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A. A. COLLINS

2,447,490

RADIO TRANSMITTING AND RECEIVING SYSTEM

Filed Feb. 28, 1944

2 Sheets-Sheet 1

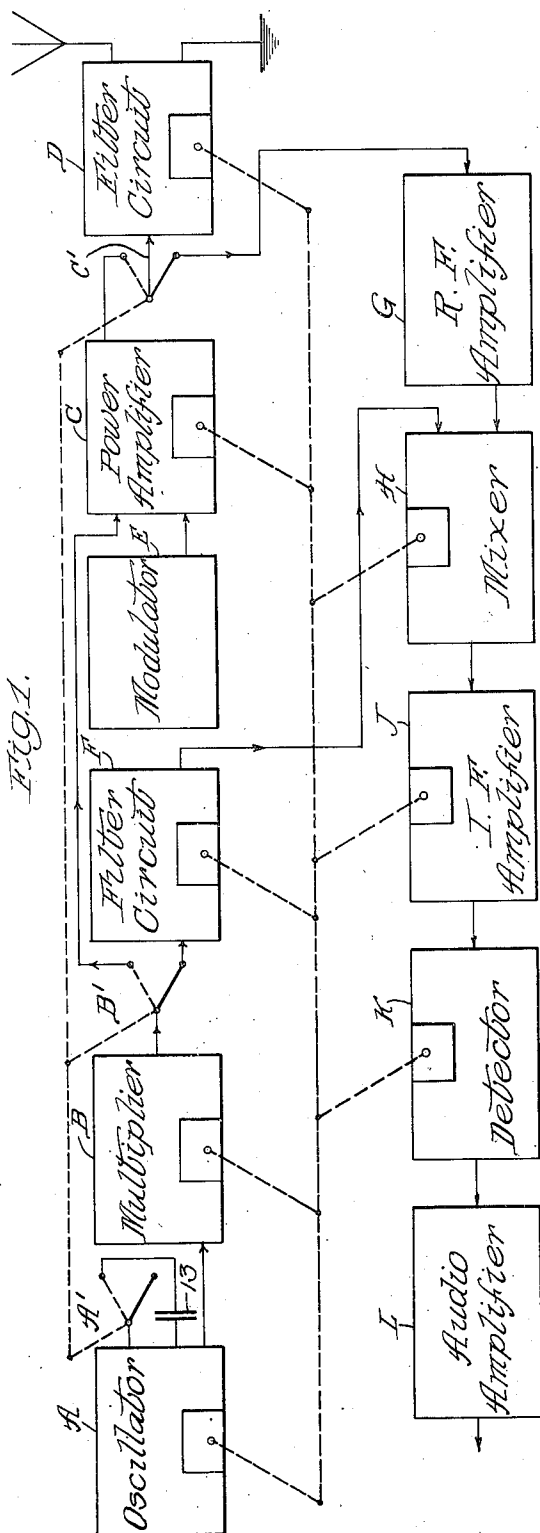
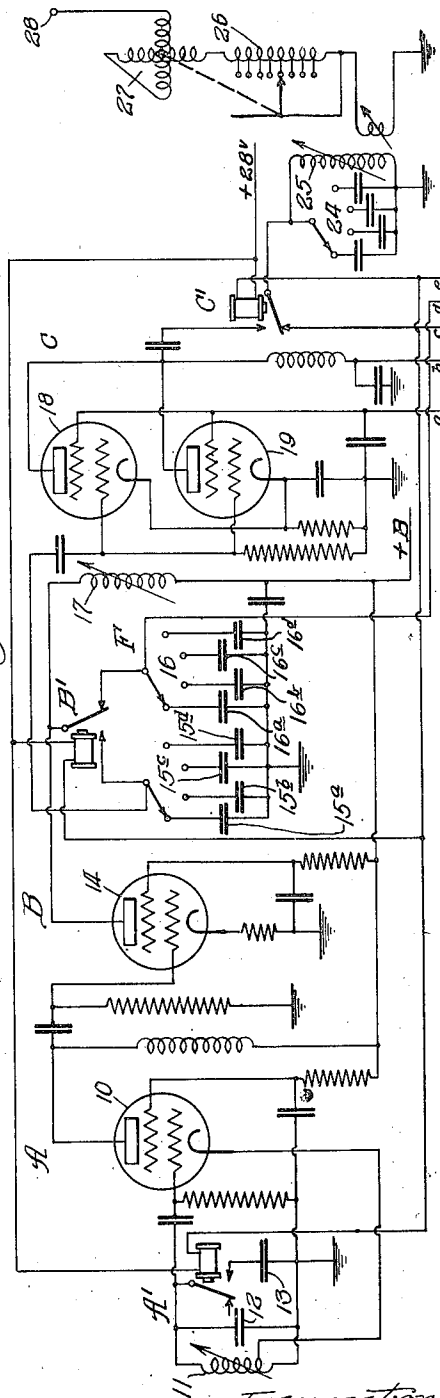


Fig. 2.



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Aug. 24, 1948.

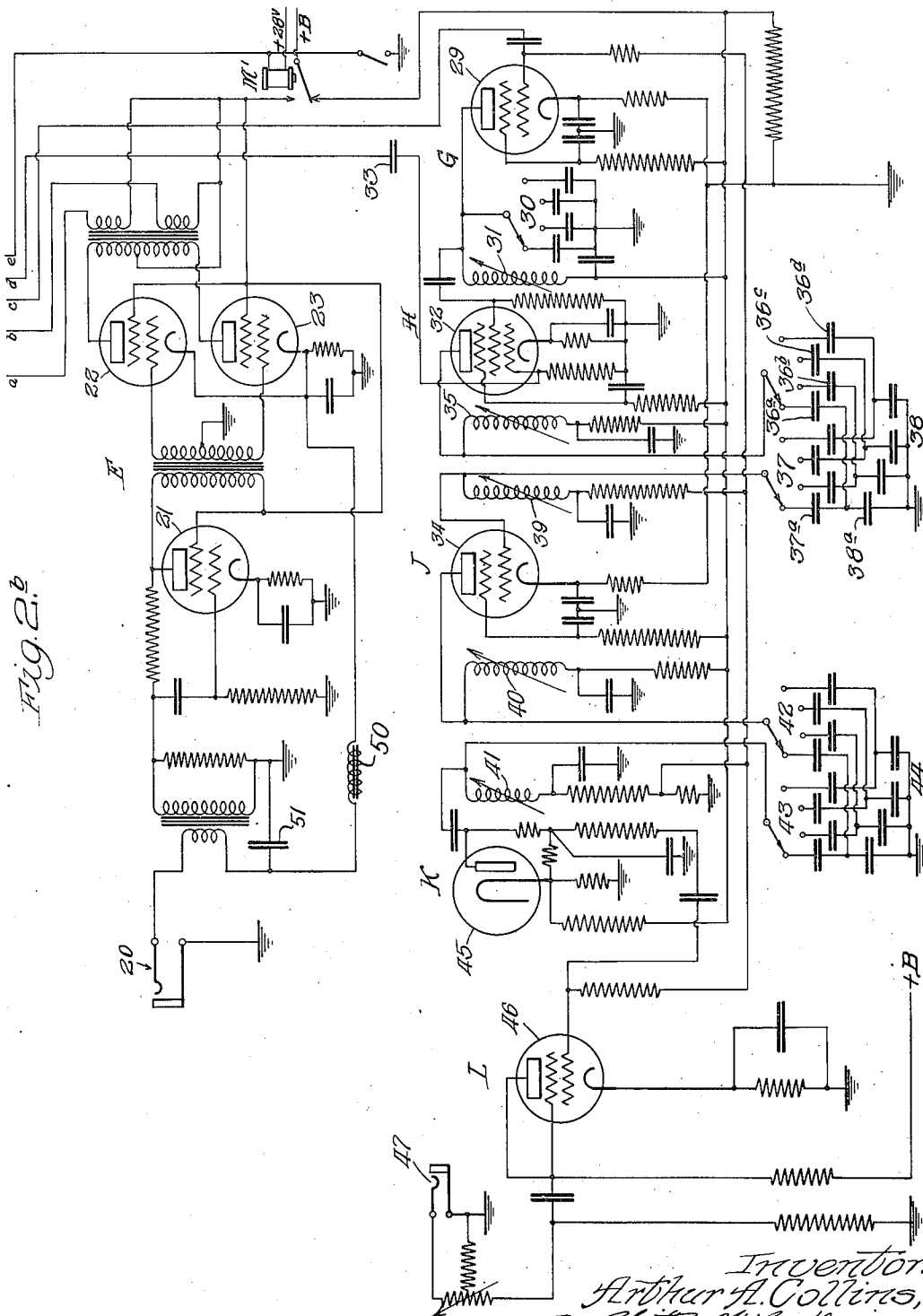
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,447,490

RADIO TRANSMITTING AND RECEIVING
SYSTEM

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Iowa

Application February 23, 1944, Serial No. 524,204

10 Claims. (Cl. 250-13)

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This invention relates to a radio transmitting and receiving system, and more particularly to a system ensuring transmission and reception on the same frequency.

One feature of this invention is that it provides an improved radio transmitting and receiving system; another feature of this invention is that a single tuning means effects coordinated selection of a desired frequency in both the transmitting and receiving portions of the system; still another feature of this invention is that transmission and reception always take place on the same frequency; and yet another feature of this invention is that the system is readily tunable to any desired frequency in any of a plurality of frequency ranges. Other features and advantages of this invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a block diagram of a system embodying my invention; and Figures 2a and 2b comprise a circuit diagram of an operable embodiment of a transmitting and receiving system corresponding to the diagram of Figure 1.

Two-way radio communication is becoming of increasing importance, and under many circumstances it is desirable to have the transmitting and receiving equipment tunable over a desired frequency range, or a plurality of frequency ranges. Under such conditions the transmitted frequency cannot be crystal controlled, but must have a frequency controlled by a tunable oscillator tank circuit. Despite the greatest care in design and construction, an oscillator tank circuit undergoes frequency changes as the result of its exposure to variations in temperature, humidity, etc., and this makes it difficult to determine accurately, by any system of dial calibration, the frequency being transmitted or received, particularly in the higher frequency bands, as those used in aircraft work.

I have devised and am here disclosing a single-control radio transmitting and receiving system wherein transmission and reception on the same frequency are ensured. This enables an operator to tune in on another station which is transmitting, and then to go on the air himself as soon as the other station ceases transmission with full assurance that his signal is on the same frequency as that on which the other station was transmitting, regardless of the setting of his tuning dial or the accuracy of its calibration. While I have devised and am here disclosing and claiming one system for securing this desired result, the result may also be secured by other

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transmitting and receiving systems of types devised by other research men collaborating with me on this problem, these other systems being the subject matter of other copending applications of Frank M. Davis (Serial No. 524,205, filed February 23, 1944, now Patent No. 2,402,606, issued June 26, 1946; Serial No. 548,978, filed August 11, 1944; and Serial No. 685,934, filed July 24, 1946), broad claims to systems of this type being included in the second mentioned Davis application, and Melvin L. Doelz (Serial No. 524,206, filed February 23, 1944).

My system comprises, as its principal elements, wave generating means variable over one or more predetermined frequency ranges, as a tunable oscillator with or without associated frequency multiplying means; means for amplifying and transmitting waves of a desired selected frequency in any of said ranges; means for displacing the frequency of the waves a given percentage (rather than a given frequency), regardless of the frequency to which the wave generating means may be tuned; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over bands corresponding to the difference between the initial and displaced frequencies of said waves throughout said ranges, tuning of the oscillator and the intermediate frequency amplifier being "ganged" or coordinated for operation by a single tuning control, and the displaced waves serving as the local heterodyning waves for the receiving system. When one has ceased transmitting, rendering the displacing means and receiving system operative, without touching the tuning control, ensures reception on the exact frequency being previously transmitted; and conversely, when another signal is being received, switching to transmission ensures sending on the exact frequency of the signal previously heard.

While I am terming the system disclosed here a "single-control system" it will be understood it is meant that there would be only a single tuning control for both the transmitting and receiving portions of the system, which would normally be housed in a single cabinet. In addition, of course, there would be a band switch, antenna coupling and loading controls, an on-off switch or several of such switches, and generally a manual volume control for the receiving portion of the system. The switch-over from transmission to reception would normally be effected by a keying relay, or by a push-button-operated relay associated with the microphone of the transmitter. With a system of this kind, no matter how inexperi-

enced the operator may be, once he finds and hears a given station (whether it be another airplane, a ground station, or the like) he is sure to be able to talk to it, sure to be on the frequency to which the receiver of that other station is tuned. Another advantage, claimed in one of the other co-pending applications, is that the same antenna tuning and loading circuit may be used for coupling both the transmitter and receiver to the antenna, so that the antenna can be tuned during reception, without breaking radio silence, with assurance that transmission will be at or very near maximum possible power without loss of time for adjustment of the antenna tuning and loading controls after transmission has been started.

In the particular embodiment of my system illustrated herewith, and referring first more particularly to the block diagram, Figure 1, a tunable oscillator A delivers its output to a multiplier B, these comprising means for generating waves of any desired selected frequency in any of a plurality of bands, the multiplier being adapted to provide various multiplications. The output of the multiplier B is connected to the movable element of a two-position switch B' (shown in the transmitting position in dotted lines and in the receiving position in solid lines), being delivered to the power amplifier C during transmission; and the amplified carrier is modulated in conventional manner by a modulator E. In the position of the switches shown in dotted lines in the drawings, the modulated output of the amplifier C is connected through the switch C' to the antenna filter circuit D, or antenna tuning and loading circuit, this being in turn connected to the antenna and to ground. This arrangement comprises a conventional tunable transmitting system.

The switch A' is adapted to connect a fixed reactance element (as the fixed condenser shown) into the tank circuit of the oscillator, and to disconnect it therefrom, to displace the frequency a given percentage; and the switches A', B' and C' are ganged so that they operate in synchronism. All of the movable elements of the three switches are shown in Figure 1 in the receiving position; all moving to their upper contacts, as shown in dotted lines, when transmission is desired.

When the system is thrown over to reception, without touching the tuning control, the operation of the frequency displacing switch A' causes the frequency of the oscillator to be displaced a given percentage, as for example 10%; and the multiplied frequency, of course, retains this same given percentage displacement. With the switches set for reception, the output of the multiplier is delivered to the filter circuit F, which is tunable and passes only the displaced frequency; the antenna and its associated filter or tuning circuit are connected through the switch C' to the input of the radio frequency amplifier G, and the output of this radio frequency amplifier G is delivered to the mixer or first detector stage H where the displaced wave from the wave generating means, delivered through the filter circuit F, serves as the local heterodyning wave to beat the incoming signal down to an intermediate frequency. The reduced frequency signal is delivered to the tunable intermediate frequency amplifier J and then passes through a second detector K and an audio amplifier L and is delivered to earphones, or some other translating means (not shown).

The difference between the desired incoming signal and the displaced frequency wave delivered by the wave generating means varies (in the sense of absolute frequency) as the result of variations in the frequency of the wave generating means, and to take care of this intermediate frequency variation the intermediate frequency amplifier is made tunable. As illustrated in the block diagram, the tuning controls of all of the tunable portions of the system are ganged. The ganging and tracking of the intermediate frequency amplifier tuned circuits with the oscillator tuned circuit is not at all difficult, since no attempt is being made to maintain a fixed frequency difference, which presents problems in accurate tracking, the displacement or local heterodyne difference being a fixed percentage. It will be understood, of course, that the various tuned circuits are provided with different elements adapted to be switched in when different bands are to be covered, the coordination being effected by the tracking of the variable reactance elements, and remaining undisturbed by the addition or subtraction of fixed reactance of the opposite character.

For the purposes of this description it will be assumed that the oscillator A is so designed as to be variable over a range of 1,000 to 1,500 kc. during transmission; and that operation of the frequency displacing switch A' (effecting removal of a portion of the fixed capacity from the tank circuit) results in the oscillator tuning from 1,100 to 1,650 kc. during reception, a 10% displacement. In this regard, it will be understood that the word "displacement" is intended broadly to cover either an increase or a decrease of frequency throughout the range, and that it can be accomplished by removal or addition of fixed reactance to the tank circuit. For convenience of description, the frequency used on transmission is being termed the "initial" or "desired" frequency, and the different frequency used for local heterodyning purposes is being termed the "displaced" frequency.

If the multiplier portion B of the system is arranged for doubling, transmission may be on any selected frequency in the range of 2,000 to 3,000 kc., double the oscillator frequency variation; and for purposes of illustration it may be assumed that a signal is being transmitted on 2,000 kc. When the system is thrown over to reception, operation of the displacing switch A' causes the oscillator frequency to be displaced from 1,000 kc. to 1,100 kc.; and results in the output of the multiplier B being displaced from 2,000 to 2,200 kc. On this band the intermediate frequency amplifier would be arranged to be tunable from 200 to 300 kc., its tuning being coordinated with that of the oscillator, so that with the oscillator at the 1,000 kc. setting, the intermediate frequency amplifier would be tuned to an intermediate frequency of 200 kc. Use of the displaced frequency of 2,200 kc., therefore, as the local heterodyne frequency, results in only signals of 2,000 or 2,400 kc. being beat to this intermediate frequency of 200 kc.; and the tuned circuits in the radio frequency portion of the receiving system would eliminate the 2,400 kc. signals in the antenna, if any, so that under these conditions the frequency received would be 2,000 kc., the same frequency as that transmitted. While this has been described as though transmission were first, it will be understood that if the system had been in condition for reception, and tuned to a 2,000 kc. desired signal, throwing

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the system over to transmission would result in transmission on the same frequency; and this would be true regardless of whether the oscillator frequency had varied from any arbitrary calibration of the dial, since tuning to the desired signal would necessarily bring the oscillator to the desired frequency, regardless of the dial calibration.

The system can be arranged to provide single-control tuning for as many other bands as may be desired. For example, arranging the multiplier to treble the oscillator frequency results in a transmission frequency anywhere in the range of 3,000 to 4,500 kc.; 10% displacement results in a displaced frequency in the range of 3,300 to 4,950 kc.; and switching the intermediate frequency tuned circuit constants would cause these tuning circuits to cover the range of 300 to 450 kc. on this second band. Again, quadrupling would give a transmitting frequency anywhere in the range of 4,000 to 6,000 kc.; a displaced frequency of 4,400 to 6,600 kc.; and the intermediate frequency amplifier would be arranged to tune from 400 to 600 kc. Two stages of multiplication might then be used, one doubling and one tripling, resulting in a transmission frequency range from 6,000 to 9,000 kc.; a displaced or local heterodyning frequency of 6,600 to 9,900 kc.; and this would be used with an intermediate frequency tuning range of 600 to 900 kc. In each case all of the tuned circuits would have a tuning range of 1.5 to 1, and the shape of the tuning curve would not be important, it only being necessary that the curves be the same in the various circuits.

Referring now more particularly to the circuit diagram of Figure 2 (comprising portions 2a and 2b), the portions corresponding to the various rectangles of the block diagram of Figure 1 are similarly lettered. The oscillator A is shown as comprising a tube 10, which may be tube type No. 12SJ7, having a tank circuit comprising a permeability tuned variable inductance 11, a fixed condenser 12 permanently in circuit, and an additional fixed condenser 13 adapted to be connected to or disconnected from the tank circuit by the displacing switch A'. While the various tuned tank circuits throughout the system are shown as having fixed condensers (except for such slight variations as may be desirable for trimming) and variable inductances, it will be understood that the principles are equally applicable to circuits where the inductances are fixed and tuned by variable condensers, displacement being effected in either case by a small fixed reactance of the same character as the main fixed reactance.

The output of the oscillator is coupled to the multiplier, here shown for simplicity of circuit illustrations as comprising a single tube 14, which may be tube type No. 12A6, although it will be understood that in commercial practice two such stages of multiplication would normally be used in cascade. The output of the multiplier has two tuning combinations associated therewith, comprising two sets of fixed condensers 15a-d and 16a-d adapted to be selectively associated with the tunable coil 17. An appropriate condenser is selected by the band switch, shown connected to the condenser 15a, to select the first band, the other condensers 15b-d being selected, respectively, for bands 2-4. When the system is thrown over to receiving condition, the switch B' renders a condenser of the group 16 operative, the combination of these condensers with

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the coil 17 then forming part of the filter circuit delivering displaced waves to the mixer of the super-heterodyne portion of the system, where they are operative as the local heterodyning waves.

When transmitting, the output of the multiplier B is delivered to the power amplifier here shown as comprising the tubes 18 and 19, which may be of tube type No. 1625, and which would in commercial practice be preceded by a pre-amplifier stage and a driver stage, for example, these being omitted for simplicity. The space current in these tubes would be modulated by power derived from the modulating portion of the system, shown in the upper half of the sheet identified as Figure 2b. This is here shown as comprising a jack 20 adapted to have a microphone or keying means connected thereto, this being coupled to a driver tube 21, which may be tube type No. 12A6, in turn transformer-coupled to modulator tubes 22 and 23, which may be 1625 tubes, the output of these modulator tubes affecting both the screen and plate voltages of the power amplifying tubes 18 and 19, through the wires a and b. A lead from jack 20 to the cathodes of modulator tubes 22 and 23 provides a D. C. actuating supply for the microphone or keying means, and has incorporated therein a reactor 50 which blocks A. C. from the cathodes of the modulator tubes. An A. C. path from jack 20 to ground is provided by the condenser 51 connected between the lower end of the primary of the input transformer and ground.

The modulated output of the power amplifier C is delivered, when the change-over switch C' is in its upper or transmitting position, to the antenna tank circuit comprising the condensers 24 and the variable inductance coil 25. This is coupled, in accordance with conventional practice for a short antenna, to antenna loading means here shown as comprising a tapped coil 26 and a variometer 27, the terminal 28 being connected to the antenna.

When the change-over switches place the system in receiving condition, the antenna tank circuit is connected, as shown in the drawings, through the wire c to the signal grid of the radio frequency amplifying tube 29, which may be tube type No. 12SK7, plate supply for the super-heterodyne receiving system being then provided by a connection through the plate-supply change-over switch M', ganged with the switches A', B' and C'. The input of the radio frequency amplifier is, of course, tuned by the tank circuit here shown as associated with the antenna. The output is tuned by a tank circuit comprising any one of the four condensers 30 and the variable inductance 31.

The output of the radio frequency amplifying section is coupled to one of the grids of the mixer tube 32; while another grid of this tube is supplied with the local heterodyning or displaced waves derived from the wave generating means comprising the oscillator A and multiplier B, these being delivered through the wire d and coupling condenser 33. The mixer, in accordance with conventional practice, beats the signal frequency down to intermediate frequency which, in the case of the first band on which the circuit is shown set, might be 200 to 300 kc., as assumed earlier.

This intermediate frequency output is delivered to an intermediate frequency amplifier J here shown as comprising the tube 34, which may be tube type No. 12SK7, it being understood that

commercially at least two similar stages of such intermediate frequency amplification would be used in cascade. In accordance with conventional intermediate frequency amplifier practice, both the inputs and outputs of a transformer coupling arrangement are tuned; but, contrary to normal practice, these coupled tuned circuits are tunable over a band, as the 200 to 300 kc. assumed in connection with band 1. The input side of the intermediate frequency coupling arrangement is here shown as comprising the variable coil 35 and the condensers 36a—d. The condensers 36a—d are each connected, respectively, to the corresponding condensers of the group 37, and to ground through a group of condensers 38. That is, when the band switch is in position to cover the first band, condensers 36a and 37a would be connected in series, with their midpoint connected to ground through the condenser 38a, all of the other condensers in these sets being inoperative. The movable element of the band switch associated with the condenser 37 is connected to one end of the variable inductance 39 to provide a tuned parallel output circuit for the intermediate frequency coupling arrangement. The purpose of using three sets of condensers is merely to provide a common reactance for coupling purposes.

The output of the tube 34 is delivered through another doubly-tuned coupling arrangement comprising the variable coils 40 and 41 and the associated sets of condensers 42, 43 and 44 to a detector here shown as a simple diode tube 45. In practice, however, this tube would usually comprise a five element tube, as tube type No. 12SR7, having the two anodes connected together and the additional grid and plate elements used, in conjunction with an appropriate tank circuit, to provide a beat frequency oscillator for code reception, this arrangement not being shown since the whole circuit is illustrated, for simplicity, merely as a voice system. The audio output of the detector tube 45 is delivered to an audio amplifying tube 46, which may be tube type No. 12SK7, the output of this being shown as supplied to a jack 47 which is adapted to be connected to earphones, a speaker, or the like. In practice, the tube 46 would normally be followed by at least one additional power stage of audio amplification.

An operative circuit of the character described and for the bands or frequency ranges previously assumed, might have the oscillator inductance 11 variable from 11 to 25 μ hy.; the multiplier, antenna tank circuit, and mixer inductances 17, 25 and 31 variable from 6.2 to 14 μ hy.; and the intermediate frequency primary and secondary inductances variable from 176 to 400 μ hy. Under these circumstances, the oscillator tank circuit principal condenser 12 might have a capacity of 825 mmfd., and the condenser 13 a capacity of 175 mmfd. The condensers 15a—d, in the multiplier output when transmitting, might have a capacity of 450, 200, 112 and 50 mmfd., respectively; and these same values might be used for the condensers 24 and 30. During reception the condensers 16 would be associated with the coil 17 to filter the multiplier output, and these might have a value of 370, 163, 92 and 41 mmfd., respectively. The intermediate frequency condensers 36a—d, and the similar condensers in the sets 37, 42 and 43, might have values of 1,600, 700, 400 and 175 mmfd., respectively, and the associated condensers of the sets 38 and 44 might have a value of .08, .04, .03, and .015 mfd.

Other circuit constants would be of conven-

tional value for the particular tubes used. The coupling condensers between the tubes 10 and 14 and between the power amplifier tubes and the antenna tank circuit might be .002 mfd.; coupling condensers between the multiplier tube 14 and the power amplifier tubes, and those associated with the tubes 29 and 32, might be .001 mfd.; while that coupling the tube 45 to the tube 46 might be a .1 mfd., and that on the input of the oscillator tube 100 mmfd. The by-pass condensers in the transmitting and receiving portions of the system might all be .002 mfd. except that in the filament in the audio amplifier tube 46, and those associated with the filaments of the driver and modulating tubes in the modulating portion which might be 20 mfd. The condensers connecting the intermediate frequency coils 35, 39, 40 and 41 to ground might be .008 mfd. The grid resistors in the multiplier and power amplifier would generally be 10,000 or 20,000 ohms; the grid leak resistors in the oscillator, multiplier and audio amplifier tubes about 50,000 ohms; that used with the driver tube 21 about $\frac{1}{2}$ meg.; that used with the tube 29 about 1 meg.; and those associated with the signal grids of the mixer and intermediate amplifier tubes from 100,000 to 500,000 ohms. The screen grid resistors used in this receiving portion of the system would preferably be of a higher value than those used in the transmitting portion as for example 100,000 ohms. The cathode resistors would be from 200 to 500 ohms, depending upon the tubes and the portions of the circuits; and other circuit elements not specifically described would follow conventional practice in connection with the types of tubes named in circuits for the purposes shown here.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. Radio apparatus of the character described, including: wave generating means variable over a predetermined frequency range; means for amplifying and transmitting waves of any selected frequency in said range; means for displacing the frequency of the waves a given percentage of the selected frequency; and a superheterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range and a mixer delivering its output to the intermediate frequency amplifier, the displaced waves serving as the local heterodyning waves for said receiving system.

2. Radio apparatus of the character described, including: wave generating means variable over a predetermined frequency range; means for amplifying and transmitting waves of any selected frequency in said range; means for displacing the frequency of the waves a given percentage of the selected frequency; and a superheterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range, a mixer delivering its output to the intermediate frequency amplifier, and means for coordinating the variation of the generating means with the tuning of the intermedi-

ate frequency amplifier, the displaced waves serving as the local heterodyning waves for said receiving system.

3. Radio apparatus of the character described, including: wave generating means variable over each of a plurality of predetermined frequency ranges; means adapted to be connected to said generating means for amplifying and transmitting waves of any selected frequency in any of said ranges; means for displacing the frequency of the waves a given percentage of the selected frequency; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a plurality of bands corresponding to the difference between the initial and displaced frequencies of said waves throughout each of said ranges, a mixer delivering its output to the intermediate frequency amplifier, means for coordinating the variation of the generating means with the tuning of the intermediate frequency amplifier, and means for connecting said mixer to said generating means, whereby the displaced waves serve as the local heterodyning waves for said receiving system.

4. Radio apparatus of the character described, including: wave generating means variable over a predetermined frequency range; means for amplifying and transmitting waves of any selected frequency in said range; means for displacing the frequency of the waves a given percentage of the selected frequency; a superheterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range, a mixer delivering its output to the intermediate frequency amplifier, and means for coordinating the variation of the generating means with the tuning of the intermediate frequency amplifier; and selectively operable means for connecting the wave generating means to the amplifying means in one operative position and for actuating the displacing means and connecting the wave generating means to the mixer of the receiving system in another operative position, whereby the displaced waves serve as the local heterodyning waves for said receiving system and the received frequency is identical with the transmitted frequency.

5. Radio apparatus of the character described, including: wave generating means variable over a predetermined frequency range; power amplifying means for amplifying waves of any selected frequency in said range; an antenna system comprising an antenna and tuning means therefor; means for displacing the frequency of the waves a given percentage of the selected frequency; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range, a mixer delivering its output to the intermediate frequency amplifier, and means for coordinating the variation of the generating means with the tuning of the intermediate frequency amplifier; and selectively operable means for connecting the wave generating means to the input of the amplifying means and the antenna system to the output thereof in one operative position and for actuating the displacing means and connecting the antenna system and the wave generating means to the mixer of the receiving system in another operative position, whereby the displaced waves serve as the local heterodyning waves for said

receiving system and the received frequency is identical with the transmitted frequency.

6. Radio apparatus of the character described, including: wave generating means variable over each of a plurality of predetermined frequency ranges; power amplifying means for amplifying waves of any selected frequency in any of said ranges; an antenna system comprising an antenna and tuning means therefor; means for displacing the frequency of the waves a given percentage of the selected frequency; a superheterodyne receiving system having an intermediate frequency amplifier tunable over a plurality of bands corresponding to the difference between the initial and displaced frequencies of said waves throughout each of said ranges, a mixer delivering its output to the intermediate frequency amplifier, and means for coordinating the variation of the generating means with the tuning of the intermediate frequency amplifier; and selectively operable means for connecting the wave generating means to the input of the amplifying means and the antenna system to the output thereof in one operative position and for actuating the displacing means and connecting the antenna system and the wave generating means to the mixer of the receiving system in another operative position, whereby the displaced waves serve as the local heterodyning waves for said receiving system and the received frequency is identical with the transmitted frequency.

7. Radio apparatus of the character described, including: wave generating means variable over each of a plurality of predetermined frequency ranges, said means including means for providing waves of a frequency displaced a given percentage from a selected frequency; a superheterodyne receiving system having an intermediate frequency amplifier tunable over a plurality of bands corresponding to the difference between the selected and displaced frequencies of said waves throughout each of said ranges, a mixer delivering its output to the intermediate frequency amplifier, and means for connecting said mixer to the generating means, whereby said displaced frequency waves serve as the local heterodyning waves for said receiving system; and a single means for effecting coordinated variation of the first mentioned means and tuning of the intermediate frequency amplifier.

8. Radio apparatus of the character described, including: an oscillator having a frequency controlling tank circuit comprising an inductive element and a capacitive element in parallel, one of said elements being variable and the other fixed; means for effecting various predetermined different multiplications of the frequency of the waves generated by the oscillator to provide a plurality of predetermined frequency ranges; means for displacing the frequency of the waves a given percentage of the selected frequency, this means comprising another reactive element of the same character as the fixed element and means for connecting this other reactive element into the tank circuit and disconnecting it therefrom; means for amplifying and transmitting waves of any selected frequency in any of said ranges; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a plurality of bands corresponding to the difference between the selected and displaced frequencies of said waves throughout each of said ranges and a mixer delivering its output to the intermediate frequency amplifier; selectively operable means for connecting the wave generating means to the

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amplifying means in one operative position and for actuating the displacing means, selecting the intermediate frequency amplifier band in accordance with the predetermined multiplication effective, and connecting the wave generating means to the mixer of the receiving system in another operative position, whereby the displaced waves serve as the local heterodyning waves for said receiving system; and a single means for effecting variation of the variable element in the oscillator tank circuit and tuning of the intermediate frequency amplifier and for coordinating said variation and tuning.

9. Radio apparatus of the character described, including: wave generating means variable over a predetermined frequency range, this means including a frequency controlling tank circuit comprising an inductive element and a capacitive element in parallel, one of said elements being variable and the other fixed; means for amplifying and transmitting waves of any selected frequency in said range; means for displacing the frequency of the waves a given percentage of the selected frequency, this means comprising another reactive element of the same character as the fixed element and means for connecting this other reactive element into the tank circuit and disconnecting it therefrom; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range, a mixer delivering its output to the intermediate frequency amplifier, and a connection for supplying the displaced waves from the generating means to the mixer, the displaced waves serving as the local heterodyning waves for said receiving system.

10. Radio apparatus of the character described, including: wave generating means variable over

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a predetermined frequency range, this means including a frequency controlling tank circuit comprising an inductive element and a capacitive element in parallel, one of said elements being variable and the other fixed; means for amplifying and transmitting waves of any selected frequency in said range; means for displacing the frequency of the waves a given percentage of the selected frequency, this means comprising another reactive element of the same character as the fixed element and means for connecting this other reactive element into the tank circuit and disconnecting it therefrom; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a band corresponding to the difference between the initial and displaced frequencies of said waves throughout said range and a mixer delivering its output to the intermediate frequency amplifier; and selectively operable means for connecting the wave generating means to the amplifying means in one operative position and for actuating the displacing means and connecting the wave generating means to the mixer of the receiving system in another operative position, whereby the displaced waves serve as the local heterodyning waves for said receiving system and the received frequency is identical with the transmitted frequency.

ARTHUR A. COLLINS.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,447,490.

August 24, 1948.

ARTHUR A. COLLINS

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 7, for "June 26, 1946" read *June 25, 1946*; column 10, line 56, claim 8, strike out the word "various";

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of December, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.