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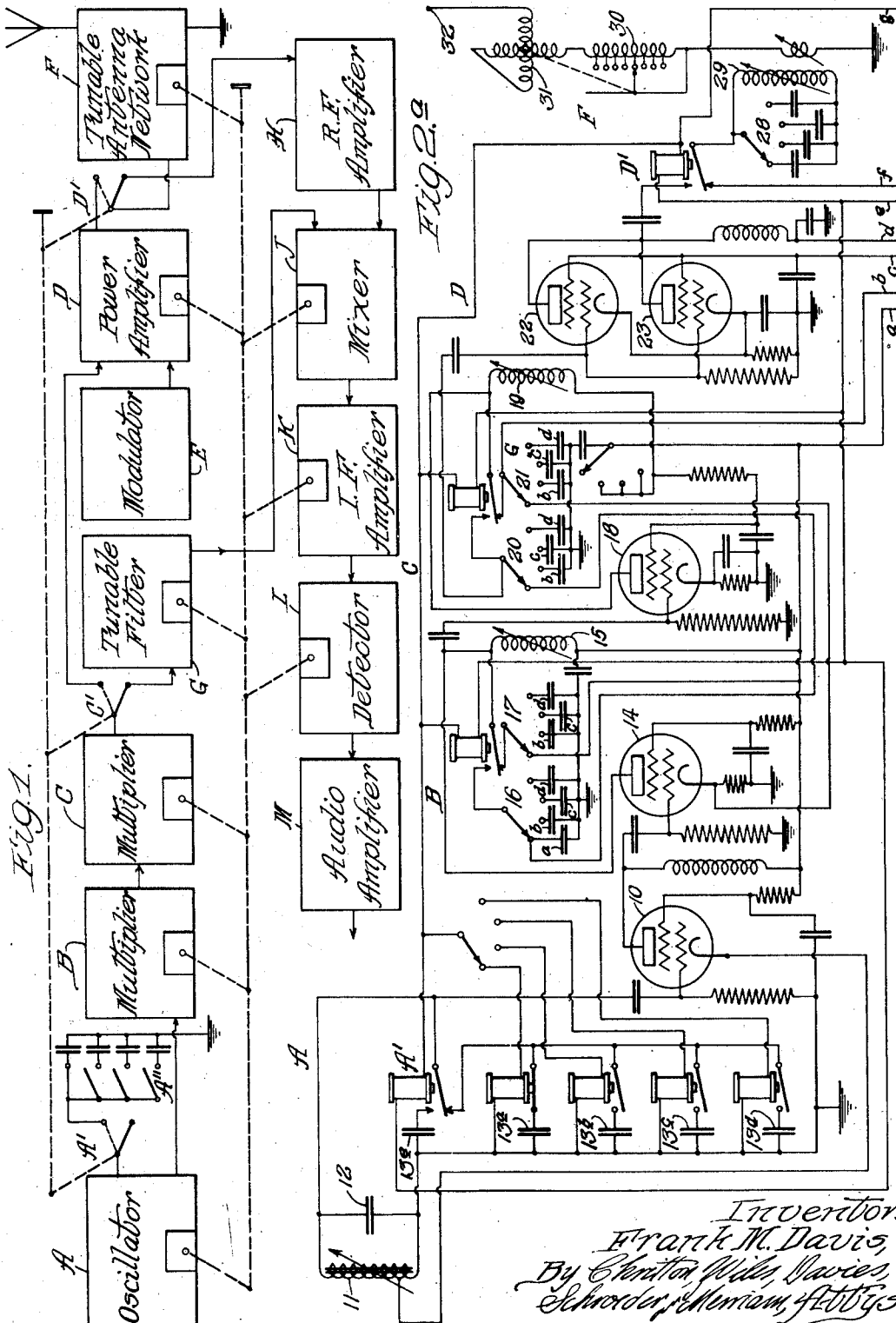
F. M. DAVIS

2,402,606

RADIO TRANSMITTING AND RECEIVING SYSTEM

Filed Feb. 28, 1944

2 Sheets-Sheet 1



Inventor:
Frank M. Davis,
By Clinton M. Davis,
Schroder, Merriam, Feltz & Co.

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2 Sheets-Sheet 2

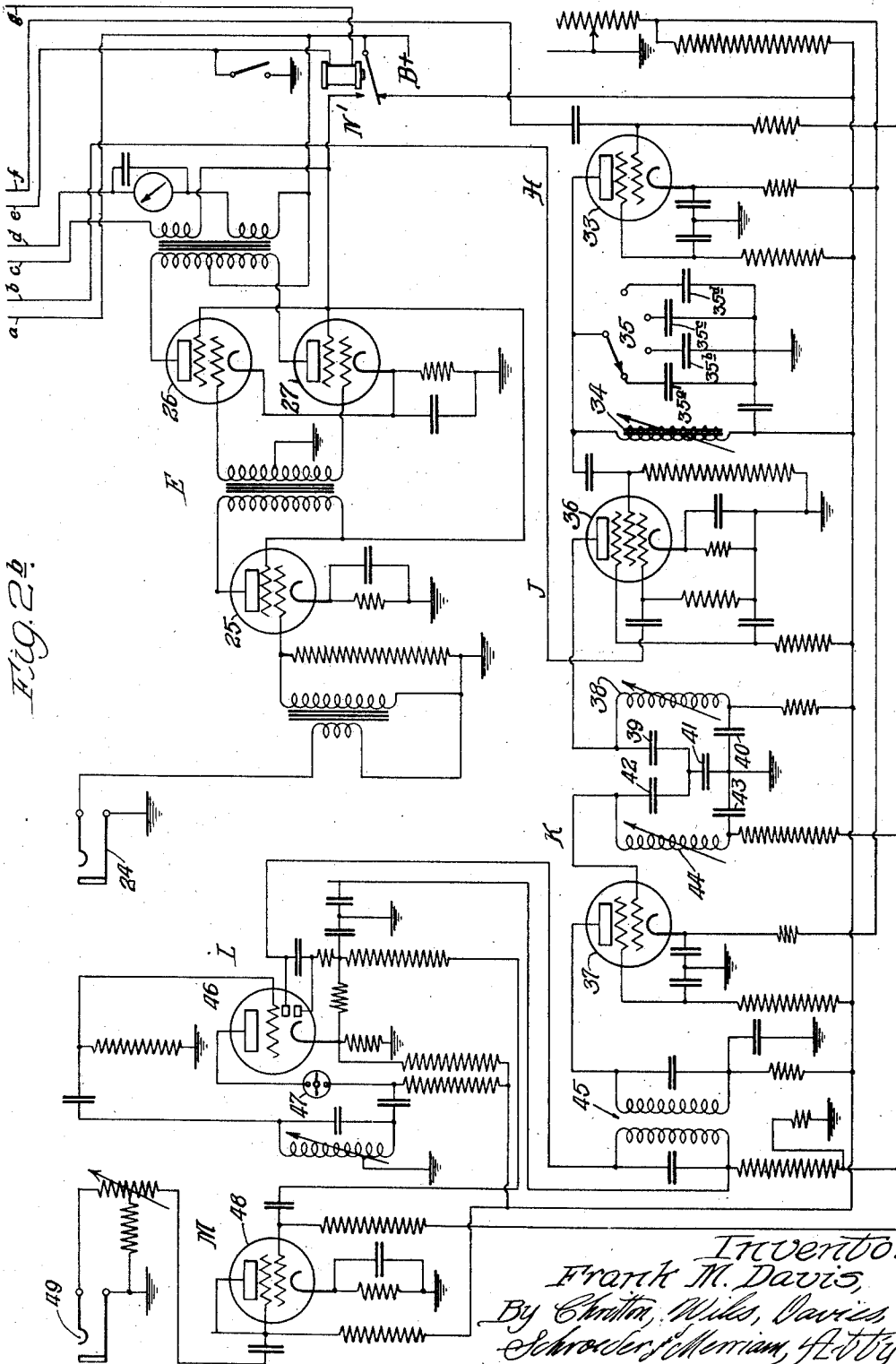


Fig. 2b

Inventor:
Frank M. Davis,
By Clinton W. Davis,
Schroeder & Merriam, Attys.

UNITED STATES PATENT OFFICE

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RADIO TRANSMITTING AND RECEIVING SYSTEM

Frank M. Davis, Cedar Rapids, Iowa, assignor to Collins Radio Company, a corporation of Iowa

Application February 28, 1944, Serial No. 524,205

7 Claims. (Cl. 250—13)

1

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 selected frequency in both the transmitting and receiving portions of the system; still another feature of this invention is that transmission and reception take place on the same frequency despite any variation of oscillator frequency from its calibrated frequencies; 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; and a further feature of this invention is that an intermediate frequency amplifier tunable over only a single band is adapted to be operative for reception in any of the 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 Figure 2, comprising the portions 2a and 2b, is 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

2

as that on which the other station was transmitting, regardless of the setting of his tuning dial or the accuracy of its calibration. The system which I am here disclosing and claiming is a variation of and an improvement on a system for achieving the desired result by displacement of the oscillator frequency a given percentage, the broader idea being the subject matter of a copending application of Arthur A. Collins, Serial No. 524,204, filed Feb. 28, 1944. The desired result of transmitting and receiving on the same frequency by a single-control arrangement may also be secured by other systems which are the subject matter of other copending applications of myself and of Melvin L. Doelz, Serial No. 548,978, filed August 11, 1944, and Serial No. 524,206, filed February 28, 1944, respectively, my other said application containing broad claims generic to the systems shown in this and all of the other above-mentioned applications.

My system comprises, as its principal elements, wave generating means variable over a plurality of predetermined frequency ranges, as a tunable oscillator with associated frequency multiplying means; means for amplifying and transmitting waves of a selected frequency in any of said ranges; means for displacing the frequency of the waves by predetermined given percentages (rather than by a given frequency), these percentages having a certain ratio to the multiplication factor thereafter used; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band, tuning of the oscillator and the intermediate frequency amplifier being "ganged" or coordinated by operation of 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 system operative without touching the tuning control ensures reception on the exact frequency being previously transmitted; and conversely, when one has finished receiving another signal, switching to transmission ensures sending on the exact frequency of the signal previously heard, regardless of any differences between actual oscillator frequency and dial setting.

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 inexperienced 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 (my application Serial No. 548,978, filed August 11, 1944), 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 here, and referring first more particularly to the block diagram, Figure 1, a tunable oscillator A delivers its output to a first multiplier B, this output being delivered in turn to a second multiplier C, these comprising means for generating waves of any desired frequency in any of a plurality of bands, the multipliers being adapted to provide an output which bears a relation to the oscillator output resulting from multiplication by a factor of anything from unity up to about 20. The output of the multiplier C is connected to the movable element of a two-position switch C' (shown in the transmitting position in dotted lines and in the receiving position in solid lines), being delivered to the power amplifier D during transmission. The amplified carrier wave is modulated in conventional manner by a modulator here identified as E. The modulated output of the power amplifier is connected through another switch D' (in its transmitting position) to the tunable antenna tank and loading network F, this being in turn connected to the antenna and to ground. This arrangement comprises a conventional tunable transmitting system.

The oscillator has associated with it another transmission-reception switch A' adapted to connect another fixed reactance element into the tank circuit of the oscillator and to disconnect it therefrom, to displace the frequency of the oscillator a desired percentage. In this particular system, illustrated as designed for use on four bands, any of four fixed condensers (determined by the band switch A'') is thrown into or out of circuit, as desired, by the switch A'. The transmission-reception switches throughout the system, as the switches A', B' and C', are ganged so that they operate in synchronism, generally by a relay operated by the closing of a single contact. The movable elements of these three switches stand in the position shown in solid lines for reception, and move to the position shown in dotted lines for transmission.

When the system is switched from transmission to reception, without touching the tuning control, the operation of the displacing switch A' causes the frequency of the oscillator to be displaced a certain percentage determined by the band switch operative. For example, the displacement condenser used on the first band might have such a

relation to the fixed condenser in the oscillator tank circuit as to result in a frequency displacement of 10%; that used in the second band might provide a displacement of 5%; that in the third band, a displacement of $3\frac{1}{3}\%$; and that in the fourth band, a displacement of 2%. With the transmission-reception switches set for reception, the output of the multiplier C is delivered to the tunable filter G, which is tuned to and designed to pass only the displaced frequency; the antenna and its associated network are connected through the switch D' to the input of the radio frequency amplifier H; and the output of this amplifier H is delivered to the mixer or first detector stage J where the displaced wave from the wave generating means, delivered through the tunable filter G, 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 K and then passes through a second detector L and an audio amplifier M, where it is delivered to some translating means, as earphones, not shown.

In any particular band or frequency range, the difference between the desired incoming signal and the displaced frequency wave delivered to the mixer J varies (in the sense of absolute frequency) as a result of variations in the frequency of the wave generating means. That is, the same percentage displacement results in a greater frequency difference at the upper end of the oscillator tuning range than at the lower end, which in turn results in the frequency of the beat note; 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 circuit with the oscillator tuned circuit may be done accurately, the circuits being of the same type, and there not being the problems present in accurate tracking of fixed frequency displacement arrangements, where tracking is usually accurate at only two or three points. The various tuned circuits are provided with different fixed reactance elements adapted to be switched in when different bands are to be covered, of course, the coordination being effected by tracking of the variable reactance elements, and not being lost or disturbed by the addition and subtraction of fixed reactances 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' results in the oscillator tuning through a different band during reception, a band displaced by a percentage determined by the particular frequency range or band on which the set is operating at that time. 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 for 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 one multiplier is doubling and the other merely passing the signal with a unity multipli-

cation factor, transmission may be on any selected frequency in the range of 2,000 to 3,000 kc., determined by the setting of the tuning control; and for purposes of illustration it may be assumed that a signal is being transmitted on 2,000 kc. On this first band the additional condenser used in conjunction with the larger fixed condenser in the tank circuit of the oscillator may have a value such that operation of the displacing switch A' causes the oscillator frequency to be displaced 10%, so that at the lower end of the band, where the tuning control is set, the oscillator frequency is displaced from 1,000 kc. to 1,100 kc. In the particular system here being disclosed, I use a wave which is a different multiple for reception than for transmission, preferably one multiple different. In the case of the first band or frequency range of the system being described, the multiplication factor used for transmission would be 2, while that used for reception would be 1, the displaced oscillator frequency being used directly as the local heterodyning wave.

It will be recalled that transmission was at a frequency of 2,000 kc. Without disturbing the tuning controls, throwing the set over to receiving causes displacement of the oscillator frequency to 1,100 kc.; and when this wave is delivered to the mixer of the super-heterodyne receiving portion of the system and beat against a 2,000 kc. incoming signal, the resultant is a 900 kc. intermediate frequency. At the upper end of the range of the oscillator the transmitted frequency would be 3,000 kc., the displaced or local heterodyning frequency 1,650 kc., so that the intermediate frequency would be 1,350 kc. That is, the intermediate frequency amplifier of the receiving portion of the system must be made tunable over a band from 900 to 1,350 kc., in this particular case. Other undesired signals of an initial frequency such that they would beat to this same intermediate frequency would be eliminated by the tuned circuits in the radio frequency portions of the receiving system, in accordance with general practice, so that the frequency received would be exactly the same as that transmitted. This is merely a function of the proper setting and tracking of the various circuits of the set, something which can be done during manufacturing or in service and maintenance depots, and the operator is always assured that he is transmitting and receiving on the same frequency, whether or not temperature or other variables cause that frequency to be different from the frequency indicated by his tuning dial.

Four representative bands of frequency ranges, and the oscillator and multiplier output frequencies, are shown in the following table:

Band	Oscillator frequency	Percent displacement	Multiplier output	Intermediate frequency
1 trans.....	1,000-1,500	10	2,000-3,000	900-1,350
1 rec.....	1,100-1,650		1,100-1,650	
2 trans.....	1,000-1,500	5	3,000-4,500	900-1,350
2 rec.....	1,050-1,575		2,100-3,150	
3 trans.....	1,000-1,500	3 1/3	4,000-6,000	900-1,350
3 rec.....	1,033-1,550		3,100-4,650	
4 trans.....	1,000-1,500	2	6,000-9,000	900-1,350
4 rec.....	1,020-1,530		5,100-7,650	

It will be noted that the ratio of the percentage displacement used in various bands is the reciprocal of the ratio of the multiplication factor used for the local heterodyning wave; and this multiplication factor is different from that used for transmission, generally one less. The multi-

plication factor in the second band (for the local heterodyne wave) is 2 while that for the first band is 1; and 5% displacement is used in the second band as compared with 10% in the first band. This results in the same absolute frequency shift or displacement of the waves at any given point of the oscillator tuning band, in the various frequency ranges. This in turn results in the difference between the local heterodyning wave and the desired signal frequency being the same in each of the different bands, as a glance at the figures listed under "intermediate frequency" will show. Accordingly, although the intermediate frequency amplifier must be made tunable, it and the oscillator are always tunable over the same band, their ranges are the same (1.5/1), and no band switching is necessary in either of these tuned circuits and they are easily ganged and tracked. Obviously, a different multiple would not have to be used for the local heterodyne waves, but the same multiple could be used and the percentage ratio so chosen that the intermediate frequency bands still need only be tunable over a single range. For example, if 10% displacement and doubling were used for the local heterodyne waves in the first band, this would provide a multiplier output of 2,200-3,300 kc., which would require an intermediate frequency amplifier tunable from 200-300 kc. It would then be necessary to use a 6 2/3% displacement in the second band which, with tripling, would give a local heterodyning frequency of 3,200-4,800 kc., or again an intermediate frequency of 200-300 kc. In any event, the ratio of the various percentages of displacement in the different bands should be the reciprocal of the ratios of the multiplication factors used for the local heterodyning waves in order to use a single intermediate frequency amplifier tuning band.

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 additional fixed condensers 13a-d adapted to be connected to or disconnected from the tank circuit in accordance with the position of the displacing switch A' and the band switches associated with each condenser. Merely for trimming purposes, another fixed condenser 13e of small capacity is in shunt with the main condenser 12 when the switch A' is in its upper or transmitting position. It will be understood that the condensers 13a-d are so proportioned that, in combination with the condenser 12, they give the desired displacement (on their respective bands) from the frequency generated by the combination of the coil 11 and the condensers 12 and 13e. Since these fixed condensers may all be of the same type and general character, temperature or other variables will affect them similarly, and the percentage displacements will always stay the same under operating conditions. While the various tuned tank circuits throughout the system are shown as having fixed condensers (fixed 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 first multiplier, here shown as comprising the tube 14, which may be tube type No. 12A6, and its tuned circuits. The two tuning combinations both employ the single variable or tunable coil 15 having selectively associated therewith two sets of fixed condensers 16a—d and 17b—d. During transmission one of the condensers 16a—d (depending upon the position of the band switch associated with them) is in shunt with the coil 15, while during reception a direct connection (on the first band) or a similar one of the condensers 17 is used to provide (with the same setting of the coil 15) a tank circuit tuned to the displaced frequency. The output of the multiplier B is delivered to the multiplier C comprising the tube 18 and another similar arrangement of tuned circuits, band switches, transmission-reception switches, etc. These are here identified as comprising the tunable coil 19 and the cooperating sets of condensers 20 and 21. As before a direct connection or an appropriate one of the condensers 20 is associated with the coil 19 during transmission when this second multiplier is operative; and a direct connection or an appropriate one of the condensers 21 is associated with the coil when the displaced waves are being delivered, this latter tuning combination providing the tunable filter for delivering the displaced local heterodyning waves to the mixer. While the band switches and transmission-reception switches are distributed throughout the circuit diagram in such a way that, as is the case with the tuned coils, it would be difficult to show that they are ganged, it would be understood that the band switches and the transmission-reception switches are ganged or coordinated, just as the tuning of the various tunable coils throughout the system.

When transmitting, the output of the multiplier section of the system is delivered to the power amplifier here shown as comprising the tubes 22 and 23, which may be of tube type No. 1625, and which would in commercial practice be preceded by a driver stage and possibly also a pre-amplifier stage, these being omitted here for simplicity. The space current in these tubes would be modulated by waves derived from the modulating portion of the system, shown in the upper right-hand half of the sheet identified as Figure 2b. This is here shown as comprising a jack 24 adapted to have a microphone or keying means connecting thereto, this being coupled to a driver tube 25, which may be tube type No. 12A6 tube (and which in practice would generally be preceded by a pre-amplifier tube) in turn transformer coupled to modulator tubes 26 and 27, which may of tube type No. 1625, the output of these modulator tubes affecting both the screen and plate voltages of the power amplifying tubes 22 and 23, through the wires c and d. The wire a carries the positive plate supply voltage for the receiving portion of the system, and the wire b provides the connection between the multiplier tunable filter circuit output and one of the grids of the mixer tube in the super-heterodyne receiving portion of the system.

The modulated output of the power amplifier is delivered, when the switch D' is in its upper or transmitting position, to the antenna tank circuit comprising the condenser 28 and the variable inductance 29. This is coupled, where it is to be used with a short antenna, to antenna loading

means here shown as comprising a tapped coil 30 and a variometer 31, the terminal 32 being adapted to be connected to the antenna.

When the system is thrown over to receiving, the antenna tank circuit is connected, as shown in the drawings, through the wire f to the signal grid of the radio frequency amplifying tube 33, which may be tube type No. 12SK7 tube, plate supply for the super-heterodyne receiving system being then provided by a connection through the plate-supply change-over switch N', ganged with the other transmission-reception switches. 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 the variable inductance 34 and the appropriate one of the condensers in the set 35, according to the position of the band switch.

The output of the radio frequency amplifying arrangement is coupled to one of the grids of the mixer tube 36; while another grid of this tube is supplied with the local heterodyning or displaced waves derived from the wave generating means comprising the oscillator and multipliers, these waves being delivered through the wire b, as previously mentioned. The mixer, in accordance with conventional practice, beats the signal frequency down to intermediate frequency which, in the case of the sets of facts assumed above, is in the band comprising 900–1,350 kc.

This intermediate frequency output is delivered to an intermediate frequency amplifier K here shown as comprising the tube 37, which may be tube type No. 12SK7 tube, it being understood that in commercial practice at least two similar stages of such intermediate frequency amplification would be used in cascade, one such stage being omitted from this circuit diagram for simplicity of illustration. 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 900–1,350 kc. band assumed. The input side of the intermediate frequency coupling arrangement is here shown as comprising the tunable coil 38 and the condensers 39, 40 and 41, this latter condenser being common with the output tank circuit of the arrangement, comprising the other condensers 42 and 43 and the tunable coil 44.

The output of the tube 37 is delivered through a fixedly tuned band pass arrangement, here identified in general as 45, designed to pass a 900–1,350 kc. band, to a detector, beat-frequency-oscillator tube 46, which may be tube type No. 12SR7. The two anodes are connected together to achieve the desired detection function, while the additional grid and plate elements cooperate with the cathode to provide a beat frequency oscillator when desired, this being turned off by opening the on-off switch 47 when voice is being received. The audio output of the detector tube 46 is delivered to an audio amplifying tube 48, which may be tube type No. 12SK7, the output of this tube being here shown as delivered to a jack 49 which is adapted to be connected to any desired translating device, as earphones. In practice it will be understood that the tube 48 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 and frequency ranges previ-

ously assumed, might have the oscillator inductance 11 variable from 11-25 microhenries; the multiplier, antenna tank circuit, and mixer inductances 15, 19, 29 and 34 variable from 6.2-14 microhenries; and the intermediate frequency primary and secondary inductances variable from 175-400 microhenries. Under these circumstances, the oscillator tank circuit principal condenser 12 might have a capacity of 800 micro-microfarads, and the condenser 13e (associated with it during transmission only) a capacity of 200 micro-microfarads; while the condensers 13a-d might have capacities, for the bands assumed, of 28, 110, 125 and 160 micro-microfarads. The condensers 15a-d in the input of the first multiplier might have a capacity of 450, 200, 112 and 50 micro-microfarads; and these same values might be used for the sets of condensers 28 and 35; while the condensers 20b-d would have values corresponding to the condensers 16b-d. The condensers 17b-d and 21b-d might have values of 163, 92 and 41 micro-microfarads, respectively; while the condensers 39-43, in the tuned portion of the intermediate frequency amplifier, might have values of 80, 8,000, 10,000, 80 and 8,000 micro-microfarads.

Other circuit constants would be of conventional 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 microfarad; coupling condensers between the multiplier tubes and between the tube 18 and the power amplifier, and those associated with the tubes 33 and 36 might be .001 microfarad; while that coupling the detector tube 46 to the tube 48 might be .1 microfarad, and that at the input of the oscillator tube 100 micro-microfarads. The by-pass condensers in the transmitting and receiving portions of the system might all be .002 microfarad, except the condenser in the filament circuit of the tube 48, and those associated with the filaments of the driver and modulating tubes 25, 26 and 27, which would preferably be in the neighborhood of 20 microfarads. The screen grid resistors in the multipliers 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 25 about 1/2 megohm; that used with the tube 33 about 1 megohm; and those associated with the signal grid of the mixer and intermediate amplifier tubes from 100,000 to 500,000 ohms. The screen grid resistors used in the receiving portion of the system would preferably be of a higher value than those used in the transmitting portion, and appropriate to the tubes employed, as for example 100,000 ohms, while the cathode resistors would be from 200 to 500 ohms depending upon the tubes and the desired cathode biasing in each portion of the circuit. The 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 each of a plurality of predetermined frequency ranges; means for amplifying and transmitting waves of any selected frequency in any of said ranges; means for displacing the frequency of the waves different given percentages of the selected frequency in the different ranges; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band, 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.

2. Radio apparatus of the character described, including: wave generating means variable over each of a plurality of predetermined frequency ranges; means for amplifying and transmitting waves of any selected frequency in any of said ranges; means for displacing the frequency of the waves different given percentages of the selected frequency in the different ranges; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band, 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, the displacement percentages being so selected that, in all said ranges, the difference between the selected frequencies and the local heterodyning frequencies is the same and corresponds to the band over which the intermediate frequency amplifier is tunable.

3. Radio apparatus of the character described, including: wave generating means variable over each of a plurality of predetermined frequency ranges; means for amplifying and transmitting waves of any selected frequency in any of said ranges; means for displacing the frequency of the waves different given percentages of the selected frequency in the different ranges; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band, 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.

4. Radio apparatus of the character described, including: an oscillator for generating waves of a variable frequency; means for effecting predetermined different multiplications of the frequency of the waves generated by the oscillator to provide a plurality of predetermined frequency ranges; means for amplifying and transmitting the waves resulting from a selected one of said multiplications; means for displacing the frequency of the waves different given percentages of

11

the selected frequency in the different ranges; and a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band, 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 and selecting a different predetermined multiplication, whereby displaced waves of a multiplication other than that used in transmitting in each said range serve as the local heterodyning waves for receiving in the same range.

5. Apparatus of the character claimed in claim 4, wherein the percentages of displacement of the selected frequency in the various predetermined frequency ranges have a ratio equal to the reciprocal of the ratio of the multiplication of the displaced waves in the various ranges, so that, in all said ranges, the difference between the desired frequencies and the local heterodyning frequencies is the same and corresponds to the band over which the intermediate frequency amplifier is tunable.

6. 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 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 different given percentages of the selected frequency in the different ranges, this means comprising other reactive elements of the same character as the fixed element and means for connecting them into the tank circuit and disconnecting them therefrom; means for amplifying and transmitting the waves resulting from a selected one of said multiplications; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band and a mixer delivering its output to the intermediate frequency

12

amplifier; selectively operable means for effecting a given predetermined multiplication and delivering the output thereof to the amplifying means in one operative position and for effecting a selected percentage displacement of the waves, a different predetermined multiplication thereof, and delivery of them to 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 coordinated variation of the variable element in the oscillator tank circuit and tuning the intermediate frequency amplifier.

7. 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 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 different given percentages of the selected frequency in the different ranges, this means comprising other reactive elements of the same character as the fixed element and means for connecting them into the tank circuit and disconnecting them therefrom; means for amplifying and transmitting the waves resulting from a selected one of said multiplications; a super-heterodyne receiving system having an intermediate frequency amplifier tunable over a certain band and a mixer delivering its output to the intermediate frequency amplifier; means for delivering waves of a selected predetermined multiplication to the mixer of the amplifying means; and means for delivering, in each case, displaced waves of a different multiplication to the receiving system; and means for coordinating variation of the variable element in the oscillator tank circuit with the tuning of the intermediate frequency amplifier, the displaced waves serving as the local heterodyning waves for said receiving system.

FRANK M. DAVIS.