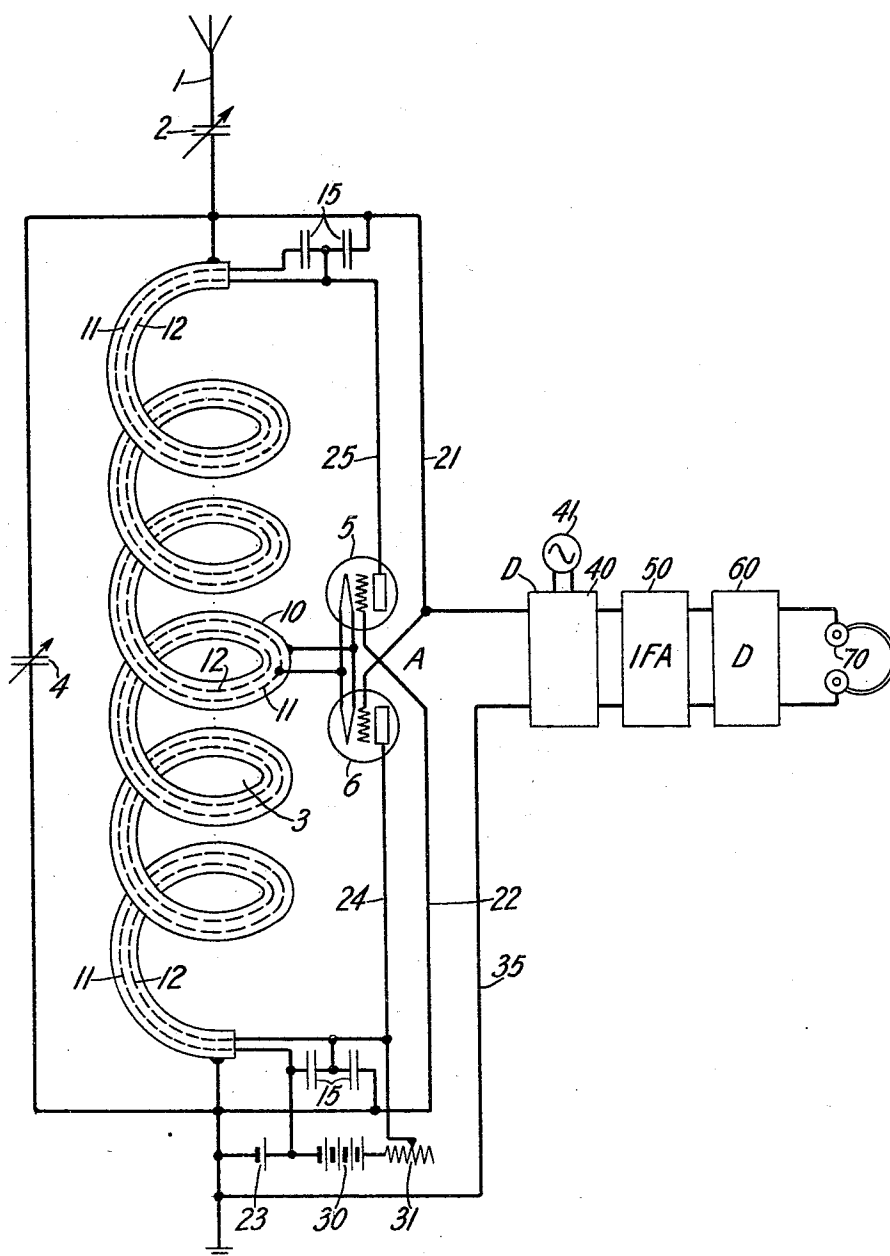


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WAVE AMPLIFYING SYSTEM
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WAVE AMPLIFYING SYSTEM

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This invention relates to electric wave transmission, and especially to systems for amplifying electric waves, as for example short waves used in radio telephony.

5 In a successive detection radio receiver embodying the invention, a push-pull Hartley oscillator type of circuit adjusted to a non-oscillatory condition is employed as a regenerative short wave amplifier having, as the
10 inductance of its tuned circuit, a coil inserted between the antenna and ground to reduce the apparent antenna resistance. The middle of the coil is connected to the amplifier filaments, the grounded end of the coil is connected to
15 the grid of one of the amplifier tubes and to the plate of the other, and the other end of the coil is connected to the other grid and to the other plate of the amplifier. The coil is also
20 included in the grid-filament circuit of the first detector, to deliver signaling waves to the detector. The coil comprises three strands insulated from each other for direct current, but forming a single inductance for high frequency. The strands afford D. C. paths, of
25 proper impedance to high frequency, for supplying the amplifier filaments with heating current from a grounded filament battery, for inductively connecting the grid of each tube of the amplifier to the filament of the tube,
30 and for supplying space current to the tubes of the amplifier.

The amplifier in the antenna circuit is made to produce large amplification of the signaling voltage. It has been found that, where
35 the total amplification of the system is very great, the ratio of the volume of the signal received at the output of the system to the volume of the received tube noise is increased by increasing the proportion of the total amplification which is obtained at the frequency
40 of the short waves received by the antenna.

The single figure of the drawing shows this successive detection short wave radio receiving system.

45 In the figure a variable coupling condenser 2 connects an antenna 1 to ground through a circuit comprising an inductance coil 3 shunted by a condenser 4.

50 A push-pull circuit of the type disclosed in U. S. Patent No. 1,472,470, October 30,

1923, to Hartley, but adjusted to a non-oscillatory condition, is employed as a regenerative amplifier A. This circuit includes electric space discharge tubes 5 and 6 connected in push-pull relation by a tuned circuit comprising the coil 3 and the condenser 4.

The coil 3 comprises a coil or helix of copper tubing 10, enclosing an insulated wire 11 and an insulated wire 12, and forming a conductor of very low resistance for high frequency waves. At the upper end of the coil 3 the coils 10, 11 and 12 are interconnected by condensers 15, each of which is of low or negligible reactance at the wave lengths to be received, which may be, for example, of the order of 25 meters. The three strands 10, 11 and 12 of coil 3 are closely coupled electromagnetically. For alternating current they constitute one coil or winding. For high frequency the resistance and the inductance of the coil 3 are substantially the resistance and the inductance of coil 10, and the resistance and the inductance of each half of coil 3 are substantially the resistance and the inductance of half of coil 10.

The upper and lower ends of strand 10 are conductively connected through conductors 21 and 22, respectively, to the grids of tubes 6 and 5, respectively, and the midpoint of this strand is conductively connected to one each of the filaments of these tubes. The other side of each of these filaments is conductively connected to the midpoint of the strand 11, and the lower ends of strands 10 and 11 are conductively connected across a grounded battery 23, which supplies heating current to the filaments through the lower halves of strands 10 and 11.

The conductor 21 and the upper half of strand 10 form a conductive path for fixing the average potential of the grid of tube 6 with reference to its filament, and the conductor 22 and the lower half of strand 10 form a conductive path for fixing the average potential of the grid of tube 5 with reference to its filament.

The upper half of coil 3 delivers the alternating current input voltage for tube 6 across the grid and the filament of that tube, and the lower half of coil 3 delivers the alternating

current input voltage for tube 5 across the grid and the filament of that tube.

The upper and lower ends of strand 12 are conductively connected, through conductors 25 and 24, respectively, to the plates of tubes 5 and 6, respectively, and the lower ends of strands 11 and 12 are conductively connected across a source of unidirectional electromotive force, comprising a battery 30 and a variable resistance 31 in series. From this source, space current is supplied to tube 5 through a circuit extending from the resistance 31 through strand 12 and conductor 25, through the space discharge path from the plate to the filament of the tube, and through the lower half of strand 11, to battery 30. Space current is supplied to tube 6 through a path extending from resistance 31, through conductor 24, through the space discharge path from the plate to the filament of the tube, and through the lower half of strand 11, to battery 30.

The output electromotive force across the plate and the filament of tube 6 is delivered to the lower half of coil 3 and the output electromotive force across the plate and the filament of tube 5 is delivered to the upper half of coil 3.

The output electrodes of each of the tubes 5 and 6 are coupled to the input electrodes of the tube by a resonant circuit comprising the inductance 3 shunted by two capacity branches, one consisting of the condenser 4 and one comprising the coupling condenser 2 in series with the impedance of the path from the antenna to earth through the natural capacity of the antenna to ground.

The degree of regeneration or amplification in the amplifier, for a given setting of the coupling condenser 2, can be controlled by varying resistance 31 to alter the effective plate voltage of the amplifier. An approximate adjustment of the amount of regeneration can be obtained by means of resistance 31 with condenser 2 adjusted at a desired capacity and fine adjustment can be made by slight readjustment of condenser 2. However, if desired, the resistance 31 can be omitted and the amount of regeneration be controlled by varying condenser 2, varying condenser 4 approximately simultaneously to maintain the receiver tuned to the frequency of the waves to be received.

The conductor 21, leading from the upper end of coil 3, and a conductor 35, leading from the lower end of the coil, connect the coil in the grid-filament circuit of a first detector 40, which with its cooperating beating oscillator 41 steps down the frequency of the signal waves delivered by coil 3 and transmits the signal waves of reduced frequency to an intermediate frequency amplifier 50. After amplification in amplifier 50 the signals, which may be speech signals, for example, are detected by a low frequency detector 60,

which delivers them to a telephone receiver 70, or other signal indicating means.

The push-pull amplifier of the type described is capable of vigorous regenerative action and effects high amplification for short waves or waves of very high radio frequencies.

The lower halves of the strands 10 and 11 are included in the amplifier resonant circuit, which is tuned to the signaling frequencies. The amplifier filaments are grounded for direct current but are maintained at a potential which is higher than ground potential by an amount equal to half of the voltage drop across coil 3 for high frequencies. Therefore, the whole of the voltage across the coil 3 can be applied across leads 21 and 35 to the input circuit of detector 40 and yet the customary desirable grounding of the detector filament for the signaling frequency can be effected, even in cases in which the lead 35 is conductively connected to the filament of the detector.

Moreover, with the filaments thus at a high frequency potential midway between the potentials of the points at which inductance 3 connects to antenna 1 and to earth, the push-pull amplifier is symmetrically connected to the path including the coupling condenser 2 and the natural capacity of the antenna to earth.

Grounding of the filaments of tubes 5 and 6 for direct current, while they are maintained at the required potential above ground for high frequencies, avoids any necessity for insulating their heating current supply source and space current supply source from earth for high frequencies. The direct current external space current paths for the tubes 5 and 6 cannot have an unduly great shunting effect upon the alternating current external plate-filament paths for the tubes, since those direct current paths include, respectively, the inductances of these alternating current paths.

Tube noise is the limiting factor in the amplification that may be usefully employed in a radio receiver, as for example, in receiving speech signals or signals transmitted for use in measuring radio field strengths or wave intensities. In receiving sets in which the available amplification is such that an appreciable output indication or deflection results from the inherent tube noise, additional amplification can be of no benefit. As regards sensitivity, such a receiver or measuring set can well be rated by its field strength equivalent of the tube noise output indication or deflection.

Increasing the ratio of gain to tube noise in the amplifying system will increase the sensitivity of such a receiver, and the sensitivity can be materially increased by employing a strongly regenerative amplifier giving a large amplification of short waves in the antenna, and thus reducing the requisite

intermediate frequency amplification, or, in other words, thus substituting regenerative amplification at the incoming frequency for a material portion of the intermediate-frequency amplification; for experiment has
5 shown that the amplification, for a given amount of tube noise, increases as the resonant frequency is increased.

At 25 meters the increase obtained in amplification for the same tube noise was about six times when a large amount of regenerative amplification of the short waves was substituted for a material portion of the intermediate frequency amplification by introducing the amplifier A in the antenna. The
10 voltage amplification of the short waves in the antenna, produced by the regenerative amplifier, is preferably of the order of at least 10 times, the function of the short wave
15 amplifier being more than merely to increase the frequency selectivity of the system. The amplification produced in the intermediate frequency amplifier may be the largest amplification, at the intermediate frequency, for
20 which the tube noise can be tolerated.

The term "short waves" is herein employed to designate waves not longer than about 214 meters.

A ground or earth connection may be a connection to any mass to which the connection serves the same purpose as would a connection to earth or to any capacity of extremely great magnitude.

What is claimed is:

35 1. An amplifier comprising a plurality of electric space discharge devices connected in balanced relation to operate without frequency translation, each of said devices having a cathode, an anode and a grid, a common input circuit and a common output circuit for said devices, said common input
40 circuit being connected to ground, means for impressing signal variations upon said common input circuit, and means for connecting said cathodes to a point on said input circuit electrically remote from said ground connection.

2. An amplifier comprising a plurality of electric space discharge devices connected
50 in balanced relation to operate without frequency translation, each of said devices having a cathode, an anode and a grid, a common input circuit and a common output circuit for said devices, said common input circuit being connected to ground, coupling means whereby signal variations produced in said output circuit are impressed upon said common input circuit, means for impressing signal variations on said common input circuit,
55 and means for connecting said cathodes to a point on said input circuit electrically remote from said ground connection.

3. An electric space discharge tube having an anode and a thermionic cathode, a
60 high frequency alternating current work circuit

connected across said anode and said cathode, said work circuit including a plurality of conductors insulated from each other effectively for direct current, a source of heating current connected to said cathode
70 through at least one of said conductors, and a source of space current connected to said anode through another of said conductors, said other conductor being distinct from said first mentioned conductors in said alternating current work circuit.

4. Amplifier means comprising two electric space discharge tubes, each having an anode, a thermionic cathode and an impedance control element, an inductance element for connecting said tubes in push-pull relation, said inductance element including a plurality of conductors insulated from each other effectively for direct currents, and sources of heating current and space current
80 connected to said cathode and anode respectively through different conductors in said inductance.

5. An electric space discharge tube having an anode and a thermionic cathode, a high frequency alternating current work circuit connected across said anode and said cathode, said work circuit including a plurality of conductors insulated from each other effectively for direct currents, a source of heating current connected to said cathode through at least one of said conductors, a source of space current connected to said anode through another of said conductors, said other conductor being distinct from said first mentioned conductors in said alternating current work circuit, means for maintaining said cathode at an alternating potential materially different from ground, and means grounding said sources and said anode for high frequency.

6. An electric space discharge tube having an anode and a thermionic cathode, a high frequency alternating current work circuit connected across said anode and said cathode, said work circuit including a plurality of conductors insulated from each other effectively for direct currents, a source of heating current connected to said cathode through at least one of said conductors, a source of space current connected to said anode through another of said conductors, said other conductor being distinct from said first mentioned conductors in said alternating current work circuit, means for maintaining said cathode at an alternating potential materially different from ground, and means for maintaining said sources at substantially the same high frequency potential as said anode.

7. An electric space discharge tube having an anode, a thermionic cathode and an impedance control element for controlling the impedance of the space discharge path between said cathode and said anode, an alter-
130

nating current input circuit connecting said cathode and said control element of said tube, the input circuit including a plurality of conductors insulated from each other effectively for direct currents, means for supplying short waves to said input circuit, a source of heating current connected to said cathode through at least one of said conductors, a source of space current connected to said anode through another of said conductors, said other conductor being distinct from said first mentioned conductors in said alternating current work circuit, means for maintaining said cathode at an alternating potential materially different from ground, and means grounding said sources and said control element for high frequency.

8. In combination with an antenna, a short wave regenerative amplifier comprising two electric space discharge tubes, each having an anode, a cathode, and an impedance control element, a tuned circuit comprising inductance and capacity and connecting said tubes in push-pull relation with the cathodes connected to the midpoint on said inductance and with one end of said inductance connected to said antenna and to the anode of one tube and to the control element of the other tube, and with the other end of said inductance connected to ground and to the other plate and control element of the amplifier, a grounded source of cathode heating current, and a source of unidirectional space current for said tubes, said inductance comprising conductors insulated from each other for connecting said first source to said cathodes, for connecting the impedance control element of each tube of the amplifier to its cathode, and for connecting said second source to the anode of each tube.

In witness whereof, we hereunto subscribe our names this 23d day of December, A. D. 1926.

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