June 1, 1943. R. H. GEORGE 2,320,518

MODULATED TRANSMITTER

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Fig. 1

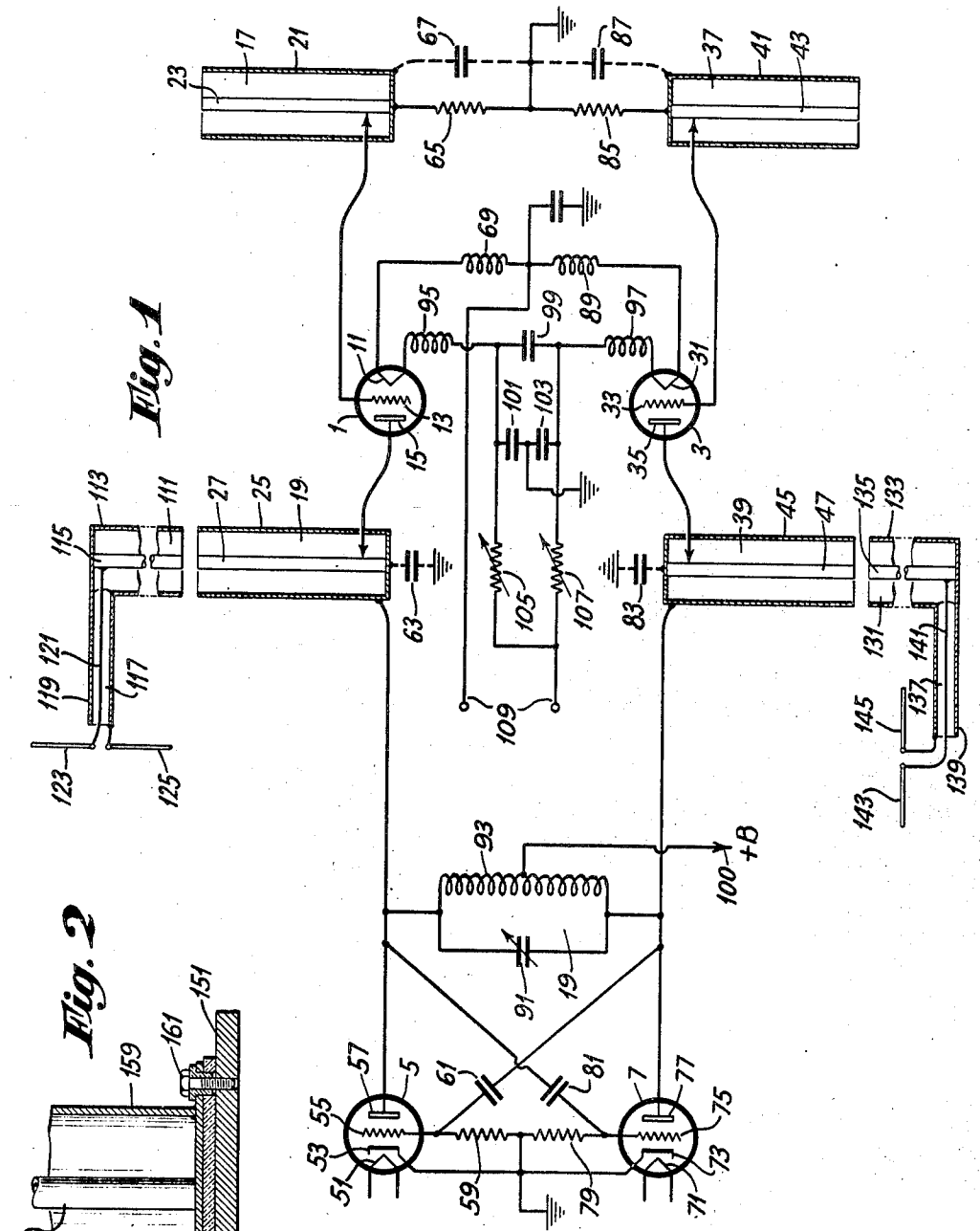


Fig. 2

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MODULATED TRANSMITTER

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8 Claims. (Cl. 250—17)

This invention relates to transmitters and particularly to modulated radio frequency transmitters of quasi-optical wave characteristics. More particularly the invention relates to the modulation of two ultra-high-frequency transmitters by a single oscillator so arranged that each of the two transmitters is modulated either alternately or sequentially or in a predetermined recurring order.

In accordance with one preferred form of the invention, the tuned radio frequency transmitters have their output electrode elements supplied through the tank circuit of an oscillator, which oscillator may conveniently be of the so-called push-pull type so that alternately first one of the transmitters and then the other has its output electrode element potential raised to such a value that oscillations may take place. Such a transmission system finds particular use in radio navigation aids for aircraft, such as disclosed by co-pending application Serial No. 198,888, filed by Roscoe H. George on March 30, 1938 for an invention relating to an Electronic indicating device which issued as U. S. Patent 2,216,707 on October 1, 1940. While the present invention is applicable to a system of the general type disclosed by the aforesaid pending application, its use is not limited to such a system but, to the contrary, the present invention may be used wherever it is desired to have two transmitters modulated alternately by a single frequency.

The present invention thus affords much greater efficiency in modulation by its circuit arrangement and at the same time it provides both a simplified circuit and one which is more easily maintained at high operational efficiency.

Another important feature of the invention is that the arrangement herein to be disclosed provides for exceedingly stable operation of a transmitter at ultra-high-frequencies, which frequencies may be of the order of 400 megacycles or more. Further, it is possible by this invention to achieve this operational stability without the use of crystal oscillators, magnetostriction oscillators, or other outside stabilized elements. This stability is achieved through the use of the so-called high Q resonant circuits in the form of quarter wave length transmission lines for both the control electrode and output electrode (frequently termed grid and plate) circuits of the transmitter tubes. Accordingly, it is one of the objects of this invention to provide a pair of highly stabilized ultra-high-frequency oscillators which shall be modulated alternately by a single oscillator.

Another object of the invention is to provide a simplified modulating circuit which shall be more efficient and more easily maintained in operating condition than modulated systems hitherto used.

A further object of the invention is to provide a highly stabilized high frequency oscillator of simple form which shall be capable of having its oscillatory energy easily abstracted and fed to an output circuit which may comprise a directive antenna array, for example.

Other objects of the invention will become apparent upon reading the following detailed discussion taken together with the drawing in which Figure 1 shows in schematic form the circuit arrangement of two radio frequency transmitters together with their output circuits and the antenna array connected to each, as well as a single push-pull oscillator which serves to modulate the two transmitters; while Figure 2 shows some of the constructional features of the quarter-wave transmission line tuned circuit used in the output (plate) and control electrode (grid) circuits of the transmitter tubes.

Turning now to Figure 1, the transmitter tubes 1 and 3 have their output electrode (anode) elements 15 and 35, respectively, connected to the center conductors 27 and 47, respectively, of the tuned quarter-wave transmission lines 19 and 39, respectively. The control electrodes (grids), 13 and 33, respectively, of tubes 1 and 3 are connected similarly to the inner conductors 23 and 43 of the tuned quarter-wave transmission line circuits 17 and 37 respectively. Bias for the control electrodes 13 and 33 is provided by the resistors 65 and 85, respectively, which have their common junction point connected to ground, and the capacities 67 and 87, which are in parallel with resistors 65 and 85, which establish the desired time-constant control circuit, are provided by the construction of the quarter-wave length transmission lines, as shown in detail in Figure 2, herein to be further described.

Referring now to the constructional features of Figure 2, the outer metal cylinder 159 is secured to a metal plate member 155, by brazing thereto, for example. The inner conductor 157 may likewise be secured (for example, by soldering, brazing or threading) into this same metal plate 155. The metal plate 155 is fastened to a metal chassis 151 (for example by screws 161) which are insulated from both the plate 155 and the chassis 151. Between the plate 155 and the

chassis 151 is a sheet of dielectric material 153, which may be mica, glass, enamel, ceramic or other suitable material, so that the end plate 155 of the transmission line, together with the chassis 151, constitutes a condenser. The capacity of this condenser, naturally, is determined by the thickness of the insulator or dielectric sheet 153 and the area of the end plate. The condenser formed by this construction is conventionally represented in Fig. 1 by the condensers 67 and 87 for the control electrode tuned transmission line, while for the output electrode transmission lines, the elements 63 and 83 (formed preferably by the same construction) form a part of the tuned transmission lines.

Electronic emitting cathodes 11 and 31 for the tubes 1 and 3 are supplied by heating current (e. g. from a 60 cycle power supply) connected to the terminals 109. The actual voltage at terminals 109 may vary in accordance with the type of tubes used. In order to preserve balance in the heating circuits at exceedingly high frequencies, a symmetrical array of chokes 69, 89, 95 and 97 are provided in the cathode circuit. In general, in order to obtain optimum operating conditions, it is desirable to have some control of the heating of the cathodes and this is provided by the variable resistors 105 and 107 which regulate the actual potential supplied each of the cathode elements 11 and 31. To preserve the symmetry, therefore, between the radio frequency chokes 95 and 97, there is condenser 99 across which two condensers 101 and 103 are connected in series. From the common conjunction point of the condensers 101 and 103 a ground connection is provided. It will thus be noted that with respect to radio frequency current which might pass through the chokes 69, 89, 95 and 97, there is preserved nevertheless a symmetrical arrangement so that no inter-action can take place in the cathode circuits of the tubes 1 and 3.

The anodes 15 and 35 of tubes 1 and 3, respectively, are connected through inductance 93 to terminal 100 to which is connected a source of voltage (marked plus B). The terminal 100 is connected to the mid-tap of the inductance 93 across which inductance is placed a tuning capacitor 91. The combination of the condenser 91 and the inductance 93 forms a tuned resonant circuit 19. From each end of the center tapped inductance 93 a connection is made to the plate or anode elements 57 and 77 of tubes 5 and 7, respectively. The cathodes 53 and 73 of these two tubes are connected together and maintained at the established ground potential by suitable connection. The electronic emitting cathode elements are heated by heaters 51 and 71, respectively, while bias for the control electrodes 55 and 75 is obtained by the use of resistors 59 and 79, respectively. Feedback from the plate circuit to the control circuits is obtained by the cross-connected condensers 61 and 81 respectively.

For the generation of oscillations in the ultra-high-frequency transmitting tubes 1 and 3, these tubes may be of the type of tube known in the art as the W. E. 316–A, since a tube of this type is so constructed as to provide minimum inner electrode capacity and minimum lead inductance. Tubes of the type known as the RCA 53 may be used for the modulator tubes 5 and 7. The oscillating energy may be fed to the output circuit, as shown in Figure 1, by using open-ended quarter-wave tuned transmission lines 111 and 131, respectively. In practice, the open end of the tuned transmission line 111 is positioned in register with the open end of tuned transmission line 19 and spaced therefrom a distance of the order of ¾ to 1 inch. The spacing is not critical but when the transmitters operate on a frequency of 400 megacycles, it is found that the spacing thus mentioned provides sufficient transfer of energy to the outside circuit which comprises a directive antenna array, of which one di-pole 123—125 is shown. For effective feeding of the antenna, a coaxial transmission line 117 is provided in which the inner conductor 121 is connected to the inner conductor 115 of the tuned transmission line 111.

The distance from the end plate at which the inner conductor 121 is connected to the inner conductor 115 is not critical but may be on the order of ½ inch to 2 inches, which, in practice, has been found to provide the optimum transfer of energy within these limits. The outer conductor 119 of transmission line 117 is connected to the outer conductor 113 of the coupling tuned transmission line 111.

At the output end of the transmission line the outer conductor 119 is connected to one-half of the di-pole 125 while the inner conductor is connected to the other di-pole 123. A similar set of connections is provided for the other plate circuit 39 on tube 3 and serves to feed the di-pole comprising the two members 143 and 145.

Where the modulated pair of transmitters is used in connection with the radio beam landing device, described and referred to above in my copending application, the di-poles 123—125 may be vertically polarized while the di-poles 143—145 may be horizontally polarized. Thus it will be appreciated that for each half cycle of the oscillator, whose frequency is determined by the resonant frequency of the tuned circuit 19, there first will be radiated vertically polarized waves and then horizontally polarized waves.

By using quarter-wave length tuned transmission lines in both the control electrode (grid) and output (anode or plate) circuit of each of the tubes 1 and 3, high stability results since these circuits have an exceedingly high Q, that is, the ratio of inductance to resistance of the tuned circuit is very large. The resulting oscillator is, therefore, highly stabilized with respect to frequency. This is particularly desirable in view of the fact that the voltage supplied by the plates 15 and 35 varies over wide limits for a range substantially equal to twice the voltage supplied to the terminal point 100 and marked plus B.

It will be readily appreciated that unless such tuned transmission lines are used, the wide variation in value of plate voltage would not produce a stabilized frequency, but rather, the output energy from the transmitter would include frequency modulated oscillations as well as amplitude modulation provided by the push-pull oscillator embodying the tubes 5 and 7. However, with the arrangement provided by the invention, even though the voltage at each of the tubes 1 and 3 at alternate ½ cycles decreases below the point at which oscillations may be maintained, nevertheless the frequency emitted from the antenna is stable.

It will thus be appreciated that the present invention provides two transmitters modulated by the same modulator in which there is a minimum number of circuit elements, yet which provides substantially 100% modulation for each of the transmitters so that the over-all operating efficiency is considerably higher than those modulating systems known prior.

It is further to be noted that considerable sim-

plicity is achieved without the loss of stability of frequency by applicant's arrangement since it is unnecessary to resort to the usual quartz crystal controlled oscillator, together with an intervening amplifier, to drive or control the stability of transmitting tubes 1 and 3.

While the invention has been described for use in connection with radio control of aircraft, it will be readily appreciated that the invention is not limited to this particular use but may be used in such systems as ultra high frequency radio relays where it is desired to provide transmitters for operating tubes in different directions and at the same time to provide a pilot frequency for automatic volume control of the light.

Having described my invention, what I claim is:

1. Transmitting apparatus comprising a push-pull oscillator, a first and a second transmitter, a horizontally polarized antenna system connected to said first transmitter, a vertically polarized antenna system connected to said second transmitter, a source of energy, and common means to energize said oscillator and said transmitters from said source and to modulate said transmitters alternately by said oscillator.

2. Transmitting apparatus comprising a push-pull oscillator having a resonant circuit, a first stabilized high-frequency transmitter, a second stabilized high-frequency transmitter, a source of energy, means to energize said oscillator from said source, and means including said resonant circuit for energizing said first and said second transmitters from said source.

3. Transmitting apparatus comprising a push-pull thermionic oscillator having two output electrodes, a tuned resonant circuit connected between said output electrodes, a source of energizing voltage connected to the tuned circuit, two independent thermionic oscillators each having an output electrode, a connection from one of the output electrodes of one of said independent oscillators to the junction point of said tuned circuit and one of the output electrodes of the push-pull oscillators, a connection from the output electrode of the other independent oscillator to the junction point of the tuned circuit and the other of said output electrodes of said push-pull oscillator, and means to derive output energy from each of the independent oscillators.

4. Transmitting apparatus comprising a first tuned grid-tuned plate thermionic oscillator, a second tuned grid-tuned plate thermionic oscillator, a push-pull thermionic oscillator having a tuned output circuit, connections from each of said tuned grid-tuned plate oscillators to the tuned output circuit, and means to energize the push-pull oscillator and two independent oscillators through said connections from a single source of energy.

5. Transmitting apparatus comprising a first tuned grid-tuned plate oscillator, said tuning being provided by open-end quarter wave length transmission lines, an open-end quarter wave length transmission line coupled to the tuned plate, means connecting said coupled transmission line to a vertically polarized antenna array, a second tuned grid-tuned plate oscillator having open-end quarter wave-length tuned transmission lines, an open-end quarter wave-length transmission line coupled to said tuned plate, means connecting said second named coupled transmission line to a horizontally polarized antenna array, a push-pull oscillator, and means including a single source of energy potential and connections from said push-pull oscillator to each of the tuned plate of the said first and second oscillators for energizing said first, said second and said push-pull oscillator.

6. A transmitting system comprising a first independent oscillator and a second independent oscillator, each of a predetermined frequency, a third oscillator having a resonant circuit, a single source of energy, connections from said resonant circuit of said third oscillator to said first and said second oscillators, and means including a connection from said source of energy to said resonant circuit for energizing said third oscillator and for energizing said first and said second oscillators through said first named connections.

7. In a radio beam landing system, the method of transmitting wave energy representative of spatial locations, which comprises the steps of producing wave energy of a first predetermined frequency, producing wave energy of a second predetermined frequency, producing wave energy of a third predetermined frequency, and alternately modulating and radiating the produced energy of the first predetermined frequency in a given plane of polarization and the produced energy of the second predetermined frequency in a plane of polarization perpendicular to the given plane of polarization, said planes of polarization being representative of the spatial location of the radiation of the wave energy.

8. Transmitting apparatus for a radio beam landing device comprising a push-pull oscillator, a first transmitter, a second transmitter, each of said transmitters having independent frequency-determining elements serving to produce a different frequency for each transmitter, a norizontally polarized antenna system connected to said first transmitter, a vertically polarized antenna system connected to said second transmitter, said polarizations representing the spatial location of the transmitters, and means to alternately key said first and said second transmitter by said push-pull oscillator.

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