Dec. 27, 1938. R. W. GEORGE ET AL. 2,141,242

ULTRA SHORT WAVE SYSTEM

Filed March 26, 1935

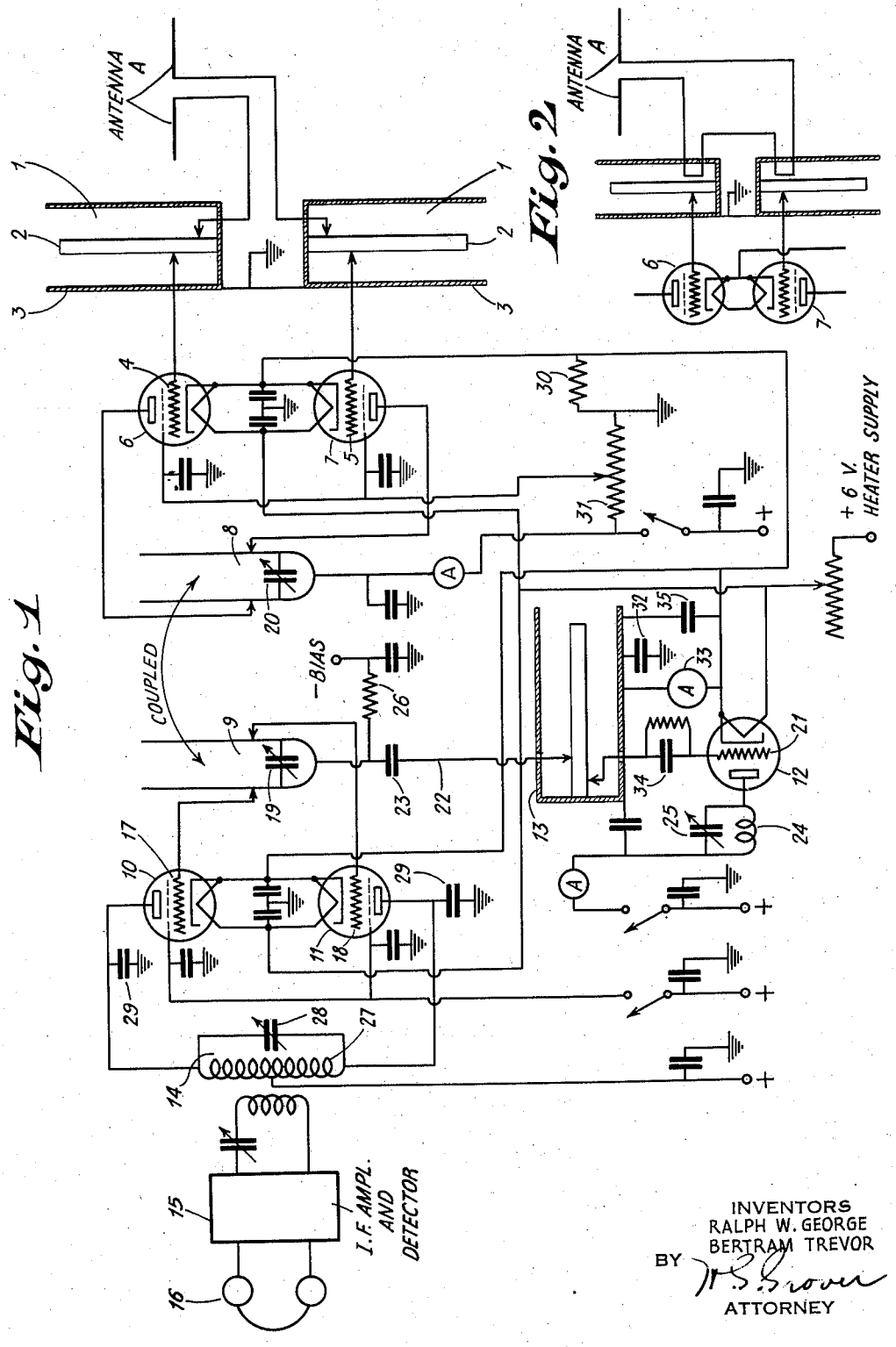

Fig. 1

Fig. 2

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Patented Dec. 27, 1938

2,141,242

UNITED STATES PATENT OFFICE

2,141,242

ULTRA SHORT WAVE SYSTEM

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Application March 26, 1935, Serial No. 13,038

19 Claims. (Cl. 250—20)

This invention relates to improvements in ultra high frequency systems, particularly in systems for receiving ultra high frequency oscillations.

An object of the present invention is to provide a very simple and highly efficient high frequency system capable of receiving ultra short waves of the order of one meter and less.

A further object is to provide a heterodyne short wave receiving system capable of utilizing with high efficiency multi-electrode electron discharge devices of the "acorn" type and other very small thermionic tubes.

Another object is to provide an ultra high frequency system wherein there is obtained efficient coupling between stages and other elements of the circuit.

A further object is to provide an ultra short wave receiver which has high frequency stability comparable with crystal control but which dispenses with the use of piezo electric crystals.

In the preferred embodiment of the invention there are employed tunable, low loss concentric transmission line resonators, both for controlling the frequency of the local heterodyne oscillator and for coupling, respectively, the oscillator and the antenna with the detector and radio frequency amplifier tubes.

It is known that a properly designed transmission line having uniformly distributed inductance has low losses and may be used to maintain the frequency of oscillations generated by an electron discharge device system to a high degree of constancy. The line, in effect, acts like a sharply tuned circuit whose reactance changes rapidly with change in frequency. In such a concentric line it is the projection of the inner conductor upon the outer conductor which determines the length of the line.

It is now proposed, in accordance with one feature of the invention, to imploy the line not only for controlling the frequency of the oscillator but also for coupling the oscillator to a stage of the system, such as the detector. To effect this result there is provided an adjustable tap from the inner conductor of the line to the input circuit of the detector.

According to another feature of the invention, two such concentric lines are used for coupling one symmetrical circuit to another symmetrical circuit; in this case, a dipole antenna is coupled to the grids of a pair of push-pull connected radio frequency amplifier tubes, the coupling being accomplished by taps which are adjustably movable over the outer surface of the inner conductor.

A further feature lies in the use of two tunable, open-ended, U-shaped resonators (hairpin type) which couple together two stages of the receiver; namely, the push-pull radio frequency amplifier and the push-pull connected detector tubes.

It is to be understood that while these and other features are herein described with special reference to receiving systems, they are not limited to use therein, since they are equally applicable to transmitting systems and other high frequency arrangements.

Other objects and features, and their advantages will appear from a reading of the following detailed description taken in conjunction with the accompanying drawing, wherein Fig. 1 illustrates a complete ultra high frequency receiving system embodying the principles of the invention, and Fig. 2 illustrates a modification of the method of coupling two symmetrical circuits by means of two concentric transmission lines.

Referring to Fig 1, there is shown an ultra high frequency heterodyne receiving system comprising, broadly, an antenna A, which is coupled through a pair of tunable, low loss, concentric transmission line resonators 1, 1 to the grids 4, 5 of a pair of push-pull connected radio frequency amplifier tubes 6, 7 whose output is coupled via tunable, open-ended, U-shaped resonators 8, 9 to the push-pull connected detector tubes 10, 11 A local heterodyne oscillator 12, whose frequency is stabilized by a low loss, concentric line resonator 13, supplies the locally generated oscillations to the detector tubes 10, 11 in parallel, and intermediate frequency energy produced in the detector tubes is resonated in the output circuit 14, tuned to this frequency, from which the energy is supplied to any suitable intermediate frequency amplifier-detector circuit 15 and utilized in a recording device, such as the headphones 16.

Concentric transmission lines 1, 1 comprise two tunable quarter-wave length resonators, each consisting of an inner conductor 2 and an outer conductor 3 coupled conductively together at one end and electrically open at their other end, the coupled ends of the two resonators being adjacent each other and connected to a surface of fixed alternating potential, such as ground, as shown. Although the two lines are shown placed end to end, it will be appreciated that this is merely for convenience, since they can be placed side by side or in any desired relative position. Such a line is characterized by a high reciprocal of power factor, i. e., low loss, and has the

advantages of ease of control and stability over conventional coil and condenser resonating circuits for ultra high frequencies. Balanced antenna A is loosely coupled directly, or inductively (Fig. 2), if desired, or capacitively, to the respective grids 4, 5 of radio frequency amplifier tubes 6, 7, by way of adjustable taps over the inner conductors 2, 2 of the lines 1, 1, at suitable points of low impedance.

Concentric lines 1, 1 and line 13 are here each chosen to be a quarter wave length long, electrically, for reasons of reliability and simplicity but it is to be understood that the length is immaterial to the practice of the invention, since a relatively long transmission line capable of accommodating a plurality of wave lengths may be used. It is preferred to utilize a concentric line of the type disclosed in United States application Serial No. 1,489, filed January 12, 1935, Patent No. 2,108,895, dated February 22, 1938, and United States Patent No. 2,077,800, granted April 20, 1937, both by Fred H. Kroger, wherein the effective length of the line remains constant irrespective of temperature fluctuations. Tuning of the concentric line resonators is accomplished by varying the length of the inner conductors since it is the profile or projection of the inner upon the outer conductor which determines the length of the line. This tuning may be effected either in the manner described by Kroger in his Patent No. 2,108,895, supra, wherein a micrometer screw adjustment at the open end of the inner conductor effectively lengthens or shortens the inner conductor, or by moving a short plug at the open end of the line by means of a shaft extending back through the inner conductor to a fine thread screw and knob arrangement, similar in action to a micrometer. The concentric line resonators, as well as the open-ended U-shaped resonators, and their respective tap clips are preferably gold plated to eliminate corrosion and improve their electrical characteristics.

Self bias for the radio frequency amplifier tubes 6, 7 is obtained by passing the heater current to all the tubes 6, 7, 10, 11, and 12 through the radio frequency bias resistor 30. The gain of the radio frequency amplifier stage is controlled by the screen grid potentiometer 31.

The output circuit of amplifiers 6, 7 comprises a long hairpin or U-shaped line resonator 8 connected to the anodes of tubes 6, 7 which resonator is inductively coupled to a similar hairpin resonator 9, the latter being in circuit with the respective grids 17, 18 of detector tubes 10 and 11. Hairpin resonators 8, 9 have legs which are each substantially a quarter wave length long. These resonators have been found to possess the advantage of enabling a better balance to be had in push-pull circuits. The anode connections from amplifier tubes 6, 7 and the grid connections from detector tubes 10 and 11, are adjustable over the lengths of the legs of the respective hairpin resonators 8, 9. Tuning is effected over a limited range by means of condensers 19 and 20, each of which in practice comprises two small condenser plates clamped directly to the two sides of the hairpin and near the voltage nodal point at its center. Because of the tuning condensers and the capacity loading from the tubes connected to the legs of the hairpin, the legs are made physically less than a quarter wave long although electrically the device acts like a quarter wave length resonator.

High frequency oscillator 12 is frequency stabilized by frequency control line resonator 13 connected to the grid 21 of the oscillator by way of the inner conductor of the line. A tap on this inner conductor feeds the heterodyne oscillations to the grids 17 and 18 of the detector tubes 10 and 11 in parallel, by means of connection 22 which extends from a point of suitable low impedance on line 13 through coupling condenser 23 to the voltage nodal point of hairpin 9. In the anode circuit of heterodyne oscillator 12 there is provided a coil 24 which is adjusted to tune the anode circuit of the oscillator and may, if desired, have a variable capacitance 25 across it for tuning purposes. It has been observed, however, that tuning over a considerable frequency range may be had by tuning only in the grid circuit of the oscillator 12 and having a fixed tuning in the anode circuit. By-pass condenser 32 serves to ground the outer conductor of line 13 without short circuiting the radio frequency bias resistor 30. A more conventional method, of course, would be to ground the outer conductor of concentric line 13 to the cathode and insert the grid current meter A—33 in series with the grid leak and cathode. The method illustrated, however, is preferred since it has the electrical advantage of not loading line 13 with the resistance of the grid leak.

Suitable bias for the detector tubes 10 and 11 is supplied through resistance 26 by the source of energy labeled "—Bias". In the output circuit of detector tubes 10 and 11 are coil 27 and tunable capacity 28 for tuning the anode circuits to the intermediate frequency produced in the detector tubes by beating the received signal collected by antenna A and amplified by radio frequency amplifiers 6, 7 with the oscillations generated by local oscillator 12. Radio frequency by-pass condensers 29, 29 connected to the respective anodes of detector tubes 10 and 11 comprise part of the tuning capacity for the tuned circuit 14. In order to obtain zero ground lead inductance and prevent the radio frequency condensers from adding inductance to the by-pass circuit, it is proposed, in practice, to clamp a separate plate in contact with the grounded panel of the receiver and adjacent to the dielectric and opposite the ungrounded plate.

The intermediate frequency amplifier and detector circuit shown in box 15 will not be described herein since any conventional, well known amplifier, demodulator and audio frequency means may be employed.

It is preferred to employ, in the receiver, vacuum tubes of very small size of the type known as the "acorn" or midget type, wherein the inter-lead capacity and the inductance of the leads are considerably less than the conventional type. Such tubes are adequately described in the co-pending application of Bernard Salzberg, Serial No. 732,028, filed June 23, 1934, Patent No. 2,030,187, dated February 11, 1936, to which reference is herein made for a complete description thereof.

In one receiver successfully used in practice, the intermediate frequency employed was five megacycles and the receiver covered a signal frequency range of approximately 68 to 78 centimeters. These figures, it is to be distinctly understood, are merely illustrative and not to be taken as limiting the invention. Obviously the use of a much higher intermediate frequency is desirable.

Fig. 2 illustrates a manner of coupling antenna A inductively to the two concentric lines 1, 1 instead of conductively, as shown in Fig. 1.

The features of the invention illustrated and

described have been selected for the purpose of clearly setting forth the principles involved. It will be apparent therefore that the structure set forth is entirely illustrative and not definitive, it being susceptible of modification to meet different conditions encountered in its use, without departing from the spirit and scope of the invention. As an illustration, the two hairpin resonators may be replaced with a pair of concentric line resonators similar to those in the radio frequency circuit using inductive or capacitive coupling or combinations of either with conductive coupling.

What is claimed is:

1. In combination, a resonant concentric transmission line having coupled inner and outer coaxial conductors devoid of concentrated reactance, input and output high frequency circuits, and individual connections from points intermediate the ends of said inner conductor to said circuits.

2. In combination, a resonant concentric transmission line effectively one-quarter wave length long at the operating frequency and having coupled inner and outer coaxial conductors devoid of concentrated reactance, input and output high frequency circuits, and individual connections extending from points of low impedance on said inner conductor intermediate the ends thereof to said circuits.

3. In combination, a first resonant concentric transmission line having inner and outer coaxial conductors coupled together at one end, and a second similar resonant concentric line, the outer coaxial conductors of both said transmission lines being coupled together, an input circuit and an output circuit, a connection from a point intermediate the ends of each inner conductor of said two concentric lines to said input circuit, and a connection from each inner conductor to said output circuit.

4. Apparatus in accordance with claim 3, characterized in this that said connections from said inner conductors to at least one of said circuits comprise a reactive coupling.

5. In combination, a first resonant concentric transmission line having inner and outer coaxial conductors coupled together at one end, and a second similar resonant concentric line, the outer coaxial conductors of both said transmission lines being coupled together, an input circuit and an output circuit, a connection from a point intermediate the ends of each inner conductor of said two concentric lines to said input circuit, and a connection from each inner conductor to said output circuit, said connections from said inner conductor to at least one of said circuits comprising an inductive coupling.

6. In combination, a first resonant concentric transmission line having inner and outer coaxial conductors coupled together at one end, and a second similar resonant concentric line, the coupled ends of both said transmission lines being substantially placed end to end, a connection from ground to said outer conductors, balanced symmetrical input and output circuits, and individual connections from points of low impedance on each inner conductor, intermediate the ends thereof, to said input and output circuits.

7. A system in accordance with claim 6, characterized in this that said balanced input circuit is a dipole antenna and said output circuit comprises a pair of push-pull connected electron discharge devices.

8. In a high frequency communication system, a U-shaped tuned circuit comprising a pair of conductors open at one of their adjacent ends and connected together at the other of their adjacent ends, a condenser bridging the trough of said U-shaped tuned circuit, said condenser being located between said trough and a plane passing transversely through the centers of the conductors of said U, high frequency apparatus, and individual connections from a point on each conductor of said pair intermediate the open end thereof and said trough to said high frequency apparatus.

9. In a high frequency communication system, a U-shaped tuned circuit comprising a pair of wires open at one of their adjacent ends and connected together at the other of their adjacent ends, a condenser bridging the trough of said U, another similarly connected U-shaped tuned circuit, said two U-shaped tuned circuits being electromagnetically coupled together, an input circuit and an output circuit, individual connections from each wire of one of said tuned circuits, intermediate the ends thereof, to said input circuit, and individual connections from each wire of said other tuned circuit, intermediate the ends thereof, to said output circuit.

10. A system in accordance with claim 9, characterized in this that said input and output circuits each comprise a pair of push-pull connected electron discharge devices, said connections to said input circuit extending to the control grids of one pair of said devices, and said connections to said output circuit extending to the anodes of said other pair of electron discharge devices.

11. In an ultra high frequency radio receiver, a pair of push-pull amplifier electron discharge devices, and a pair of push-pull detector electron discharge devices, the output of said amplifier devices being coupled to the input of said detector devices, said output and input each including a U-shaped tuned circuit composed of a pair of substantially parallel wires directly and conductively coupled together at one of their adjacent ends, open ended at their other ends and having a condenser connected across said wires, energy supply means connected to the voltage nodal point of each U-shaped tuned circuit, and connections from the wires of said U-shaped tuned circuits, intermediate the ends thereof, to said electron discharge devices.

12. In an ultra high frequency radio receiver, a pair of push-pull amplifier electron discharge devices, and a pair of push-pull detector electron discharge devices, the output of said amplifier devices being coupled to the input of said detector devices, said output and input each including a U-shaped tuned circuit composed of a pair of substantially parallel wires coupled together at one of their adjacent ends, open ended at their other ends and having a condenser connected across said wires, a connection from each wire of said U-shaped tuned circuit to its associated circuit, means for supplying a positive potential to the voltage nodal point of the U-shaped tuned circuit associated with the output of said amplifiers, and means for supplying a negative potential together with high frequency oscillations to the voltage nodal point of the U-shaped tuned circuit associated with the input of said detectors.

13. A system in accordance with claim 12, characterized in this that said last means includes a local heterodyne oscillator provided with a frequency control concentric transmission line having inner and outer coaxial conductors coupled together at one end, and an adjustable tap con-

necting said inner conductor from a point of suitable low impedance to the voltage nodal point of the U-shaped tuned circuit of said detectors.

14. An ultra high frequency radio receiver comprising a dipole antenna, a first concentric transmission line having inner and outer coaxial conductors coupled together at one end, and a second similar concentric line, the coupled ends of both said transmission lines being placed adjacent each other, a connection from ground to said outer conductors, a pair of electron discharge device amplifiers each having a control grid and an anode, a connection from one of said control grids to an inner conductor of one of said lines, and a connection from the other control grid to the inner conductor of said other line, and similar connections from the arms of said dipole to said inner conductors, an output circuit connected to the anodes of said amplifiers, a pair of push-pull connected electron discharge device detectors having an input circuit, said output and input circuits being coupled together and each including a U-shaped tuned circuit composed of a pair of substantially parallel wires directly and conductively coupled together at one of their adjacent ends and a tunable condenser connected across said wires, and a connection from each wire of said U-shaped tuned circuit to its associated circuit, means for supplying a positive potential to the voltage nodal point of the U-shaped tuned circuit associated with the output of said amplifiers and means for supplying a negative potential together with high frequency oscillations to the voltage nodal point of the U-shaped tuned circuit associated with the input of said detectors.

15. In an ultra short wave heterodyne receiver, an energy collector, an amplifier for the collected energy, a detector comprising a pair of electron discharge devices, an input circuit for said detector comprising a U-shaped tuned circuit, a heterodyne oscillator, a resonant concentric transmission line for controlling the frequency of said oscillator, and means for connecting said concentric line controlled oscillator in parallel and said amplifier in phase opposition with respect to the legs of said U-shaped tuned input circuit.

16. In combination, a resonant concentric transmission line having coupled inner and outer coaxial conductors, input and output high frequency circuits, and individual connections conductively connecting said inner conductor, intermediate the ends thereof, to said circuits.

17. In combination, in an ultra short wave system, a tuned circuit including an open ended U-shaped conductor having an over-all length substantially one-half wave length long, said U-shaped conductor comprising a pair of parallel wires connected together at one of their adjacent ends and open at their other ends, a pair of push-pull connected electron discharge devices each having a grid, cathode and anode, connections extending from said anodes to points on said conductor on opposite sides of the center of said conductor and intermediate the ends thereof, a connection from said center to said cathodes, and circuits respectively coupling together said grids and cathodes.

18. In combination, a resonant concentric transmission line having inner and outer concentric coaxial conductors devoid of concentrated reactance coupled together at one of their adjacent ends and open ended at their other adjacent ends, an electron discharge device oscillator having an anode, cathode and grid, a connection from said inner conductor to said grid, a grid leak circuit comprising a condenser shunted by a resistance in said connection, and a tuned circuit comprising an inductance coil connecting said anode and said outer conductor, and means for capacitively coupling said cathode to said outer conductor whereby said electron discharge device oscillator is frequency stabilized by said concentric line.

19. In combination, a first resonant concentric transmission line having inner and outer coaxial conductors, means devoid of concentrated inductance for coupling said conductors together at one end, and a second similar resonant concentric line, the outer coaxial conductors of both said transmission lines being coupled together, an input circuit and an ouput circuit, a connection from each inner conductor of said two concentric lines to said input circuit, and a connection from each inner conductor to said output circuit.

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