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COUPLING DEVICE

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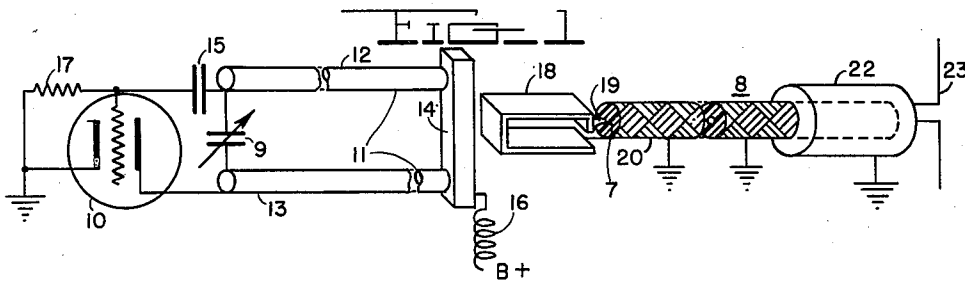


FIG. 2

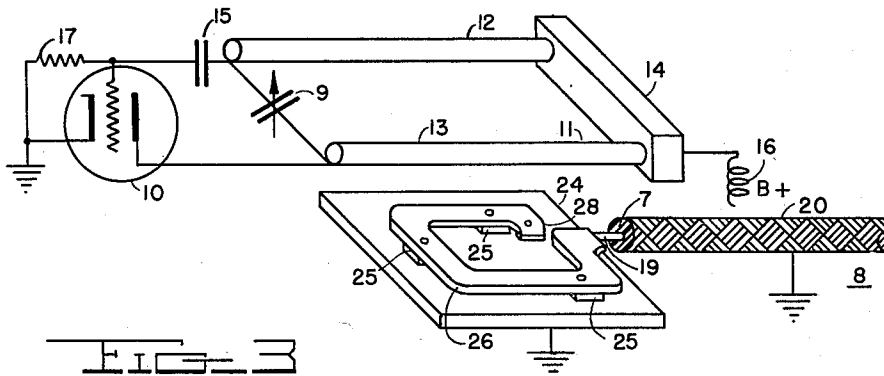


FIG. 3

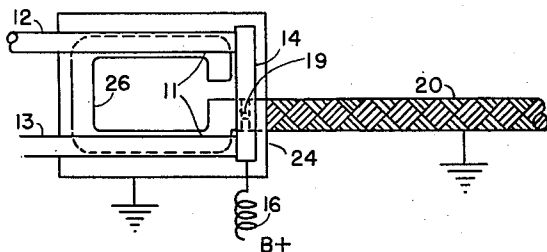


FIG. 5

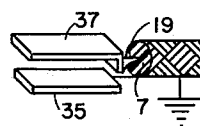
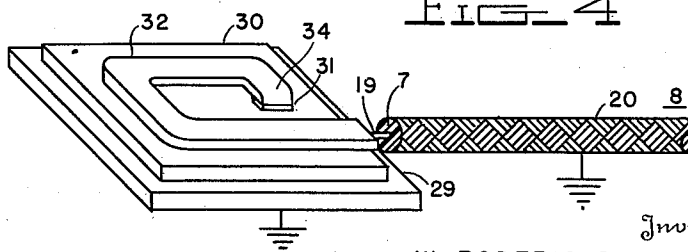


FIG. 4



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COUPLING DEVICE

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This invention relates to the problem of coupling a source of high frequency energy to a low impedance load. The invention is more particularly directed to the problem of coupling a tuned circuit to a low impedance transmission line.

Whereas the invention has many applications, it is of special utility in coupling the tank circuit of a radio transmitter to a low impedance transmission line feeding the antenna.

It is an object of the invention to provide means matching a low impedance transmission line or coupling the line to a high impedance electrical network.

It is a further object of the invention to provide a highly efficient coupling network for feeding a low impedance transmission line.

Yet another object of the invention is to provide means for electrically coupling a low impedance transmission line to another network at high efficiency over a wide frequency band.

It is a more specific object of the invention to provide means for coupling a radio frequency generator to a low impedance transmission line through a coupling device matching the transmission line impedance.

The coupling elements of the present invention are primarily intended for application at high frequency work, where difficulty is encountered in efficiently transferring large amounts of energy from a tuned circuit to a low impedance line.

Coupling elements previously used in this field have been relatively ineffective due largely to the fact that their impedance varies considerably with small frequency variations, and further that their impedance does not match that of the transmission line.

The invention will be further described with reference to the exemplary embodiments shown in the drawing, wherein:

Figure 1 illustrates a circuit diagram, partially schematic, of a high-frequency signal transmitting system employing therein an embodiment of the invention.

Figure 2 shows a transmitter circuit similar to Figure 1 in which another embodiment of the invention is shown in perspective.

Figure 3 illustrates a plan view of a portion of the resonant tank circuit of a transmitter and the modified coupling device shown in Figure 2 in an operating position.

Figure 4 is a perspective view of another embodiment of the invention in which a block of dielectric material separates the loop from a supporting ground plate, and

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Figure 5 is a perspective view of another embodiment of the invention wherein the separated metallic plates form the energy pickup device.

Coupling elements of the present invention may be employed for either electromagnetic or electrostatic coupling. The invention as shown in Figure 1 includes an electromagnetic coupling loop. The source of energy in the system of Figure 1 consists of a resonant circuit which, as shown, is a resonant line section 11. This section comprises line elements 12 and 13 shorted across one end by conductor 14. For excitation the resonant circuit is coupled in an oscillator network, and for this purpose line 13 is connected to the anode of tube 10. Line element 12 is connected through blocking condenser 15 to the grid of tube 10, which is returned to ground through resistor 17. Anode potential is supplied through radio frequency choke 16. The operating frequency may be varied over a range by condenser 9 connected across the open ends of the line section.

The resonant circuit 11 of Figure 1 is coupled to a load, shown as antenna 23, through a low impedance concentric transmission line 8. The impedance of line 8 is matched to that of antenna 23 by transformer section 22. Line 8 therefore constitutes a flat line.

Line 8 is coupled to resonant circuit 11 inductively through loop 18. This loop is specifically constructed to have a characteristic impedance matching that of line 8. Since this eliminates any electrical discontinuity between the coupling element and the line itself, standing waves with their attendant loss of energy are eliminated from the coupling element itself. Further, the characteristic impedance of the coupling element is not dependent upon the frequency of excitation, and consequently maximum coupling may be effected with efficiency over a comparatively wide band. As a result, in a system such as shown in Figure 1, the operating frequency may be varied by condenser 9 without requiring attendant adjustment of the coupling system.

The characteristic impedance of line 8 depends, as is well known, upon the ratio of the diameter of inner conductor 19 to that of outer conductor 20, and upon the dielectric constant of the insulating material 7 interposed between the conductors. In common with two wire line employing solid dielectric, the coaxial line shown has low impedance.

The characteristic impedance of coupling element 18 depends upon the width and spacing of

the elements, and the interposed dielectric constant, substantially according to the formula:

$$Z_0 = \frac{377}{1 + \frac{D}{d}} \cdot \frac{1}{\sqrt{e}}$$

"D" is the width of the conducting strip, "d" is the spacing of the horizontal parallel portions of the strip, and "e" is the dielectric constant of the interposing material. In the embodiment shown in Figure 1 air is employed as the dielectric, having a dielectric constant equal of unity. For the normal range of low impedance lines "D" is larger than "d."

In the system shown in Figure 1, the transmission line coupling element 18 is short-circuited at its end, and has a rectangular formation. If transmission line 8 is assumed to have a characteristic impedance of 50 ohms, the ratio of width to spacing of the coupling element to obtain this value with air dielectric is substantially 6.5. In the drawings for the purpose of clarity of illustration, a smaller ratio is shown.

Another embodiment of the operating principles of the invention is shown in the electro-magnetic coupling element of Figures 2 and 3. As in the system of Figure 1, the energy is derived from a resonant line section 11 and is coupled into a low impedance concentric line 8, which is terminated by a matching load not shown. In this form of the invention the coupling section comprises a flat conductor positioned above a metallic ground plate. In this construction, the characteristic impedance of the coupling element as a transmission line also depends upon the ratio of the width of the conductor to its spacing from the ground plate, and also upon the dielectric constant of the interposed material. Due to the fact that one of the transmission line conductors is effectively extended to form the ground plate, the characteristic impedance differs from that of section 18 shown in Figure 1, and may be found substantially according to the formula:

$$Z_0 = \frac{377}{2 + \frac{D}{d}} \cdot \frac{1}{\sqrt{e}}$$

"D" is the width of the upper transmission line member comprising the flat elongated conductor, and "d" is the spacing between this conductor and the ground plate. "e" is the dielectric constant of the interposed material.

In the embodiment shown in Figure 2 metallic member 24 constitutes the ground plate. The transmission line conductor, which is connected to the inner element of concentric line 8, is shown at 26. This conductor may be curved in its own plane to form a flat loop above the ground plate, as is shown in Figure 2. The upper conductor is positioned above ground plate 24 on insulating blocks 25.

In order to obtain magnetic coupling to the tuned circuit 11 shown in Figure 2, the conductor positioned above the ground plate is connected at its extremity thereto. For this purpose end 28 of conductor 26 is turned downwardly to form an electrical contact with ground plate 24.

As in the system shown in Figure 1, it will be understood that the dimensions and proportions of the coupling element shown in Figure 2 are such as to obtain an impedance match between this element and the concentric line 8, in accordance with the formula given above.

A top elevation view of the system shown in Figure 2 is disclosed in Figure 3. As is preferable

for magnetic coupling, the coupling loop 26 is positioned closely beneath the high current end of the resonant line section 11.

Whereas in the system of Figures 2 and 3 the average dielectric constant of the material interposed between coupling 26 and ground plate 24 may be considered to be substantially unity, in the embodiment shown in Figure 4 a dielectric sheet 30 is interposed between loop 32 and ground plate 29. It will be understood that this effectively lowers the characteristic impedance of the coupling element in accordance with the dielectric constant of sheet 30. Consequently, the use of a dielectric sheet interposed between the coupling loop and the ground plate allows further latitude in the design of the coupling element in order to obtain a match to transmission line 8.

In the system shown in Figure 4, end 34 of the coupling 32 is turned downwardly through aperture 31 in the insulating member 30, and is there electrically connected to the ground plate. Consequently, this coupling element may be used for magnetic coupling in such a system as shown in Figure 2.

An electrostatic coupling element constructed according to the principles of the invention is shown in Figure 5. Such elements differ from those disclosed in Figures 1 through 4 in that the end of the coupling element is not short-circuited and may be capacitatively energized in proximity to a conductor carrying a radio frequency voltage, such as the unshorted end of one of the transmission line members of resonant section 11 shown in Figure 1.

Employment of the coupling section for electrostatic energization does not affect the dimensions of the device. Consequently, the same may be constructed according to the above stated formulae, as a transmission line, or as a flat conductor operating in relation to an extended ground plane. The embodiment shown in Figure 5 constitutes a transmission line section in all respects similar to that of Figure 1, except that it is open at the end. As shown in this figure the coupling elements comprises a pair of flat plates, 35 and 37. Plate 35 is grounded as is the lower member of element 18 of Figure 1 for connection with the external member of the concentric line. Upper plate 37 is directly connected to the central conductor 19 of the line. As in the preceding embodiments, the physical dimensions of the coupling element itself will be selected in accordance with the above noted formulae, and match the concentric lines impedance without electrical discontinuity.

While there has been described preferred embodiments of this invention it is obvious to those skilled in the art that various changes and modifications can be made therein without departing from the spirit of the invention and the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without payment of any royalty thereon or therefor.

I claim:

1. In combination, a low impedance radio frequency transmission line, and a coupling element connected thereto comprising a pair of opposed laterally extended plate conductors, one of said conductors being formed as a flat loop, the other conductor underlying said loop, said conductors having a characteristic radio frequency impedance matching that of the line.

2. In combination, a low impedance radio frequency transmission line having solid dielectric interposed between conducting members, and a coupling element connected thereto comprising a pair of opposed laterally extended plate conductors, one of said conductors being formed as a flat loop, the other conductor underlying said loop, said conductors having a characteristic radio frequency impedance matching that of the line.

3. In combination, a low impedance radio frequency concentric transmission line, and a coupling element connected thereto comprising a pair of opposed laterally extended plate conductors, one of said conductors being formed as a flat loop, the other conductor underlying said loop, said conductors having a characteristic radio frequency impedance matching that of the line.

4. In combination, a low impedance radio frequency transmission line, and an electromagnetic coupling element connected thereto comprising a pair of opposed laterally extended plate conductors forming an electrically closed circuit, one of said conductors being formed as a flat loop and the other of said conductors underlying said loop, said conductors having a characteristic radio frequency impedance matching that of the line.

5. In combination, a low impedance radio frequency transmission line, and an electromagnetic coupling element connected thereto comprising a pair of opposed laterally extended plate conductors forming an electrically closed circuit, one of said conductors being formed as a flat loop, and the other of said conductors underlying said loop and areas within and without said loop, said conductors having a characteristic radio frequency impedance matching that of the line.

6. In combination, a low impedance radio frequency transmission line, and an electromagnetic coupling element connected thereto comprising a pair of opposed laterally extended plate conductors forming an electrically closed circuit, one of said conductors being formed as a flat loop, and the other of said conductors forming a conducting sheet underlying the loop area and extending beyond the same, and a solid dielectric interposed between the two conductors, said conductors having a characteristic radio frequency impedance matching that of the transmission line.

7. In combination, means for generating a high frequency magnetic field, a low impedance transmission line, and an electromagnetic coupling element connected thereto comprising a pair of opposed laterally extended plate conductors, one of said conductors being formed as a flat loop, said conductors forming an electrically closed circuit and having a characteristic radio frequency impedance equal to that of the transmission line, said coupling element being positioned within said field.

8. In combination, an oscillation generator including a resonant line, a low radio frequency impedance coaxial transmission line having inner and outer conductors defining a space of annular cross section therebetween, a solid dielectric filling said space, and a coupling device disposed in magnetically coupled relationship with the resonant line and having an impedance equal to the characteristic radio frequency impedance of the transmission line, the coupling device comprising two flat conductive plates arranged in closely spaced parallel planes, one conductive

plate being connected to the inner conductor of the coaxial line and the other plate being connected to the outer conductor, the conductive plates being connected together at a point removed from the connection with the transmission line, whereby there is maximum energy transfer to the coaxial transmission line.

9. In combination, a low impedance radio frequency two conductor transmission line having a region between the conductors, a solid dielectric filling said region, capacitative space coupling means therefor consisting of a first laterally extended plate conductor connected to one transmission line conductor, a second laterally extended plate conductor opposed to the first in spaced relationship and connected to the other transmission line conductor, and insulation means interposed between the plate conductors of a dielectric constant establishing their characteristic radio frequency impedance at a value matching that of the transmission line.

10. In combination, a low impedance radio frequency two conductor transmission line having a region between the conductors, a solid dielectric filling said region, space coupling means therefor consisting of a first laterally extended plate conductor connected to one transmission line conductor, a second laterally extended plate conductor opposed to the first in at least partially spaced relationship and connected to the other transmission line conductor, and insulation means interposed between the plate conductors of a dielectric constant establishing their characteristic radio frequency impedance at a value matching that of the transmission line.

11. The structure defined in claim 10 further including a resonant circuit positioned in exciting relation to said coupling means.

12. In combination, a low impedance radio frequency two conductor transmission line having a region between the conductors, a solid dielectric filling said region, space coupling means therefor consisting of a first laterally extended conductor connected to one transmission line conductor, a second laterally extended plate conductor larger than the first extended conductor and affording a ground plane with respect thereto and in at least partially spaced relation therewith, and insulation means interposed between the extended conductors of a dielectric constant establishing their characteristic radio frequency impedance at a value matching that of the transmission line.

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