June 24, 1941. A. M. BRAATEN 2,247,217

RESONANT LINE COUPLING CIRCUIT

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Fig. 1

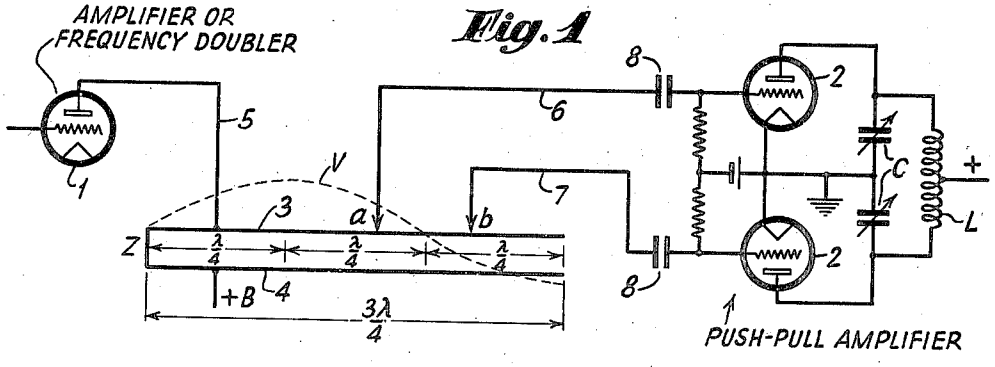


Fig. 2

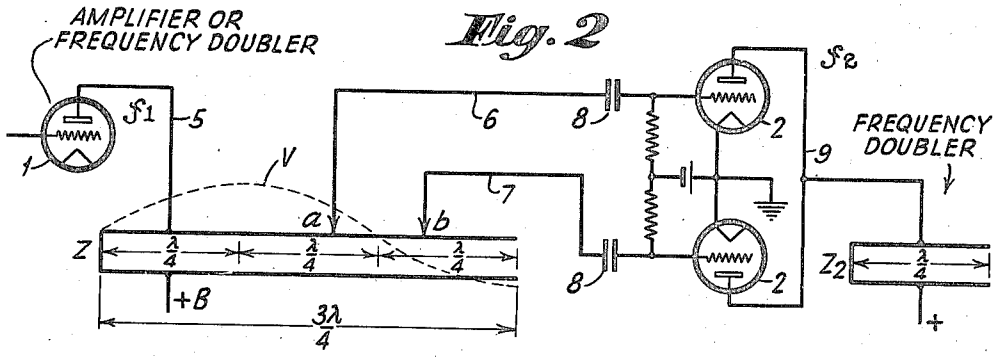
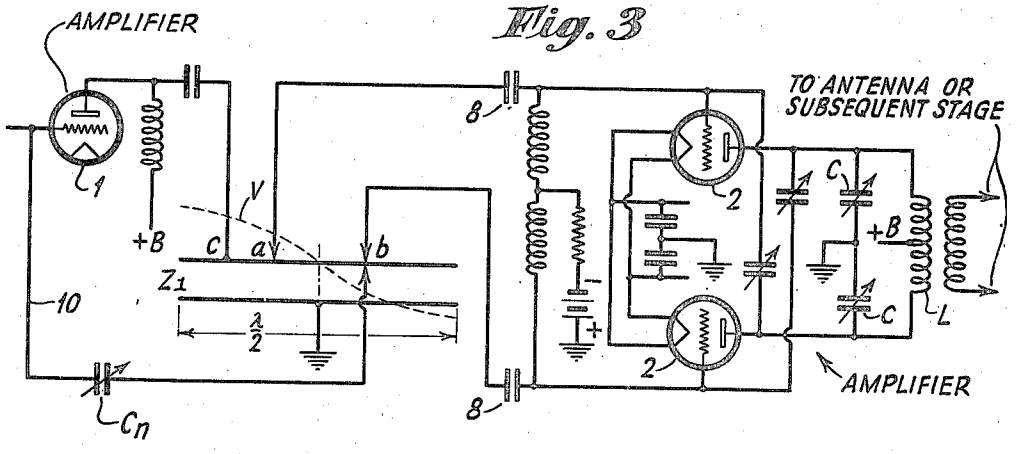


Fig. 3



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Fig. 4

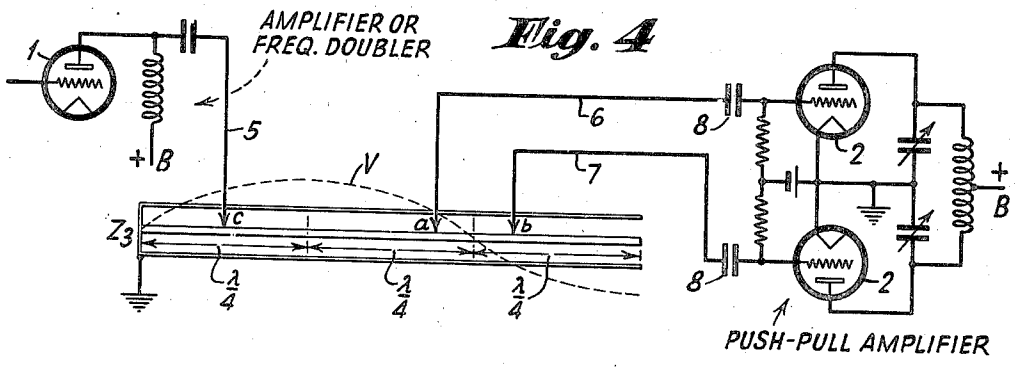


Fig. 5

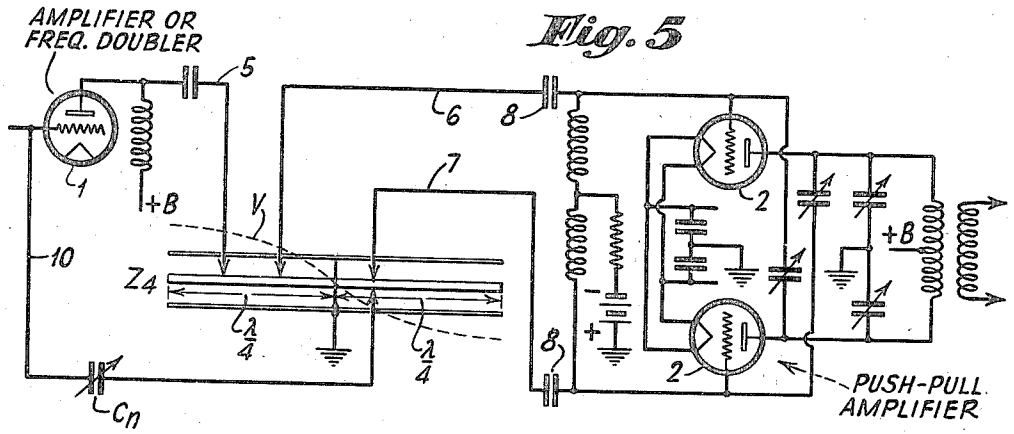
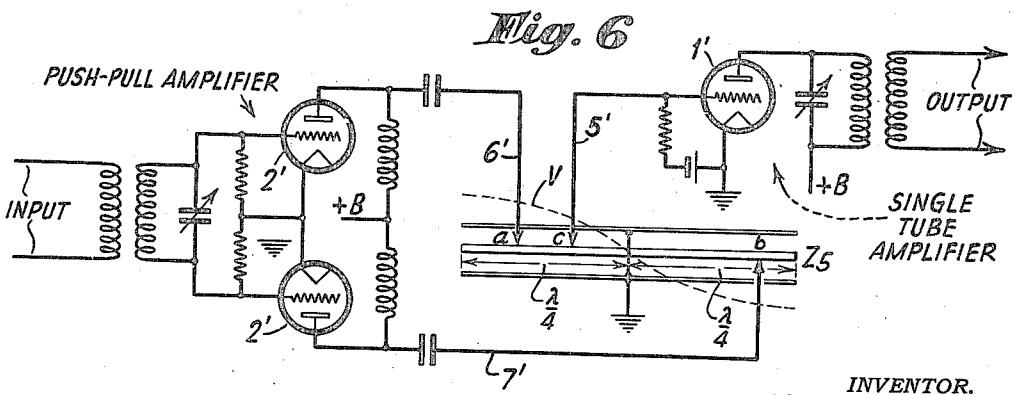


Fig. 6



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2,247,217

RESONANT LINE COUPLING CIRCUIT

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Application April 28, 1938, Serial No. 204,765

7 Claims. (Cl. 179—171)

The invention relates generally to improvements in high frequency circuits employing resonant lines as coupling elements between stages, and provides ways and means for coupling a single vacuum tube stage to a push-pull vacuum tube stage in a simple and efficient manner.

By means of the present invention a two-conductor resonant line may be employed to couple the output of a single tube amplifier to the balanced input of a push-pull amplifier, and/or to couple the balanced output of a push-pull circuit to the input of a single vacuum tube circuit. According to one feature of the invention, the resonant line may serve the dual purpose of an interstage coupling element and as a means for neutralizing a single vacuum tube amplifier circuit.

A better understanding of the invention may be had by referring to the following description which is accompanied by drawings, wherein Figs. 1 to 6, inclusive, illustrate, by way of example, different embodiments of the present invention. In these drawings the same parts have been labeled by the same reference characters.

Referring to Fig. 1, there is shown a two-conductor resonant line Z for coupling the output of an unsymmetrical circuit, in this case a single tube amplifier or frequency doubler stage 1 to the input circuit of a symmetrical or push-pull amplifier stage comprising two tubes 2, 2. Resonant line Z consists of two parallel conductors 3, 4, three-quarters of a wavelength long, short circuited at one end. The voltage distribution along this resonant line is indicated by the dotted curve, labeled V. It should be seen from an inspection of this curve that a voltage nodal point exists at the point one-quarter of a wavelength away from the open end of the line. The output of stage 1 is connected through a lead 5 to a suitable point on the resonant line Z, which point preferably provides an impedance which matches the impedance of the output circuit of the unsymmetrical stage 1. The input circuit to the symmetrical or balanced push-pull amplifier stage 2, 2 is connected to the line by means of leads 6 and 7, which connect to points on the line oppositely disposed with respect to the voltage nodal point thereon. These points are labeled *a* and *b*. If both tubes of the symmetrical push-pull stage have the same characteristics, which is usually the case, points *a* and *b* should be located equal distances on both sides of the voltage nodal point so as to provide equal and opposite polarities on the grids of the tubes 2, 2. The polarizing voltage for the anode of stage 1 may be supplied in a suitable manner by a source of potential +B connected to a point on the resonant line Z. Because of the short-circuit on the line, there will be a direct connection from this source of potential to the anode of the single vacuum tube 1. Voltage from this source, however, will be prevented from being impressed on the grids of the symmetrical circuit by blocking condensers 8, 8 serially inserted in the leads 6 and 7. Any suitable sort of parallel tuned output circuit LC may be used for the push-pull amplifier stage.

Fig. 2 is an arrangement which is similar to Fig. 1, except that the symmetrical circuit in this case comprises a frequency doubler for multiplying the frequency of the waves impressed on the input circuit of this stage. Tubes 2, 2 in Fig. 2 have their anodes connected in parallel by means of a lead 9, from which a connection extends to a suitable tuned circuit such as a quarter wavelength resonant line Z_2. Although the tuned circuit in the output of the symmetrical frequency doubler has been shown as being a resonant line, it will be understood that if desired this particular tuned circuit may be of the lumped reactance type, such as the coil and condenser shown in Fig. 1. The frequency of the single stage 1 has been indicated by the symbol f_1 on lead 5, while the frequency of the output of the symmetrical frequency doubler has been indicated by the symbol f_2. It should be noted that the symmetrical circuit of Fig. 2 accentuates certain harmonics, while that of Fig. 1 eliminates certain harmonics in the output.

Fig. 3 illustrates the use of an open-ended half wavelength resonant line Z_1 as the coupling element between the unsymmetrical single tube stage 1, and the symmetrical push-pull circuit 2, 2. The mid-point of the resonant line Z_1 is grounded at its nodal point, i. e., the center of the one-half wavelength line, so as to provide a radio frequency return path to the amplifier of tube 1. It will be obvious from an inspection of the voltage curve on the resonant line of this figure, that points *a* and *b* have opposite instantaneous polarities impressed thereon in the same manner as the correspondingly marked points on Figs. 1 and 2. An additional feature of Fig. 3 resides in the neutralization connection 10 from a suitable point on resonant line B to the grid of stage 1, so as to provide a feed-back to the grid of a suitable voltage to neutralize the voltage impressed on the grid due to the inter-electrode capacity of the tube. An adjustable neutralizing condenser C_n is placed in series

with the lead 10 to function as a capacitive feed-back and also to adjust the amount of feed-back for neutralization purposes. In the arrangement shown in this figure, it is preferred that stage 1 be a high frequency amplifier and that the push-pull or symmetrical stage 2, 2 also be an amplifier.

It should be understood that the connections from the various stages to the resonant line of Figs. 1, 2 and 3, discussed above, and of the figures to be later discussed, are suitably chosen to match the impedance of the line at these points of connection to the circuits associated with the connections.

Figs. 4 and 5 illustrate arrangements which are substantially identical, respectively, to Figs. 1 and 3, except for the substitution of a concentric resonant line for the parallel wire resonant line in Figs. 1 and 3. In Fig. 4 there is provided a concentric resonant line Z_3 three-quarters of a wavelength long having an inner conductor and an outer conductor, both short circuited and grounded at one end. The connections 5, 6 and 7 from the two stages which are coupled together by the resonant line, extend and connect to the inner conductor of the line Z_3. These connections are, of course, insulated from the outer conductor of the line at their points of entry into the line.

In Fig. 5 the resonant line Z_4 is a concentric line open at both ends and grounded at its center. Here again the connections 5, 6 and 7, as well as neutralizing connection 10, extend to the inner conductor of the line and are insulated from the outer conductor at the points of entry to the resonant line.

Fig. 6 shows one way, merely by way of illustration, of how the output of a symmetrical circuit, such as a push-pull stage 2', 2' can be coupled to the input of an unsymmetrical single tube stage by means of the resonant line coupling circuit Z_5. Line Z_5 in this case is, shown by way of example only, an open-ended half wavelength concentric resonant line whose inner and outer conductors are grounded at their centers. The output connections 6' and 7' from the push-pull stage are coupled to the inner conductor of the line at points symmetrically and oppositely disposed with respect to the voltage nodal point on the line. The input connection 5' for the single tube stage 1' also connects to the inner conductor of the resonant line at a suitable point *c* which will match the impedance of the line to that of the opposite circuit of the tube. It is preferred that both the push-pull stage 2', 2' and the single tube stage 1' be high frequency amplifiers. Although the resonant line Z_5 has been shown as being of the concentric type, it will be obvious that, if desired, this line can be of the parallel two-wire type, such as illustrated in Fig. 3.

It is to be distinctly understood that the invention is not limited to the precise arrangements shown in the drawings, since various modifications may be made without departing from the spirit and scope thereof.

What is claimed is:

1. In a high frequency coupling arrangement, an unsymmetrical high frequency amplifier vacuum tube stage and a symmetrical high frequency vacuum tube stage, a two-conductor resonant line at least three-quarters of a wavelength long at the operating frequency coupling said stages together, said line being short-circuit at one end, a connection from said unsymmetrical stage to a point on one conductor of said line intermediate its ends which point has a desired impedance relative to that of said stage, and a pair of connections from said symmetrical stage to other points on said one conductor of said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point thereon.

2. In a high frequency coupling arrangement for coupling an unsymmetrical high frequency vacuum tube stage to a symmetrical high frequency vacuum tube stage, a two-conductor resonant line three-quarters of a wavelength long at the operating frequency, said line being short circuited at one end, a connection from said unsymmetrical stage to a point on said line which has a desired impedance relative to that of said stage, and a pair of connections from said symmetrical stage to points on said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point thereon.

3. In a high frequency coupling arrangement for coupling the output circuit of a single vacuum tube stage to the push-pull input circuit of a balanced two-tube stage, a two-conductor resonant line at least one-half wavelength long at the operating frequency, a connection from the output of said single stage to a point on one conductor of said line which matches the output impedance of said stage, and a pair of connections from the input of said balanced stage to points on the same conductor of said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point thereon, and a capacitive connection from a suitable point on said same conductor of said line to the input of said single tube stage for neutralizing the interelectrode capacity thereof.

4. In a high frequency coupling arrangement, an unsymmetrical high frequency circuit and a symmetrical high frequency circuit, a two-conductor resonant line at least one-half wavelength long at the operating frequency coupling said two circuits together, a connection from said unsymmetrical circuit to a point on one conductor of said resonant line intermediate the ends of said line, and a pair of connections from said symmetrical circuit to points on said one conductor of said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point, and a capacitive connection from still another point on said one conductor to one of the circuits for neutralizing the interelectrode capacity thereof.

5. In a high frequency coupling arrangement for coupling an unsymmetrical high frequency vacuum tube stage to a symmetrical high frequency vacuum tube stage, a concentric transmission line three-quarters of a wavelength long at the operating frequency, said line being short circuited and grounded at one end, a connection from said unsymmetrical stage to a point on the inner conductor of said line which has a desired impedance relative to that of said stage, and a pair of connections from said symmetrical stage to points on said inner conductor which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point thereon.

6. In a high frequency coupling arrangement, an unsymmetrical high frequency circuit and a symmetrical high frequency circuit, a two-conductor resonant line at least three-quarters of a wavelength long at the operating frequency coupling said two circuits together, said line being short circuited at one end, a connection from said

unsymmetrical circuit to a point on said resonant line, a pair of connections from said symmetrical circuit to points on said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point, a condenser in each of said pair of connections, and means for supplying to said line a polarizing potential for said unsymmetrical circuit.

7. In a high frequency coupling arrangement for coupling an unsymmetrical high frequency vacuum tube stage to a symmetrical high frequency vacuum tube stage, a two-conductor resonant line at least three-quarters of a wavelength long at the operating frequency, said line being short circuited at one end, a connection from said unsymmetrical stage to a point on said line which has a desired impedance relative to that of said stage, and a pair of connections from said symmetrical stage to points on said line which are intermediate the ends thereof and oppositely disposed with respect to a voltage nodal point thereon, said point of connection on said line to said unsymmetrical stage being more than a quarter wavelength away from said voltage nodal point.

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