May 3, 1932. E. KARPLUS 1,856,709

COUPLING ARRANGEMENT FOR COMPENSATED HIGH FREQUENCY AMPLIFIERS

Filed Jan. 9, 1928

Fig. 1

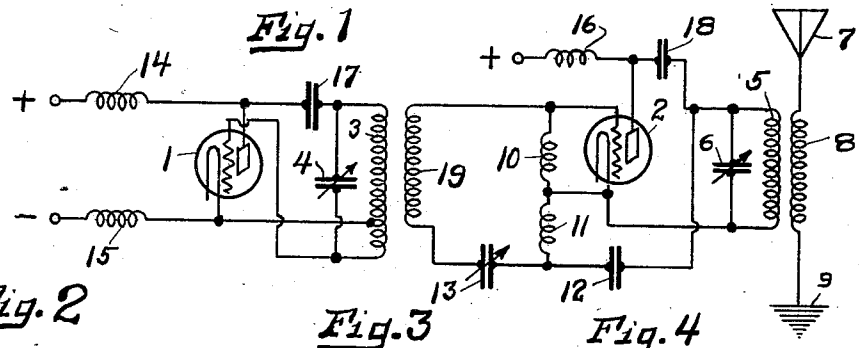


Fig. 2

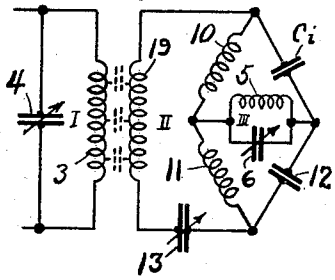


Fig. 3

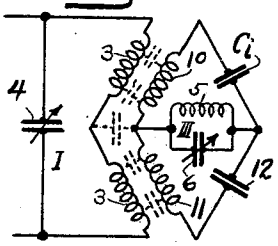


Fig. 4

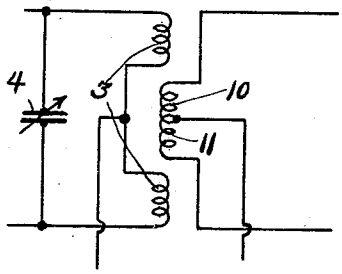


Fig. 5

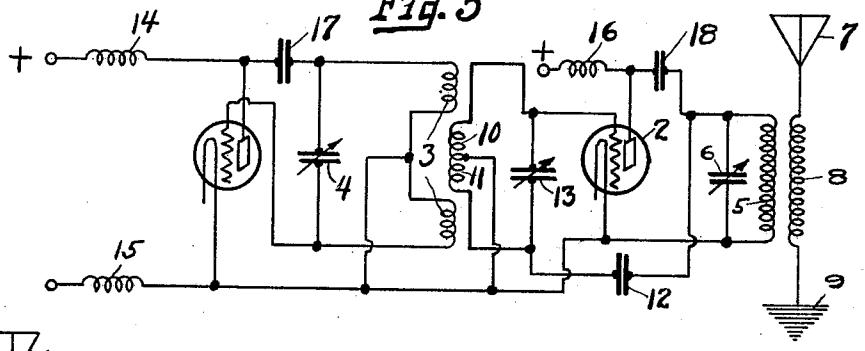
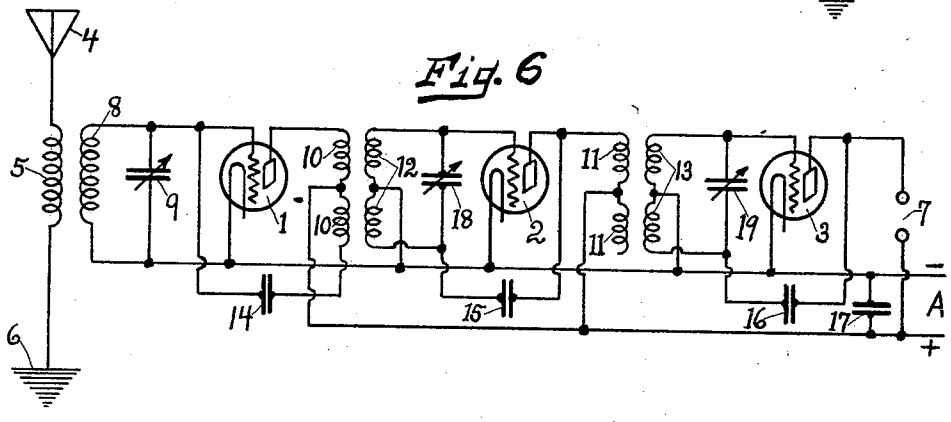


Fig. 6



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UNITED STATES PATENT OFFICE

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COUPLING ARRANGEMENT FOR COMPENSATED HIGH FREQUENCY AMPLIFIERS

Application filed January 9, 1928, Serial No. 245,616, and in Germany January 11, 1927.

This invention refers particularly to coupling arrangements for compensated high frequency amplifiers such as may be used for sending and receiving apparatus for wireless telegraphy or telephony with short waves. A well-known method of preventing undesirable coupling between tuned tube circuits is termed a neutrodyne connection. This circuit consists of a bridge connection or a compensating connection in which the grid or anode coil is split into two parts which form two branches of the bridge, while the two other branches are formed by the internal capacity of the tube and by a neutralizing condenser. The diagonal connection then includes the coupled circuit, that is, with the grid compensation it is the anode circuit, with the anode compensation it is the grid circuit.

It has been found with the use of short waves especially that the prevention of coupling which is secured in this manner is not complete. Thus, if the coupling or tuning is changed, the equalizing of the bridge must also be changed. These changes may be attributed to the fact that the balance is disturbed by the capacity influence of coupling coils, which becomes especially conspicuous with the use of short waves.

These observations apply to the receiving circuits just as much as to the sending circuits, especially of the separately controlled type. The latter, as is well known, may have a controlling oscillation generated in the master sender, brought up by several amplifiers connected in cascade to the desired power output of the main sender.

According to this invention the disturbing capacity influence between the coupling coils is prevented by dividing the coils symmetrically and by arranging them in such a way that the potential is distributed symmetrically on the two coils and remains symmetrical with the changes of tuning and coupling. The invention is illustrated by several examples on accompanying drawings.

Fig. 1 shows the application of the balancing or neutrodyne principle to a separately controlled sender,

Fig. 2 is a diagrammatic illustration of the principle of operation of Fig. 1,

Fig. 3 is another modification of a usual balancing connection,

Fig. 4 shows the relation of coupling coils according to the principle of this invention,

Fig. 5 is an arrangement of amplifier for separately controlled sending circuit according to the principle illustrated in Fig. 3, and

Fig. 6 illustrates the principle of this invention as applied to an amplifier in a receiving circuit.

It is known that in separately controlled tube senders regeneration or reaction of the main sender on the master sender may take place very easily. This phenomenon depends, as mentioned above, on the same causes as the regeneration or reaction of a high frequency amplifier consisting of a number of tubes in cascade, that is, due to the coupling of the individual oscillating circuits through the internal capacity of the tubes. The compensation known in connection with the high frequency amplifiers by the name of neutrodyne connection or bridge for preventing coupling of individual oscillating circuits may be therefore used to advantage on a separately controlled tube sender as shown in Fig. 1. In this figure, 1 represents the master sender, with self-oscillating three-point connection. The anode self-inductance is 3 and the anode tuning capacity 4; 2 is the main sending tube with the anode self-inductance 5 and tuning capacity 6. This inductance 5 is coupled with a utilization circuit which in the example illustrated is an antenna circuit consisting of antenna 7, coupling coil 8 and ground 9. The desired prevention of coupling is achieved by dividing the grid coil of the main sender in this case (although anode coil could also be used) into two substantially equal parts 10 and 11 in such a way that they, together with the inner tube capacity between the grid and the anode, and with a neutralizing or compensating condenser 12 form the arms of a bridge, while the diagonals of this bridge are formed by the circuit which is to be separated, that is, the anode circuit in this case.

Furthermore, in Fig. 1 numeral 13 represents a tuning condenser; 14, 15 and 16 are the choke coils to block off the high fre-

quency from the anode supply circuit; 17 and 18 represent the blocking condenser to block off the direct current from the parts of the circuit carrying high frequency, and finally, 19 represents a grid circuit coupling coil.

The prevention of coupling of the oscillating circuits secured in this manner is, as mentioned above, insufficient for short waves, since with a change of tuning of the oscillating circuit or else with the change in coupling between the main and the master oscillator, or between the main oscillator and the antenna, the equalization of the bridge is distributed.

This can be explained as follows:—

In the circuit coupled to the bridge circuit, that is, in the example illustrated, the master sending circuit (or with an anode compensation, the antenna circuit) in addition to the inductive coupling has moreover a capacitative coupling, through the coupling capacity of the coils. This is explained more clearly in Fig. 2, in which this relation is illustrated. The numerals correspond to the elements of Fig. 1; I represents the anode circuit of the master sender, II the grid circuit of the main sender, and III the anode circuit of the main sender. The capacitative coupling between circuits I and II is illustrated by dotted line condensers between coils 3 and 19. It is this coupling which the bridge arrangement as illustrated is incapable of balancing.

Fig. 3 shows an arrangement usual with neutrodyne receiving connections, in which the anode circuit of a tube is directly applied to the grid of the following tube, that is, without any intermediary circuit. The capacitative coupling between the coils is illustrated again by dotted lines. If the equalization of the bridge is so arranged that the inductive reaction of the coupled circuits does not take place, a capacitative influence would still remain, which would change with the change of coupling or the tuning of the circuit. This would disturb the balance which is set up accurately at a definite coupling and tuning.

According to the present invention these capacitative influences between the circuits inductively coupled to the main sender are prevented or reduced to a harmless value. The capacitative action could be prevented by sufficient separation of the coupling coils. However, the inductive coupling would be lost at the same time. According to the invention, these objections are avoided by coupling the oscillating circuits with coils which are divided in an entirely symmetrical manner. A further thought of the invention is in the arrangement of one coil in the neighborhood of a symmetry point of the other coil at which all potential is absent. An illustration of this arrangement is shown in Figs. 4 and 5, the numerals of which correspond to those of Fig. 1. In these figures the symmetrically split grid coil of the main sender 10 and 11 is placed inside of the anode coil 3 of the master sender with a three-point connection. With this arrangement both the main sender and the master sender coils have fully symmetrical potential distribution, which symmetry remains also with the changes in tuning or coupling. In this way the compensation of the grid circuit of the main sender can be maintained after the first setting. However, since the parts of the main sender coil which carry potential are located in the neighborhood of the parts of the master sender coil which have no potential, the distributing capacitative influence of the main sender on the master sender is practically prevented. The coupling transformer 10—12 serves for deriving compensating potential for both tubes 1 and 2 and at the same time, the compensating potential for tube 1 being derived from the primary of the transformer i. e., grid compensating circuit arrangement, and the compensating potential of tube 2 being derived from the secondary of the transformer i. e., anode compensating circuit arrangement. A special advantage of this arrangement is in the fact that in spite of the small capacitative influence the inductive coupling of the master sender on the grid circuit of the main sender can be made almost fixed. In order to destroy as much as possible the capacitative action it may be desirable to make the inner coil of two narrow superposed windings of thin wire.

In somewhat simpler manner it is possible to connect the antenna coil to the anode circuit or reverse, using at the same time anode compensation.

Fig. 6 shows finally a receiving circuit which is connected according to the invention; 1, 2, and 3 are three high frequency amplifying tubes connected in cascade. These tubes amplify the energy from the antenna circuit, taken from antenna 4, antenna coupling coil 5, and earth connection 6. They conduct further the amplified energy to a rectifying arrangement 7 for eventual connection with further low frequency amplifiers. Numerals 8 and 9 are tuning means (as inductance and capacity) of the secondary circuit coupled to the aperiodic antenna. Numerals 10, 11, 12 and 13 are the coupling coils (high frequency transformers) between the individual tube stages; and 14, 15 and 16 represent the compensating condensers. For the rest, the connection corresponds in general with the separately excited sender, as described above. The point of symmetry of coils 12 and 13 are connected with the zero potential point, that is, the negative pole of the heating battery. The symmetry points of coils 10 and 11 are in a similar manner

connected to a bridging connection 17 so that on both coils of the group 10 and 11 or 12 and 13 there is the same potential division and the additional capacitative influence does not occur with the change of conditions. Numerals 18 and 19 are grid tuning condensers.

According to the object of this invention the location of one coil may again be at the symmetry point of another coil, at which there is no potential. In this way the capacitative influence is brought to a minimum and in spite of that the coupling may be made sufficiently tight with short waves, the capacitative by-path for high frequency being almost completely removed.

Having described my invention, what I declare to be new and desire to secure and protect by Letters Patent of the United States is:—

1. In combination with a neutralized high frequency amplifying system, a vacuum tube having anode, cathode and control electrodes, a primary inductance coil for receiving oscillating currents to be amplified by said tube, said inductance having its mid point tapped and connected to the zero reference point of said system, whereby equal high frequency potential occurs at the ends of said inductance, a secondary inductance arranged symmetrically within said first inductance coil and also having its mid point tapped and connected with the zero potential reference point of said system for producing controlling potential and compensating potential for said vacuum tube, and the capacitative couplings of said inductances varying uniformly with changes in frequency and degree of coupling.

2. In combination with a neutralized high frequency amplifying system, a vacuum tube having anode, cathode and grid electrodes, a primary inductance coil receiving oscillating currents to be amplified by said tube, said coil having its mid point tapped and connected with the zero potential reference point of said system, a secondary inductance coil arranged symmetrically within said first inductance coil and having its mid point tapped and connected with said cathode being at zero reference potential, the capacitative couplings of said inductances varying uniformly with changes in frequency and degree of coupling, a variable tuning condenser in parallel with said secondary coil and circuit connections from one end of said second coil to said grid electrode, a further connection from the other end of said secondary coil to the anode of said vacuum tube and a neutralizing condenser in said last mentioned connection.

3. In combination with a neutralized high frequency amplifying system; a vacuum tube having anode, cathode and control electrode; a primary inductance coil consisting of two equal sections spaced from each other and with their winding axis coinciding; a connection from the mid-point of said sections to the zero reference point of the amplifier system whereby equal high frequency potential occurs at the opposite ends of said sections; a secondary inductance coil arranged within the space between said sections of said primary inductance coil and symmetrical thereto, its winding axis coinciding with the axis of said primary coils, said secondary inductance also having its mid-point tapped and connected with the potential for said vacuum tube and the capacitative couplings of said inductances varying uniformly with changes in frequency and degree of coupling.

In testimony whereof I have affixed my signature.

EDUARD KARPLUS.