of the plunger may be varied by means of arm 28 rigidly attached to cylinder 18 and extending outside the cavity through a longitudinal slit in conductor 12. The position cylinders 20 and 22 may be varied by a similar arm 30 arranged in a similar manner.

In Fig. 2 the metallic portion of the plunger is rigidly attached to an annulus 32 of an insulating material mounted on central conductor 33. An annular metallic conductor 34, of which one face 36 serves to terminate the coaxial cavity, has circumferential indentations 38 and 40 on its inner and outer surfaces, respectively, which are partially covered, as shown, by thin metallic cylindrical sleeves 42 and 44. Two similar cylindrical sleeves 46 and 48 are attached respectively to the inner and outer peripheries of face 36 and extend longitudinally into the cavity.

Fig. 3 shows a similar arrangement in which an insulating annulus 50 supports a conducting annulus 52 to which are attached two cylindrical sleeves 54 and 56. Cylindrical sleeves 54 and 56 are bent back through 180° as shown to form a total of four coaxial cylinders.

Fig. 4 shows an arrangement similar to that shown in Fig. 3. One double cylindrical sleeve has been removed, and the conducting annulus 58 makes direct electrical contact with the outer conductor 60 of the cavity.

In understanding the operation of the apparatus of Fig. 1 it may be seen that inner conductor 10 together with cylindrical sleeves 16 and 20 may be considered to be a section of electrical transmission line of rather low characteristic impedance. If this section of line is one-fourth wave length long at the operating frequency and is terminated with a very high impedance at point *a*, the input impedance at point *b* will be very low, in effect a short circuit. The imped-

ance presented to this section of line at point *a* is in effect made up of the impedance of the cavity to the left of point *a* in series with the impedance of the section of short circuited transmission line made up of cylindrical sleeves **16**, **18**, **20** and **22**. If this section of line is also approximately one-fourth wave length long and is short circuited at *c*, it appears as a high impedance at *a*, and consequently the impedance at *b* is low. This arrangement also applies to the section of transmission line made up of cylindrical sleeves **18** and **22** and the outer conductor **12** of the cavity.

It is obvious from the above description that an effective short circuit is maintained at *b* only so long as the distance A in Fig. 1 is approximately one-fourth wave length. In order to make use of such a device over a large frequency range, the length A is made adjustable by sliding cylinders **20** and **22** inside of cylinders **16** and **18**. Electrical contact is maintained by sliding contacts **24** and **26**. The position of the plunger and the magnitude of dimension A may be adjusted from outside the cavity by means of arms **28** and **30** respectively, which, if desired, may be attached to the same tuning control.

If it is desired to cause the tuning plunger to be operative over a wide band of frequencies without utilizing two separate tuning adjustments, an arrangement of the type shown in Fig. 2 may be employed. Annulus **34** and cylindrical sleeve **42** form a section of coaxial transmission line short-circuited at *d*. If the electrical length of this line is one-fourth wave length, then an effective high impedance is presented at point *e*. A second equivalent transmission line is formed by cylindrical sleeve **42** and central conductor **33**. The impedance of this line in series with the high impedance at *e* appears across, and in effect terminates, a third transmission line formed by cylindrical sleeve **46** and central conductor **33**. Thus if the electrical distance from point *e* to point *f* is one-fourth wave length, then the impedance presented at point *f* will be quite low. In a similar manner the impedance presented at point *f'* is low. Face **36** of the tuning plunger is displaced from points *f* and *f'* by a distance B. A dual resonant characteristic is introduced into the plunger by choosing dimension B and the distances between points *d* and *e* and between points *e* and *f* to be equal to one-fourth wave length at widely different frequencies. The importance of maintaining an extremely low impedance at points *f* and *f'* has been materially reduced by displacing these points a distance B which is an appreciable part of one-fourth wave length from the face **36** of the plunger. The effect of this procedure is to place points *f* and *f'* at a position in the coaxial cavity which is of somewhat higher impedance, that is, a point of higher voltage and lower current. The operation thus becomes effective over a wide range of frequencies.

Fig. 3 shows a plunger operating on the same principles as the plunger of Fig. 2 except that the various elements are arranged in a different manner which makes the plunger more compact.

Fig. 4 shows a plunger in which a direct sliding contact is made between the outer conductor and the plunger, and which utilizes the principles set forth above to obtain a low impedance between the central conductor and the plunger.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention.

The invention claimed is:

1. In combination with a coaxial line cavity resonator, a tuning plunger for electrically tuning said coaxial cavity resonator, said plunger including an insulating annulus so arranged as to fit between the inner and outer conductors of said coaxial cavity resonator, the axis of said annulus being parallel to the axis of said cavity resonator; a conducting annulus having one end attached to said insulating annulus and having the same axis as said insulating annulus, said conducting annulus not making electrical contact with either the inner or outer conductors of said resonator, said conducting annulus having circumferential indentations upon both its inner and outer surfaces, the axial length of each such indentation being approximately one-fourth of an electrical wave length at a first given frequency; a first pair of conducting concentric cylinders coaxial about the axis of said resonator and connected to said one end of said conducting annulus, said first pair of cylinders partially covering the inner and outer circumferential indentations respectively of said conducting annulus; and a second pair of conducting concentric cylinders coaxial about the axis of said resonator and attached to the inner and outer circumferences respectively of said conducting annulus at its other end, said second pair of cylinders extending beyond said other end of said conducting annulus for an axial distance that is approximately equal to one-fourth of an electrical wave length at a second given frequeney, the position of said plunger being variable with respect to said resonator.

2. In combination with a coaxial line cavity resonator, a tuning plunger for electrically tuning said coaxial cavity resonator, said plunger including an insulating annulus so arranged as to fit between the inner and outer conductors of said cavity resonator, the axis of said annulus being parallel to the axis of said cavity resonator; a conducting annulus attached to and having the same axis as said insulating annulus, said conducting annulus not making electrical contact with either the inner or outer conductors of said coaxial cavity resonator; and four conducting cylinders coaxial about the axis of said resonator, two of said cylinders being connected to said conducting annulus along the circumferences of one end of each, the opposite ends of each of said two of said cylinders being connected along the entire circumferences thereof to the ends of the remaining two of said cylinders which are remote from said conducting annulus, the position of said plunger being variable with respect to said resonator, the lengths of said cylinders being approximately one-fourth of an electrical wave length at a first given frequency, and said cylinders extending beyond said conducting annulus for a distance approximately equal to one-fourth of an electrical wave length at a second given frequency.

3. In combination with a coaxial line cavity resonator, a tuning plunger for electrically tuning said coaxial cavity resonator, said plunger including an insulating annulus so arranged as to fit between the inner and outer conductors of said cavity resonator, the axis of said annulus being parallel to the axis of said cavity resonator; a conducting annulus attached to and having the same axis as said insulating annulus; a series of sliding contacts along the outer circum-

ference of said conducting annulus and making electrical contact with the outer conductor of said resonator; and two conducting cylinders coaxial about the axis of said resonator, the outer of said cylinders being connected along the circumference of one end to the inner circumference of said conducting annulus, the opposite end of said cylinder extending beyond said annulus to a distance approximately equal to one-fourth of an electrical wave length at a first given frequency, said opposite end of said outer cylinder being attached along its circumference to one end of the other of said cylinders, said other of said cylinders extending back to and within the central aperture of said conducting annulus, the length of each of said cylinders being approximately one-fourth of an electrical wave length at a second given frequency, the position of said plunger being variable with respect to said cavity.

4. In combination, a first coaxial line and a plunger for short-circuiting said first coaxial line, said plunger including a conducting annular portion of a size to fit between the concentric conductors of said first coaxial line and be spaced from at least one of said conductors, and at least two cylinders concentrically disposed about the center conductor of said first coaxial line and having an axial length that is substantially a quarter of a wavelength at at least one given operating frequency, said cylinders being electrically connected to said conducting annular portion, said concentric cylinders and said one conductor of said first coaxial line forming at least second, third, and fourth coaxial quarter wavelength lines, said second line being formed by one of said cylinders and said one conductor and being open-circuited at a distance substantially a quarter wavelength from said conducting annular portion, said third line being formed by the other of said cylinders and said conducting annular portion and being short-circuited at one end to provide a first high input impedance for said second line, and said fourth line being formed by said other cylinder and said one conductor and being open-circuited and providing a second impedance that is in series with said first high impedance of said third line, said first and second impedances terminating said second line, the end of said second line that is near said conducting annular element thereby having an extremely low impedance.

5. The combination of claim 4, wherein said one conductor is the center conductor of said first coaxial line.

6. In combination, a coaxial line, and a plunger for short-circuiting said coaxial line, said plunger comprising a conductive annular element disposed between the concentric conductors of said coaxial line and electrically insulated from at least one of said conductors, and first and second cylinder elements disposed between the conductors of said coaxial line and coaxially disposed about the center conductor of said coaxial line nearer to said one conductor than to the other of said conductors, one end of said first cylinder element being electrically connected to one end of said annular element, one end of said second cylinder element being electrically connected to the other end of one of the two other of said elements, the lengths of said cylinder elements being respectively equal to approximately one-fourth of an electrical wavelength at a first given frequency, and one end of at least one of said cylinder elements extending beyond a face of said annular element by a distance approximately equal to one-fourth of an electrical wavelength at a second given frequency.

7. The combination of claim 6, wherein said first and second cylinder elements respectively form with said center conductor first and second open-circuited coaxial lines, the first of which provides a high impedance termination for the second, and said first cylinder element and said annular element form a short-circuited coaxial line also providing a high impedance termination for said second open-circuited coaxial line.

8. The combination of claim 7, wherein said annular element is electrically insulated from both said conductors and further including third and fourth cylinder elements connected together like said first and second cylinder elements and being coaxial with and disposed between the conductors of said coaxial line as well as being electrically connected to said annular element, said third and fourth cylinder elements being disposed nearer to said other conductor of said coaxial line than to said one conductor and forming with one another, with said other conductor and with said annular element coaxial lines electrically identical with those formed by said first and second cylinder elements, said annular element, and said one conductor.

9. The combination of claim 6, wherein said first and second cylinder elements respectively form with said center conductor first and second open-circuited coaxial lines, the first of which provides a high impedance termination for the second, and said first and second cylinder elements together form a short-circuited coaxial line also providing a high impedance termination for said second open-circuited coaxial line.

10. The combination of claim 9, wherein said annular element is electrically insulated from both said conductors and further including third and fourth cylinder elements connected together like said first and second cylinder elements and being coaxial with and disposed between the conductors of said coaxial line as well as being electrically connected to said annular element, said third and fourth cylinder elements being disposed nearer to said other conductor of said coaxial line than to said one conductor and forming with one another, with said other conductor and with said annular element coaxial lines electrically identical with those formed by said first and second cylinder elements, said annular element, and said one conductor.

11. The combination of claim 9, wherein said one conductor is the center conductor of the first-named coaxial line, and said annular element is in slidable electrical contact with the other conductor of said first-named coaxial line.

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