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ULTRA HIGH FREQUENCY AMPLIFIER SYSTEM

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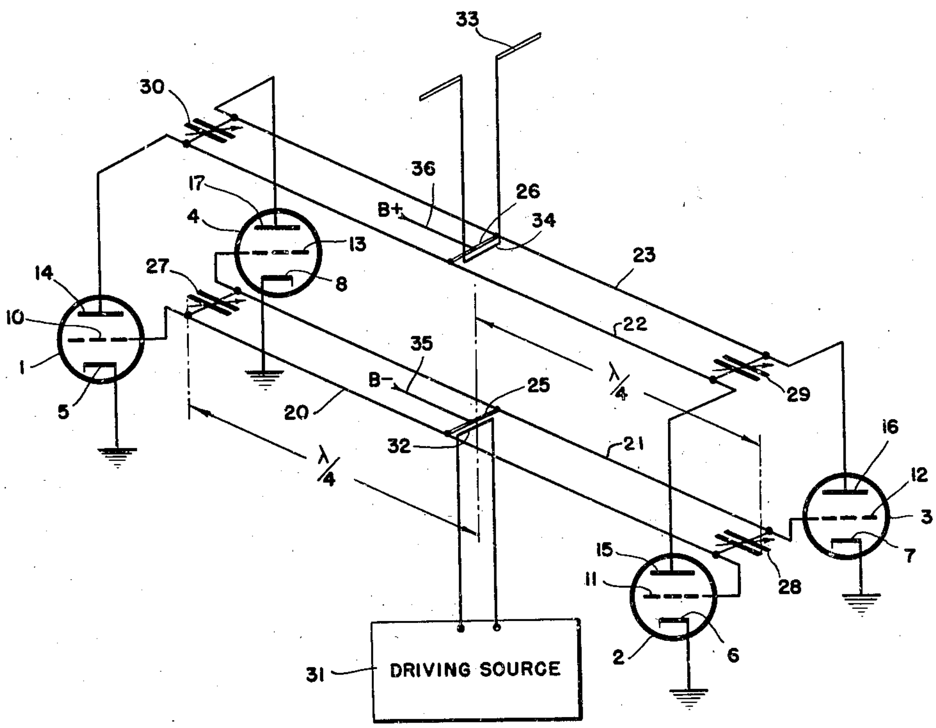

INVENTOR
WILLIAM T. BROWN

BY [signature]
ATTORNEY

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ULTRA HIGH FREQUENCY AMPLIFIER SYSTEM

William T. Brown, Fort Wayne, Ind., assignor, by mesne assignments, to Farnsworth Research Corporation, a corporation of Indiana

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5 Claims. (Cl. 179—171)

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This invention relates to amplifier systems and particularly to push-pull amplifying stages adapted for ultra-high frequency transmitters.

The advantages of a push-pull amplifier are well known to those skilled in the art. Amplifiers of this type deliver a greater output particularly at high and ultra-high frequencies. Another advantage of a push-pull amplifier is that the capacitances of the thermionic tube electrodes are connected in series and thus minimized. It has already been suggested to use a push-pull connected amplifier as the power amplifying stage of a modulated carrier wave transmitter. To this end the input circuit of two push-pull connected thermionic tubes is formed by a pair of parallel straight conductors connected to the two grids of the tubes and short-circuited at the far end. The output circuit is constituted by another pair of straight conductors connected to the plates of the two tubes and short-circuited at the far end. In order to obtain still larger outputs, particularly at ultra-high frequencies, it is desirable to use more than one pair of tubes connected in push-pull. In that case the problem arises how to connect, for instance, two pairs of tubes in such a manner that the interelectrode grid and plate capacitances of the thermionic tubes are minimized.

It is an object of the present invention, therefore, to provide a push-pull amplifier system suitable for amplifying signals at ultra-high frequencies.

Another object of the invention is to provide ultra-high frequency amplifying stages where a plurality of thermionic tubes are connected in push-pull parallel circuits in a manner to reduce the plate and grid capacitances of the tubes.

In accordance with the present invention, there is provided an amplifier for ultra-high frequencies comprising two pairs of thermionic devices each including a grid and an anode. Resonant grid circuits are provided each interconnecting the grids of one pair of the thermionic devices as well as resonant anode circuits each interconnecting the anodes of one pair of the thermionic devices. Means are provided for coupling a common driving source to the grid circuits and further means for coupling a common utilization device to the anode circuits.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

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In the accompanying drawing, the single figure is a schematic representation in perspective of an amplifier system embodying the present invention.

Referring now more particularly to the single figure of the drawing, there is shown an amplifier system including thermionic vacuum tubes 1, 2, 3 and 4. Thermionic tubes 1 to 4 comprise, respectively, cathodes 5, 6, 7, 8, grids 10, 11, 12, 13 and anodes 14, 15, 16 and 17. Grids 10 and 11 are interconnected by resonant conductor 20, while resonant conductor 21 interconnects grids 12 and 13. Conductors 20 and 21 are arranged in parallel and form a two-wire transmission line. Similarly, anodes 14 and 15 are interconnected by resonant conductor 22 and anodes 16 and 17 are interconnected by resonant conductor 23, conductors 22 and 23 being arranged in parallel and forming a two-wire transmission line.

Grid conductors 20 and 21 have their mid points short-circuited by cross bar or bridging member 25. Similarly, anode conductors 22 and 23 have their mid points short-circuited by cross bar or bridging member 26. Variable tuning condensers 27, 28, 29 and 30 may be shunted across grid transmission line 20, 21 and anode transmission line 22, 23, respectively. Tuning condensers 27 to 30 serve for tuning grid transmission line 20, 21 and anode transmission line 22, 23 to a predetermined wave length. However, they are not essential to the operation of the amplifier system of the invention and hence may be omitted.

Preferably, the section of each of the four conductors 20, 21, 22 and 23 arranged between bridging members 25 and 26, respectively, and its associated electrode has an effective length equivalent to a quarter-wave length of the carrier wave or signal to be amplified, as indicated in the drawing. However, the effective length of each of the eight sections of conductors 21, 22, 23 and 24 may also be equivalent to an odd multiple of a quarter-wave length. The total effective length of each of the four conductors 21, 22, 23 and 24, therefore, is equivalent to a half-wave length or an odd multiple thereof. It should be understood, however, that due to the effect of the capacitances of grids 10 to 13 and the capacitances of condensers 27 to 30 the physical length of conductors 21, 22, 23 and 24 should be less than a half-wave length or an odd multiple thereof in order to make the equivalent length of the conductors equal to a half-wave length multipled by an odd number.

A driving source, schematically indicated at 31, is coupled by coupling bar **32** to bridging member **25** in the manner of a transformer coupling. A load or utilization device, schematically represented by dipole antenna **33**, is coupled similarly by coupling bar **34** to bridging member **26**. The four cathodes **5**, **6**, **7** and **8** are connected to a common reference potential such, for example, as ground. Each cathode has been shown connected individually to ground. Actually, however, cathodes **5** to **8** may be kept at ground potential by means of a suitable transmission line connected to ground which, for instance, may have a length between ground and each cathode equivalent to a half-wave length or a multiple thereof. The negative grid biasing voltage may be supplied to bridging member **25** through lead **35**, as shown schematically. Similarly, the positive anode potential may be supplied through lead **36** to bridging member **26**.

The amplifier system of the invention operates as follows. Transmission line **20**, **21** is equivalent to resonant circuits interconnecting grids **10**, **11**, **12** and **13**. Driving source **31** is coupled to bridging member **25** in the manner of a transformer coupling. Hence, grids **10** and **13** are in phase opposition as well as grids **11** and **12**. Furthermore, a standing wave is developed in conductor **20** at its resonant frequency. Thus, the standing voltage wave has a nodal point at the connection of conductor **20** to bridging member **25**. The ventral sections or antinodes of the standing voltage wave occur at grids **10** and **11** and, hence, it will be seen that grids **10** and **11** are also in phase opposition. The standing voltage wave developed in conductor **21** also has its nodal point at the center point thereof, while the ventral sections or antinodes are at the far ends, that is, at grids **12** and **13**. Accordingly, tubes **1** and **3** are in phase with one another and so are tubes **2** and **4**. On the other hand, tubes **2** and **4** are in phase opposition with respect to tubes **1** and **3**. The cycle of operation is such that at a certain instant tubes **1** and **3** will conduct space current, while tubes **2** and **4** are biased to cut-off. After a certain time interval tubes **1** and **3** will be biased to cut-off, while tubes **2** and **4** conduct space current. Hence, two of the four tubes **1**, **2**, **3** and **4** are always operating in parallel.

By virtue of the fact that conductors **20** and **21** have an effective length from bridging member **25** to their respective electrodes equivalent to a quarter-wave length multiplied by an odd number, a small voltage impressed on bridging member **25** will result in a high voltage at grids **10**, **11**, **12** and **13**. This is due to the fact that a quarter-wave transmission line functions as an impedance inverting network. In a similar manner, the load or utilization device coupled to bridging member **26** should have a low impedance so that plates **14**, **15**, **16** and **17** look into a high impedance.

In some cases it may be desirable to utilize an impedance matching network between driving source **31** and its coupling bar **32**, as well as between the utilization device, such as dipole antenna **33**, and its coupling bar **34**. Such an impedance matching network may take the form of a quarter-wave transmission line of suitable impedance.

It is to be understood that driving source **31** may, for instance, be directly connected to grid transmission line **20**, **21**. Similarly, dipole antenna **33** could be directly connected to anode transmission line **22**, **23** instead of being coupled

thereto. One of the main advantages of the amplifier system of the invention is that the grid and plate capacitances of tubes **1**, **2**, **3** and **4** are minimized. On the other hand, a larger output may be obtained because at any instant two of the four tubes are connected in parallel, both conducting space current. The amplifier system of the invention is noteworthy for its high degree of symmetry which is always an important consideration in ultra-high frequency circuits.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An amplifier for ultra-high frequencies comprising two pairs of thermionic devices each including a grid and an anode, two grid conductors forming a resonant two-wire transmission line, each of said grid conductors interconnecting the grids of one pair of said devices for maintaining them in phase opposition, a first bridging member for short-circuiting the center points of said grid transmission line, two anode conductors forming a resonant two-wire transmission line, each of said anode conductors interconnecting the anodes of one pair of said devices, a second bridging member for short-circuiting the center points of said anode transmission line, a driving source coupled to said first bridging member, and a utilization device coupled to said second bridging member.

2. An amplifier for ultra-high frequencies comprising two pairs of thermionic devices each including a grid and an anode, two grid conductors forming a resonant two-wire transmission line, each of said grid conductors interconnecting the grids of one pair of said devices for maintaining them in phase opposition, a first bridging member for short-circuiting the center points of said grid transmission line, two anode conductors forming a resonant two-wire transmission line, each of said anode conductors interconnecting the anodes of one pair of said devices, a second bridging member for short-circuiting the center points of said anode transmission line, said transmission lines being substantially resonant to the same frequency, means for coupling a driving source to said grid transmission line, and means for coupling a common utilization device to said anode transmission line.

3. An amplifier for ultra-high frequencies comprising two pairs of thermionic devices each having a grid, an anode and a cathode, said cathodes being connected to a common reference potential, two grid conductors forming a resonant two-wire transmission line, each of said grid conductors interconnecting the grids of one pair of said devices for maintaining them in phase opposition, a first bridging member for short-circuiting the center points of said grid transmission line, two anode conductors forming a resonant two-wire transmission line, each of said anode conductors interconnecting the anodes of one pair of said devices, a second bridging member for short-circuiting the center points of said anode transmission line, said transmission lines being substantially resonant to the same frequency, a driving source coupled to said first bridging member, and

a utilization device coupled to said second bridging member.

4. An amplifier for ultra-high frequencies comprising two pairs of thermionic devices each including a grid electrode and an anode electrode, two grid conductors forming a two-wire transmission line, each of said grid conductors interconnecting the grids of one pair of said devices, a first bridging member for short-circuiting the center points of said grid transmission line, two anode conductors forming a two-wire transmission line, each of said anode conductors interconnecting the anodes of one pair of said devices, a second bridging member for short-circuiting the center points of said anode transmission line, the effective length of each conductor from its center point to its associated electrode being substantially equal to a quarter-wave length of the signal to be amplified multiplied by an odd number, means for coupling a driving source to said grid transmission line, and means for coupling a utilization device to said anode transmission line, whereby said pairs of thermionic devices are connected in push-pull.

5. An amplified for ultra-high frequencies comprising two pairs of thermionic devices each having a grid electrode, an anode electrode and a cathode, said cathodes being connected to a common reference potential, two grid conductors forming a two-wire transmission line, each of said grid conductors interconnecting the grids of one pair of said devices, a first bridging member for short-circuiting the center points of said grid transmission line, two anode conductors forming a two-wire transmission line, each of said anode conductors interconnecting the anodes of one pair of said devices, a second bridging member for short-circuiting the center points of said anode transmission line, the effective length of each conductor from its center point to its associated electrode being substantially equal to a quarter-wave length of the signal to be amplified multiplied by an odd number, a driving source coupled to said first bridging member, and a utilization device coupled to said second bridging member, whereby said pairs of thermionic devices are connected in push-pull.

WILLIAM T. BROWN.

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