May 8, 1945. W. P. LEAR 2,375,421

DIRECTION RADIO TRANSMITTING SYSTEM

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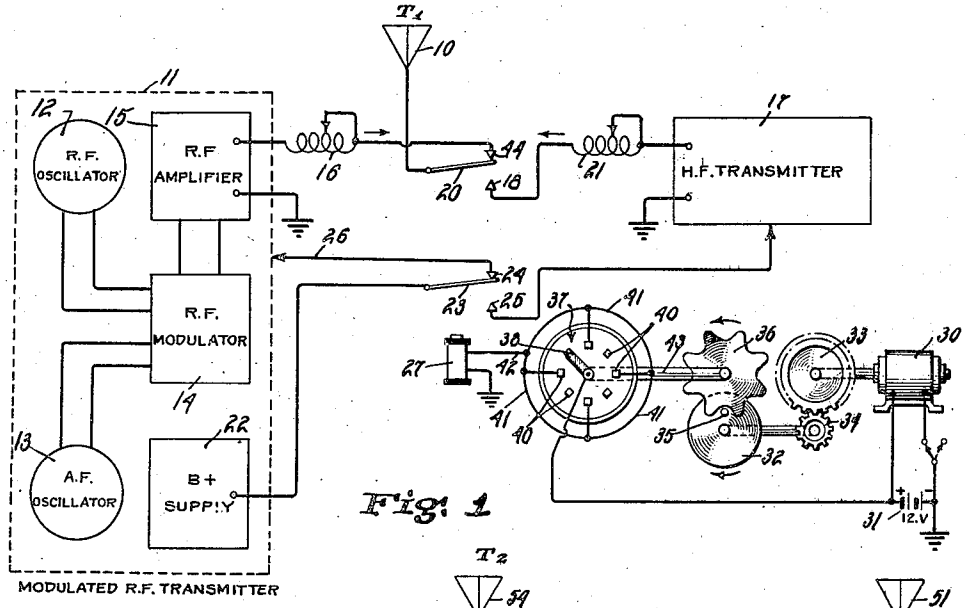


Fig. 1

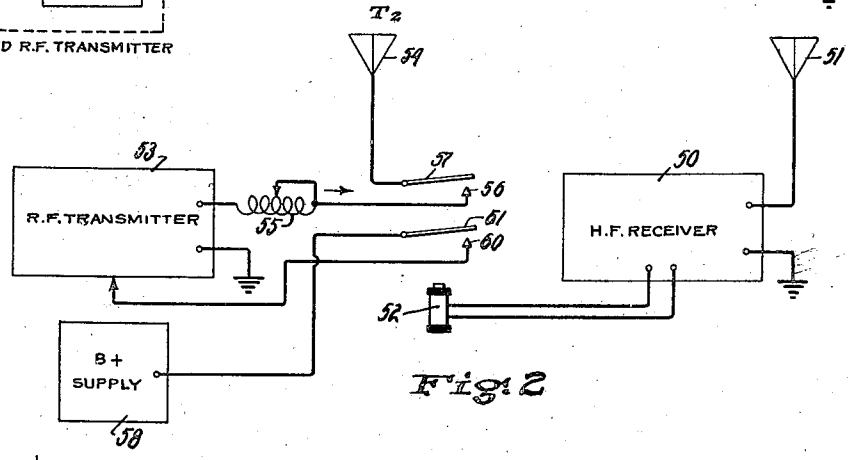


Fig. 2

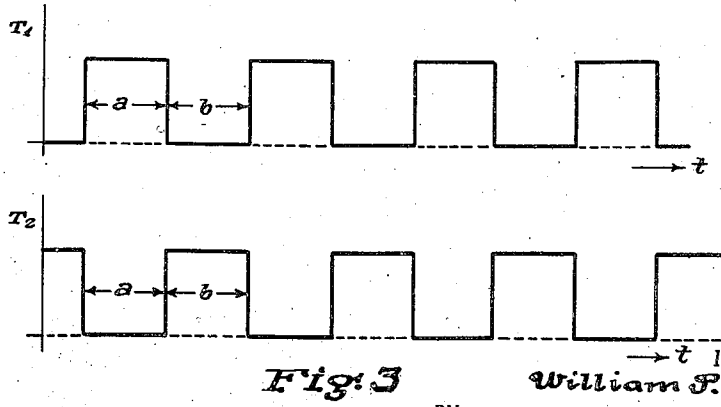


Fig. 3

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DIRECTION RADIO TRANSMITTING SYSTEM

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Original application August 25, 1939, Serial No. 291,807. Divided and this application July 24, 1943, Serial No. 495,978

14 Claims. (Cl. 250—6)

This invention relates to signal transmitting arrangements for radio guidance systems, and more particularly relates to such arrangements in which the radiation of a plurality of radio transmitters is successively switched on and off. This case is a division of my copending application entitled "Radio guidance system," Serial No. 291,807 filed August 25, 1939, which is assigned to the same assignee as the present case.

In accordance with my present invention I provide a radio transmitting arrangement including two spaced non-directional transmitter stations having the same carrier frequency. The radiation of the stations is successively switched on and off at predetermined intervals. The respective signals of the two stations are differentiated either with separate audio frequency modulations, or with tone modulation of one signal, the other signal being unmodulated. Switching means controlled by a constant speed motor are employed for successively connecting and disconnecting a high frequency transmitter associated with one station with its antenna. The thus produced intermittent signal is picked up by the second transmitter station and causes the latter to radiate alternately with the first station in dependence upon the received high frequency signal.

The signal transmitting arrangement of the present invention may find particular application in connection with the radio guidance receiver systems disclosed in my copending application above referred to. The receiver systems disclosed therein comprise means for automatically deriving and maintaining an individual directional bearing on each of the radio signals radiated by two transmitter stations. To provide an instrument approach system, two non-directional transmitters are spaced from each other and arranged in line with the desired runway or approach path. The pilot of an airplane or other mobile craft is thus continually made aware of his position. Other fields of application of the signal transmitting arrangement of the present invention will be readily apparent to those skilled in the art.

It is accordingly an object of my present invention to provide novel radio signal transmitting arrangements including means for successively effecting signal radiation from several transmitters.

Another object of the invention is to provide two spaced non-directional radio transmitter stations, one of which produces an intermittent control signal for successively switching on and off the second transmitter station.

These and further objects of my present invention will become apparent in the following description of an exemplification thereof shown in the accompanying drawing, in which:

Fig. 1 is a schematic electrical diagram of the arrangement at one of the transmitter stations of the present invention.

Fig. 2 is a schematic electrical diagram of the arrangement at the second transmitter station.

Fig. 3 shows curves illustrating the electric switching operation for the two transmitter stations of Figs. 1 and 2.

Referring to the drawing, Fig. 1 is a schematic arrangement corresponding to one of the transmitters here designated as T_1; and Fig. 2 to the other, T_2. The transmitter stations of Figs. 1 and 2 both have the same carrier frequency. Transmitting antenna 10 is designed to efficiently radiate the radio frequency signal of T_1. Any suitable carrier frequency may be used such as a commercial frequency, a broadcast frequency, if permissible, a high frequency, or even an ultra-high frequency. A carrier frequency of, for example, 209 kilocycles may be used for T_1 and T_2. Similarly, a frequency of say 1614 kilocycles may be used, or 4790 cycles, etc.

The radio frequency generator for T_1 is schematically indicated within dotted rectangle 11. Radio frequency oscillator 12 generates the carrier at the preferred radio frequency. An audio frequency oscillator 13 generates the tone signal for modulating the radio frequency carrier. The tone or audio frequency is used to distinguish the radiation of station T_1 from that of station T_2. The audio frequency of generator 13 may be 75 cycles, 150 cycles or higher as desired. The radio frequency carrier is modulated by the audio frequency tone at radio frequency modulator 14, the output of which is connected to radio frequency amplifier 15. The output of amplifier 15 is connected to loading coil 16 and in turn to antenna 10. Loading coil 16 is adjusted for most efficient radiation of the radio frequency wave through antenna 10.

An arrangement is provided for maintaining the transmission of the modulated radio frequency wave through antenna 10 for a predetermined period, in the range say of one-third to one-half of a second; extinguishing the transmission of the radio signals corresponding to 11 at station T_1; and successively providing for the transmission of the radio frequency signal from the other station T_2, of Fig. 2. To this end,

a high frequency relaying transmitter 17 is arranged to radiate from antenna 10 to control remote transmitter T_2. Transmitter 17 radiates while transmitter 11 is extinguished and vice versa.

In the system of Fig. 1, I employ the same antenna 10 for the transmission of both the modulated radio frequency wave from transmitter 11 as well as the high frequency relaying signal from unit 17. Separate antennae may be used. The output of transmitter 17 is connected to back contact 18 of relay armature 20 through a loading coil 21. When relay armature 20 connects with back contact 18, high frequency transmitter 17 is connected to antenna 10. Loading coil 21 is adjusted for most efficient radiation of the high frequency wave from antenna 10. To insure the proper extinguishing of the radiation from both transmitters, I prefer to disconnect the positive B potential supply 22 from the transmitters during their respective non-radiating periods. For this purpose, I use relay armature 23 connected to B supply 22 which is connected to radio frequency generator 11 through relay contact 24 and lead 26 as shown schematically. Common B supply 22 is also connectable to high frequency transmitter 17 through relay contact 25 when armature 23 contacts therewith upon energization of solenoid 27.

In the described switching-over arrangement for stations T_1 and T_2, any time lag due to the action of relays or other components should be properly designed and arranged to give the indicated mode of operation. To simplify the exposition, no lag will be assumed. However, suitable construction in practice to accomplish the desired results will be apparent to those skilled in the art. The design of the commutators, cams or other switch-over means should be such as to take into account the lag in the connection and disconnection of the circuits by the relays and associated armatures.

Relay solenoid 27 is suitably energized at the proper time intervals to attract relay armatures 20 and 23 from their normal upper position shown, to the lower contact position for correspondingly extinguishing the generation and transmission of the radio frequency signal of unit 11 and initiating the generation and transmission of the high frequency relay signal of unit 17 through the antenna 10 successively and without overlapping. A preferred transmission and cessation interval in practice is one-third of a second where the transmitter stations are used for aircraft guidance. However, it is to be understood that different intervals, such as one-half second or greater are equally suitable, as are intervals of less than one-third second also feasible. If the transmitter system is used for marine guidance longer intervals are useful since the approach speed of the vessel to be guided is considerably less.

An arrangement for periodically energizing relay solenoid 27 to effect the successive switching at predetermined intervals is diagrammatically illustrated in Fig. 1. The timing intervals are equal and cyclic, not necessarily absolute in value, but generally within the predetermined timing interval desired. A constant speed motor 30 is energized through a local potential source 31, such as a 12 volt battery. An alternating current motor and supply also may be used. Motor 30 drives disk 32 through suitable reduction gearing 33, 34. A pin 35 projects from the face of disk 32. A star wheel 36 is arranged to coact with pin 35 on each revolution of disk 32. Star wheel 36 is advanced through an arc equal to the width of one of its teeth during each revolution of disk 32. The speed of motor 30 as well as the ratio of the respective gearings 33, 34 and 35, 36 is designed so as to advance the commutator 37 by one segment corresponding to one switching interval; in one-third of a second in the present case.

Commutator 37 comprises switch arm or blade 38 rotatable over a plurality of equi-spaced contact segments 40. Alternate segments 40 are connected together by connections leads 41 and in turn connected to relay solenoid 27 through lead 42. Switch arm 38 is electrically insulated from contacts 40 and is connected to one side of the potential source, namely battery 31. Switch arm 38 is shown on one of the insolated contacts. The motivation of switch arm 38 is by star wheel 36 interconnected through shaft 43. The battery circuit through relay 27 and ground is open during such position. When switch arm 38 engages one of the four interconnected contact elements 40 of commutator 37, relay 27 is energized by battery 31 to attract armatures 20 and 23 to the downward or front contact position.

Armatures 20 and 23 are normally biased upwards towards their back contacts 44 and 24, respectively maintaining transmitter 11 energized and connected for radiation through antenna 10. When relay 27 is energized, armatures 20 and 23 are attracted to front contacts 18 and 25, respectively, energizing high frequency relaying transmitter 17 and connecting it to antenna 10 for radiation. During this interval, radio signal transmitter 11 is deenergized and not transmitting, through disconnection of B supply 22 therefrom. Constant speed motor 30 causes star wheel 36 to advance one segment for every predetermined interval. Commutator arm 38 accordingly is moved to successively cause energization and deenergization of relay 27 resulting in corresponding alternate transmission of modulated radio signal from unit 11 and high frequency relaying signal from unit 17.

While transmitter unit 11 is quiescent and high frequency relay transmitter 17 is radiating from station T_1, high frequency receiver 50 of Fig. 2 is energized. Antenna 51 of tuned receiver 50 picks up the radiated high frequency signals from unit 17. The output of high frequency receiver 50 is connected to relay solenoid 52 for effecting transmission of radio frequency transmitter 53 at station T_2. Radio frequency transmitter 53 is connectible to transmitter antenna 54 through adjustable loading coil 55, front relay contact 56, and relay armature 57. Positive B supply 58 is connectible to radio frequency transmitter 53 through contact 60 and armature 61 of relay 52. Energization of solenoid 52 by receiver 50 during the high frequency relaying period causes the attraction of armatures 57 and 61 against front relay contacts 56 and 60, respectively. This energizes radio frequency transmitter 53 with B supply 58 and connects the output of transmitter 53 to antenna 54 for radiation.

Radio frequency transmitter 53 preferably has the same carrier frequency as transmitter unit 11 of Fig. 1, corresponding to the frequency of oscillator 12. Although audio frequency modulation of radio frequency transmitter 53 may be used, I prefer to employ no modulation of the signal from transmitter 53 but transmit a continuous wave signal instead.

Fig. 3 shows curves illustrating the relative periods of transmission of stations T_1 and T_2 to give the radio guidance signals. The equally spaced rectangular curves represent the uniform duration of transmission of the radio frequency signals. Signal transmission period *a* of station T_1 is equivalent to the cessation of transmission period *a* of station T_2. Similarly, cessation of transmission period *b* of station T_1 corresponds to the duration of transmission period *b* of station T_2. Signal transmission from both stations T_1 and T_2 is at the maximum amplitude during radiation. In the transmission systems of Figs. 1 and 2, stations T_1 and T_2 have the same radio frequency carrier, the signal from station T_1 being modulated with an audio frequency signal such as 75 cycles and that from station T_2 being continuous wave. It is not necessary to have the stations T_1 and T_2 radiate for the full indicated intervals. However, simultaneous transmission of T_1 and T_2 should not occur when a common carrier frequency and only one distinguishing modulation signal is used.

Various changes and modifications may be made to the details of construction of the invention without departing from the broader spirit and scope thereof, and accordingly, I do not intend to be limited except as set forth in the following claims.

I claim:

1. A radio guidance system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during reception of said relaying radio signals.

2. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter remotely situated from said first transmitter and having means for generating radio signals of substantially the same carrier frequency as the signals radiated by said first transmitter, a relaying radio frequency transmitter located at said first transmitter, means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during reception of said relaying radio signals.

3. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter remotely situated from said first transmitter and having means for generating radio signals of substantially the same carrier frequency as the signals radiated by said first transmitter, one of said radio frequency signals being modulated, a relaying transmitter of high frequency radio signals located at said first transmitter, means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during the period of reception of said relaying radio signals.

4. A radio guidance system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, periodically actuated means including a relay unit and switches in circuital connection with said first and relaying transmitters operated by said relay unit for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during the period of reception of said relaying radio signals.

5. A radio guidance system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, a relay unit, means for periodically energizing and deenergizing said relay unit for predetermined intervals, switches operated by said relay unit and connected with said first and relaying transmitters for successively effecting radiation thereof, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, a relay connected to said radio receiver, and switching means arranged for operation by said relay and connected in circuit with said second transmitter for effecting radiation of radio signals from said second transmitter during the period of reception of said relaying radio signals.

6. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, a constant speed motor, a relay, a periodic switching means driven by said motor and in circuit with said relay and a current source for energizing said relay for predetermined intervals, switches in circuital connection with said first and relaying transmitters and operated by said relay for successively effecting radiation of radio signals by said first and relaying transmitters, a radio receiver located at said second transmitter responsive to radio signals radiated from said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during the period of reception of said relaying radio signals.

7. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, a constant speed motor, a commutator having spaced insulated contacts, a rotary switch arm engageable with said contacts and driven by said motor, a relay connected with alternate contacts on said commutator, said switch arm being connected with a current source for energizing said relay for predetermined intervals, switches operated by said relay for alternately effecting radiation of

radio signals by said first and relaying transmitters in dependence upon the motivation of said switch arm, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, and means connected to said radio receiver for effecting radiation of radio signals from said second transmitter during the period of reception of said relaying radio signals.

8. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, a constant speed motor, a relay, a periodic switching means driven by said motor and in electric circuit relation with said relay and a current source for energizing said relay for predetermined intervals, switches in circuital connection with said first and relaying transmitters and operated by said relay for successively effecting radiation of radio signals by said first and relaying transmitters, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, a second relay associated with said radio receiver and operable thereby during reception of radio signals from said relaying transmitter, and switch means arranged for operation by said second relay and connected in circuit with said second transmitter for effecting radiation of radio signals therefrom during the period of reception of said relaying radio signals.

9. A direction radio transmitting system comprising a first transmitter of radio frequency signals, a second transmitter of radio frequency signals remotely situated from said first transmitter, a relaying radio frequency transmitter located at said first transmitter, a constant speed motor, a commutator having spaced insulated contacts, rotary switch arm engageable with said contacts and driven by said motor, a relay connected with alternate contacts on said commutator, said switch arm being connected with a current source for energizing said relay for predetermined intervals, switches operated by said relay for alternately effecting radiation of radio signals by said first and relaying transmitters in dependence upon the motivation of said switch arm, a radio receiver located at said second transmitter responsive to radio signals radiated by said relaying transmitter, a second relay associated with said radio receiver and operable thereby during reception of radio signals from said relaying transmitter, and switch means arranged for operation by said second relay and connected in circuit with said second transmitter for effecting radiation of radio signals therefrom during the period of reception of said relaying radio signals.

10. A signal transmission arrangement for a radio guidance system comprising a first transmitter of radio frequency signals; a second transmitter of radio frequency signals remotely situated from said first transmitter; a relaying radio frequency transmitter located at said first transmitter; a common antenna for said first transmitter and said relaying transmitter; means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals and including a device for successively connecting said first transmitter and said relaying transmitter to said antenna during such predetermined intervals; a radio receiver located at said second transmitter and responsive to signals radiated by said relaying transmitter; and means connected to said receiver for effecting radiation of signals by said second transmitter during the period of reception of said relaying radio signals.

11. A signal transmission arrangement for a radio guidance system comprising a first transmitter of radio frequency signals; a second transmitter of radio frequency signals remotely situated from said first transmitter; a relaying radio frequency transmitter located at said first transmitter; means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals; mechanism for positively interrupting radiation of said first transmitter when said relaying transmitter is radiating and of said relaying transmitter when said first transmitter is radiating; a radio receiver located at said second transmitter and responsive to signals radiated by said relaying transmitter; and means connected to said receiver for effecting radiation of signals by said second transmitter during the period of reception of said relaying radio signals.

12. A signal transmission arrangement for a radio guidance system comprising a first transmitter of radio frequency signals; a second transmitter of radio frequency signals remotely situated from said first transmitter; a relaying radio frequency transmitter located at said first transmitter; a common antenna for said first transmitter and said relaying transmitter; means for successively effecting radiation of radio signals by said first and relaying transmitters for predetermined intervals and including a device for successively connecting said first transmitter and said relaying transmitter to said antenna during such predetermined intervals and for successively disconnecting said first transmitter and said relaying transmitter from said antenna during the period when either thereof is not effective to radiate signals; a radio receiver located at said second transmitter and responsive to signals radiated by said relaying transmitter; and means connected to said receiver for effecting radiation of signals by said second transmitter during the period of reception of said relaying radio signals.

13. A signal transmission arrangement for a radio guidance system comprising a first transmitter of radio frequency signals; a relaying radio frequency transmitter located at said first transmitter; a common antenna for said first transmitter and said relaying transmitter; a B-power supply located at said first transmitter; a device for successively connecting each of said transmitters to said antenna and said B-power supply for a predetermined interval and simultaneously therewith disconnecting the other of said transmitters from said antenna and B-power supply during such predetermined interval; a second transmitter of radio frequency signals remotely situated from said first transmitter; a radio receiver located at said second transmitter and responsive to signals radiated by said relaying transmitter; and means connected to said receiver for effecting radiation of signals by said second transmitter during the period of reception of said relaying radio signals.

14. A signal transmission arrangement for a radio guidance system comprising a first transmitter of radio frequency signals; a relaying radio frequency transmitter located at said first transmitter; a common antenna for said first transmitter and said relaying transmitter; a B-power supply located at said first transmitter; means for successively effecting radiation of radio sig-

nals by said first and relaying transmitters for predetermined intervals and including a relay unit including a first set of contacts connected to said first transmitter, a second set of contacts connected to said relaying transmitter, a pair of armatures connected respectively to said antenna and B-power supply, and a solenoid for moving said armatures between said first and second sets of contacts, and mechanism for periodically energizing and deenergizing said solenoid; a second transmitter of radio frequency signals remotely situated from said first transmitter; a radio receiver located at said second transmitter and responsive to signals radiated by said relaying transmitter; and means connected to said receiver for effecting radiation of signals by said second transmitter during the period of reception of said relaying radio signals.

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