June 20, 1944. L. DE KRAMOLIN 2,351,934

SELECTIVITY APPARATUS

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Fig. 1.

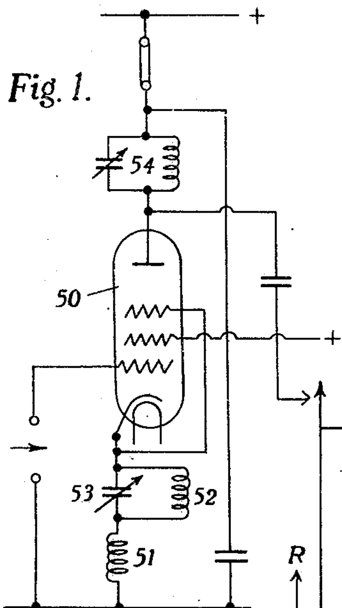


Fig. 2.

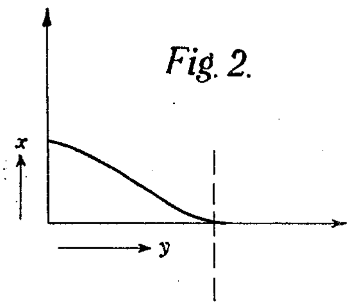


Fig. 3.

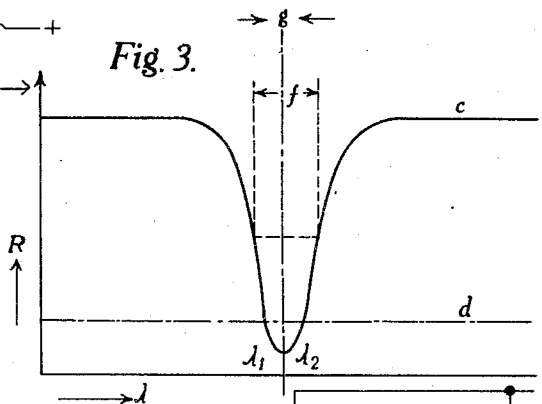


Fig. 4.

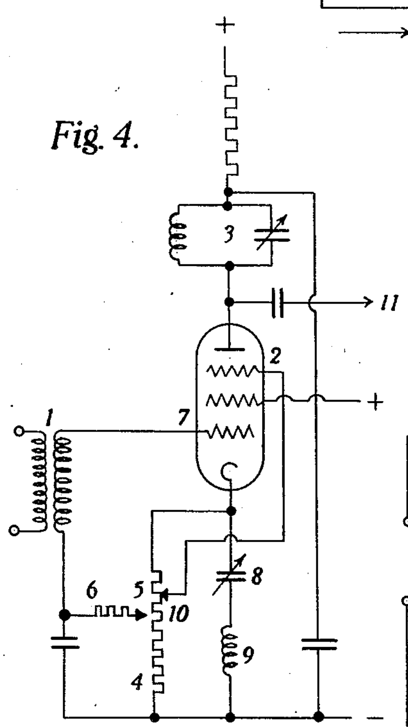
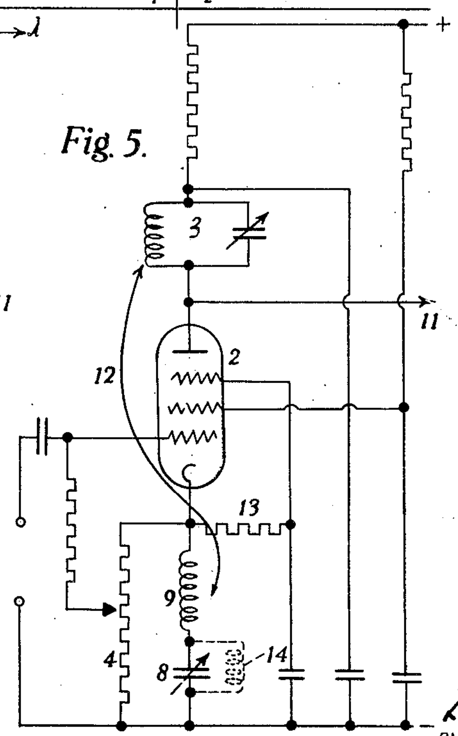


Fig. 5.



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SELECTIVITY APPARATUS

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Fig. 6.

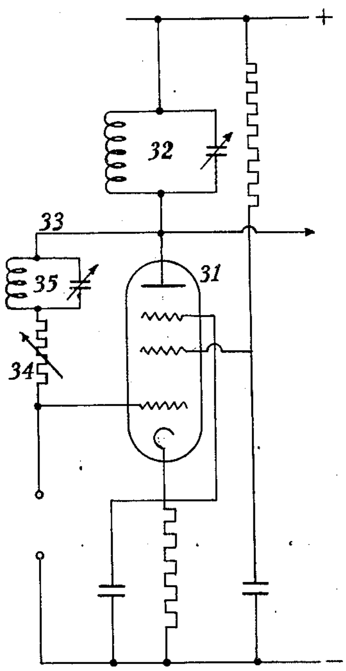
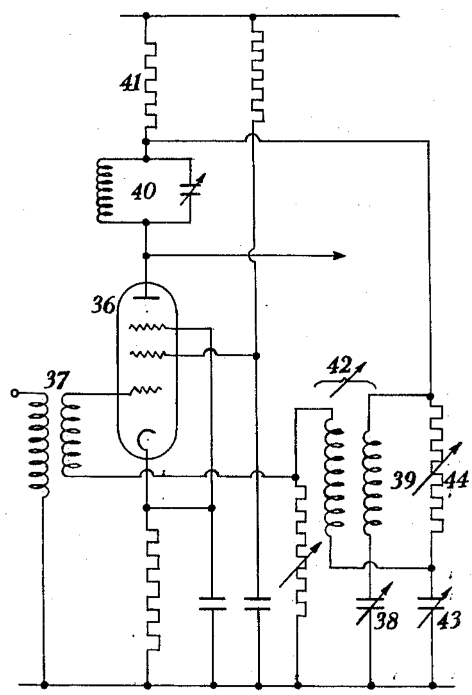


Fig. 7.



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SELECTIVITY APPARATUS

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Fig. 8.

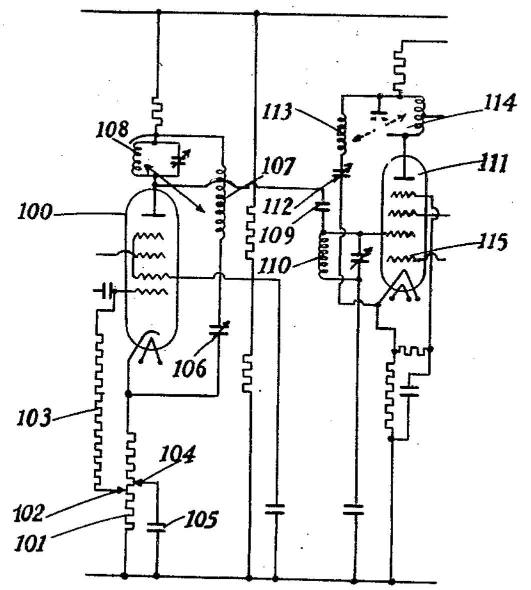


Fig. 9.

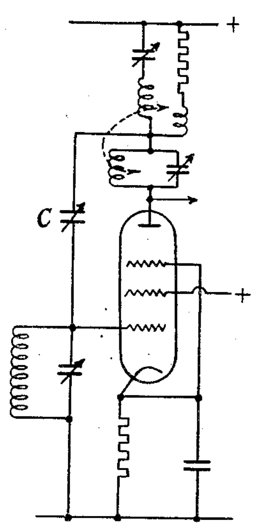
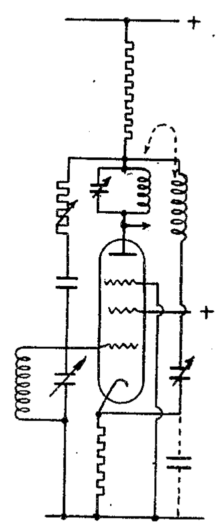


Fig. 10.



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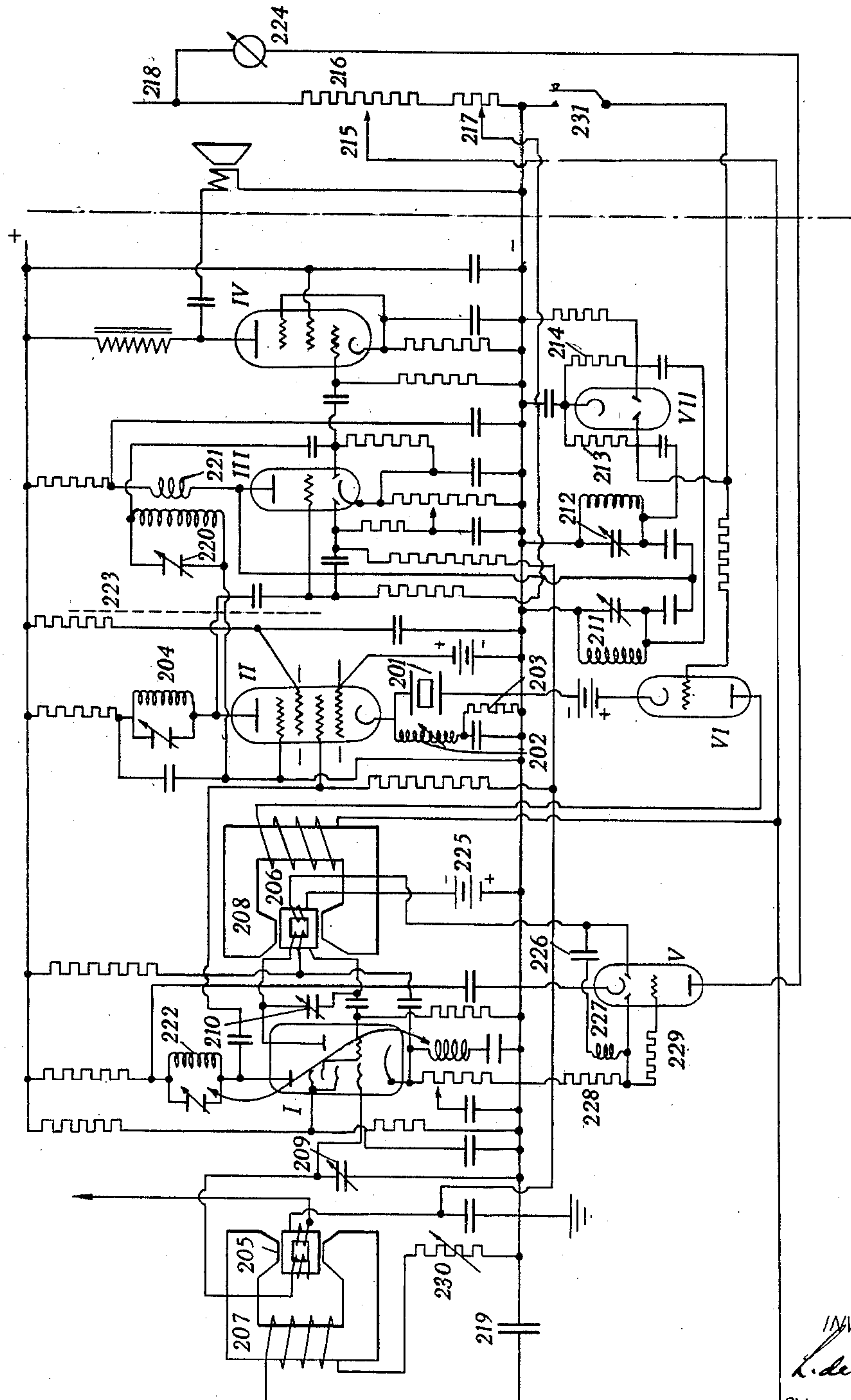

Fig. 11.

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Fig. 12.

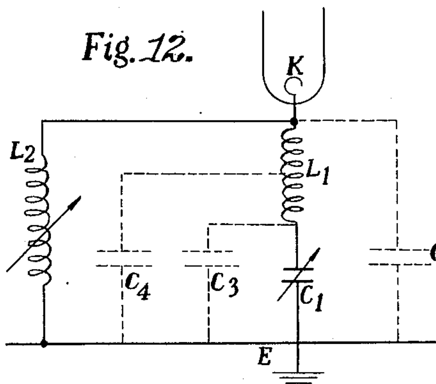


Fig. 13

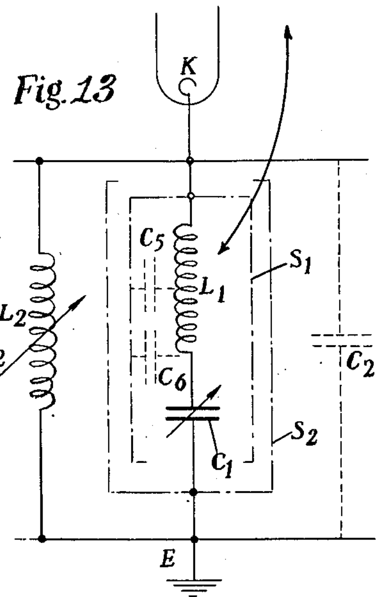
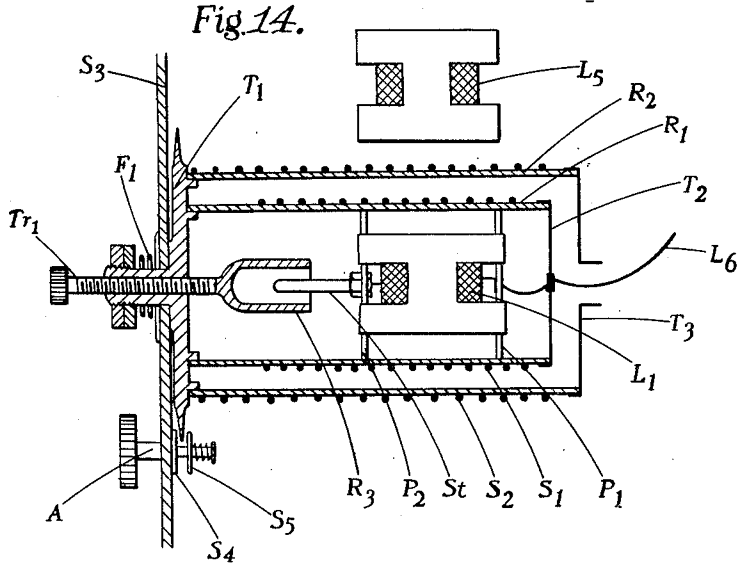


Fig. 14.



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Patented June 20, 1944

2,351,934

UNITED STATES PATENT OFFICE

2,351,934

SELECTIVITY APPARATUS

Ladislas de Kramolin, Berlin-Kladow, Germany; vested in the Alien Property Custodian

Application December 22, 1937, Serial No. 181,087
In Germany December 22, 1936

7 Claims. (Cl. 179—171)

The present invention relates to selectivity arrangements for oscillatory circuits and particularly for radio receiving and transmitting circuits.

In general, the selective qualities of a set which are obtainable with oscillatory circuits are dependent upon the determinative portions of these circuits alone, so that normally it is not possible to obtain with tuning circuits which are composed of given capacities and inductances, and with the losses peculiar to these determinative portions, a greater separating sharpness than approximately corresponds to the half-value width of such a circuit, the separating sharpness being intended to mean here the interval between two channels to be separated.

If, therefore, the half-value width of an oscillatory circuit amounts to 10 kilocycles, it is therefore not possible to obtain the result, by any desired number of such circuits in an arrangement, that it allows of separating channels from one another, the interval of which is less than 10 kilocycles.

According to the present invention, use is made of counter-coupling or negative feed-back channels in amplifying arrangements, which counter-coupling channels contain filter means dependent upon frequency, that is, for instance, oscillatory circuits or combinations of such oscillatory circuits (band filters or limiting filters or the like), whereby selective structures can be produced which are not subject to the above limitations.

The circuits inserted in the counter-coupling channels may be series or parallel resonant circuits or combinations of both types, and the counter-coupling channels may either lie in the anode circuits or equivalent circuits themselves, in which they are arranged either in the anode or cathode supply leads of the amplifier units, or they may lie in the supply leads to individual or several control or auxiliary electrodes, the essential fact always residing in that they serve as means for obtaining a selective counter-coupling.

In order that the invention may be more clearly understood, various embodiments will be described with reference to the accompanying drawings

In the drawings:

Fig. 1 shows a circuit arrangement according to the invention,

Figs. 2 and 3 show curves for explaining the operation of the arrangement according to Fig. 1,

Figs. 4 and 5 show details of alternative circuit arrangements,

Figs. 6 and 7 show further modified circuits according to this invention,

Fig. 8 shows the application of the invention to a mixing tube and intermediate frequency amplifier of a superheterodyne receiver,

Fig. 9 shows an alternative circuit detail according to this invention in which the series resonant circuit is placed in the anode lead,

Fig. 10 shows a modification of Fig. 9,

Fig. 11 shows a superheterodyne receiver circuit embodying the selectivity circuits according to this invention,

Fig. 12 explains the capacity losses with selectivity circuits according to this invention,

Fig. 13 shows an arrangement of shielding for avoiding these losses,

Fig. 14 shows constructional details of a component according to this invention.

If an amplifier according to Fig. 1 is constructed, for instance, with a pentode 50 in the well-known connection with a tuned anode circuit 54, and if at first the constructional elements in the cathode lead, namely, the inductances 51, the choke 52 and the condenser 53 are imagined to be replaced by a normal variable resistance, the following can be observed:

No consideration will be given in the first place to the production of the grid bias for the input grid, but it is assumed that, by means of a constant favourable grid bias produced in some manner, the valve operates on the steepest part of characteristic which can be controlled by the input voltage to be amplified. If, now, the resistance imagined in the cathode lead is given the value zero, the highest amplification is given by the other determining portions of the circuit. If the resistance is slowly increased, commencing from zero, a diagram results which is illustrated in an approximate manner in Fig. 2. In this curve the value x represents the particular amplification which corresponds to a resistance value y of the variable resistance imagined in the cathode lead. The curve shows that, on gradually increasing the resistance, the amplification decreases, since, of course, with increasing resistance, the counter-voltage becoming effective at the input grid of the tube continuously increases. The input circuit of the tube, which is inserted at the place indicated by the arrow between the grid supply lead and negative pole may, in this case, be constructed in any desired way.

As the curve in Fig. 2 shows, at a certain limiting value of y, x has become equal to zero, that is, even with a further increase of y no further substantial change takes place in the arrangement. The actual operations probably show small deviations from the curve shown due to stray capacities, since however, especially with tubes having a high amplification factor and great steepness, only small resonance values suffice to obtain in the curve the value of y indicated by the chain-dotted section line, the parallel capacities do not falsify the conditions set forth, to any great extent.

Therefore, the law exists that amplification occurs below a certain value of y, but no further amplification occurs above a certain value of y.

The network formed by the constructional elements 51, 52 and 53 now corresponds to a series resonant circuit, since the choke coil 52 connected in parallel with the condenser 53 is to have such a high inductance that it acts merely as a capacitive reactance for the frequencies to be considered here, while, on the other hand, it allows the anode direct current necessary for the working of the tube to reach the cathode.

Curve C in Fig. 3 shows the resistance of the combination 51, 52, 53 which is effective at different frequencies, the abscissae indicating wavelengths and the ordinates resistances.

Commencing from small wave-length values, the combination has a certain, rather considerable reactance of capacitive nature. On approaching the resonance frequency, the capacitive reactance gradually falls until reaching the resonance frequency. At this resonance frequency, the capacitive reactance has completely disappeared and the arrangement has a minimum effective resistance. On further increase of the wave-length, the effective resistance of the combination increases again, in which case at increasing wave-length it now has an inductive character.

For the consideration to be undertaken here in the first instance, it is not important whether the resistance is purely ohmic capacitive or inductive, but only the potential drop occurring due to the resistance is of interest. If we now consider the curve c in Fig. 3, it is found, as was not otherwise to be expected, that it is a question here substantially of an inversely recorded resonance curve, the resonance sharpness, that is, the obtainable flank steepness, half-value width etc. being given by the loss resistance of the circuits employed, in other words, by the circuit quality. Therefore, under normal conditions, only a definite selectivity determined by the half-value width of the resonance curve can be obtained with these given constructional elements.

If, however, the determinative portions of the circuit, on the one hand, and the determinative portions of a tube arrangement according to Fig. 1 are so chosen that the limiting value of the resistance y as represented in Fig. 2 by the chain-dotted line is illustrated by the chain-dotted line d as entered in Fig. 3, the following results: since an amplification, of course, only occurs at all if the resistance in the cathode circuit is, for instance, less than the value d, then on passing through the wave-length spectrum (see Fig. 3) no amplification occurs at all if, commencing at the minimum wave length, advancement is made up to the value λ_1. Only commencing from the value λ_1 does amplification begin, which increases, reaches its maximum amount at the resonance value of the circuit, and then falls again until the wave length λ_2 is reached, whereas after exceeding this wave-length value, all amplification again ceases.

Whereas there is obtained by the determinative portions of the circuit a resonance curve which has a half-value width f, the width of the whole range, within which an amplification takes place, is characterised only by the wave-range g in Fig. 3.

It is therefore seen that by this means it is possible, with the aid of a circuit which in itself would not render possible any separation of transmitters of a certain frequency interval, even in the case of several cascade circuits, to construct an amplifier which has a greater separating sharpness.

Since, especially at high frequencies, stray capacities may introduce errors, it is important to work with tubes having a relatively high reciprocal of the amplification factor and high steepness. On the other hand, it is also desirable that the tubes shall have a high internal resistance, in order that even with good tuning circuits, 54 in the anode circuit of the arrangement (Fig. 1), no excessive current intensity drop occurs near the resonance position.

In order to make the current drop in the tube small and thus also the effective counter-coupling at the input grid in the case of anode circuit coupling to the next amplifying stage or other circuits, it may also be desirable to connect ohmic resistances in series with the circuit 54. Of course, when coupling subsequent circuits, however, no restriction is made to the tuned anode circuit coupling, but, for coupling, tuned or non-tuned transformers and all other possibilities of coupling well-known per se of periodic or aperiodic nature may be employed.

Instead of a simple series resonant circuit after the fashion of Fig. 1, there may also be inserted in the cathode lead a plurality of circuits or networks, filters or the like, which produce a larger number of channels due to the effects illustrated by Figs. 2 and 3, or, alternatively, band or limiting filters may be used in the cathode supply lead, whereby the frequency ranges approximately determined by these filters then undergo a sharper separation than by the filter means alone.

The arrangement therefore serves quite generally to increase the flank steepness and to increase the obtainable selectivity with any frequency-differentiating or any other filter means.

Instead of working at the lower bend, it is also possible to work at the upper bend of an amplifying arrangement; instead of tubes, any other amplifiers may be used accordingly.

Further modifications of the invention are shown in Figs. 4–7.

Fig. 4 shows an arrangement in which 1 is the input transformer of a pentode 2. The amplified output arises in the tuned anode circuit 3. In the cathode supply lead, a resistance 4 is inserted, from which the grid bias for the control grid 7 can be derived through a slider 5 and de-coupling resistance 6.

For the oscillations reaching the control grid 7 through the transformer 1, the resistance 4 constitutes a counter-coupling arrangement. By this means, therefore, in contradistinction to a back-coupling, amplification-reducing voltages are introduced.

An exception exists only for such oscillations to which the series resonant circuit 8, 9 is tuned, since for these oscillations the resistance 4 is practically short-circuited.

Since very slight variations of the capacity 8 are already accompanied by very material alterations of the selectivity and sensitivity, a variation in the series resonant circuit 8, 9 or a displacement of the slider 10 in any apparatus, particularly in a receiving set, may also be used for selectivity or sensitivity regulation.

On manual adjustment, in this case, the three variables, namely, the resistance 10, the inductance 9 or the condenser 8 may be operated.

The arrangement appears to have a substantially greater importance, however, for an automatic sensitivity or selectivity regulation, since, as has been mentioned, small variations in this circuit already produce considerable effects, so that, with the aid of small control voltages, by means of control tubes, by means of condensers dependent upon voltage (for instance, piezo-electric arrangements) or by means of inductances dependent upon voltage or current (e. g. pre-magnetising arrangements of iron-containing coils) the required small variations of the capacity, inductance or resistance in this circuit can be produced.

Since the series resonant circuit 8, 9 has a small resistance only for the oscillations to which it is tuned, it is clear that a back-coupling which is effective between the series resonant circuit 8, 9 and the tuned anode circuit 3 will be effective only for the natural frequency of these circuits. It increases the selectivity further and increases the sensitivity for the tuning frequencies. The back-coupling, in this case, may be effected both inductively and capacitively.

In Fig. 5, an inductive back-coupling is illustrated by the curved arrow 12.

Figure 6 shows another form of construction of a counter-coupling which has similar effects. Here, in a tube 31 which has, in a manner well-known per se, a tuned anode circuit 32, a connection 33 from the anode to the grid is provided.

Since, as is well-known, the anode voltage is displaced 180° in phase with respect to the grid voltage, then by suitable return of a part of the anode voltage to the grid, a counter-coupling can be obtained. By varying the resistance 34, the level of this returned voltage can be favourably adjusted. If this resistance is so adjusted that the voltage impressed from the anode circuit upon the grid is equal to the input voltage reaching the grid, then no amplification occurs at all, since the two voltages having, as mentioned, a phase displacement of 180°, neutralise one another.

If, in addition to the resistance 34, a tuned circuit 35 is provided, then since this tuning circuit constitutes a high resistance for its natural frequency, only a small counter-voltage will be transmitted at this natural frequency to the input grid and, therefore, this frequency is amplified. It is therefore seen that owing to the circuit 35 a further means of selection is provided, which can be used independently or together with other tuning circuits as, for instance, the circuit 32, for separating desired frequencies.

A further constructional example of the inventive idea is illustrated in Fig. 7. As has already been mentioned, it is necessary for the obtaining of the highest possible selectivity that the counter-coupling shall be made as strong as possible for all undesirable frequencies. However, in arrangements, for instance, according to the constructional examples shown in Figs. 4 and 5, this means that the resistance 4 is made high and that also the resistance 8, 9 is to be very high for all frequencies, with the exception of the resonant frequencies.

This resistance, however, becomes greater, the smaller the capacity and the greater the inductance of this circuit can be made for a given wavelength.

Since it is essential that for this purpose all stray capacities shall be reduced if possible, for which reason also the corresponding cathodes are to have the smallest possible capacity with respect to their heating body or other apparatus parts, it is also preferable to make the coils 9, or the like as small as possible in order to make them poor in capacity. Since, in this case, however, the mutual spacing between the turns must not be reduced too much for the same reason, a small copper cross-section and thus a relatively high effective resistance of the coils, of course, results.

In order apparently to reduce this effective resistance which, of course, is also maintained in the case of resonance and which acts for the resonance frequency as a counter-coupling, the use of back-coupling has already been recommended, which, however, is not irremissible.

The constructional example in Figure 7 shows a possibility of completely avoiding the occurrence of a counter-coupling even without back-coupling for the case of resonance.

36 is an amplifying tube, to which input voltages are supplied through the transformer 37. To the anode of the tube 36, for instance, a tuned anode circuit 40 is again connected. The amplified currents are kept away from the anode voltage source by the de-coupling resistance 41 and pass through a blocking condenser to a network, from which the counter-coupling voltages or back-coupling voltages can be derived.

The above-mentioned network is so arranged that for the desired frequency even without the use of an additional damping-reducing back-coupling, no counter-coupling voltages can arise at the input grid.

For this purpose, in the first instance, the series combination 38, 39 is again tuned to the desired frequency. Then, by means of the variable coupling 42, an adjustment is effected at which for undesired frequencies an adequate counter-voltage arises at the input grid of 36. By the tuning of the condenser 43 and adjustment of the resistance 44, there can then be found upon subsequent correction at the condenser 38 a position at which absolutely no counter-voltage arises for the desired frequency at the input grid.

A further constructional example of the present invention applied to a mixing tube and intermediate frequency amplifier of a "single-span" superheterodyne receiver is shown in Fig. 8.

In this example, the resistance 101 connecting the cathode of the mixing tube 100 with the negative anode voltage lead serves for counter-coupling. By means of a slider 102 which connects the grid-leak resistance 103 to any desired point of this cathode resistance, the most favourable grid bias of the mixing tube can be adjusted; with the slider 104 shown opposite, which is connected to an earthed condenser 105, the degree of counter-coupling can be adjusted to the desired resistance.

This counter-coupling has a double effect. On the one hand, it acts in a linearising manner with regard to the frequencies reaching the input grid of the mixing tube and, furthermore, it acts through the agency of the series resonant circuit 106, 107 connecting the cathode to the tuned anode circuit 108, to increase the selectivity. This series resonant circuit, as is indicated by the dotted arrow, may be adjustably coupled with the tuned anode circuit.

The anode tuning circuit 108 of the mixing tube is then coupled through a small capacity 109 to the input tuning circuit 110 of the intermediate-frequency amplifier tube 111. The coupling between both tuning circuits is to be so loose that no broadening of the resonance curve occurs since at these high frequencies the necessary selectivity is not obtained otherwise. Also with the tube 111 a series resonant circuit 112, 113 connecting the anode circuit 114 with the cathode is provided, which acts to increase the selectivity.

Since the series resonant circuit 112, 113 couples the cathode to the anode circuit, then owing to the control-grid-cathode capacity through this series resonant circuit, a coupling between the grid circuit and anode circuit may result, which would then cause an instability of the amplifier. In order to remove this, there is inserted between the cathode and control grid an auxiliary grid 115 which has a screening effect between these two electrodes. Since, with the series resonant circuits serving for increasing selectivity, it may lead to difficulties if also the anode current of the oscillator tube flows through the cathode resistance of the mixing tube, as may be the case with combined oscillator and mixing tubes (for example, type ACH1) frequently used at the present day, it is preferable either to use a separate oscillator tube or to transmit the oscillator oscillation inductively to the mixing tube grid.

In order to avoid the undesirable coupling which may arise between the anode and input circuit of the tube 111 owing to the cathode control-grid capacity, without being constrained to employ a separate tube with a screened cathode, a circuit according to Fig. 9 may be advisable. Here, the series resonant circuit is placed between the anode tuning circuit and the positive pole of the anode voltage source. The counter-coupling is effected here by a special condenser C, which only requires a low capacity. In order to supply voltage to the anode, the series resonant circuit in the anode supply lead must be bridged over by a resistance which acts as decoupling resistance. A choke connected in parallel with the series circuit condenser could also serve this purpose. However, since the abovementioned resistance would be connected in parallel with the input circuit of the tube and, therefore, has a damping and selectivity-worsening effect, it is preferable to connect a choke with the resistance, as is shown in Fig. 9. The series circuit and tuned anode circuit may again be coupled together, as is indicated by the arrow, in which case by adjustment and possible reversal of polarity of the coupling, care may be taken that a removal of damping increasing the selectivity, but no self-oscillation, occurs.

Fig. 10 shows a further possibility of connection. The series resonant circuit is connected here again between the upper anode circuit connection and the cathode. The counter-coupling channel contains, in addition to a condenser, a variable high-ohmic resistance, which serves for adjusting the counter-coupling. The anode circuit and series circuit may then again be coupled together. The cathode may be bridged over with respect to earth by a condenser, which is indicated by the dotted line in the drawings.

If, for screening of the input grid against the cathode, an additional grid arranged between the cathode and the control grid is employed, as in the tube 111 of Fig. 8, then it is desirable, in order to obtain adequate steepnesses, to bias this grid positively as a space-charge grid. In this case, however, certain difficulties arise. If the reciprocal of the amplification factor of this cathode-screen is made small enough to obtain a very effective screening, then this cathode screen, if it acts as a space-charge grid, must itself pass an amount of current which is very large in proportion, in order to obtain a desirable high control-grid steepness in the tube. If, however, the reciprocal of the amplification factor of this space-charge grid is made large enough, in which case desirably high steepness can be obtained at the control grid without inconveniently high space-charge grid current, the screening effect is small.

It has therefore proved to be preferable to separate the screening effect and the space-charge grid effect and to arrange directly in front of the cathode a pure screen-grid which is approximately at cathode potential or negative potential and which undertakes the prevention of capacitive coupling between the cathode and control grid; then, outside this grid, an actual space-charge grid with a relatively high reciprocal of the amplification factor, whereby the necessary steepness is produced at the control grid without the space-charge grid having to receive disproportionally high currents and then to arrange the actual control grid on the outside of this space-charge grid.

Since a quartz crystal electrically corresponds to a series resonant circuit, that is, a circuit having very small capacity, then according to a feature of the invention, the series resonant circuit is constituted by a quartz crystal.

Fig. 11 shows a constructional example of this idea of the invention. The idea of the invention is illustrated here in a remotely-controlled set, the control quartz being situated in the cathode circuit of the tube II. The quartz itself with its holder is denoted here by 201. Since the static capacity of the quartz with its holder would constitute a parallel path for the undesirable oscillations, this parallel capacity is tuned out by a coil 202, which is preferably made variable. The tuning-out has the effect that the static capacity of the quartz and of the support as well as the remaining stray capacities together with the coil 202 form an oscillatory circuit, which is tuned to the oscillations to be received. Connected in series with the coil 202 is the resistance 203, bridged over by a parallel condenser, which resistance serves for producing the grid bias. This resistance 203, it is true, damps the oscillatory circuit 201, 202, but this is not detrimental in the present case, since the oscillatory circuit 201, 202 of course is to serve for tuning out undesirable frequencies. Its resonance curve becomes so broad owing to the resistance 203, that, for all frequencies which are at all still amplified by the anode circuit 204 of the arrangement, an effective blocking in the cathode lead is produced, which is only interrupted by the narrow frequency band, which the quartz crystal 201 passes. Since the selectivity of the quartz crystal is extremely great, that is, the band which is passed by it is only very narrow, an extremely selective receiving set can be produced in this manner.

The input circuit of the superheterodyne receiver consists of the coil 205 to which the antenna circuit is also coupled at a tapping, as well as the rotary condenser 209, which serves for the adjustment of the wave-range as well as for the approximate establishment of synchronism between the input circuit and oscillator circuit. The oscillator circuit is formed from the coils on the core 206 and the condenser 210. The cores 205 and 206 consist of a Ferrocart-like material, it being, however, preferable to give these a somewhat higher permeability than is otherwise usual for high-frequency cores. The cores are situated between the poles of two magnets 207 and 208, the magnetism of which can be varied by a regulatable magnetising direct current for the purpose of the tuning of the set. The receiver is arranged in a manner well-known per se, with the aid of the diode VII and the circuits 211 and 212, which are somewhat detuned in opposite directions with respect to the intermediate frequency, for an automatic tuning correction. The difference voltage arising at the resistances 213 and 214 is used in a manner well-known per se for the regulation of the automatic correction of the tuning, this difference voltage being effective at the grid of the auxiliary tube VI.

In the anode circuit of the tube VI, the exciting windings of the two magnets 207 and 208 are inserted in parallel connection. The anode voltage for the tube VI may be derived at the operating post through the slide 215 from the resistance 216 which therefore acts as potentiometer. The resistance 216 is connected, on one hand, through a smaller resistance 217 to the negative pole of the anode voltage source, while, on the other hand, it is connected through the lead 218 to the positive pole.

The tube III, which is a duo-diode-triode, is employed both for automatic volume control and for demodulation. The control grid of this tube is connected here through a blocking condenser direct to the oscillatory circuit 204. The oscillatory circuit 220 is inductively coupled to the anode circuit of the tube III by means of the coupling coil 221.

Between the two circuits 204 and 220, an electrostatic screen 223 is provided, which may consist, for instance, of a number of parallel earthed wires arranged close to one another and has the effect that the two circuits 220 and 204 can be inductively coupled together, without appreciably influencing one another capacitively.

By means of the resistance 217 at the operating post and the corresponding slider, the bias for the tube III may be made negative to such an extent that practically no more sound comes through, whereas, on the other hand, by reduction of the negative bias, the back-coupling condition can be reached, that is, the set can be adjusted to maximum volume and sensitivity.

In order to make the automatic volume control independent of the adjustment of the volume at the operating post, the diode is connected for the volume control direct to the circuit 204.

In order that the back-coupling between the circuit 222 and the corresponding cathode circuit shall not be influenced by variations of the oscillator voltage, the oscillator voltage is limited by a diode in the tube V. This is effected by negatively biasing the particular diode path by means of a biasing battery 225 or other source of bias, that is, no damping of the circuit whatsoever is caused, as long as the oscillator voltage does not exceed the bias. If, however, the amount of the bias is reached, then from this point onwards the diode path acts practically as a short-circuit and thus prevents a further increase of the voltage, so that the oscillator voltage is kept constant over the entire range.

The second diode path of the tube V is also connected to the oscillator voltage through a relatively large blocking condenser 226 and a choke coil 227. The choke 227, with respect to which the capacitive resistance of the condenser 226 is negligible, forms together with the capacity of the corresponding diode path a member dependent upon frequency, so that at the corresponding diode path a voltage is effective which is merely dependent on the frequency of the oscillator. This voltage is rectified and produces at the resistance 228 a direct current voltage, which acts through the resistance 229 on the grid of the tube V and therefore controls the anode current of the tube V in accordance with the oscillator frequency, so that the instrument 224, which measures the current of the tube V, can be calibrated in frequencies.

It has already been mentioned above that it is preferable for the dimensioning of the series resonant circuit, which is to be situated in a counter-coupling channel, that is, for instance, in the supply to the cathode of an amplifying tube, to make the capacity of this circuit as small as possible in order to obtain as small a band width as possible.

In Fig. 12, the conditions which arise, in particular, at very small tuning capacities C_1, are pictorially illustrated. E is here the common earth lead or an equivalent zero lead of the apparatus and K the cathode, in the supply of which the said tuning circuit is to lie. L_1 is the tuning inductance.

It is now found that, in the first instance, two kinds of stray capacities are existent, firstly, the capacity C_2 shown in dotted lines, which therefore primarily constitutes the stray capacity between the cathode and that end of the coil L_1 which is connected to the cathode, with respect to earth, and, furthermore, the stray capacities C_3 and C_4. If the stray capacity C_2 becomes rather large this means that, in addition to the path through L_1 and C_1, a further parallel path to the cathode is existent, and it is apparent that the selective properties of the circuit L_1, C_1 must become ineffective if the parallel path C_2 receives such a small resistance in relation to the resistance provided by the actual tuning elements themselves, that this last-mentioned resistance is useless for the operation of the apparatus.

This drawback may then be obviated, as has already been mentioned above if there is connected in parallel with the capacity C_2 a coil L_2, preferably a variometer, and the inductance of this variometer L_2 is varied until this coil together with the stray capacities is tuned to the desired frequencies.

Since the selectivity of the arrangement is already roughly produced by the usual anode circuit or grid circuit tuning means and the tuning of the stray capacity C_2 and the coil L_2 is effected to the same frequencies as those of the said selection means, the following case is then given: By the said tuning means on the anode or control-grid side, only a certain frequency band is, in general, conducted to the arrangement, and substantially the same frequency band is tuned out again by the counter-coupling resistance, which is formed by the tuning means C_2, L_2, so that, if only this capacity C_2 and L_2 were provided, practically nothing at all is amplified.

It is seen that the pass range of the amplifier is now exclusively determined by the tuning of L_1, C_1, and it should be assumed that no difference whatever exists any longer in making C_1 as small as may be desired. This is not true, however, owing to the stray capacities C_4 and particularly C_3.

These two last-mentioned stray capacities lie in parallel with the actual tuning capacity C_1, and it is obvious that therefore the tuning capacity C_1 can never be made smaller than the value which is determined by the capacities C_4 and particularly C_3. Practical experiments have shown that the smallest effective value of C_1 which can be obtained in this manner lies at approximately 2–4 cms. capacity. These values are just sufficient to obtain in a tube with sufficient steepness, even at 1600 kilocycles, band widths which lie at about 10 kilocycles or even less. The adequate steepness may also be obtained, regardless of the fact that the geometrical arrangement of a normal tube is correspondingly chosen, by utilising a space-charge grid effect, as has also already been described.

However, cases may arise where it is undesirable to use tubes of such high steepness and, moreover, it would also be desirable to reduce the band widths materially, since then the possibilities arise of obtaining in the short-wave range substantially more favourable selectivities than hitherto. This may also be valuable for the ranges in longer waves, since, for instance, an apparatus according to the so-called "single-span" superhet principle can then be constructed, which receives a very high intermediate frequency and yet is sufficiently selective.

It is shown in Fig. 13 how this can be carried out. This figure corresponds substantially to the arrangement of Fig. 12, except that a screen S_1 is also provided aver the tuning circuit L_1, C_1 or at least over the coil L_1. This screen is shown in chain-dotted lines, whereby it is to be indicated that it is not made of solid material, but that for many cases, particularly when the coil L_1 is to couple to some other coil, it is preferable to make it of a wire network of parallel wires or the like, so that an electrostatic screening takes place, but an inductive coupling with another coil is possible.

If this screen S_1 were now connected to earth potential, the conditions would not be improved but worsened, since, of course, the stray capacity of the coil L_1 towards earth is then further increased. The screen S_1 is therefore kept at cathode potential, as indicated in the drawings. All stray lines of force which issue from the coil L_1 and would otherwise discharge on the earth lead E are then intercepted by the screen S_1 and, therefore, an increased capacity of the coil L_1 towards the cathode side develops, which, however, as is to be shown in the following, is not detrimental for the present purpose.

Seen from the cathode side, the two stray capacities C_5 and C_6, which correspond to the first-mentioned stray capacities C_3 and C_4, now no longer lie in parallel with the condenser C_1 but in series with this condenser. Since, however, a series connection of condensers, as is well-known, always has a smaller capacity than the smallest individual capacity of the series circuit, it is now possible to adjust any small capacities with the condenser C_1. With respect to the inductance of the coil L_1, the stray capacities C_5 and C_6 cause an apparent inductance increase, which can be compensated by suitable dimensioning of the coil L_1.

Since, as has already been previously pointed out, it is absolutely necessary that the screening should be as complete as possible between the individual circuits whilst the coil L_1 shall be capable of coupling, for the purpose of the neutralisation of existent residual couplings or for obtaining a removal of damping or the like, to the anode circuit coil or grid-circuit coil, the difficulty arises that owing to the screen S_1, which is, of course, at cathode potential, a capacitive coupling could arise towards a further coil, with which the coil L_1 is to be coupled. In order to avoid this, a further earthed screen S_2 is arranged at some distance from the screen S_1. By the two screens S_1, S_2 or by the mutual capacity of these two screens, which, if it becomes very disturbing, can of course be reduced by arranging the two screens at a somewhat greater distance from one another, no drawback is generally obtained, because the capacity of the two screens S_1, S_2 to one another is, of course, only connected in parallel with the stray capacity C_2 which exists in any case, and can be tuned out by corresponding adjustment of the variometer.

The variometer L_2 may, in this case, be of a very simple construction. Usually, ordinary honeycomb winding coils which are variable in their relative position are sufficient. Therefore, for example, a fixed coil may be provided, with respect to which a second coil may be moved, towards or away from it, by means of a spindle or the like. The two coils constituting the variometer L_2 need not be of particularly damping-free construction, since it may be favourable, if the band tuned out by the tuning means L_2, C_2 is rather broad, whereby the tuning is then little critical.

As great a dynamic resistance of the tuning circuit C_2, L_2 as possible is also unnecessary, since a dynamic resistance of 10 to 20,000 ohms is already sufficient to suppress amplification practically completely.

On the other hand, a large damping again has the advantage that possibly a particular subsequent correction of the tuning at the coil L_2 or at a small tuning condenser connected in parallel with the capacity C_2 is no longer necessary. For this reason, it may be preferable to wind the coil or the coils L_2 from very thin or resistance wire, in which case then this high resistance or this relatively high resistance of the coils L_2 presents the additional advantage that it can be used for producing a certain direct current potential drop, which produces the grid bias of the control grid with respect to the cathode K.

An example of a constructional arrangement of the individual parts in an arrangement according to Fig. 13 is given by Fig. 14. L_1 is here again the tuning winding of the series resonant circuit, which in the present constructional example is arranged on a double-T-shaped coil of high-frequency iron. Such a high-frequency iron may be, for instance, the well-known H-core made of "Sirufer." The iron core of the coil L_1 projects through corresponding recesses in the two plates P_1 and P_2 in such a manner that thereby the coil core undergoes a firm support within a Bakelite tube R_1. The Bakelite tubes R_1 and R_2 are fixed to corresponding recesses of a metal plate T_1. The metal plate T_1 has a tubular extension which projects through the screen S_3, which is earthed and may represent the screening wall of some screening box or the like. By means of a spring F_1, the plate T_1 is pressed against the screening wall in such a manner that it can be rotated about the tubular member passing through the screening wall S_3.

Between the two friction discs S_4 and S_5, which are resiliently pressed together, the tapered edge of the plate T_1 is gripped in such a manner that, by rotation of the driving wheel A, the whole body containing the tuning core with winding L_1 can be rotated about its axis, whereby a variable coupling can be obtained between the coil L_1 and the coil L_5, which may belong to the anode circuit or any other circuit of the receiver.

One end of the coil L_1 is connected to the plate T_2, which in turn is connected by a screened lead L_6 to the cathode. The other supply lead to the coil L_1 terminates at the pin *St*. This pin forms together with the metal tube R_3, which is fixed to the drive Tr_1 a capacity which corresponds to the capacity C_1 in Figs. 24 and 25 and can be varied in its value by more or less screwing-in of the drive Tr_1.

The tube R_1 carries at its outer side a wire spiral S_1 which preferably has a medium pitch. The winding preferably has a free end and is connected also to the plate T_2 and one feeding end of the coil L_1 or through the lead L_6 to the cathode of the tube, and corresponds to the screen S_1 in Fig. 25. The large pitch of the coil S_1 prevents it having an appreciable inductance. If, however, the whole apparatus is intended for the reception of rather short waves, or if it is a question of a short-wave transmitting apparatus in which the inductance also of a coil of large pitch could already lie within the resonance position of other constructional elements, then it may be advisable to provide, instead of a coil, only individual wire rings on the tube R_1, which may possibly be slotted and all electrically connected together by a transverse lead and connected to the plate T_2.

Likewise, the tube R_2 also carries a wire coil S_2 which is constructed substantially in accordance with the wire coil S_1, but is electrically connected to the plate T_1 instead of T_2.

I claim:

1. An electronic tube circuit arrangement comprising a cathode, an anode, and at least one grid, a counter-coupling channel and a series resonant circuit arranged in said cathode supply lead, and screening means surrounding the inductance of said series resonant circuit and connected to said cathode.

2. An electronic tube circuit arrangement comprising a cathode, an anode and at least one grid, a counter-coupling channel and a series resonant circuit arranged in said cathode supply lead, a tuned anode circuit, and a back-coupling between said series resonant circuit and said tuned anode circuit.

3. Arrangement for obtaining a selectivity increasing effect in tuning apparatus comprising an electronic tube having a cathode, at least one grid and an anode, a counter-coupling channel adjusted to stop the electron stream flowing from the cathode to the anode, and a resonant circuit tuned to the desired frequency and connected with the counter-coupling channel and rendering the counter-coupling channel substantially ineffective at said desired frequency.

4. Selective arrangement comprising an electronic tube having an anode, a cathode, and at least one grid, a negative feed-back circuit connected with said tube and adjusted so to bias the grid as to render the tube non-conductive, and a resonant circuit tuned to the desired frequency and rendering said negative feed-back circuit inoperative and the tube conductive at said frequency.

5. An electronic tube circuit arrangement comprising a cathode, an anode, and at least one grid, a counter-coupling channel, a series resonant circuit the natural frequency of which may be varied by varying a bias applied to one of the components of said series resonant circuit, and means for applying a variable bias to said component.

6. An electronic tube circuit arrangement comprising a cathode, an anode, and at least one grid, a counter-coupling channel connected in the cathode supply lead, a series resonant circuit connected in parallel to said counter-coupling channel, a first screening means surrounding the inductance of said series resonant circuit and connected to said cathode, and a second screening means surrounding said first screening means and connected to ground.

7. An electronic tube circuit arrangement comprising a cathode, an anode, and at least one grid, a negative feed-back channel arranged in said cathode supply lead, a series-resonant circuit connected in parallel with said negative feed-back channel, a tuned circuit connected in the supply lead to said anode, and a back-coupling connection between said tuned anode circuit and said series-resonant circuit.

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