Aug. 26, 1941. K. RATH 2,253,942

SELECTIVITY CONTROL SYSTEM

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FIG. 1.

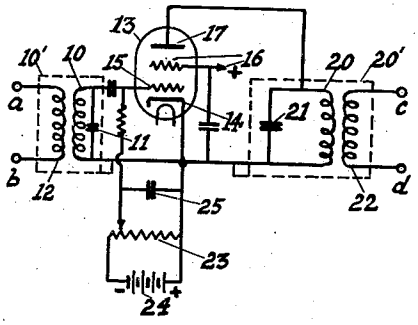


FIG. 1A.

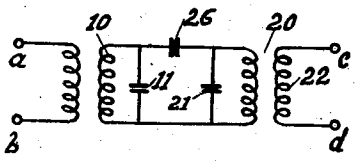


FIG. 2.

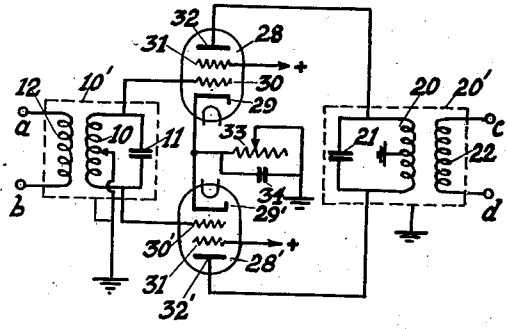


FIG. 2A.

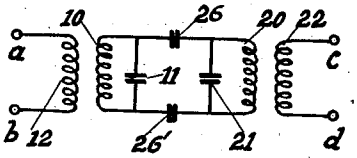
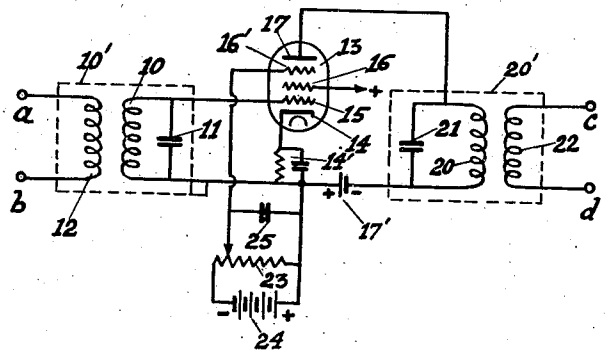


FIG. 3.



INVENTOR
KARL RATH
BY Samuel Ostrolenk
ATTORNEY

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FIG. 4A.

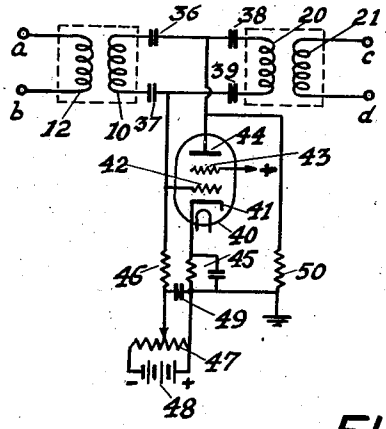


FIG. 4B.

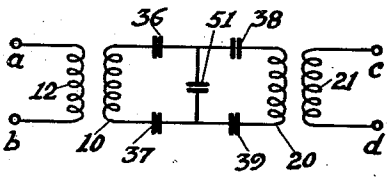
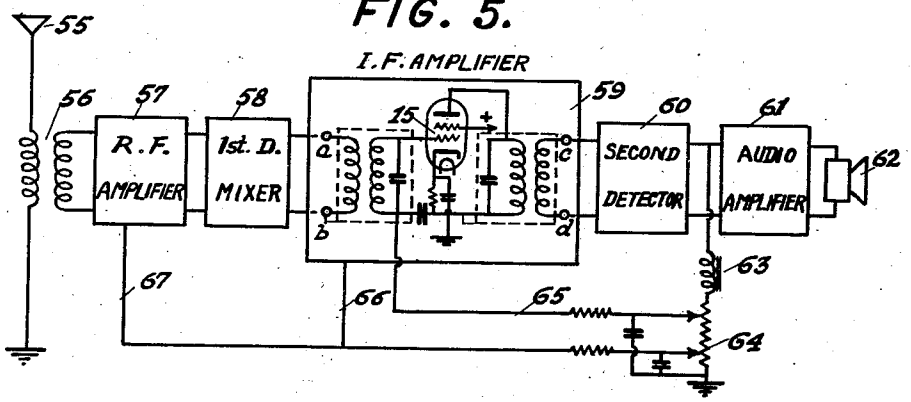


FIG. 5.



INVENTOR
KARL RATH
BY
ATTORNEY

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FIG. 6.

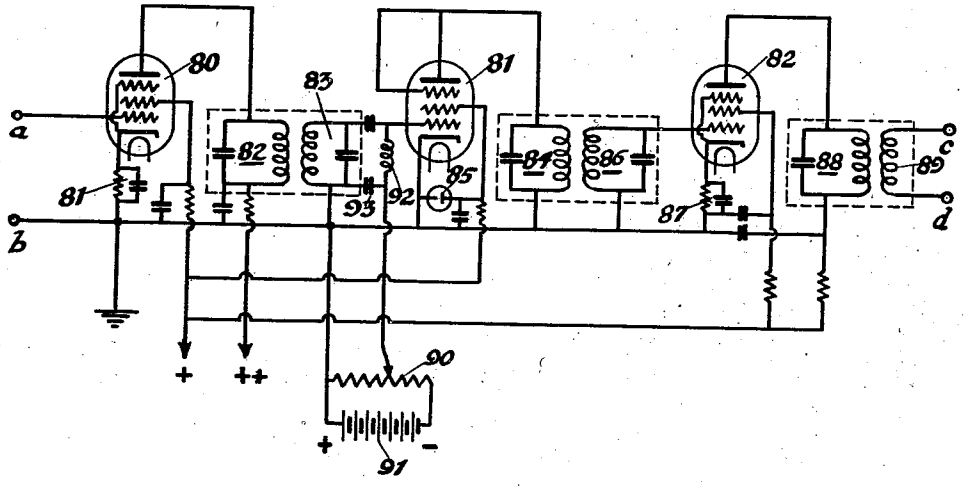
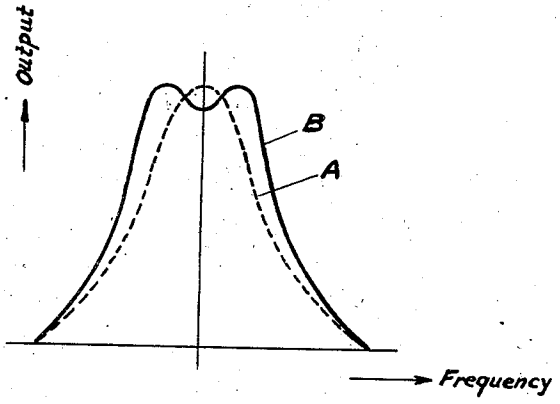


FIG. 7.



INVENTOR
KARL RATH
BY Samuel Ostrolenk
ATTORNEY

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UNITED STATES PATENT OFFICE

2,253,942

SELECTIVITY CONTROL SYSTEM

Karl Rath, New York, N. Y., assignor to Radio Patents Corporation, a corporation of New York

Application April 24, 1940, Serial No. 331,407

14 Claims. (Cl. 250—20)

The present invention relates to electric filter circuits or networks for transmitting wave energy of both low and high frequency and more particularly to a novel arrangement for and a method of controlling the propagation factor or coupling coefficient of such circuits in dependence upon an electric controlling current or potential.

The problem of controlling the coupling coefficient or frequency acceptance band of an electrical filter circuit or network in dependence upon a controlling current or potential arises in many cases in practice in both high frequency and low frequency signalling systems. Thus, it is often desirable to vary the frequency response or transmission band width between the input and the output of an electrical system in a desired manner such as in the case of manual or automatic selectivity control in a radio receiver and for various other uses.

Accordingly, a basic object of the present invention is the provision in a transmission network including band-pass, low-pass, or high-pass filters for transmitting electric wave energy, such as a modulated carrier signal in a radio receiver or the like, of means for effectively varying the electrical propagation factor or frequency band width purely electrically in proportion to variations of an electric controlling current or potential.

Another object is to provide an automatic fidelity control for a radio receiver of the type wherein the resonance curve of a tunable network is automatically varied in response to the variations in amplitude of the received signalling energy.

Still another object is to improve generally the efficiency of radio receiving systems and particularly to provide automatic selectivity control in such a manner as to increase the frequency acceptance band and in turn the fidelity of the sound or other signals being transmitted in proportion to an increase of the signal strength, and to narrow the band width of the system for weaker signals, thereby to maintain optimum signal-to-noise ratio and fidelity consistent with varying interference and receiving conditions.

The above and further objects and advantages of the invention will become more apparent from the following detailed description taken with reference to the accompanying drawings forming part of this specification and wherein;

Figure 1 shows a band-pass filter incorporating an adjustable coupling according to the invention;

Figure 1*a* is a diagram showing the equivalent known filter network,

Figure 2 shows a modification of an adjustable filter of the type shown by the equivalent diagram in Figure 2*a*,

Figure 3 shows a further modification of the filter according to Figure 1,

Figures 4*a* and 4*b* show further modifications of an adjustable filter according to the invention and its known equivalent circuit, respectively.

Figure 5 illustrates an adjustable filter according to the invention embodied in a radio receiver for effecting an automatic selectivity control,

Figure 6 is a circuit diagram of a complete adjustable bandpass filter embodied in an amplifier such as the intermediate frequency amplifier in a radio receiver or the like, and

Figure 7 shows the variation of the resonance curve or frequency response characteristic in dependence upon the control potential obtained by a system according to Figure 6.

Like reference numerals identify like parts throughout the different views of the drawings.

With the above objects in view the invention involves the use of a variable space charge brought about in an electron discharge tube between a first accelerating electrode maintained at a relatively high positive potential with respect to the cathode and another decelerating electrode maintained at a relatively low, including zero and negative, potential with respect to said first electrode and located at the side opposite from the cathode with respect to the first electrode. The first electrode may be the screen grid of a tube of standard construction having a plate maintained at cathode potential or biased negatively with respect to the cathode, in such a manner as to substantially prevent a steady electron current from being conveyed to said plate. If the electron current in such a tube is modulated in accordance with signal oscillations such as by impressing a signal potential upon a further control grid located near the cathode, a variable space charge also known as a virtual cathode will be established adjacent to the plate or other output electrode. This variable space charge or virtual cathode takes the form of a sheath of electrons of increased density spaced from the plate at a predetermined distance and being in electrical connection or coupling with the cathode and the other electrodes through the space current of the tube. The effect of the variable space charge on the plate will be to induce a variable charge on the latter which will give rise to a plate current in an associated circuit

of the same frequency as that of the oscillations impressed upon the control grid or other space current control element. The plate potential is displaced by 90° relative to the grid alternating voltage due to the capacitative induction by the variable space charge or virtual cathode in the manner described.

According to the invention a variable space charge coupling of the above type is employed as an effective coupling element between units or elements of a filter or transmission network for transmitting wave energy in a radio or other electrical communication system.

The space charge coupling and in turn the propagation factor between an input and output circuit associated with the coupling tube is controlled in any suitable manner such as by varying the steady bias on the input control grid, by varying the screen grid voltage, by controlling the bias upon a special control electrode, by varying the decelerating potential on the plate or other output electrode or in any other suitable manner adapted to vary the distance of the electron sheath from the plate and/or its concentration or electron density. An explanation of the variable capacity effect obtained in applicant's system in dependence upon a variable electric controlling magnitude such as a bias potential impressed upon a control grid or any other suitable control element, may be given as follows. As the grid potential becomes more positive the initial acceleration of electrons emitted by the cathode and attracted by the positive or screen grid will be increased thereby enabling such electrons to move to a point nearer to the plate before being repelled by the latter whereby the distance of the virtual cathode or electron sheath from the plate will be decreased resulting in an increase of the capacity in a manner well understood. The opposite effect takes place if the grid potential is made more negative causing a decrease of the initial acceleration of the electrons. Although this explanation has been verified by tests and experiments made by applicant, the amount of electrons or intensity of the space current was found to also play a part in the control and variation of the space charge coupling in addition to or in combination with the variation of the distance of the virtual cathode or electron sheath from the plate or other output electrode.

Referring to Figure 1, there is shown a band-pass filter comprising in a known manner a primary tuned circuit composed of an inductance 10 shunted by condenser 11 and a secondary tuned circuit composed of an inductance 20 shunted by a condenser 21. Electric wave energy such as modulated carrier signals are impressed upon the primary circuit 10—11 by way of input terminals *a*—*b* and coupling coil 12 in inductive relation with the circuit 10—11, and output energy is derived from terminals *c*—*d* by way of coupling coil 22 in inductive relation with the circuit 20—21. The primary and secondary circuits 10—11 and 20—21 are coupled with each other capacitatively as shown in the equivalent circuit of known type in Figure 1*a* by way of coupling condenser 26.

According to the present invention, the coupling condenser 26 is replaced by a variable space charge coupling constituted by an electron discharge tube 13 and adapted to be readily controlled in proportion to the variation of an electric controlling current or potential. The tube 13 in the example shown comprises a cathode 14 which may be either directly or indirectly heated, an input control grid 15, a screen grid 16 maintained in a known manner at a high positive potential with respect to the cathode and a plate 17. The primary circuit 10—11 in the example shown is coupled to the grid 15 and cathode 14 by way of a coupling condenser 18 and an adjustable resistance 23 forming a potentiometer together with a biasing battery 24 and serving to control the intensity or magnitude of the space charge coupling and in turn the coupling coefficient between the circuits 10—11 and 20—21. Item 25 is a by-passing condenser for the potentiometer resistance 23. The screen grid 16 is advantageously by-passed to ground through a condenser in a manner well understood, whereby the screen grid acts substantially as an accelerating electrode at ground alternating potential in producing a variable space charge or virtual cathode in accordance with the invention.

In the example shown the secondary circuit 20—21 is directly coupled between the plate 17 and cathode 14, whereby the plate 17 is at cathode potential. If desirable, the plate may be biased negatively with respect to the cathode, such as by the provision of a suitable biasing source, as shown at 17' in Figure 3, in such a manner as to substantially prevent a steady stream of electrons emitted by the cathode and passing the openings of the positive grid 16 from being conveyed to the plate and to produce an intense variable space charge or dense electron sheath between the plate 17 and the grid 16. This space charge provides an efficient capacitative coupling between the circuits 10—11 and 20—21. The latter may be tuned to the same frequency or they may be slightly detuned to obtain a desired band width characteristic. A further advantage of such a circuit in addition to the possibility of efficiently controlling the band width or propagation factor by an electrical potential is the fact that the resonant circuits 10—11 and 20—21 are coupled with each other substantially uni-laterally only; that is, in a direction from the input to the output of the tube 13, thus enabling an independent adjustment and balance of the system without mutual reaction as in the case in the equivalent known circuit employing a physical coupling condenser as shown in Figure 1A.

Referring to Figure 2, there is shown a filter network of the type according to Figure 2A with the coupling condensers 26 and 26' being replaced by space charge couplings in accordance with the invention. The resonant circuits 10—11 and 20—21 in this example are coupled in push-pull to the cathodes 29 and 29' and input grids 30 and 30' of a pair of electron discharge tubes 28 and 28', respectively. The tubes further comprise screen grids 31 and 31' maintained at suitable positive potentials with respect to the cathodes, and anodes or plates 32 and 32'. The center points of the inductances 10 and 20 are connected to ground or any other potential reference point of the system in the manner customary in push-pull systems. The cathodes 29 and 29' are connected to ground through a variable grid biasing resistance 33 by-passed by a condenser 34 serving to adjust the variable space charge between the screen grids 31 and 31' and the anodes 32 and 32', respectively, for effecting a proportionate variation of the coupling coefficient or

band width of the system in substantially the same manner as described hereinbefore. In place of a solid plate any other output electrode in the form of a suitably biased grid, such as the suppressor grid of a pentode of known construction may be used for the purpose of the invention as is readily understood from the above.

Referring to Figure 3 which substantially corresponds to Figure 1, there is shown an alternative method of controlling the coupling coefficient by the provision of an additional control grid 16' located between the screen grid 16 and the plate 17 and variably biased with respect to the cathode by the aid of a source 24 and potentiometer 23 in a manner similar to that shown in Figure 1. Item 14' is a biasing network in the cathode-to-ground lead to provide proper negative bias potential for the grid 15 to insure favorable operating conditions of the tube. If desired, an additional biasing source 17' may be provided in the plate circuit. In practice a slight steady electron current may be conveyed to the plate which will not materially affect the function of the tube as a variable capacity or reactive energy transmission element from its input to its output circuit.

Referring to Figure 4A, there is shown a further modification of a filter circuit of the general type shown in Figure 4B comprising a pair of condensers 36 and 38 connected between the upper ends of the inductances 10 and 20, a pair of further condensers 37 and 39 connected between the lower ends of the inductances 10 and 20 and a coupling condenser 51 placed between the junction points of the condensers 36, 38 and 37, 39. Figure 4A shows the equivalent circuit according to the invention embodying a space charge coupling in place of the condenser 51 constituted by an electron discharge tube 40 having a cathode 41, a control grid 42, a screen grid 43, and a plate 44. The grid 42 is connected to the junction between the condensers 37 and 39 on the one hand and to the cathode through a grid lead resistance 46, a variable part of a potentiometer resistance 47 shunted by the biasing battery 48 and a further biasing resistance 45 by-passed by a condenser and having its terminal opposite to the cathode grounded as shown. The potentiometer 47 is further by-passed by condenser 49. The plate 44 is connected to the junction between condensers 36 and 38 on the one hand and to ground through a suitable impedance such as an ohmic resistance 50. There is thus provided a variable space charge coupling in place of a condenser 51 in Figure 4B whose magnitude can be controlled in an easy and efficient manner such as by varying the grid bias in the manner illustrated to control the propagation constant or transmission characteristic.

Referring to Figure 5, there is shown a radio receiver in block diagram form embodying an adjustable coupling network according to the invention to effect an automatic selectivity or band width control. Radio signals received by an antenna 55 are impressed upon a radio frequency amplifier 57 by way of a coupling transformer 56 and converted into intermediate frequency signals in a first detector-mixer stage 58 in a manner well understood by those skilled in the art. The intermediate frequency signals are selectively and efficiently amplified in an intermediate frequency amplifier 59 including at least one stage embodying an adjustable coupling or band width control according to the invention which may be of any of the types described hereinbefore. In the example shown this coupling circuit is substantially similar to that according to Figure 1 wherein the input and output resonant circuits are tuned to the intermediate frequency of the receiver. The amplified intermediate frequency signals are impressed upon the second detector for demodulation, and the demodulated signals are further amplified in an audio amplifier 61 supplying an output for energizing a suitable translating device such as a loud speaker 62. A portion of the rectified energy is derived from the detector 60 by way of a choke coil 63 and a potentiometer resistance 64 which by proper filtering will supply in a known manner a potential varying proportionately to the carrier amplitude of the radio frequency energy being received and serving in a known manner for automatic volume control by controlling one or more variable mu high frequency and/or intermediate frequency amplifying stages. In the example illustrated, this is indicated by the leads 66 and 67. A further potential derived from resistance 64 is impressed upon the grid 15 of the variable coupling stage in the intermediate frequency amplifier in such a manner as to increase or decrease, respectively, the coupling effected by the variable space charge in proportion to an increase and decrease of the average amplitude of the received signal energy. In the example shown, if the signal strength increases the direct current through resistance 64 will increase thereby rendering the grid 15 more positive and increasing the variable space charge between the screen grid and plate of the coupling tube; that is, in turn increasing the coupling coefficient or band width of the control stage. Vice versa, if the signal strength decreases the grid 15 will become negative, thereby decreasing the coupling and narrowing the band width. In this manner the selectivity of the receiver will be automatically controlled to provide low selectivity or wide acceptance band width for strong or local signals in which case noise and interference are substantially blanketed by the signal and to provide high selectivity or narrow band width in case of weak or distant signals and substantial elimination of noise and interference which without narrowing the acceptance band width would be increased considerably relative to the signal amplitude and in most cases render reception unpleasant and annoying, if not totally impossible.

The circuits 10—11 and 20—21 are advantageously shielded from the remaining parts of the system such as by the aid of screens 10' and 20' resulting in further prevention of mutual reaction between the circuits and increased operational stability of the system.

Figure 6 is a complete diagram of a two-stage amplifier which may form a part of the intermediate frequency section of a superheterodyne receiver and embodies an adjustable band-pass filter or coupling network constructed in accordance with the invention. The input stage energized by way of terminal *a*—*b* is comprised of a pentode vacuum tube 80 provided with a biasing network 81 inserted in its cathode lead and a tuned output circuit 82, while the output stage is comprised of a pentode vacuum tube 82 provided with a tuned input circuit 86, grid biasing network 87 inserted in its cathode lead and a resonant output circuit 88 in inductive relation with coupling inductance 89 connected to output terminal *c*—*d*. The band-pass network interposed between the circuits 82 and 86 comprises coupling electron tube 81, input resonant circuit

83 and output resonant circuit 84 connected in accordance with the invention in the manner described hereinabove. Item 85 represents a gas discharge tube connecting the screen or positive grid of the coupling tube 81 to ground to insure a substantially steady positive potential and to stabilize the space charge coupling. The latter is controlled by a variable biasing potential provided by a suitable source 91 in conjunction with adjustable voltage divider 90 and impressed upon the control grid and cathode of the coupling tube. 92 is a choke coil in the control lead to prevent alternating currents from entering the control source and 93 is a blocking condenser preventing short circuiting of the control potential.

According to experiments conducted by applicant it has been found that the effective band width or frequency response characteristic of an amplifier as shown in Figure 6 can be controlled in an easy and efficient manner by varying the bias by adjusting the potentiometer 90 as illustrated in Figure 7. In the latter, the amplifier output is plotted as a function of frequency and curve A represents the selectivity or frequency response curve for a relatively high negative potential on the input grid of the coupling tube (about —22 volts used in the tests) while curve B relates to a substantially decreased grid bias (somewhat less than zero according to the tests) showing a substantial widening or increase of the band width in accordance with the principle underlying this invention. As is understood, the band width control potential for the coupling tube may be derived from any suitable source, such as an AVC network in a radio receiver to effect automatic band width control in a manner understood from the foregoing.

It will be evident from the foregoing that the invention is not limited to the specific circuits and arrangement of parts and details described and disclosed herein for illustration but that the underlying inventive idea and principle are susceptible of numerous modifications and variations coming within the broader scope and spirit of the invention as defined by the appended claims. Thus, the circuits shown may be used as phase shifting systems to adjust the phase of an output potential derived from the output circuit of the coupling electron tube in relation to the phase of the input potential in proportion to the instantaneous magnitude of a controlling potential or current which may vary in accordance with a modulating signal to produce phase modulated output oscillations from a carrier of constant phase impressed upon the input of the tube. Many other uses will suggest themselves to those skilled in the art. The specification and drawings are accordingly to be regarded in an illustrative rather than in a limiting sense.

I claim:

1. An electric filter for transmitting oscillatory energy comprising an input circuit and an output circuit, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a steady positive potential with respect to said cathode, means whereby said output electrode is maintained at a relatively low steady potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling said input circuit to said control grid and cathode, means for coupling said output circuit to said output electrode and cathode, a source of variable direct current bias potential, and further means for controlling said space charge in accordance with variations of said bias potential.

2. An electric filter for transmitting oscillatory energy comprising an input circuit and an output circuit, reactive coupling means between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and a plate, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said plate at a relatively low steady potential with respect to said screen grid, to bring about a variable space charge adjacent to said plate, means for coupling said input circuit to said control grid and cathode, means for coupling said output circuit to said plate and cathode, a source of variable direct current bias potential, and further means for controlling said space charge in accordance with variaitons of said bias potential.

3. An electric filter for transmitting oscillatory energy comprising an input circuit and an output circuit, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and a plate, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said plate at a steady negative potential with respect to said cathode, means for coupling said input circuit to said control grid and cathode, further means for coupling said output circuit to said plate and cathode, a source of variable direct current bias potential, and means for controlling said space charge in accordance with variations of said bias potential.

4. An electric filter for transmitting oscillatory energy comprising a pair of resonant circuits tuned to a predetermined frequency, reactive coupling means between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said output electrode at a relatively low steady potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling one of said resonant circuits to said control grid and cathode, further means for coupling the other resonant circuit to said output electrode and cathode, a source of variable direct current bias potential, and means for controlling said space charge in accordance with variations of said bias potential.

5. A band-pass filter comprising a first and a second resonant circuit tuned to a predetermined frequency, a reactive coupling between said resonant circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and a plate, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said plate at a negative potential with respect to said cathode, means for coupling one of said resonant circuits to said control grid and cathode, further means for coupling the other resonant circuit to said plate and cathode, a source of variable direct current

bias potential, and means for variably accelerating the space current through said tube in accordance with said bias potential.

6. A band-pass filter comprising a pair of resonant circuits, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a relatively high steady positive potential with respect to said cathode, means whereby said output electrode is maintained at a relatively low potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling one of said resonant circuits to said control grid and cathode, further means for coupling the other resonant circuit to said output electrode and cathode, a source of variable direct current bias potential, means to apply said bias potential to said control grid for controlling the coupling between said circuits effected by said electron tube.

7. A band-pass filter comprising a pair of resonant circuits, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid, and a plate, means for maintaining said screen grid at a steady positive potential with respect to the said cathode, further means for maintaining said plate at a negative potential with respect to said cathode, means for coupling one of said resonant circuits to said control grid and cathode, further means for coupling the other resonant circuit to said plate and cathode, a source of variable direct current bias potential, and means for applying said bias potential to said control grid to vary the effective coupling between said circuits effected by said electron tube.

8. The combination with a radio receiver, of a band-pass filter embodied in said receiver, said band-pass filter comprising a first and a second resonant circuit, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means whereby said output electrode is maintained at a relatively low steady potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling one of said resonant circuits to said control grid and cathode, further means for coupling the other resonant circuit to said output electrode and cathode, means associated with said receiver for generating a control potential proportional to the carrier amplitude of the signal energy being received, and means for controlling said space charge in dependence upon said control potential to increase and decrease the coupling between said circuits effected by said electron tube in proportion to increasing and decreasing signal strength.

9. The combination with a superheterodyne radio receiver, of a band-pass filter embodied in the intermediate frequency section of said receiver, said band-pass filter comprising a first and a second tuned circuit resonant to the intermediate frequency, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a positive potential with respect to said cathode, further means whereby said output electrode is maintained at a relatively low steady potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling said first resonant circuit to said control grid and cathode, further means for coupling said second resonant circuit to said output electrode and cathode, means associated with said receiver for generating a control potential proportional to the carrier amplitude of the signal energy being received, and means for controlling said space charge by said control potential to vary the coupling between said resonant circuits effected by said electron tube in proportion to variations of the signal strength.

10. The combination with a superheterodyne radio receiver, of a band-pass filter embodies in the intermediate frequency section of said receiver, said band-pass filter comprising a first and a second resonant circuit tuned to the intermediate frequency, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means whereby said output electrode is maintained at a relatively low steady potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling said first resonant circuit to said control grid and cathode, further means for coupling said resonant circuit to said output electrode and cathode, means associated with said receiver for generating a control potential proportional to the carrier amplitude of the signal energy being received, means for impressing said control potential upon said control grid to control the coupling between said resonant circuits effected by said electron tube in proportion to variations of the signal strength.

11. The combination with a superheterodyne radio receiver, of a band-pass filter embodied in the intermediate frequency section of said receiver, said band-pass filter comprising a first and a second resonant circuit tuned to the intermediate frequency, a reactive coupling between said circuits being constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and a plate, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said plate at a negative steady potential with respect to said cathode, means for coupling said first resonant circuit to said control grid and cathode, further means for coupling said second resonant circuit to said plate and cathode, means associated with said receiver for generating a control potential proportional to the carrier amplitude of the signal energy being received, and means for applying said control potential to said control grid.

12. A system of the character described comprising a first and a second impedance means, a reactive coupling between said impedance means constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a relatively high positive steady potential with respect to the cathode, further means for maintaining said output electrode at a negative potential with respect to said screen grid to bring about a variable space charge adjacent to said output electrode, means for coupling said first impedance means to said control

grid and cathode, means for coupling said second impedance means to said output electrode and cathode, a source of variable direct current bias potential, and means for controlling said space charge in dependence upon variations of said bias potential to correspondingly vary the coupling between said first and second impedance means effected by said electron tube.

13. An electric filter network for transmitting oscillatory energy comprising a first and a second, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and a plate, means for maintaining said screen grid at a steady positive potential with respect to said cathode, further means for maintaining said plate at a relatively low steady potential with respect to said screen grid to substantially prevent a steady electron current from being conveyed to said plate and to bring about a concentrated electron space charge adjacent to said plate, means for coupling said first circuit to said control grid and cathode, further means for coupling said second circuit to said plate and cathode, a source of direct current bias potential, and means for controlling said space charge in accordance with variations of said bias potential to correspondingly vary the coupling between said first and second circuit effected by said electron tube.

14. An electric filter network for transmitting oscillatory energy comprising a first and a second circuit, a reactive coupling between said circuits constituted by an electron discharge tube having at least a cathode, a control grid, a screen grid and an output electrode, means for maintaining said screen grid at a steady positive potential with respect to said cathode, means whereby said output electrode is maintained at a relatively low steady potential with respect to said screen grid to substantially prevent a steady electron current from being conveyed to said output electrode and to bring about a variable space charge adjacent to said output electrode, means for coupling said first circuit to said control grid and cathode, means for coupling said second circuit to said output electrode and cathode, a source of variable direct current bias potential, and further means for controlling said space charge in accordance with variations of said bias potential to correspondingly vary the coupling between said first and second circuit effected by said electron tube.

KARL RATH.