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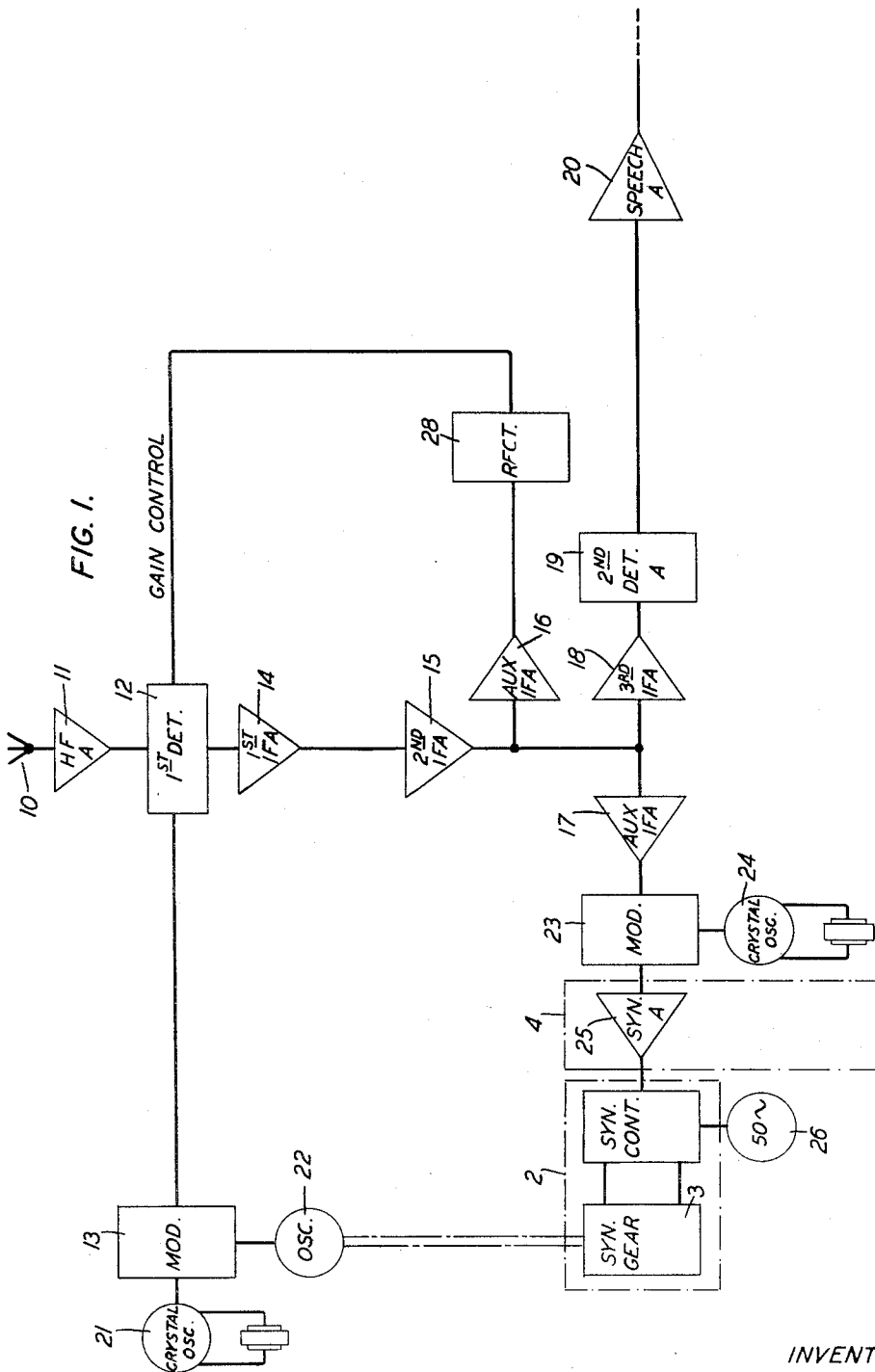
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1,932,465

RADIO RECEIVING SYSTEM

Filed March 15, 1932

3 Sheets-Sheet 1



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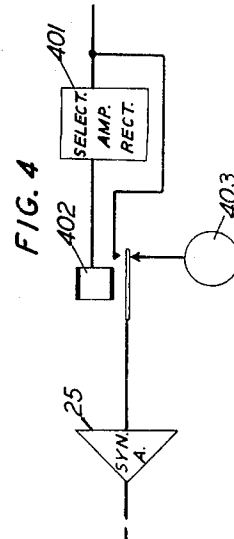
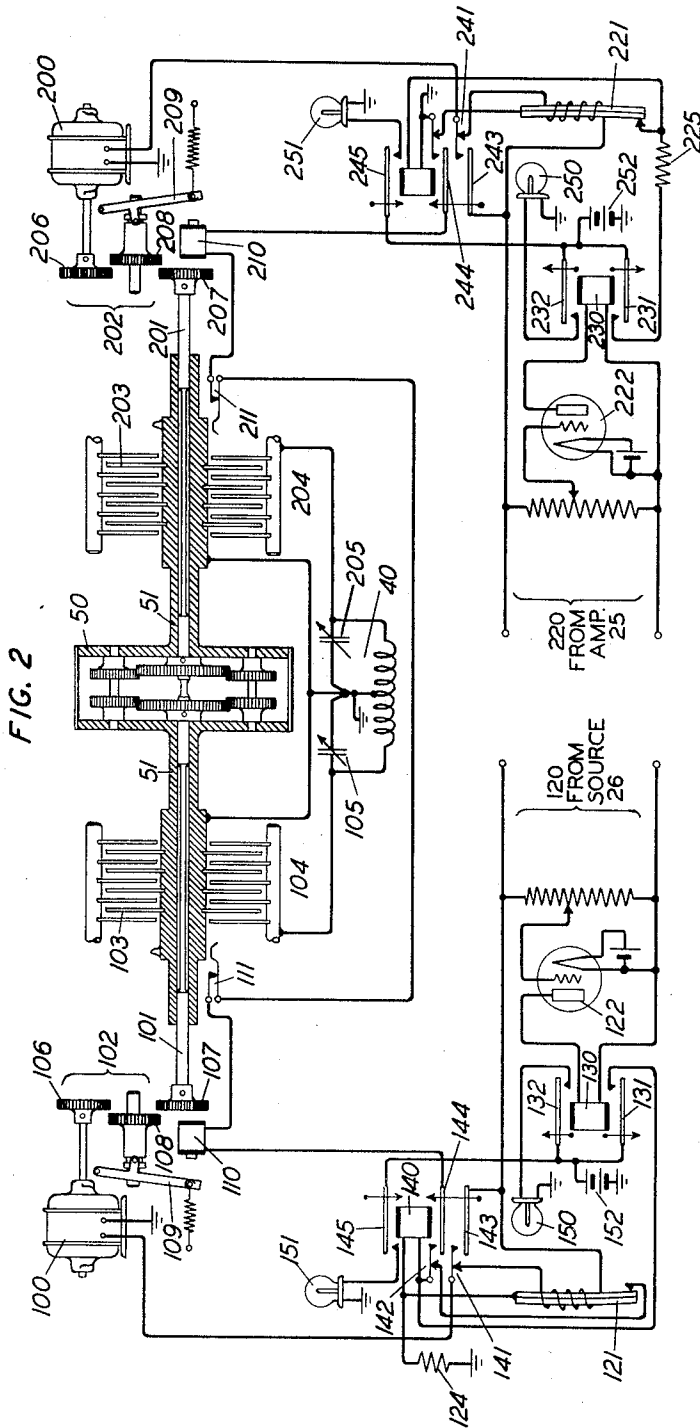
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3 Sheets-Sheet 2



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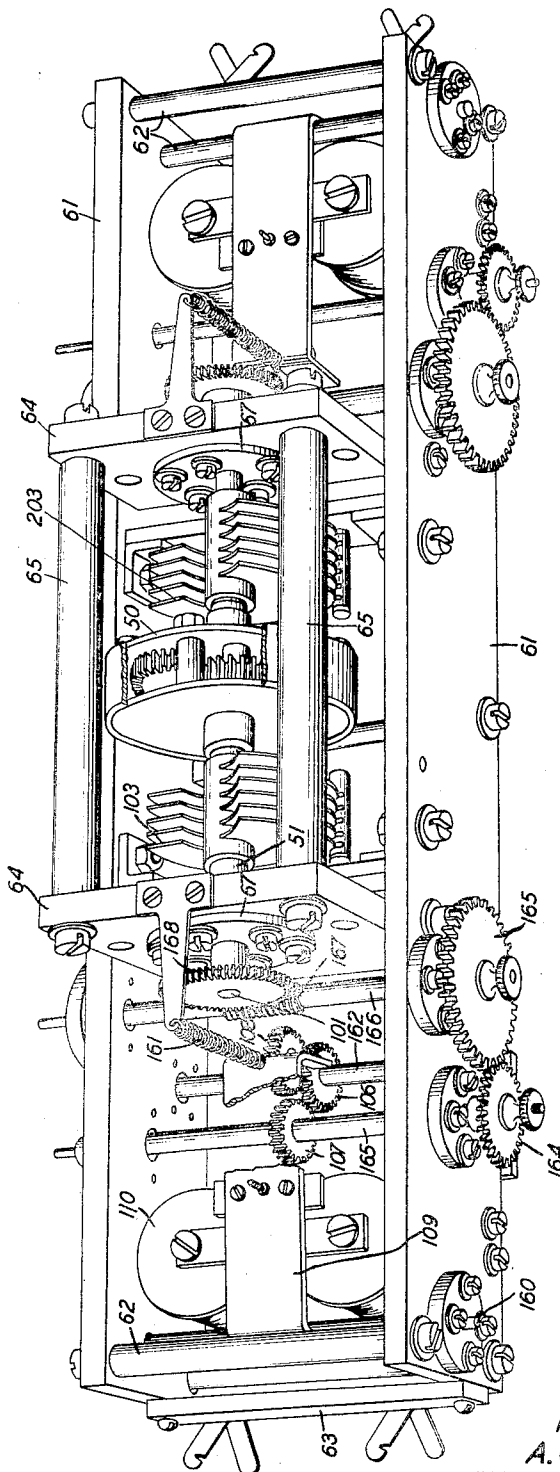
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FIG. 3



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RADIO RECEIVING SYSTEM

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7 Claims. (Cl. 250—20)

This invention relates to systems for generating and controlling electrical waves, particularly to systems for controlling the production of electrical waves in radio receiving systems.

5 In a radio receiver it is often desirable to use a wave the frequency of which is in fixed relationship to the carrier frequency of the received wave. This is not only necessary in systems in which only a single side band is transmitted and
10 the carrier resupplied at the receiver, but also in multiple detection systems in which the received wave is combined with a local wave to produce a wave which can be more readily selected and amplified. Obviously in systems of
15 the first type any variation between the original and resupplied carrier waves will produce a distortion of the resultant signal wave. Likewise in systems of the second type any variation in the frequency relation of the received and locally
20 supplied waves will produce a variation in the resultant intermediate frequency wave from the frequency for which the selecting and amplifying circuits are designed, which will result in a loss in output level and a distortion of the signal
25 wave. In the case of short radio waves, for example of the order of 15 megacycles, not only is it extremely difficult and involved to maintain constant the frequency relation of the waves at the transmitter and the receiver, but also fading
30 often produces an apparent change in the frequency of the incoming carrier which must be compensated for by a corresponding change in the frequency of the wave supplied at the receiver.

35 An object of this invention is to maintain a constant frequency relation between a wave supplied at a radio receiver and the incoming carrier wave.

40 As will appear from the description which follows, the invention comprises several features many of which are not limited in their application to the specific type of system disclosed herein but may be used for example in synchronizing systems for other purposes.

45 In the specific embodiment of the invention shown in the drawings and described in detail below the heterodyning wave of a radio receiver is generated by combining the output of a high frequency piezo-electric crystal controlled oscillator with the output of a tuned circuit oscillator.
50 The frequency of this heterodyning wave is controlled by a mechanism which automatically regulates a variable condenser of the oscillator tuned circuit. In order to effect this control the intermediate frequency wave which results from the combining of the heterodyning

55 wave and the incoming radio wave is combined with the output of a very constant frequency crystal controlled oscillator to obtain a wave of low frequency suitable for driving a synchronous motor. This motor is employed for driving one
60 end of a differential gear mechanism, the other end of which is driven by a second synchronous motor supplied with current from a source of stable low frequency. These two synchronous
65 motors are so arranged that when they are both driven at their respective synchronous speeds, the two ends of the differential gear mechanism revolve in opposite directions at equal speeds. The planetary portion of the differential gear
70 mechanism is mechanically connected to the tuning condenser of the tuned circuit oscillator. The result is that any variation in the low frequency wave obtained from the intermediate frequency
75 wave will produce a movement of the planetary portion of the differential gear mechanism which in turn produces an adjustment of the tuning condenser to restore the frequency to normal. With such a system the frequency of the intermediate frequency wave is maintained constant
80 irrespective of variations in the frequency of the incoming wave or in the frequency of the wave from the heterodyning source, since either type of variation will produce a compensating adjustment of the condenser of the tuned circuit oscillator.
85

85 The stability of the system depends upon the constancy of frequency of the piezo-electric controlled oscillator used for beating down the frequency of the intermediate frequency wave and of the source used for driving the synchronous
90 motor connected to the opposite end of the differential gear mechanism. Alternating current sources of frequency of the order used for such purposes may be maintained sufficiently constant
95 in frequency to give the required stability of the high frequency wave. It should be noted that the variations in frequency of the high frequency waves are of substantially the same absolute frequency as the variations in the low
100 frequency waves. In this respect, the system differs from those types of systems in which a high frequency wave is obtained by harmonic generation of a constant low frequency wave since in such systems the variations are multiplied in the same order as the base frequency is
105 multiplied.

110 The synchronizing mechanism is supplied with an automatic control and protection circuit which operates to delay the mechanical connections of either motor to the differential gear

mechanism until both motors have had time to come up to synchronous speed and to disconnect both motors from the gear mechanism in case of an interruption in either source of power for any material time. The system also operates to automatically start up the gear mechanism upon the restoration of an interrupted power source.

The invention can be more readily understood by reference to the following detailed description in connection with the drawings in which:

Fig. 1 is a block schematic drawing of a radio receiver;

Fig. 2 is a detail schematic diagram of the synchronizing control indicated by the dot-dash line 2 of Fig. 1;

Fig. 3 is a perspective view of the synchronizing gear used in the circuit of Fig. 2; and

Fig. 4 is a block schematic diagram of an alternative circuit which may be substituted for the portion indicated by the dash-dot line 4 of Fig. 1.

Referring to Fig. 1, the waves received in the antenna 10 are amplified in the high frequency amplifier 11 and supplied to the first detector 12 where they are combined with the heterodyne waves produced by the modulator 13 and the resultant intermediate frequency waves are selectively amplified in the intermediate frequency amplifiers 14 and 15. The output of the second intermediate frequency amplifier 15 is branched into three paths: (1) To the auxiliary intermediate frequency amplifier 16 for providing an automatic gain control; (2) To a second auxiliary intermediate frequency amplifier 17 to provide the synchronizing control; and (3) To the third intermediate frequency amplifier 18. The output of this third intermediate frequency amplifier is supplied to the second detector 19 in which the waves are detected and the resultant signal waves supplied to the speech amplifier 20.

The gain control is effected in a manner well known in the art, the output of the auxiliary amplifier 16 being supplied to the rectifier 28 and the resultant unidirectional voltage applied to the grid of the high frequency detector 12 to control its operating characteristic.

The heterodyning wave is produced in the modulator 13 by combining the output of the piezo-electric crystal controlled oscillator 21 with that of the tuned circuit oscillator 22. For example, if a wave of 18 megacycles is being received in the antenna 10 and an intermediate frequency wave of 250 kilocycles is desired, the crystal oscillator 21 may be designed to produce a wave of 17 megacycles and the oscillator 22 a wave of 750 kilocycles so that when the two waves are combined in the modulator 13 there will be produced a sum frequency wave of 17.75 megacycles. (The above figures are given only for the purpose of illustration.) The frequency of the wave produced by the oscillator 22 is controlled so that the intermediate frequency output of the detector 12 will remain constant irrespective of variations in the frequency of the wave received in the antenna 10 or that generated in the oscillator 21. This control is effected by means of the circuit connected to the output of the auxiliary intermediate amplifier 17.

The output of the auxiliary intermediate frequency amplifier 17 is combined in the modulator 23 with the output of a piezo-electric crystal controlled oscillator 24. The oscillator 24 may be chosen to produce a frequency of 250.4 kilocycles so that when it is combined with the in-

termediate frequency waves, there will be produced a difference frequency of 400 cycles per second. This difference frequency wave is amplified in the synchronizing amplifier 25 which should preferably include a low pass filter for eliminating the effect of noise and signal waves. The output of this amplifier is used to drive a motor connected to one end of the synchronizing gear 3. The other end of the gear is driven by a 50-cycle wave supplied from the source 26. The two synchronous motors supplied with the 400 and the 50-cycle waves, respectively, are so connected to a differential gear mechanism that when both are running at their synchronous speeds, the two sides of the differential gear mechanism will be rotating at the same speed. The planetary portion of the differential gear mechanism is connected to the tuning condenser of the oscillator 22 so that when the speed of the two sides of the gear mechanism varies with respect to each other, the tuning condenser will be adjusted to so change the frequency of the oscillator output as to bring the intermediate frequency wave back to its normal value. The operation of this portion of the system will be more readily understood by reference to Figs. 2 and 3. Fig. 2 shows schematically the synchronizing gear and its control circuit. Fig. 3 shows in detail the mechanical construction of the synchronizing gear.

Referring first to Fig. 2, there is provided a 50-cycle motor 100, and a 400-cycle motor 200 which are connected to the drive shafts 101 and 201, respectively, through the respective magnetic clutch mechanisms 102 and 202. The motors are so designed with respect to the number of poles and the gear ratios by which they are connected to the drive shaft are so proportioned that when each is running at its synchronous speed, the two drive shafts 101 and 201 will be rotating at the same speed.

The housing 50 of the planetary portion of the differential gear mechanism is mounted on the hollow shaft 51 which also carries the two sets of movable plates 103 and 203 of the variable condensers 104 and 204, respectively. Thus, when the drive shafts 101 and 201 are both rotating at the same speed the planetary portion of the differential gear mechanism and consequently the movable plates of the condensers 104 and 204 will remain fixed. However, any difference in speed of rotation of the drive shafts will result in a movement of the planetary portion and a consequent movement of the movable condenser plates 103 and 203.

The condensers 104 and 204 are connected in shunt to the main tuning condensers 105 and 205 of the frequency determining circuit 40 of the oscillator 22. Thus, any variation in the frequency of the waves supplied to the 400-cycle synchronous motor 202, which means a variation from normal of the frequency of the intermediate frequency wave will result in such a change in the frequency of the wave generated by the oscillator 22 as to restore the frequency of the intermediate frequency wave to normal and consequently bring the speed of the shaft back to the same speed as that of the shaft 101.

The magnetic clutch mechanism 102 comprises an idling pinion 108 carried by the armature 109 of the relay 110. When this relay is operated the armature is attracted to cause the pinion 108 to come into mesh with the pinion 106 carried by the motor 101 and the pinion 107 carried by the drive shaft 101 thus causing the motor to operate

the drive shaft. The magnetic clutch mechanism 202 is similar in construction and operation.

The synchronizing mechanism is provided with an automatic control circuit associated with each motor. These control circuits comprise fundamentally, thermal relays 121 and 221 which operate upon the energization of the respective motors to delay the connection of the motors to the differential gear mechanisms until both have had time to come up to synchronous speed and slow release relays 130 and 230 which operate to disconnect the motors from the differential gear mechanism in case of any material interruption in either source of power, but which will hold up during momentary interruptions of power.

The control circuit also includes the three-element vacuum tube rectifiers 122 and 222 which rectify the current from the respective 50-cycle and 400-cycle sources for operating the relays 130 and 230, respectively. In addition there are provided auxiliary relays 140 and 240 and signal lamps 150, 151, 250 and 251 and operating batteries 152 and 252.

The control circuit can best be understood from a description of its operation. Let us assume that the radio receiver is to be put into operation and the procedure has reached the point where power is supplied to the terminal 120 from the 50-cycle source 26 and to the terminal 220 from the synchronizing amplifier 25 which supplies the 400-cycle wave. Considering first the operation of the control circuit for the 50-cycle motor 100, current will be supplied to the winding of the relay 121 and the motor 50 in series through the contact 141 of the relay 140 so that the motor will start to operate, building up to synchronous speed. During this period relay 140 is prevented from operating by the connection from the upper terminal of its winding through the armature and contact of relay 121, contact 142 to the lower terminal of the winding of relay 140. Simultaneously, the current supplied from the source 26 will be rectified by the tube 122 to operate relay 130 so that current will be supplied to the winding of the relay 140 from the battery 152 through the armature 131 and contact of the relay 130, winding of the relay 140, resistance 124 to ground. The relay 121 is so designed that its time of operation is equal or slightly greater than the time required for the motor 100 to build up to synchronous speed. After that time has expired the relay 120 will operate to remove the short circuit from the winding of the relay 140 by the opening of contact 142.

The operation of the relay 140 completes a direct supply circuit for the motor 100 through the armature 143 at the same time opening the power supply circuit to the winding of relay 121 at the contact 141. Simultaneously the left-hand portion of the control circuit for the magnetic clutches 110 and 210 is completed through the armature 144 of the relay 140. Thus, when a similar sequence of operation has been completed in the control circuit of the motor 200, the magnetic clutch operating circuit will be completed through the following connection: From battery 152 through armature 131 of relay 130, armature 144 of relay 140, winding of clutch magnet 110, contact 111, contact 212, winding of clutch magnet 210, and armature 244 of relay 240 to ground.

In the case of interruption of power from either of the sources 25 or 26 for a sufficient time to cause the release of either of the relays 130 or 230, the respective relay will release opening the

magnetic clutch circuit at the armature 131 or 231 and releasing the relays 140 and 240. Upon the restoration of the power supply, the circuit will be automatically restored to an operating condition through the same sequence of operation described above for starting up the system.

When the relays 140 and 240 are operated, the circuits for the indicating lamps 151 and 251 are completed to the respective armatures 145 and 245 thus giving an indication of the operation of the system.

Contacts 111 and 211 are provided to prevent the condensers 104 and 204 from overrunning. When the shaft 51 is moved in either direction a sufficient amount to bring the condensers near the point of maximum movement a cam member operates to open one of the contacts 111 or 211 to open the circuit for the clutch magnets 110 and 210 thus preventing any further movement.

While Fig. 2 shows the differential gear mechanism diagrammatically, Fig. 3 shows the actual mechanical construction thereof. This mechanism is built in a main frame comprising longitudinal plates 61 and cross bars 62 and 63. In the center of the main frame there is provided an auxiliary frame comprising plates 64 supported between the plates 61 and connected by the longitudinal member 65. This auxiliary frame supports the differential gear mechanism proper while the driving and clutch mechanisms are supported in the remaining portions of the main frame.

The hollow shaft 51 of the differential gear mechanism which carries the planetary gear portion 50 and the movable plates 103 and 203 of the condensers is carried in the bearings 67 mounted on the plates 64. The driving shafts 101 and 102 (the latter not shown) are supported in the hollow shaft 50.

Since the driving and clutch mechanisms at the two ends are identical, only that for the shaft 101 will be described in detail. The electromagnetic clutch 102 comprises the magnet 110 and the armature member 109 which is pivotally mounted at one end by the shaft 160 supported in bearings in the plates 61. The other end of the armature member 109 carries the idler gear 108. The spring 161 which supports the armature 109 from the end plate 64 holds the gear 108 out of mesh. The driving motor 100 (not shown) is connected by a worm and gear or other suitable mechanism to the shaft 162 which is journaled in the plates 61. This shaft carries the gear 106 and when the magnet 110 is actuated the armature moves to bring the idler pinion 108 in mesh with gears 106 and 107, the latter of which is carried by the shaft 163, also journaled in the plates 61. The shaft 163 carries a pinion 164 which meshes with another pinion 165 carried by shaft 166, journaled in the plates 61 and carrying a worm 167 which meshes with the worm gear 168 mounted on shaft 101.

This specific embodiment of the invention described is a radio receiver for use in the more usual type of radio systems in which the carrier is transmitted along with one or both side bands. However, the invention is equally applicable to carrier suppression systems. Such a system of transmitted waves would be modulated by a synchronizing tone of 400-cycles or some other frequency which could be readily separated from the signal band. The oscillator 24 would then supply the local carrier and there would be provided in the output of the modulator 23 selective

means for separating the signal from the synchronizing tone.

While in the preceding description the specific frequencies assigned to the various waves are given primarily for the purpose of illustration, their relative values are indicative of the principle of operation of applicant's invention. The difficulty in operating an oscillator or other generator to produce a wave of constant frequency is directly proportional to the frequency of the wave. In applicant's system, the stability of operation depends only on the constancy of the crystal controlled oscillator 24. Thus in the embodiment specifically described herein the controlled oscillator must produce a wave of frequency of the order of 18 megacycles, while the oscillator 24 is operated at about 250 kilocycles. It has been found that it is possible to maintain the frequency of such an oscillator sufficiently constant even to meet the rigid requirements of single side band transmission.

The effects of fading may be such that on occasion the received carrier will be so reduced in amplitude for a sufficient period to cause the shut down of the synchronizing mechanism. This may cause serious interruption in the operation of the receiver particularly since even after such a fading period some time will be consumed before the synchronizing mechanism will again start up. Fig. 4 shows a circuit for overcoming such difficulties. This additional circuit is inserted in the receiver between the modulator 23 and the synchronizing gear 3 as indicated by the dash-dot line —4—. The circuit comprises a selective amplifier rectifier 401 having its input connected to the output of the modulator 23 and the output connected to the winding of relay 402. The amplifier rectifier 401 is selective to waves in the neighborhood of 400 cycles to the exclusion of waves of other frequencies. Thus, when no carrier is being received there will be no 400-cycle wave in the output of the modulator 23 and the relay 402 will be in the released position. Under such conditions, the 400-cycle wave will be supplied from the oscillator 403 to the synchronizing amplifier 25 and consequently to the synchronizing gear 3, maintaining it in operation. As soon as the carrier wave is received there will be present in the output of the modulator 23 a 400-cycle wave which will operate relay 402 and supply the output of the modulator 23 to the synchronizing amplifier 25 and synchronizing gear 3 to put the system in a proper operating condition.

Similarly at any time that there is an interruption of the received carrier, the relay 402 will release and connect the 400-cycle source 403 to the synchronizing gear so that it will remain in an operating condition ready to be instantaneously responsive to a received carrier.

What is claimed is:

1. In combination, an electrical oscillator having a variable impedance element for controlling the frequency of the generated waves, a separate source of electrical waves, and means for controlling the frequency of the waves generated by said oscillator so that they bear a definite frequency relation to waves from said separate source said means comprising a differential gear mechanism having two members driven synchronously by waves from said oscillator and said source respectively, and a planetary portion arranged to control said variable impedance element.

2. In combination, a source of electrical waves having a variable impedance element for con-

trolling the frequency of the generated waves, a second source of electrical waves, and means for controlling the frequency of the waves generated by the first mentioned source so that they bear a definite frequency relation to the waves from said second source comprising a differential gear mechanism having two driven members and a planetary portion, means for synchronously driving each of said driven members by waves from one of said sources, electrically controlled clutch means for connecting the driven means, to the respective differential gear members, a time control device associated with each of the driving means and operated a sufficient interval after power is supplied to the respective driving means to allow said means to come up to synchronous speed, and a control circuit for said electrically controlled clutch means operated by the operation of both of said time control devices to operate the clutch means.

3. In combination, according to the next preceding claim, means operated by an interruption of the supply to either of the driving means for releasing both of the electrically controlled clutch means.

4. In a radio receiving system, a first source of waves, means for combining the received waves with waves from said source to produce waves of different frequencies, means for selectively amplifying said waves of different frequencies, a source of waves of substantially constant frequency differing from said different frequency waves by a comparatively low frequency, means for combining the selectively amplified different frequency waves with waves from said source of substantially constant frequency to produce a wave of said comparatively low frequency, a source of waves of substantially constant low frequency, and means responsive to a comparison of the output of the last mentioned wave combining means and the waves from said source of waves of substantially constant comparatively low frequency for controlling the frequency of the waves generated by said first source of waves.

5. In a radio receiving system, a first source of waves having a variable impedance element for controlling the frequencies of the generated waves, means for combining the received waves with waves from said first source to produce a wave of different frequency, means for selectively amplifying said wave of different frequency, a source of waves of substantially constant frequency differing from said different frequency by a comparatively low frequency, means for combining the selectively amplified different frequency wave and waves from said source of substantially constant frequency to produce a wave of said comparatively low frequency, and a differential gear mechanism having a member driven synchronously by the waves of said comparatively low frequency from the last mentioned combining means, and a second member driven at a substantially constant speed, and a planetary portion mechanically connected to said variable impedance element to control the frequency of the waves from said first source of waves.

6. In a radio receiving system, a first source of waves comprising a piezo-electric element for giving a basic control of the frequency of the generated waves and a variable impedance element for giving a vernier control of the frequency of the generated waves, means for combining the received waves with waves from said first source to produce a wave of different fre-

quency, a piezo-electric controlled oscillator producing waves of substantially constant frequency differing from said different frequency wave by a comparatively low frequency, means
5 for combining the different frequency wave and waves from the piezo-electric controlled source to produce a wave of such comparatively low frequency, a source of waves of substantially constant comparatively low frequency, and means
10 responsive to a comparison of the output of the last mentioned wave combining means and the waves from said source of waves of substantially constant comparatively low frequency for controlling the frequency of the waves generated
15 by said first source of waves.

7. In a system for receiving a signal modulated wave, a first source of waves, means for combining the signal modulated waves with waves from said source to produce a different frequency signal modulated wave, means for selectively amplifying said different frequency signal modu-

lated waves, a source of waves of substantially constant frequency differing from said different frequency signal modulated waves by a frequency lower than any of the signal frequencies, means for combining the selectively amplified
80 different frequency modulated signal waves and the waves from said source of substantially constant frequency, means for selecting from the output of the last mentioned combining means the lower frequency waves to the exclusion of
85 waves of substantially higher frequencies, a source of waves of constant frequency, and means responsive to the comparison of waves from the last mentioned source and the selected lower frequency waves for controlling the frequency of
90 the waves generated by said first source of waves to maintain substantially constant the frequency of said different frequency signal modulated waves.

AXEL G. JENSEN. 95

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