

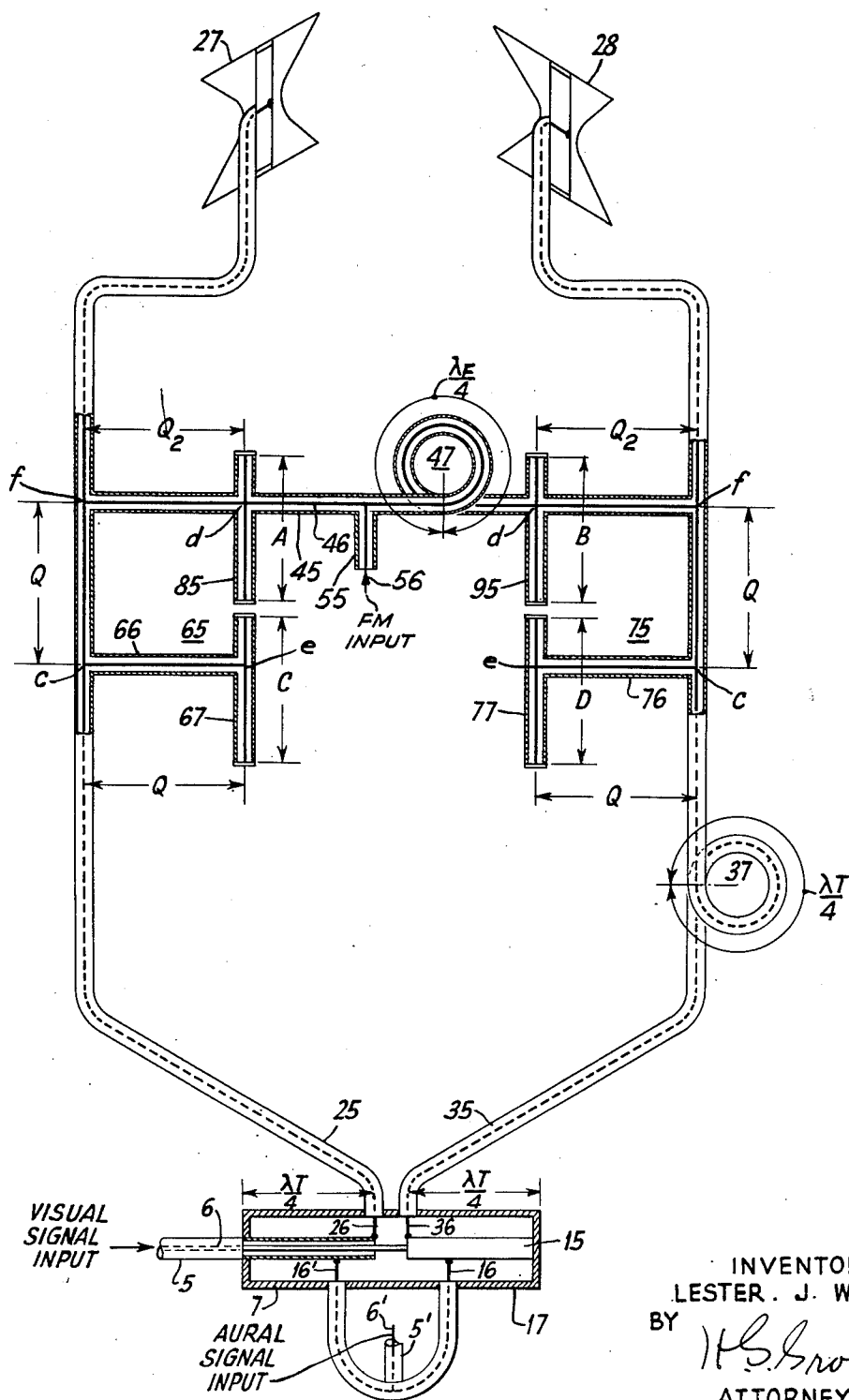
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TRANSMISSION LINE NETWORK

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TRANSMISSION LINE NETWORK

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The present invention relates to electrical transmission line systems and more particularly to a system for feeding a load such as an antenna system simultaneously with energy from a number of different transmitters operating at different frequencies.

One of the objects of the present invention is to enable three transmitters operating at different frequencies to feed the same load system simultaneously over branch circuits so arranged that there is no reaction between the several transmitters.

Another object of the present invention is to enable a plurality of transmitters operating at different frequencies to feed a turnstile antenna without interaction between the transmitters.

Another object of the present invention is to provide a combining network for feeding radio frequency energy from three or more transmitters into a single antenna.

Still a further object of the present invention is the provision of a triplexing unit for feeding frequency modulated signals simultaneously with television signals into a common antenna.

In accordance with the principles of the present invention there is employed, between one transmitter and a load circuit, a transformer for converting from a single side or unbalanced circuit to a circuit balanced with respect to ground. Across the balanced circuit is connected a half wave loop circuit with the second transmitter connected to its midpoint. Energy from the second transmitter is thus introduced into the balanced "push-pull" circuit in a "push-pull" relationship. Then in order to obtain a phase quadrature relationship at the output, one side of the balanced circuit is made a quarter wave longer than the other.

The present invention further contemplates the addition of a bridging transmission line across the balanced circuit, beyond the phase quadrature loop, for feeding signals at a third frequency into the system. The bridging transmission line has an individual phase quadrature loop associated therewith whereby energy from the third transmitter fed into the pair of lines carrying energy in phase quadrature relationship is also introduced in a phase quadrature relationship. The three signals thus combined may be applied to mutually perpendicular dipole radiators of a turnstile antenna for radiating a rotating field. Rejection circuits or "notch filters" are provided in the balanced lines and in the bridging lines to prevent energy from any of the

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transmitters from appearing at any of the other transmitters.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a single figure of drawing illustrating in diagrammatic form an embodiment of the present invention.

Referring now to the figure there is shown in the lower part thereof a concentric transmission line having an outer sheath 5 and an inner conductor 6 energized from a transmitter (not shown) supplying, for example, a visual signal modulated carrier wave. The figure further shows a pair of coaxial transmission lines adapted to be energized in a push-pull relationship, one of said lines being composed of an outer sheath conductor 25 and an inner conductor 26 and the other being composed of an outer sheath conductor 35 and an inner conductor 36. The outer sheaths 5, 25 and 35 may be grounded if desired. Inner conductor 35 has a direct conductive connection to inner conductor 6 and is, therefore, energized in the same relationship as inner conductor 6. Inner conductor 26 is directly connected to the end of sheath 5 of the visual signal input coaxial transmission line and is, therefore, energized in phase opposition to the inner conductor 36. In order to uncouple the last quarter wave section of the visual signal transmission line 5, 6 from the remainder of the same that one side of the balanced circuit is not shorted, I have provided an outer shell 7 surrounding the end of sheath 5. The shell 7 has a length equal to one quarter of the operating wavelength and is connected to sheath 5 at its end remote from the open end of sheath 5. A second quarter wave shell 17 having the same diameter as outer shell 7 is arranged in an end on relation therewith. Within the shell section 17 and coaxially arranged therewith is an inner conductor 15 having the same diameter as the outer diameter of sheath 5 of the visual signal input transmission line. Though I have referred to shells 7 and 17 separately for convenience in description, it should be understood, that in practice, it may be found more convenient to form them in one continuous piece. The inner conductor 15 is connected at its inner end to the center conductor 6 of the visual signal input transmission line and also to the center conductor 36 of one of the balanced lines. The other end of conductor 15 is electrically connected to the remote end of shell 17.

In order to feed the balanced transmission lines 25, 26 and 35, 36 from a second transmitter

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carrying the aural signal, I have provided a transmission line loop having inner conductors 16, 16' and having an overall length of one-half of the operating wavelength connected to the adjacent ends of sheath 5 and conductor 15. At the junction between conductors 16 and 16' is connected the inner conductor 6' of a transmission line connected to the aural signal transmitter. Conductor 6' is surrounded by an outer shell 5'. The half wave loop formed by conductors 16 and 16' has substantially no effect on the operation of the circuit so far as the picture transmitter is concerned. However, energy from the aural signal transmitter is fed to conductors 26 and 36 through exactly equivalent lengths of line and therefore, in an in-phase or "push-push" relationship. By means of the connections as so far described it will be seen that lines 25, 26 and 35, 36 carry visual signal energy in a balanced phase opposing relationship and aural signal energy in an in-phase relationship. Now, since it is desired to feed the mutually perpendicular arms 27 and 28 of the turnstile antenna in a phase quadrature relationship, a quarter wave loop 37 is placed in transmission line 35, 36. By this means both signals are applied to the antenna in the proper phase relationship for mutually non-interfering radiation.

Now, in order to feed a third signal, which may be a frequency modulated signal, into the system, I have provided a bridging line having an outer conductor 45 and an inner conductor 46 connected across lines 25, 26 and 35, 36 beyond the phase quadrature loop 37. The signals from the third transmitter are applied to the bridging line 45 and 46 through a further coaxial transmission line having an outer sheath 55 and inner conductor 56. A phase quadrature loop 47 is inserted in the bridging line at one side of the input lines 55, 56 so that the energy from the third transmitter is applied in a phase quadrature relationship to transmission lines 25 and 35 whereby it also energizes the antenna arms 27 and 28 in a proper relationship. Now, in order to prevent the frequency modulated signals from the third transmitter from entering the diplexing unit and thence arriving at either the visual signal transmitter or the audio signal transmitter, I have provided a pair of trap circuits or "notch filters" 65 and 75, one individual to each of the balanced transmission lines 25, 26 and 35, 36. Each of these notch filters is an arrangement of coaxial transmission lines in a generally T-shaped configuration. In filter 65, transmission line 66 forms the leg of the T while line 67 forms the top of the T. Similarly notch filter 75 includes transmission line 76 as the leg of the T and line 77 as the top of the T. Now filter 65 is connected to transmission line 25 at a distance Q from the point of connection of the bridging transmission line 45, 46 while the length of line 66 is also equal to Q. Line 67, forming the top of the T, has a length C and is open circuited at both ends. The location of filter 75 and the length of line 76 are the same as for filter 65. The length of transmission line 77, forming the top of the T, is indicated as distance D. In the bridging line 45, 46 I have provided a pair of filters 85 and 95 consisting of lengths A and B of coaxial transmission line connected to the inner conductors at points d, at distances Q₂ from each end of the lines 45, 46. Now, if one assumes in an ideal case for the moment that distance Q₁ is equal to a quarter wavelength at the frequency modulated mid-band frequency

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and distances A, B, C, and D are each a half wavelength at that same frequency, it will be seen that for FM signals a low impedance is presented at point c, c on transmission lines 25 and 35. The quarter wavelength distance Q₁ at the mid-band television frequency, inverts this impedance, thus presenting a high impedance to frequency modulated input at the junction points f, f between bridging transmission line 45, 46 and the balanced lines 25, 35. Thus, no energy from the frequency modulated transmitter can proceed along transmission lines 25, 26 and 35, 36 to the picture signal transmitter or the aural signal transmitter. Likewise for picture signal frequencies and aural signal frequencies points d, d on bridging transmission line 45, 46 present a low impedance with a consequent high impedance at the junction points f, f of transmission line 45, 46 with the balanced lines 25, 26 and 35, 36 due to the impedance inversion brought about by distance Q₂ being a quarter wavelength at the television midband frequency. Thus, no energy from either the picture signal transmitter or the audio signal transmitter can enter the frequency modulated transmitter.

Now, in some practical cases the operating frequency of the frequency modulated transmitter is higher than the television frequency, while in other cases it is lower than the television frequencies. The line lengths Q, therefore, may be advantageously compromised from the ideal quarter wavelength dimensioning and Q may be made equal to Q₂. In some cases they may be made a length midway between a quarter wave at the frequency modulated frequency and a quarter wave at the television frequencies. Thus, where the frequency of the frequency modulated transmitter is lower than the frequency of the television transmitters the lengths Q are made less than a quarter wavelength at the frequency modulated frequency and the lengths C and D may be adjusted to present a capacitive reactance to the lines 66 and 76 of the length Q. For the case where the frequency modulated frequency is higher than the television frequency the distances Q are more than a quarter wavelength at FM frequency and the lengths C and D must be such as to present an inductive reactance to the lines 66 and 76. In any case the resultant reactance at points c, c presented by line lengths 67 and 77 must be low at the frequency of the third transmitter. Lengths A and B are subject to a slightly different requirement. It is necessary that half of the power from the third transmitter flows into each antenna line 25, 26 and 35, 36. Therefore, the points d, d must have identical impedance as seen from the input line 55, 56. The load circuit at points d, d for the third transmitter consists of the antenna resistance shunted by the reactance of each of the Q length line elements which lead to points c, c along transmission lines 25, 26 and 35, 36. Line lengths A and B must, therefore, be adjusted so that these reactances are tuned out.

While I have illustrated a particular embodiment of the present invention, it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement without departing from the spirit and scope of the invention.

What is claimed is:

1. A triplexer arrangement for translating radio wave energy of three separated bands of frequencies to a utilization device, including a

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pair of coaxial transmission lines for carrying radio wave energy of two of said frequency bands adjacent each other, the lengths of said transmission lines differing by a quarter wavelength at a given frequency intermediate the uppermost and lowermost frequencies of said two bands to present energy in phase quadrature relationship at the output ends of said transmission lines with respect to the energy applied to the input ends of said coaxial transmission lines, a concentric transmission line bridged across said pair of coaxial transmission lines for carrying radio wave energy of a third frequency band outside said two frequency bands applied to said bridging transmission line at a predetermined point, the distance from said predetermined point to said output ends of said coaxial transmission lines differing by a quarter wavelength at the midband frequency of said third frequency band to present energy in phase quadrature relationship at said output ends, means interposed in said concentric transmission line between said predetermined point and the points of connection of said concentric transmission line to said pair of coaxial transmission lines to prevent flow of energy at frequencies within said two frequency bands from the input ends of said coaxial transmission lines toward said predetermined point on said concentric transmission line, further means interposed in said pair of coaxial transmission lines between the points of connection thereof to said concentric transmission line and the input ends of the coaxial transmission lines to prevent flow of energy at frequencies in said third frequency band from said predetermined point on said concentric transmission line toward said input ends of said coaxial transmission lines.

2. A transmission line arrangement including a pair of coaxial transmission lines for carrying radio wave energy of a given frequency, the lengths of said transmission lines differing by a quarter wavelength at said given frequency to present energy in phase quadrature relationship at the output ends of said coaxial transmission lines with respect to the energy applied to the input ends of said coaxial transmission lines, a concentric transmission line bridged across said pair of coaxial transmission lines for carrying radio wave energy of a frequency different from said given frequency applied to said concentric transmission line at a predetermined point, the distance from said point to said output ends of said coaxial transmission lines differing by a quarter wavelength at said different frequency to present energy in phase quadrature relationship at said output ends, trap circuits connected to said concentric transmission line between said predetermined point and the points of connection of said concentric transmission line to said pair of coaxial transmission lines, said trap circuits presenting substantially short circuit impedance at said given frequency and substantially open circuit impedance at said different frequency across said concentric transmission line, further trap circuits coupled to said coaxial transmission lines between the points of connection thereof to said concentric transmission line and the input ends of said coaxial transmission lines, said further trap circuits being coupled to present substantially short circuit impedance at said different frequency and substantially open circuit impedance at said given frequency across said coaxial transmission lines, each of said trap circuits comprising an open-ended coaxial transmission line section substantially a half wave-

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length long at said given frequency and being adjusted to present high impedance at said different frequency at the point of connection of said trap circuit, said coupling being made by lengths of concentric transmission line a quarter wavelength long at said different frequency.

3. A triplexing arrangement including a pair of coaxial transmission lines for carrying aural and visual signals of a television program of frequency bands centered about a given frequency intermediate the lowermost and the uppermost frequency limits of said bands, the lengths of said coaxial transmission lines differing by a quarter wavelength at said given frequency to present energy in phase quadrature relationship at the output ends of said coaxial transmission lines with respect to the energy applied at the input ends of said coaxial transmission lines, a concentric transmission line bridged across said pair of coaxial transmission lines for carrying radio wave energy of a band of frequencies about a frequency within said band different from said given frequency applied to said concentric transmission line at a predetermined point, the distance from said predetermined point to the points of connection of said concentric transmission line to said coaxial transmission lines differing by a quarter wavelength at said different frequency to present energy in phase quadrature relationship at the output ends of said coaxial transmission lines, trap circuits connected to said concentric transmission line at distances from the points of connection to said pair of coaxial transmission lines intermediate a quarter wavelength at said given frequency and a quarter wavelength at said different frequency, said trap circuits being connected to present a high impedance across said concentric transmission line to said energy of said band of frequencies about said different frequency and substantially short circuit impedance to energy of said television frequency bands, further trap circuits coupled to said coaxial transmission lines at said intermediate distances from the points of connection of said concentric transmission line to said coaxial transmission line, said coupling being made by lengths of coaxial transmission line of said intermediate length, said further trap circuits being coupled to present a high impedance across said coaxial transmission lines at frequencies of said television program bands and a substantially short circuit impedance to energy of said band of frequencies about said different frequency, each of said trap circuits comprising an open-ended transmission line section relatively a half wavelength long at said different frequency and being adjusted to present high impedance at said different frequency at a point substantially equal to a quarter wavelength at said given frequency from one end of the open-ended transmission line section.

4. A transmission line arrangement including a pair of coaxial transmission lines for carrying radio wave energy of a given frequency, the lengths of said coaxial transmission lines differing by a quarter wavelength at said given frequency to present energy in phase quadrature relationship at the output ends of said coaxial transmission lines with respect to the energy applied at the input ends of said coaxial transmission lines, a concentric transmission line bridged across said pair of coaxial transmission lines for carrying radio wave energy of another frequency different from said given frequency applied to said concentric transmission line at a predetermined point, the distance from said point to said

output ends of said coaxial transmission lines differing by a quarter wavelength at said different frequency to present energy in phase quadrature relationship at the output ends of said coaxial transmission lines, trap circuits connected to said concentric transmission line at distances from the points of connection to said pair of transmission lines intermediate a quarter wavelength at said given frequency and a quarter wavelength at said different frequency, said trap circuits being connected to present substantially open circuit impedance across said concentric transmission line at said other frequency and substantially short circuit impedance at said given frequency, further trap circuits coupled to said coaxial transmission lines at said intermediate distances from the points of connection to said concentric transmission line, said coupling being made by lengths of coaxial transmission line of said intermediate length, said further trap circuits being coupled to present substantially open circuit impedance across said coaxial transmission lines at said given frequency and substantially short circuit impedance at said other frequency, each of said trap circuits having the point of connection located substantially a quarter wavelength at said given frequency from one end of said open-ended transmission line section and an overall length adjusted to present high impedance at said point of connection.

5. A transmission line arrangement including a pair of transmission lines for carrying radio wave energy of a wide range of frequencies about a given frequency within said range, the lengths of said pair of transmission lines differing by a quarter wavelength at said given frequency to present energy in phase quadrature relationship at the output ends of said transmission lines with respect to the energy applied at the input ends of said pair of transmission lines, another transmission line bridged across said pair of transmission lines for carrying radio wave energy band of other frequencies about a frequency within said band different from said given frequency applied to said bridging transmission line at a predetermined point, the distance from said point to said output ends of said pair of transmission lines differing by a quarter wavelength at said different frequency to present energy in phase quadrature relationship at said output ends of said pair of transmission lines, trap circuits connected to said bridging transmission line at distances from the points of connection to said pair of transmission lines intermediate a quarter wavelength at said given frequency and a quarter wavelength at said different frequency, said trap circuits being connected to present substantially short circuit impedance across said concentric transmission line to energy of said wide range of frequencies and substantially open circuit impedance to energy of said other frequencies, further trap circuits coupled to said transmission lines at said intermediate distances from the points of connection of said pair of transmission lines to said bridging transmission line, said coupling being made by lengths of transmission line of said intermediate length, said further trap circuit being coupled to present substantially short circuit impedance across said coaxial transmission lines to energy of said other frequencies and substantially open circuit impedance to energy

of said wide range of frequencies, said trap circuits comprising open-ended transmission line sections relatively a half wavelength long at said different frequency and having points of connection located substantially a quarter wavelength at said given frequency from one end of said open-ended transmission line section, said line sections being adjusted to present high impedance and substantially zero reactance at said different frequency at said points of connection.

6. A transmission line arrangement including a pair of transmission lines for carrying aural and visual signals of a television program of a given midband frequency, the lengths of said transmission lines differing by a quarter wavelength at said given midband frequency to present energy in phase quadrature relationship at the output ends of said transmission lines with respect to the energy applied at the input ends of said transmission lines, another transmission line bridged across said pair of transmission lines for carrying radio wave energy of a frequency different from said given frequency applied to said bridging transmission line at a predetermined point, the distance from said point to the points of connection of said bridging transmission line to said pair of transmission lines differing by a quarter wavelength at said different frequency to present energy in phase quadrature relationship at said output ends of said pair of transmission lines, trap circuits connected to said bridging transmission line at distances from the points of connection of said bridging transmission line to said pair of transmission lines intermediate a quarter wavelength at said given midband frequency and a quarter wavelength at said different frequency, said trap circuits being connected to present substantially short circuit impedance across said concentric transmission line at said given midband frequency and substantially open circuit impedance at said different frequency, further trap circuits coupled to said pair of transmission lines at said intermediate distances from the points of connection of said pair of transmission lines to said bridging transmission line, said coupling being made by lengths of transmission line of said intermediate length, said further trap circuits being coupled to present substantially short circuit impedance across said coaxial transmission lines at said different frequency and substantially open circuit impedance at said given midband frequency, said trap circuits each comprising open-ended transmission line sections relatively a half wavelength long at said different frequency and having a point of connection located substantially a quarter wavelength at said given frequency from one end, said transmission line sections being adjusted to present high impedance at said different frequency to said point of connection.

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