

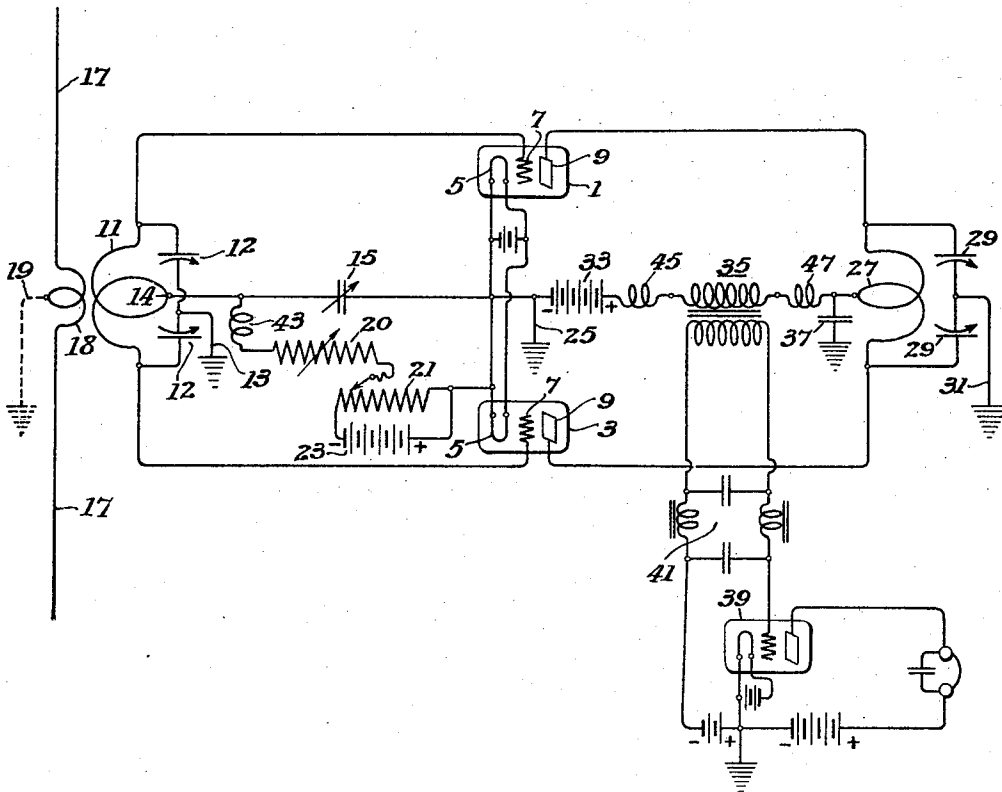
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RADIO APPARATUS

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RADIO APPARATUS

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My invention relates to radio apparatus and it has particular relation to apparatus for the reception of radio signals at ultra-high frequencies.

Considerable difficulty, heretofore, has been experienced in receiving radio signals at ultra-high frequencies by reason of the generation, in the receiving apparatus, of parasitic local oscillations at the frequency determined by intentional tuning and at other frequencies. Ultra-high frequency receivers, as heretofore constructed, being more or less asymmetrical with respect to ground, have also required extensive shielding to prevent their being disturbed by the capacity to ground of nearby objects or by the hand of the receiving operator.

In short, the reception of radio signals at frequencies above 35 megacycles has been attended by so many difficulties that it has, commercially, heretofore been impracticable.

It is, accordingly, an object of my invention to provide apparatus particularly adapted to the reception of radio signals at ultra-high frequencies.

Another object of my invention is to provide a radio receiver, of the aforementioned type, wherein the effect of parasitic local oscillations is negligible.

An additional object of my invention is to provide a radio receiver that shall be substantially immune to detuning by reason of the capacity to ground of nearby objects.

A still further, and more specific, object of my invention, is to provide a radio receiver that shall require minimum shielding.

The foregoing objects and other objects appertenant thereto, I accomplish, broadly, by providing a receiving system wherein the circuits carrying radio frequency currents are symmetrical with respect to ground and I purposely maintain the system strongly oscillating at a frequency of the order of that of an incoming signal whereby parasitic oscillations are ineffective to impair signal reception. In addition, I provide means whereby the generated oscillations are prevented, periodically, from attaining too great an amplitude and I so interconnect and dispose the component parts of my improved

receiver that the thermionic devices constituting the oscillation generator also serve, in parallel, as demodulators.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment, when read in connection with the accompanying drawing.

The single figure of the drawing is a diagrammatic view of a radio receiver embodying my invention.

Referring specifically to the drawing, a radio receiver, comprising a preferred embodiment of my invention, includes a plurality of thermionic devices 1 and 3, which may be of the three-electrode type, each having a cathode 5, a grid 7, and a plate 9.

The several thermionic devices are disposed in push-pull relation insofar as their input and output circuits, carrying currents at radio frequencies, are concerned. In other words, the devices are provided with a common input circuit constituted by an inductor 11 having a plurality of serially connected, simultaneously adjustable, condensers 12 disposed in shunt thereto, the terminals of the said inductor being connected to the grids, respectively, of the said thermionic devices. The rotors of the tuning condensers are provided with a ground connection 13, whereby the input circuit is rendered electrically symmetrical with respect to ground.

An intermediate point 14 on the input inductor is connected, through a grid condenser 15, common to both thermionic devices, to the cathode circuit of the tubes. The grid condenser, though desirable for vernier control, is not an essential element.

A preferred antenna system is constituted by two straight wires 17 that extend in opposite directions from the ends of a coupling coil 18 disposed within the inductor 11. The overall length of the antenna is not critical. For best results at any given frequency, however, it is desirable that a current loop be

established at the mid-point of the coil 18. The mid-point of the coil may or may not be provided with a ground connection 19.

Biassing potential for the tubes is supplied over an adjustable grid leak 20, one terminal of which is connected to the intermediate point 14 on the input inductor, and the other terminal of which may be connected to the movable arm of a potentiometer 21 disposed in shunt relation to a grid biasing battery 23, or the said terminal may be connected directly to the negative pole of the said battery, if desired.

The cathodes of the thermionic tubes are provided with a common ground connection 25.

The radio frequency output circuit of my improved system is constituted by an inductor 27 shunted by a plurality of tuning condensers 29 connected in series, the rotors of which are provided with a ground connection 31 to render the circuit electrically symmetrical.

The input and output circuits may, without departing from the spirit of my invention, take other forms most suited to the frequencies it is desired to receive. For example, at extremely high frequencies the tuning condensers 12 and 29 may be omitted and tuning may be accomplished by symmetrically varying the inductance of each of the coils 11 and 27, in any convenient way.

Plate potential for the tubes is supplied over a circuit including a plate potential source 33 and the primary winding of an audio frequency output transformer 35, it being understood, of course, that any other suitable coupling element, such as a resistor or a choke-coil, may be substituted for the said transformer.

Preferably, the point upon the output inductor, to which is connected the conductor supplying plate potential, is located at the electrical center of the inductor.

A by-pass condenser 37 is connected in shunt to the plate potential source and the primary winding of the audio frequency transformer.

The terminals of the secondary winding of the audio frequency transformer are connected, respectively, to the grid and cathode of an audio frequency amplifier tube 39, in the output circuit of which may be disposed a telephone head-set, the primary winding of an audio frequency transformer (not shown), or some other well-known coupling device, if further stages of amplification are to be used.

A filter 41 is, preferably, interposed between the secondary winding of the audio frequency transformer and the input terminals of the audio frequency amplifying tube, for a purpose that, hereinafter, will be referred to again. In order to improve the

stability of the system those portions thereof that, presumably, do not carry currents at radio frequencies may be isolated by suitable choke-coils such as the coils 43, 45 and 47 shown in the drawing.

In the operation of my improved receiving system, the radio frequency input and output circuits of the push-pull stage are adjusted to substantial syntony with the frequency of an incoming carrier-wave. In such event, the system oscillates vigorously and the several tubes in the push-pull stage draw a considerable amount of grid current. The grid current drawn by the tubes causes the grid condenser 15 to acquire a negative charge which tends to stop the oscillations, or to materially reduce their amplitude.

If the system is permitted to oscillate freely, signal reception, except of continuous waves, is impeded. I, therefore, so adjust the grid biasing potential by movement of the potentiometer arm, by varying the magnitude of the grid leak 20, or by altering the capacity of the grid condenser 15, that the charge acquired by the said condenser shall leak off at a definite rate.

By adjustment of the grid condenser or the grid leak, or both, the leakage of the charge may be rendered discontinuous and may be given any desired periodicity from a succession of pulses at a rate of one or two per second, up to a frequency far beyond the limits of audibility.

When the rate of leakage is properly correlated to the carrier-wave frequency of an incoming signal, the system exhibits very remarkable sensitivity, insofar as signal reception is concerned, yet it is substantially immune to "hand capacity" effects.

Although the scope of my invention is not to be restricted by any theory of operation advanced herein, it is my present belief that the sensitivity may well be ascribed to the fact that the system has negative resistance, at least periodically, and that the signal builds up during these periods of negative resistance until it is of such amplitude that it is rectified by the thermionic tubes 1 and 3 functioning in parallel. The periodicity of the negative resistance is introduced by the blocking action of the common grid condenser 15 and grid leak 20, or by the action of the grid leak 20, if the grid condenser is omitted, and is influenced by the plate-circuit impedance.

At any rate, the system behaves as though the several thermionic tubes function in parallel to demodulate an incoming signal, since the demodulated signal appears in the primary winding of the audio frequency transformer over which plate potential is supplied to the tubes.

As opposed to the theory outlined above, it is noted that when the variation frequency is brought into the region of audibility, it seems to be present with substantially unvarying

amplitude in the output circuit, irrespective of the amplitude of the demodulated signal, provided the filter 41 is omitted. It is highly probable, therefore, that certain additional phenomena are present during signal reception, the character of which I have not yet definitely determined.

In a commercial receiver constructed according to my invention, the three thermionic tubes are of the type known as Radiotron 230, operating at a filament potential of two volts. The potential supplied by the biasing battery is substantially nine volts and the plate potential found best is in the neighborhood of 135 volts. The variable grid leak 20 has a resistance of the order of 150,000 ohms or more and the common grid condenser has a capacity of the order of substantially .00025 microfarad. The input and output inductors, for the satisfactory reception of signals at frequencies of the order of 75 megacycles, each have an inductance equivalent to that of a coil comprising three or four turns of No. 8 B & S gauge wire wound upon a form 1½" in diameter, the turns being spaced apart ⅜", and the four simultaneously adjustable tuning condensers each have a maximum capacity of 35 to 50 micromicrofarads.

It should be clearly understood that tubes of the three-electrode type have been chosen merely for purposes of illustration and that my invention is not restricted to their specific use. It should also be apparent that I may utilize individual grid condensers and grid leaks, either fixed or adjustable, in lieu of the common grid-condenser 16 and grid leak 20 shown. In the latter event, the input inductor may or may not be provided with a connection to ground to establish an electrical center.

I wish also to point out that, in case individual grid condensers and grid leaks are employed, the grid leaks may either be connected in shunt to the respective grid condensers, or they may be connected in series across the grid terminals of the several tubes. When disposed directly across the grid terminals, the junction point of the grid leaks is, preferably, connected to the negative terminal of the grid biasing source through a variable resistor and, for micro adjustment, a variable condenser may be connected in shunt to both the said variable resistor and the said source.

By reason of the fact that, when the grid leaks are disposed in shunt relation to the input inductor, they exert a damping effect, this arrangement oscillates less readily than the circuit first described, and is not considered by me to be especially suitable for ultra-high frequencies. It does, however, give quite good results for frequencies of the order of 10 megacycles, and lower.

It is interesting to note that my improved receiving system is reversible. In other words, it is equally as well adapted to the

transmission of signals, at ultra high frequencies, as the reception thereof and lends itself admirably to duplex operation.

In the event that it is desired to transmit signals the transformer 35 may be replaced by another suitable transformer, or by a choke-coil and plate potential is supplied thereover to the tubes 1 and 3 and to a modulator tube.

If portability is essential the entire system may be housed in a metal box to which one end of the coil 18 is connected. Signal radiation may be had by disposing one end of a small exterior antenna in capacitive relation to the box, the other end extending into the interior thereof and being connected to the otherwise free end of the coil 18. The radiating system is then complete and is in effect a dipole, one side of which is the metal box, the other side being the extending wire.

The variation frequency, during use of the system as a transmitter, may be prevented from being developed by reducing the resistance of the leak resistor 20 to such a value that the tubes 1 and 3 do not block.

Inasmuch as it will be obvious, to those skilled in the art, how to interconnect the various elements of my improved systems through change-over switches and the like, whereby duplex operation may be had either by utilizing the tube 39 as a modulator or by the use of a separate modulating device, it is not necessary to complicate the drawing by the addition thereto of further details.

Although I have illustrated a specific embodiment of my invention, and have described certain variants thereof, numerous other modifications will be apparent to those skilled in the art. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. The method of modulated carrier wave reception which includes deriving a plurality of unidirectional components from a modulated carrier wave, generating oscillations, conjointly utilizing said components to modify said oscillations at a predetermined periodicity correlated to the frequency of the carrier wave, and demodulating said modified oscillations.

2. The method of modulated carrier wave reception which includes generating oscillations, causing the amplitude of said oscillations to be periodically limited at a rate correlated to the frequency of the carrier wave, deriving a plurality of discrete components from said carrier wave, further modifying said oscillations by the conjoint action of said components, and demodulating said modified oscillations.

3. The method of intelligence-reception by the use of a plurality of thermionic tubes disposed in balanced relation, which includes

causing said tubes to generate oscillations at a frequency of the order of that of a desired signal, causing the amplitude of said oscillations to be limited periodically, utilizing a
 5 signal wave to further modify said oscillations, and demodulating said modified oscillations by said tubes to produce audible signal-indications.

4. The method of intelligence-reception
 10 through the use of a plurality of thermionic tubes disposed in balanced relation and having common input and output circuits which includes causing said tubes to generate oscillations, impressing a modulated signal wave
 15 upon said input circuit, and utilizing currents at audio-frequency appearing in said output circuit for the production of signal-indications.

5. The method of eliminating "hand-capacity" effect upon a signal-receiving system including a plurality of thermionic tubes disposed in balanced relation, which comprises maintaining the system in oscillation at a frequency of the order of that of a desired signal wave and adjusting the rate of
 25 grid leakage of said tubes to periodically limit the amplitude of the oscillations at a rate correlated to the oscillation frequency.

6. In a signal receiving apparatus, a plurality of thermionic tubes disposed in balanced relation, means for impressing a carrier wave thereon in balanced relation, means whereby said tubes may be caused to generate oscillations, and means providing a discontinuous grid leakage from the tubes, said
 35 means being adjustable for periodically limiting the amplitude of the generated oscillations at a rate correlated to the frequency of the impressed carrier wave.

7. In a signal receiving apparatus, a plurality of thermionic tubes disposed in balanced relation, means enabling said tubes to generate oscillations, means for impressing a modulated signal wave on said tubes in balanced relation, and means providing a discontinuous grid leakage from the tubes, said
 45 means being common to said tubes and being adjustable within a predetermined range for periodically limiting the amplitude of said oscillations at a rate correlated to the frequency of the impressed signal wave.

8. In a signal receiving apparatus, a pair of balanced thermionic tubes having a common tunable input circuit and a common tunable output circuit, said circuits being electrically symmetrical about an element common thereto whereby tuning of said circuits to approximate syntony causes the generation of oscillations, a source of biasing potential and a variable high resistance connected in the common input circuit, and an audio frequency coupling element connected in said common output circuit.

9. The method of modulated carrier wave
 55 reception, through the use of a plurality of

thermionic tubes disposed in balanced relation and having common input and output circuits, which includes causing said tubes to generate oscillations, causing said oscillations to be limited periodically at a rate correlated to the carrier wave frequency, impressing a modulated signal wave upon said input circuit, and utilizing currents at audio-frequency appearing in said output circuit for the production of signal-indications.

In testimony whereof, I have hereunto subscribed my name this 9th day of January, 1931.

CARLETON D. HAIGIS.