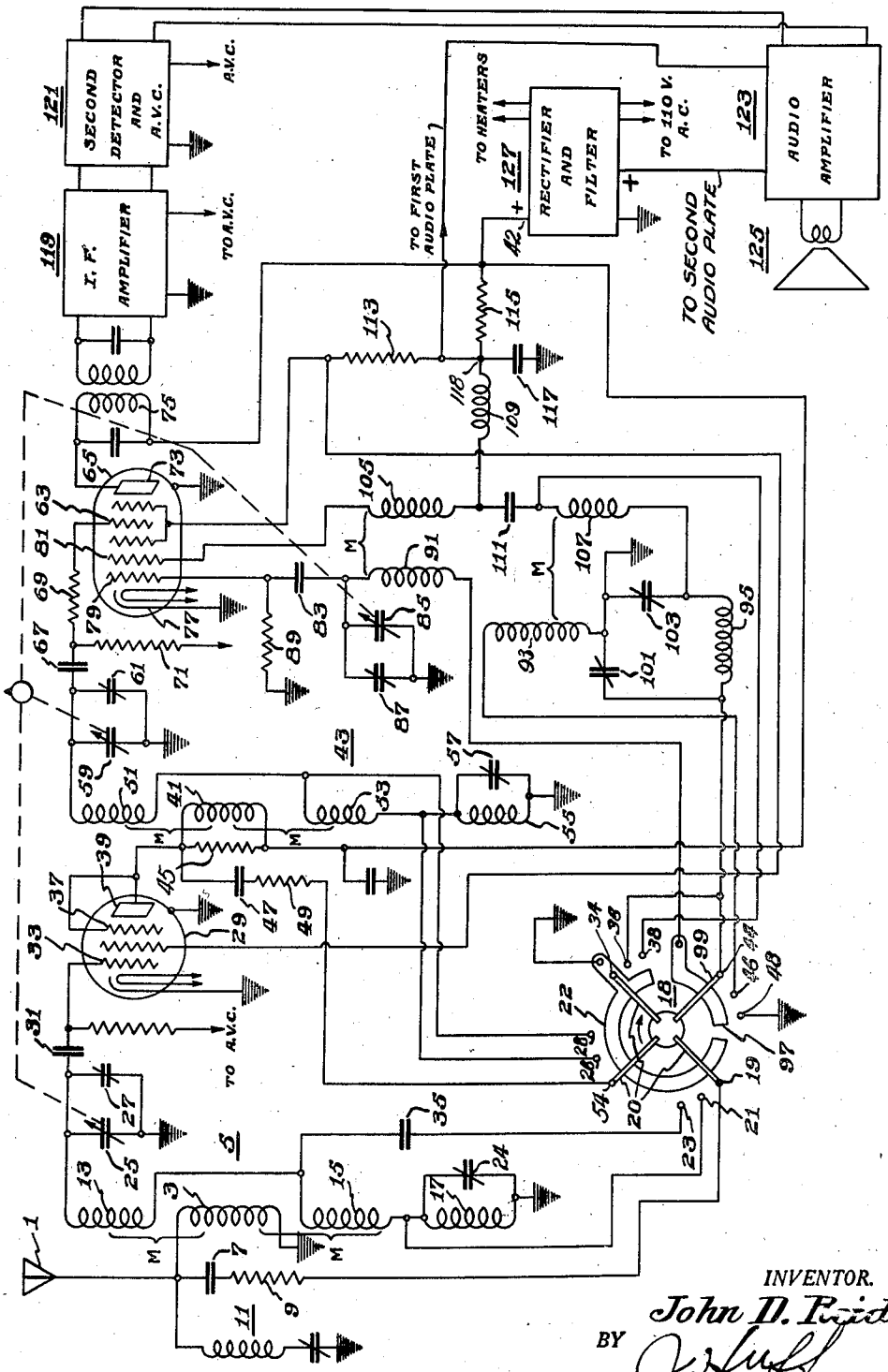
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RADIO RECEIVING SYSTEM

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## RADIO RECEIVING SYSTEM

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4 Claims. (Cl. 250—20)

My invention relates to a radio receiving system. More specifically, my invention relates to a simplified all-wave superheterodyne receiver in which the first detector and local oscillator may be combined in a multi-purpose thermionic tube. The application is a division of my copending application Serial No. 42,903, filed September 30, 1935, granted May 10, 1938 as Patent No. 2,116,713.

The development of the circuits for superheterodyne radio receivers has been progressing toward simplicity of parts and wiring. The use of higher frequencies for broadcast transmission has brought about the design of many all-wave receivers. These receivers are characterized by a plurality of tuning inductors and capacitors which require most complicated switching means with resulting complication of wiring. Thus no small part of the approach to a simplified superheterodyne has been lost in the development of the all-wave receiver.

Receiver development has been accompanied by improvements in thermionic tubes. The tubes have, for example, been simplified by the inclusion and combination of several electrodes in a single envelop to serve several functions. These tubes are called multi-purpose tubes. Although the multi-purpose tube has decided benefits at low frequency, difficulties have been experienced at the higher frequencies. I propose to overcome these and other difficulties by the present invention which may be best understood by reference to the accompanying drawing and specification.

One of the objects of my invention is found in the simplified means for selectively choosing any one of a plurality of frequency ranges.

Another object is the method of avoiding the degenerative effects of a combined first detector and local oscillator tube.

A further object is in the means employed to avoid fluttering or overall audio feedback, and ripple effects which are troublesome in superheterodyne circuits.

A still further object is the method of coupling the antenna system to the all-wave receiver embodying my invention.

Additional objects will be found in the accompanying specification.

In the accompanying drawing is shown a schematic diagram of one embodiment of my invention applied to an all-wave superheterodyne. The intermediate frequency amplifier, the second detector and automatic volume control, the audio frequency amplifier, the loudspeaker, and the power source of rectified, filter current are not part of my invention, per se. These several elements are well known to those skilled in the art and do not require detailed illustration.

In the accompanying schematic diagram an antenna 1 is connected to the primary 3 of a radio frequency transformer 5. The inductance of the primary is preferably chosen so that, with the antenna capacity and its own inherent capacity, it will resonate within the tuning range of the middle frequency band of the receiver. On the first or lowest frequency band, a capacitor 7 and resistor 9 are serially connected across the primary. The capacitor lowers the resonant frequency of the primary to a value within the lowest frequency band of the receiver. A series circuit 11, resonant to the frequency of the intermediate frequency amplifier, is shunted across the primary to attenuate voltages of interfering signals.

The secondary of the radio frequency transformer is composed of three windings 13, 15, 17 which are used respectively in the high, medium and low frequency band of the receiver. The first and second of these windings 13, 15 are mutually coupled to the primary 3.

A single section, three position range switch 18 is connected to selectively choose the desired operating range. In this switch contact arms 20 move over a grounded commutator 22. In this switch the first three contacts 19, 21, 23 are connected to the proper inductors and capacitors for the low, medium, and high frequency ranges. The first contact 19 connects the capacitor 7 and resistor 9 across the primary. The capacity tunes the primary to a frequency within the low range. The resistor 11 dampens the primary circuit and prevents undesirable reactions with the tuned secondary circuit. The secondary circuit on the low range is composed of the three secondary windings, 13, 15, 17, which are serially connected, a trimmer capacitor 24 across the third of these windings, and a variable capacitor 25 which has a parallel connected trimmer capacitor 27. One side of the variable capacitor 25 is grounded and the other side connected to the free end of secondary winding 13; the free end of the third secondary winding 17 is grounded, and thus one side of the low-range secondary circuit is grounded. A thermionic radio frequency amplifier 29 is connected across the secondary circuit by a blocking capacitor 31, which connects the high potential terminal of the secondary circuit to the control grid 33, and by the grounded cathode of the amplifier 29. The control grid is biased by a direct current

potential derived from the automatic volume control rectifier.

The medium frequency range is chosen by placing the range switch on the second contact 21. In this position the range switch disconnects the capacitor 7 which shunts the primary. The effect of removing this capacity is to tune the antenna or primary circuit within the range of the medium range. The third secondary winding 17 is short-circuited and grounded. The secondary inductance is composed of the first and secondary windings 13, 15. The tuning capacitance is made up of the variable capacitor 25 and the trimmer capacitor 27.

The high frequency range is chosen by moving the range switch to the third contact 23. In this position the antenna or primary circuit is tuned to a frequency lower than the lowest frequency within the high frequency range. The secondary circuit is composed of the first secondary winding 13 which is connected to ground through a tracking capacitor 35. The function of the tracking capacitor will be described below. The reactance of the remaining secondary windings 15, 17 is negative at the high frequencies of this range and its effect is to increase the capacity of the tracking capacitor.

The output circuit of the radio frequency amplifier is of the low impedance type. The anode circuit within the tube is made of low impedance by joining the screen electrode 37 to the anode 39. The anode is connected to the primary 41 of a radio frequency transformer 43. The primary is also connected to the positive terminal 42 of the B voltage source 127. The inductance of the primary is chosen so that with its associated capacity it will resonate at a frequency just below the lowest frequency of the high frequency range. A damping resistor 45 is shunted across the primary to avoid pronounced resonance peaks.

On the low frequency range the range selector switch is positioned on terminal 54 which is grounded by arm 20 so that the primary 41 is effectively shunted by a capacitor 47 and a resistor 49. The combined effect of these elements is to tune the primary to a frequency within the lowest frequency range and further damp its resonant peak. The secondary of the transformer 43 is made up of three secondary windings 51, 53, 55 which are serially conducted. The first two windings 51, 53 are mutually coupled to the primary. A trimmer capacity 57 is shunted across the third winding 55. The tuning is accomplished by a variable capacitor 59 which is shunted by a trimmer capacitor 61. The variable capacitor is grounded.

The high potential terminal of the secondary circuit is connected to the control grid 63 of the first detector and local oscillator tube 65 through a capacitor 67 and a series resistor 69. The junction between the capacitor 67 and the series resistor 69 is connected through a grid resistor 71 to the negative terminal of the automatic volume control means. The output circuit comprises the anode 73, a resonant circuit 75 tuned to the intermediate frequency, and a connection to the positive terminal 42 of the B current source 127.

When the range switch is placed on the contact 21 which is selected for the medium frequency range, the terminal connection 54, which shunts the capacitor 47 and series resistor 49 across the primary 41, is opened. The primary 41 without the shunt capacity resonates within the medium frequency range. The third secondary winding 55 is short-circuited by the range switch arm 20 which grounds terminal 26. The secondary inductance in the medium range is composed of the first and second windings 51, 53. The adjustable tuning capacity is made up of the inherent capacities of the circuit and the variable capacitor 59 with its trimmer 61. The secondary circuit is coupled to the first detector and mixing tube 65 as described above.

In the high frequency range the primary tunes below the lowest frequency of the high frequency tuning range. Its resonant peak occurs at a frequency which is close to the range, and has an effect which is substantially equalled by the tracking capacitor 35 previously mentioned. The second and third windings 53, 55 are short-circuited by contact arm 20 which grounds terminal 28. The secondary circuit of transformer 43 is tuned by the variable capacitor 59 and the inherent capacities associated with the circuit.

The local oscillator is comprised of a cathode 77, grid 79, and anode 81 which electrodes are included within the envelop of the first detector 65. The cathode is grounded. The grid is connected through a grid capacitor 83 to the high potential terminal of a variable capacitor 85 which is shunted by a trimmer capacitor 87 and grounded. The grid is connected to a grid leak resistor 89 which is grounded.

Three inductors 91, 93, 95 comprise the inductance of the grid circuit. Of these inductors, the high potential terminal of the first inductor 91 is connected to the variable capacitor 85. The low potential terminal of the first inductor 91 is connected by means of a commutator 97 to an insulated movable blade 99 of the range switch 18. The second inductor 93 has its low potential terminal grounded and its high potential terminal connected to the contact 46 of the range switch. The third inductor 95 has its high potential terminal connected to the range switch contact 44. A trimmer capacitor 101 connects from the high potential terminal of this inductor 95 to ground. The low potential terminal of the third inductor 95 is connected to ground by tracking capacitor 103.

The anode circuit of the oscillator includes two inductors 105, 107. The first of these inductors 105 is connected to the anode 81 and to the positive terminal 42 of the B voltage source 127 through a radio frequency choke 109 and a filter network 115, 117 which will be described below. This inductor 105 is also mutually coupled to the first grid circuit inductor 91 and through a blocking capacitor 111 to the second anode inductor 107. The second anode inductor 107 is connected through the tracking capacitor 103 to ground. This common capacity 103 connection is also the feedback connection for the low frequency range of the oscillator. The second anode inductor 107 is mutually coupled to the second grid circuit inductor 93 for feedback at the medium frequency range.

On the low frequency range the grid circuit of the oscillator is tuned to the signal frequency plus the intermediate frequency, which may be 460 kilocycles by way of example. The grid circuit is comprised of the first and third inductors 91, 95, shunt trimmer capacitors 87, 101, the variable capacitor 85, and the series tracking capacitor 103. The feedback is primarily through the tracking capacitor 103 which is common to the grid and anode circuits. This common capacitor 103 increases the effective coupling as the frequency is decreased. The anode circuit is

composed of the two anode circuit inductors 105, 107 which are connected by the blocking capacitor 111. The mutual coupling between the first grid inductor 91 and the first anode inductor 105 tends to increase the feedback at the higher oscillator frequencies. The second anode inductor 107 increases the load in the anode circuit.

The oscillator for the medium or middle frequency range has a grid circuit which is composed of the first and second grid inductors 91, 93 and the variable and fixed capacitors 85, 87. The anode circuit is composed of the two anode inductors 105, 107. The second of these inductors is mutually coupled to the second grid inductor 93. It will be observed that the usual tracking capacitor is omitted. The omission of the tracking capacitor is possible because the effect of the radio frequency primary 41, which is tuned within the medium range, is to gradually decrease the resonant frequency of the detector input circuit as it is tuned to higher frequencies. Also the tuning of the detector input circuit becomes relatively broad, as the resonant frequency of the primary 41, which is highly damped with resistor 45, is approached. Therefore, the tracking is less critical in the region of the resonant frequency of the primary. This condition exists at the high frequency end of the detector input circuit. A similar condition obtains at the low frequency end of the radio frequency input circuit due to the resonant frequency of the antenna circuit. Thus by properly proportioning the inductors 15, 53, satisfactory tracking may be obtained without the use of series tracking capacitors. The omission of series capacitors permits a wide frequency range to be covered. The oscillator per se is made to oscillate at a frequency equal to the signal frequency plus the intermediate frequency. In this medium frequency range the third grid inductor 95 of the oscillator is short-circuited, by the connection of terminal 36 and arm 29 of range switch 18, to avoid undesired reactions.

It will be observed that the oscillator for the low and middle frequency ranges has been adjusted to operate at frequencies which are higher than the signal frequency by the amount of the intermediate frequency. It has been the practice by those skilled in the art to follow the same practice at the higher frequency ranges, for example, above six megacycles. Where the first detector and oscillator tubes are combined in a single envelope, the oscillator reacts in an anti-regenerative sense on the first detector when the oscillator frequency is higher than the detector frequency. This anti-regenerative effect or degeneration is probably due to some inherent capacity coupling or the like between the oscillator electrodes and the control grid electrode. In the presence of such capacity, if the oscillator circuit is tuned to a higher frequency than the signal, the control grid circuit will be a capacitive reactance and produce degenerative effects.

I have found that these effects, which greatly attenuate the incoming signal may not only be avoided but the incoming signal may be greatly amplified by making the control grid circuit inductive with respect to the tuned oscillator circuit. This is the proper condition for regenerative rather than degenerative effects. Under some conditions the first detector may tend to oscillate at the higher frequencies. A relatively low value of resistance serially connected to the control grid will overcome this tendency and still preserve the signal amplification.

The inductive effect is brought about by the simple expedient of tuning the oscillator to a frequency equal to the signal frequency minus the intermediate frequency in the high frequency range. The grid circuit of the oscillator in the high frequency range is composed of the first grid inductor 91, the trimmer capacitor 87, and the variable capacitor 85. The anode circuit is composed of the first anode inductor 105 which is mutually coupled to the first grid inductor. The junction between the blocking capacitor 111 and second anode inductor 107 is grounded in this range by the range switch 18.

Since the oscillator frequency on the high frequency range is maintained at a constant frequency below the radio frequency and detector input circuits, no series tracking capacitor is used in the oscillator. In place of the usual oscillator tracking capacitor, a series tracking capacitor 35 is employed in the radio frequency input circuit. This capacitor keeps the radio frequency input circuit at the required constant frequency above the oscillator frequency. A series tracking capacitor is not required in the detector input circuit because of the effect of the primary 41. This primary is resonant below the low frequency end of the high frequency range, and as its resonant frequency is approached, the primary reduces the rate of change of frequency of the detector input circuit. This effect is equivalent to the series tracking capacitor 35 in the radio frequency input circuit and is used to make the several circuits track properly.

It should be noted that the oscillator anode and screen grid are both connected to the same positive terminal of the power supply. The voltage to the screen grid is reduced by a series resistor 113. A second series resistor 115 and grounded capacitor 117 act as an effective audio frequency filter. If the potential of the positive source varies, the filter will greatly attenuate these variations which become most serious on the high frequency ranges. Moreover, the oscillator anode and the screen grid have opposing effects which tend to neutralize the effect of voltage variations and thereby prevent power supply ripple or "flutter". The term "flutter" is used to describe overall audio frequency fluctuations which are fed from the audio amplifier to the oscillator and repeated through the system. Because of the excellent filtering and comparative freedom of the oscillator anode and oscillator screen potential from audio frequency variations, I have found that this terminal 118 is a suitable junction for anode potential of the first audio amplifier.

In the diagram I have omitted a detailed showing of the heater circuits, and the automatic volume control circuits. These connections are indicated but are not completed. This omission simplifies the diagram. The output of the first detector and local oscillator may be fed to an intermediate frequency amplifier 119, and hence to a second detector and A. V. C. circuit 121. The output of the second detector may be amplified by an audio amplifier 123 and reproduced by a loudspeaker 125. A power source 127 for the system may be batteries, alternating current, which may be rectified and filtered, or the like. I have mentioned the terms high, medium or middle, and low frequency ranges, which may cover, respectively, the following ranges: 6 to 18 megacycles, 1.6 to 6 megacycles and 540 to 1000 kilocycles.

It should be noted that the variable capacitors

25, 59, 85 are connected to a single control. Each of these variable capacitors is shunted by trimmer capacitors which align the tunable circuits in the high and medium frequency ranges. The use of a single trimmer for the two ranges is effected by choosing inductors which are carefully held to the proper values of inductance and distributed capacity. Additional trimmer capacitors are preferred in the low range as it would be difficult and expensive to manufacture the inductors of larger value to the exactness required if trimmers were to be omitted.

I have described a radio receiving system which effectively covers three ranges of frequencies, and in which the antenna is effectively coupled on all frequency ranges. The oscillator has been made to overcome serious degenerative effects by substituting a regenerative gain for the degenerative loss. The circuit connections and filter arrangements prevent fluttering. Numerous modifications within the scope of my invention will occur to those skilled in the art. It should be understood that I do not intend to limit my invention except as required by the prior art and the appended claims.

I claim as my invention:

1. In a device of the character described, a local oscillator including a thermionic tube having cathode, grid, oscillator anode, control grid, screen grid and anode electrodes; an intermediate amplifier, a detector and an audio amplifier; a source of power subject to variations initiated through said amplifiers by a change in the frequency of said oscillator, connections from said source to said local oscillator and said intermediate and said audio amplifiers; a filter for audio frequency currents connected between said source of power and said oscillator anode and screen grid electrodes, so that oscillations due to the effect of changing frequency on the source of power and the source of power on the frequency are prevented.

2. In a superheterodyne receiver, a thermionic local oscillator having cathode, oscillator anode, and screen grid electrodes, an audio amplifier, a source of direct current potential subject to load variations, connections from said source to said audio amplifier, connections including a common resistor from said oscillator anode and said screen grid electrodes to said source, a capacitor effectively connected across said resistor whereby variations in said source potential initiated by changes in said oscillator frequency cause variations in screen grid current through said common resistor which tend to oppose changes in potential on said oscillator anode, and thus to oppose said frequency changes.

3. In a superheterodyne receiver, a thermionic local oscillator having cathode, oscillator anode and screen grid electrodes, a radio frequency amplifier tube having a screen grid electrode, a source of direct current potential subject to load variations, connections including a first and a second resistor between said source and said oscillator and amplifier screen grid electrodes, connections including said first resistor between said oscillator anode electrode and said source, and a capacitor effectively connected across said first resistor, whereby variations in said source potential cause variations in the total screen grid current through said common resistor which tend to oppose changes in potential on said oscillator anode.

4. In a superheterodyne receiver having a local oscillator which employs a screen grid electrode, the method of reducing flutter which is caused by the reaction of changing direct current potentials on the frequency of said local oscillator which includes the steps of filtering the direct current potential to partially remove said variations, and applying a compensating potential to said screen grid electrode whose reaction on the frequency of said oscillator is equal in degree but opposite in sense to the normal reaction of said frequency to changes in said direct current potential.

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