

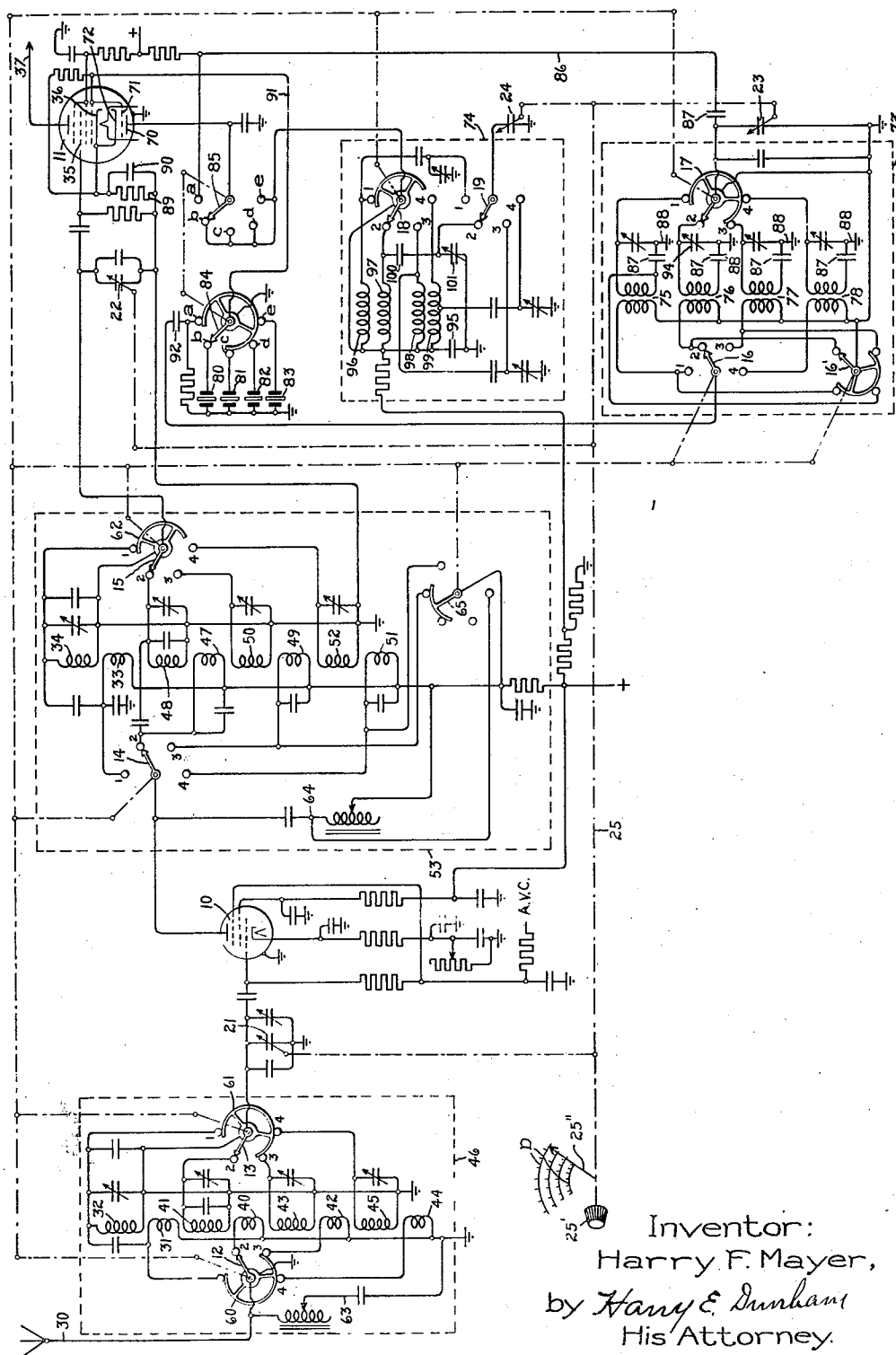
July 13, 1943.

H. F. MAYER

2,323,924

SUPERHETERODYNE RECEIVER

Filed Dec. 11, 1941



Inventor:
Harry F. Mayer,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,323,924

SUPERHETERODYNE RECEIVER

Harry F. Mayer, Schenectady, N. Y., assignor to
General Electric Company, a corporation of
New York

Application December 11, 1941, Serial No. 422,528

6 Claims. (Cl. 250—20)

My invention relates to superheterodyne receivers and particularly to such receivers used for radio reception.

My invention has for one of its objects to provide improved and simplified means whereby a receiver tunable over a broad band of frequencies for reception of signals of any frequency in said band is adapted for reception of certain fixed frequencies in said band with crystal control of the local oscillator.

In certain short wave applications of radio receivers it is desirable that the receiver be tunable over a broad band of frequencies as, for example, the range from 1.5 megacycles to 12 megacycles, and that it be adapted for reception of any frequency in such a range. It is also desirable that signals of certain frequencies in the band be received with certainty as to the frequency being received and without any readjustment of the receiver during reception.

For example, it frequently is desirable to receive in a receiver tunable over a broad range of frequency, signals, which are transmitted on a carrier wave, the frequency of which is known to the operator of the receiving equipment, but which is transmitted only during the actual transmission of the signals that are to be received. Thus the operator has no time in which to readjust, or retune, his receiver during reception. Instead the equipment must be such that it may be adjusted to a desired frequency, as indicated solely by a dial calibration on the equipment itself and which may then be relied upon to receive the desired signals when transmitted without any readjustment of the tuning.

An object of my invention is to provide a receiver capable of such operation which is of simple and economical construction and which affords such operation notwithstanding the variations in circuit constants and tuning which are produced by temperature or humidity variations and by manufacturing tolerances.

A further object of my invention is to provide means whereby the local oscillator employed for reception in the fixed channels may be crystal controlled and whereby the tuning for such reception with crystal control is effected in response to operation of the same tuning member by which variable tuning over the band is secured.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further

objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure represents an embodiment of my invention.

Referring to the drawing, I have illustrated therein the circuits of the radio frequency portion of a radio receiver, which comprise an electron discharge device 10, which acts as a radio frequency amplifier, and an electron discharge device 11 which acts as a local oscillator and converter for converting the received oscillations to oscillations of intermediate frequency, the intermediate frequency being, as usual, in superheterodyne receivers, constant for all received signals.

The particular circuit shown is one adapted for operation over a wide range of frequencies extending, for example, from 1.5 megacycles to 12 megacycles. To effect the tuning over this wide range, switching means comprising switches 12, 13, 14, 15, 16, 16', 17, 18 and 19 are provided, each of these switches having four positions designated, respectively, 1, 2, 3 and 4 on the drawing, each position corresponding to a particular band of frequencies in the total range over which reception is desired, the different bands being adjacent in the range. When the band change switch is in any of its four positions, the receiver is tunable over the respective band by means of a suitable unicontrol condenser assembly comprising condensers 21, 22 and 23. These condensers are variable and mechanically connected together and to a suitable movable mechanical control member as indicated by the dot and dash line 25. This member 25 may be provided with a suitable handle, or knob, 25' to permit its convenient manual adjustment and it is likewise provided with a suitable index member 25'' arranged to cooperate with four dials D each of which bears a frequency calibration corresponding with one of the bands over which the receiver is tunable. These elements are only conventionally indicated on the drawing since any suitable arrangement for the purpose may be employed.

For a more detailed description of the circuit let it be assumed that all of the switches are in the position designated 1 on the diagram. Oscillations are then supplied from the antenna 30 through the transformer comprising windings 31 and 32 and switch 13 to the control electrode and cathode of the amplifier 10. Such oscillations are amplified in the amplifier 10 and are supplied through the transformer comprising

windings 33 and 34 and thence through switch 15 to the space between control electrode 35 and the cathode 36 of the converter 11. These oscillations are then beat with oscillations produced by the local oscillator, which later will be described, to produce the intermediate frequency, which is supplied from the anode of the converter over conductor 37 to subsequent portions of the receiver.

Similar operation occurs when the switches 12 to 19 are in any of their other positions 2, 3 and 4 but different windings of the various transformers are employed. Thus, if switches 12 to 15 be in their position 2 transformer windings 40 and 41 are employed in the antenna circuit and windings 47 and 48 are employed in the interstage circuits. If the switches 12 to 15 be in the third position, the transformer windings 42, 43 and 49, 50 are employed and if the switches be in their fourth position then windings 44, 45 and 51, 52 are employed. These various windings may be shunted by trimmer condensers, fixed or adjustable, as desired, and, in general, the radio circuits comprising these windings are of any desired design common in the practice of such circuits.

The antenna circuits including switches 12 and 13 may, if desired, be suitably shielded from the remainder of the apparatus by a shield indicated by the dotted lines 46, and similarly the interstage circuits may be shielded by the shield represented by the dotted lines 53.

Switches 12, 13 and 15 are provided with short circuiting means 60, 61, and 62 whereby unused transformer windings are short circuited during operation of the system in any particular frequency band. Trap circuits 63 and 64 are also provided to short circuit and thus prevent reception in these circuits of received carrier waves having the frequency of the intermediate frequency currents which appear on conductor 37; also a switch 65, uncontrolled with switches 12 to 19 is provided to effect certain additional short-circuiting connections in the apparatus housed by the shield 53.

The local oscillator of the system comprises the anode 70, control electrode 71, and cathode 72 of the electron discharge device 11. The control electrode 71 is connected directly to the control grid 36 of the converter thereby to afford coupling between the local oscillator and converter.

This discharge device is provided with two sets of circuit connections, one set being represented by the equipment within the dotted rectangle 73 and the other set comprising the equipment within the dotted rectangle 74.

The equipment 73 comprises circuits adapted to couple the input electrodes 71, 72 and output electrodes 70, 72 of the discharge device 11, 72 for regeneration thereby to produce oscillations having the local oscillator frequency which, when combined with received signal currents, produces the intermediate frequency appearing on conductor 37. This equipment includes switches 16 and 17 together with four transformers 75, 76, 77 and 78 which are respectively connected in circuit by the switches 16 and 17 in the different positions thereof, thereby to couple the input and output electrodes of the discharge device to support oscillations in the different frequency bands over which the oscillator operates. In any position of the switch, the frequency of the oscillations produced may be varied over the respective band by means of the condenser 23,

which is uncontrolled with the condensers 21 and 22.

The equipment 74 comprises the anode circuits which, when connected to the anode 70, adapts the discharge device for operation as a crystal controlled oscillator with the frequency controlled by means of one or another of the different crystals 80, 81, 82 and 83, which may be connected in circuit between the grid 71 and the cathode through a switch 84. These anode circuits comprise anode circuit inductances 96, 97, 98 and 99 which may be selectively connected in circuit with the anode 70 and cathode 72 by means of switch 18. Each of these inductances is provided with its respective trimmer and padder condensers and is arranged by means of switch 19 to be connected selectively with variable condenser 24 whereby it is tuned over its respective band of frequencies. This condenser 24 is uncontrolled with the condensers 21, 22 and 23 and may be built into the same mechanical assembly.

Switches 84 and 85 are uncontrolled with each other but are not uncontrolled with the switches 12 to 19. These switches have five positions designated *a*, *b*, *c*, *d*, and *e*. When it is desired to tune over the whole range of frequencies and to receive any signal that may be transmitted on a carrier frequency in that range the switches 84 and 85 are in their position *a*. In this position the circuits of the local oscillator is made up of circuit components in equipment 73.

When it is desired to receive a particular station operating on a known preassigned frequency corresponding to a particular crystal which is provided, then switches 84 and 85 are operated to a position corresponding to that crystal. The grid circuit of the local oscillator then includes the corresponding crystal, and the anode circuit includes the circuit components comprised within the equipment 74 and which adapt the local oscillator for operation at a frequency controlled by the respective piezo electric crystal.

Assume now that the switches 84 and 85 are in their positions *a*. The circuits of the local oscillator are then as follows. The anode circuit extends from the anode 70 through the switch 85 in its position *a*, conductor 86, condenser 87, armature of switch 17 and the secondary winding of that one of the transformers 75, 76, 77 and 78 corresponding to the instant position of the switch 17 and its corresponding padding condenser 87 to ground at the point 88, and thence from ground through the resistance and capacitance combination 89, 90 to the cathode of the discharge device. Similarly, the grid circuit of the local oscillator extends from the control electrode 71 through conductor 91, switch 84 in its position *a*, condenser 92, switch 16 and that one of the primary windings of transformer 75, 76, 77 or 78 corresponding to the instant position of the switch 16 and thence to ground and back to the cathode of the discharge device through the resistance and capacitance combination 89 and 90.

With the switches 16 and 17 in the position shown on the drawing the transformer 76 is in circuit and thus couples the anode and grid circuit of the discharge device. The secondary winding of this transformer is tuned to the desired frequency by means of the condenser 23 of the uncontrolled condenser assembly, this condenser being shunted by the trimmer condenser 94. Each of the unused primary windings 75, 77 and 78 of these transformers are short circuited by means of the switch 16'. Thus, the frequency of the oscillations is determined by the trans-

former 76 and the circuit connected therewith, including the variable condenser 23, and is such that when combined with the received oscillations it produces the desired intermediate frequency.

By operation of the uncontrolled switches 12 to 19 through their different positions, and by tuning the system by means of the uncontrol condensers 21, 22, 23, any frequency in the desired range may be received.

If the operator desires to receive signals from a particular station, which he knows to operate on a particular carrier frequency corresponding to which he has a piezo electric crystal, he operates his switches 84 and 85 to the position corresponding to that station and to that crystal. These switches 84 and 85, on leaving their positions *a*, respectively break the grid and anode connections to the apparatus 73. Switch 84 connects the control electrode 71 to that one of the piezo electric crystals 80 to 83 corresponding to the desired station. Switch 85 connects the anode 70 to the armature of switch 18 in equipment 74. This switch may now be operated to the position in which that one of the inductance devices 96 to 99 corresponding to the respective crystal is connected in circuit. The tuning condensers 21, 22, 23, 24 are then operated to the frequency of the station to be received. The equipment is thus in readiness for reception of the desired station.

If the station to be received has a frequency corresponding to the frequency of crystal 80, the operator turns his switches 84 and 85 to their position *b* and his band switches 12 to 19 to the band in which the frequency of the desired station falls which, we will say, is the band corresponding to position 2 of the switches 12 to 19. The grid circuit of the local oscillator now extends from the grid 71 through switch 84 and crystal 80 back to the cathode 72 of the discharge device. The anode circuit then extends from the anode 70 through switch 85 in its position *b*, switch 18 in its position 2, coil 97 and condenser 95, back to the cathode. Coil 97 is connected through padding condenser 100 and switch 19 across variable tuning condenser 24 and trimmer condenser 101. The operator now tunes the receiver to the station to be received by adjusting his uncontrolled tuning condenser assembly 21 to 24 and the desired station may be received.

It will be seen that the equipment may be provided with as many crystals as desired each corresponding to a particular preassigned station frequency within the total range over which the equipment operates. These frequencies may all be in one band of that range (in which case only one of the inductances 96 to 99 is required) or they may be distributed throughout the different bands, one or more in each band. The switches 18 and 19 select the band and switch 84 the particular crystal, and condenser 24, uncontrolled with the other tuning condensers 21, 22 and 23, tunes the respective inductance for operation with the selected crystal for reception of the desired station.

Switch 19, uncontrolled with switch 18 connects the condenser 24 across that one of the coils 96, 97, 98 or 99 which is in circuit. Additional condensers comprising the usual series padding condensers and shunt trimming condensers are employed, as desired, and in circuit arrangements such as those shown on the drawing. These circuits are adjusted, in accordance with ordinary piezo electric oscillator practice, to resonate at frequencies somewhat higher than

the natural frequency of the crystal to be employed. Since the different coils 96 to 99 operate in different frequency bands, the extent to which these coils resonate above the frequency of the crystal may vary in the different bands, in order to maintain substantially constant amplitude of oscillation for all frequencies. For example, let us suppose that the crystal 80 is adjusted for operation at a frequency in the highest frequency band and that coil 96 is employed in that band. This coil is adjusted to resonate with its associated capacity including the condenser 24 at a frequency, let us say, 5% higher than the natural frequency of the crystal 80. If crystal 81 has a frequency in the next lower range of frequencies, then coil 95 is adjusted to resonate at the frequency for best operation of the crystal oscillator at the frequency determined by that crystal. It may resonate at a frequency 10% above the frequency of the crystal. Similarly, if the crystal 82 be employed in the still lower band, the coil 93 which is employed therewith may resonate at a frequency even farther from the crystal frequency as, for example, 20% above it. By this means, the tendency for the lower frequency crystals to oscillate at greater amplitude is compensated, and the mixer section of the converter tube receives the optimum oscillator voltage at all frequencies.

It will be observed that, in accordance with my invention, by merely throwing switches 84 and 85 between position *a* and a position corresponding to a particular crystal corresponding to a desired station for which the band switch and tuning control member have been adjusted, reception is had either with crystal control of the local oscillator or with the usual manually tuned local superheterodyne oscillator. Of course, with the switches 84 and 85 in the *a* position, due to variations in tuning of the local oscillation circuits 73 by reason of temperature, humidity, manufacturing tolerances, etc., and the resultant misalignment of these circuits with the tuning dial calibration usually provided with such receivers, it may be that no signal is received even though the tuning control member be adjusted to the assigned frequency of the desired station as indicated by the dial and that station be in operation. Considerable readjustment of the tuning control member may be required before the desired station is received, this adjustment varying from time to time. If switches 84 and 85 be thrown to the crystal corresponding to the desired station with the tuning control member adjusted in accordance with the dial calibration corresponding to the desired station, that station is received with reliability and without any adjustment of the tuning control member or other part of the circuit. This is very important, especially where the transmitter from which signals are to be received is normally inoperative and operates only during the transmission of the message to be received, thus allowing no time for readjustments.

Since the local oscillator tuned by the crystal includes coils for operation over the respective bands, each being maintained in tuning alignment with the dial by the tuning condenser 24, the crystals may be changed as desired to receive any frequency in any of the bands with the reliability above pointed out. Variations in these coils by reason of temperature, humidity and manufacturing tolerances are not important. These crystal oscillation circuits may be tuned,

as previously described, at frequencies sufficiently above the corresponding dial calibrations by amounts varying in the different bands to assure operation of the local crystal oscillation throughout the entire frequency range with the same intensity.

My invention possesses the important advantage that it permits the use of crystals, and two or more crystals, in the various bands of frequencies over which the receiver is tunable and at the same time it does not greatly increase the complication and cost of the equipment. It obviates the necessity of a considerable number of trimmer condensers for each of the crystal channels and the complicated switching mechanism necessary for their proper connection with the circuit. In accordance with my invention, the problem of switching for the different crystal channels is reduced to a minimum. In addition, in accordance with my invention, to change the frequency of the crystal channels requires merely the substitution of crystals, no other adjustment of the circuit being required. This is in striking contrast to arrangements in accordance with previous practice, in which such change in channel frequency amounts to a laboratory operation on the equipment.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications both in the circuit arrangement and in the instrumentalities employed may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination, in a high frequency receiver, of a signal input circuit, a local oscillator, a crystal oscillator, means to render said oscillators alternatively operative, means to combine oscillations received in said input circuit with oscillations produced by either one or the other of said oscillators to produce beat currents, means to tune said input circuit, said local oscillator and said crystal oscillator in unison over respective ranges of frequency to maintain said beat currents of constant frequency for all signals received, the ranges over which said local oscillator and crystal oscillator are tuned for operation being the same, said crystal oscillator including a plurality of piezoelectric crystals to control the frequency of said crystal oscillator, and means to select a crystal corresponding to the frequency to be received, whereby said receiver is operative over a range of frequencies determined by said tuning means when said local oscillator is operative and is operative to receive certain fixed predetermined frequencies in said range when tuned to said fixed frequencies and said first and last means are operated to render said crystal oscillator operative and to select the crystal corresponding to the frequency to be received.

2. The combination, in a superheterodyne receiver, of a signal input circuit, a local oscillator including an electron discharge device having circuit means for operation as a master oscillator at a frequency continuously variable over a wide range of frequencies, and circuit means for operation under crystal control at any one of a plurality of fixed predetermined frequencies in said range, switching means to select either of said circuit means, unicontrol means to tune both of said circuit means for operation over the same

range of frequencies and said input circuit over its corresponding range of frequencies, whereby any frequency in the wide range to which said input circuit is tunable may be received and certain fixed predetermined frequencies in said range may be received with crystal control of said local oscillator.

3. The combination, in a superheterodyne receiver of a signal input circuit, a local oscillator including an electron discharge device having input and output electrodes, a local feedback circuit continuously tunable over a range of frequencies, a local oscillatory circuit, a plurality of piezoelectric crystals, a switch having a plurality of positions and arranged in one position to couple said input and output electrodes through said local feedback circuit for the generation of oscillations having frequencies determined by the tuning thereof and continuously variable with said tuning, and in other positions to connect any one of said plurality of piezo electric crystals to said input electrodes, and to connect said local oscillatory circuit to said output electrodes for generation of oscillations having frequencies determined by said crystals, and unicontrol means to tune both of said local circuits for operation over the same range of frequencies and said input circuit for operation over its corresponding range of frequency.

4. A superheterodyne receiver adapted for operation over a plurality of bands of frequencies, said receiver including a local oscillator comprising an electron discharge device and two groups of circuits, each of said groups of circuits including circuits adapted to be connected with said discharge device to generate oscillations having frequencies in the different respective bands of frequencies corresponding to the bands of frequencies to be received, each group including a band selector switch to alter said circuits in accordance with the band to be received, said bands of both groups being the same for any position of said band selector switch, and each group including a variable condenser, said condensers being uncontrolled and variable to tune the respective circuit over the band determined by the respective band selector switch, a plurality of piezoelectric crystals each crystal corresponding to a desired station, a station selector, said station selector having a plurality of station selector positions and another position, and said station selector being arranged when in any station selector position to connect said discharge device through the band selector switch in one of said groups to a circuit selected thereby and to connect one of said crystals to said discharge device to control the frequency of oscillations produced in the selected circuit, and when in said other position to interrupt said connections and to connect said discharge device through the band selector switch in the other group to the circuit selected thereby, whereby when said station selector switch is in any station selector position only the frequency corresponding to the respective crystal is received and when said station selector is in said other position any frequency in the bands determined by the position of said band selector switch may be received.

5. In combination, an electron discharge device, two groups of circuits therefor one of said groups being arranged for generation of oscillations having frequencies continuously variable over any of a plurality of bands of frequencies, and the other group including means tunable continuously for operation over the same bands

of frequencies, and each group including a switch to select the bands, the frequency varying means of said one group and tuning means of the other group being uncontrolled and operable in any band selected, a plurality of crystals having different natural frequencies falling in different bands, a switch having a plurality of crystal selector positions and another position, said switch in said crystal selector positions selectively connecting said crystals to said discharge device and simultaneously connecting said discharge device to said other group of circuits through the band selector switch of said other group, thereby to produce oscillations of the frequency determined by the selected crystal, and said switch in said other position, interrupting said connections to said crystals and to said other group and to connect said discharge device to said one group through the selector switch thereof.

6. The combination, in a radio receiver, of a signal input circuit, a normally operative local oscillator, a normally inoperative local oscillator, both of said oscillators being tunable over the same range of frequencies and said input circuit being tunable in unison therewith over a corresponding range of frequencies, a plurality of crystals connected to control the frequency produced by said normally inoperative local oscillator, each crystal having a different frequency, and switch means to render said normally operative oscillator inoperative, to select one of said crystals, and to render said normally inoperative oscillator operative at the frequency determined by the selected crystal when tuned to the corresponding frequency.

HARRY F. MAYER.