May 22, 1951 D. KLEIS ET AL 2,554,107

PUSH-PULL MIXING CIRCUIT

Filed Feb. 12, 1947

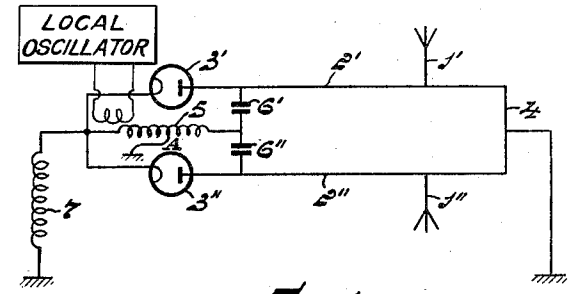

Fig. 1

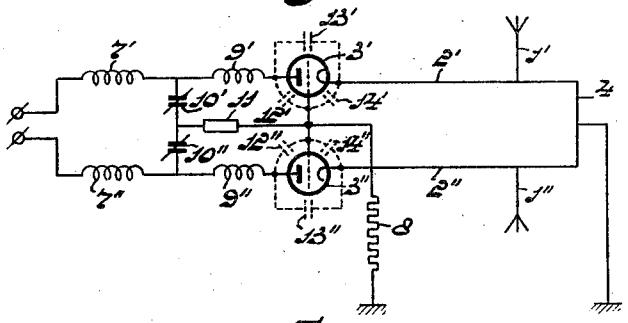

Fig. 2

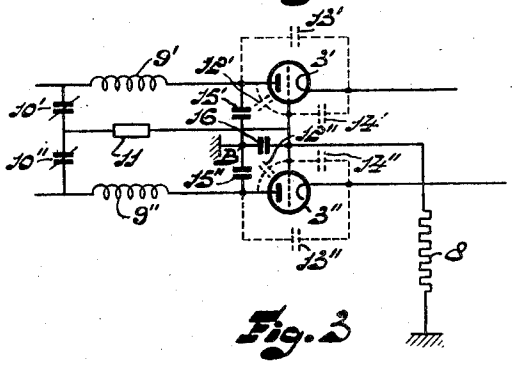

Fig. 3

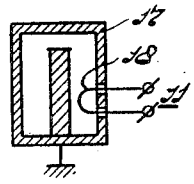

Fig. 4

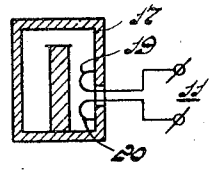

Fig. 5

D. KLEIS & A. VAN WEEL
INVENTORS
BY Fred M Vogel
AGENT

Patented May 22, 1951 2,554,107

UNITED STATES PATENT OFFICE

2,554,107

PUSH-PULL MIXING CIRCUIT

Derk Kleis and Adelbert van Weel, Eindhoven, Netherlands, assignors to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application February 12, 1947, Serial No. 728,134
In the Netherlands July 26, 1944

Section 1, Public Law 690, August 8, 1946
Patent expires July 26, 1964

5 Claims. (Cl. 250—20)

1

This invention relates to a mixing circuit, more particularly for ultra-short waves, in which the incoming oscillations and the local oscillations are supplied respectively in push-pull and in phase coincidence to the input electrodes of two discharge systems.

In a superheterodyne receiver for ultra-short waves, in which the local oscillations and the incoming oscillations are supplied respectively in phase coincidence and, through an adjustable Lecher system, in push-pull to the mixing tubes, it was previously proposed to connect the aerial to the push-pull circuit at a point where a voltage node occurs with respect to the local oscillations. This was accomplished by lengthening the Lecher wires on the side remote from the mixing tubes by a suitable amount and by interconnecting the ends by means of a short-circuiting bridge which is coupled to a point of constant potential. This arrangement prevented radiation of the local oscillations by the aerial, while the influence of variations in the impedance of the aerial on the tuning of the circuit was eliminated.

The invention is directed to the attainment of the same object by simpler means and in a more efficacious manner. The invention provides a circuit-arrangement in which the aerial does not radiate the local oscillations, even if the frequency of these oscillations is varied over a broad range.

According to the invention, in the aforesaid mixing circuit the local oscillations are supplied to the discharge systems in a particular manner and the impedances between the discharge systems and a point of constant potential (earth) are so chosen that substantially no voltage having the frequency of the local oscillations is produced between the input electrodes of the discharge systems and the point of constant potential.

The local oscillations are preferably supplied in such a manner and the said impedances are given such values that, with any adjustment over a broad frequency range, substantially no voltage having the frequency of the local oscillations is produced between the input electrodes and the point of constant potential.

In order to attain the object aimed at, the input electrodes of the discharge systems may, for example, be connected, via a path of comparatively low impedance for the local oscillations, to a point of constant potential (earth), and one or more other pairs of electrodes of the discharge systems may be connected to the point of constant potential via a path of comparatively high impedance.

2

The local oscillations can effectively be supplied to the discharge systems in such manner that the push-pull circuit through which the incoming oscillations are supplied to the discharge systems and the co-phase circuit or circuits through which the local oscillations are supplied to the discharge systems, have only the discharge systems in common.

With each of the discharge systems the source of local oscillations can advantageously be coupled between a pair of electrodes. If each of the discharge systems is coupled separately with the source of local oscillations, for example by inductive means, each of the two circuits having the same phase, of which at each instance one of the discharge systems forms part, is preferably tuned to the frequency of the local oscillations. If the discharge systems are fed in parallel connection by the source of local oscillations, the circuit having the same phase as this source, the parallel-connected input impedances of the discharge systems and the parallel-connected coupling impedances, is tuned to the frequency of the local oscillations.

Furthermore, a material improvement of the circuit according to the invention may be obtained by connecting one or more points, which in the part of the co-phase circuit have the same potential as the input electrodes of the discharge systems, to a point of constant potential (earth) either directly or through a path of low impedance with respect to the local oscillations.

The latter step has the effect of reducing the radiation of local oscillations by the aerial almost to nothing. Besides, in this circuit arrangement the direct current supply of the discharge tubes may take place in a very simple manner.

In order that the invention may be clearly understood and readily carried into effect, it will now be set out more fully with reference to the accompanying drawing in which:

Figure 1 is a schematic diagram of a mixing circuit according to the invention,

Figure 2 is a schematic diagram of another mixing circuit according to the invention,

Figure 3 is a schematic diagram of a third mixing circuit according to the invention,

Figure 4 shows one cavity resonator arrangement for use in the circuit of the invention, and

Figure 5 shows another cavity resonator arrangement for use in the circuit of the invention.

Fig. 1 shows a mixing circuit pertaining to a superheterodyne receiver for short waves, in which the invention is applied. The oscillations received by a dipole aerial 1', 1'' are supplied in

push-pull to the input electrodes of two mixing diodes 3', 3'' by means of two conductors 2', 2''. The latter form part of a Lecher system which is tuned to the frequency of the incoming oscillations by means of an earthed short-circuiting bridge 4. The aerial 1', 1'' is connected to a point of the Lecher system 2', 2'', so as to obtain a correct adaptation of the aerial to the mixing tubes.

A local oscillator is coupled by inductive means with a coil 5, one end of which is connected to the anodes of the discharge systems through condensers 6', 6'', the other end being connected to the junction of the cathodes of the two mixing diodes. The local oscillations are consequently supplied in phase coincidence to the mixing diodes.

In this connection it may be observed that the co-phase circuit through which the local oscillations are supplied to the mixing diodes, and the push-pull circuit through which the incoming oscillations are supplied to the mixing diodes have solely the mixing diodes in common. In circuit-arrangements previously proposed, the whole of the push-pull circuit was included in the co-phase circuit.

The said junction of the cathodes of the mixing diodes is earthed through a path of comparatively high impedance relatively to the local oscillations. In the present case the path is through a choke or a system of chokes 7'. The cathode direct current and the current for the filaments are supplied to the two mixing diodes through the said choke or chokes.

The intermediate-frequency output voltage is obtained in push-pull from the mixing diodes.

In order that a maximum voltage of the frequency of the local oscillations may be supplied to the input electrodes of the mixing diodes, the co-phase circuit, formed by the inductance coil 5, the parallel-connected coupling capacities 6', 6'' and the parallel-connected input impedances of the two mixing diodes 3', 3'', is tuned to the frequency of the local oscillations.

By using the afore-described method by which the local oscillations are supplied to the input electrodes of the mixing diodes and by the choice of the impedance between the cathodes of the mixing diodes and earth, in the present case a choke which constitutes a high impedance relatively to the frequency of the local oscillations, it is ensured that between the input electrodes and earth substantially no voltage having the frequency of the local oscillations occurs. The local oscillation voltage which occurs between the input electrodes on the one hand and between the interconnected cathodes of the mixing diodes on the other hand brings about a high local oscillation voltage across the choke 7 and only a very low voltage across the impedance between the input electrodes and earth. This voltage division occurs because of the high impedance of the choke 7 and the low impedance of the Lecher-system 6 with respect to the local oscillations. Consequently, between the dipole aerial 1', 1'' and earth there is substantially no voltage of the frequency of the local oscillations and therefore the aerial does not radiate oscillations of this frequency. This applies not only to one definite frequency of the local oscillations, but also applies when this frequency is varied through a broad range. This is of importance for receivers tunable in a broad range of frequencies.

Under certain conditions it may occur that the co-phase impedance between the input electrodes of the mixing diodes and earth (via the push-pull circuit) accidentally assumes a high value. In this case the object aimed at can nevertheless be attained in a simple manner, since in the co-phase part of the circuit, one or more points (points of symmetry) which have the same potential for the frequency of the local oscillations as the input electrodes may be connected to earth. In the present circuit-arrangements this may be effected by connecting to earth point A of the coil 5. This point is chosen so that in the circuit constituted by the coil 5, the capacity 6' and the mixing diodes 3' and 3'' and the capacity 6'' respectively, the point A has the same potential as the anode of the mixing diode 3'. This is the case when the inductance of the coil 5 to the left and to the right of point A is approximately inversely proportional to the input capacity of one of the diodes 3', 3'' and the capacity of one of the condensers 6', 6''.

If two co-phase circuits (double coil 5) are used and if each of these circuits includes a coupling condenser (6', 6''), it is possible to indicate a point A on each of the coils, which can serve as a point of symmetry for one of the anodes.

By connecting point A to earth the input electrodes of the two mixing diodes and, consequently, the aerial 1', 1'', are effectively at earth potential with respect to the local oscillations. The aerial is thus prevented under any condition from radiating local oscillations and this, practically speaking, independently of the frequency of the local oscillations.

The circuit-arrangement offers the additional advantage that the cathode direct current and the heating currents can be supplied via point A so that the choke or the system of chokes 7 may be dispensed with.

Fig. 2 shows a circuit-arrangement in which the push-pull circuit is included between the cathodes of two mixing triodes 3', 3''. The control grids of these triodes are jointly connected to earth through a high resistance 8. The local oscillations are generated by the circuit itself. To this end, the co-phase circuit provided between the anodes and the control grids of the mixing triodes is tuned to the frequency of the local oscillations. This circuit is constituted by the parallel connection of two inductance coils 9', 9'', the parallel connection of two capacities 10', 10'', an impedance 11 arranged between the junction of the capacities 10', 10'' and the interconnected control grids, and by the parallel-connected anode-control grid capacities of the mixing triodes 12', 12''. The figure furthermore shows the anode-cathode capacities 13', 13'' and the control grid-cathode capacities 14', 14''. The positive feedback required for the generation of the local oscillations is brought about by means of the aforesaid internal capacities of the tubes. The local oscillations generated are supplied in phase to the input electrodes of the mixing triodes.

The intermediate-frequency output voltage is taken from the circuit through chokes 7', 7''. The direct current supply of the anodes of the mixing triodes also takes place through this path. The control grids may be given an appropriate biassing potential via the resistance 8.

The co-phase impedance which occurs between the anode and earth relatively to the local oscillations is determined substantially by the impedance of the chokes 7', 7'', whereas the corresponding impedance between the control grids and earth is determined by the resistance 8.

These impedances are chosen so that their value, with respect to the local oscillations, is high as compared with the co-phase impedance which occurs between the cathodes of the triodes and earth, measured via the push-pull circuit. It is thus ensured in a manner similar to that in the circuit shown in Fig. 1 that substantially no voltage having the frequency of the local oscillations can occur between the input electrodes of the triodes 3', 3'' and earth and, consequently, between the aerial 1', 1'' and earth.

If, however, the co-phase impedance between the two cathodes and earth should accidentally assume a high value, one or more suitably chosen points of the co-phase circuit may be earthed in the same manner as used in the circuit shown in Fig. 1, so that under any conditions it is ensured that the aerial cannot radiate local oscillations.

It is frequently possible to indicate on the impedance 11 a point whose potential with respect to the local oscillations corresponds to that of the cathodes of the mixing triodes. By earthing this point it may be ensured that the cathodes and, consequently, the aerial are earthed with respect to the local oscillations. In those cases in which it is not possible to indicate a point of symmetry of the cathodes on the impedance 11, or in which it is not desirable to earth a point of this impedance, a point of symmetry of the cathodes of the mixing triodes may be obtained in the co-phase circuit by providing some few impedances, for example, some few capacities, and this point may then be earthed.

Such a case is assumed in Fig. 3, in which only the corresponding parts of the circuit-arrangement shown in Fig. 2 are represented separately. The point of symmetry of the cathodes of the mixing diodes is now obtained by arranging two series-connected capacities 15', 15'' between the anodes of the mixing triodes 3', 3'' and by connecting the junction B of these capacities, on the one hand via a condenser 16, to the control grids of the triodes and, on the other hand, directly to earth. The point B constitutes the desired point of symmetry provided that the ratio between the capacities 13' and 14' is equal to the ratio between the capacity 15' and half the capacity of the condenser 16.

In order to stabilize the oscillator frequency, it is frequently advisable to realise the impedance 11 as a cavity resonator whose outside is earthed. In this case the mixing systems may be coupled with the cavity resonator by means of a coupling loop completely insulated from the cavity resonator. In an alternative arrangement, the two supply lines to the cavity resonator may be realised in the form of loops which are led-in so as to be insulated from the outside and which are secured to the inside of the cavity resonator at such a height that the input electrodes of the mixing systems are effectively at earth potential with respect to the frequency of the local oscillations.

Fig. 4 shows a cavity resonator 17, in which use is made of a coupling loop 18 which is completely insulated from the cavity resonator. Fig. 5 shows a cavity resonator in which two coupling loops 19 and 20 are led-in in an insulated manner and are secured to the inner wall of the cavity resonator at the desired points. The ratio between the surfaces of the loops determines the point of symmetry with respect to the input electrodes.

What we claim is:

1. An electrical circuit arrangement for mixing a first wave and a second wave to produce an intermediate frequency wave, comprising a pair of mixing elements each having a pair of cooperating electrodes, a Lecher-system tuned to the frequency of said first wave and having an open end thereof coupled to a corresponding electrode of each of said mixing elements in push-pull relationship and having a closed end, means to couple said closed end to a point at constant potential of said circuit arrangement, impedance means intercoupling said corresponding electrodes and the other electrodes of said mixing elements, means to apply said second wave to said impedance means thereby to apply said second wave to said mixing elements in phase coincidence, an impedance element having a high impedance value at the frequency of said second wave intercoupling said other electrodes and said point at constant potential substantially to isolate said other electrodes from said point of constant potential at the frequency of said second wave, an output circuit coupled to said mixing elements, and means to apply said first wave to said Lecher-system thereby to develop said intermediate frequency wave in said output circuit.

2. An electrical circuit arrangement for mixing a first wave and a second wave to produce an intermediate frequency wave, comprising a pair of mixing elements each having a pair of cooperating electrodes, a Lecher-system tuned to the frequency of said first wave and having an open end thereof coupled to a corresponding electrode of each of said mixing elements in push-pull relationship and having a closed end, means to couple said closed end to a point at ground potential of said circuit arrangement, impedance means intercoupling said corresponding electrodes and the other electrodes of said mixing elements, means to apply said second wave to said impedance means thereby to apply said second wave to said mixing elements in phase coincidence, an inductance element having a high reactance value at the frequency of said second wave intercoupling said other electrodes and said point at ground potential substantially to isolate said other electrodes from said point at ground potential at the frequency of said second wave, an output circuit coupled to said mixing elements, and means to apply said first wave to said Lecher-system thereby to develop said intermediate frequency wave in said output circuit.

3. An electrical circuit arrangement for mixing a first wave and a second wave to produce an intermediate frequency wave, comprising a pair of mixing elements each having an anode and a cathode, a Lecher-system tuned to the frequency of said first wave and having an open end thereof coupled to the anodes of said mixing elements in push-pull relationship and having a closed end, means to couple said closed end to a point at ground potential of said circuit arrangement, a first inductive element intercoupling the anodes and cathodes of said mixing elements, means to apply said second wave to said first inductive element thereby to apply said second wave to said mixing elements in phase coincidence, a second inductive element having a high reactance value at the frequency of said second wave intercoupling said cathodes and said point at ground potential substantially to isolate said cathodes from said point at ground potential at the frequency of said second wave, an output circuit coupled to said mixing elements, and means to apply said first wave to said Lecher-

system thereby to develop said intermediate frequency wave in said output circuit.

4. An electrical circuit arrangement for mixing a first wave and a second wave to produce an intermediate frequency wave, comprising a pair of mixing elements each having an anode and a cathode electrode, a Lecher-system tuned to the frequency of said first wave and having an open end thereof coupled to a corresponding electrode of each of said mixing elements in push-pull relationship and having a closed end, means to couple said closed end to a point at ground potential of said circuit arrangement, a tapped inductive element intercoupling said corresponding electrodes and the other electrodes of said mixing elements, means to couple the tapping of said tapped inductive element to said point at ground potential, means to apply said second wave to said tapped inductive element thereby to apply said second wave to said mixing elements in phase coincidence, an inductive element having a high reactance value at the frequency of said second wave intercoupling said other electrodes and said point at ground potential substantially to isolate said other electrodes from said point at ground potential at the frequency of said second wave, an output circuit coupled to said mixing elements, and means to apply said first wave to said Lecher-system thereby to develop said intermediate frequency wave in said output circuit.

5. An electrical circuit arrangement for mixing a first wave and a second wave to produce an intermediate frequency wave, comprising a pair of mixing elements each having an anode and a cathode electrode, a Lecher-system tuned to the frequency of said first wave and having an open end thereof coupled to a corresponding electrode of each of said mixing elements in push-pull relationship and having a closed end, means to couple said closed end to a point at ground potential of said circuit arrangement, a first inductive element having one end thereof coupled

to the other electrodes of said mixing elements, first and second capacitive elements coupled in series between said corresponding electrodes and having a junction, means to couple the other end of said inductive element to said junction, said mixing elements, said first inductive element and said capacitive elements constituting a pair of series circuits each tuned to the frequency of said second wave, means to apply said second wave to said first inductive element thereby to apply said second wave to said mixing elements in phase coincidence, a second inductive element having a high reactance value at the frequency of said second wave intercoupling said other electrodes and said point at ground potential substantially to isolate said other electrodes from said point at ground potential at the frequency of said second wave, an ouput circuit coupled to said mixing elements, and means to apply said first wave to said Lecher-system thereby to develop said intermediate frequency wave in said output circuit.

DERK KLEIS.
ADELBERT VAN WEEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,968,610	Mathieu	July 31, 1934
1,978,446	Aubert	Oct. 30, 1934
2,101,438	Lindenblad	Dec. 7, 1937
2,211,003	Conklin	Aug. 13, 1940
2,434,474	Strutt	Jan. 13, 1948
2,441,452	Strutt et al.	May 11, 1948
2,453,078	Posthumus	Nov. 2, 1948

FOREIGN PATENTS

Number	Country	Date
507,495	Great Britain	June 15, 1939
544,675	Great Britain	July 14, 1943