May 23, 1939. A. ALFORD 2,159,647

DIVERSITY TRANSMISSION

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FIG. 2.

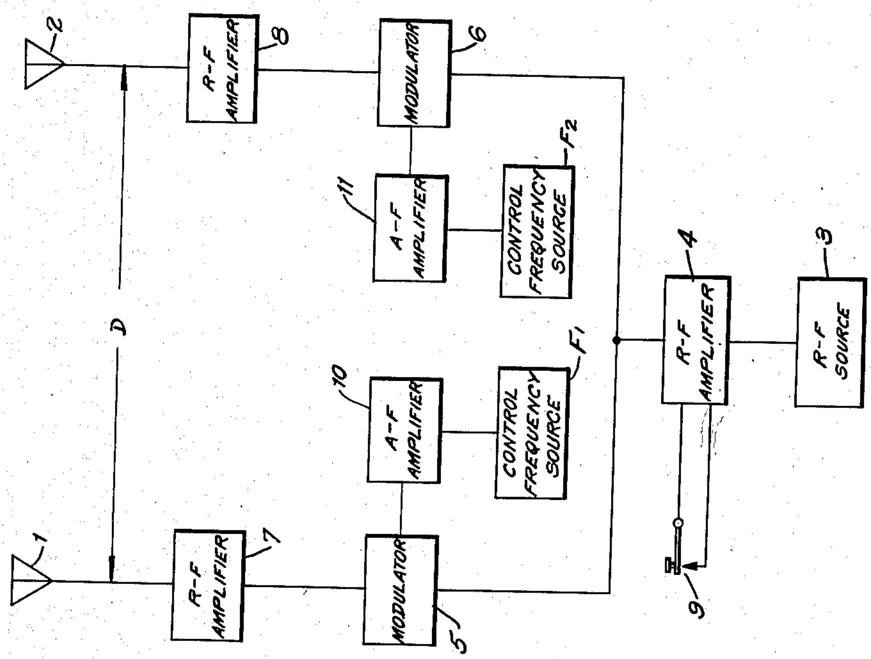
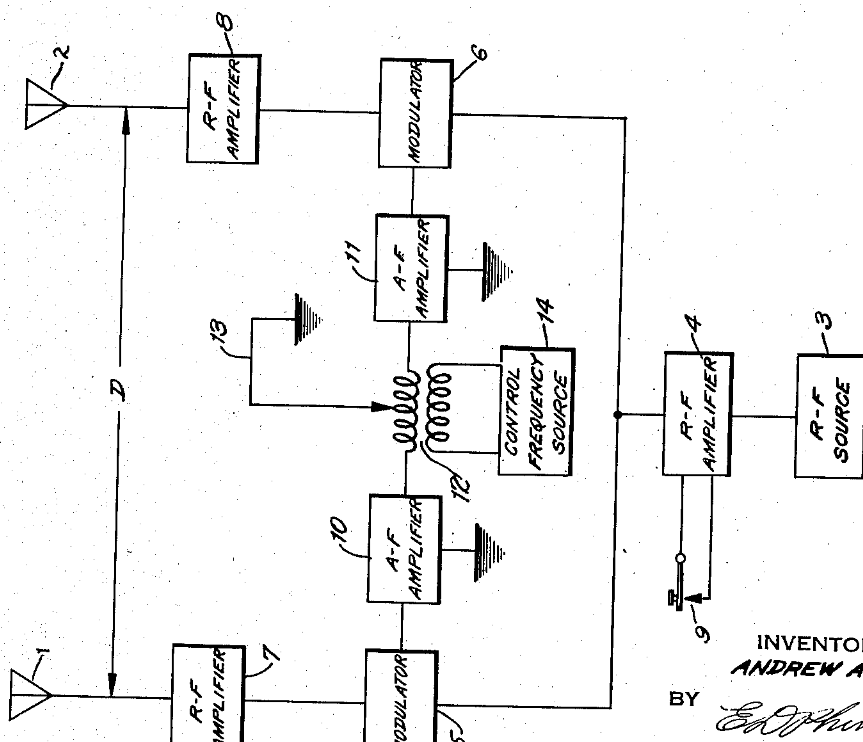


FIG. 1.



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DIVERSITY TRANSMISSION

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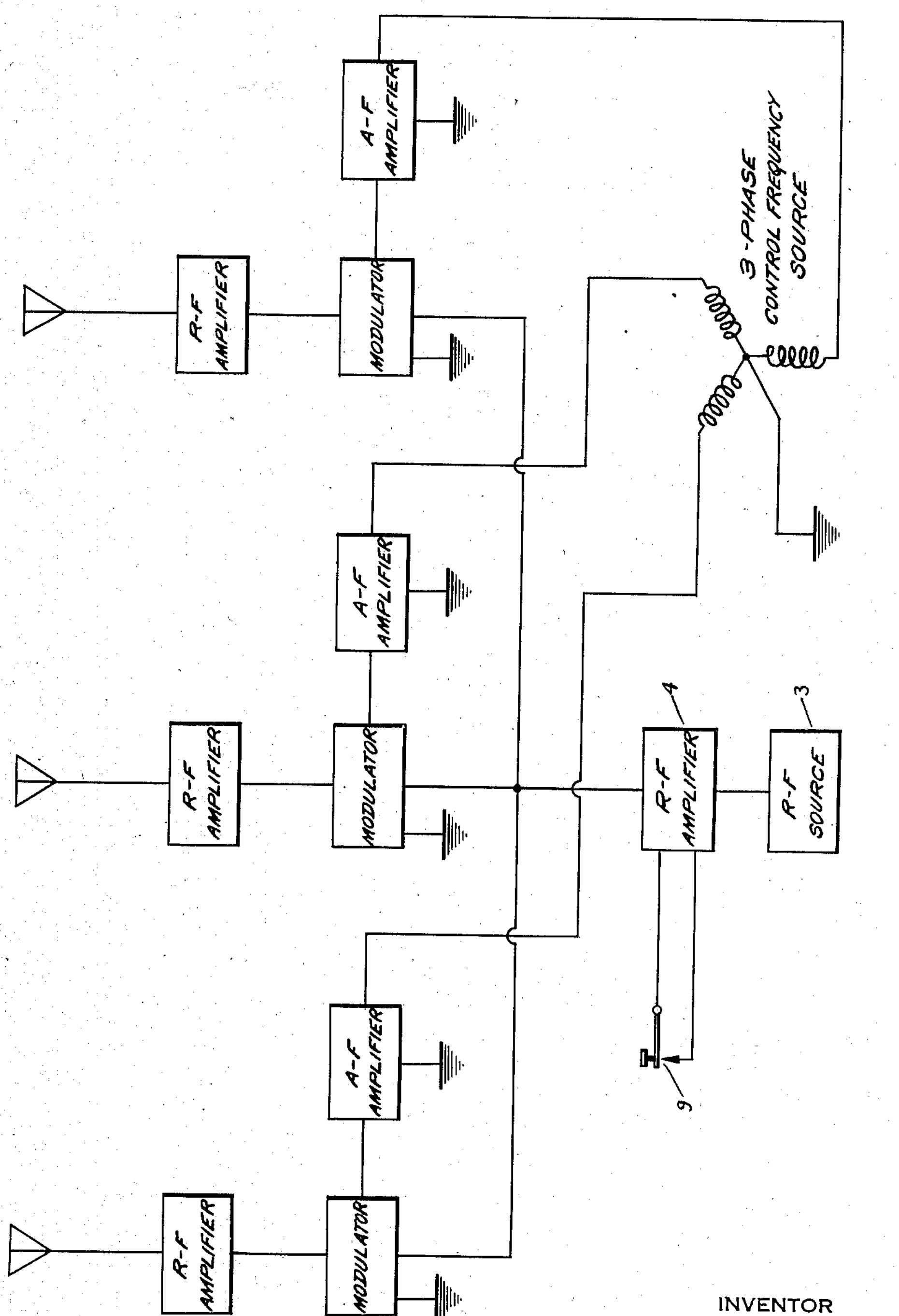
FIG. 3.



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DIVERSITY TRANSMISSION

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6 Claims. (Cl. 250—17)

This invention relates to radio transmission systems and pertains more particularly to radio transmission systems utilizing a plurality of antennae for the transmission of a single message.

It is an object of my invention to provide an improved form of radio transmission system according to which a plurality of spaced transmitting antennae are utilized whereby improved reception with less fading is obtained.

A further object of my invention is to provide a transmission system utilizing two or more antennae spaced apart each being energized successively, whereby a signal is transmitted to a distant point with a minimum of fading.

In accordance with my invention successive parts of a message are transmitted over different paths to a distant point. This result is obtained by providing two or more antennae spaced apart a distance which may be relatively small, e. g., a few wavelengths, this spacing preferably being in a lateral direction with respect to a line between the transmitting and the receiving station. These several transmitting antennae are connected to apparatus which is adapted to energize them successively in a rapid manner, whereby the message which it is desired to transmit is conveyed in a series of very small elemental portions, emitted successively by the several antennae utilized. The rapidity of the successive transmissions by the different transmitters and their associated antennae is preferably so great that each transmitter is rendered operative and inoperative many times per second, for example, of the order of several hundred times per second. This means that in the transmission of telegraph messages, to which the invention is particularly applicable, one dot of a code signal would be transmitted by the successive operation of two or more transmitters, these operations, for example, being of the order of hundreds per second for each transmitter. The successive energization of the antennae is preferably complete, from a maximum to zero. Alternatively, however, the degree of energization of the antennae may be varied successively so that a pulsating wave never dropping to zero is transmitted from each antenna.

In carrying out the invention, while a plurality of antennae spaced apart are necessary, one or several radio transmitting apparatus may be associated therewith, the only requisite being that the energy be emitted successively from the several antennae, preferably only one antenna radiating at a time.

By the use of this invention, it is possible to avoid the detrimental effects of fading of the transmission of signals even where the receiving antenna is located on a ship or on a plot of land which is too small for the erection of a large antenna system which would afford a diversity reception effect. Furthermore, it is possible to transmit by means of a pair of antennae a message which can be received with greatly reduced fading effects at a plurality of stations at spaced points, this assuring that the added expense of antenna duplication will be reduced to a minimum, since an expensive, elaborate antenna structure at each receiving point is not necessary.

The above mentioned and further objects and advantages of my invention and the manner of attaining them will be more fully explained in the following description taken in conjunction with the accompanying drawings:

In the drawings Fig. 1 illustrates diagrammatically a radio transmitting system embodying my invention, wherein two modulators and a single control frequency source are used. Fig. 2 illustrates a modified form of my invention wherein two separate control frequencies are used, and Fig. 3 illustrates still another modification of my invention wherein three transmitters and a common three phase control frequency source are utilized.

Referring more particularly to the drawings, reference numerals **1** and **2** indicate, respectively, two transmitting antennae which are spaced apart by distance D. A radio frequency oscillator is indicated by reference numeral **3**, this oscillator passing energy to radio frequency amplifier **4**, the output of which is connected to modulators **5** and **6**, which are associated with antennae **1** and **2**, respectively, the energy from the modulators being amplified by radio frequency amplifiers **7** and **8**, if desired. Key or other modulating device **9** is provided, by means of which the operation of the radio frequency amplifier **4** may be interrupted by any known method. For example, the key may apply a blocking potential to the grid of one or several of the tubes thereof, whereby the flow of the radio frequency carrier current from the source **3** to the modulators **5** and **6** may be interrupted to transmit a desired signal.

Each of the modulators is under the control of a control frequency supplied by an audio frequency amplifier, the latter being indicated by reference numerals **10** and **11**, respectively. The modulators are preferably of the vacuum tube type and in this case the amplified current supplied thereto from the audio amplifier is preferably impressed on the plate circuit thereof so that when the amplified current rises, the modulator is rendered operative to pass carrier current, while when the audio current decreases, the modulator is rendered inoperative to pass the carrier current. The two modulators are supplied with current from the transformer 12 having its center point grounded at 13, the primary of this transformer being energized by the control frequency source 14, the frequency of this last mentioned source may be, for example, of the order of several hundred cycles per second, although a higher or lower frequency may be used. For example if speech transmission is desired the control frequency should be higher than the highest audio frequency to be transmitted. If in this case the control frequency is not superaudible suitable filter means should be provided to prevent the control frequency from being audible with the received signal.

The control frequency current is therefore applied to the two amplifiers 10 and 11 in opposite phase and as a result the amplified currents are supplied to the modulators 5 and 6 in opposite phase, whereby one modulator is rendered operative while the other is rendered inoperative to transmit a signal. The frequency of the control current is such that the periods of operativeness and inoperativeness of each modulator following each other in rapid succession at a rate, for example, of several hundred per second. When it is desired to transmit a signal the key 9 is depressed thereby rendering the amplifier 4 operative to pass an amplified current to the modulators 5 and 6, the closing of the key, for example, removing a blocking potential from the grid of the amplifier or in any other well known way rendering the amplifier operative. The radio frequency carrier current from the source 3 is then amplified in the amplifier 4 and conducted to the modulators 5 and 6.

The passage of this current through the modulators will, however, be dependent upon the conductivity or operativeness thereof, which is determined by the control frequency from source 14. In the very short intervals of time during which each modulator is operative, the carrier current from amplifier 4 will pass to the corresponding antenna, e. g. through the amplifier 7 and then to the antenna 1. At the same time that current is being passed to antenna 1, preferably no current passes to the antenna 2 and vice versa. Therefore, the antennae 1 and 2 radiate alternately a succession of short impulses, a number of which, for example fifteen, are required to form a dot or other element of the transmitted signal.

These successive wave impulses then pass through the surrounding space to the receiving antennae over different paths, since the antennae are spaced apart a distance D. This spacing is preferably in a lateral direction with respect to a line extending from the transmitting station to the receiving station, and is preferably of the order of several wavelengths of the transmitted frequency. Although the lateral spacing is preferred, other spacing may be used. In cases where the transmitting antennae are spaced longitudinally with respect to a line connecting a transmitting and receiving station, it will be found preferable to make the distance between them larger than when the horizontal spacing is used.

I have found in practice that with the antenna spaced as set forth and energized alternately, a signal of much higher average level for a given transmitter output will be obtained than when a conventional transmitting system is used.

Fig. 2 illustrates a modified form of my invention wherein the control frequency supplied to the modulator 5 is different from the control frequency supplied to the modulator 6, these two frequencies which may differ by the order of hundreds, for example, being energized independently of one another. The control frequencies may be 500 and 900 cycles per second although other frequencies showing a greater or lesser difference may be used. While the arrangement of Fig. 1, wherein the operation of the two modulators is positively interlocked, will generally be found preferable, the arrangement of Fig. 2 also shows advantages since for a large part of the transmission period one modulator will be passing current to the transmitting antenna while the other modulator is not. Therefore, for a large proportion of the time it will not be possible for two signals from the two transmitting antennae to arrive at the receiving antenna at the same time, at least at the same amplitude, thereby assuring that during that portion of the transmission period no fading at the receiving station, due to the reception of two different signals of opposed phase and substantially equal strength can occur.

Fig. 3 shows a still further modification of my invention wherein three transmitting antennae are utilized in conjunction with a three phase control frequency source. Here the transmitting antennae will be rendered operative successively to transmit elemental portions of the signals to be radiated. Where three antennae are used they may be spaced at right angles with respect to a line between the transmitting and receiving stations, or at any other desired angle, or the three antennae may be arranged in triangular or other non-linear relation.

In carrying out the invention the several amplifiers are not essential since the radio frequency current may be keyed or otherwise modulated directly at the source 3 and the control frequency may be passed directly to the several modulators without being first amplified. While it is desirable to apply the control frequency to the plate of the modulator tubes, this control current may instead be applied to the grids of the modulator tubes to produce periodic blocking thereof. In operation it is preferable that the modulation be of the C type, whereby successive sharp waves will be transmitted. The key or modulating device 9 may be associated with the several modulators, e. g., 5 and 6 of Fig. 1, instead of with the amplifier of the radio frequency carrier current and in this case the carrier current and the signaling current would both be applied directly to the modulator in the usual way for either grid or plate modulation, while the control frequency would be applied either to the grid or plate of the modulating tube to cause periodic blocking thereof.

In connection with the arrangement of Fig. 2, the two control frequencies may be generated independently if desired, while at the same time still maintaining a fixed phase relationship between them, through the use of a common power line. For example, the several control frequencies may be generated from the same 60 cycle power line supply, by the use of frequency multipliers of any known type and in this case the two frequencies may be the same, the desired phase opposition for the operation of the several modulators being insured through the common connection to the power line.

In actual operation I have found that two transmitting stations operating at a frequency of 14,725 kc. and spaced apart laterally a distance of about 29 wavelengths with respect to a line extending toward the receiving station when rendered operative alternately as described hereinabove, will transmit over a distance of about 2800 miles with such greatly reduced fading that a transmitter power of one kilowatt will produce substantially the same signal strength at the receiving station, as when 20 kilowatts of power are supplied by one of the transmitters alone.

While I have described particular embodiments of my invention for the purposes of illustration, it should be understood that various modifications and adaptations thereof occurring to one skilled in the art, may be made within the spirit of the invention, as set forth in the appended claims.

I claim:

1. A radio transmitting system comprising two antennae having substantially similar transmission characteristics, spaced apart a small number of wavelengths of the frequency which is to be transmitted, a modulator for each antenna, a common source of carrier frequency current for the several modulators, means for causing the carrier current in one of said modulators to decrease to a minimum value while the carrier current in the other of said modulators increases to a maximum value, whereby the said antennae are caused to radiate alternately, and means for modulating said common carrier current.

2. A radio transmitting system comprising three antennae having substantially similar transmission characteristics, spaced apart a distance of a few wavelengths of the frequency to be transmitted, a modulator for each of said antennae, a common source of carrier frequency for said modulators, a source of three phase control frequency and means for applying a different phase thereof to each one of said modulators, whereby the radiation emitted from one of said antennae is caused to increase while the radiation from another of said antennae is caused to decrease.

3. The method of radio communication which comprises transmitting elemental portions of a message successively from different points by radiations having substantially similar vertical radiation characteristics, said points being spaced apart several wavelengths of the transmitted frequency, the rapidity of such successive transmission being such that a large number of said elements are included in the smallest unit of the transmitted message.

4. The method of radio communication which comprises substantially similarly transmitting elemental portions of a message successively from different points by radiations having substantially similar vertical and horizontal radiation characteristics, said points being spaced apart several wavelengths of the transmitted frequency, the rapidity of such successive transmission being of the order of several hundred cycles per second.

5. A radio transmitting system comprising a plurality of antennae having substantially semilar transmission characteristics spaced apart laterally several wavelengths of the transmitted frequency with respect to a line extending between the transmitting station and the receiving station, and means for energizing said antennae alternately in rapid succession so that each antenna is rendered operative and inoperative several times during the transmission of a single elemental portion of the message to be transmitted.

6. A radio transmitting system comprising a plurality of antennae spaced apart a small number of wavelengths of the frequency which is to be transmitted, a modulator for each antenna and means for supplying a different control frequency for each of said modulators whereby the carrier current in each of said modulators decreases to a minimum value and increases to a maximum value in timed relation with the respective control frequencies whereby the said antennae are caused to radiate periodically, and means for simultaneously controlling the radiation from said two antennae in accordance with the same signal to be transmitted.

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