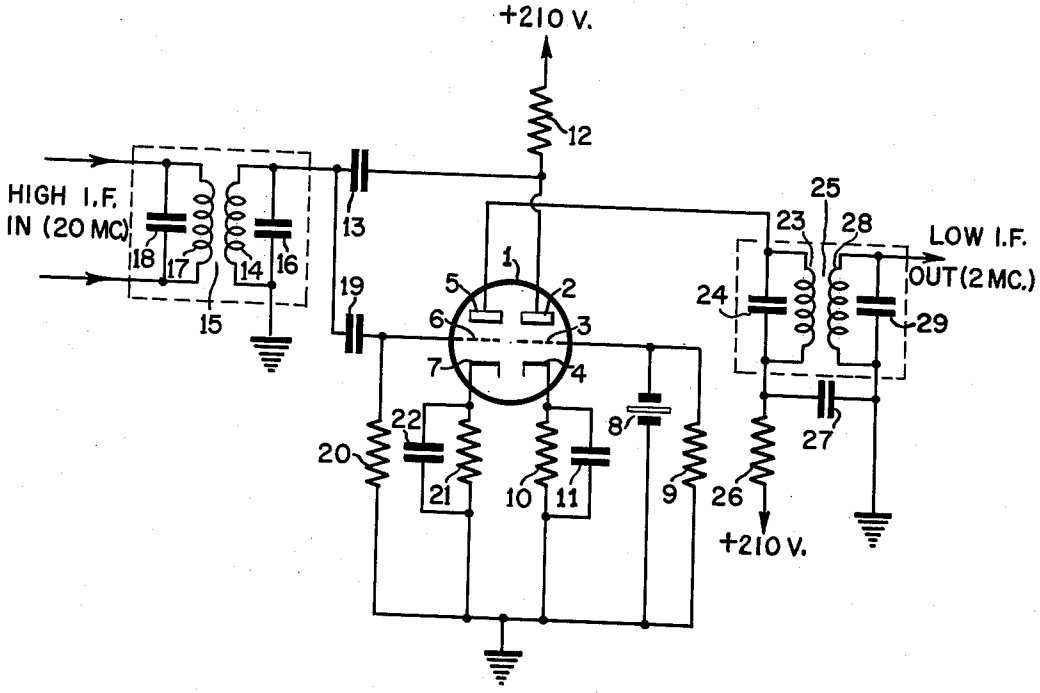
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MIXER CIRCUIT

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# MIXER CIRCUIT

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This invention relates to a mixer circuit, and more particularly to a combined oscillator-doubler-mixer circuit.

Although not limited thereto, this invention is particularly useful in the receiver portion of a mobile transmitter-receiver, for converting a signal of high intermediate frequency (I. F.) to a lower intermediate frequency. In such mobile equipment, it is highly advantageous to reduce as much as possible the number of tubes and circuit components utilized, in order to reduce the total weight and cost of the equipment.

Accordingly, an object of this invention is to devise an oscillator-mixer circuit which uses fewer components and tubes than those of the prior art ordinarily use.

Another object is to provide a novel oscillator-multiplier-mixer circuit utilizing only a single tube.

A further object is to devise a novel doubler-mixer circuit in which no extra tuned circuit is necessary in order to effect the doubling function.

Still another object is to device an improved oscillator-doubler-mixer circuit which is rather simple in construction yet highly effective in operation.

The objects of this invention are accomplished, briefly, in the following manner: A single twin-triode vacuum tube is utilized in this invention, the first triode section acting as the oscillator-multiplier and the second triode section as the mixer. The three electrodes of the first triode section are connected as a crystal-controlled Colpitts oscillator. Frequency multiplication (doubling) is effected in the anode circuit of this first section through the action of the secondary of a tuned input transformer which is coupled to such anode circuit and to the primary of which the signal to be heterodyned down in frequency is applied. The multiplied (doubled) frequency and the signal to be heterodyned down are then both fed to the grid of the second triode section, and mixing of these two frequencies takes place in this section, the changed frequency being taken from the anode of this second triode section.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein the single figure is a schematic representation of a circuit arrangement according to this invention.

Now referring to the drawing, the evacuated electron discharge device **1** is the single tube used as an oscillator-doubler-mixer according to this invention. Tube **1** is of the twin-triode type and may be type 12AU7 or 12AT7, having two entirely independent triode sections, the first of which consists of anode **2**, grid or control electrode **3** and cathode **4**, and the second of which consists of anode **5**, grid or control electrode **6** and cathode **7**. A piezoelectric crystal **8** is connected between grid **3** and ground, a resistor **9** being connected across this crystal, or also between grid **3** and ground. Cathode **4** is connected through a parallel RC network, consisting of a resistor **10** and a capacitor **11**, to ground or one



electrode of crystal **8**. The interelectrode capacitance between grid **3** and cathode **4**, and the capacitor **11** from cathode **4** to ground, provide a capacitive voltage divider across crystal **8** (which can be considered a tuned circuit), and the intermediate point or tap on this divider is connected to the cathode **4**. Polarizing potential for the first triode section **2**, **3**, **4** is provided by connecting the anode **2** through a resistor **12** to the positive terminal (+210 v.) of a source of unidirectional potential.

The tube elements **2**—**4** with the associated circuit, provide a crystal-controlled Colpitts oscillator. In order to complete the oscillatory circuit, anode **2** is coupled to ground (the side of "tuned circuit" crystal **8** opposite to the grid side thereof). This latter coupling is made from anode **2**, through a capacitor **13** and also through a parallel tuned circuit consisting of the secondary winding **14** of an input transformer **15** and a capacitor **16**, to ground. Capacitor **13** is of such value as to have low impedance at the crystal frequency, which as an example may be eleven megacycles. Transformer secondary **14** is tuned (by means of capacitor **16**)) to nearly twice the crystal frequency, and as an example such secondary may be tuned to twenty megacycles. Since secondary **14** is parallel tuned to twenty megacycles, it offers low impedance to ground at the eleven-mc. crystal frequency. Therefore, the anode **2** of the oscillator triode section **2**—**4** is essentially at ground potential at the crystal frequency, and may be considered connected to the grounded side of crystal **8**. As a result, the triode section **2**—**4** acts as a crystal-controlled Colpitts oscillator, producing oscillations which appear at anode **2**. Due to the fact that the equivalent resonant circuit **8** is connected essentially between grid **3** and cathode **4**, the oscillator effectively produces oscillations between such grid and cathode, so that the frequency of the oscillator is not affected by any tuning of the anode circuit of the oscillator.

The transformer **15** is tuned to the high intermediate frequency (I. F.=20 mc.) of the input signal which is to be beaten down or heterodyned down in frequency by the mixer circuit of the invention. The input signal is representative of energy received on a radio receiver, reduced in frequency in a suitable mixer or detector, and then applied to winding **17** of transformer **15**. This high I. F. is sufficiently close to the oscillator second harmonic (which in the example chosen would be 22 mc.) to provide sufficient impedance at the 22 mc. doubled frequency to cause frequency doubling action to take place in the anode circuit of the oscillator **2**—**4**, to the anode **2** of which the tuned transformer secondary **14** is connected. Thus, the second harmonic of the crystal oscillator frequency (22 mc.) appears in the secondary circuit **14** of transformer **15**.

It may therefore be seen that one triode half or section (elements **2**, **3** and **4**) of the twin triode tube **1** acts as a heterodyne oscillator-frequency doubler.

The high intermediate frequency (20 mc., for example) input signal to the mixer of the invention is applied across the tuned primary winding **17** of transformer **15**. Winding **17** is tuned by means of a parallel capacitor **18**.

Both the second harmonic of the crystal frequency and the high I. F. input or signal frequency are applied to grid **6** through a capacitor **19** connected between the ungrounded end of winding **14** and such grid. A grid leak resistor **20** is connected between grid **6** and ground. A cathode biasing arrangement, consisting of a resistor **21** and a capacitor **22** in parallel, is connected between cathode **7** and ground. In order to provide an output circuit and in order to apply the proper polarizing potential to anode **5**, said anode is connected through the primary winding **23** (tuned by a parallel capacitor **24**) of an output transformer **25** and through a resistor **26**, to the posi-

tive terminal (+210 v.) of a source of unidirectional potential. A bypass capacitor **27** is connected between the anode end of resistor **26** and ground, in order to keep the I. F. out of the unidirectional potential source.

The second triode half or section (elements **5**, **6** and **7**) of the twin triode tube **1** acts as a mixer. The second harmonic (22 mc.) of the crystal frequency beats with the high I. F. input frequency (20 mc.) in the mixer half of tube **1** (both of these last-named frequencies being applied to grid **6** of this triode section) to give the low I. F. of 2 mc. which appears in the primary winding **23** coupled to anode **5**. Winding **23** is tuned to the 2 mc. difference frequency, by means of capacitor **24**. One end of the secondary **28** of transformer **25** is grounded, while the low I. F. mixer output (2 mc.) is taken from the other end of said secondary. Winding **28** is tuned to the 2-mc. difference frequency, by means of a parallel capacitor **29**.

Transformer secondary **14**, being tuned to the high I. F. input frequency of 20 mc. and therefore offering low impedance at frequencies remote therefrom, provides filtering action, in effect by-passing to ground, and preventing from getting to the mixer grid **6**, the fundamental crystal frequency, or harmonic frequencies thereof other than the second. In this way, spurious responses are prevented. In addition, the transformer **15** provides an effective means of coupling the oscillator-multiplier **2**, **3**, **4** and also the input signal, to the mixer **5**, **6**, **7**. Also, since the secondary **14** of this transformer is used for frequency doubling, no separate or additional tuned circuit is necessary to effect such doubling.

It can be seen, from the foregoing description, that only a single tube **1** is needed for the entire oscillator-doubler-mixer function, both halves of a twin-element tube being utilized.

The following values are given but only by way of example, for the components illustrated in the drawing. These values were actually used in a circuit built according to this invention and successfully tested.

| | | |
|---|---|---|
| Resistor **9** | ohms | 100,000 |
| Resistor **10** | do | 2,700 |
| Resistor **12** | do | 47,000 |
| Resistor **20** | do | 100,000 |
| Resistor **21** | do | 2,700 |
| Resistor **26** | do | 1,000 |
| Capacitor **11** | mmfd | 27 |
| Capacitor **13** | mmfd | 100 |
| Capacitor **16** | mmfd | 22 |
| Capacitor **18** | mmfd | 22 |
| Capacitor **19** | mmfd | 33 |
| Capacitor **22** | mfd | .01 |
| Capacitor **24** | mmfd | 51 |
| Capacitor **27** | mfd | .01 |
| Capacitor **29** | mmfd | 51 |

The low I. F. (2 mc.) output from transformer **25** is fed to suitable low frequency conversion circuits to transform the same to an audio frequency for utilization in a transducer circuit such as a loudspeaker or headphones.

The term "ground" herein employed is not limited to an actual earthed connection but is deemed to include a point of zero radio frequency or fixed reference potential.

What is claimed is:

1. In a mixer circuit for a receiver, an electrode structure having a plurality of electrodes including an anode electrode, a resonant circuit intercoupling said electrodes for the generation of oscillatory energy, said energy appearing at said anode electrode, a parallel resonant circuit having substantial impedance at a selected harmonic of the frequency of said oscillatory energy but negligible impedance at said oscillatory energy frequency, means coupling one end of said last-named circuit to said anode electrode, means connecting the other end of said last-named circuit to ground, whereby oscillatory energy of said harmonic frequency appears in said parallel resonant circuit, means for supplying received signal energy to said parallel resonant circuit, a triode electrode structure having anode, cathode and control electrodes, means for applying the voltage across only said parallel resonant circuit to said control electrode as the sole signal input thereto, and an output circuit coupled to said last-named anode electrode.



2. In a mixer circuit for a receiver, an electrode structure having a plurality of electrodes including an anode electrode, a resonant circuit intercoupling said electrodes for the generation of oscillatory energy, said energy appearing at said anode electrode, a parallel resonant circuit tuned to the frequency of the received signal energy and having substantial impedance at a selected harmonic of the frequency of said oscillatory energy but negligible impedance at said oscillatory energy frequency, the received signal energy and the selected harmonic frequency being of the same order of magnitude, means coupling one end of said last-named circuit to said anode electrode, means connecting the other end of said last-named circuit to ground, whereby oscillatory energy of said harmonic frequency appears in said parallel resonant circuit, means for supplying received signal energy to said parallel resonant circuit, a triode electrode structure having anode, cathode and control electrodes, means for applying the voltage across only said parallel resonant circuit to said control electrode as the sole signal input thereto, and an output circuit coupled to said last-named anode electrode.

3. In a mixer circuit for a receiver, an electrode structure having a plurality of electrodes including an anode electrode, a resonant circuit intercoupling said electrodes for the generation of oscillatory energy, said energy appearing at said anode electrode, a transformer having a parallel tuned secondary winding and a primary winding, said tuned secondary winding having substantial impedance at a selected harmonic of the frequency of said oscillatory energy but negligible impedance at said oscillatory energy frequency, means for supplying received signal energy to said primary winding, means coupling one end of said secondary winding to said anode electrode, means connecting the other end of said secondary winding to ground, whereby oscillatory energy of said harmonic frequency appears in said secondary winding, a triode electrode structure having anode, cathode and control electrodes, means for applying the voltage across only said secondary winding to said control electrode as the sole signal input thereto, and an output circuit coupled to said last-named anode electrode.

4. In a mixer circuit for a receiver, a triode electrode structure having a plurality of electrodes including an anode electrode, a resonant circuit intercoupling said electrodes for the generation of oscillatory energy, said energy appearing at said anode electrode and said resonant circuit including a piezoelectric crystal for stabilizing the frequency of said energy, a transformer having a secondary which is parallel tuned to the frequency of the received signal energy, said secondary having substantial impedance at a selected harmonic of the frequency of said oscillatory energy but negligible impedance at said oscillatory energy frequency and the received signal energy frequency and the selected harmonic frequency being of the same order of magnitude, whereby oscillatory energy of said harmonic frequency appears in said secondary, means for supplying the received signal energy to the primary of said transformer, means coupling one end of said secondary to said anode electrode, means coupling the other end of said secondary to ground, a triode electrode structure having anode, cathode and control electrodes, means for applying the voltage developed across only said secondary to said control electrode as the sole signal input thereto, and an output circuit coupled to said last-named anode electrode.

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