DE LOSS K. MARTIN

DIRECTIVE RADIO REPEATING SYSTEM

Filed Dec. 28, 1921

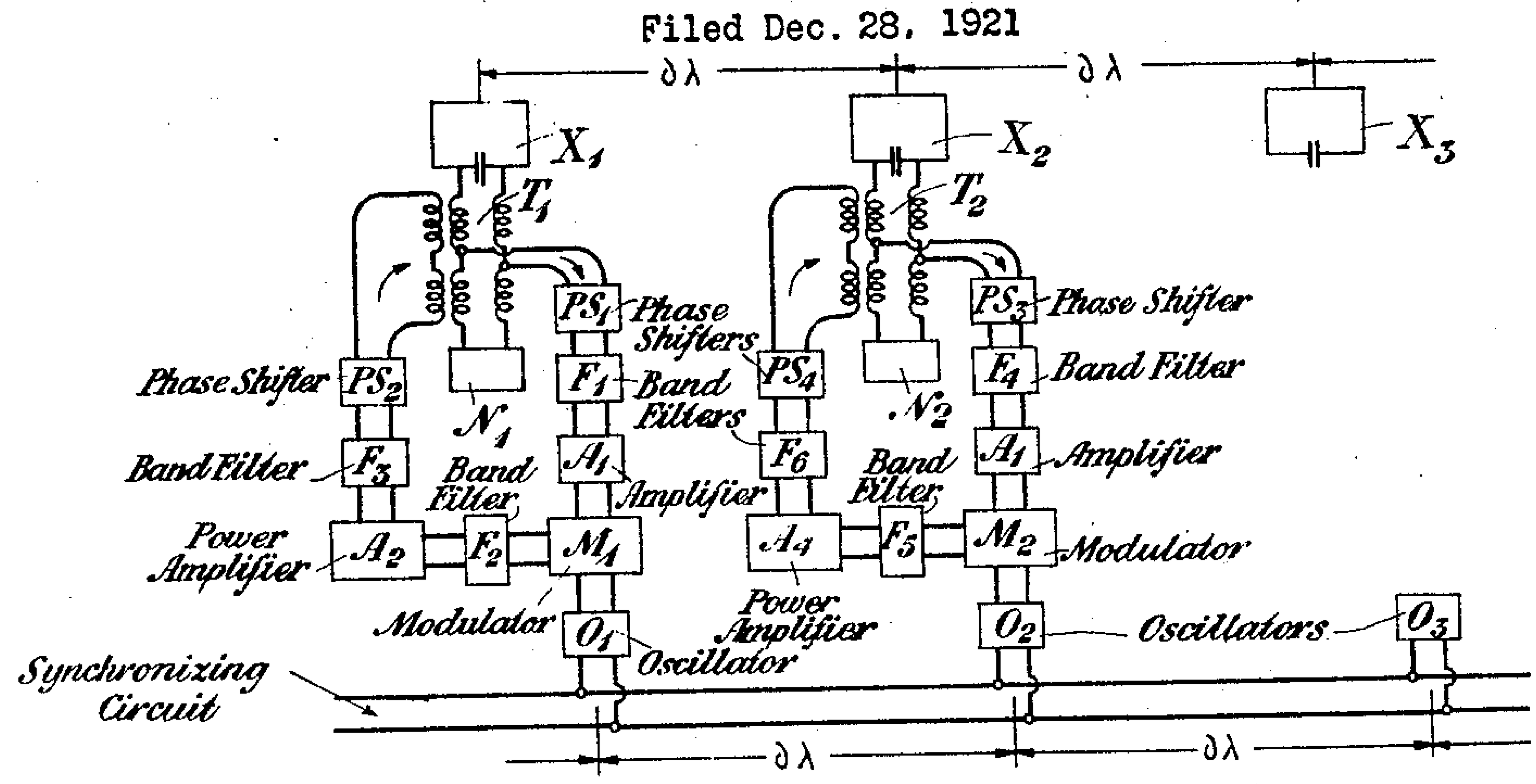

Fig. 1

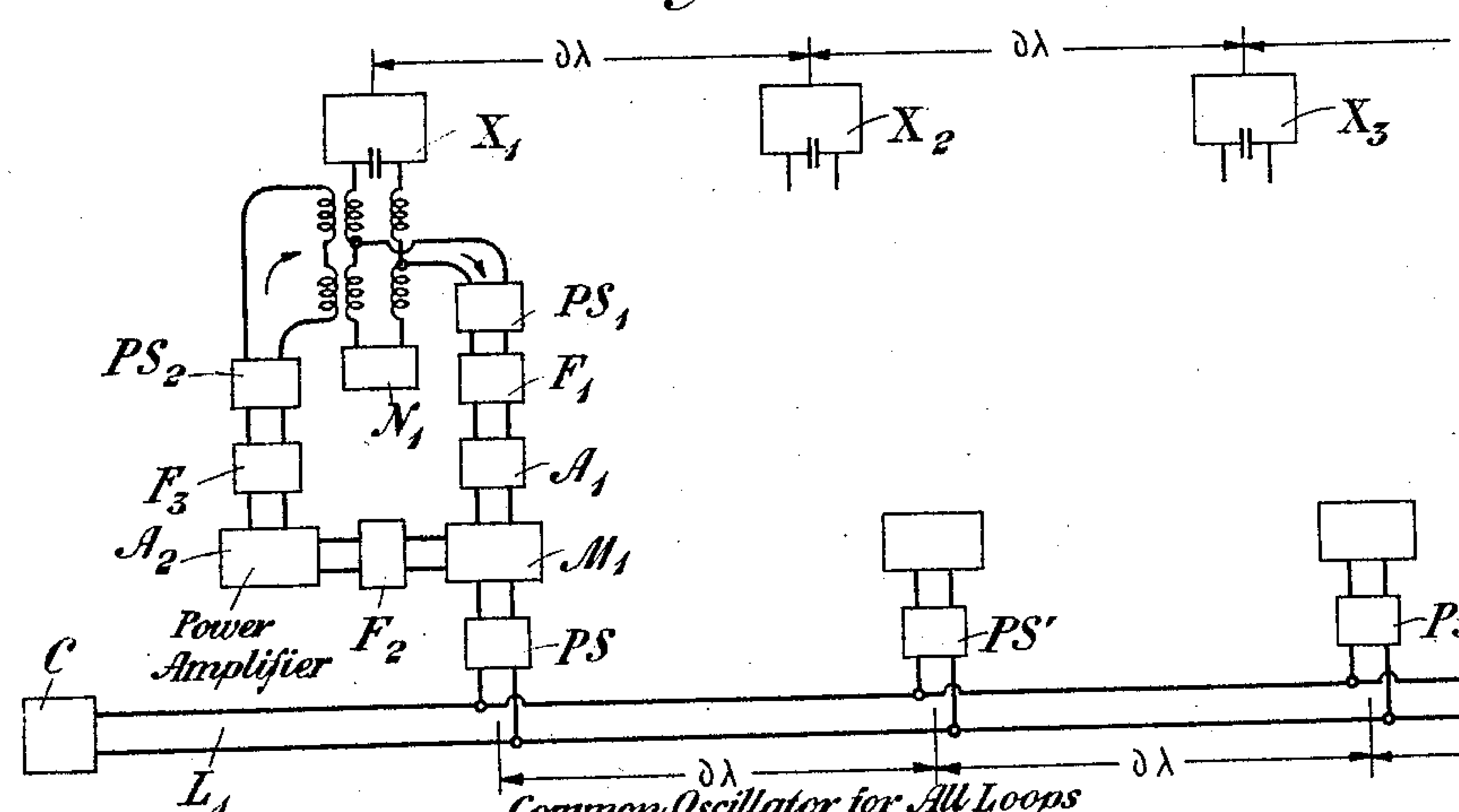

Fig. 2

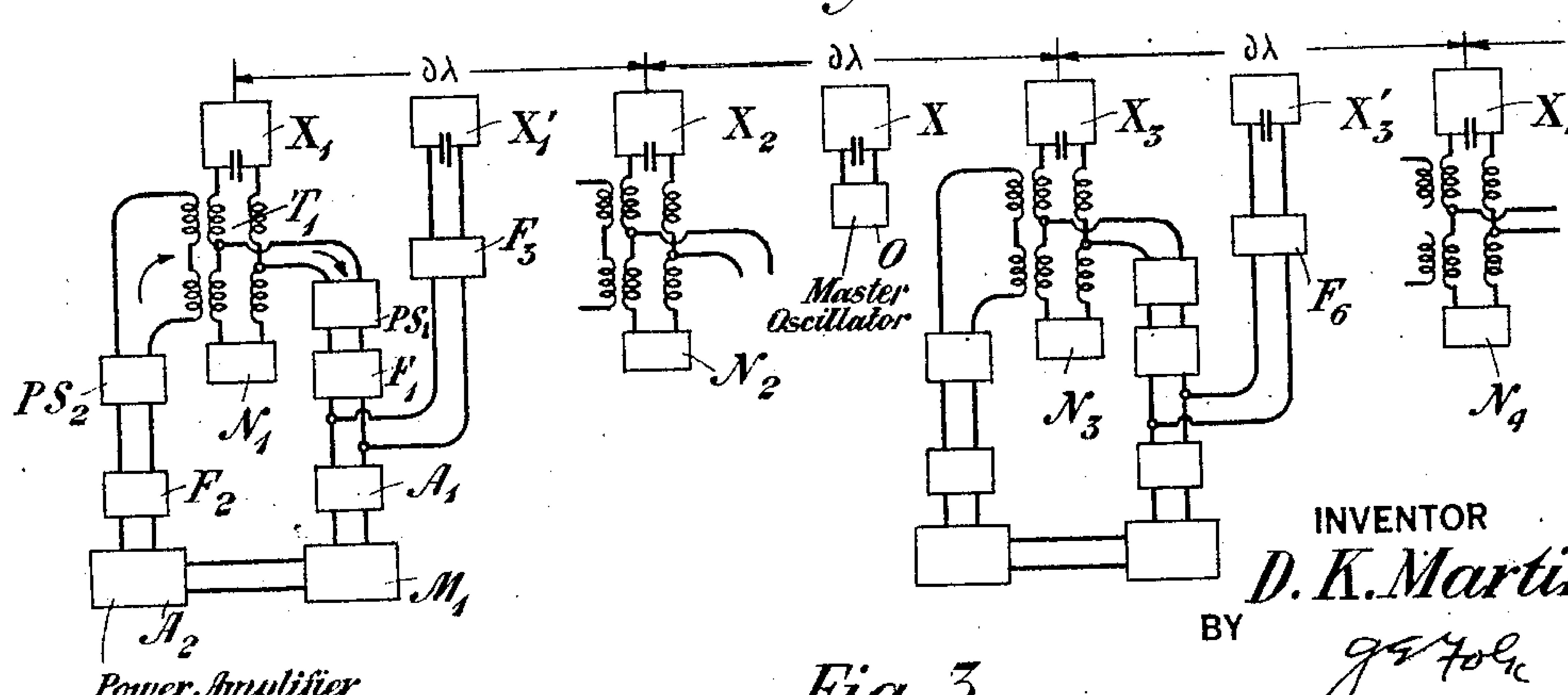

Fig. 3

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Patented Feb. 14, 1928. **1,658,851**

UNITED STATES PATENT OFFICE.

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DIRECTIVE RADIO REPEATING SYSTEM.

Application filed December 28, 1921. Serial No. 525,444.

This invention relates to directive radio repeating systems and especially to that type of system in which the transmitted amplified waves have a different frequency from the received waves.

In the copending applications of Espenschied and Martin, Serial Nos. 525,442 and 525,443, both filed December 28, 1921, there is disclosed a plurality of means for relaying radio signals in which the frequency of the received signals is changed at the repeating stations, so that transmission is effected at a different frequency from reception. One of the objects of the present invention is to provide in a directive radio repeating station means for supplying the beating oscillations to each modulating circuit of the said station, which means are characterized by an arrangement for ensuring synchronism of the oscillations impressed upon each modulating circuit.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing of which Figure 1 shows a plurality of antennæ indicating an array, each antenna having its amplifying and frequency changing circuit and a source of oscillations individual thereto, the said oscillators being connected to a common circuit for synchronizing purposes; Fig. 2 represents a similar antenna array with individual amplifying and frequency changing circuits, but having a single source of beating oscillations common to all the local amplifying circuits; and Fig. 3 indicates a similar antenna array in which the beating oscillations are supplied from a master antenna through the ether to each antenna for impression upon its individual amplifying and frequency changing circuit.

In Fig. 1, X_1, X_2, and X_3 represent three loop antennæ constituting a part of a single array intended for the reception and transmission of signals, but it is to be understood that the invention is not limited to any particular form of antenna. Each antenna is connected with its individual amplifying and frequency changing circuit by a transformer, such as T_1, associated with the antenna X_1. Since all of the local circuits are similar, the description will be confined to that one associated with the antenna X_1. The local circuit, connected to the antenna X_1 by the transformer T_1, comprises a network N_1 designed to balance the antenna X_1, a phase shifting device PS_1, a band filter F_1, designed to transmit the frequencies present in the received band of oscillations, an amplifier A_1, which may be of single-stage or multi-stage type, a modulator M_1, which is designed to beat together the oscillations of the received band and also unmodulated oscillations from the local source O_1, a second band filter F_2 designed to transmit either the upper or lower side band frequencies resulting from the said modulation process, a high power amplifier A_2, a third band filter F_3, having the same characteristic as F_2 and a phase shifting device PS_2 designed to control the phase of the current applied to the loop X_1 of the antenna array for transmission therefrom. Each local circuit has connected thereto a source of oscillations, O_1, O_2, and O_3, which are designed to produce oscillations of the same frequency.

In order to insure identity of frequency of the oscillations produced by each local oscillator, a synchronizing circuit extends between the adjacent oscillators and thus connects all of them together. This circuit is not a power supply circuit, but serves to transmit only such currents between the various oscillators as result from lack of synchronism and which is necessary to restore synchronism to the system of oscillators. Phase shifting devices may, if necessary, be inserted between each oscillator and its point of connection with the common circuit, in order to correct for phase displacement.

The mode of operation of the arrangement in which the invention is embodied is as follows: Current of the signaling frequency will be set up in each of the antennæ X_1, X_2, and X_3 as a result of the passage of a wave across the array. The current set up in the loop X_1, for example, will be transmitted by the transformer T_1 to the local circuit, traversing the phase shifting device PS_1, the band filter F_1 and the low power amplifier A_1. This current, which for example, may comprise a band of frequencies based upon the carrier frequency f_1, will be modulated at M_1 by current of a frequency f_3. As a result, the band of frequencies which will be based upon a new carrier frequency $f_2=(f_1+f_3)$ or $=(f_1-f_3)$ will be transmitted through the band filter F_2, amplified by the power amplifier A_2, transmitted through the filter F_3 and given the proper phase displacement by the phase shifting device PS_2 before radiating from the antenna X_1. Similar action is taking place simultaneously in each local circuit connected with and individual to the other antennæ of the array, but the phase displacement of the current in each local circuit, produced by the phase shifting devices of each local circuit, may differ in order to obtain the desired directional characteristic for the array. When, however, the desired directivity of reception and transmission has been attained by a definite setting of the phase shifting devices it will continue unchanged so long as synchronism is maintained between the various oscillators of the system.

The arrangement shown in Fig. 2 is, in general, similar to that shown in Fig. 1 with the exception that a single source of oscillations O is designed to provide the beating oscillations for all of the local amplifying circuits. Thus, in Fig. 2, beating oscillations of the frequency f_3, generated by the oscillator C at the left-hand side of the figure, are transmitted over the circuit L_1, and are impressed upon each local circuit by means of branch circuits, connected with the main circuit L_1 at a definite fraction of a wave apart, for the purpose of supplying the beating oscillations to each local amplifying and frequency changing circuit. Phase shifting devices PS, PS′ and PS″ are inserted on each of said branch circuits, between the common circuit L_1 and each local circuit for the purpose of compensating for the phase displacement of the beating oscillations in each branch circuit due to the transmission of high frequency currents over the common transmission line L_1. In this manner synchronism is ensured for the beating oscillations applied to the modulators of each local circuit of the entire array.

The arrangement shown in Fig. 3 differs in principle from that shown in Fig. 2 in that the beating oscillations are supplied from a common source to each local amplifying circuit through the ether instead of over a metallic circuit, as in Fig. 2. In Fig. 3, X_1, X_2, X_3 and X_4 represent loop antennæ designed for the reception and transmission of the signal frequencies and representing part of an array. Each antenna is connected with its individual amplifying and frequency changing circuit by means of a transformer, such as T_1 shown in connection with the antenna X_1. Each local circuit has also connected thereto another antenna, such as X_1', which is designed to receive the beating oscillations from a common source of oscillations, represented by the antenna X connected with the oscillator O, and to impress the beating oscillations upon the local circuit.

When signaling oscillations of, for example, the frequency f_1, together with the band of frequencies superimposed thereon, are received by the antenna X_1, they will be impressed by the transformer T_1 upon the input branch of the local amplifying circuit. These received signaling oscillations will be transmitted through the phase shifting device PS_1 and thence through the band filter F_1 designed to transmit this band of frequencies. The beating oscillations radiated by the antenna X will be received by the antenna X_1, tuned to this frequency, and also by other similar antennæ of the array. These oscillations will be transmitted through the filter F_3 and impressed upon the amplifier A_1 together with the band of signaling oscillations which have passed through the band filter F_1. The amplified oscillations of both the signaling and the beating frequencies will be modulated by the modulator M_1, and the resultant bands of oscillations of, for example, the frequencies represented by f_2 will be amplified by the amplifier A_2. These bands of frequencies will be impressed upon the band filter F_2 which is designed to transmit only one band as, for example, $F_1—F_3$. Oscillations of these frequencies will be given the proper phase displacement by the phase shifting device PS_2, and will be transmitted from the antenna X_1. The action taking place in the other local circuits connected with the antennæ X_2, X_3, X_4, etc., will be similar to that taking place in the local circuit connected with the antenna X_1 excepting, as pointed out particularly in connection with Fig. 1, that the phase displacement of the oscillations in the local circuits may differ.

Although in the forms in which the invention has been disclosed balanced loop antennæ have been shown, it is to be understood that the invention is not limited to a particular type of antenna structure but it may be used in connection with any type of antenna structure or any type of balancing such as the balanced ground-vertical antenna structure shown in the copending application of Espenschied and Martin Serial No. 525,442. It will be seen that by means of the arrangements heretofore described I have provided, in a radio repeating system having directive characteristics, means for supplying the beating oscillations necessary for changing the frequencies of the currents transmitted through such repeating stations, which means are designed to produce synchronism of the oscillations applied to each of the modulating circuits of the system.

Although this invention has been described as embodied in a certain form and arrangement of parts, it is to be understood that it is capable of embodiment in other and more widely varied forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a radio repeating system, the combination with a directive antenna array comprising a plurality of antennæ symmetrically arranged, of a plurality of modulating circuits individual to and connected with each of said antennæ, and means common to all of said circuits to apply synchronous beating oscillations thereto.

2. In a radio repeating system, the combination with a directive antenna array comprising a plurality of antennæ symmetrically arranged, of a plurality of modulating circuits individual to and connected with each of said antennæ, a central source of beating oscillations connected with each of said modulating circuits, and means connected with each of said modulating circuits to insure synchronism of the beating oscillations in each of said circuits.

3. In a radio repeating system comprising an antenna array, comprising a plurality of antennæ symmetrically arranged, amplifying circuits having phase controlling means and frequency changing means associated therewith individual to and connected with each of said antennæ, the method of repeating, which consists in receiving oscillations of definite frequency, impressing upon its amplifying circuit the oscillations received by each antenna, beating in each frequency changing means the received oscillations together with oscillations of different frequency, automatically maintaining in synchronism the modulating oscillations supplied to each frequency changing means and radiating the oscillations of the frequency resulting from modulation.

4. In a directive radio relay characterized by the reception and transmission of the same signaling channel at different frequencies, the method of modulation, which consists in transmitting the modulating frequency from a central source, correcting the phase of the modulating oscillations supplied to each modulator of the system and beating the received frequency with the modulating frequency from the said central source.

5. In a directive radio signaling system, the combination with a plurality of antennæ symmetrically spaced constituting an antenna array of a plurality of frequency translating circuits, each individual to and connected with one of said antennæ, each translating circuit including a modulator and an oscillator, and means to maintain in synchronism and phase all of said oscillators.

6. In a directive radio signaling system, the combination with a plurality of antennæ symmetrically spaced constituting an antenna array of a plurality of frequency translating circuits, each individual to one of said antennæ, each translating circuit having a modulator, an amplifier and an oscillator connected with said modulator and means to maintain in synchronism and phase all of the said oscillators.

In testimony whereof, I have signed my name to this specification this 27th day of December, 1921.

DE LOSS K. MARTIN.