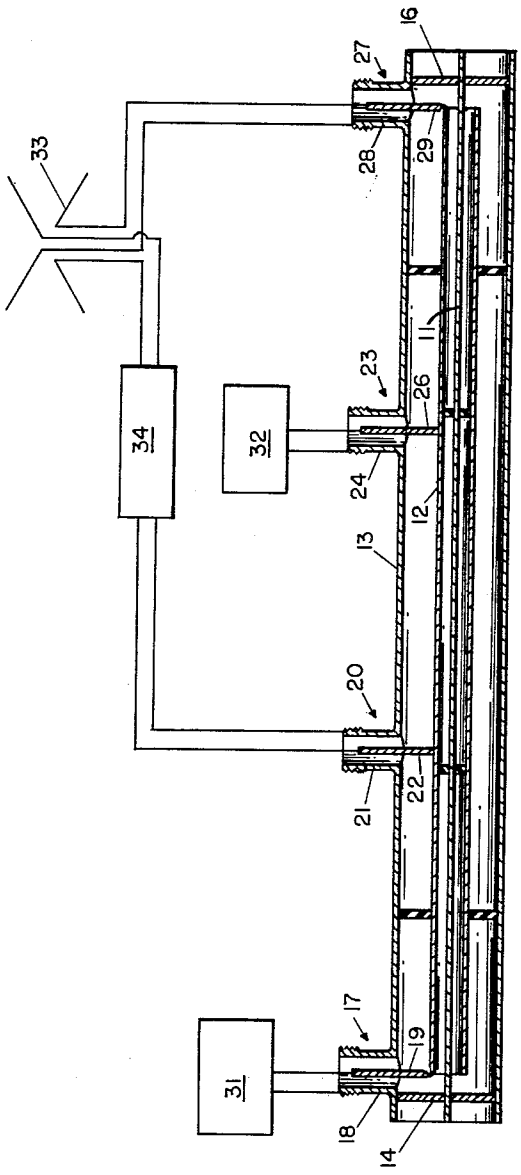
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MIXER CIRCUIT

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MIXER CIRCUIT

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This invention relates to electric circuits for mixing very high frequency alternating currents. It relates in particular to the so-called hybrid ring mixer.

Heretofore hybrid ring mixers for mixing two alternating currents having substantially the same very high frequency have been constructed in a toroidal or rectangular form. Each of these forms is bulky and ill-adapted for having fine adjustments made thereon to obtain the best possible performance.

Therefore, it is one object of this invention to provide an improved mixing circuit.

Other objects are to provide a more compact high frequency mixing circuit, and to provide such a circuit in a form suitable for having fine adjustments made thereon.

Further objects will be apparent after studying the specification together with the drawing in which the only figure is a longitudinal sectional view of the mixer.

The invention comprises a first coaxial transmission line having an electrical length of about three-fourths of the wavelengths of either of two alternating currents to be mixed. The difference in frequency between the two currents must be small compared to the frequency of either current. Surrounding the first transmission line is a hollow conductor which, together with the outer conductor of the first line, forms a second transmission line. The coaxial signal outlets are substantially equally spaced along the outer conductor, one outlet at or near each end thereof, and two more between the outer two, so that the distance between adjacent outlets is approximately one-fourth of a wavelength of the operating frequencies. The outer conductor of each coaxial outlet is electrically directly connected to the outer conductor of the second transmission line, and the inner conductor of each coaxial outlet is electrically directly connected to the outer conductor of the first transmission line.

The term "outlet" as used herein is intended to denote either "input terminal" or "output terminal." The generic term must be used since there is no inherent functional distinction between the four components so designated.

The drawing shows one form of the invention in which the coaxial transmission lines consist of linear elements. The center conductor of the first, or inner, transmission line is a conductor **11**, which may be hollow and of any cross-sectional shape. In accordance with standard engineering practices and for purposes of simplicity, conductor **11** and the outer conductors of both transmission lines have circular cross-sections in the embodiment shown.

Surrounding conductor **11** and insulated therefrom in fixed spaced relationship is a hollow tubular conductor **12** forming the outer conductor of the first transmission line and the inner conductor of the second transmission line. Surrounding conductor **12** and insulated therefrom in fixed spaced relationship is another hollow, tubular conductor **13** forming the outer conductor of the second transmission line. The conductor **13** is electrically short-circuited near each end thereof to the innermost conductor **11** by means comprising slideable shorting discs **14** and **16**.

Near one end of the conductor **13** is a coaxial signal outlet **17** having the outer conductor **18** thereof rigidly connected, mechanically and electrically, to the conductor **13**. The inner conductor **19** of outlet **17** is connected directly to a nearby point on conductor **12**. Axially displaced along the conductor **13** from the outlet **17** is a second coaxial signal outlet **20**, the outer conductor **21** of which is connected to conductor **13**, and the inner conductor **22** of which is directly connected to conductor **12**, exactly as is outlet **17**. Still further along the conductor **13**, a third coaxial outlet **23** comprising an outer conductor **24** and an inner conductor **26** is similarly connected to conductors **13** and **12** respectively. Near the other end of the conductor **13** is a fourth coaxial outlet **27** comprising an outer conductor **28** and an inner conductor **29** similarly connected to conductors **13** and **12** respectively.

It is well known from the theory of hybrid ring mixers that the impedance Z_0 of all four outlets may be the same, in which case, the impedance of each of the inner and outer transmission lines should be

$$\frac{Z_0}{\sqrt{2}}$$

Other impedance relationships may be used as described in "Microwave Duplexes" by Smullin and Montgomery, this book being volume **14** of the Radiation Laboratory Series. The proper impedances may be obtained in the well-known way by selecting the ratio of the diameters of the inner and outer conductors of both transmission lines.

The circuit components connected to the mixer are shown in diagrammatic form and comprise a first signal source **31** connected to supply alternating current to the outlet **17**, although, as will be described hereinafter, any of the four outlets may be used. A second source **32** of alternating current is connected to the outlet **23**. Utilization devices **33**, comprising in this illustration, the two sections of a dipole antenna, are connected to the center conductors **22** and **29** of the outlets **20** and **27** respectively.

The operation of the mixer is predicated on the bridge-type balance which obtains between the four outlets. Although the two sources **31** and **32** need not supply alternating currents of exactly the same frequency, the two frequencies must be within the bandpass tolerance of the mixer. For example, the video carrier frequency of 609.25 megacycles together with the normal sidebands lying between 608 and 613.75 megacycles may be supplied by source **31**; and the aural carrier frequency of 613.75 megacycles with sidebands between 613.7 and 613.8 megacycles may be supplied by source **32**. These frequencies are merely illustrative of one way in which the mixer circuit has been used and are not to be considered as limitations of the invention. For these frequencies, the length of the two transmission lines should be approximately 0.368 meter long, corresponding to three-fourths of a wave-length of the median frequency of 611.5 megacycles. The distance between adjacent pairs of outlets such as outlets **17** and **20**, or **20** and **23**, or **23** and **27** should be approximately 0.123 meter, corresponding to one-fourth of a wavelength of the median frequency.

The signal applied to the outlet **17** is propagated along the outer transmission line, and, simultaneously, by means of the short-circuiting element **14**, along the inner transmission line. If proper termination be assumed so that no standing waves are built up in either the inner or outer transmission lines, the phase of the signal at outlet **27** lags the phase at outlet **17** by substantially 270°, since the length of each transmission line is substantially three-

fourths of a wavelength of the signal frequency. On the other hand, the phase of the signal at outlet **20** lags the phase of the signal applied to outlet **17** by only 90°, since the electrical distance between outlets **17** and **20** is one one-fourth wavelength along the outer transmission line. The electrical distance from outlet **17** through the inner transmission line and back along the outer line to outlet **20** is one and one-quarter wavelengths which results in effectively the same 90° phase lag.

It will be noted that the signal traveling along the inner transmission line is exactly in phase with the signal traveling along the outer transmission line at outlets **20** and **27**.

In the same way, the electrical distance between outlets **17** and **23** is one-half of a wavelength along the outer line and one wavelength along the inner and outer lines. Therefore, due to the phase opposition which obtains, no electrical energy may be withdrawn at the outlet **23**, provided, of course, that the frequency of the signal is within the mixer passband. The inverse is likewise true so that the sources **31** and **32** are effectively isolated from each other.

A signal applied by the source **32** to the outlet **23** also splits in the same way as the signal applied to the outlet **17**. However, the signals from outlet **23** arrive at both outlets **20** and **27** with the same 90° phase lag and are in phase with each other. Since it is well-known that signals applied to the turn-stile antenna should come from two sources differing in phase by 90°, the signals applied to the outlets **17** and **23** may be used for this purpose. Since the signals applied to the outlet **17** may be taken from the outlets **20** and **27** with a phase difference of 180° and the signals applied to the outlet **23** may be taken from the outlets **20** and **27** in the same phase, these with 0° phase difference between them, it is only necessary to provide a 90° phase shift between either outlet **20** or outlet **27** and the corresponding branch of the turn-stile antenna **33**. It is immaterial whether the 90° phase shift device **34** be connected to outlet **20** or **27** and also whether the phase shift device provides a leading or lagging phase shift.

Although one embodiment of this invention has been shown and described, it will be obvious to those skilled in the art that modifications may be made without departing from the scope thereof as embodied in the following claims.

What is claimed is:

1. An electrical mixer circuit for electrical waves within a band about a predetermined wavelength, said circuit comprising a first conductive member having an effective length substantially three-quarters of said predetermined wavelength; a second tubular conductive member having substantially the same effective length as said first conductive member, said first and second conductive members forming a coaxial transmission line; a third tubular conductive member having substantially the same effective length as said second conductive member and surrounding said second conductive member to form in combination therewith a coaxial transmission line; a conductive connection between said first and third conductive members at both ends thereof; and four coaxial outlets each having the outer conductor thereof electrically connected to said third conductive member and the inner conductor thereof connected to said second conductive member, one of said outlets at substantially each end of said conductive members, the two remaining outlets being substantially equally spaced along said conductive members from each other and from the outlets at said ends.

2. An electrical mixer circuit for electrical waves within a band about a predetermined wavelength, said circuit comprising a first hollow tubular conductive member having an effective length substantially three-quarters of said predetermined wavelength, a second tubular conductive member having substantially the same effective length as said first conductive member and located therein to form a coaxial transmision line therewith; four coaxial outlets each having an impedance Z and each having the outer conductor thereof electrically connected to said first conductive member and the inner conductor thereof connected to said second conductive member, said outlets being spaced substantially one-quarter wavelength apart along said conductive members with an outlet adjacent each end thereof; a third conductive member having substantially the same effective length as said first conductive member and lying within said second conductive member to form a second coaxial transmission line therewith, an electrical connection between said first and said third conductive members, substantially at the ends thereof, the impedance of said first and said second transmission lines being equal to

$$\frac{Z}{\sqrt{2}}$$

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