July 31, 1934. G. A. MATHIEU 1,968,610

THERMIONIC AMPLIFYING SYSTEM

Filed March 21, 1932 3 Sheets-Sheet 1

Fig. 1

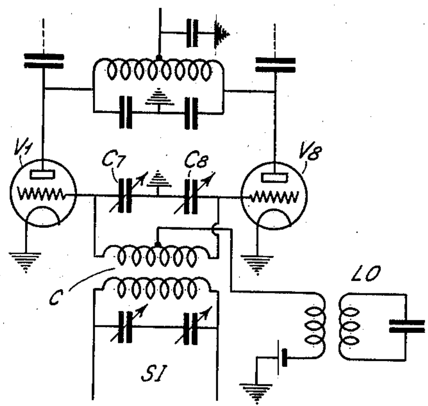

Fig. 2

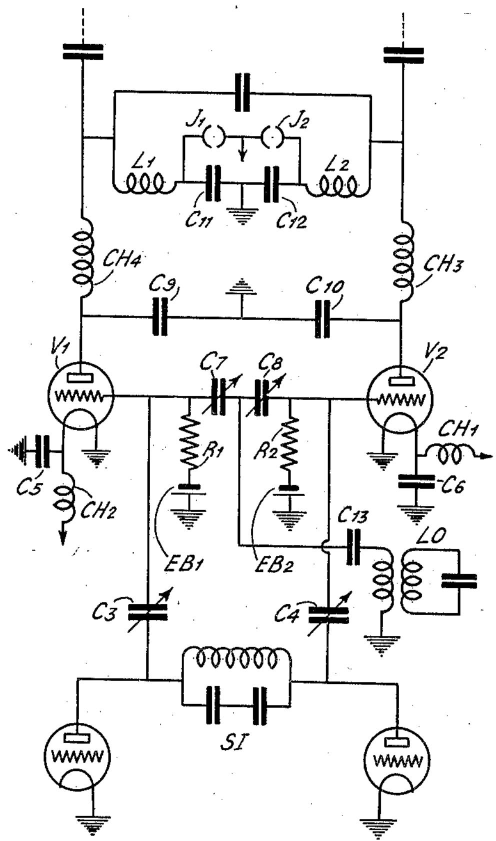

Fig. 3

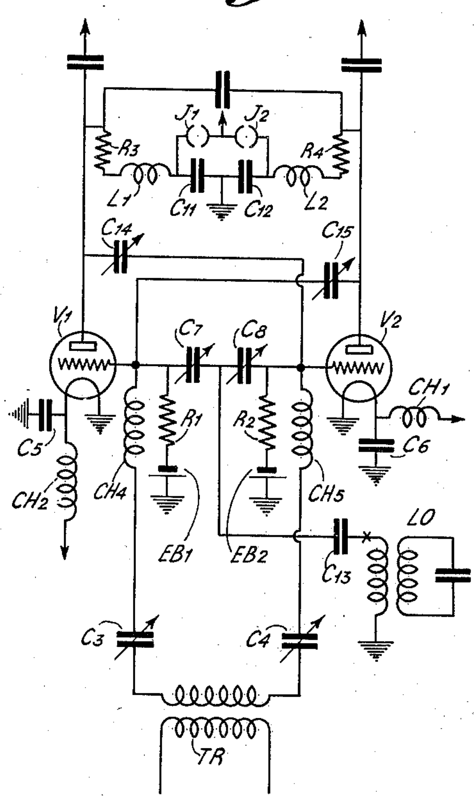

Fig. 4

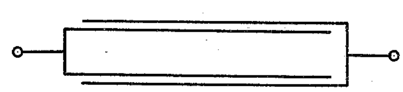

Fig. 5

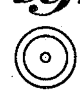

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Fig. 6

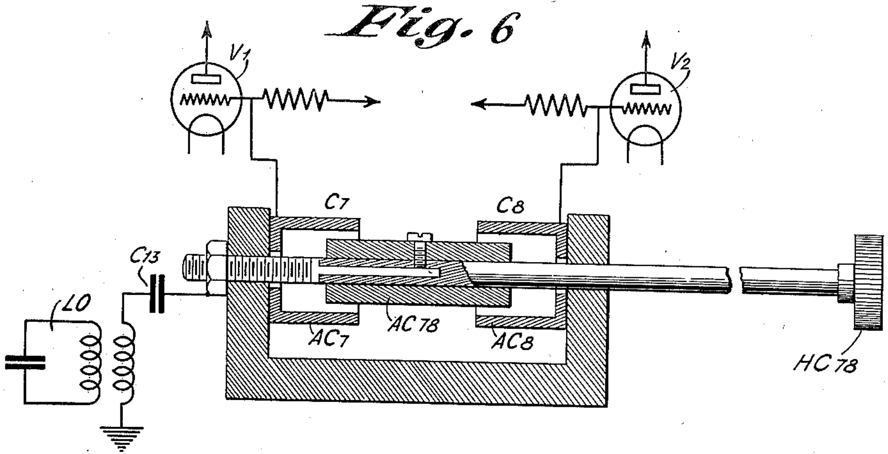

Fig. 7

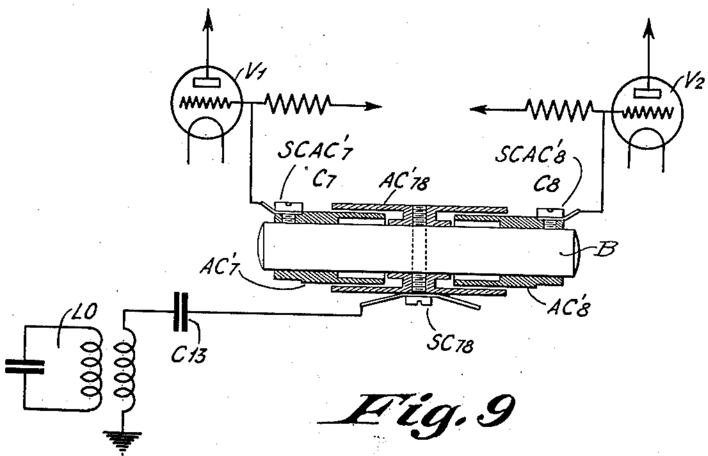

Fig. 9

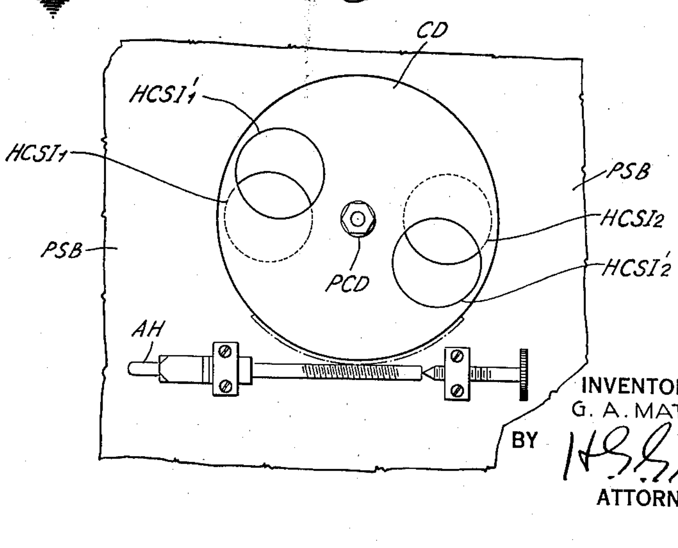

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Fig. 8

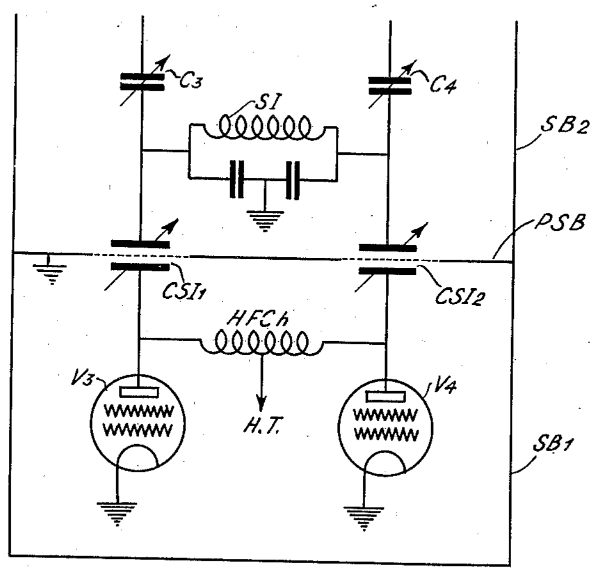
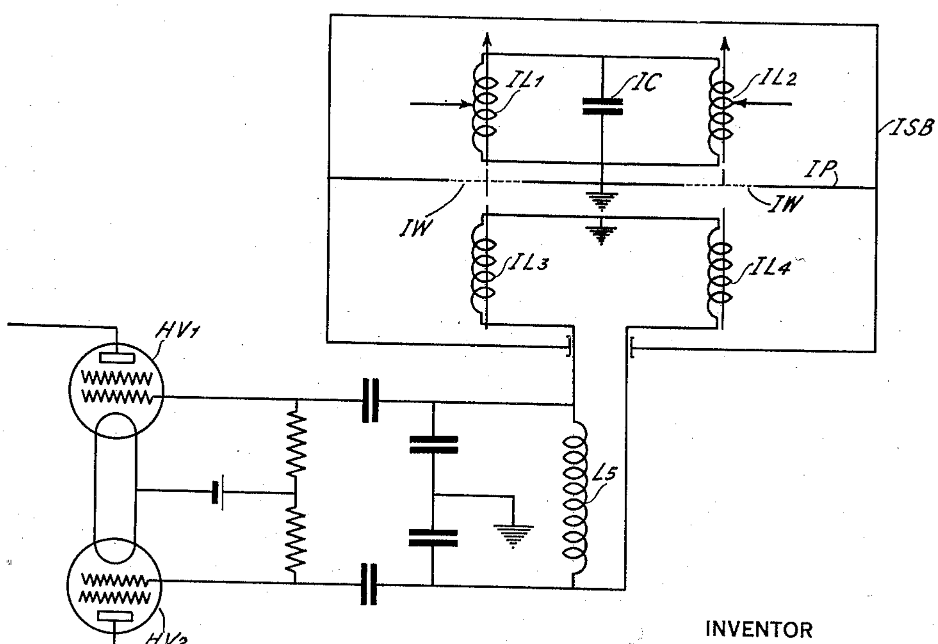


Fig. 10



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UNITED STATES PATENT OFFICE

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THERMIONIC AMPLIFYING SYSTEM

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Application March 21, 1932, Serial No. 600,104
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11 Claims. (Cl. 250—20)

The invention relates to thermionic amplifying systems and more particularly to a thermionic receiving amplifier of high sensitivity suitable for use on very short waves.

The invention provides an improved amplifying system of the kind in which a frequency changer is applied for changing the frequency of the signals to be amplified.

The invention is illustrated by and explained in connection with the accompanying drawings in which Figure 1 shows a known frequency changer arrangement, Figure 2 a frequency changing arrangement of the general type illustrated in Figure 1 but improved in accordance with the present invention, Figure 3 a modification of the arrangement shown in Figure 2, and Figures 4 and 5 are constructions of a condenser suitable for use in carrying out the inventions. Figures 6 and 7 illustrate, in section, condenser arrangements which may be utilized in this invention. Figure 8 is a preferred schematic arrangement for obtaining a weak coupling effect. Figure 9 is a front view of a portion of the apparatus used in Figure 8. Figure 10 illustrates a preferred arrangement for coupling the aerial to the first stage of a high frequency amplifier of a receiver.

Referring to Figure 1, this shows a known arrangement which has been employed as a frequency changer in an amplifying system for amplifying signals. As will be seen this frequency changing arrangement consists of a pair of valves whose grids are connected to one another through a pair of condensers in series and also through an inductance in shunt across said condensers, the middle point between the two condensers being earthed and the mid tapping on the coil shunting said condensers being taken through a further coil to earth, said further coil receiving local oscillations impressed through a circuit indicated in the figure as LO. The output circuit of the valve is of usual form, and is symmetrical with respect to earth as regards alternating current. As shown, the anode circuit comprises a pair of condensers shunted by a coil, the loop circuit thus constituted being connected between the anodes of the two valves, the point between the two condensers being earthed and a centre tapping on the coil being earthed through a condenser and being also connected to the positive source of anode potential. Signals are applied to the grids of the valves from the signal input circuit SI via the coupling C.

Now when the circuit shown in Figure 1 is preceded by a powerful high frequency amplifier, and, more especially, when it is employed for receiving short waves of the order of 10 metres or less, serious practical difficulties are introduced by reason of the very high "noise level" which occurs, in part by reason of the liability of the detector valves to break into self-oscillation and in part owing to the difficulty of obtaining an effective and satisfactory coupling to the output circuit of the high frequency amplifier. It will be obvious that it is desirable that there be a very strong action from the local oscillator on the two grid circuits of the push pull modulating valves which are working in parallel. In the circuit shown in the figure, the local oscillator voltages are applied from the middle of the grid coil, and it is quite difficult to obtain a strong action in this way, especially at very high frequencies, owing to the choking effect of the grid coil and also owing to the low reactances offered between the grids and earth by the tuning condensers. Moreover, unless the tapping on the grid coil be exactly at the centre (a requirement which in practice is hardly ever realized) circulating current due to the local oscillator will flow round the valve input circuit and thus the symmetry of the arrangement and many of the advantages of the circuit would be lost. Further it is exceedingly difficult to obtain two valves whose characteristics are and will remain exactly the same. Another serious disadvantage arises by reason of the tendency of the modulating valves to oscillate, due to the starting action of the local oscillator when it comes in tune with the output circuit of the frequency changer during tuning operations.

The present invention provides an improved circuit arrangement in which these disadvantages are avoided.

The invention also provides certain detailed improvements in arrangements for applying amplified radio frequency signals to the frequency changer of a superheterodyne receiver in accordance with the principal feature of the invention.

According to this principal feature of this invention, a frequency changer arrangement suitable for use in connection with a receiver for receiving very short wave lengths comprises two modulating valves whose grids are electrostatically coupled in parallel to a source of local oscillations, said grids being also electrostatically coupled in push-pull to an input signal circuit.

Preferably the coupling between the grids and the local oscillator is such that action of the oscillator upon said grids is separately adjustable for each grid, and preferably also the arrangement is such that the bias for each grid is independently adjustable.

Figure 2 of the drawings shows the general circuit arrangement of Figure 1, modified in accordance with the present invention. As will be seen, local oscillations from a source LO are applied through a condenser C_{13} and through two variable condensers C_7C_8 to the grids of the modulating valves V_1V_2, these grids being also coupled through variable condensers C_3C_4 to the signal input circuit generally indicated at SI. R_1R_2 are a pair of as nearly as possible pure ohmic resistances in series with batteries EB_1, EB_2, for applying grid voltage to the valves V_1V_2. If desired, potentiometers may be associated with the batteries EB_1 and EB_2 and in certain cases the resistances R_1R_2 may be replaced by chokes or chokes in series with resistances. The output circuit includes condensers C_9C_{10} and chokes CH_3 and CH_4 for the purpose of preventing any possibility of plate modulation. These chokes and condensers though desirable are not indispensable. Jacks J_1 and J_2 are provided in shunt with condensers C_{11} and C_{12} to facilitate "checking up" the various circuit adjustments and the output circuit inductances are shown at L_1 and L_2. Where the arrangement is for use on very short wave lengths, the provision of condensers C_5 and C_6 and filament chokes CH_1 and CH_2, as shown, will be found to be of advantage.

The condenser C_{13} serves to prevent any inductive coupling between the local oscillator and the valves. This condenser may conveniently be constructed as a condenser tube with air or any other suitable dielectric, and may form constructionally part of the circuit. For example, the arrangement shown in Figures 4 and 5 of the drawings may be conveniently employed, Figure 4 being a schematic sectional elevation and Figure 5 being an end view. The condenser C_{13} may, however, be dispensed with altogether, though its presence will generally be found of advantage.

Figure 3 of the drawings shows a modification of the arrangement shown in Figure 2, and it will be noted that high frequency chokes CH_4 and CH_5 have been introduced to prevent circulating current from the local oscillator flowing through the fairly large capacities C_3 and C_4, and through the secondary windings of the input transformer TR. C_{14} and C_{15} are so-called neutralizing condensers. If desired, the valves V_1 and V_2 may be replaced by so-called screened grid valves, as also can the valves V_1 and V_2 of Figure 2. Where it is desired to cause the output circuit to admit the two side bands, resistances R_3 and R_4 may be introduced, the output circuit being tuned to the same frequency as that of the local oscillator. In the case of one side band transmission only, however, the resistances R_3 and R_4 should be omitted and the output circuit made of as low damping as possible and tuned to one of the side band frequencies.

Preferably the condensers C_7C_8 of Figures 2 and 3 of the drawings are constituted by a single condenser structure which may be, and preferably is, a differential condenser structure.

Figure 6 of the accompanying drawings shows, in schematic section, a form of differential condenser which may be employed to constitute the said condensers C_7 and C_8, the figure showing, also in diagrammatic form, just sufficient of the circuit of Figure 2 or Figure 3 to identify the connections of the said condenser structure.

Referring to the accompanying Figure 6 in more detail, the condenser structure comprises an insulated carrier member HC_{78} upon which is mounted a pair of fixed tubular electrodes AC_7 and AC_8, these electrodes corresponding to those electrodes of the condensers C_7 and C_8 which are directly connected to the grids of the valves V_1 and V_2. Electrostatically coupled to the electrodes AC_7 and AC_8 is a movable electrode or condenser armature AC_{78} which, as shown, is so mounted that it may, by operation of a handle HC_{78} (which actuates a screw), be moved towards the fixed electrode AC_7 or towards the fixed electrode AC_8. The armature AC_{78} is electrically connected to the condenser C_{13} of Figures 2 and 3 and thence to a coil which is coupled to the local oscillator LO. It will be seen that the condenser illustrated in Figure 6 is a differential condenser since any movement of the handle HC_{78} to increase the capacity of the condenser C_7 will also decrease the capacity of the condenser C_8, and vice versa.

Figure 7 of the accompanying drawings shows another arrangement which may be employed in place of that shown in Figure 6. The construction shown in Figure 7 comprises, in effect, two independently separately adjustable condensers, one of which constitutes the condenser C_7, and the other the condenser C_8. These condensers have a common electrode AC'_{78} which is tubular and of the form shown in section in Figure 2 of the drawings. The electrode AC'_{78} is mounted upon an insulating bar B by means of a set screw SC_{78} which passes through said electrode and bar as illustrated. On the bar B is adjustably mounted a pair of tubular movable electrodes AC'_7 and AC'_8 which electrodes are so dimensioned that they may be entered into the electrode AC'_{78} at either end thereof to adjustable extents. The electrodes AC'_7 and AC'_8 are held in any predetermined position of adjustment by screws $SCAC'_7$ and $SCAC'_8$ which pass through the said electrodes into the central bar B. The connections to the condenser structure shown in the accompanying Figure 7 correspond to those of the structure shown in Figure 6.

A superheterodyne receiver in accordance with this invention may, of course, and in general practice ordinarily will, include a high frequency amplifier preceding the frequency changer, this high frequency amplifier embodying one or more than one amplifier stages. To put the matter in another way, the signal output circuit SI of Figure 2 of the drawings may (as is indeed indicated in this figure) be energized from a high frequency employing any desired suitable number of tuned high frequency stages. It has been found that with a superheterodyne receiver in accordance with the present invention, if the heterodyne wave impressed on the grids of the valves V_1V_2 (see Figure 2 of the drawings) be very accurately balanced, an extremely small coupling is all that is required between the output circuit of a preceding high frequency amplifier and the input circuit to the frequency changer, and indeed the use of an extremely weak coupling is advantageous inasmuch as it results in a substantial increase in the ratio of signals to "noise".

Figure 8 of the accompanying drawings shows diagrammatically a preferred arrangement whereby a weak adjustable coupling may be obtained. In this figure, V_3V_4 represent the valves of a final push-pull connected stage of a radio frequency amplifier, the anode potential being applied to the valves via a centre tapping upon a choke HF*Ch*. The stage including the valves V_3V_4 is enclosed within a screening box SB_1 and the frequency changer stage within a screening box SB_2, this box having a common partition PSB. The partition PSB is provided with holes or apertures and on either side of these holes or apertures are arranged condenser electrodes which, as indicated in the accompanying Figure 8, constitute the condensers coupling the valves V_3V_4, to the circuit SI. The coupling condensers thus constituted are indicated by the reference letters CSI_1 and CSI_2 and are preferably so arranged that there is no need to move their constituent electrodes to vary their capacities, the desired adjustment being obtained by cutting off to an adjustable degree the apertures in the partition PSB. Figure 9 of the accompanying drawings shows schematically one arrangement whereby the variation of the capacity of the condensers CSI_1 and CSI_2 may be effected. Referring to Figure 9, the apertures in the partition PSB are indicated at $HCSI_1$ and $HCSI_2$. Rotatably mounted upon the partition PSB is a circular disc CD said disc being pivoted at PCD and being arranged to be rotated for example, by a worm drive from a handle (not shown) which is attached to the shaft AH. The circular disc CD is provided with two apertures $HCSI'_1$ and $HCSI'_2$ of the same size as the apertures in the partition and so positioned that as the disc CD is rotated the apertures in the partition may be masked to a greater or less extent, the masking of course being determined by the position of the circular disc and the apertures therein with respect to the positions of the fixed apertures in the partition. Thus by rotating the shaft AH, the value of the coupling condensers CSI_1 and CSI_2 may be varied.

It is, of course, to be understood that one electrode of each of the condensers CSI_1 and CSI_2 is arranged on one side of the appropriate aperture and the other electrode on the other side the rotating disc structure with the associated apertures in the partition being located between the electrodes of the condensers, i. e. in the dielectric spaces thereof. The partition PSB is, of course, earthed and the disc CD is also earthed.

Figure 10 shows a preferred arrangement for coupling the aerial to the first stage of a high frequency amplifier of a receiver in accordance with this invention. It has been found that with short wave working, considerable practical difficulty exists in coupling an ordinary earthed screened feeder leading from an antenna to the input circuit of a push-pull high frequency amplifier and the accompanying Figure 10 shows an arrangement in which this is employed in a satisfactory manner. Referring to Figure 10, the ends of the feeder wires (which ends are indicated by arrow heads) are tapped upon two coils IL_1 and IL_2 which are connected in parallel with one another and with a condenser IC. These coils and condensers are mounted as shown within a screening box ISB having a partition IP within which are formed windows or apertures IW. The coils IL_1 and IL_2 are arranged opposite coils IL_3 and IL_4, and the coils IL_1 and IL_2 IL_3 and IL_4 being so positioned that coil IL_1 is magnetically coupled to coil IL_3 through a window IW, the coil IL_2 being also coupled to the coil IL_4 through a window IW. In order to prevent electrostatic coupling, suitable wire gauze is preferably stretched across the windows IW. Means for varying the magnetic coupling without necessitating movement of the coils are provided. A rotating disc and aperture structure similar to that shown in the accompanying Figure 9 may be employed. The coils IL_1 and IL_2 and the condenser IC are earthed to the box ISB at one end, and the coils IL_3 and IL_4 are also earthed at one end, the other ends of the last mentioned coils being connected across a coil L_5 which is connected as shown between the grids of the first stage of the high frequency amplifier, the valves of which are indicated in Figure 10 at HV_1 and HV_2. These valves are preferably screened grid valves. The push pull effect is obtained by reversing the direction of winding coils IL_3 and IL_4 and preferably the inductance of the coils IL_3 and IL_4 is made considerably bigger than that of the coils IL_1 and IL_2 in order that variation of the effective inductance of the coil L_5 due to variation of the coupling via the windows IW may be as small as possible. The tapping upon coils IL_1 and IL_2 are chosen so that the impedance presented by the circuit IL_1 $ICIL_2$ to the feeder connected thereto, matches the surge impedance of said feeder.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A superheterodyne receiver suitable for use on very short wave lengths and including a frequency changer arrangement comprising two modulating valves whose grids are electrostatically coupled in parallel to a source of local oscillations, said grids being also electrostatically coupled in push-pull to an input signal circuit.

2. A superheterodyne receiver suitable for use on very short wave lengths and including a frequency changer arrangement comprising two modulating valves whose grids are electrostatically coupled in parallel to a source of local oscillations, an adjustable capacitance located between each of said grids and said source of local oscillations, said grids being also electrostatically coupled in push-pull to an input signal circuit.

3. An arrangement as defined in claim 1 and in which bias for each grid is independently adjustable.

4. An arrangement as defined in claim 1 in which the two grids are connected to one another through a pair of condensers in series, the common point of said condensers being connected to a coupling condenser through which the local oscillations are applied.

5. An arrangement as defined in claim 1 in which the two grids are connected together through a pair of condensers in series, said condensers being constituted by a mechanically unitary structure comprising a common electrode and two other electrodes adjustably positioned with respect thereto.

6. Translating apparatus having, in combination, a detector circuit comprising two electron discharge devices having their corresponding control electrodes connected together through two variable condensers serially arranged between said electrodes, a connection including a capacity from a point intermediate said condensers to a local oscillator circuit, separate sources of biasing potentials for said control electrodes, and individual resistances intermediate said sources and said electrodes, a signal input circuit, and means for electrostatically connecting said control electrodes to said signal input circuit.

7. Translating apparatus suitable for short waves having, in combination, two modulating electron discharge devices whose control electrodes are connected together by a pair of seri-

ally connected and differentially arranged condensers whereby increase of capacity of one condenser is accompanied by decrease in capacity of the other, a signal input circuit, electrostatic connections from said control electrodes to said signal input circuit, a connection from the midpoint of said differentially arranged condenser structure to a source of local oscillations, and biasing means for said control electrodes.

8. A superheterodyne receiver comprising two push-pull connected electron discharge devices each having anode, cathode and control electrodes, a connection consisting solely of two serially arranged variable condensers between the control electrodes of said devices, individual biasing means for each control electrode, a source of local oscillations and an electrostatic connection from said source to a point between said two variable condensers, a signal input circuit coupled to both of said control electrodes through additional variable condensers individual to each control electrode.

9. A superheterodyne receiver comprising two push-pull connected electron discharge devices each having anode, cathode and control electrodes, a connection consisting solely of two serially arranged variable condensers between the control electrodes of said devices, individual biasing means for each control electrode, a source of local oscillations and an electrostatic connection from said source to a point between said two variable condensers, a signal input circuit coupled to both of said control electrodes through additional variable condensers individual to each control electrode, and a choke coil connected in series with each of said last condensers.

10. A super-heterodyne receiver suitable for use on very short wave lengths and including a frequency changer arrangement comprising two modulating valves whose grids are electrostatically coupled in parallel to a source of local oscillations, a pair of amplifier valves, the grids of said modulating valves being coupled in push-pull to the output circuits of said amplifying valves, said frequency changer arrangement being enclosed within a screening box and said amplifying valves being enclosed within another screening box.

11. A superheterodyne receiver suitable for use on very short wave lengths and including a frequency changer arrangement comprising two modulating valves whose grids are electrostatically coupled in parallel to a source of local oscillations, a pair of multi-electrode amplifier valves whose anodes are connected together through a high frequency choke coil, connections from the grids of said modulator valves to the anodes of the amplifier valves, each connection including two serially connected capacity reactances, and a circuit comprising an inductance in parallel with a capacitance extending from the junction point of the two capacities of one connection to the junction point of the two capacities of the other connection.

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