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G. H. BROWN

2,082,096

RADIO TRANSMISSION SYSTEM

Filed Nov. 19, 1935

2 Sheets-Sheet 1

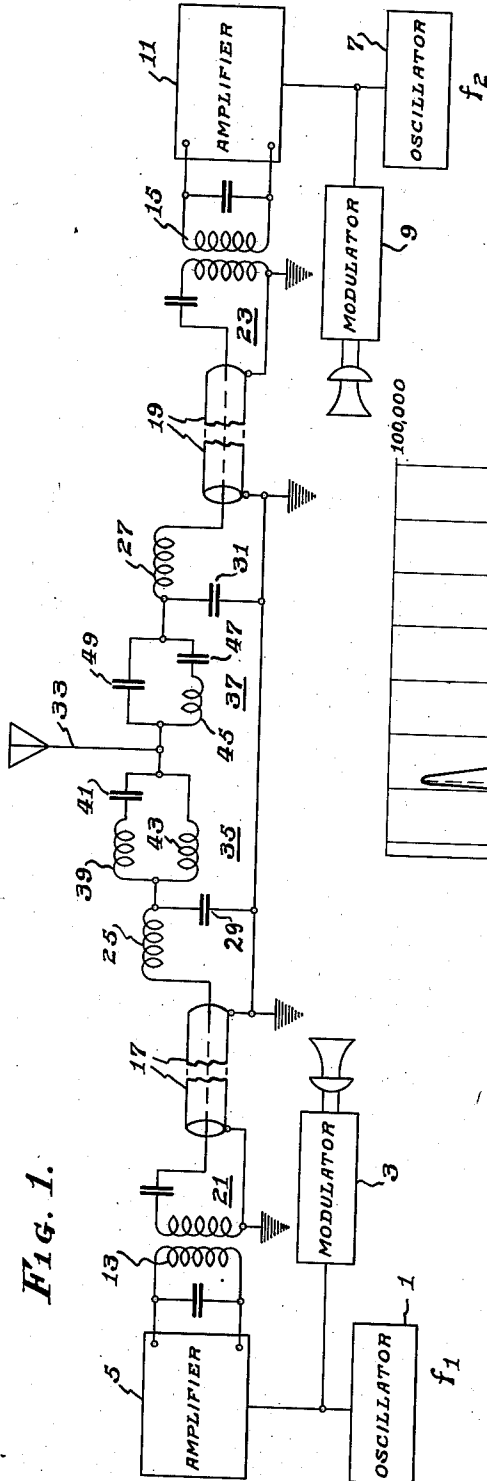


Fig. 1.

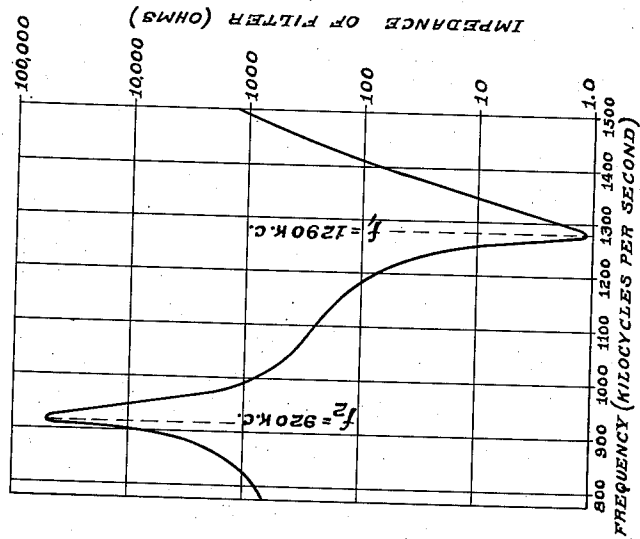


Fig. 3.

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2 Sheets-Sheet 2

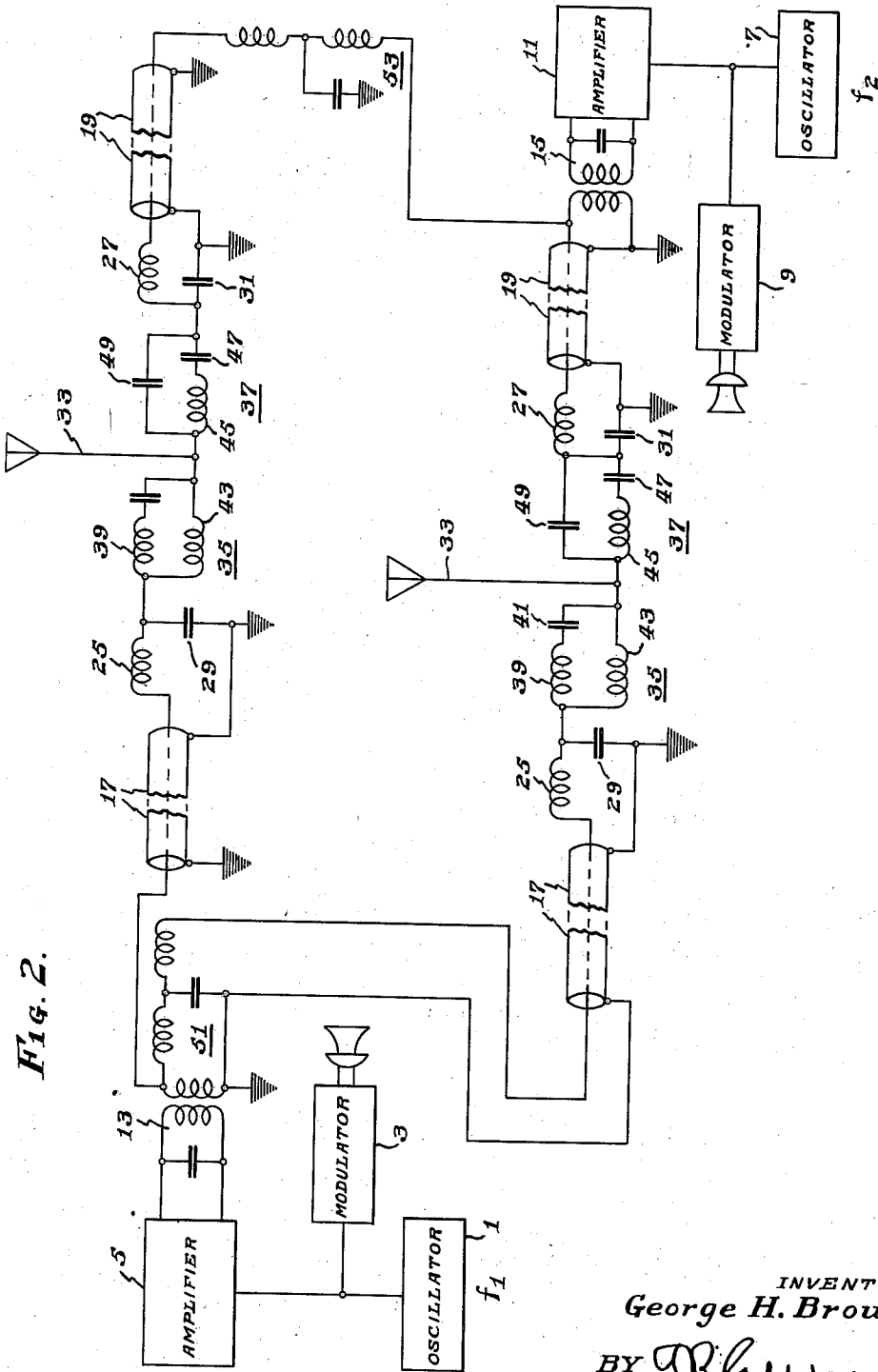


Fig. 2.

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RADIO TRANSMISSION SYSTEM

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8 Claims. (Cl. 250-9)

My invention relates broadly to a radio transmission system. More specifically my invention relates to a transmission system in which a single antenna structure is connected to two radio frequency generators operating at different frequencies. My invention further relates to the radiation of radio frequency energy on different wave lengths and with different field patterns.

An efficient radio broadcast station usually employs an antenna structure which will give maximum transmission range for the applied power. Such antenna structures are relatively expensive at the lower broadcast frequencies. If two or more broadcasting stations could operate at different frequencies with a common antenna, a great saving would result. The common antenna of my invention not only effects a saving but it avoids the distortion of field pattern and modulation which often occurs when two transmitting antennas are operated relatively close to each other in space and in frequency. In many cases each transmitter or station will be operated with a different field pattern. I propose to combine the antenna structure and at the same time preserve any desired directional transmission or field pattern which could be obtained with the common antenna structure when operated by separate transmitters.

One of the objects of my invention is to use a common antenna structure for the transmission of two or more radio programs on different wave lengths or frequencies.

Another object is to radiate, from a single antenna system, two or more radio frequency waves at different wave lengths and with different field patterns.

A further object is to arrange a transmission network between a single antenna system and two or more transmitters operating on different frequencies so that the transmitters will not intermodulate.

Additional objects will appear from the accompanying specification and appended claims.

My invention may be most readily understood by reference to the accompanying drawings of which Figure 1 is a diagrammatic illustration of one embodiment of my invention.

Figure 2 is a schematic diagram of an embodiment of my invention in which a pair of antennas are used as common radiators and in which the radiation patterns may be different, and

Figure 3 is a graph showing the impedance

characteristic of a suitable filter such as may be employed in my invention.

In Figure 1 a pair of radio transmitters are represented by block diagrams 1, 3, 5 and 7, 9, 11. These transmitters are comprised of oscillators, modulators, and amplifiers. Since each of these units are not part of my invention, per se, and are well known to those skilled in the art, I have not attempted to illustrate the details of each. Each of the stations are generating radio frequency carrier currents of a different frequency. These carrier currents may be modulated by telephonic signals, or the like, of the same or different origin. The modulated carrier currents may be amplified. The outputs of the amplifiers 5, 11 may include resonant circuits 13-15. The resonant output circuits 13-15 are coupled respectively to a pair of concentric conductors 17-19 through a pair of suitable matching circuits 21-23. The output ends of each of the concentric lines terminate in matching impedances comprising inductors 25, 27 and capacitors 29, 31. The concentric lines and their terminating impedances are grounded.

If the frequency of one oscillator 1 is f_1 and the frequency of the other oscillator 7 is f_2 , means must be employed to couple each oscillator to a common antenna 33 and to prevent coupling between the two oscillators through their associated circuits. Such means is found in the filter networks 35, 37. The filter network 35 connected between the antenna 33 and the terminating impedance 25-29 is series resonant to currents of frequency f_1 from the first oscillator 1. The parallel impedance of the filter 35 is a maximum for currents of frequency f_2 from second oscillator 7. Thus the filter network 35 offers minimum impedance to currents flowing from the first transmitter 1, 3, 5 and maximum impedance to currents from the second transmitter 7, 9, 11.

In a similar manner the filter 37 is series resonant to currents of a frequency f_2 from the second oscillator 7 and parallel resonant to currents of a frequency f_1 from the first oscillator 1. Thus this filter network offers very little impedance to currents flowing from the second transmitter 7, 9, 11 and maximum impedance to currents from the first transmitter 1, 3, 5.

Although filter networks of numerous types may be used, I have found that if f_1 is of higher frequency than f_2 , a network 35 comprising two arms may be used. One of these arms employs an inductor 39 and a capacitor 41. The other arm is an inductor 43 which shunts the first arm. The first arm of inductor 39 and capacitor 41 is

series resonant to currents of the higher frequency f_1 . The two arms comprising inductor 39, capacitor 41, and inductor 43 are parallel resonant to currents of the lower frequency.

As a similar example the filter network 37 is made up of two arms. One of the arms consists of inductor 45 and a capacitor 47. The other arm is a capacitor 49 which is shunted across the first arm. The inductor 45 and capacitor 47 are series resonant to currents of the lower frequency f_2 . The two arms comprising inductor 45, capacitor 47 and capacitor 49 are parallel resonant to currents of the higher frequency f_1 .

By way of example, if $f_1=1290$ kilocycles and $f_2=920$ kilocycles, the filter network 35 may be constituted as follows:

$$\begin{aligned} L_1 &= 59.8 \times 10^{-6} \text{ henries} \\ L_2 &= 59.8 \times 10^{-6} \text{ do.} \\ C_1 &= 257 \times 10^{-12} \text{ farads} \\ R_1 &= \text{Resistance of coil } L_1 = 1.15 \text{ ohms} \\ R_2 &= \text{do.} \quad L_2 = 1.15 \text{ do.} \end{aligned}$$

In this combination, $L_1 C_1$ constitute one arm and L_2 is the other arm of the filter network. Figure 3 is a graph representing the impedance of this filter in ohms plotted against frequency in kilocycles. It may be seen that the impedance to currents of the higher frequency f_1 is 1.1 ohms. The impedance to currents of the lower frequency f_2 is 54,000 ohms.

A similar result may be obtained for the network represented as 37. If the two transmitters are operating on greatly different powers, a single filter network may offer sufficient attenuation to prevent undesirable modulation effects.

The foregoing embodiment of my invention is applicable to a common antenna structure associated with a pair of transmitters or generators operating at different frequencies. In Figure 2 I have illustrated an embodiment of my invention in which a pair of antenna structures are made common radiators for a pair of generators operating at different frequencies. In this arrangement the essential difference is that the relative phases of the currents of each frequency may be separately adjusted in each antenna. By properly phasing the respective currents, the same or different field patterns may be obtained for the different frequencies.

The field pattern determines the directive characteristic of the transmitters. The directive characteristic of two or more antennas is not, per se, my invention. The design of such antenna arrays is discussed fully in a paper entitled "Certain factors affecting the gain of directive antennas" by G. C. Southworth in the Proceedings of the Institute of Radio Engineers for September, 1930 (vol. 18, No. 9, pages 1502-1536). As a practical matter it is often highly desirable to suppress the radiation of a wave of one frequency in a given direction and to suppress the wave of another frequency in some other direction. In like manner it may be desirable to increase radiation in a given direction.

The circuit diagram shown in Figure 2 is essentially the same as Figure 1; therefore, similar elements are given similar reference numerals. The present diagram indicates a pair of transmitters 1, 3, 5 and 7, 9, 11. Each transmitter impresses modulated carrier currents on pairs of concentric transmission lines 17, 17 and 19, 19. The terminals of the transmission lines are each connected to suitable impedance circuits 25, 29 and 27, 31. Filter networks, 35, 35 and 37, 37 are connected between the terminations of the con-

centric lines and the antennas 33, 33. The filter networks operate to offer low series impedance to currents from each transmitter to the antennas but high parallel impedance to currents between the transmitters themselves.

The desired field pattern is obtained by including a phasing network 51, 53 in one of each of the pairs of concentric transmission lines from each of the transmitters. The phasing network 51 operates to alter the relative phases of currents of frequencies f_1 , in the pair of antennas to which the transmitter 1, 3, 5 is coupled. In like manner the reactor 53 operates to alter the relative phases of currents of frequency f_2 in the pair of antennas to which the transmitter 7, 9, 11 is coupled. Since the filter networks 35, 37 substantially prevent the reaction of currents from the two transmitters, it is entirely feasible to adjust the phases of antenna currents of one frequency independent of antenna currents of the other frequency.

Thus I have described an antenna system in which a common radiator or antenna structure may be used for two or more transmitters operating on different frequencies. The circuit arrangements are adapted to the use of two or more antennas and two or more transmitters operating at different frequencies and having different field patterns. In the case of a dipole antenna, pairs of filter networks may be used. Although I have shown concentric lines, I do not intend to exclude the use of transposed transmission lines, and the like. The illustration of pairs of antennas and pairs of transmitters is merely by way of example, because a plurality of either may be used.

While I have shown one type of filter network, other types will provide satisfactory operation. Two or more filters may be serially connected to increase attenuation of undesired currents. My invention is only limited as required by the prior art and the appended claims.

I claim as my invention:

1. A radio transmission system comprising an antenna; a first transmitter operating at a given frequency; a second transmitter operating at a different frequency from the first-mentioned frequency; coupling means for couplings said first transmitter to said antenna including a filter composed of three elements, two of which are serially connected and are shunted by the third, said filter being series resonant to currents of the first-mentioned frequency and parallel resonant to currents of the second-mentioned frequency; and means coupling the other of said transmitters to said antenna.

2. A radio transmission system comprising an antenna; a first transmitter operating at a given frequency; a second transmitter operating at a different frequency from the first-mentioned frequency; coupling means for coupling said first transmitter to said antenna including a filter composed of three elements, two of which are serially connected and are shunted by the third, said filter being series resonant to currents of the first-mentioned frequency and parallel resonant to currents of the second-mentioned frequency; and a second coupling means for coupling said second transmitter to said antenna including a second filter composed of three elements, two of which are serially connected and are shunted by the third, said second filter being series resonant to currents of the second-mentioned frequency and parallel resonant to currents of the first-mentioned frequency.

3. In a system of the class described an an-

tenna; a first generator of currents of frequency f_1 ; a second generator of currents of frequency f_2 ; a pair of filter networks, the first of said filters comprising three elements, two of which are serially connected and shunted by a third, said filter being series resonant to currents of f_1 frequency and parallel resonant to currents of f_2 frequency, the second of said filters comprising three elements, two of which are serially connected and shunted by a third, said second filter being series resonant to currents of f_2 frequency and parallel resonant to currents of f_1 frequency; means connecting said filters to said antenna; and two concentric lines, one coupling the first filter to the generator of currents of f_1 frequency and the other coupling the second filter to the generator of currents of f_2 frequency.

4. In a radio transmission system, a pair of radio frequency transmitters operating at different frequencies, a plurality of antenna structures; means coupling the first of said generators to said antenna structures and comprising three elements, two of which are serially connected and shunted by a third, said filter being series resonant to currents of the frequency of said first generator and parallel resonant to currents of the frequency of the second of said generators; means coupling the second of said generators to said antenna structures, and phasing means included in the coupling means to at least one of said antenna structures so that the relative phase of currents in said antennas may be adjusted.

5. A radio transmission system comprising a plurality of antennas; a first transmitter operating at a given frequency; a second transmitter operating at a different frequency from the first-mentioned frequency; coupling means for coupling said first transmitter to said antennas including a filter comprising a pair of inductors and a capacitor, one of said inductors and said capacitor being serially connected and shunted

by the other inductor, said filter being series resonant to currents of the first-mentioned frequency and parallel resonant to currents of the second-mentioned frequency; means coupling the second of said transmitters to said antennas; and means for determining the relative phases of currents of one of said frequencies in said plurality of antennas.

6. In a system of the class described, a plurality of antennas; a first generator of currents of frequency f_1 ; a second generator of currents of frequency f_2 ; a pair of filter networks, the first of said filters comprising a pair of inductors and a capacitor, one of said inductors and said capacitor being serially connected and shunted by the other inductor, said first filter being series resonant to currents of f_1 frequency and parallel resonant to currents of f_2 frequency, the second of said filters comprising a pair of capacitors and an inductor, one of said capacitors and said inductor being serially connected and shunted by the other capacitor, said second filter being series resonant to currents of f_2 frequency and parallel resonant to currents of f_1 frequency; means connecting said filters to said antennas; two concentric lines, one coupling the first filter to the generator of currents of f_1 frequency and the other coupling the second filter to the generator of currents of f_2 frequency; and means for adjusting the relative phases of currents of frequency f_1 in different antennas of said plurality of antennas.

7. In a system of the character of claim 5, means for determining the relative phases of currents of the other of said frequencies in said plurality of antennas.

8. In a system of the character of claim 6, means for adjusting the relative phases of currents of frequency f_2 in different antennas of said plurality of antennas.

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