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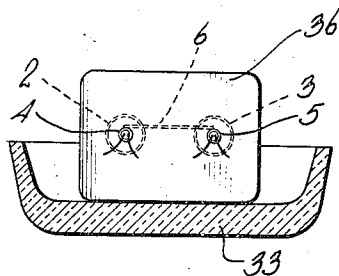
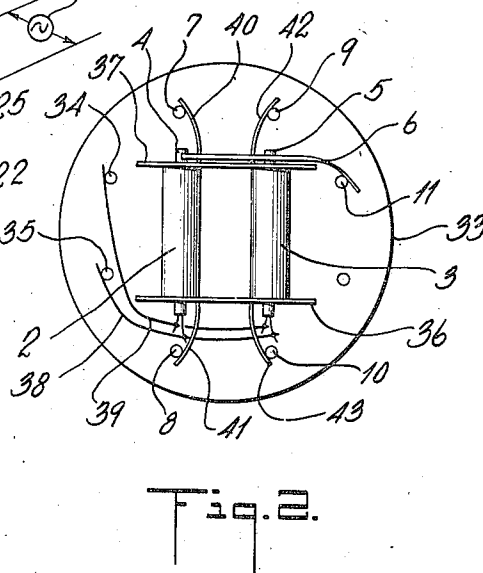
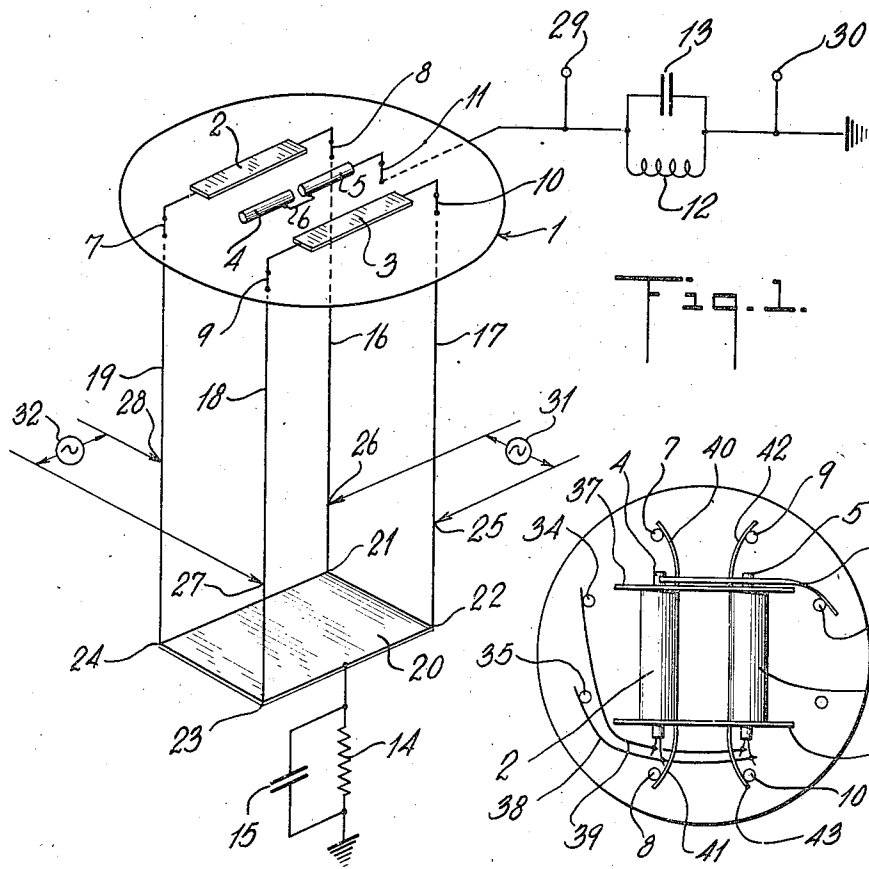
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2,410,387

HIGH FREQUENCY WAVE SIGNALING SYSTEM

Filed Feb. 14, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

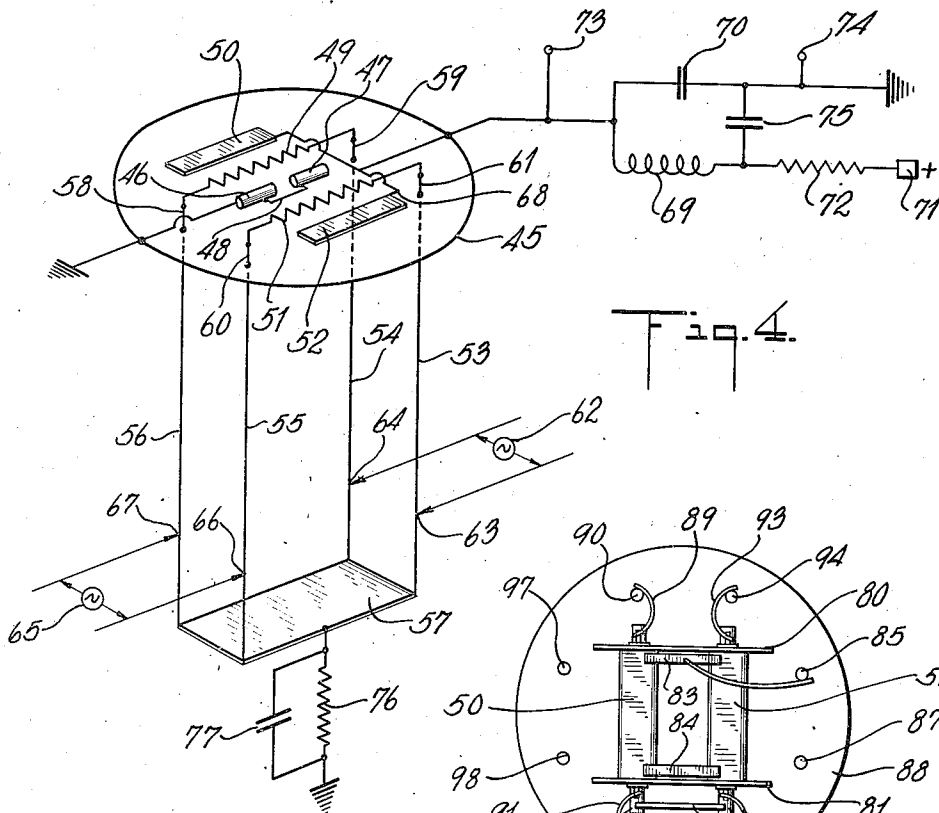


Fig. 4.

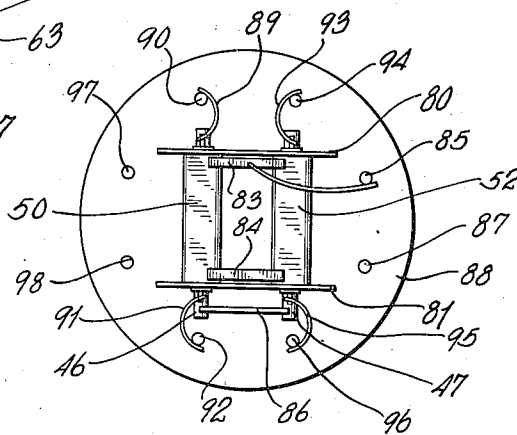


Fig. 5.

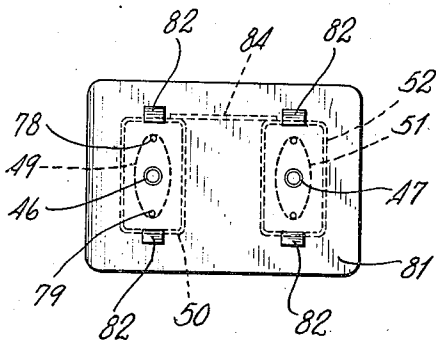


Fig. 6.

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HIGH-FREQUENCY WAVE SIGNALING
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17 Claims. (Cl. 250—20)

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This invention relates to frequency converter circuits and in particular to circuits for heterodyne reception of ultra high-frequency signals of the order of 600 megacycles.

At frequencies of this order tuned transmission lines are preferably used as resonance circuits, and they are applied widely for oscillation generators, measuring devices, and antennas. They have advantages for matching impedances with associated circuit elements, can be simply adjusted, and can be easily balanced with respect to neighboring conductors or ground. Their absolute physical dimensions are small at frequencies of about 600 megacycles, as e. g., the corresponding quarter wave length for this frequency is only about five inches. In all practical cases, the absolute dimensions are still smaller, because the capacities and inductances of the associated tube electrodes and their leads have the same effect as an increase in length of a tuned transmission line without these accidental lumped reactances.

It is a principal object of the invention to provide tunable heterodyne converter circuits which can be operated at frequencies of the order of 600 megacycles, that is, at higher frequencies than is possible with known circuits. This objective is attained without any reduction in the size or spacing of the elements used in the converter tubes.

It is another principal object of the invention to provide two sets of tuned transmission lines for feeding two high-frequency oscillations into the input of a tuned double diode converter circuit, which allows separate and independent matching with the impedances of the elements which inject the signal frequency and the local oscillator frequency.

A feature of the invention relates to the design of a tuned full-wave triode detector amplifier circuit, in which the back coupling at signal and local frequencies from output to input electrodes is completely eliminated because the plates are connected in parallel while the grids are fed in push-pull relation.

Another feature of the invention provides the use of a special construction double triode in a full-wave beat detector circuit, which materially simplifies the attainment of the foregoing objects and features of the invention.

It is a further object of the invention to provide means for feeding the two heterodyning or input oscillations in push pull to the plates of two diode tubes in such a way that there is nearly no un-

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desirable feedback from the signal input line into the local oscillator circuit.

Another object of the invention is to provide means for feeding the grids of a tuned full-wave double triode detector in push pull by both heterodyning frequencies, whereby interlocking of the local oscillator with the signal frequency is substantially prevented.

A further feature of the invention relates to a simplified signal frequency tuned input circuit for a full-wave tuned detector tube circuit, which consists of a quarter-wave line composed of four parallel wires or rods or tubings, which are short-circuited at one end and each of which is attached to the two ends of one of the two input electrodes of the tuned full-wave detector tube.

A feature of the invention relates to a converter circuit using a double triode in which the two cathodes of the two triode sections are short-circuited inside the envelope of the tube whereby undesirable loading of the input circuits of the tube is reduced to a minimum.

The invention will now be described in connection with the drawings, in which

Fig. 1 is a schematic diagram of a tuned double diode full-wave detector circuit incorporating the invention.

Figs. 2 and 3 are views of a diode of Fig. 1.

Fig. 4 is a schematic diagram of the full wave double triode detector amplifier circuit incorporating the invention.

Figs. 5 and 6 give views of the lead connections and mount structure of the tube which is preferably used in the circuit shown in Fig. 4.

Referring to Fig. 1, there is shown a thermionic vacuum tube of the double diode type wherein numeral 1 represents the enclosing evacuated bulb or envelope; 2 and 3 represent respectively the diode anodes or plates; and 4, 5, represent the cathodes for the respective plates 2 and 3. It will be understood that the showing of the electrode arrangements in Fig. 1 is purely schematic and that preferably each plate has its own cathode so that the electron stream between one cathode and its anode is not interfered with by the electron stream between the other cathode and its anode. Such a structural arrangement is shown and described in connection with Figs. 2 and 3 of the drawings.

In Fig. 1, each of the cathodes is of the indirectly heated type comprising a metal sleeve with a coating of emissive material on its outer surface and with a filament or heater wire insulatingly supported within the sleeve. The cathode sleeves are directly connected by a short metal jumper 6.

For simplicity, the heater wires for the cathodes and their lead-ins are omitted from the drawing. Each plate or anode is provided with two separate lead-ins sealed through the bulb 1, thus 7 and 8 are the lead-ins for plate 2; 9 and 10 are the lead-ins for plate 3; and 11 is the lead-in for the cathodes. The common cathode lead-in 11 is connected directly to one side of the intermediate frequency tank circuit consisting of the high frequency inductance 12 and its shunt tuning condenser 13. The other side of this tank circuit is connected to ground through resistor 14 and a large capacity condenser 15. Tuned transmission line 16, 17, and tuned transmission line 18, 19, are connected respectively to the lead-ins 8, 10, and 9, 7, and are in the form of parallel rigid wires or metal tubes or rods which can be adjusted as a unit in length and are maintained parallel at equal distances from one another by suitable means (not shown). The four-line conductors are equal in length and are short-circuited by a metal plate or jumper 20 at the points 21, 22, 23 and 24, so as to form a double quarter wave transmission line with all the conductors extending in the same direction from tube 1. For a detailed description of a typical supporting, adjusting and spacing arrangement for the lines 16-19, reference may be had to application Serial No. 417,068, filed October 30, 1941.

Incoming ultra high-frequency signal energy from source 31 is applied at points 25, 26, to the right-hand section of the tuned quarter-wave line so as to be in push-pull relation to the two diode plates 2, 3, over lead-ins 8 and 10. Local heterodyning frequency from source 32 is applied at points 27 and 28 to the left-hand section of the quarter-wave line also in push-pull relation to the plates 2 and 3 over lead-ins 7 and 9. The resultant intermediate frequency in the nature of a heterodyne between the ultra high-frequency signals from source 31 and the local frequency from source 32, is taken off at points 29 and 30, that is between the cathode side of the intermediate frequency tuned circuit 12, 13 and ground. I have found that with this arrangement, it is possible to receive and convert ultra high-frequency signals of the order of 600 megacycles with great stability and efficiency. Furthermore, the reactances in the common cathode lead 11 have no detrimental effect upon the ultra high-frequency performance since the two halves of the tuned tank circuit and oscillatory system can be balanced with respect to ground so that the two signal currents in the common cathode lead i. e., the currents of the frequency of source 31 and of source 32, cancel each other out. This arrangement also obviates the employment of special filtering elements in the intermediate frequency circuit for elimination of the ultra high-frequency components.

Thus the adjustment of location of the coupling points 25 and 26 can be carried out on one branch of the tuned signal frequency line 16, 17, leading to diode plates 2, 3, quite independently of the adjustment of the location of the signal input points 27, 28, on the other branch 18, 19. In particular, the connecting lines from the two high frequency sources 31, 32, to the diode plates can always be kept at a distance at least as large as the distance of the two branches 16, 17, and 18, 19, from each other. This renders it possible to adjust the feeding points 25, 26, for the signal frequency injection without mechanical interference with the corresponding adjustment of the feeding points 27, 28, for the local oscillations.

The simplification of the matching adjustment above described is substantially improved by the use of a special construction of double diode tube, which is provided with two plate leads for each diode plate, the leads being arranged symmetrically with respect to each other and to the cathodes and with all the connections extending in the same direction from the tube. The common cathode lead-in from the two cathodes enables complete cancellation of the ultra high-frequency signal component as stated above.

The circuit of Fig. 1 can be utilized with known types of double diode tubes by providing a separation of the two tuned quarter-wave lines for the signal frequency outside the tube as above described. However, with such conventional tube designs, there would be introduced additional undesired lumped reactances by reason of the electrode arrangement and the unsymmetrical connections of the various electrodes to their respective tube prongs. These lumped reactances have the effect of reducing the upper frequency limit at which the full wave double diode circuit of Fig. 1 can be used with satisfactory efficiency. Accordingly, there is shown in Figs. 2 and 3, a preferred construction of double diode tube for achieving the best results with the circuits of Fig. 1.

For purposes of simplicity, the bulb of the tube is omitted from Fig. 1 which merely shows the base or header 33 of the tube, this header preferably being of glass in the form of a button or disc as distinguished from the conventional single plane press and which is sealed to the usual glass bulb as disclosed for example in said application Serial No. 417,068, filed October 30, 1941. Sealed in a vacuum-type manner through the base 33 of the bulb, and preferably equally spaced around a circle are the various lead-in pins or prongs 7, 8, 9, 10, 11, 34 and 35. Supported on the base 33 by means of the rectangular mica disc spacers 36, 37, are two sets of diodes; one diode comprising the indirectly heated cathode sleeve 4 with its cylindrical anode 2 and the other diode comprising the indirectly heated sleeve cathode 5 and its surrounding cylindrical anode 3. The filamentary heaters for the two cathode sleeves are connected in parallel by wires 38, 39, which are connected to the contact prongs 34, 35. It will be understood of course, that the electrodes of each diode are suitably fastened or anchored between the mica discs 36 and 37 in any manner well-known in the art so as to preserve the proper spaced relation between each cathode and its associated anode and likewise to preserve a fixed space relation between the two diode sections.

The two cathode sleeves 4 and 5 are electrically and directly connected by the short metal jumper 6 which in turn is connected to the prong 11. One end of plate 2 is connected by jumper 40 to prong 7 and the opposite end of this same plate is connected by jumper 41 to prong 8. Likewise, one end of plate 3 is connected by jumper 42 to prong 9 and the opposite end of plate 3 is connected by jumper 43 to prong 10. The various jumpers in addition to providing symmetrical connections to the plate ends, may also serve to anchor the entire double diode assembly against movement with respect to the bulb base 33. It will be understood of course, that after the electrode mount has been assembled and connected in place, and the bulb has been sealed to the base 33, the tube is subjected

to high evacuation and an exhaust schedule such as is well-known in the radio tube art.

Fig. 4 shows the invention embodied in connection with a full-wave tuned double triode mixer tube. This arrangement has the advantage of combining amplification with the advantages of the full-wave diode mixer arrangements of Fig. 1. The tube 45 is shown schematically and includes a pair of electron-emitting cathodes 46, 47, connected by a short metal strap 48. Associated with cathode 46 is a control grid 49 and a plate anode 50. Likewise, associated with cathode 47 is a control grid 51 and plate anode 52. The grids 49 and 51 are fed in push-pull relation in the same manner as are the diode plates 2, 3, of Fig. 1. Thus the line 53, 54 and line 55, 56, are short-circuited at their corresponding ends by the metal plate 57 to form a double quarter-wave transmission line. Each of the grids is provided with a pair of lead-ins 58, 59, and 60, 61, which are sealed through the glass base of the tube 45 and symmetrically arranged with respect to the anodes and cathodes. The ultra high-frequency signal from the source 62 is applied at the points 63, 64, to the lines 53 and 54, while the local heterodyning frequency from the source 65 is applied at the points 66, 67, to the lines 55 and 56.

The plates 50 and 52 are connected together by a metal strap 68 and are connected to one end of the tuned tank circuit comprising the high-frequency inductance 69 and condenser 70. The steady positive operating potential for the plates 50 and 52 is supplied from the terminal 71 of a suitable power supply source through the resistor 72 and inductance 69. The intermediate frequency resulting from the heterodyne of waves from sources 62 and 65 is taken off between the points 73, 74, of the intermediate frequency circuit 69, 70. The condenser 75 in conjunction with the resistor 72 separates the A. C. component of the plate voltage from the D. C. component thereof. A grid leak resistor 76 and parallel connected grid leak condenser 77 are connected between the short-circuiting plate 57 and ground. By this arrangement, the various circuit elements can be easily balanced with respect to neighboring conductors or ground and the ultra high-frequency component of the input signal is cancelled out across the points 73, 74.

Referring to Figs. 5 and 6, there is shown in more detailed form, a preferred form of tube mount for use in the system of Fig. 4. The mount comprises two separate triode units consisting of the electron-emitting cathode sleeves 46, 47. Surrounding cathode 46 is the helically wound grid 49 which, in the well-known manner, is carried by a pair of metal side rods 78, 79. Surrounding the grid is the rectangular box-like plate anode 50. Likewise, surrounding the cathode 47 is the helical control grid 51 and the surrounding plate anode 52. For purposes of simplicity, the filamentary heaters for the cathodes 46 and 47 are omitted, it being understood that they are insulatingly mounted within the cathodes in any well-known manner.

Each triode unit is assembled between a pair of end mica spacers 80, 81, which are provided with openings in the well-known manner to receive the ends of the cathodes, the ends of the grid side rods and the turned-over ears 82 of the plate electrodes. Thus both triodes form a rigid unitary construction with the various electrodes accurately and permanently spaced by

means of the members 80 and 81. The plates 50, 52, are connected together at their adjacent opposite ends by short metal straps 83, 84. One of the jumpers, for example jumper 83, is connected to the lead-in pin or prong 85. The two cathode sleeves 46, 47, are likewise connected together by a short metal jumper 86 which is connected by a jumper (not shown) to the common lead-in pin 87. Preferably, the glass base 88 of the bulb has eight pins sealed therethrough and equally spaced around a circle, and the duplex triode unit is positioned symmetrically with respect thereto. One end of grid 49 is connected by jumper 89 to pin 90 and the other end is connected by jumper 91 to pin 92. Likewise, one end of grid 51 is connected by jumper 93 to pin 94 and the other end is connected by jumper 95 to pin 96. The remaining pins 97, 98, are connected to the cathode heater filaments (not shown). With the foregoing arrangement, it is possible to effect the symmetrical connections to the two tuned transmission lines 53, 54, and 55, 56. The tube may be plugged in to a socket such as shown in said application Serial No. 417,068, filed October 30, 1941, and the effective length of the tuned transmission lines may be varied as described in said application.

While certain specific structures and embodiments have been disclosed, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What I claim is:

1. A high frequency wave converting system, comprising a double diode tube having the cathodes connected together with a common single lead-in, a tuned tank circuit connected between said lead-in and ground, a pair of tuned double transmission lines, one line being connected in push-pull relation to corresponding points of respective diode plates, the other line being connected in push-pull relation to other corresponding points of said plates, means to connect high frequency signals across the first line, means to connect a source of local oscillations across said other line, and means to lead off a resultant intermediate frequency from across said tank circuit.

2. A high frequency wave converting system according to claim 1, in which the high frequency signal source and the source of the local oscillations are adjustably connected to their tuned transmission lines so that the impedances of said sources are matched with respect to the terminating impedance of said lines.

3. A high frequency wave converting system according to claim 1, in which one end of said tank circuit is connected to said common cathode lead-in and the opposite end of said tank circuit is connected through a non-resonant impedance in parallel to all the ends of said transmission lines remote from said diodes.

4. A high frequency wave converting system according to claim 1, in which all the lead-ins of the double diode tube extend in the same direction therefrom and said pairs of tuned transmission lines also extend in the same direction from said tube.

5. A high frequency wave converting system comprising a double diode tube having the cathodes connected together, a pair of tuned transmission lines extending in the same direction from the electrodes of the diode, one line being excited in push pull by high frequency signals and connected to corresponding points on respec-

tive diode plates, the other line being excited in push-pull by local oscillations and connected to other corresponding points on said plates, a tuned intermediate frequency tank circuit connecting said cathodes to ground, and a non-resonant impedance network connecting to ground all the ends of said lines remote from said diodes whereby intermediate frequency waves across the terminals of said tank circuit are effectively cancelled out.

6. A high frequency wave converting system according to claim 17 in which said tube is a double diode having the anodes fed in push-pull respectively by said high frequency signal waves and said heterodyne waves.

7. A high frequency wave converting system according to claim 17 in which said tube is of the double triode type with the control grids fed in push-pull respectively by said high frequency signal waves and by said heterodyne waves, and in which the tuned intermediate frequency circuit is excited in parallel by the plate currents of the triodes.

8. In a high frequency wave converting system, a double diode electron tube having a pair of electron-emitting cathodes and a cooperating pair of anodes, a pair of lead-ins for each anode connected symmetrically to different points thereof, a common lead-in for both cathodes, a tuned intermediate frequency tank circuit having one end connected to said common lead-in, and the other end connected through a non-resonant impedance network and in parallel to all the lead-ins connected to said anodes.

9. A high frequency wave converting system according to claim 8, in which the tank circuit is connected to all said anode lead-ins through a pair of tuned quarter-wave transmission lines, and a source of high frequency signal waves is connected across one tuned line and a local oscillation source is connected across the other tuned line.

10. In a high frequency wave converting system, a double diode, each diode having a linear cathode and an anode extending along the cathode, a pair of transmission line conductors connected at their corresponding ends to spaced points of one anode the other ends of said conductors being short-circuited and forming with said anode a substantially complete inductive loop, another pair of transmission line conductors connected at their corresponding ends to spaced points on the other anode said other pair of conductors being short-circuited at their opposite ends and forming with said other anode a complete inductive loop, a tuned intermediate frequency circuit connected at one end to the cathodes of said diodes, and at the other end to the short-circuited ends of said transmission line conductors, a source of high frequency signal energy connected across predetermined points of a pair of said lines to excite said anodes in push-pull relation, and a source of local frequency heterodyne oscillations connected across the other pair of lines to excite said anodes in push-pull relation.

11. In a high frequency wave converting system, a double triode, each triode having a linear cathode, an anode, and a grid substantially coextensive with the anode, a pair of transmission line conductors connected at their corresponding ends to spaced points on the grid of one triode, the other ends of said conductors being short-circuited and forming with the grid a substantially complete inductive loop, another pair of

transmission line conductors connected at their corresponding ends to spaced points on the grid of the other triode said other pair of conductors being short-circuited at their opposite ends and forming with the said grid of said other triode a substantially complete inductive loop, a tuned intermediate frequency tank circuit connected at one end in parallel to the plates of both triodes and at the other end to the short-circuited ends of said transmission line conductors, a source of high frequency signal energy connected across predetermined points of one pair of said lines feeding the grids of the two triodes in push-pull relation, and a local source of heterodyning oscillations connected at predetermined points to the other pair of lines and also feeding the grids of said triodes in push-pull relation.

12. A double diode tube for ultra high-frequency conversion, comprising a pair of cathodes each having a corresponding anode, a pair of separate lead-ins for one anode and connected to spaced points on said anode, another pair of separate lead-ins for the other anode and connected to corresponding spaced points on said other anode, and a common lead-in connected to both said cathodes, all said lead-ins extending in substantially the same direction from said tube.

13. A double diode tube according to claim 12, in which the two sets of diode electrodes are interlocked as a rigid unit by insulating spacers at opposite ends.

14. A double diode tube for ultra high-frequency wave conversion comprising a pair of diodes rigidly interconnected as a mechanical unit, means to support said unit on a tube header, said header having a plurality of pairs of lead-ins sealed therein and symmetrically positioned with respect to said unit, all said lead-ins extending in substantially the same direction from the electrodes of the diodes, one pair of said lead-ins being connected to opposite ends of one diode plate, another pair of lead-ins being connected to opposite ends of the other diode plate, means connecting the cathodes of the diodes directly together and a common connection from said last-mentioned means to another of said pins.

15. A duplex triode tube for ultra high-frequency wave conversion comprising a pair of triodes rigidly interconnected as a mechanical unit, means to support said unit on a tube header, said header having a plurality of pairs of lead-ins sealed therein and all extending in substantially the same direction from the electrodes of the triodes, one pair of lead-ins being connected to opposite ends of the grid of one triode and another pair of lead-ins being connected to the opposite ends of the grid of the other triode, means connecting the plates of the triodes directly together, a connection from the last-mentioned means to another lead-in member, said triode units being supported symmetrically with respect to all the said lead-ins and means to connect the cathodes directly together within the tube whereby undesirable loading of the input circuits to the triodes is reduced to a minimum.

16. A double triode for high-frequency wave conversion comprising an envelope enclosing a pair of triode mounts, means within the envelope directly short-circuiting the plates of the triodes, and means also within the envelope directly short-circuiting the cathodes, and symmetrical lead-in connections for the opposite ends of each grid electrode.

17. In a high frequency wave converting system, an electron tube having at least one pair of

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push-pull input electrodes and a pair of output electrodes, a pair of tuned transmission lines, one line having its conductors connected to one set of end points of the two input electrodes, the other line having its conductors connected to the other end points of each of the same input electrodes, means to apply a high frequency signal across one of the lines in push-pull relation to said

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input electrodes, means to apply a local heterodyne frequency signal to the other line also in push-pull relation to said input electrodes, and a tuned intermediate frequency circuit connected to a common terminal of the two output electrodes.

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